# A38 Derby Junctions
# TR010022
# Volume 7
# 7.1 Flood Risk Assessment

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**The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009**

# A38 Derby Junctions Development Consent Order 202[ ]

## Flood Risk Assessment

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# A38 Derby Junctions

## Kingsway Junction Flood Risk Assessment

**Report Number: HE514503-ACM-EWE-Z1_ZZ_ZZ_ZZ-RP-HF-0001 P04 S4**
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# EXECUTIVE SUMMARY

### Scheme Details

AECOM has been commissioned by Highways England to provide design services regarding the development of the A38 Derby Junctions Scheme (referred to herein as "the Scheme"). This Scheme concerns three junctions on the A38 in Derby as follows:

- A38/ A5111 Kingsway junction
- A38/ A52 Markeaton junction
- A38/ A61 Little Eaton junction

In flood risk terms, the Scheme at Kingsway junction would increase impermeable surfacing and potential surface water runoff, and would require the realignment of Bramble Brook at the Kingsway junction which is culverted under the existing junction with open space within the junction being used for flood storage. This area is known locally as the "Grand Canyon" due to the channel and flow depths that occur during severe rainfall events.

This Flood Risk Assessment (FRA) comprises one of a number of documents supporting the environmental assessment of the Scheme as reported in the Environmental Statement. A separate Road Drainage Strategy (Report Number HE514503-ACM-HDG-A38_SW_PR_ZZ-RP-CD-0002, Highways England 2019) has been produced. The Road Drainage Strategy Report considers the management of surface water runoff from the proposals.

### Flood Risk Assessment

An FRA has been undertaken in accordance with the National Policy Statement for National Networks (NPSNN) and the National Planning Policy Framework (NPPF) and taking into account guidance provided in the Design Manual for Roads and Bridges (DMRB). According to the NPSNN and NPPF, applications for development proposals of 1 hectare (ha) or greater located in Flood Zone 1 and all proposals for new development located in Flood Zones 2 and 3 should be accompanied by a FRA. This FRA has, therefore, been undertaken to determine:

- The risks of flooding to the Scheme.
- The risks of flooding that could result from the Scheme.
- Appropriate flood risk mitigation measures.

The main aim of this FRA is to demonstrate that flooding risks can be suitably managed associated with the Scheme design. This FRA has been prepared following hydraulic modelling of Bramble Brook which has enabled suitable flood risk mitigation measures to be defined and incorporated into the Scheme design.

### Outcome of the Flood Risk Assessment

This FRA has established that there would be high overall risk of fluvial (river) flooding to the Scheme without the inclusion of appropriate mitigation measures. Mitigation measures have been designed in concept using hydraulic modelling of Bramble Brook to represent watercourse realignment and flood storage areas for the 1 in 100 year flood event plus an allowance for climate change.

Surface water flood risk from the Scheme site to adjacent areas would also increase as a result of highway expansion without appropriate mitigation. A drainage strategy has been developed in parallel with this FRA as a separate report which demonstrates that surface water risks can be managed appropriately.

Incorporation of the mitigation measures as detailed herein indicate that flood risks associated with the Scheme at Kingsway junction can be appropriately managed. Should the Scheme gain development consent, further consultation will be undertaken during the Scheme detailed design with the Environment Agency (EA), Derby City Council (DCiC), Severn Trent Water (STW) and other statutory agencies as applicable.

# 1 INTRODUCTION

## 1.1 Commission

1.1.1 AECOM has been commissioned by Highways England to provide design services regarding the development of the A38 Derby Junctions Scheme (referred to herein as "the Scheme"). This Scheme concerns three junctions on the A38 in Derby as follows:

- A38/ A5111 Kingsway junction
- A38/ A52 Markeaton junction
- A38/ A61 Little Eaton junction

1.1.2 AECOM has been requested by Highways England to carry out a Flood Risk Assessment (FRA) for the Scheme at Kingsway junction. This FRA has been prepared in accordance with the National Policy Statement for National Networks (NPSNN[1]) and the 2019 National Planning Policy Framework (NPPF[2]), its associated Planning Practice Guidance (PPG[3]) and the Design Manual for Roads and Bridges (DMRB[4]).

1.1.3 The Road Drainage Strategy (Report Number HE514503-ACM-HDG-A38_SW_PR_ZZ-RP-CD-0002, Highways England 2019) is contained in Appendix 13.4 of the Environmental Statement (ES) (ES Volume 3). It has been developed alongside this report, with the flood risk and drainage assessment informing each other.

## 1.2 Scheme Background

1.2.1 The existing Kingsway junction is currently an at-grade, three-armed roundabout located on the A38 in Derby, providing a connection between the A38 and A5111 (Kingsway).

1.2.2 This FRA is based on the best flood risk information provided available. The Environment Agency (EA) Flood Map for Planning (Rivers and Sea)[5] shows that the entire Scheme site at Kingsway junction is located within Flood Zone 1 of Main Rivers[6].

1.2.3 However, Kingsway junction is known to have significant flood risk issues that are not represented on the EA Main River flood maps. The Derby City Council (DCiC) Level 1 Strategic Flood Risk Assessment (SFRA) Review undertaken in April 2013[7] identifies in Plan No. 429,333 that Bramble Brook through Kingsway junction is located within Flood Zone 3 and is consequently at risk of fluvial flooding during a 1 in 100 year event. The flood zone classification characterised by DCiC in the SFRA supersedes the Flood Zone 1 designation by the EA on its online Flood Map for Planning (Rivers and Sea).

[1] Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/387222/npsnn-print.pdf
[2] Available online: http://planningguidance.planningportal.gov.uk/blog/policy/
[3] Available online: http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/
[4] Available online: http://www.standardsforhighways.co.uk/ha/standards/dmrb/index.htm
[5] Available online: http://www.environment-agency.gov.uk/homeandleisure/floods/38329.aspx
[6] See http://apps.environment-agency.gov.uk/wiyby/151293.aspx
[7] Available online: http://www.derby.gov.uk/environment-and-planning/planning/planning-evidence-base-9%20jan-2015/

1.2.4 Lead Local Flood Authorities (LLFAs)[8], in this case DCiC, have the responsibility for managing the risk of flooding from ordinary watercourses, as well as surface water and groundwater.

1.2.5 Kingsway junction area is covered by DCiC's Derby Integrated Catchment Model (DICM), which is a combined sewer and watercourse model originally developed from Severn Trent Water (STW) sewer plans. The model provides high level information on the watercourse and sewer network around the junction and has been used to assess flood levels relevant to the existing junction. Model updates have been used to inform the conceptual assessment of Scheme mitigation measures, as described later in this report.

## 1.3 The Scheme

1.3.1 The Scheme entails the provision of grade-separation at Kingsway junction. The proposed Kingsway junction would comprise a dumb-bell roundabout arrangement and linkages at existing ground level, with the A38 passing beneath in an underpass. The existing A38 carriageways would form the northbound and southbound slip roads. The proposed improvement would be predominantly on-line with local access provided by a side road link to Kingsway Park Close from the eastern dumbbell roundabout.

1.3.2 In addition to grade-separation of the existing A38/ A5111 Kingsway junction (with the A38 mainline passing beneath the bridge connecting the new roundabouts), the number of lanes on the A38 between Kingsway junction and the A38/ A52 Markeaton junction would be increased from two to three lanes in each direction. Two existing bridges over Brackensdale Avenue would be widened to cater for the provision of the additional lane on each carriageway. The existing accesses from the A38 onto Brackensdale Avenue and Raleigh Street would be closed for safety reasons. The existing carriageway associated with the left in/ left out access onto the A38 from Brackensdale Avenue would thus be made redundant by the Scheme.

1.3.3 The Scheme layout is shown in Appendix A together with details of the Scheme boundary.

## 1.4 Planning Process

1.4.1 The Scheme is a Nationally Significant Infrastructure Project (NSIP) and thus a Development Consent Order (DCO) application is to be made to the Planning Inspectorate (The Inspectorate). The DCO application will be accompanied by an Environmental Impact Assessment (EIA) as reported within an Environment Statement.

1.4.2 Given the above, the Scheme is subject to consideration by The Inspectorate, rather than being subject to planning control by the Local Planning Authority (LPA). Highways England is the promoter and the Applicant for the Scheme and would also be responsible for Scheme maintenance (with the exception of those parts of the Scheme that would be the responsibility of third parties such as the local authority and landowners).

[8] See https://www.gov.uk/government/publications/ordinary-watercourse-regulation-advice-note

## 1.5 Aims and Objectives

1.5.1 This report comprises an FRA of the proposed Kingsway junction. The assessment has involved assessing flood risks to the Scheme site, advising on the potential constraints to the Scheme, assessing the potential impact of the Scheme on flood risks in the wider area and providing outline mitigation measures and a road drainage strategy. To complete this study the following objectives have been met:

- Review the development plans with respect to flood information in national and local policy documents, strategic flood risk documents and relevant previous and local studies that cover the area of the Scheme.
- Acquire and review the DICM used by DCiC to assess flood risks at strategic level across Derby, update the model with local topographic and sewer surveys, and use the updated model to assess the baseline and Scheme scenarios and define mitigation measures.
- Assess all other potential sources of flood risk including surface water, drainage infrastructure, groundwater and artificial sources.
- Identify requirements for surface water runoff attenuation from the Scheme site and the implications for storm water attenuation/ storage.
- Propose suitable flood mitigation measures (where applicable) in line with the recommendations of current best practice.
- Produce a report that summarises flood risk at the site and surface water considerations appropriate for the Scheme, in accordance with the NPSNN, NPPF, PPG and DMRB.

# 2 SITE AND SURROUNDING AREA

## 2.1 Site Location

2.1.1 The existing Kingsway junction is located approximately 2km to the south-west of Derby and centred at Ordnance Survey National Grid Reference 432815, 336085. It forms the intersection of the A38 from the north and south and the A5111 (Kingsway) from the east. The Scheme location is illustrated in Figure 2-1 (also refer to Appendix 1).

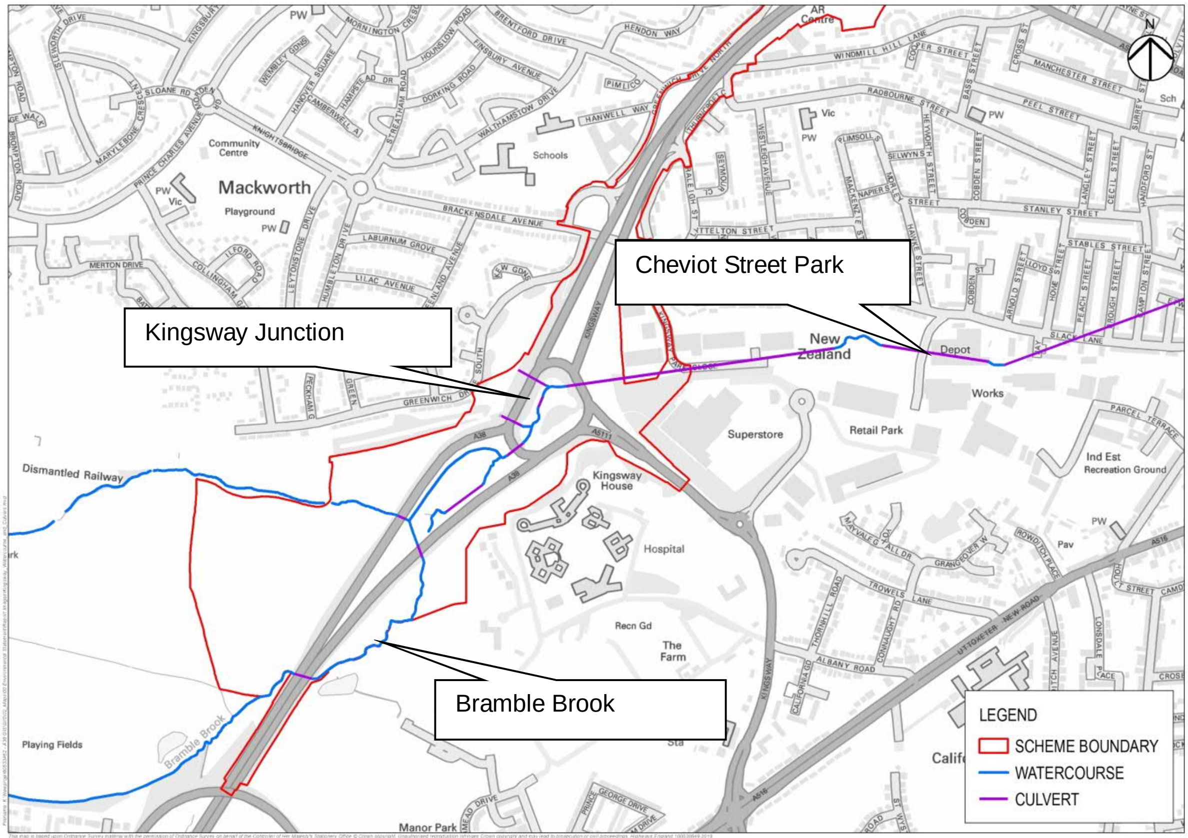



**Figure 2-1: Site Location Map and Water Features**



## 2.2 Existing Junction

2.2.1 The existing junction is largely on embankment with the A38 southbound (south of the junction) being in a slight cutting and at-grade. There is a depression in the centre of the junction relative to carriageway level, which is occupied by Bramble Brook - this area is known locally as the “Grand Canyon”. The onward culvert of the Bramble Brook from the junction has a restricted capacity resulting in the low lying areas of the junction forming an informal flood storage area. This provides flood risk benefits to the urbanised area of Derby downstream of the A38 junction. The approaches to the junction are in cuttings, at-grade and on embankment.

2.2.2 Bramble Brook is culverted under the A38 several times and has two culverted connections inside the existing junction. The brook discharges eastwards from the junction via another culvert. Immediately to the north and east of the site are residential properties and open green space. The land to the south is occupied by

Kingsway hospital, whilst the Kingsway Retail Park is located to the east and south-east, with residential properties located further afield. A cutting associated with a disused railway is located to the north-west of the junction.

## 2.3 Topographic Setting

2.3.1 The topographic survey for Kingsway junction shows that the south of the existing junction is at an elevation of approximately 74.5m AOD (above ordnance datum), whilst the northern section is at approximately 76.5m AOD. There is a deep depression within the middle of the roundabout which is occupied by Bramble Brook which serves as a flood storage area during flood events.

2.3.2 The A38 rises away from junction to the north and falls to the south. To the east the A5111 Kingsway rises quickly away from the site, reaching an elevation of approximately 84m AOD at the Kingsway Retail Park roundabout approximately 300m away.

## 2.4 Local Water Features

2.4.1 Bramble Brook is an Ordinary Watercourse which flows through the middle of the Kingsway junction. The brook flows from the south-west as an open channel and passes beneath the A38 within a culvert that extends approximately 500m east, all of which is represented in the DICM model received by AECOM in June 2015. The baseline model suggests that the area within the Kingsway junction stores the 1 in 100 year flood event at depths up to approximately 4.0m.

2.4.2 Bramble Brook flows east away from the junction where it enters another culvert with around 50% of flows diverted into a 1,200mm diameter STW sewer. The remainder flows through the city and is almost entirely culverted, receiving a series of surface water inflows.

## 2.5 Geology/ Hydrogeology

2.5.1 The A38 Derby Junctions Ground Investigation Report (Report Number HE514503-ACM-VGT-A38_SW_PR_ZZ-PR-GE-0003_P02_24, 2018) states that the ground conditions comprise topsoil and Made Ground, underlain by Mercia Mudstone Group and the Tarporley Siltstone Formation (Siltstone, Mudstone and Sandstone). A strip of Alluvium is indicated running south-west to north-east through the junction as stated in the A38 Derby Junctions Ground Investigation Report (Report Number HE514503-ACM-VGT-A38_SW_PR_ZZ-PR-GE-0003_P02_24, 2018).

2.5.2 The Made Ground comprises existing embankment fill to depths of up to 2.3m, whilst the Alluvium is described as clay and silt material to depths of 2.6m. Some of this material may be weathered Mercia Mudstone Group material.

2.5.3 The Mercia Mudstone Group material comprises a weathered profile, typically becoming less weathered with depth. The near surface material is described as stiff and very stiff, friable clay with mudstone fragments. The less weathered material, typically at greater depths, is described as weak mudstone. This material includes bands of grey siltstone and sandstone.

2.5.4 According to DEFRA Magic mapping[9], the bedrock is classified as a Secondary B aquifer; lower permeability layers which store and yield limited amounts of

[9] Available at: https://magic.defra.gov.uk/MagicMap.aspx Last accessed November 2018.

groundwater due to localised features. The superficial deposits are considered to be unproductive strata i.e. low permeability deposits that have negligible significance for water supply or river base flow.

2.5.5 Groundwater used for drinking water is protected by the EA. The EA classifies zones around potable groundwater abstraction points as Source Protection Zones (SPZs). These are designed to limit potential pollution activities and have implications for how surface water is managed e.g. by infiltration. According to the EA, the site at Kingsway junction does not lay within an SPZ, with the closest zone located approximately 2.8km to the east of the junction.

# 3 REGULATORY POSITION

## 3.1 National Policy Statement for National Networks (NPSNN)

3.1.1 The primary basis for deciding whether or not to grant a Development Consent Order (DCO) is the National Policy Statement for National Networks (NPSNN) which, at Sections 4 and 5, sets out policies to guide how DCO applications will be decided and how the impacts of national networks infrastructure should be considered.

3.1.2 Flood risk paragraphs 5.90 – 5.115 state that the Secretary of State should be satisfied that flood risk will not be increased elsewhere and should only consider development appropriate in areas at risk of flooding where it can be demonstrated that: the most vulnerable development is located in areas of lowest flood risk unless there are overriding reasons to prefer a different location; development is appropriately flood resilient and resistant, including safe access and escape routes where required; that any residual risk can be safely managed, including by emergency planning; and that priority is given to the use of sustainable drainage systems (SuDs). Applications for projects should be accompanied by a flood risk assessment (FRA) to assess all risks of flooding and take climate change into account.

3.1.3 In preparing an FRA an applicant should:

- Consider the risk of all forms 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 lifetime.
- Take the impacts of climate change into account, clearly stating the development lifetime over which the assessment has been made.
- Consider the vulnerability of those using the infrastructure including arrangements for safe access and exit.
- Include the assessment of the remaining (known as ‘residual’) risk after risk reduction measures have been taken into account and demonstrate that this is acceptable for the particular project.
- Consider if there is a need to remain operational during a worst case flood event over the development’s lifetime.
- Provide the evidence for the Secretary of State to apply the Sequential Test and Exception Test as appropriate.

## 3.2 National Planning Policy Framework (NPPF)

3.2.1 Section 14 of the NPPF (revised in February 2019) and the associated 2014 Planning Practice Guidance (PPG) provides the current guidance for planning with respect to flood risk and meeting the challenges associated with climate change. The NPPF advocates a sequential approach for the planning process in order to steer development to areas with the lowest possible risk of flooding. It is important to note the revision to the 2012 NPPF in 2018 and 2019. The FRA has been completed in accordance with the 2019 revision and the associated 2014 PPG.

3.2.2 As discussed in Section 1.2, although the EA Flood Map for Planning (Rivers and Sea) identifies the Scheme at Kingsway junction as being within Flood Zone 1, the

DCiC SFRA Review (2013) shows Bramble Brook as having an associated Flood Zone 3 designation. Upon being revised in 2014, Table 2 within the PPG states that the junction lies within the 'Essential Infrastructure' vulnerability classification. Table 3, which provides a matrix identifying which vulnerability classifications are appropriate within each flood zone, demonstrates that 'Essential Infrastructure' developments within Flood Zone 3 require the Exception Test to be undertaken. In particular, Table 3 states that "*In Flood Zone 3a essential infrastructure should be designed and constructed to remain operational and safe in times of flood*". The safe operation of the junction during a flood is a key focus of the hydraulic modelling undertaken to inform this FRA.

### 3.3 Design Manual for Roads and Bridges (DMRB)

3.3.1 Highways England and other highway authorities have a responsibility to keep trunk roads and local roads respectively free from flooding (relevant legislation includes the Highways Act 1980 and the Land Drainage Acts 1991 and 1994).

3.3.2 The DMRB primarily refers to the former PPS25 (now superseded by the NPPF) for FRA and flood mitigation guidance, and emphasises the need for consultation with the EA early in the design process.

3.3.3 The DMRB offers guidance on hydraulic design of highway drainage systems, and assessment, and guidance on mitigation techniques for roads (and embankments) that encroach into floodplains. The latter is not applicable in this case because the site is in Flood Zone 1.

3.3.4 More detailed discussion of highway surface water management and sustainable drainage is provided in Section 6.

### 3.4 Local Plan Review – Adopted Plan

3.4.1 The current adopted Local Plan for study area is The Derby City Local Plan - Part 1 Core Strategy (2017)[10] which sets out the long term strategy for promoting and managing development in the city up to 2028. The plan forms part a statutory framework to be used in addition to the on-going policies from the City of Derby Local Plan Review (2006)[11].

3.4.2 In terms of flood protection the Local Plan, 'CP2 Responding to Climate Change' aims to protect important flood plain areas and provides guidance relating to development within these areas. The policy states:

'*Except where satisfactory compensatory measures are provided to off-set any potential adverse effects for development on the water environment and associated lands, planning permission will not be granted for development which:*

*a. Lies within undefended areas at risk of flooding;*

*b. Would create or exacerbate flooding elsewhere;*

*c. Results in the loss of natural floodplain;*

[10] Available at: https://www.derby.gov.uk/media/derbycitycouncil/contentassets/documents/policiesandguidance/planning/CDLPR_2017.pdf
[11] Available online: https://www.derby.gov.uk/media/derbycitycouncil/contentassets/documents/policiesandguidance/planning/CDLPR_2017.pdf

d. *Would impede access to a watercourse for maintenance or flood defence purposes;*

e. *Does not provide for the adequate management of surface run-off using sustainable drainage principles, unless it can be demonstrated that their use is inappropriate.'*

3.4.3 The Scheme is an NSIP and therefore subject to a DCO. In order to obtain development consent, Highways England must demonstrate that flood risk has been adequately managed. Furthermore, planning consent will only be granted where compensating measures are proposed to mitigate potential flood problems.

3.4.4 The draft Core Strategy provides policy and guidance relating to flood risk and water management. It must be ensured that development is flood resilient and resistant and that flood risk is not increased to people or property within the surrounding area. Development must also be designed and laid out to incorporate SuDS and ensure that runoff is directed to areas where it does not cause harm to others.

3.4.5 In addition to the Local Plan, Supplementary Planning Documents were updated to adopt a revised 'Adopted Planning Obligations SPD' published in August 2018[12]. According to the Manor and Kingsway Hospital SPD, an area of land to the south of the junction, adjacent to the Kingsway hospital, is allocated as a 'Major mixed-use regeneration opportunity'. Land at the former Manor and Kingsway hospital (AC19 – Manor Kingsway) is allocated for a minimum of 500 new high quality homes in addition to 200 key order units, 6.9ha of business development and a park and ride interchange. These will be complemented by the provision of local facilities, amenities and job opportunities, transforming the area into a new sustainable extension to the suburbs of Mickleover and Littleover. This emphasises the need to manage flood risk from the Scheme to adjacent areas.

## 3.5 Strategic Flood Risk Assessment (SFRA)

3.5.1 In October 2013 DCiC prepared a Level 1 Strategic Flood Risk Assessment (SFRA)[13] to assist the city in meeting the requirements of national policy. The SFRA provides general advice on flood risks and on the principles and application of sustainable drainage.

3.5.2 A mapping review and explanation review of the SFRA was undertaken in April 2013 and revised the fluvial Flood Zone designation of the Bramble Brook and shows that the Bramble Brook through the Kingsway junction is located within Flood Zone 3.

3.5.3 In relation to the Scheme site, part of the SFRA focuses on Bramble Brook and the risk that it poses to the surrounding area. According to the SFRA, floodwaters accumulate at the culvert beneath the A38 due to the trash screens becoming blocked by debris. Further downstream, just beyond the Kingsway junction, the brook enters a culverted section within the Cheviot Street Park where there is a 1,200mm overflow weir in which it has been estimated that during a 1 in 100 year flow, approximately 50% of the brook flows into a STW sewer. From this area onwards,

[12] Available online: https://www.derby.gov.uk/media/derbycitycouncil/contentassets/documents/policiesandguidance/planning/Manor_Kingsway_SPD.pdf

[13] Available online: https://www.derby.gov.uk/media/derbycitycouncil/contentassets/documents/policiesandguidance/planning/SFRA_1_Update_Explanation_V3.pdf

the brook flows almost entirely in culverts to its outfall. It is noted that there is concern regarding the condition of some of the culverts with ongoing repair and maintenance required for maintaining capacity.

3.5.4 SFRA highlights that Bramble Brook frequently floods due to the narrow channel with little freeboard, multiple highways culverts and mature vegetation that often blocks culvert screens.

### 3.6 Preliminary Flood Risk Assessment (PFRA)

3.6.1 In 2011 DCiC produced its Preliminary Flood Risk Assessment (PFRA)[14] which represented the first stage in recording and monitoring flooding in Derby. The high level assessment addresses flood risk from surface water groundwater, ordinary watercourses and canals. Main rivers and reservoirs were excluded from the scope as they were covered under a separate assessment.

3.6.2 The PFRA states that during 1932, fluvial flooding was reported within the Bramble and Littleover Brook catchment which led to the inundation of properties. Following these events, a major flood relief culvert (Bramble Brook Culvert) was constructed which helped manage flooding within the area. It was considered that further assessment of Bramble Brook is required due to overall capacity and the condition of the open and culverted channel sections.

3.6.3 According to the PFRA, no other sources present a significant risk to the Scheme site.

### 3.7 Our City Our River

3.7.1 The Our City Our River Masterplan[15] has been developed jointly by DCiC and the EA since 2012, and sets out a shared vision to reduce flood risk in Derby and transform the City's relationship with the River Derwent by helping to encourage economic regeneration in areas currently at risk of flooding.

3.7.2 Our City Our River is focused on the River Derwent and has no impact on Kingsway junction or Bramble Brook.

### 3.8 Consultation

3.8.1 AECOM has been consulting with DCiC, EA and STW regarding flooding and highway drainage design issues since 2015.

**Derby City Council (DCiC)**

3.8.2 DCiC is the LLFA responsible for managing the risk of flooding from surface water, groundwater and ordinary watercourses in the vicinity of the Scheme at Kingsway junction, and has been consulted regarding local flood risks, available data and the drainage design.

3.8.3 DCiC is also the Land Drainage Authority for Bramble Brook and is responsible for issuing consents for any works requiring approval under the Land Drainage Act (1991).

[14] Available online: https://www.derby.gov.uk/media/derbycitycouncil/contentassets/documents/policiesandguidance/planning/SFRA_1_Update_Explanation_V3.pdf

[15] Available at: https://www.derby.gov.uk/media/derbycitycouncil/contentassets/documents/environmentandplanning/OurCityOurRiverMasterplan2013.pdf

3.8.4 DCiC has provided AECOM with an extract of a strategic flood risk model covering the Kingsway junction area. The model integrates watercourse and STW sewer networks, and has been reviewed and updated to assess flood risks and inform Scheme designs, as described in Section 6.

**Environment Agency (EA)**

3.8.5 The EA has been consulted on the Kingsway junction improvement proposals. Given that Main Rivers are unlikely to be affected at Kingsway junction, the EA had no particular comments on fluvial flood risks for the proposals, but did emphasise that surface water runoff should be controlled to existing rates or less.

**Severn Trent Water (STW)**

3.8.6 Consultation has been undertaken with STW with regard to their assets in the vicinity of the Scheme at Kingsway junction. It is noted that the STW sewer network forms the basis of DCiC’s strategic flood model and all STW sewers relevant to the Scheme at Kingsway junction are represented in the model.

# 4 SOURCES OF FLOODING AND FLOOD RISK

## 4.1 Introduction

4.1.1 The NPPF (and the NPSNN for NSIPs) requires that all potential sources of flooding that could affect a development are considered within an FRA. This includes flooding from rivers and the sea, directly from rainfall on the ground surface and rising groundwater, overwhelmed sewers and drainage systems. Flooding from reservoirs, canals, lakes and other artificial sources must also be considered. There should be demonstration of how these should be managed so that the development remains safe throughout its lifetime, taking into account climate change.

## 4.2 Historic Flooding

4.2.1 Fluvial flooding occurred in the Bramble Brook and Littleover Brook catchment in 1932. The Bramble Brook culvert was subsequently constructed to manage the frequent flooding.

4.2.2 The Highways England Drainage Data Management System (HE DDMS) database was investigated for records of historic flooding at the Scheme site. One flood event is reported (ID 12470) in the vicinity of the Scheme at Kingsway junction, which occurred midway between the Kingsway and Markeaton junctions. Flooding was reported on the A38 southbound Palm Court roundabout slip road and onto the A38 south towards Markeaton Island in September 2013, and remedial action was taken (unblocking a gully).

## 4.3 Fluvial

4.3.1 Flooding from fluvial sources (rivers) can occur through inundation of floodplains from rivers and watercourses, or inundation of areas outside of the floodplain due to influence of bridges, embankments and other features that can restrict flow.

4.3.2 The EA Flood Map for Planning (Rivers and Sea)[16] shows that Kingsway junction is located within Flood Zone 1, and at very low risk of flooding from Main Rivers. There are no formal flood defences identified on EA mapping along Bramble Brook through Kingsway junction.

4.3.3 However, as discussed in Section 2.4, there is an ordinary watercourse (Bramble Brook) which flows through the centre of the junction which could potentially cause flooding issues to the Kingsway area. Bramble Brook is identified in the DCiC SFRA review as having an associated fluvial Flood Zone 3.

4.3.4 Discussions regarding the Scheme at Kingsway junction with DCiC identified that initial modelling of the Kingsway area indicated significant flood risks issues within and upstream/ downstream of Kingsway junction.

4.3.5 Outputs requested from DCiC's DICM, which is a combined sewer and watercourse model originally developed from STW sewer plans, suggested that approximately 5,000m$^3$ of floodwater accumulates at the junction during a 1 in 100 year event, with the potential to inundate commercial and industrial properties.

4.3.6 Fluvial flood risks at Kingsway junction are therefore high. Additional work including updating of the DICM based on the latest topographical survey of the junction has

[16] Available at: https://flood-map-for-planning.service.gov.uk/confirm-location?easting=333158&northing=391230&placeOrPostcode=kingsway Last Accessed November 2018.

been undertaken within this study to understand these risks and develop suitable mitigation measures - this is discussed further in Section 5.

## 4.4 Tidal

4.4.1 Tidal flood sources include the sea and estuaries. Kingsway junction is effectively at no risk of flooding from tidal sources.

## 4.5 Groundwater

4.5.1 Groundwater flooding occurs as a result of water rising up from the underlying aquifer or from water flowing from springs. This tends to occur after long periods of sustained high rainfall, and the areas at most risk are often low-lying where the water table is more likely to be at shallow depth. Groundwater flooding is known to occur in areas underlain by major aquifers, although increasingly it is also being associated with more localised floodplain sands and gravels. It tends to occur sporadically in both location and time, and because of the more gradual movement and drainage of water, and tends to last longer than fluvial, pluvial or sewer flooding.

4.5.2 The Scheme design at Kingsway junction includes placing a small part of the mainline A38 in cutting, which would exacerbate any existing groundwater risks.

4.5.3 As highlighted in the A38 Derby Junctions Ground Investigation Report (Report Number HE514503-ACM-VGT-A38_SW_PR_ZZ-PR-GE-0003_P02_24, 2018), Kingsway junction lies over bedrock geology of Mercia Mudstone Group and the Tarporley Siltstone Formation (Siltstone, Mudstone and Sandstone). The underlying geology is therefore permeable and has the potential to contain varying groundwater levels.

4.5.4 According to the Areas Susceptible to Groundwater Flooding Map within the PFRA, Kingsway junction lies within an area considered to have a risk of <25%, although DCiC has no records of groundwater flooding in the vicinity of the site.

4.5.5 The A38 Derby Junctions Ground Investigation Report indicates that groundwater levels have been recorded at approximately 0.5m to 1.5m depth beneath original ground level, which may now be several metres below current carriageway level.

4.5.6 Overall, the risk of groundwater flooding is considered to be medium.

## 4.6 Surface Water

4.6.1 Overland flow results from rainfall that fails to infiltrate the surface and travels over the ground surface; this is exacerbated where the permeability of the ground is low due to the type of soil and geology (e.g. clay soils) or urban development. Surface water flow is also promoted in areas of steep topography which can rapidly convey water that has failed to penetrate the surface.

4.6.2 The EA Flood Map for Surface Water[17] shows that there are areas around the existing Kingsway junction at a ‘high’ risk of surface water flooding, although the highways themselves are not shown as being directly at risk.

4.6.3 There are shown to be three overland surface water flow paths through the public open space to the west of the junction (Mackworth Park), including a flow path within the disused railway cutting to the immediate west of the junction. The most southerly

[17] Available at: https://flood-map-for-planning.service.gov.uk/confirm-location?easting=333158&northing=391230&placeOrPostcode=kingsway Last Accessed November 2018.

of these flow paths joins the Bramble Brook prior to its upstream culvert beneath the A38. The flow path through the centre of the parkland has an existing culvert beneath the western carriageway of the A38. The flow path within the disused railway has an existing embankment and restricted culvert that is shown to attenuate overland flow upstream of the junction. There is an existing 0.8m diameter culvert from the railway cutting through to the centre of Kingsway junction. These flow paths are included within the DCIM and will therefore be retained with culverted connections to Bramble Brook.

4.6.4 As the Scheme at Kingsway junction would increase the amount of impermeable surface, the amount of surface water runoff from the area would also increase.

4.6.5 The risk of surface water flooding from overland flow paths is consequently considered holistically alongside the risk of fluvial flooding within the hydraulic modelling of the Bramble Brook. Mitigation measures would be required to control surface water flood risks from the proposed junction. The Road Drainage Strategy (Report Number HE514503-ACM-HDG-A38_SW_PR_ZZ-RP-CD-0002, Highways England 2019) provides details of the proposed drainage works at Kingsway junction – these are discussed in Section 6.

### 4.7 Sewers

4.7.1 Flooding can occur as a result of infrastructure failure e.g. blocked sewers or failed pumping stations. Sewer flooding can occur when the system surcharges due to the volume or intensity of rainfall exceeding the capacity of the sewer, or if the system becomes blocked by debris or sediment.

4.7.2 No sewer flooding records have been identified in the vicinity of the Scheme at Kingsway junction.

4.7.3 The DICM is a combined sewer and watercourse model originally developed from STW sewer plans that has been reviewed and updated as part of this assessment. Review of the model has identified that flood risks to the Kingsway junction area are associated with culverted watercourses rather than sewers.

4.7.4 As described above, the Road Drainage Strategy report states that the existing highway pavement and drainage collection systems would be replaced as part of the junction improvements, and detailed drainage design including sewers will take place during the detailed design.

4.7.5 Overall, the risk of sewer flooding at Kingsway junction is considered to be low.

### 4.8 Artificial Sources

4.8.1 Artificial sources include raised channels such as canals or storage features such as ponds and reservoirs. According to OS mapping there are no significant canals, ponds or storage features located in the proximity of the Scheme at Kingsway junction. There is a disused railway cutting that has previously been identified as having a high risk of surface water flooding and creating informal flood storage as a result of culvert restrictions. This artificial source of flooding is within the DCIM and is consequently considered in detail in the holistic assessment of flooding from rivers and surface water surrounding the junction.

4.8.2 The EA Map of Flood Risk from Reservoirs[18] indicates that Kingsway junction is not at risk of flooding from reservoirs.

4.8.3 The risk of flooding from artificial sources is considered to be low.

## 4.9 Climate Change

4.9.1 The United Kingdom Climate Impacts Programme is assessing implications of climate change in the UK. Climate change scenarios for the UK predict that winters will be wetter by up to 15% by the 2020s from the 1961 to 1990 baseline, summers will possibly be drier by up to 20% by the 2020s from the 1961 to 1990 baseline, snowfall amounts will decrease significantly, and extreme winter precipitation will become more frequent.

4.9.2 In February 2016 the EA released updated guidance on the climate change allowances to be used in Flood Risk Assessments. The Bramble Brook is located within the Humber River Basin District and the total potential change in watercourse flows anticipated for the 2080s (2070 to 2115) is 50% for the upper end allowance.

4.9.3 The EA and DCiC have confirmed that 40% allowance for climate change is appropriate for assessing watercourses at the site and this has been incorporated into the DICM (and subsequent model updates, see Section 5). It was agreed with DCiC that during design, sensitivity scenarios would be carried out for the 50% climate change allowance to determine the hazards associated with this upper end increase. A 40% allowance for climate change has been made with regard to the drainage design.

4.9.4 It is not considered likely that climate change, as it is currently predicted, will have significant impacts on the flood risks described above, subject to the necessary allowances being made in the Scheme drainage design.

## 4.10 Summary

4.10.1 The key findings of the flood risk review are as follows:

- The risk of fluvial flooding from Bramble Brook at Kingsway junction is considered to be high. Hydraulic modelling including conceptual mitigation measure designs has been undertaken to demonstrate how flood risks could be managed to acceptable levels - this is described in Section 5.
- There is no realistic risk of tidal flooding in the vicinity of Kingsway junction.
- The risk of groundwater flooding is considered to be medium.
- The risk of surface water flooding to Kingsway junction is high and is considered holistically alongside the risk of fluvial flooding within the DCIM, discussed in more detail in Section 5. The risk of increased surface water runoff from the Scheme arrangement to surrounding areas is considered to be high. The A38 road drainage strategy has been developed to describe how runoff would be controlled from the Scheme to existing rates - this is summarised in Section 6.
- The risk of sewer flooding is considered to be low.
- The risk of flooding from artificial sources is considered to be low.

[18] Available at: https://flood-map-for-planning.service.gov.uk/ Last Accessed November 2018.

# 5 HYDRAULIC MODELLING AND CONCEPTUAL ASSESSMENT OF FLUVIAL MITIGATION MEASURES

## 5.1 Overview

5.1.1 Hydraulic modelling has been used to assess the fluvial flood risk to the existing Kingsway junction, the effects of the Scheme, and the mitigation measures required to manage fluvial flood risk appropriately.

5.1.2 The hydraulic model of Kingsway junction and surrounding area has been developed sequentially as follows:

- An extract from the wider strategic DICM was provided by DCiC in June 2015 (see Appendix B for details), focussing on Kingsway junction.
- The extract from the strategic DICM was reviewed initially, to confirm inclusion of the relevant watercourses and sewer network and the scale of flood risks to the existing junction. This model was termed the 'Existing Baseline Model' for the purpose of this study.
- The 'Existing Baseline Model' was updated with:
  - Refinements to representation of key model features that impact on runoff volume and timing.
  - Local topographic survey data merged with the latest LiDAR ground model.

5.1.3 This model was termed the 'Refined Baseline Model', and was prepared to review the baseline flood risk to the existing junction from Bramble Brook and the impacts of the Scheme.

5.1.4 The 'Refined Baseline Model' was updated with the designs for the Scheme, including road and embankment levels, realignment of Bramble Brook, extension of the Kingsway junction culvert and reconnection of some local sewers. This model was termed the 'Proposed Arrangement Model', and was used to identify flood risks to the proposed Kingsway junction arrangement.

5.1.5 The 'Proposed Arrangement Model' for the Scheme was used to assess high level flood mitigation measures, in order to demonstrate in concept that flood levels can be managed to a safe peak level below the preliminary road design levels.

## 5.2 Strategic Flood Model (Existing Baseline Model)

5.2.1 Bramble Brook and the local STW sewer network are represented in the DICM (see Figure 5-1), which is a strategic scale model developed by DCiC.

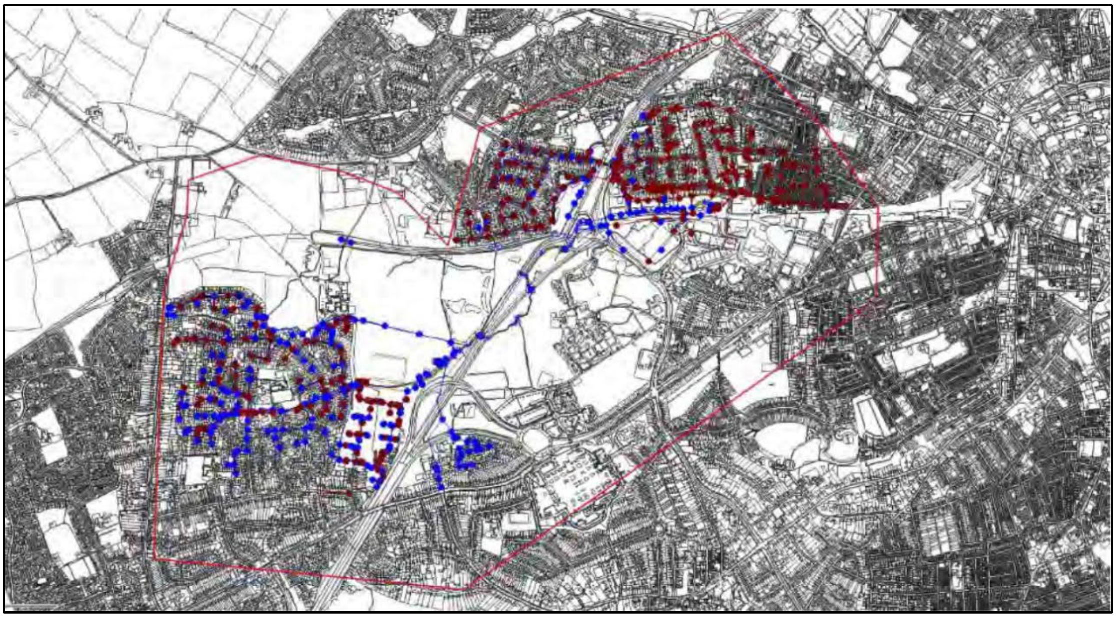


**Figure 6-1: DICM model extents affecting the A38 Kingsway junction**

5.2.2 A technical note describing the DICM construction and purpose is included as Appendix B, and briefly summarised below.

5.2.3 The original basis of the DICM was STW's Drainage Area Plan model (originally developed in 2004, but updated and amended up to and including 2014) built in InfoWorks CS. The sewer model concentrates on the sewer network, but includes some watercourses that interact with it. The representation of Bramble Brook was updated based on surveys carried out in 2011, and further modified to tie in with the LIDAR digital terrain model to allow 2D overland flow modelling using InfoWorks ICM, version 5.5. The latest update of the Digital Terrain Model (DTM) was obtained and incorporated in October 2014.

5.2.4 The model does not explicitly include any representation of the existing surface water drainage network from the current A38 Kingsway junction. The model includes, where available, culverts through the junction infrastructure.

5.2.5 During a site visit undertaken by AECOM (5th November 2014) it was noted that the natural watercourse marked on maps was completely dry while the former railway cutting to the north-west of the junction appeared to have standing or flowing water. This was discussed with DCiC in December 2014 who confirmed that all sections of the brook operate when the catchment is saturated and are appropriately represented in the DICM.

5.2.6 An extract of the DICM covering Kingsway junction area was provided to AECOM in June 2015. The model was provided with catchment wide rainfall profiles for the following Annual Exceedance Probability (AEP) storm events:

- 10%, 4%, 2% and 1%, plus the 1% with 20% climate change allowance.
- Durations 60, 90 and 120 minutes, summer storms.

5.2.7 Indicative model runs suggested flood depths of up to approximately 2m in the middle of the existing junction for the 1% AEP event with 20% climate change allowance.

5.2.8 These results were not intended for Scheme design purposes, but were important to illustrate the scale of potential flooding to the existing junction and Scheme and to set objectives for subsequent model development.

5.2.9 In view of the above, baseline runs of the model extract undertaken by AECOM roughly indicated a 1% AEP event (with 20% climate change) flood level of 68.05m AOD at key model node SK32368101_CWC (see Figure 5-2) i.e. the middle of the existing Kingsway junction immediately upstream of the 500m culvert extending eastwards away from the junction. This also served to identify the culvert as the principal throttle point for flood water at Kingsway junction.

5.2.10 For reference, local ground levels for the existing junction are approximately 68.60m AOD, but it is intended that the low point of the proposed junction design will have a lower elevation than the existing scenario.

## 5.3 Refined Baseline Model

5.3.1 Since the DICM was designed for strategic applications across the Derby City area, the Kingsway extract has been updated to make it suitable for local scale assessments in this study.

5.3.2 A technical note describing how the DICM was updated to the Refined Baseline Model is included as Appendix C, and briefly summarised below.

5.3.3 Culvert dimensions, channel cross-sections and culvert inlets/ outlets were all updated with survey data collected for the Scheme in 2015.

5.3.4 The latest LiDAR ground model was combined with updated topographic survey data (effectively a spot level survey) to create a TIN ground model, and this was used in the Refined Baseline Model.

5.3.5 The in-channel geometry of watercourses, the sewer network and the model hydrology have not been updated, although the merging of topographic survey data with LiDAR has improved representation of the channel banks/ culvert cover.

5.3.6 A number of updates to the models representation of runoff generation follow the recommendations made in the previous version of the FRA for Kingsway junction. These recommended refinements were submitted to DCiC for approval, and the agreed approach has been implemented. Additional refinements were made for hydrological reasons – these are detailed in Appendix C.

5.3.7 The model was re-run, and flood level results within the vicinity of Kingsway junction were analysed with respect to existing ground levels (see Figure 5-2).

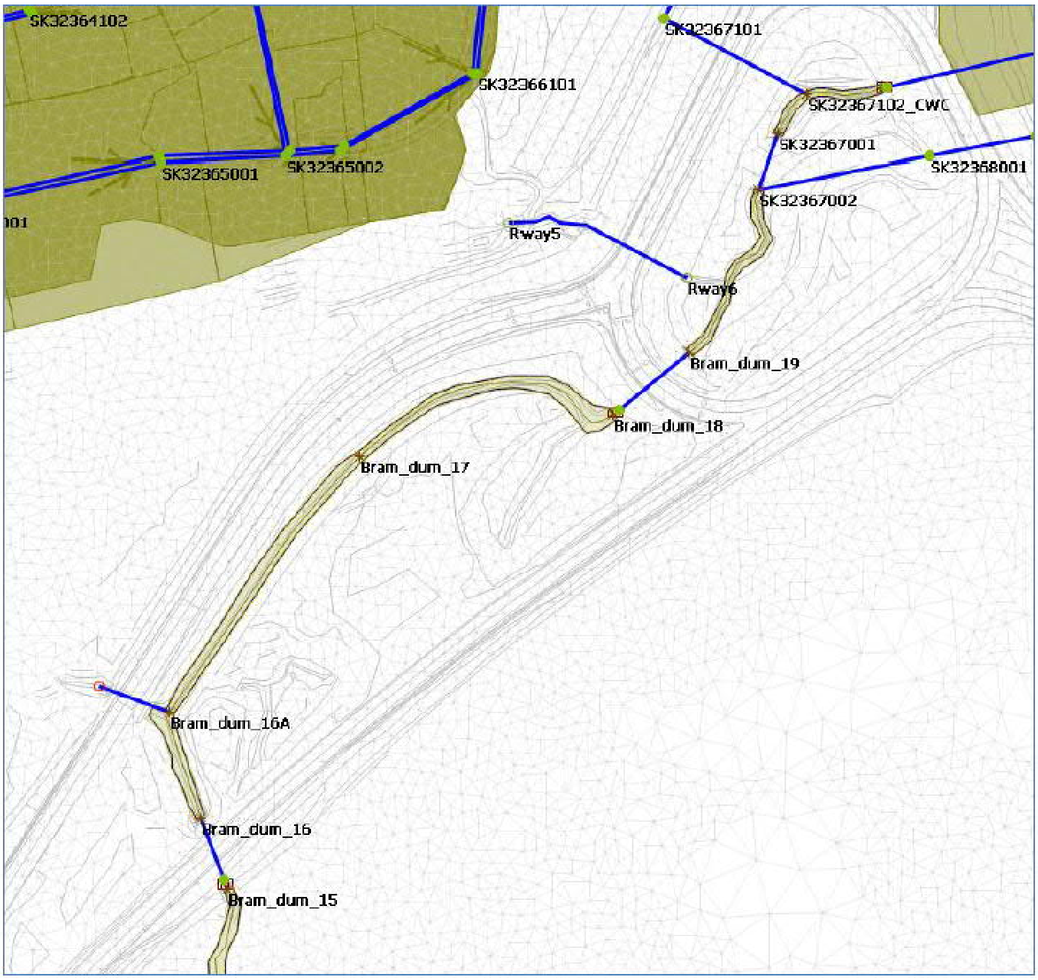



**Figure 5-2: Model nodes local to the A38 Kingsway Junction (baseline scenario)**

5.3.8 Updated model runs indicated a 1% AEP event (with 20% climate change allowance) had a flood level of 66.69m AOD at key model node SK32368101_CWC. This confirms that the model refinements have reduced the predicted level of flood risk.

5.3.9 Going forward however, the assessment of flood risk has been made against the 1% AEP event with 40% climate change allowance. It was agreed with DCiC that this was the most cautious approach, and this also corresponds with the requirements of Highways England.

## 5.4 Proposed Arrangement Model

5.4.1 The Refined Baseline Model was used to assess the Scheme by updating it to reflect the latest junction design. The updates made use of 'Mesh Level Zones', a specific feature of the InfoWorks ICM software that allows ground levels to be specified at vertices forming a polygon. These polygons were imported or derived from the design drawings, and utilised to form a model representation of the proposed ground works, as illustrated in Figure 5-3. The resulting model is referred to as the Proposed Arrangement Model.

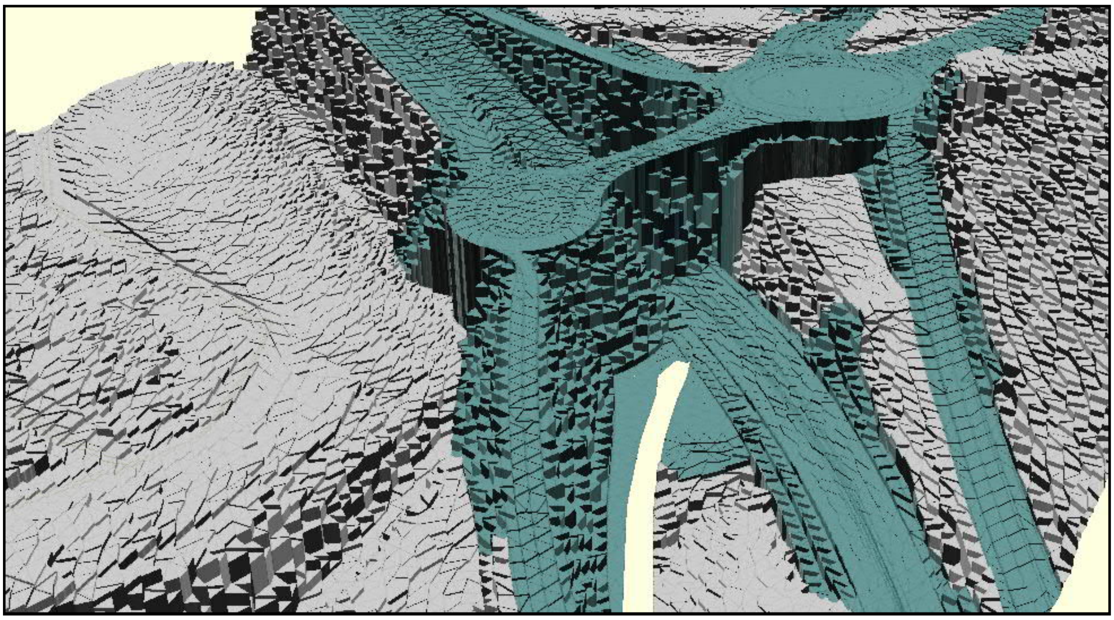


**Figure 5-3: Model geometry of the Proposed Arrangement Model (A38 Kingsway junction)**

5.4.2 A technical note describing how the Proposed Arrangement Model was used to investigate the Scheme is included as Appendix C, and briefly summarised below. The modelling is sufficient to demonstrate flood risk concepts.

5.4.3 The model does not include an explicit representation of the proposed surface water drainage infrastructure for the upgraded junction, although outfall discharges to the Bramble Brook (open channel and culvert sections) have been included.

5.4.4 The aspiration for this stage of junction design was to avoid flooding the proposed A38 mainline carriageway. This was found to be unachievable without the use of mitigation. The flood level at the proposed culvert inlet resulted in flooding of the highway at the 1% AEP event plus 40% climate change (as well as the 1% AEP event), as shown in Figure 5-4.

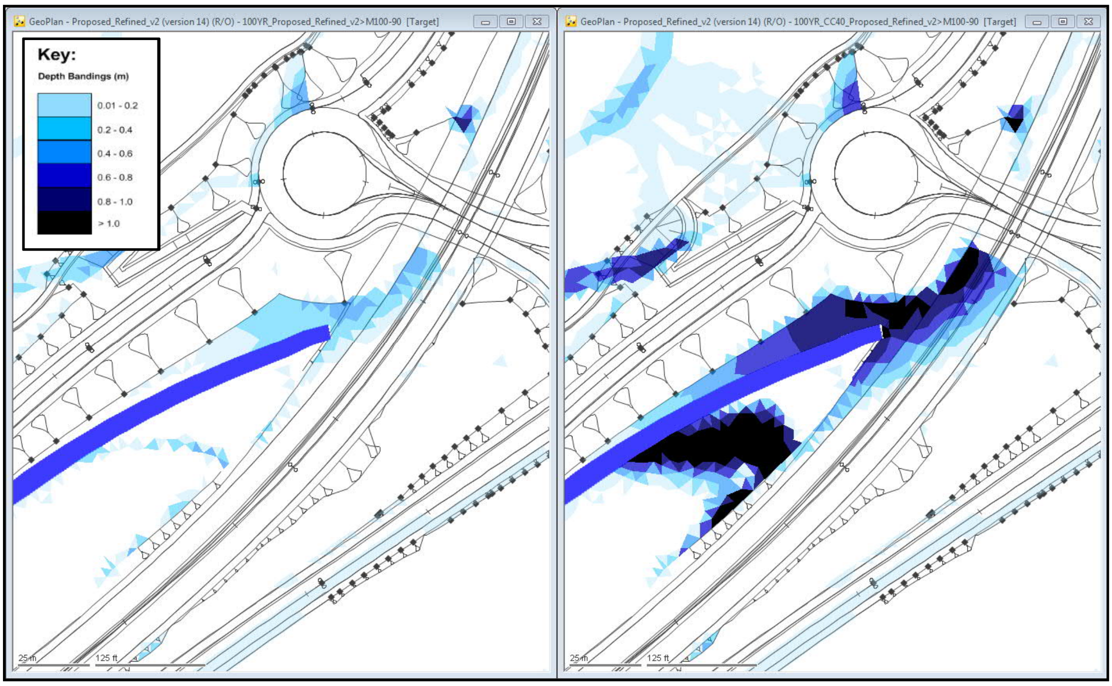



**Figure 5-4: Flood depth map at Kingsway junction of the Proposed Arrangement Model during the 1% AEP event (left) and 1% AEP event plus 40% climate change (right) (without mitigation)**

5.4.5 Flood mitigation measures were therefore assessed in concept for the proposed junction, in order to investigate whether peak flood levels at the junction could be lowered to avoid flooding the road.

## 5.5 Proposed Arrangement Model with Mitigation

5.5.1 Initially, a mitigation measure was tested that comprised a single flood storage area within Kingsway junction. This storage area was located between the main carriageway and northbound diverge slip road, and adjacent to the right bank of the re-aligned Bramble Brook. The concept was to commence filling of the flood storage area from a lateral weir constructed within the right bank of Bramble Brook, thus storing the volume in the top part of the inflow hydrograph. The flood storage area would drain via a flapped outfall to the Bramble Brook culvert through Kingsway junction post-event.

5.5.2 It was found that this was not sufficient on its own to reduce the flood level at the culvert inlet sufficiently and to thus prevent the highway from being flooded, although flood levels reduced by approximately 0.5m.

5.5.3 As such, further flood mitigation was investigated, culminating in the provision of three upstream flood storage areas within the Kingsway hospital site. The concept for these storage areas was similar to that within Kingsway junction as previously described. The combined impact of these upstream flood storage areas reduced the pass-forward flow to the Bramble Brook within Kingsway junction, and reduced flood levels by a further 0.5m (i.e. a reduction of approximately 1m in total). This was enough to reduce the flood level below the proposed main carriageway at the culvert inlet, and prevent flooding of the main carriageway (see Figure 5-5).

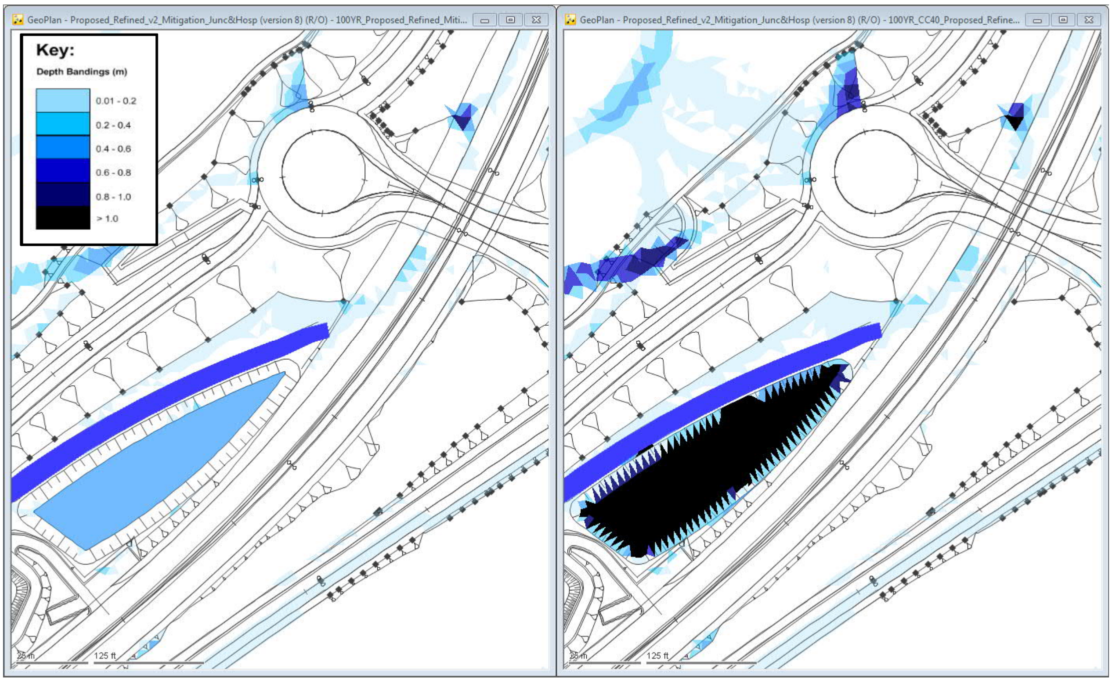



**Figure 5-5: Flood depth map at Kingsway junction of the Proposed Arrangement Model with mitigation during the 1% AEP event (left) and 1% AEP event plus 40% climate change (right)**

5.5.4 Note that there is some residual flooding shown on the main carriageway. This is a result of direct surface runoff, and would be dealt with by the highway drainage network.

### 5.6 Impact on Downstream Flood Risk

5.6.1 The proposed Kingsway junction involves fully culverting the Bramble Brook under the new bridge and through the main carriageway embankment. This culvert would commence from the downstream end of the realigned Bramble Brook, and reconnect with the existing downstream culvert at its previous inlet (which currently takes flow from the second section of open channel within the existing Kingsway junction).

5.6.2 As a result of the Scheme, flow reductions are achieved in the design event (1% AEP plus 40% climate change) due to a reduced culvert size through Kingsway junction. This is further reduced with the inclusion of the defined mitigation strategy.

5.6.3 Appendix C provides details of the alterations to culvert arrangement and sizes, and the subsequent flow reductions downstream.

# 6 SURFACE WATER MITIGATION MEASURES

## 6.1 Overview

6.1.1 Hydraulic modelling as reported in Section 5 has been used to assess the fluvial flood risk to the existing Kingsway junction, the effects of the Scheme, and the mitigation measures required to manage fluvial flood risk appropriately.

6.1.2 The Road Drainage Strategy (Report Number HE514503-ACM-HDG-A38_SW_PR_ZZ-RP-CD-0002, Highways England 2019) is available as a separate report and should be read in parallel with this FRA (provided as Appendix 1.4 in the Environmental Statement). The drainage strategy indicates that the highway drainage design at Kingsway junction comprises the following:

- Highway runoff attenuation pond within the junction footprint.
- Underground highway runoff storage tank within Mackworth Park.
- Two underground cellular storage tanks or crates within each of the junction dumbbell roundabouts.
- Realignment of Bramble Brook within the junction plus associated culverting.
- Attenuation using oversized carrier pipes.
- Narrow filter drains.
- Combined kerb drainage units.
- Trapped gully pots and road-side linear drains.
- Petrol interceptors at outfalls and connections to existing public sewers (five outfalls in total, with one swale discharge into a tributary of Bramble Brook within Mackworth Park).
- By-pass separators.

6.1.3 The surface water management strategy for the Scheme design is summarised in the sections below.

## 6.2 Runoff collection and conveyance

6.2.1 Kingsway junction’s preliminary drainage design has been split into five catchments.

6.2.2 Runoff from the carriageway would be collected via a combination of road edge channels, gullies and combined kerb drainage units (where required). The proposed overbridges allow for bridge drainage/ combined kerb drainage units on the bridge deck.

6.2.3 The use of carrier pipes ensures spillages would be contained within the drainage system and would not infiltrate to ground close to source. Subsurface drainage would be provided via narrow filter drains where necessary.

## 6.3 Attenuation and pollution control

6.3.1 A greenfield runoff rate (GRR) (4.6l/s/ha) has been agreed with DCiC for use within the preliminary design calculations.

**Catchment 1**

6.3.2 The runoff from this catchment would outfall into Bramble Brook located within the junction. Attenuation storage up to and including the 100 year + 40% climate change (CC) event would be provided by attenuation tanks, oversized pipes and a lined pond. The preliminary design allowable discharge rates have been calculated using a GRR of 4.6l/s/ha for the new impermeable areas and restricted to ensure betterment over the existing situation for the site.

6.3.3 Treatment of the runoff prior to discharge would be provided by an attenuation pond located within the junction. The existing highway drainage system includes no vegetative treatment systems, so the Scheme would provide enhancements to highway runoff water quality. Penstocks would be provided upstream of the attenuation pond to allow cut off in the event of spillage on the highway (e.g. following a road accident etc.). The spillage would be contained within the carrier system and road surface.

**Catchment 2**

6.3.4 The runoff from this catchment would outfall into a tributary of Bramble Brook adjacent to the northbound slip road. Attenuation storage up to and including the 100 year + 40%CC event would be provided by oversized pipes and a lined attenuation tank (buried). The preliminary design allowable discharge rates have been calculated using a GRR of 4.6l/s/ha for the new impermeable areas and restricted to ensure betterment over the existing situation for the site.

6.3.5 A petrol interceptor would be located upstream of the lined attenuation tank. A lined ditch would convey the attenuated runoff from the attenuation tank to the Bramble Brook tributary outfall. The lined ditch would provide water quality enhancements. The existing highway runoff drainage system includes no vegetative treatment systems, so the Scheme would provide betterment with regards to highway runoff water quality. Penstocks would be provided upstream of the buried attenuation tank to allow cut off in the event of a highway spillage. The spillage would be contained within the carrier system and road surface.

**Catchment 3**

6.3.6 The discharge from the catchment would be restricted to match existing discharge rates, ensuring no detriment in terms of downstream flood risk. Attenuation would be provided within the drainage pipe network to ensure no flooding from the site in a 1 in 100 year + 40% CC rainfall event. The existing drainage connections (subject to condition assessment) would be retained. No vegetative highway runoff treatment would be provided due to the site constraints, matching existing conditions.

**Catchment 4**

6.3.7 The discharge from the catchment would be restricted to match existing discharge rates, ensuring no detriment in terms of downstream flood risk. Attenuation would be provided within the drainage pipe network to ensure no flooding from the site in a 1 in 100 year + 40% CC rainfall event. The existing drainage connections (subject to condition assessment) would be retained. No vegetative highway runoff treatment would be provided due to the site constraints, matching existing conditions.

**Catchment 5**

6.3.8 The discharge from the catchment would be restricted to match existing discharge rates, ensuring no detriment in terms of downstream flood risk. Attenuation would be provided within the drainage pipe network to ensure no flooding from the site in a 1 in 100 year + 40% CC rainfall event. Catchment 5 would discharge into the Bramble Brook culvert. No vegetative highway runoff treatment would be provided due to the site constraints. A petrol interceptor would be located upstream of the connection to the culvert.

## 6.4 Land drainage

6.4.1 Bramble Brook would be affected by the new junction arrangements and would need to be diverted within the junction.

6.4.2 Existing culverted sections of the brook would also be affected by the new road alignment; consequently, a new culverted section would be constructed linking the new Bramble Brook alignment with the existing incoming 900mm diameter culverts to the west of the interchange. Proposed earthwork drainage would be located at the top of cuttings or at the toe of embankment to capture surface flows from natural catchments which would outfall into the carrier pipes.

# 7 CONCLUSIONS

7.1.1 This Flood Risk Assessment (FRA) has reviewed the Scheme proposals at Kingsway junction. Flood risks to, and resulting from, the Scheme were assessed as follows:

- The risk of fluvial flooding from Bramble Brook to the proposed junction was assessed. It was found that the main carriageway would be at risk in both the 1% AEP and 1% AEP plus 40% climate change events, without suitable mitigation
- There is no realistic risk of tidal flooding.
- The risk of groundwater flooding is considered to be medium which is concluded in the A38 Derby Junctions Ground Investigation Report (Report Number HE514503-ACM-VGT-A38_SW_PR_ZZ-PR-GE-0003_P02_24, 2018).
- The risk of surface water flooding to the site is high and has been considered alongside the risk of fluvial flooding within the DCIM. However, the risk of increased surface water runoff from the new junction arrangement to surrounding areas is considered to be high. The road drainage strategy has been developed which describe how SuDS would be used to control runoff from the Scheme to existing rates.
- The risk of sewer flooding is considered to be low.
- The risk of flooding from artificial sources is considered to be low.

7.1.2 Hydraulic modelling has been used to assess fluvial risks. A truncated version of the existing strategic DICM was supplied by DCiC. This was then updated with local topographic and culvert survey data, and refined to improve representation of runoff variability. Iterations were run to understand flood risks associated with the preliminary proposed junction design.

7.1.3 Hydraulic modelling demonstrated that the low point of the proposed junction would be at risk of flooding without mitigation. Modelling was therefore used to assess flood storage mitigation measures.

7.1.4 The proposed mitigation measures consist of flood storage areas both within the proposed Kingsway junction, and upstream within the Kingsway hospital site. Flow into the extended culvert beneath the proposed junction was shown to be attenuated by the flood storage areas; resulting in a scenario in which the main carriageway is not flooded from Bramble Brook during the 1% AEP plus 40% climate change events.

7.1.5 Further modelling will be undertaken during the Scheme detailed design stage to optimise the design of the proposed flood storage areas.

7.1.6 Surface water flood risks from the Scheme would be managed through drainage designs as detailed in the Road Drainage Strategy (Highways England, 2019). The main features of the design include a highway runoff attenuation pond within the junction footprint, underground highway runoff storage tank within Mackworth Park, two underground cellular storage tanks or crates within each of the junction dumbbell roundabouts, realignment of Bramble Brook within the junction plus associated culverting, attenuation using oversized carrier pipes, narrow filter drains, CKD units, trapped gully pots and road-side linear drains, petrol interceptors at outfalls and connections to existing public sewers, by-pass separators. The Road Drainage

Strategy report (Highways England, 2019[19]) is available as a separate report and should be read in parallel with this FRA.

7.1.7 Incorporation of the mitigation measures as detailed herein indicate that flood risks associated with the Scheme at Kingsway junction can be appropriately managed.

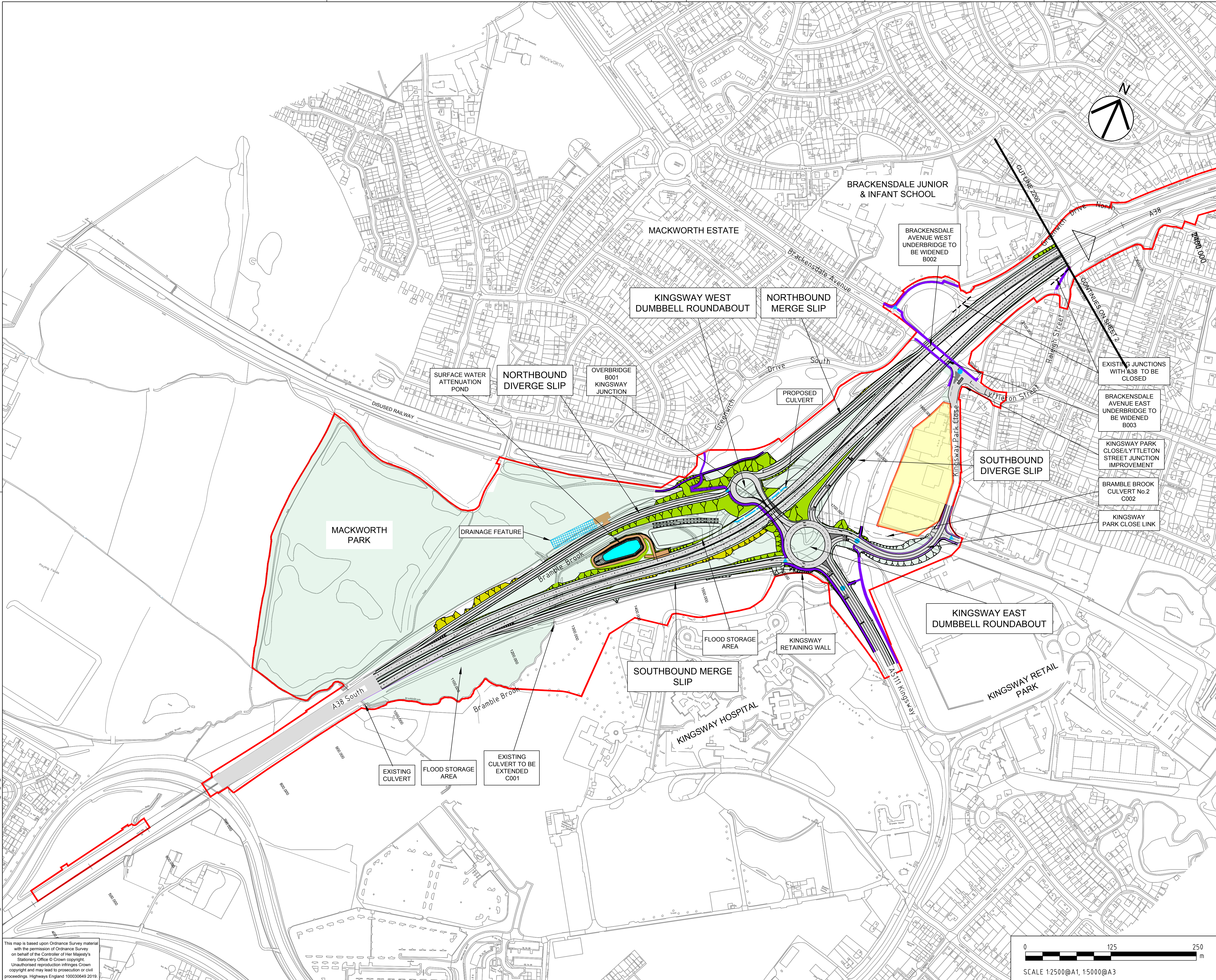
[19] Road Drainage Strategy (Report Number HE514503-ACM-HDG-A38_SW_PR_ZZ-RP-CD-0002, Highways England 2019)

# 8 KINGSWAY FLOOD MODEL LIMITATIONS

8.1.1 The following limitations of the hydraulic modelling as reported herein are acknowledged:

- Wider updates to the 2D domain within the hydraulic model have been recommended in consultation with DCiC, including roughness and runoff parameters.
- The hydraulic modelling has not taken into consideration existing local highway drainage and has not incorporated the reduction in surface water runoff from the highway as a result of proposed surface water drainage attenuation features prior to discharge into Bramble Brook.
- The 'baseline' hydraulic model did not take into consideration existing highway drainage system. The 'proposed' hydraulic model implicitly allows for runoff from the new highway drainage system, accounting for any reductions due to attenuation and/ or storage within ponds or the network itself.
- Further modelling will be required during the Scheme detailed design stage.

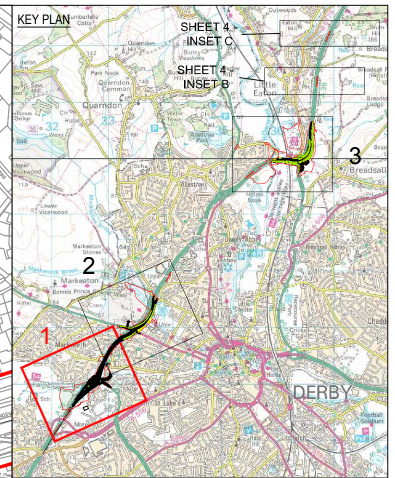
# Appendix A Scheme Design and Boundary Drawings






Plot Date : 04 March 2019 18:31:36

KEY PLAN




NOTES

1. 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 IN METRES, ALL CHAINAGES, LEVELS AND COORDINATES ARE IN METRES UNLESS DEFINED OTHERWISE.

KEY:

- The Design
- Limits of Land to be acquired or used permanently or temporarily
- Proposed Footway/Cycleway
- Proposed Footway
- Public Right of Way Diversion
- Existing Right of Way to be stopped up
- Area Not Included within the DCO Boundary
- Proposed Controlled Crossing
- Proposed Un-Controlled Crossing
- Embankment
- Cuttings
- Access Track
- Combined Access track & Footway/C'way
- Environmental Mitigation
- Highway to be stopped up
- Proposed Culvert
- Streams

| Revision Details | By / Check | Date | Suffix |
|---|---|---|---|
| First Issue | LE / GS | 20/02/19 | P01 |
| First Issue | LE / GS | 04/03/19 | P02 |

Purpose of issue

FINAL

Client
Highways England
Floor 5
Two Colmore Square
38 Colmore Circus
Birmingham
B4 6BN

Development Consent Order Number

TR010022

Project Title

# A38 DERBY JUNCTIONS

Drawing Title

## GENERAL ARRANGEMENT REGULATION 5(2)(O) SHEET 1 OF 4

| Designed | Drawn | Checked | Approved | Date |
|---|---|---|---|---|
| | LE | GS | GS | 04/03/19 |

| Internal Project No. | Suitability |
|---|---|
| 60533462 | S3 |
| **Scale @ A1** | **Zone** |
| 1:2500 | Whole Scheme |



Drawing Number
Highways England PIN | Originator | Volume
HE514503 -ACM -DCO -
A38_SW_PR_ZZ -DR-DC-0021
Location | Type | Role | Number

Rev
P02

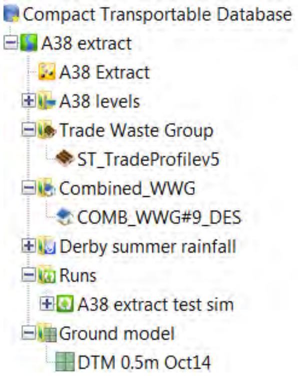
# Appendix B Technical Note on the Derby A38 ICM Model

# Technical note

| | | | |
|---|---|---|---|
| **Project:** | Derby A38 ICM model | **To:** | AECOM |
| **Subject:** | Modelling notes | **From:** | Atkins |
| **Date:** | 12 Jun 2015 | **cc:** | Nick Tolley (Derby City Council) |

### Introduction

This Technical Note describes the contents and preparation of the ICM model for use in checking the impact of proposed works on and around the A30 Kingsway Roundabout on the flood risk in Derby. The model should not be used for any other purpose. The purpose of the Technical Note is to outline the background for the model and is not a user guide.  The model is contained in an ICM Transportable Database named “Derby A38 extract.icmt” and has the following contents.




The model is an extract from the larger Derby Integrated Catchment Model, which was prepared for Derby City Council to assess overall flood risk in the catchment. It has not been prepared to the level of detail that may be necessary in any given location to enable it to be used for detailed design of drainage works or to assess flood risk to a particular property or area with a high level of confidence.

In particular, it has been built using existing models from various sources and of varying ages, updated in some locations based on local knowledge but not systematically checked against current surveys or other sources of information. A degree of caution is recommended when using the model. The sewer system has been verified as part of Severn Trent’s SMP process but the water course elements of the model should be treated as unverified.

### Main Data Sources

The original basis of the model was Severn Trent Water’s Drainage Area Plan model (originally in 2004 but updated and amended up to and including 2014) built in InfoWorks CS. The sewer model concentrates on the sewer network but includes some watercourses that interact with it.  In particular, Bramble Brook, which is the focus of the potential drainage works on the A38, was represented in the original models.

The representation of Bramble Brook was updated based on surveys carried out in 2011, and further modified to tie in with the LIDAR digital terrain model to allow 2D overland flow modelling using InfoWorks ICM, version 5.5. The latest update of the DTM was obtained and incorporated in October 2014.

Figure 1 shows the overall model extents. The 2D zone boundary is shown in red. The surface water system is shown in blue and the foul/ combined system in brown.

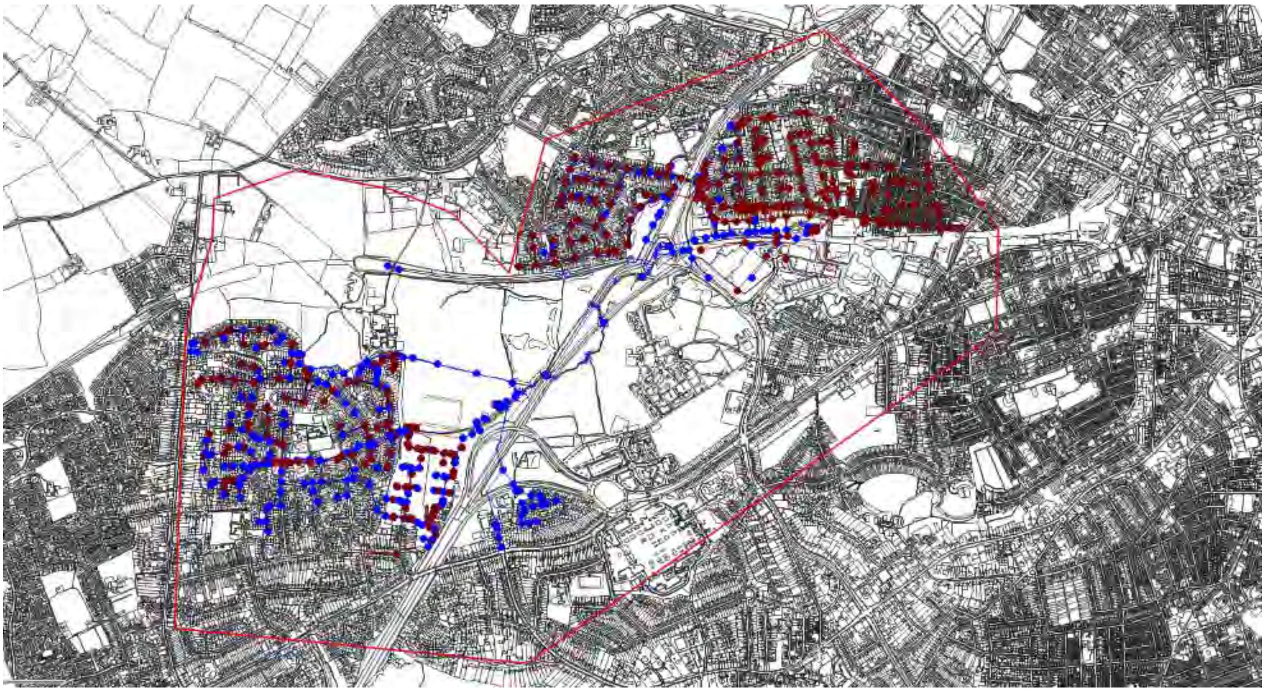
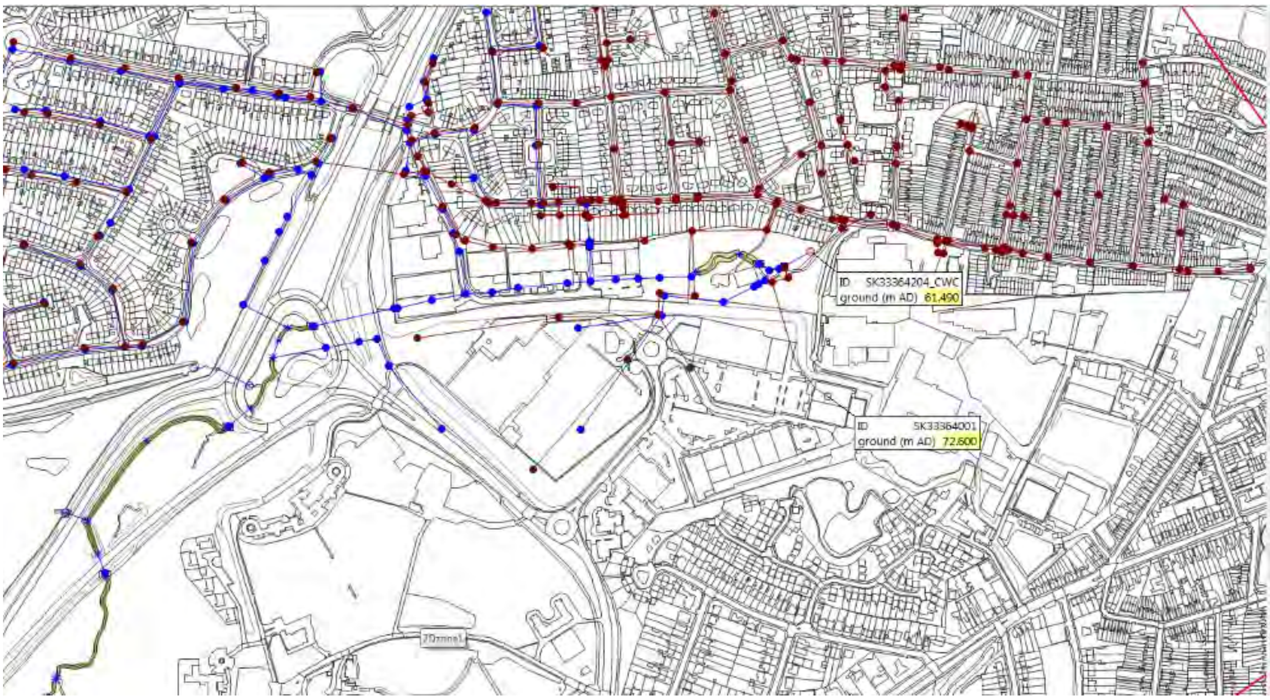


Figure 1 – Model Extents

The extents have been chosen to ensure that all potential flows to the area of interest are generated within the model. The foul/ combined system has been included as it contributes significant flood volumes during severe events.

### Model boundaries

All flows are generated within the model from the rainfall applied. There are therefore no upstream boundary conditions. The downstream boundaries are two manholes SK33364204_CWC and SK33364001, as shown on Figure 2. The first is on the culverted section of Bramble Brook, the second on the Southern Orbital Sewer to which Bramble Brook spills in severe events via an overflow included in the model. Time-varying level boundaries to suit a range of rainfall events have been provided for these outfalls.



# Technical note

There is another outfall at manhole SK31346800 in the south-west corner of the catchment. This receives pumped flows from Mickleover foul pumping station, which discharges out of the catchment. No level boundary is needed at this point.

### 2D Zone

The 2D zone in the Derby model has been trimmed down to suit the catchment of the area of interest. The Ground Grid data on which it is based has been included to allow the 2D zone to be re-meshed to suit proposed options. Runoff is generated by rainfall direct to the mesh in areas outside the subcatchments associated with sewer manholes, so the zone should not be amended or removed. Associated roughness and infiltration zones have been included and should not be amended or removed as they contribute to surface water runoff and routing.

### Rainfall events and levels

The following storms have been provided:

10, 25, 50 and 100 years plus 100 years with 20% uplift for climate change.

Durations 60, 90 and 120 minutes, summer storms.

Summer events have been provided as these have been found to be critical in terms of peak flows in the network and flood extents. The runoff from the 2D mesh has been set to represent a saturated catchment as this is the condition which has caused flooding problems in the past. Events with “normal” summer and winter catchment wetness tend to cause less flooding than the saturated soil and summer storm conditions reflected in the model.

Note that it is important to use the corresponding level file in a simulation to go with a given rainfall event.

### Trade and Wastewater flows

As the foul/ combined system is included, the appropriate trade and population-related flow generators have been provided. These are the same for any event.

### Simulations

A sample simulation has been included in the database to show the run setup. Note that it includes timestep logging and use of a GPU card for 2D calculations “when available”. A GPU card will speed up simulations considerably but is not necessary, and timestep logging is useful for identifying causes of any instabilities that may arise. It can be disabled if preferred.

# Appendix C Technical Note on the A38 Kingsway Hydraulic Model Update

| | | |
|---|---|---|
| **Project Name:** | A38 Kingsway Junction | |
| **AECOM Project Number:** | 60533462 | |
| **Title:** | Kingsway Modelling Technical Note | |
| **Date:** | 14th November 2018 | |
| **Authors:** | Ben Brough<br>Andrew Heath-Brown | Graduate Consultant<br>Associate Technical Director |
| **Reviewer:** | Simon Wild | |
| **Approver:** | Andy Wilson | |

# 1. Background

A Level 2 Flood Risk Assessment (FRA) for Kingsway junction was undertaken in 2016 and reported in 47071319-URS-05-RP-EN-005 (Highways England, July 2016). Additional flood risk modelling were subsequently undertaken at Kingsway junction in order to further develop mitigation proposals for the proposed offline flood storage areas within the Kingsway Hospital site. This was undertaken alongside modelling of an option to divert Bramble Brook through Mackworth Park. Details of this modelling and the associated results were reported in a Technical Note 47071319-URS-05-TN-EN-029 (Highways England, December 2016). The Technical Note also presented results from a 'refined' baseline model, based on recommendations made in the preceding Level 2 FRA, although these refinements were not applied to the option modelling.

The modelling, and the associated mitigation optioneering, was targeted on the 1% Annual Exceedance Probability (AEP) event plus 20% climate change allowance (in respect of rainfall intensity).

# 2. Required Updates

The associated flood risk modelling at Kingsway junction requires updating to address a number of key factors, as set out below:

- The proposed Kingsway junction design arrangement has been amended since the previous FRA;
- Additional topographic survey data of the area has been obtained;
- The option to divert Bramble Brook through Mackworth Park was determined to not be viable, therefore all mitigation and other design proposals should assume that Bramble Brook is retained within the Kingsway junction; and
- Climate change allowances have changed in line with latest Environment Agency (EA) guidelines, requiring a 40% increase in rainfall intensity at the 1% AEP event to be mitigated against.

Furthermore, and following the recommendations made in the Level 2 FRA and tested in the subsequent Technical Note, the flood risk modelling approach has been refined. The proposed refinements were summarised and presented to Derby City Council (DCiC) for approval – these were agreed by Nick Tolley DCiC in an email dated 20th July 2017.

The proposed refinements to the baseline model, as well as the consideration of the 40% climate change allowance scenario, also meant that the downstream boundary conditions required update. It was agreed that these would be provided from the wider Derby IUD model.

Full details of the model update process are presented below.

# 3. Overview

The process by which the Kingsway junction flood risk modelling has has been updated is summarised in *Intermediate & Final Versions

Figure 1. The development of these four model versions is described in the sections below.


*Intermediate & Final Versions

**Figure 1: Process by which Kingsway hydraulic model has been updated**

# 4. Existing Baseline Model

The Existing Baseline Model is effectively a truncated version of the city wide strategic Derby IUD model (as developed by Atkins and provided by DCiC). The model was, however, updated as reported in 47071319-URS-05-RP-EN-005. A Technical Note produced by Atkins as part of the model handover for this study is provided as part of the main FRA.

# 5. Refined Baseline Model (Intermediate Version)

The Refined Baseline Model incorporates a number of refinements over the Existing Baseline Model. Firstly, and as agreed with DCiC, refinements were made to the representation of key model features that impact on runoff volume and timing. In summary, these were changes that were applied within the model 2D domain, and are as follows:

- Global roughness coefficient increased to 0.035, relating to open grassland;
- Roughness increased in woodland areas to 0.1, whereas roughness coefficients reduced for roads to 0.015;
- Buildings raised by 150mm, associated with elevated thresholds. In addition, porous polygons used to slow water flow through buildings; and
- The mesh refined such that the maximum triangle size is 16m$^2$ and the minimum element area 4m$^2$ (a decrease from 40m$^2$ and 10m$^2$ respectively).

Secondly, the associated ground model provided for the Existing Baseline Model has been modified to incorporate an increased level of detail within and around the existing junction. This was done by creating a TIN ground model from the topographic survey CAD drawing, and ‘stamping’ it onto the original (LiDAR based) ground model. Figure 2Figure 3 compare the representation of the existing Kingsway junction using the original (LiDAR based) ground model and the modified ground model respectively. The figures are based on 3D views produced within the InfoWorks ICM software (vertical exaggeration x5).

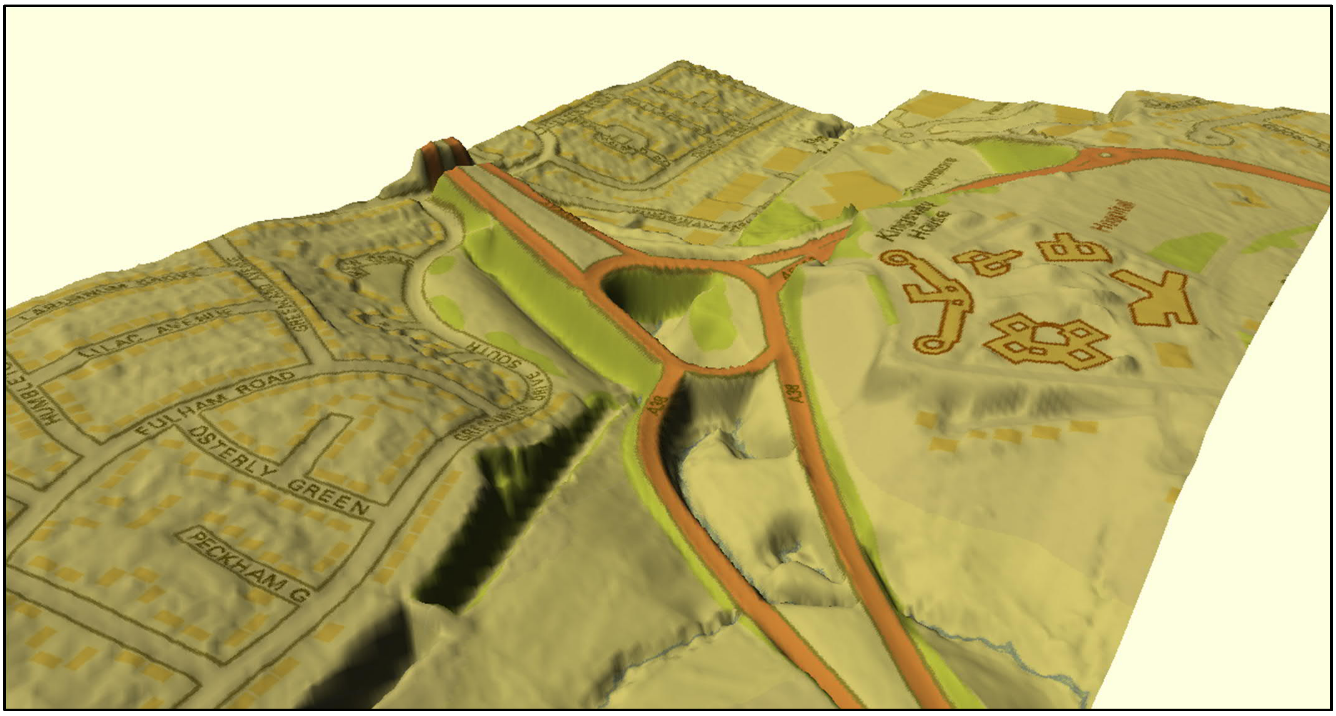



**Figure 2: Representation of the existing Kingsway junction based on the original (LiDAR based) ground model**

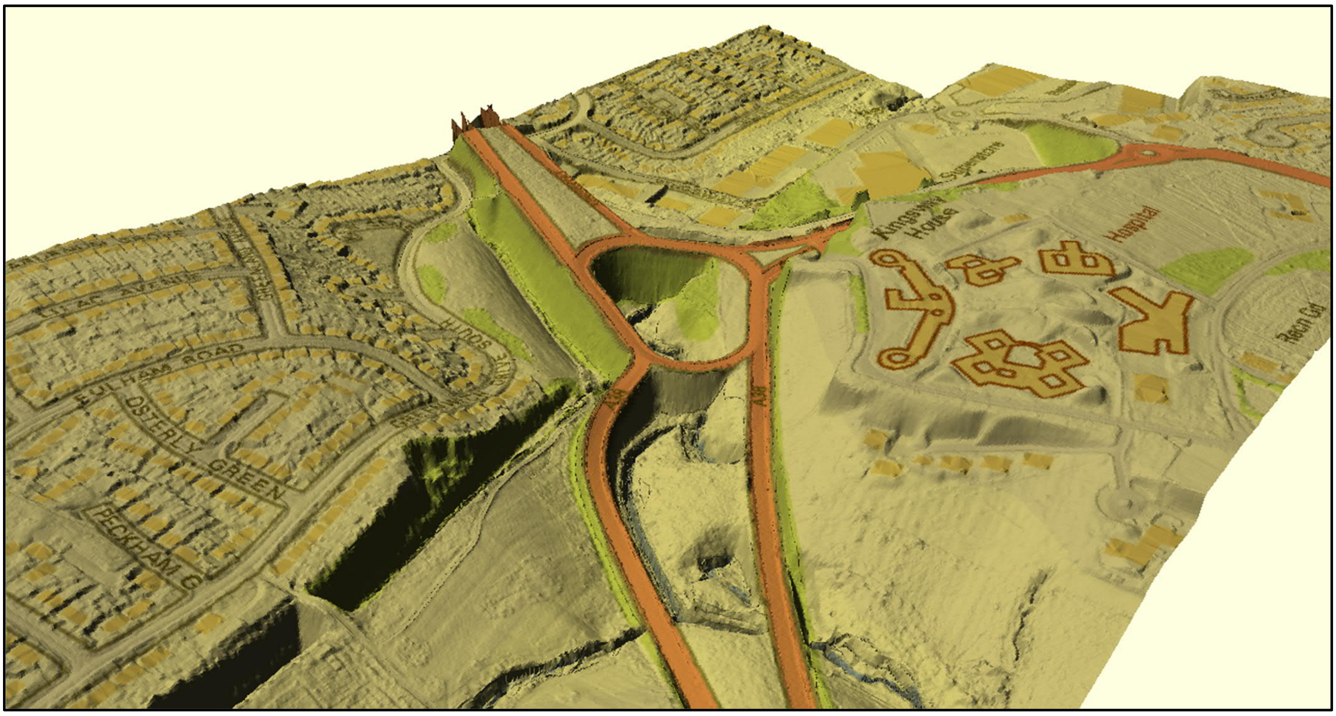



**Figure 3: Representation of the existing Kingsway junction based on the modified ground model (incorporating topographic survey with the LiDAR as a TIN ground model)**

The 3D views provide confirmation that whilst the general topography remains identical, the addition of the detailed survey data provides an improved level of detail for key topographic features.

# 6. Model Hydrology

***Background***

As part of the handover of an extract from the original Derby IUD model, design storm events were provided with AEPs of 10%, 4%, 2% and 1%, plus the 1% AEP event with 20% uplift for climate change. These design storm events were provided for durations of 60, 90 and 120 minutes, and were based on the summer storm profile. Summer events were provided as these had been found to be critical in terms of peak flows in the network and flood extents.

***Hydrology Update***

The provided design storm event data has not been altered. However, in order to assess the impact of the proposed Kingsway junction design at the required design standard, the 1% AEP event with 40% uplift for climate change was also created.

In the original strategic Derby IUD model, runoff from non-urban areas (i.e. not covered by sewers) was generated by directly applying rainfall to the ground surface. It was assumed that 35% of the total rainfall was able to produce runoff (i.e. 65% is lost by ponding, infiltration, evaporation etc.) – such a value has historically been considered typical of a permeable surface in a surface water model.

However, for Mackworth Park, this was overridden by an ‘Infiltration Zone’ (and associated ‘Infiltration Surface’), which generated 81% runoff from rainfall inputs. It is understood that this high percentage runoff had been incorporated in the original model to reflect observed flow conditions in the various drainage channels and watercourses when the catchment is saturated. This is considered appropriate for strategic purposes, but is unlikely to be reflective of design conditions. The justifications for this are as follows:

- Based on catchment descriptors for the Bramble Brook catchment, SAAR and PROPWET are low (692mm and 0.35 respectively), indicating that typically the catchment is not saturated;
- A saturated catchment may occur, but would result in a reduced frequency flow event relative to the frequency of the rainfall event being applied; and
- The refinements applied to the model network (as descried previously) provide an improved representation of key model features that impact on runoff volume and timing (more appropriate to the level of detail required for this study).

To further support this justification, hydrological analysis using standard UK methods was undertaken and compared against results from the original strategic model, as described below.

***Hydrological Analysis and Existing Flows***

Flows within Bramble Brook are generated within the model by rainfall-runoff processes only. In order to provide a ‘sense’ check on the calculated model flows, both the ReFH rainfall-runoff method, and the updated ReFH2 method, has been applied.

There are some limitations associated with the application of these methods in this instance. These are as follows:

- The catchment was selected from the FEH CD-ROM to the culvert downstream of the existing Kingsway junction;
- The ReFH method does not account for urbanisation explicitly; and

- Climate change flows are based on a 40% increase in the calculated 1% AEP event flow (rather than a 40% increase in rainfall intensity).

However, the methods are considered sufficiently suitable to undertake a valid comparison with the flows being generated by the direct rainfall approach being used within the hydraulic model.

The results of the analysis are presented in Table 1. Results are presented for the 90-minute duration applied within the model, and the recommended/ critical duration as calculated by FEH methods (and per the ReFH and ReFH2 recommendations).

| | Method | ReFH | | ReFH2 (as rural) | | ReFH2 (urbanised) | |
|---|---|---|---|---|---|---|---|
| | Duration | 90mins | 2hrs 45mins | 90mins | 5hrs 30mins | 90mins | 5hrs 30mins |
| AEP event | 1% | 3.2m$^3$/s | 3.6m$^3$/s | 2.4m$^3$/s | 3.3m$^3$/s | 3.2m$^3$/s | 4.0m$^3$/s |
| | 1% (plus 40% climate change) | 4.5m$^3$/s | 5.0m$^3$/s | 3.4m$^3$/s | 4.6m$^3$/s | 4.5m$^3$/s | 5.0m$^3$/s |

**Table 1: Comparison of peak flow estimates from the Bramble Brook catchment using different UK-based rainfall-runoff methods (to downstream of the Kingsway junction)**

Table 1 confirms that both methods produce similar (absolute) magnitude flows. The urban component of the ReFH2 method results in an approximate 25% increase in peak flows relative to the 'as-rural' variation. The longer duration events produce higher magnitude peak flows than the 90-minute storm being applied to the model. However, these durations are based on an approximation method originating from the FEH, and does not account for the variations in runoff timing as well as explicit model representation.

The results were then compared against the calculated peak flows generated by the Refined Baseline Model, for the 90-minute storm only. The comparisons were undertaken at the start of the open channel section within Cheviot Street park, between Cheviot Street and Kingsway Retail Park (approximate NGR SK 3340 36200), and are given in Table 2.

| | Method | Original DCiC / Atkins Model | Refined Baseline Model (Intermediate Version) | ReFH | ReFH2 (as rural) | ReFH2 (urbanised) |
|---|---|---|---|---|---|---|
| AEP event | 1% | 9.7m$^3$/s | 8.8m$^3$/s | 3.2m$^3$/s | 2.4m$^3$/s | 3.2m$^3$/s |
| | 1% (plus 40% climate change) | 10.9m$^3$/s | 9.8m$^3$/s | 4.5m$^3$/s | 3.4m$^3$/s | 4.5m$^3$/s |

**Table 2: Comparison of 'Original Model' and 'Refined Baseline Model (Intermediate Version)' flows against those estimated from various UK-based rainfall-runoff methods**

This hydrological analysis using standard UK methods indicates that the flows resulting from the original DCiC/ Atkins model were overestimated when applying the stated 'strategic condition' for Mackworth Park as a 'design condition'. Even with the agreed refinements applied to the model 2D domain (and the topographic updates), the flows were up to 3 or 4 times larger than those estimated by standard UK methods. As such, it was considered appropriate to further refine the baseline model to represent a more realistic 'design condition' in respect of runoff from Mackworth Park.

# 7. Refined Baseline Model (Final Version)

The design condition was amended so that Mackworth Park has a runoff potential of 35% as per other 'non-urban' areas within the model, and this was done by removing the associated 'Infiltration Zone'. This was done in conjunction with the other model refinements as previously mentioned (i.e. that formed the intermediate version of the Refined Baseline Model). The impact on peak flows relative to the 'Original' model set-up, and in comparison to the standard UK methods, are summarised in Table 3.

| | Method | Original DCiC / Atkins Model | Refined Baseline Model (Final Version) | ReFH | ReFH2 (as rural) | ReFH2 (urbanised) |
|---|---|---|---|---|---|---|
| AEP event | 1% | 9.7m$^3$/s | 5.9m$^3$/s | 3.2m$^3$/s | 2.4m$^3$/s | 3.2m$^3$/s |
| | 1% (plus 40% climate change) | 10.9m$^3$/s | 8.5m$^3$/s | 4.5m$^3$/s | 3.4m$^3$/s | 4.5m$^3$/s |

**Table 3: Comparison of 'Original Model' and 'Refined Baseline Model (Final Version)' flows against those estimated from various UK-based rainfall-runoff methods**

The results show that with a reduction in runoff potential from Mackworth Park, peak flows downstream of the Kingsway junction were also reduced, bringing them closer to the peak flows estimated from the standard UK hydrological methods.

# 8. Boundary Conditions

All flows are generated within the model from the rainfall applied. There are therefore no upstream boundary conditions. The downstream boundaries are two manholes SK33364204_CWC and SK33364001 2. The first is on the culverted section of Bramble Brook, the second on the Southern Orbital Sewer to which Bramble Brook spills in severe events via an overflow included in the model. Time-varying level boundaries to suit a range of rainfall events were provided for these outfalls as part of the original model handover of wider Derby IUD model (Atkins, 2015). These included the 1% AEP event plus 20% climate change for the 60, 90 and 120-minute storm event.

As a result of the refinements to the baseline model, it was determined that these downstream boundary conditions should be updated. A copy of the Refined Baseline Model (for the existing arrangement) was provided to Atkins, with the intention that this would be imported into their wider Derby IUD model. This model would then be re-run with the previously provided storm events, as well as the 1% AEP event plus 40% climate change, in order to update the downstream boundary conditions.

Atkins provided the revised boundary conditions, and these were incorporated into the model runs undertaken with both the 'Refined Baseline Model (Final Version)' and the 'Proposed Arrangement Model' (the latter of which is discussed below).

# 9. Proposed Arrangement Model

The Proposed Arrangement Model was developed from the Refined Baseline Model, in that it retained the refinements made to the 2D domain and the updated ground model. However, this model was amended to incorporate the proposed junction arrangement of the Kingsway junction. As per previous modelling, Mesh Level Zones have been used to alter ground levels through the junction to represent the proposed junction design. However, the representation is significantly more detailed than previous versions, with design levels for embankment toe and crest explicitly used from the design drawings. The proposed realignment of Bramble Brook (within the junction) was also based on the proposed route within the design drawings. A 3D visualisation of the junction as represented in the model is provided in Figure 4.

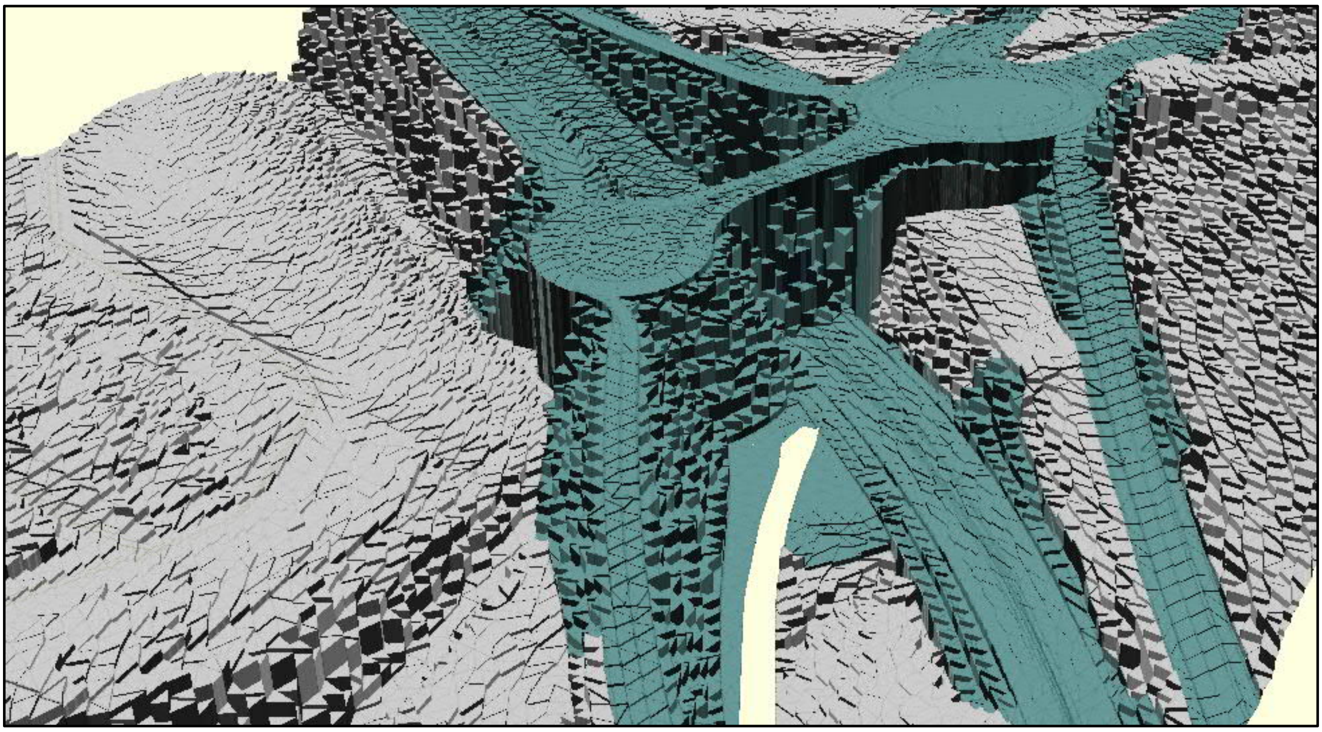


**Figure 4: 3D Visualisation of proposed Kingsway junction (mesh level zones shown in green)**

In order to represent possible surface runoff through the main carriageway (i.e. under the bridge), a 1D conduit was added to the model (note that this is not depicted in Figure 4, as this only provides visualisation of the 2D model surface).

Figure 5 and FigureFigure 6 demonstrate the current and proposed arrangements of Kingsway junction, with the realignment of the Bramble Brook and the associated long-section of the watercourse. The realignment of the watercourse increases the brook length by approximately 24m, but the bed level at the downstream limit has not been adjusted (therefore the bed gradient reduces slightly).


**Figure 5: Plan and long section of existing Bramble Brook alignment (against OS mapping of Kingsway Existing Junction Arrangement)**

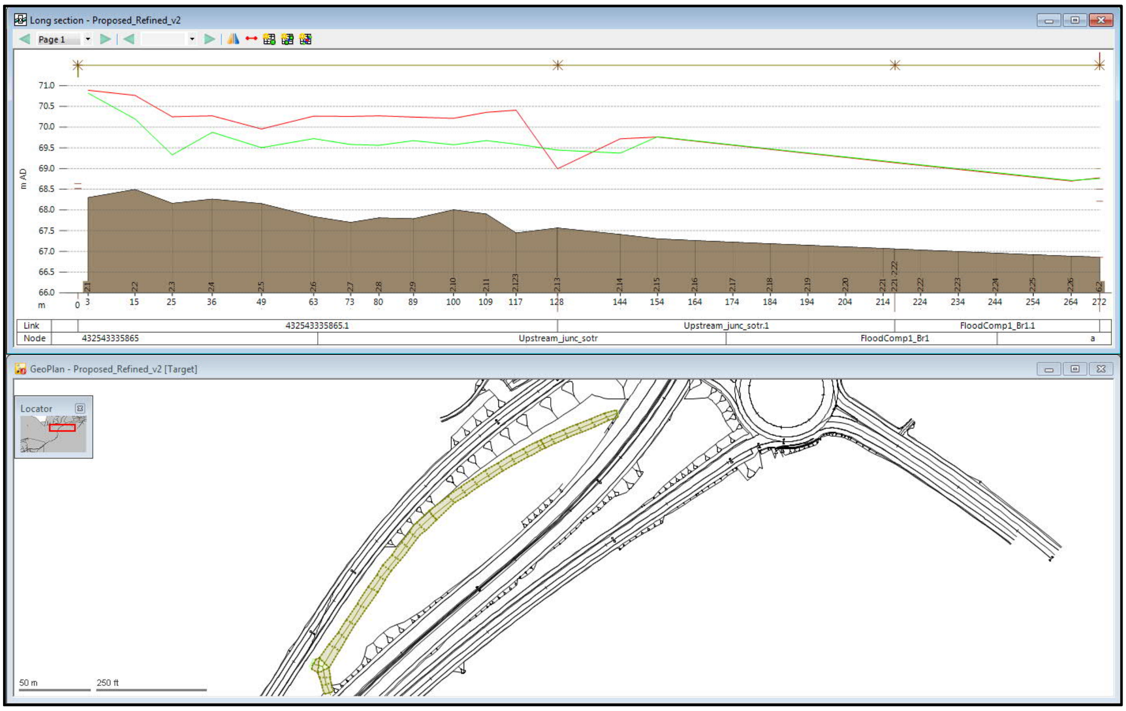



**Figure 6: Plan and long section of proposed Bramble Brook realignment (against CAD drawing of Kingsway Proposed Junction Arrangement)**

In addition to the Bramble Brook realignment, the subsequent downstream connections have been altered as part of the proposed Kingsway junction design. The route of the Bramble Brook within the junction is proposed to be in culvert; the route of this culvert would be parallel with the northern carriageway of the A38, and would be located underneath the associated verge. Existing connection points from the disused railway line to the south-west and the housing estate to the north-west, as well as the downstream connection to the main Bramble Brook culvert flowing away from the existing junction, would be retained. An existing connection from the A5111 link road would be diverted underneath a new access road from Kingsway Park Close, and connected downstream (i.e. into the main Bramble Brook watercourse culvert). These changes are shown in Figure 7. In total, 126m of open channel within the existing junction would be culverted as part of the proposed junction arrangement.

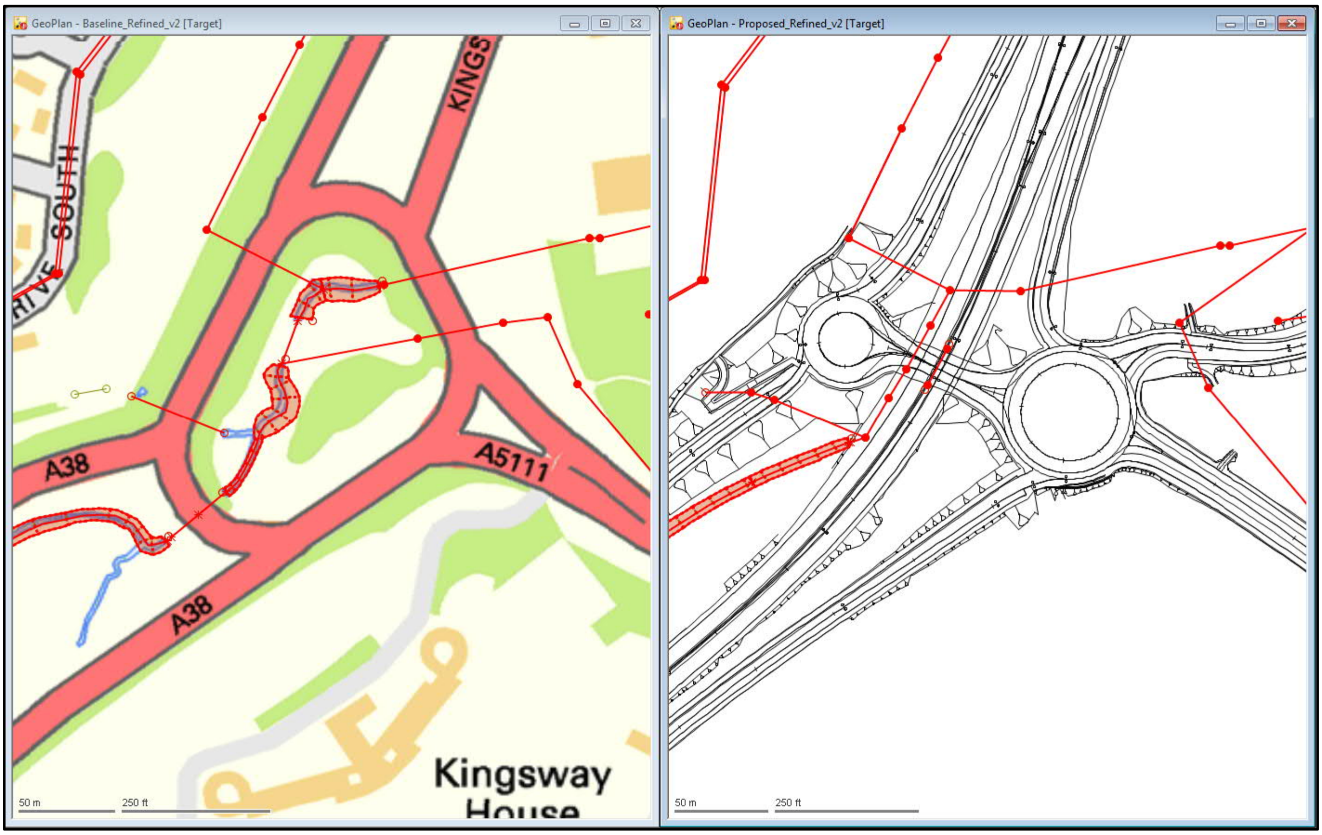



**Figure 7: Comparison of existing/ proposed culvert and sewer connections within the existing/ proposed junction arrangements**

As part of the proposals, there is a requirement for highway drainage to be designed and incorporated into the proposed junction arrangement. Details of this are reported separately, but in summary it is planned to attenuate highway runoff within a series of attenuation ponds and underground storage tanks, and limit their outflow discharge to an agreed greenfield runoff rate of 4.6l/s/ha. This is only required for the net increase in impermeable surface.

The drainage team has provided information regarding the drainage design for the Proposed Junction Arrangement. The design culminates in 5 outfalls, of which 2 are attenuated and stored within tanks/ponds, and three are attenuated within the drainage network but have free discharge to the Bramble Brook culvert (both through the junction and downstream). Within the integrated model, the free discharge outfalls (from the worst-case 15-minute duration storm, used as part of the drainage design) were included as point inflows to the relevant location along the Bramble Brook culvert. Since the worst-case fluvial event resulted from a 90-minute duration storm, it was assumed that peak discharge would be achieved 30 minutes after the start of the design rainfall event and maintained (although this is likely to be an overestimate of response time). The purpose of this allowance within the model was to include any impacts of highway drainage within the system on flood levels (particularly at within the proposed junction), and to assess it in a 'worst-case' scenario.

# 10. Proposed Arrangement Model with Mitigation

In order to reduce flood levels at the inlet to the Bramble Brook culvert (through the Kingsway junction), a mitigation solution has been designed (concept only) and modelled.

***Kingsway Junction Flood Storage Area***

The mitigation solution originally involved the provision of an offline flood storage area within the Kingsway junction only. This solution has been retained, with the flood storage area being located between the realigned Bramble Brook/ western slip road and the proposed main A38 carriageway, immediately upstream of the Bramble Brook culvert through the proposed junction. A highway surface water attenuation pond is located adjacent and to the south-west of the offline storage area. Figure 8 shows the proposed plan area of this offline flood storage and the highway surface water attenuation pond.

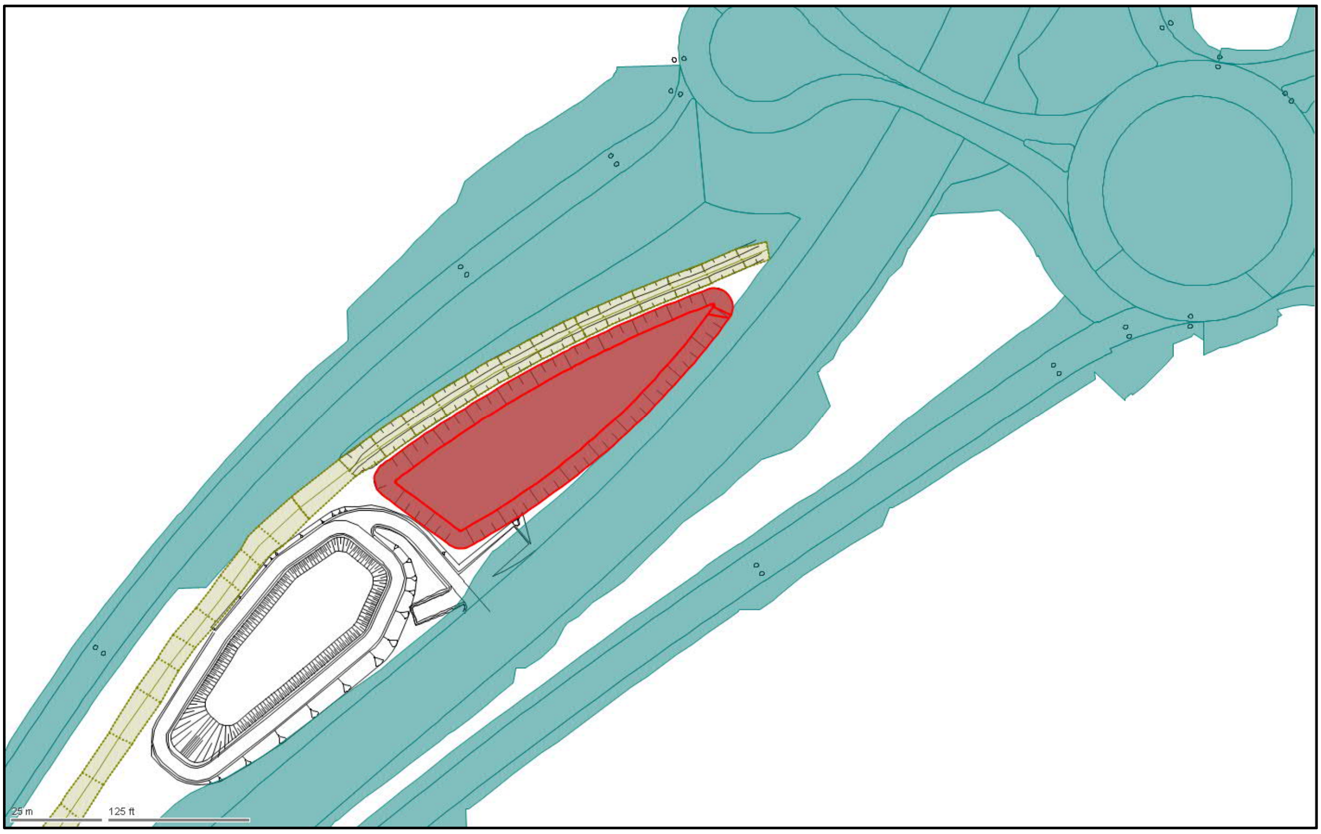



**Figure 8: Location of proposed offline flood storage area**

The proposal would be to construct a lateral weir within the right bank of the (realigned) Bramble Brook, allowing the storage area to commence filling with the rising limb of the flood hydrograph. The offline storage area would be excavated to a lowest level corresponding with the bed of the existing watercourse route, with a slight gradient to drain it towards a flapped outlet structure through the bank, close to the Bramble Brook culvert.

In the hydraulic model, a 1D weir unit was used to connect the Bramble Brook to the offline storage. The storage area was modelled using Mesh Level Zones, and is therefore represented as part of the 2D mesh. This therefore incorporates roughness impacts and associated timing affecting the filling/ draining of the storage area. A 1D flapped conduit unit connected the offline storage back into the Bramble Brook at the culvert inlet to the Kingsway junction (the flap vale ensures the offline storage cannot drain out until levels in the main channel have reduced). Table 4 summarises the levels and volumes associated with the Kingsway Junction Flood Storage Area.

| Name | Base Level (m AOD) | Base Area (m2) | Top Level (m AOD) | Top Area (m2) | Weir Crest (m AOD) |
|---|---|---|---|---|---|
| Kingsway Junction FSA | 67.0 | 1,570 | Variable* | 2,680 | 68.0 |

*Top levels tie in with top of bank along realigned Bramble Brook, and final ground levels adjacent to main carriageway

**Table 4: Summary of proposed mitigation flood storage area at Kingsway junction**

***Kingsway Hospital Site Flood Mitigation***

The Kingsway junction offline storage area as detailed above did not provide sufficient attenuation of peak flows to prevent the A38 main carriageway from being flooded during a 1% AEP plus 40% climate change event.

Therefore, the proposed mitigation solution was expanded to include three additional offline flood storage areas further upstream on Bramble Brook, within the Kingsway hospital site adjacent to Bramble Brook. These are in addition to the Kingsway Junction Flood Storage Area as shown in Figure 8. Figure 9 shows the proposed location and plan area of the Kingsway Hospital Flood Storage Areas.

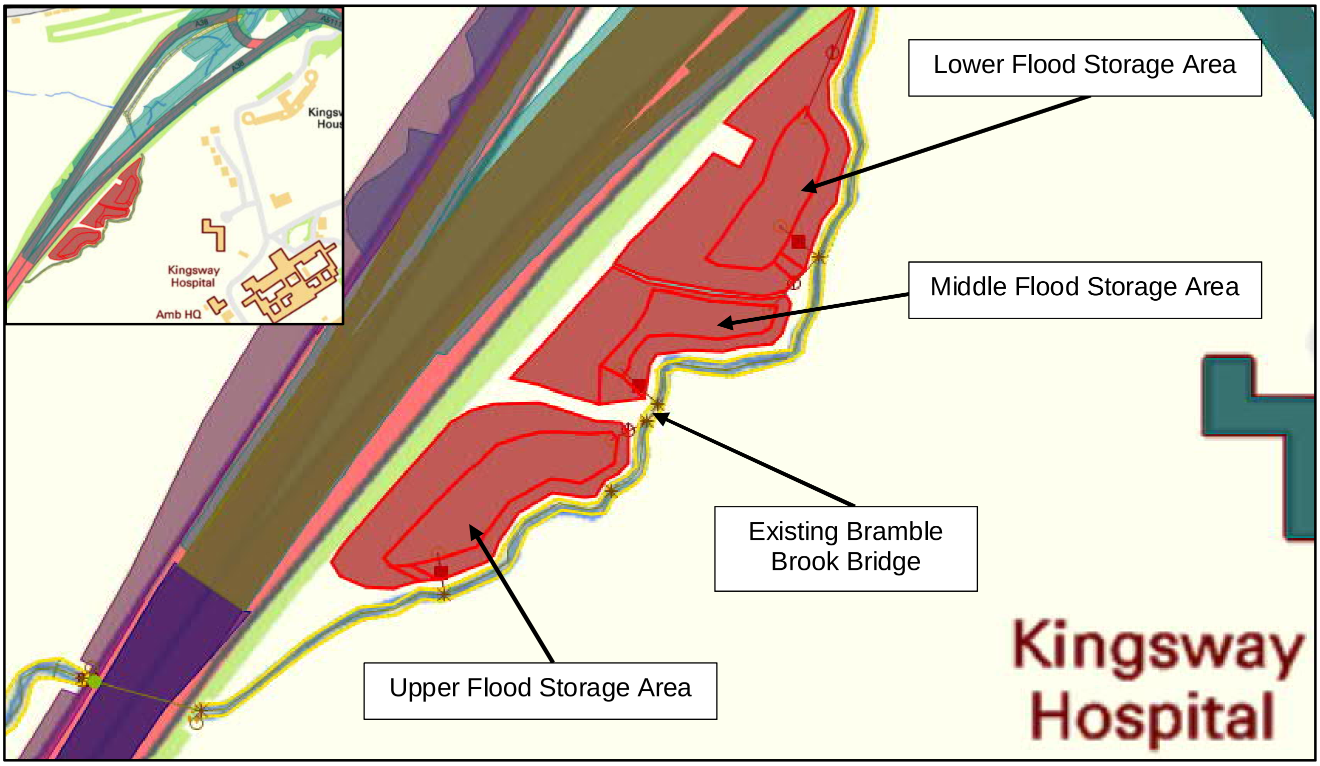



**Figure 9: Location of the proposed Kingsway Hospital offline flood storage areas**

Due to the steep topography of Bramble Brook, the additional flood storage areas have been split into three separate storage areas, as shown in Figure 9.

The lower and middle flood storage areas would be connected through a small strip of lowered land, effectively acting as a spillway between the two storage areas. The lowered spillway would allow for a larger middle flood storage area, whilst retaining a 1 in 3 gradient slope. Furthermore, the spillway would allow the middle flood storage area to overtop into the lower flood storage, rather than overtopping back into Bramble Brook. Details of the proposed flood storage areas are provided in Table 5.

| Name | Base Level (m AOD) | Base Area ($m^2$) | Top Level (m AOD) | Top Area ($m^2$) | Weir Crest (m AOD) |
|---|---|---|---|---|---|
| Kingsway Hospital FSA (Upper) | 72.2 | 1,150 | Variable | 2,780 | 73.80 |
| Kingsway Hospital FSA (Middle) | 71.0 | 540 | Variable | 1,810 | 72.55 |
| Kingsway Hospital FSA (Lower) | 69.6 | 790 | Variable | 2,960 | 71.32 |

*Top levels tie in with existing ground levels, although with some minor bank raising adjacent to Bramble Brook

**Table 5: Summary of proposed mitigation flood storage areas at Kingsway Hospital site**

The three additional flood storage areas would be located in close proximity to an existing electrical pylon. This pylon would require an access road that cannot be inundated in times of floods, allowing maintenance access to the pylon at all times. This access has been incorporated into the flood storage design.

The proposed access road would be 10m wide and would utilize the existing bridge over the Bramble Brook, labelled in Figure 9. The access would go from the existing bridge, in-between the upper and middle flood storage areas, and along the top of the middle and lower flood storage areas towards the electrical pylon that lies on a 10 by 10 m un-modified platform.

# 11. Model Results

***Proposed Arrangement Model***

The Proposed Arrangement Model of the proposed scenario (i.e. the proposed Kingsway junction design) has been run for the 1% AEP event plus 40% climate change (as well as other provided design rainfall events, including the 1% AEP event and the 1% plus 20% climate change event). This model run provides the results without any mitigation measures.

The resulting flooding at the Kingsway junction culvert inlet was reviewed, in order to assess the need for the mitigation measures. The flood extent/ depth map is shown in Figure 10 for the 1% AEP event, and 1% AEP event plus 40% climate change.

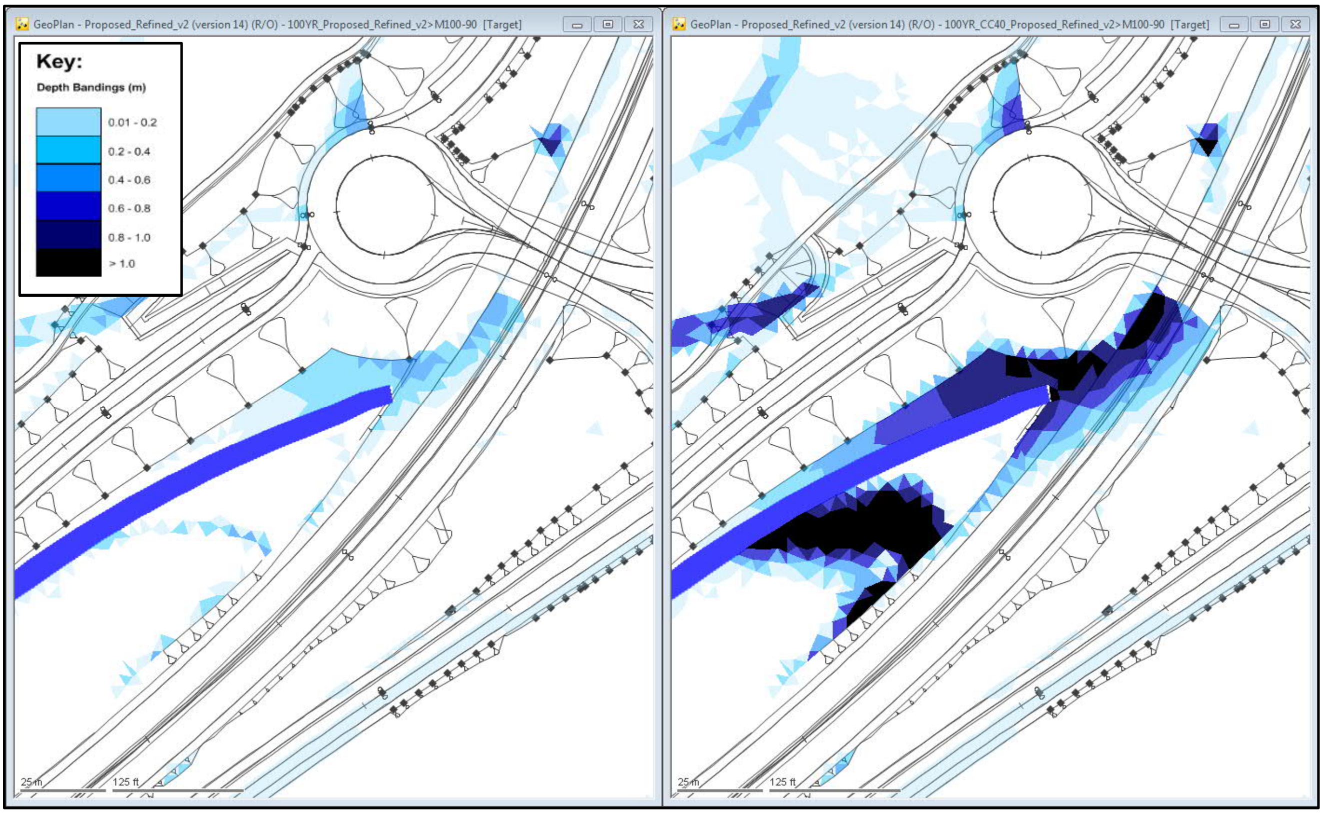



**Figure 10: Flood depth map at Kingsway junction of the proposed arrangement model during the 1% AEP event (left) and 1% AEP event plus 40% climate change (right)**

As a result, it was clear that the defined mitigation measures are necessary, namely the development of the flood storage areas within Kingsway junction and upstream within the Kingsway hospital site. The impact of these mitigation measures on flooding is discussed below.

***Proposed Arrangement Model with Mitigation***

The Proposed Arrangement Model with Mitigation has been run for the 1% AEP event plus 40% climate change (as well as other provided design rainfall events, including the 1% AEP event and the 1% plus 20% climate change event). This model run demonstrates the impact of the proposed mitigation measures, in terms of flood risk at the proposed junction. The flood extent/ depth map is shown in Figure 11.

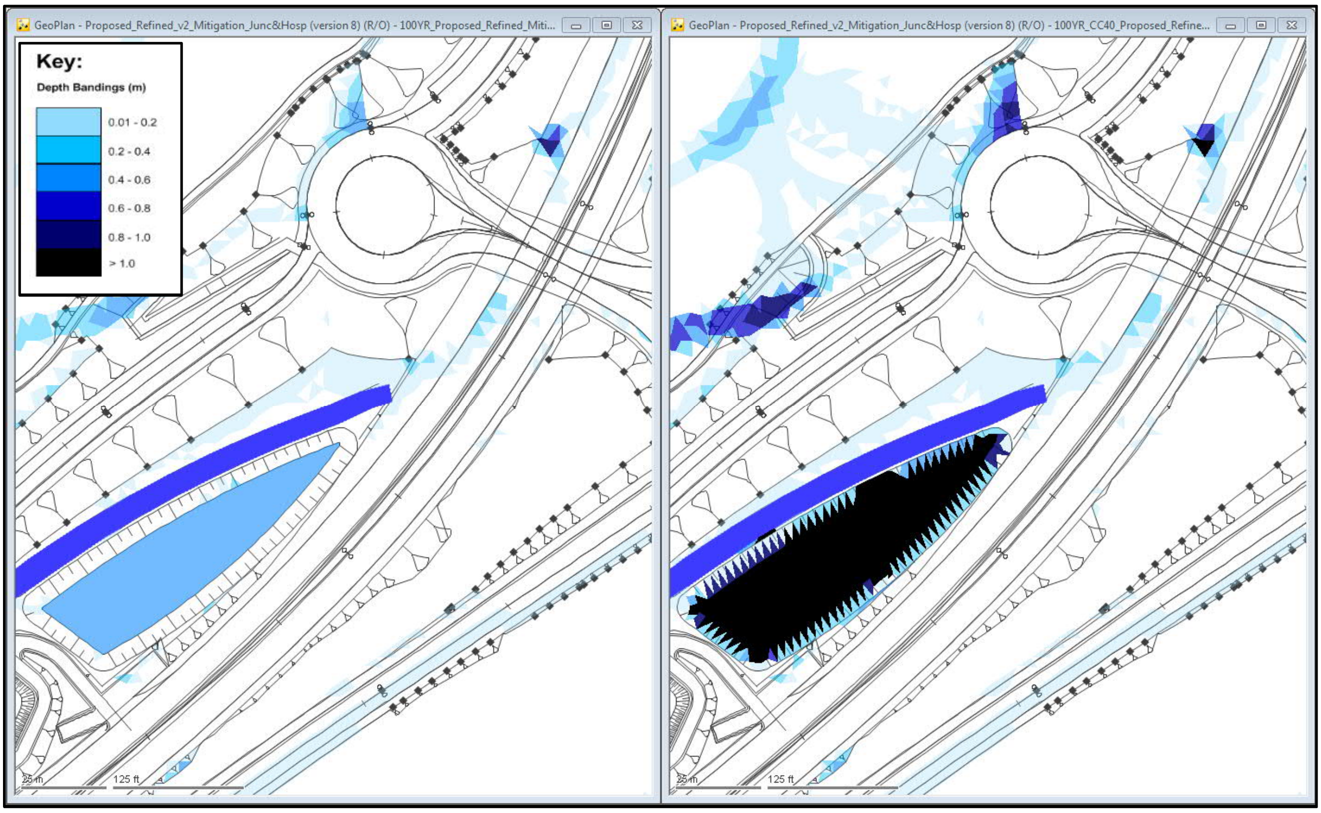



**Figure 11: Flood depth map at Kingsway junction of the proposed arrangement model with mitigation during the 1% AEP event (left) and 1% AEP event plus 40% climate change (right)**

The impact of the mitigation flood storage areas is demonstrated, providing a sufficient reduction in flood levels to prevent flow onto the main A38 highway. Although the figure does suggest some flooding of the main highway occurs, a closer inspection of the results indicates that this would be generated by direct rainfall onto the highway (and would therefore be captured by the proposed drainage network).

***Impact of Highway Drainage***

As previously stated, the Proposed Arrangement Model with Mitigation for Bramble Brook has incorporated discharges from the proposed highway drainage system. The inflows from the drainage system to the Bramble Brook were based on simulations of the drainage model for a 1% AEP event plus 40% climate change allowance, using a 15-minute ‘worst-case’ storm. In comparison to a version of the Proposed Arrangement Model with Mitigation in which the highway drainage inflows were excluded, it was found that the peak flood level at the Kingsway junction culvert inlet would reduce by 330mm. This confirms that the highway drainage can have a significant impact on peak flood levels.

***Impact on Downstream Flood Risk***

The proposed Kingsway junction involves fully culverting the Bramble Brook under the new bridge/ through the main carriageway embankment. This culvert would commence from the downstream end of the realigned Bramble Brook, and reconnect with the existing downstream culvert at its previous inlet (which currently takes flow from the second section of open channel within the existing Kingsway junction). This is shown in Figure 12.

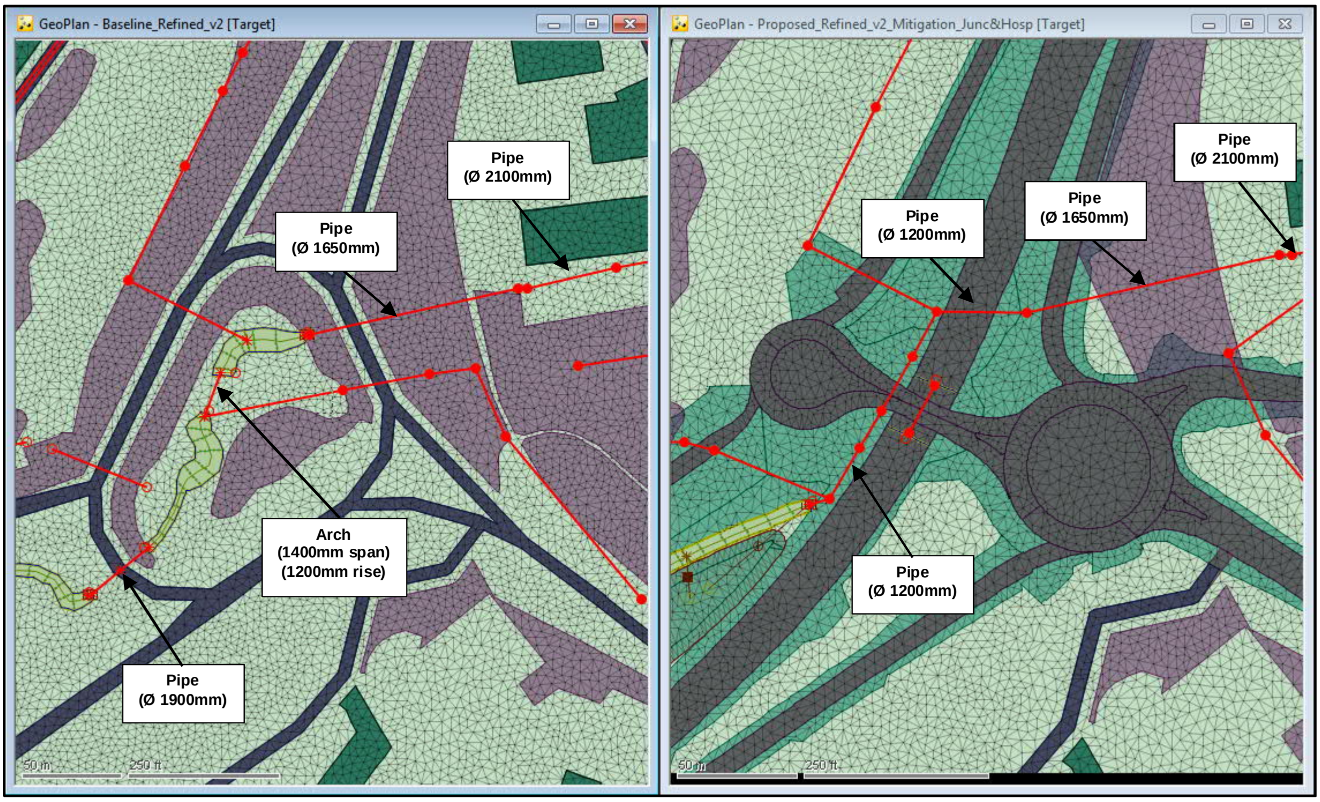



**Figure 12: Culverting proposals at Kingsway junction**

Figure 12 also confirms the various sizes/ shapes of the main Bramble Brook culvert in both the existing and proposed scenarios.

It has already been stated that the refinement to the baseline model has reduced flows downstream of Kingsway junction (see Table 3). However, this reduction is attributable only to modelling decisions, and not as a result of the scheme proposals.

As a result of the proposed scheme, flow reductions are achieved in the design event (1% AEP plus 40% climate change) due to the reduced culvert size through Kingsway junction. This is further reduced with the inclusion of the defined flood mitigation strategy. Table 6 confirms these reductions.

| AEP | Refined Baseline Model | Proposed Arrangement Model | Proposed Arrangement Model with Mitigation |
|---|---|---|---|
| 1% | 5.9$m^3$/s | 6.0$m^3$/s | 5.8$m^3$/s |
| 1% (plus 40% climate change) | 8.5$m^3$/s | 7.4$m^3$/s | 7.1$m^3$/s |

**Table 6: Summary of reductions in downstream flows as a result of proposed scheme**

In summary, it is concluded that the proposed scheme would have a benefit on downstream flood risk for Derby, although these benefits are likely to only be seen during extreme events.

# A38 Derby Junctions

## Markeaton Junction Flood Risk Assessment

**Report Number: HE514503-ACM-EWE-Z2_ZZ_ZZ_ZZ-RP-HF-0001 P04 S4**
**March 2019**

# Contents



## Appendices



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# EXECUTIVE SUMMARY

## Scheme Details

AECOM has been commissioned by Highways England to provide design services regarding the development of the A38 Derby Junctions Scheme (referred to herein as "the Scheme"). This Scheme concerns three junctions on the A38 in Derby as follows:

- A38/ A5111 Kingsway junction
- A38/ A52 Markeaton junction
- A38/ A61 Little Eaton junction

In flood risk terms, the Scheme at Markeaton junction would increase impermeable surfacing and potential surface water runoff.

This Flood Risk Assessment (FRA) comprises one of a number of documents supporting the environmental assessment of the Scheme as reported in the Environmental Statement. A separate Road Drainage Strategy (Report Number HE514503-ACM-HDG-A38_SW_PR_ZZ-RP-CD-0002, Highways England 2019) has been produced. The Road Drainage Strategy report considers the management of surface water runoff from the Scheme.

## Flood Risk Assessment

An FRA has been undertaken in accordance with the National Policy Statement for National Networks (NPSNN) and the 2019 National Planning Policy Framework (NPPF) and taking into account guidance provided in the Design Manual for Roads and Bridges (DMRB). According to the NPSNN and NPPF, applications for development proposals of 1 hectare (ha) or greater located in Flood Zone 1 and all proposals for new development located in Flood Zones 2 and 3 should be accompanied by a FRA. This FRA has therefore been undertaken to determine:

- The risks of flooding to the Scheme.
- The risks of flooding that could result from the Scheme.
- Appropriate flood risk mitigation measures.

The main aim of this FRA is to demonstrate that flood risks can be suitably managed associated with Scheme design. It should be noted that hydraulic modelling was not required as part of this FRA.

## Outcome of the Flood Risk Assessment

This FRA has established that there would be low overall risk of flooding to the Scheme at the proposed Markeaton junction. However, surface water flood risk from Markeaton junction to adjacent areas would increase as a result of highway expansion without appropriate mitigation. A road drainage strategy has been developed in parallel with this FRA as a separate report which demonstrates that surface water risks can be managed appropriately.

Incorporation of the mitigation measures as detailed herein indicate that flood risks associated with the Scheme at Markeaton junction can be appropriately managed. Should the Scheme gain development consent, further consultation will be undertaken during the Scheme detailed design with the Environment Agency (EA), Derby City Council (DCiC), Severn Trent Water (STW) and other statutory agencies as applicable.

# 1 INTRODUCTION

## 1.1 Commission

1.1.1 AECOM has been commissioned by Highways England to provide design services regarding the development of the A38 Derby Junctions Scheme (referred to herein as “the Scheme”). This Scheme concerns three junctions on the A38 in Derby as follows:

- A38/ A5111 Kingsway junction
- A38/ A52 Markeaton junction
- A38/ A61 Little Eaton junction

1.1.2 AECOM has been requested by Highways England to carry out a FRA for the Scheme at Markeaton junction. This FRA has been prepared in accordance with the National Policy Statement for National Networks (NPSNN[1]) and the National Planning Policy Framework (NPPF[2]), its associated Planning Practice Guidance (PPG[3]) and the Design Manual for Roads and Bridges (DMRB[4]).

1.1.3 The Road Drainage Strategy (Report Number HE514503-ACM-HDG-A38_SW_PR_ZZ-RP-CD-0002, Highways England 2019) is contained in Appendix 13.4 of the Environmental Statement (ES) (ES Volume 3). It has been developed alongside this report, with the flood risk and drainage assessment informing each other.

## 1.2 Scheme Background

1.2.1 The existing Markeaton junction is currently an at-grade, four-armed roundabout located along the A38 at Derby, providing a connection between the A38 and the A52 Ashbourne Road.

1.2.2 This FRA is based on the best flood risk information provided available. The Environment Agency (EA) Flood Map for Planning (Rivers and Sea)[5] shows that the Scheme site at Markeaton junction is located within Flood Zone 1 of Main Rivers with the exception of Markeaton Brook which is in Flood Zones 2 and 3[6].

1.2.3 Lead Local Flood Authorities (LLFAs)[7], in this case Derby City Council (DCiC), have lead responsibility for managing the risk of flooding from ordinary watercourses, as well as surface water and groundwater.

## 1.3 The Scheme

1.3.1 The Scheme entails the provision of grade-separation at Markeaton junction. The proposed Markeaton junction would comprise an enlarged two-bridge roundabout at existing ground level with the A38 passing beneath in an underpass to the south-east of the existing roundabout with slip roads connecting the A38 to the new roundabout. Retaining walls would be constructed between the A38 and the slip roads to reduce the footprint of the junction. The northbound merge slip road would be approximately

[1] Available online
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/387222/npsnn-print.pdf
[2] Available online: http://planningguidance.planningportal.gov.uk/blog/policy/
[3] Available online: http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/
[4] Available online: http://www.standardsforhighways.co.uk/ha/standards/dmrb/index.htm
[5] Available online:: http://www.environment-agency.gov.uk/homeandleisure/floods/38329.aspx
[6] Available online: See http://apps.environment-agency.gov.uk/wiyby/151293.aspx
[7] Available online: See https://www.gov.uk/government/publications/ordinary-watercourse-regulation-advice-note

on the line of the existing northbound carriageway adjacent to Markeaton Park.

1.3.2 In addition to grade-separation of the existing A38/ A52 Markeaton junction, additional lanes are proposed in both directions between the Markeaton and Kedleston Road junctions and through Markeaton junction. The existing footbridge to the north of the junction would be demolished and replaced in the same location (with a longer span to allow for the additional lanes on the new A38). The existing access from the A38 onto Enfield Road would be closed.

1.3.3 The Scheme layout is shown in Appendix A.

## 1.4 Planning Process

1.4.1 The Scheme is a Nationally Significant Infrastructure Project (NSIP) and thus a Development Consent Order (DCO) application is to be made to the Planning Inspectorate (The Inspectorate). The DCO application will be accompanied by an Environmental Impact Assessment (EIA) as reported within an Environmental Statement.

1.4.2 Given the above, the Scheme is subject to consideration by The Inspectorate, rather than being subject to planning control by the Local Planning Authority (LPA). Highways England is the promoter and the Applicant for the Scheme, and would also be responsible for the Scheme maintenance (with the exception of those parts of the Scheme that would be the responsibility of third parties such as the local authority and landowners).

## 1.5 Aims and Objectives

1.5.1 This report comprises an FRA of the proposed Markeaton junction. The assessment has involved assessing flood risks to the Scheme site, advising on the potential constraints to the Scheme, assessing the potential impacts of the Scheme on flood risks in the wider area and providing outline mitigation measures and a road drainage strategy. To complete this study the following objectives have been met:

- Review the development plans with respect to flood information in national and local policy documents, strategic flood risk documents and relevant previous and local studies that cover the area of the Scheme.
- Assess potential sources of flood risk including rivers, surface water, drainage infrastructure, groundwater and artificial sources.
- Identify requirements for surface water runoff attenuation from the site and the implications for storm water attenuation/ storage.
- Propose suitable flood mitigation measures (where applicable) in line with the recommendations of current best practice.
- Produce a report that summarises flood risk at the site and surface water considerations appropriate for the Scheme, in accordance with the NPSNN, NPPF, PPG and DMRB.

# 2 SITE AND SURROUNDING AREA

## 2.1 Site Location

2.1.1 The existing Markeaton junction is located approximately 1.5km to the west of Derby, Derbyshire at Ordnance Survey National Grid Reference 433440, 336970. It forms the intersection of the A38 from the north and south and the A52 from the east and west. The Scheme location is shown in Figure 2-1.

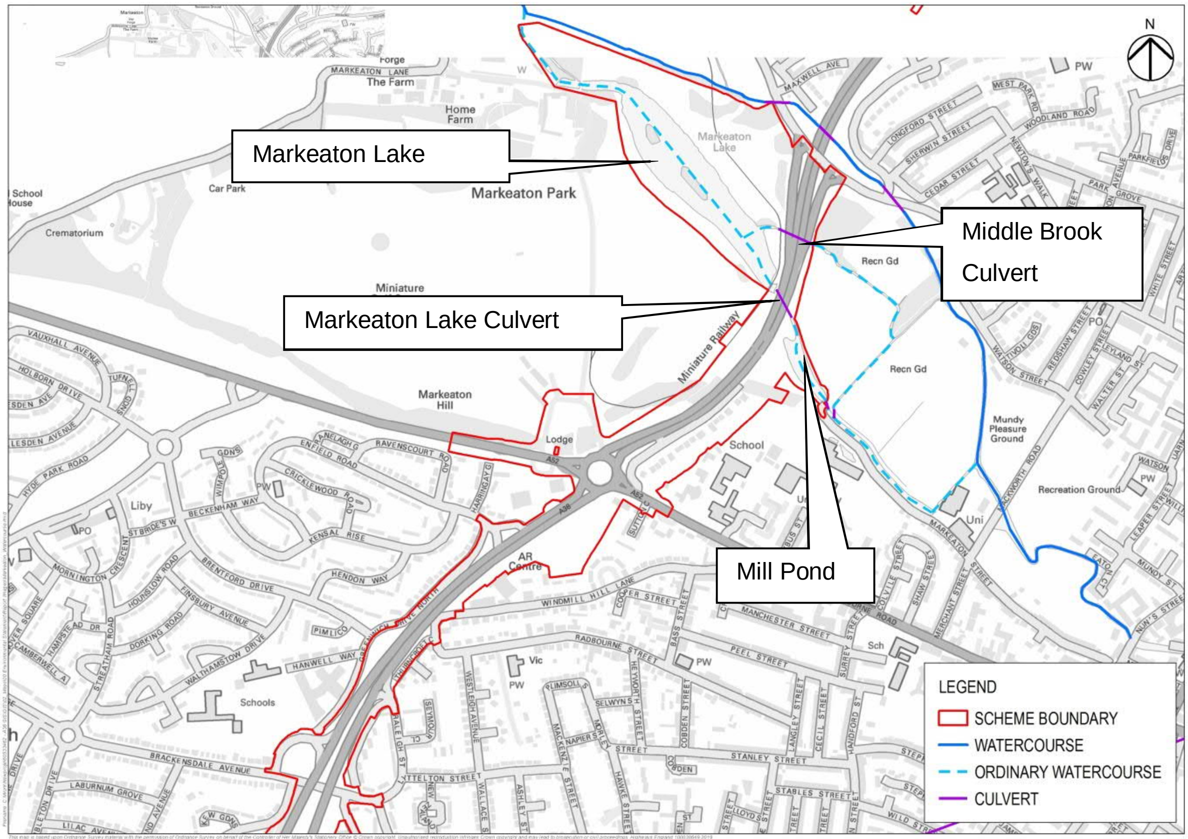


**Figure 2-1: Site location map and water features**



## 2.2 Existing Junction

2.2.1 Immediately to the north of the existing junction site is Markeaton Park which contains playing fields, a golf course and Markeaton Lake. Residential properties are located immediately to the east, west and south, which include the properties along Queensway and the A52. Immediately to the west of the junction is a petrol filling station and fast food restaurant.

## 2.3 Topographic Setting

2.3.1 The topographic survey for Markeaton junction shows that the junction is at a level of approximately 65m AOD (above ordnance datum). The land and connecting roads to the north and east fall away from Markeaton junction with the A38 to the north falling to a level of approximately 57.2m AOD in the area where it crosses Markeaton Lake. Roads from the south and west both slope gently down to the junction.

## 2.4 Local Water Features

2.4.1 Markeaton Brook flows from north-west to south-east, flowing beneath the A38 approximately 650m to the north-east of Markeaton junction. The brook then flows east where it eventually discharges into Mill Fleam. Markeaton Brook is the largest of the Derby Brook watercourses and has a total catchment of approximately 50km$^2$.

2.4.2 Mackworth Brook flows from the north-west and joins Markeaton Brook shortly upstream of the culvert beneath the A38.

2.4.3 Both Markeaton Brook and Mackworth Brook are connected to a significant watercourse diversion, the Northern Relief Culvert, upstream of Markeaton Lake. The culvert serves as flood relief for the area downstream of Markeaton Lake by diverting peak flows directly to the River Derwent.

2.4.4 Markeaton Lake is located approximately 450m to the north of the junction. The Markeaton Lake culvert and the Middle Brook culvert convey flows beneath the A38 before they join Markeaton Brook further downstream.

2.4.5 Figure 2-1 shows the water resources within the vicinity of Markeaton Junction.

## 2.5 Geology and Hydrogeology

2.5.1 Ground conditions comprise topsoil, overlying Made Ground, both underlain by rocks of the Mercia Mudstone Group and the Tarporley Siltstone Formation (Siltstone, Mudstone and Sandstone) (as stated in the A38 Derby Junctions Ground Investigation Report (Report Number HE514503-ACM-VGT-A38_SW_PR_ZZ-PR-GE-0003_P02_24, 2018)).

2.5.2 The Made Ground comprises embankment fill and previous road construction material up to a depth of 3.2m. Mercia Mudstone Group material comprises a weathered profile, typically becoming less weathered with depth. The material is typically described as red and grey stiff to hard, sometimes soft. The less weathered material, typically found at greater depths is described as a very weak mudstone. The material includes laminations and bands of grey siltstone and sandstone.

2.5.3 To the north-east of the junction, alluvium underlain by River Terrace Deposits is indicated. The alluvium is indicated to be up to 4.1m thick and is typically very soft to firm silty clay or sandy silty clay. The River Terrace Deposits are typically fine to coarse, sand and/or gravel with a thickness of up to 4.1m.

2.5.4 According to the DEFRA Magic mapping[8], the bedrock is classified as a Secondary A aquifer; permeable layers capable of supporting water supplies at a local rather than a strategic scale, and in some cases forming an important source of base flow to rivers. The superficial River Terrace Deposits are mapped as Secondary B aquifer;

[8] Available at: https://magic.defra.gov.uk/MagicMap.aspx. Last Accessed November 2018.

lower permeability layers which store and yield limited amounts of groundwater due to localised features.

2.5.5 Groundwater used for drinking water is protected by the EA. The EA classifies zones around potable groundwater abstraction points as Source Protection Zones (SPZs). These are designed to limit potential pollution activities and have implications for how surface water is managed, e.g. by infiltration. According to the EA, the site at Markeaton junction is not located within an SPZ, with the closest zone located approximately 2.3km to the north of the junction.

# 3 REGULATORY POSITION

## 3.1 National Policy Statement for National Networks (NPSNN)

3.1.1 The primary basis for deciding whether or not to grant a Development Consent Order (DCO) is the National Policy Statement for National Networks (NPSNN) which, at Sections 4 and 5, sets out policies to guide how DCO applications will be decided and how the impacts of national networks infrastructure should be considered.

3.1.2 Flood risk paragraphs 5.90 – 5.115 state that the Secretary of State should be satisfied that flood risk will not be increased elsewhere and should only consider development appropriate in areas at risk of flooding where it can be demonstrated that: the most vulnerable development is located in areas of lowest flood risk unless there are overriding reasons to prefer a different location; development is appropriately flood resilient and resistant, including safe access and escape routes where required; that any residual risk can be safely managed, including by emergency planning; and that priority is given to the use of sustainable drainage systems (SuDs). Applications for projects should be accompanied by a flood risk assessment (FRA) to assess all risks of flooding and take climate change into account.

3.1.3 In preparing an FRA an applicant should:

- Consider the risk of all forms 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 lifetime.
- Take the impacts of climate change into account, clearly stating the development lifetime over which the assessment has been made.
- Consider the vulnerability of those using the infrastructure including arrangements for safe access and exit.
- Include the assessment of the remaining (known as ‘residual’) risk after risk reduction measures have been taken in to account and demonstrate that this is acceptable for the particular project.
- Consider if there is a need to remain operational during a worst case flood event over the development’s lifetime.
- Provide the evidence for the Secretary of State to apply the Sequential Test and Exception Test as appropriate.

## 3.2 National Planning Policy Framework (NPPF)

3.2.1 Section 14 of the NPPF (revised in February 2019) and the associated 2014 Planning Practice Guidance (PPG) provides the current guidance for planning with respect to flood risk and meeting the challenges associated climate change. The NPPF advocates a sequential approach for the planning process in order to steer development to areas with the lowest possible risk of flooding. It is important to note the revision to the 2012 NPPF in 2018 and 2019. This FRA has been completed in accordance line with the 2019 revision and the associated 2014 PPG.

3.2.2 As discussed in Section 1.2, the EA Flood Map confirms that most of the Scheme at Markeaton junction is located within Flood Zone 1. According to Table 2 within the

PPG, this means that it lies within the 'Essential Infrastructure' vulnerability classification. Table 3 within the PPG, which provides a matrix identifying which vulnerability classifications are appropriate within each flood zone, demonstrates that 'Essential Infrastructure' developments are permitted within Flood Zone 1.

3.2.3 The Scheme area near Markeaton Brook is within Flood Zone 2, with areas either side of the carriageway within Flood Zone 3. 'Essential Infrastructure' development is permitted within Flood Zone 2.

### 3.3 Design Manual for Roads and Bridges (DMRB)

3.3.1 Highways England and other highway authorities have a responsibility to keep trunk roads and local roads respectively free from flooding (relevant legislation includes the Highways Act 1980 and the Land Drainage Acts 1991 and 1994).

3.3.2 The DMRB primarily refers to the former PPS25 (Planning Policy Statement 25, now superseded by the NPPF) for FRA and flood mitigation guidance, and emphasises the need for consultation with the EA early in the design process.

3.3.3 The DMRB offers guidance on hydraulic design of highway drainage systems, and assessment, and guidance on mitigation techniques for roads (and embankments) that encroach into floodplains. The latter is not applicable in this case because the site is in Flood Zone 1.

3.3.4 More detailed discussion of highway surface water management and sustainable drainage is provided in Section 5.

### 3.4 Local Plan Review – Adopted Plan

3.4.1 The current adopted Local Plan for the study area is The Derby City Local Plan- Part 1 Core Strategy (2017)[9] which sets out the long term strategy for promoting and managing development in the city up to 2028. The plan forms part of a statutory framework to be used in addition to the on-going policies from the City of Derby local Plan Review (2006)[10].

3.4.2 In terms of flood protection the Local Plan, 'CP2 Responding to Climate Change' aims to protect important flood plain areas and provides guidance relating to development within these areas. The policy states:

'*Except where satisfactory compensatory measures are provided to off-set any potential adverse effects for development on the water environment and associated lands, planning permission will not be granted for development which:*

*a. Lies within undefended areas at risk of flooding;*

*b. Would create or exacerbate flooding elsewhere;*

*c. Results in the loss of natural floodplain;*

*d. Would impede access to a watercourse for maintenance or flood defence purposes;*

*e. Does not provide for the adequate management of surface run-off using sustainable drainage principles, unless it can be demonstrated that their use is inappropriate.'*

[9] Available online: http://www.derby.gov.uk/environment-and-planning/planning/planning-policy/
[10] Available online: http://www.derby.gov.uk/environment-and-planning/planning/local-development-framework/

3.4.3 The Scheme is an NSIP and therefore subject to a DCO. In order to obtain development consent, Highways England must demonstrate that flood risk has been adequately managed. Furthermore, planning consent will only be granted where compensating measures are proposed to mitigate potential flood problems.

3.4.4 The draft Core Strategy provides policy and guidance relating to flood risk and water management. It must be ensured that development is flood resilient and resistant and that flood risk is not increased to people or property within the surrounding area. Development must also be designed and laid out to incorporate sustainable drainage systems (SuDS) and ensure that runoff is directed to areas where it does not cause harm to others.

3.4.5 There are no development plans described in the Core Strategy that are in the vicinity of Markeaton junction.

### 3.5 Strategic Flood Risk Assessment(SFRA)

3.5.1 In October 2013 DCiC prepared a Level 1 Strategic Flood Risk Assessment (SFRA)[11] to assist the city in meeting the requirements of national policy. The SFRA provides general advice on flood risks and on the principles and application of sustainable drainage.

3.5.2 According to the SFRA numerous flood events from Markeaton Brook occurred in the 1930s. This led to construction of the Northern Relief Culvert in 1937 and since its introduction, the SFRA reports that fluvial flooding events have reduced.

3.5.3 Both the Markeaton and Mackworth Brooks have been modelled as traditionally they have posed a threat to the city because the watercourse capacities are restricted. The SFRA states that Markeaton Brook is prone to flooding as a result of:

- Insufficient capacity – the brook course is narrow and overgrown in many places. The capacity of the open sections is generally around 9-14 cumecs (as reported in the 2007 SFRA), however this is only a third of the required capacity should the flood diversion system at Markeaton Park fail. The capacity may have also reduced since 2007 due to siltation.
- Markeaton junction is not assessed within the SFRA, but this study notes that the junction does not lie within an area which is mapped as a potential problem area for the 1 in 100 year flood event from Markeaton Brook should defences fail. The SFRA describes how overflows at Markeaton Park into the Northern Relief Culvert should provide a high level of flood defence to the area now proposed for junction improvements, although this would be dependent on regular maintenance of assets.

### 3.6 Preliminary Flood Risk Assessment (PFRA)

3.6.1 In 2011 DCiC produced its Preliminary Flood Risk Assessment (PFRA)[12] which represented the first stage in recording and monitoring flooding in Derby. The high level assessment addresses flood risk from surface water groundwater, ordinary watercourses and canals. Main rivers and reservoirs were excluded from the scope as they were covered under a separate assessment.

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[11] Available online: https://www.derby.gov.uk/media/derbycitycouncil/contentassets/documents/policiesandguidance/planning/SFRA_1_Update_Explanation_V3.pdf

[12] Available online: http://enjoyfreepdf.com/download/derby-city-council-preliminary-flood-risk-assessment/

3.6.2 The PFRA does not include any details of historic flooding at, or within the vicinity of Markeaton junction.

## 3.7 Our City Our River

3.7.1 The Our City Our River Masterplan[13] has been developed jointly by DCiC and the EA since 2012, and sets out a shared vision to reduce flood risk in Derby and transform the City's relationship with the River Derwent by helping to encourage economic regeneration in areas currently at risk of flooding.

3.7.2 Our City Our River describes flow control structures and pumping stations that may be required to prevent the River Derwent backing up Markeaton Brook culvert in the city centre area, but this would not affect Markeaton junction.

## 3.8 Consultation

3.8.1 AECOM has been consulting with DCiC, EA and STW regarding flooding and highway drainage design issues since 2015..

### Derby City Council (DCiC)

3.8.2 DCiC is the LLFA responsible for managing the risk of flooding from surface water, groundwater and ordinary watercourses in the vicinity of the Scheme at Markeaton junction, and has been consulted regarding local flood risks, available data and the drainage design.

3.8.3 DCiC is also the Land Drainage Authority for Markeaton Brook and is responsible for issuing consents for any works requiring approval under the Land Drainage Act (1991).

### Environment Agency (EA)

3.8.4 The EA has been consulted on the Markeaton junction improvement proposals. Given that Main Rivers are unlikely to be affected at Markeaton junction, the EA had no particular comments on fluvial flood risks for the proposals, but did emphasise that surface water runoff should be controlled to existing rates or less.

### Severn Trent Water (STW)

3.8.5 Consultation has been undertaken with STW with regard to their assets in the vicinity of the Scheme at Markeaton junction. .

[13] Available at: https://www.derby.gov.uk/media/derbycitycouncil/contentassets/documents/environmentandplanning/OurCityOurRiverMasterplan2013.pdf

# 4 SOURCES OF FLOODING AND FLOOD RISK

## 4.1 Introduction

4.1.1 The NPPF (and the NPSNN for NSIPs) requires that all potential sources of flooding that could affect a development are considered within an FRA. This includes flooding from rivers and the sea, directly from rainfall on the ground surface and rising groundwater, overwhelmed sewers and drainage systems. Flooding from reservoirs, canals, lakes and other artificial sources must also be considered. There should be demonstration of how these should be managed so that the development remains safe throughout its lifetime, taking into account climate change.

## 4.2 Historic Flooding

4.2.1 Fluvial flooding occurred in Markeaton Brook catchment in the 1930s, and the Northern Relief Culvert was subsequently constructed to manage flood risk.

4.2.2 The Highways England Drainage Data Management System (HE DDMS) database was investigated for records of historic flooding at the Scheme site. One flood event is reported (ID 12470) in the vicinity of the Scheme at Markeaton junction, which occurred midway between the Kingsway and Markeaton junctions. Flooding was reported on the A38 southbound Palm Court roundabout slip road and onto the A38 south towards Markeaton junction in September 2013, and remedial action was taken (unblocking a gully).

## 4.3 Fluvial

4.3.1 Flooding from fluvial sources (rivers) can occur through inundation of floodplains from rivers and watercourses, or inundation of areas outside of the floodplain due to influence of bridges, embankments and other features that can restrict flow.

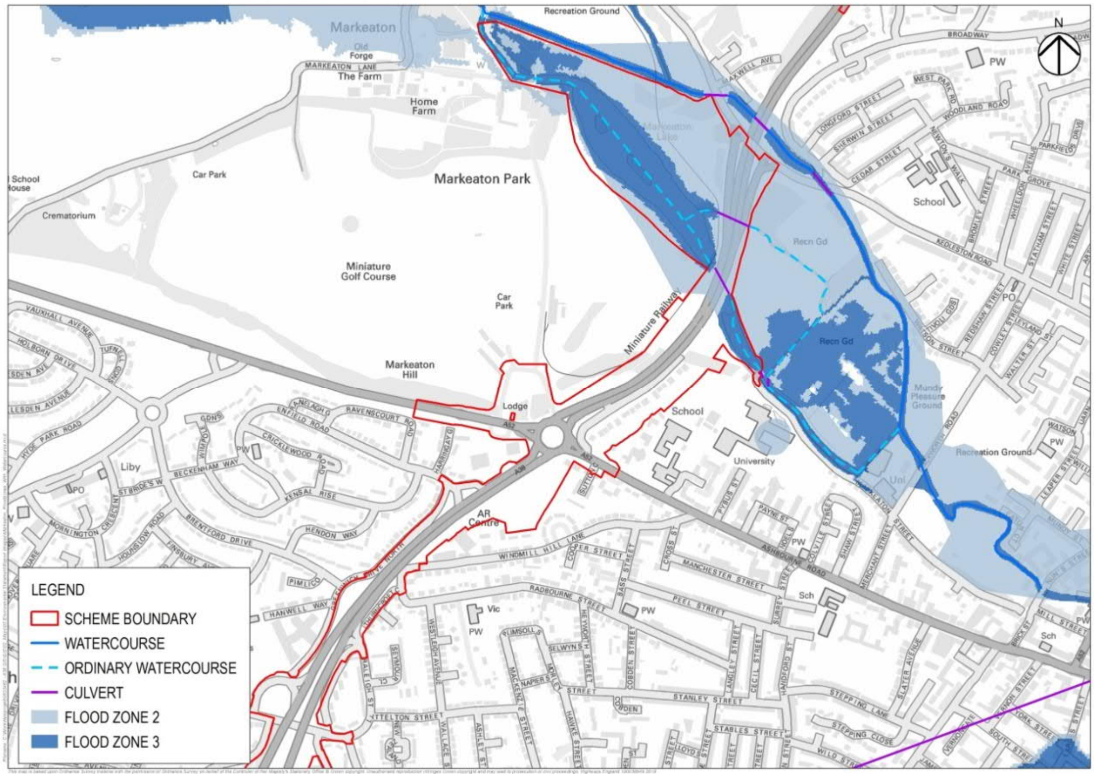


**Figure 4-1: Fluvial flood map with Scheme extent**
(areas not within Flood Zones 2 and 3 are within Flood Zone 1)

4.3.2 The fluvial flood maps (refer to Figure 4-1) show that Markeaton junction is largely at very low risk of flooding from Main Rivers. However, the northern parts of the Scheme are located in Flood Zone 2 due to the close proximity to Markeaton Brook (as identified in Figure 2-1).

## 4.4 Tidal

4.4.1 Tidal flood sources include the sea and estuaries. There are no tidal sources within close proximity of the junction, therefore, Markeaton junction is not considered to be at any risk from this source.

## 4.5 Groundwater

4.5.1 Groundwater flooding occurs as a result of water rising up from the underlying aquifer or from water flowing from springs. This tends to occur after long periods of sustained high rainfall, and the areas at most risk are often low-lying where the water table is more likely to be at shallow depth. Groundwater flooding is known to occur in areas underlain by major aquifers, although increasingly it is also being associated with more localised floodplain sands and gravels. It tends to occur sporadically in both location and time, and because of the more gradual movement and drainage of water, and tends to last longer than fluvial, pluvial or sewer flooding.

4.5.2 As highlighted in the A38 Derby Junctions Ground Investigation Report (Report Number HE514503-ACM-VGT-A38_SW_PR_ZZ-PR-GE-0003_P02_24, 2018), Markeaton junction lies over bedrock geology of Mercia Mudstone Group and the Tarporley Siltstone Formation (Siltstone, Mudstone and Sandstone). The underlying geology is therefore permeable.

4.5.3 According to the Areas Susceptible to Groundwater Flooding Map within the PFRA, the majority of Markeaton junction lies within an area considered to have a risk of >=50% <75%, although DCiC has no records of groundwater flooding in the vicinity of the site.

4.5.4 The A38 Derby Junctions Ground Investigation Report indicates that groundwater was typically encountered at depths of around 2.5m to 3.5m in the vicinity of the junction and 9.0m to the south, possibly within semi-confining layers of the Mercia Mudstone Group. To the north-east of the junction, in the area of Markeaton Lake, shallow groundwater depths of 1.0m to 3.0m were encountered within the river terrace and alluvium deposits.

4.5.5 Overall, the risk of groundwater flooding is considered to be high.

## 4.6 Surface Water

4.6.1 Overland flow results from rainfall that fails to infiltrate the surface and travels over the ground surface; this is exacerbated where the permeability of the ground is low due to the type of soil and geology (e.g. clay soils) or urban development. Surface water flow is also promoted in areas of steep topography which can rapidly convey water that has failed to penetrate the surface.

4.6.2 EA long term flood risk maps (Figure 4-2)[14] show that there are areas along the edge of the existing highway infrastructure at a 'high' risk of surface water flooding. These

[14] Available at: https://flood-map-for-planning.service.gov.uk/. Last Accessed November 2018

areas fall within the Scheme boundary and will therefore need to be managed through the proposed road drainage strategy (see Section 5).

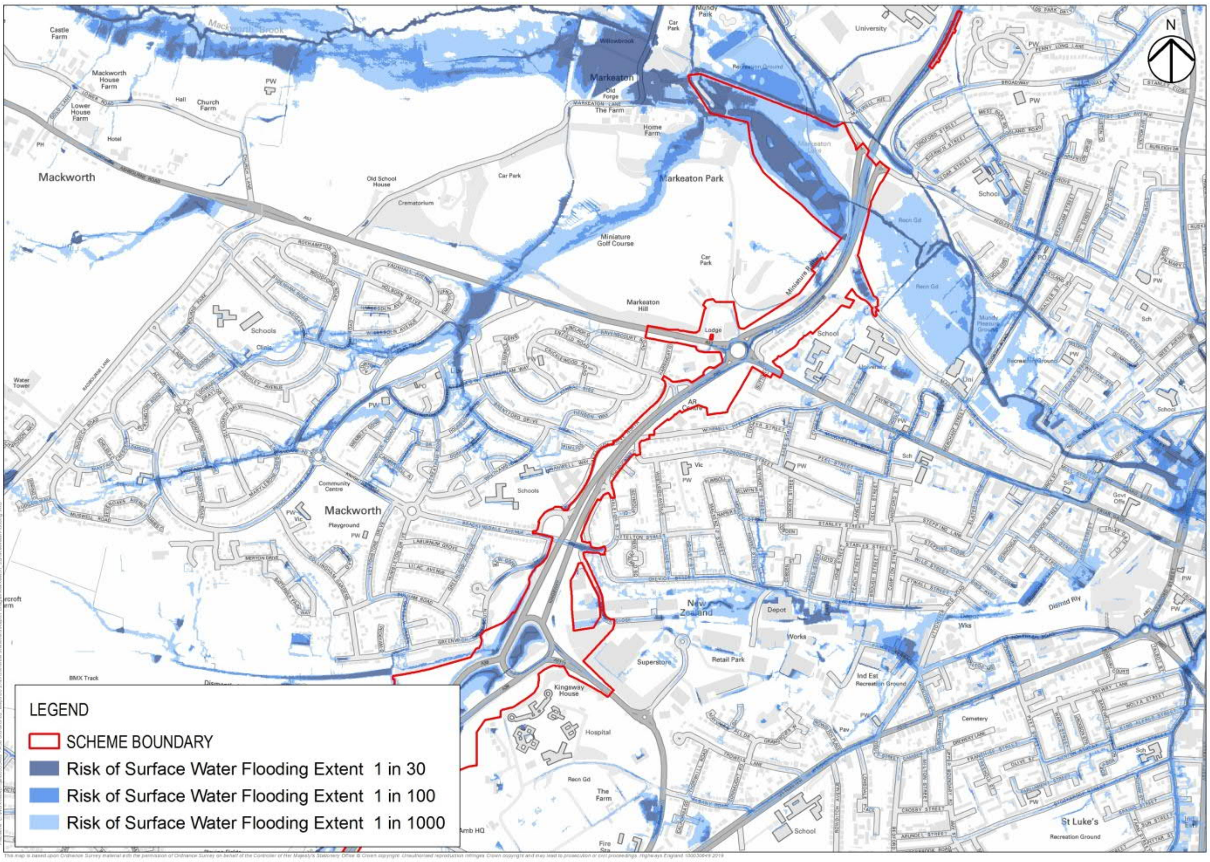


**Figure 4-2: Environment Agency flood map for surface water**

4.6.3 As the Scheme at Markeaton junction would increase the amount of impermeable surface, the amount of surface water runoff from the area would also increase.

4.6.4 Surface water flood risks to the Scheme at Markeaton junction are considered to be medium, but mitigation measures would be required to control surface water flood risks from the proposed junction. These issues are discussed in Section 5.

## 4.7 Sewers

4.7.1 Flooding can occur as a result of infrastructure failure e.g. blocked sewers or failed pumping stations. Sewer flooding can occur when the system surcharges due to the volume or intensity of rainfall exceeding the capacity of the sewer, or if the system becomes blocked by debris or sediment.

4.7.2 No sewer flooding records have been identified in the vicinity of the Scheme at Markeaton junction.

4.7.3 As described above, the Road Drainage Strategy (Report Number HE514503-ACM-HDG-A38_SW_PR_ZZ-RP-CD-0002, Highways England, 2019) states that the existing highway pavement and drainage collection systems would be replaced as part of the junction improvements, and detailed drainage design including sewers and a pumping station would take place during detailed design.

4.7.4 The current risk of sewer flooding at the Markeaton junction site is considered to be low.

### 4.8 Artificial Sources

4.8.1 Artificial sources include raised channels such as canals or storage features such as ponds and reservoirs. Markeaton Lake is located approximately 450m to the north of the junction and adjacent to the Scheme and presents a flood risk to the site. There are two weirs at the lake outlet and there is a low likelihood of both structures blocking at the same time. According to OS mapping, there are no other significant canals, ponds or storage features located in the proximity of the Scheme at Markeaton junction.

4.8.2 The EA Map of Flood Risk from Reservoirs[15] indicates that Markeaton junction is not at risk of flooding from reservoirs.

4.8.3 The risk of flooding from artificial sources is considered to be low.

### 4.9 Climate Change

4.9.1 The United Kingdom Climate Impacts Programme is assessing implications of climate change in the UK. Climate change scenarios for the UK predict that winters will be wetter by up to 15% by the 2020s, summers will possibly be drier by up to 20% by the 2020s, snowfall amounts will decrease significantly, and extreme winter precipitation will become more frequent.

4.9.2 In February 2016 the EA released updated guidance on the climate change allowances to be used in Flood Risk Assessments. The Markeaton Brook is located within the Humber River Basin District and the total potential change in watercourse flows anticipated for the 2080s (2070 to 2115) is 50% for the upper end allowance.

4.9.3 The EA and DCiC have confirmed that 40% allowance for climate change is appropriate for assessing the Scheme site and this is incorporated into the drainage assessments described in Section 5.

4.9.4 It is not considered likely that climate change, as it is currently predicted, will have significant impacts on the flood risks described above, subject to the necessary allowances being made in the Scheme drainage design.

### 4.10 Summary

4.10.1 Key findings of the flood risk review are as follows:

- The risk of fluvial flooding to the proposed Markeaton junction is considered to be low.
- There is no realistic risk of tidal flooding.
- The risk of groundwater flooding is considered to be medium.
- The risk of surface water flooding to the proposed Markeaton junction is low. However, the risk of increased surface water runoff from the Scheme arrangement to surrounding areas is considered to be high. The road drainage strategy has been developed to describe how attenuation would be used to control runoff from the Scheme to existing rates – refer to Section 5.
- The risk of sewer flooding is considered to be low.
- The risk of flooding from artificial sources is considered to be low.

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[15] Available at: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map Last Accessed November 2018.

# 5 SURFACE WATER MITIGATION MEASURES

5.1.1 The Road Drainage Strategy (Report Number HE514503-ACM-HDG-A38_SW_PR_ZZ-RP-CD-0002, Highways England, 2019) is available as a separate report and should be read in parallel with this FRA. The Road Drainage Strategy report indicates that the highway drainage design at Markeaton junction comprises the following:

- Pumping station adjacent to the southbound diverge slip road to pump highway runoff from the mainline cutting.
- To provide groundwater exclusion and avoid post-construction groundwater pumping, a secant pile retaining wall is proposed along both sides of the main cutting, combined with a water excluding reinforced concrete base slab.
- Attenuation using the carrier pipework network.
- Narrow filter drains.
- Combined kerb drainage units.
- Use of underground tanks or cellular storage (allowance for two separate storage tanks under the area left vacant by building demolition at Queensway).
- Surface sedimentation pond.
- Trapped gully pots and road-side linear drains.
- Petrol interceptors at outfalls and connections to existing public sewers – includes a swale discharge into Mill Pond.
- By-pass separators.

## 5.2 Runoff collection and conveyance

5.2.1 Markeaton junction's preliminary drainage design consist of six catchments.

5.2.2 Runoff from the carriageway would be collected via a combination of road edge channels, gullies and combined kerb drainage units (where required). The proposed overbridges allow for bridge drainage/ combined kerb drainage units on the bridge deck.

5.2.3 The use of carrier pipes would ensure that spillages would be contained within the drainage system and would not infiltrate to ground close to source. Subsurface drainage would be provided via narrow filter drains throughout where necessary.

5.2.4 To provide groundwater exclusion from the new underpass and avoid post-construction groundwater pumping, a secant form of pile construction is proposed, combined with a water excluding reinforced concrete base slab. Due to potential high groundwater levels, the structural arrangement would be required to exclude groundwater, with the capacity to resist uplift pressures. Temporary pumping of groundwater would be required during construction. Permanent pumping of surface water would be required, as the underpass would be below the level of nearby watercourses.

5.2.5 The carriageway within the A38 mainline cut would be approximately 7.8m below existing ground level near chainage 2,850m (approximately 400m to the west of the nearest watercourse).

5.2.6 A pumping station would be required to convey surface water runoff from the majority of the new A38 mainline to the surface. The pumping station would be located beside the junction's southbound diverge slip road.

5.2.7 Further consultation is required to determine the electrical supply to the pumping station and would be carried out in the detail design stage. A risk-based approach at detailed design stage would be completed to fully understand the implications of the inclusion or exclusion of an electrical backup system or systems. Access to the pumping station would be from the adjacent slip road.

## 5.3 Attenuation and pollution control

5.3.1 A GRR of 4.6l/s/ha has been agreed with DCiC for use within the preliminary design calculations.

**Catchment 6**

5.3.2 The widening of the Markeaton Park entrance road would provide an increase in impermeable area. The discharge from the catchment would be restricted to match existing discharge rates, ensuring no detriment in terms of downstream flood risk. Attenuation would be provided within the existing pipe network/ upgraded pipe network to ensure no flooding from the site in a 1 in 100 year + 40% CC rainfall event. Drainage information regarding the existing network would be ascertained through a drainage survey during the detailed design stage.

5.3.3 Catchment 6 would discharge into the existing drainage network within Markeaton Park.

**Catchment 7**

5.3.4 The discharge from the catchment would be restricted to match existing discharge rates, ensuring no detriment in terms of downstream flood risk. Attenuation would be provided within the pipe network to ensure no flooding from the site in a 1 in 100 year + 40% CC rainfall event. The existing connections to the existing Markeaton Lake culvert (subject to condition assessment) would be retained. No vegetative highway runoff treatment would be provided due to the site constraints, matching existing conditions. An open highway runoff attenuation and treatment feature was not feasible in this location as it would require land take from Markeaton Park.

5.3.5 A petrol interceptor would be located upstream of the connection to the culvert.

**Catchments 8 and 9**

5.3.6 The northbound and southbound slip roads of Kedleston Road junction would discharge to the existing culvert connecting Markeaton Lake with Middle Brook.

5.3.7 The discharge from the catchment would be restricted to match existing discharge rates, ensuring no detriment in terms of downstream flood risk. Attenuation would be provided within the pipe network to ensure no flooding from the site in a 1 in 100 year + 40% CC rainfall event. The existing connections to the existing culvert (subject to condition assessment) would be retained. No vegetative highway runoff treatment would be provided due to the site constraints, matching existing conditions.

**Catchment 10**

5.3.8 Attenuation up to and including 100 year + 40% climate change storm event would be provided within the pipe network, lined attenuation tanks (underground) and a lined vegetated treatment forebay (open water storage pond). The runoff from this catchment would outfall into Mill Pond.

5.3.9 Due to the size of attenuation required, it would not be possible to attenuate all highway runoff using open water features, especially as this area would be used for replacement public open space offered in exchange for public open space lost due to the Scheme. As such, a combination of buried attenuation and surface water features compatible with a public open space land use is proposed.

5.3.10 Markeaton junction's preliminary drainage design includes a vegetated lined open ditch to convey highway runoff water from the pumping station to the initial lined attenuation tank (buried). The flow would then conveyed via a vegetated lined open ditch from this tank to the lined open forebay pond which would provide further treatment of the runoff. The lined forebay (which would be planted) would consist of water to a depth of approximately 300mm and would be sized to hold the first flush generated from the catchment, equal to the first 10mm of rainfall across the road surface from a 10 year storm event (HA103/06). Another vegetated lined open ditch would convey the water from the forebay to a second buried attenuation tank. A further vegetated lined open ditch would convey the runoff from the second buried attenuation tank to the proposed discharge point into Mill Pond.

5.3.11 The first flush would be held back by the lined forebay and which would drain through to the second buried attenuation tank via a filter drain. The retention time of the lined forebay would be greater than 24 hours.

5.3.12 The preliminary design allowable discharge rates have been calculated using a GRR of 4.6l/s/ha for the new impermeable areas as agreed with DCiC and restricted to ensure betterment over the existing situation for the site.

5.3.13 Penstocks would be provided upstream of the attenuation tanks to allow cut off in the event of a spillage on the highway. The spillage would be contained within the carrier/ system and/ or lined ditches.

**Catchment 11**

5.3.14 South-east of the proposed A38 underpass, the A52 would drain via existing gullies into the DCiC highway drainage system on Ashbourne Road. There would be a reduction in the drained area with the Scheme and consequently a reduction in peak runoff flows.

# 6 CONCLUSIONS

6.1.1 The proposed Markeaton junction would increase the impermeable surfacing and potential surface water runoff.

6.1.2 This Flood Risk Assessment (FRA) has reviewed the Scheme proposals at Markeaton junction. Flood risks to, and resulting from, the Scheme were assessed as follows:

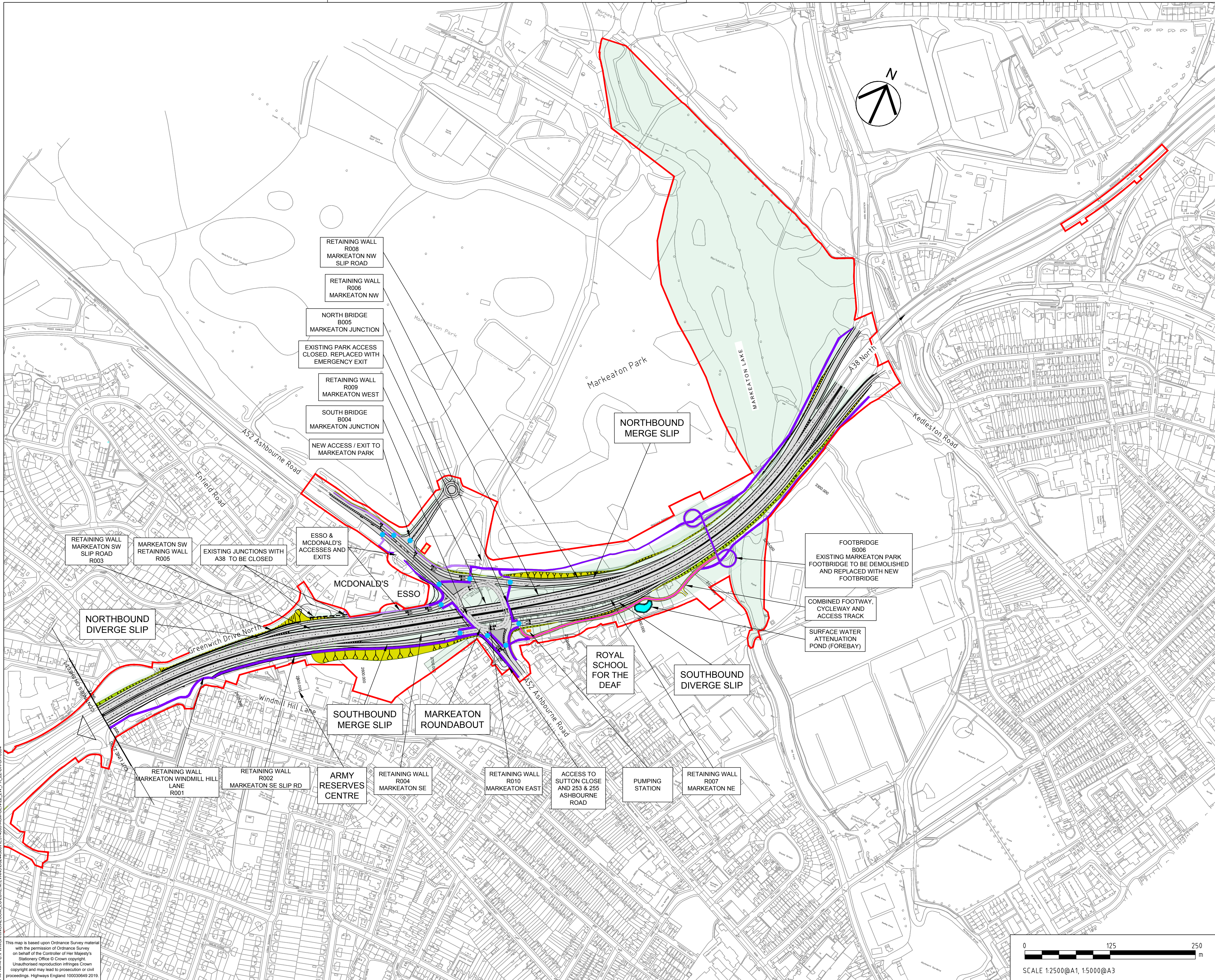
- The risk of fluvial flooding to the proposed Markeaton junction improvement is considered to be low.
- There is no realistic risk of tidal flooding.
- The risk of groundwater flooding is considered to be medium.
- The risk of surface water flooding to Markeaton junction is low. However, the risk of increased surface water runoff from the Scheme arrangement to surrounding areas is considered to be high. The road drainage strategy has been developed to illustrate how runoff from the Scheme would be controlled to existing rates (this is summarised in Section 5).
- The risk of sewer flooding is considered to be low.
- The risk of flooding from artificial sources is considered to be low.

6.1.3 Surface water flood risks from the Scheme would be managed through the drainage design as detailed in the Road Drainage Strategy (Report Number HE514503-ACM-HDG-A38_SW_PR_ZZ-RP-CD-0002, Highways England, 2019).

6.1.4 Pumping station adjacent to the southbound diverge slip road to pump highway runoff from the mainline cutting, attenuation using the carrier pipework network, narrow filter drains; combined kerb drainage units, use of underground storage tanks or cellular storage (allowance for two separate storage tanks under the area left vacant by building demolition at Queensway), plus a surface sedimentation pond, trapped gully pots and road-side linear drains, petrol interceptors at outfalls and connections to existing public sewers, by-pass separators. The Road Drainage Strategy is available as a separate report and should be read in parallel with this FRA.

6.1.5 Incorporation of the mitigation measures as detailed herein indicate that flood risks associated with the Scheme at Markeaton junction can be appropriately managed.

# Appendix A Scheme Design and Boundary

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Plot Date: 04 March 2019 18:32:02

KEY PLAN

SHEET 4 - INSET C
SHEET 4 - INSET B
1 2 3
DERBY

NOTES

PLEASE REFER TO 1:1000 SERIES DRAWINGS FOR:
- MAIN PEDESTRIAN/CYCLE ROUTES AND CROSSING POINTS
- INDICATIVE ROAD MARKINGS
- MAINTENANCE ACCESS AREAS
- FENCING (INCLUDING ENVIRONMENTAL BARRIERS)

KEY:

- The Design
- Limits of Land to be acquired or used permanently or temporarily
- Proposed Footway/Cycleway
- Proposed Footway
- Public Right of Way Diversion
- Existing Right of Way to be stopped up
- Area Not Included within the DCO Boundary
- Proposed Controlled Crossing
- Proposed Un-Controlled Crossing
- Embankment
- Cuttings
- Access Track
- Combined Access track & Footway/C'way
- Environmental Mitigation
- Highway to be stopped up
- Proposed Culvert
- Streams

| Revision Details | By / Check | Date | Suffix |
|---|---|---|---|
| First Issue | LE / GS | 20/02/19 | P01 |
| First Issue | LE / GS | 04/03/19 | P02 |

Purpose of issue
FINAL

Client
Highways England
Floor 5
Two Colmore Square
38 Colmore Circus
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B4 6BN

Development Consent Order Number
TR010022

Project Title
A38
DERBY JUNCTIONS

Drawing Title
GENERAL ARRANGEMENT
REGULATION 5(2)(O)
SHEET 2 OF 4

| Designed | Drawn | Checked | Approved | Date |
|---|---|---|---|---|
| | LE | GS | GS | 04/03/19 |

| Internal Project No. | Suitability |
|---|---|
| 60533462 | S3 |
| Scale @ A1 | Zone |
| 1:2500 | Whole Scheme |



Drawing Number
Highways England PIN | Originator | Volume
HE514503 -ACM -DCO -
A38_SW_PR_ZZ -DR-DC-0022
Location | Type | Role | Number

Rev
P02

# A38 Derby Junctions

## Little Eaton Junction Flood Risk Assessment

**Report Number: HE514503-ACM-EWE-Z3_ZW_PR_ZZ-RP-HF-0001 P04 S4**
**March 2019**

# Contents

## Appendices



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# EXECUTIVE SUMMARY


### Scheme Details

AECOM has been commissioned by Highways England to provide design services regarding the development of the A38 Derby Junctions Scheme (referred to herein as “the Scheme”). This Scheme concerns three junctions on the A38 in Derby as follows:

- A38/ A5111 Kingsway junction
- A38/ A52 Markeaton junction
- A38/ A61 Little Eaton junction

In flood risk terms, the Scheme at Little Eaton junction would increase impermeable surfacing and potential surface water runoff. The northern extent of the proposed Little Eaton junction falls within Flood Zone 1 (low flood risks), although most of the Scheme would be located within the extent of the extreme flood outline (Flood Zone 2) of the River Derwent, whilst the western elements fall within and adjacent to Flood Zone 3. The remaining parts of the Scheme are located within Flood Zone 1 with a very low risk of flooding. Special attention has therefore been made to the potential impact of the Scheme on the floodplain i.e. the loss of floodplain storage as a result of changes to the junction footprint.

In addition, there is significant attenuation of surface water runoff adjacent to the existing A38 associated with a stream emanating from Breadsall Manor, as well as surface water flooding downstream associated with Boosemore Brook and Dam Brook. As such, investigations have been undertaken to define appropriate surface water flooding solutions.

This Flood Risk Assessment (FRA) comprises one of a number of documents supporting the environmental assessment of the Scheme as reported in the Environmental Statement (ES). A separate Road Drainage Strategy (Report Number HE514503-ACM-HDG-A38_SW_PR_ZZ-RP-CD-0002, Highways England 2019) has been produced. The Road Drainage Strategy considers the management of surface water runoff from the proposals.

### Flood Risk Assessment

An FRA has been undertaken in accordance with the National Policy Statement for National Networks (NPSNN) and the National Planning Policy Framework (NPPF) and taking into account guidance provided in the Design Manual for Roads and Bridges (DMRB). According to the NPSNN and NPPF, applications for development proposals of 1 hectare (ha) or greater located in Flood Zone 1 and all proposals for new development located in Flood Zones 2 and 3 should be accompanied by a FRA.

This FRA has therefore been undertaken to determine:

1) The risks of flooding to the Scheme.
2) The risks of flooding that could result from the Scheme.
3) Appropriate flood risk mitigation measures.

The main aim of this FRA is to demonstrate that flooding risks can be suitably managed associated with the Scheme. This FRA supports the environmental impact assessment (EIA) as reported within the Scheme ES. This FRA has been prepared following hydraulic modelling of the River Derwent and Dam Brook which has enabled suitable flood risk mitigation measures to be defined and incorporated into the Scheme design.

**Outcome of the Flood Risk Assessment**

This FRA has established that there would be a loss of River Derwent floodplain storage due to the increased footprint of the Scheme at Little Eaton junction and therefore mitigation measures are required. Hydraulic modelling has been used to test various flood storage and floodplain compensation areas for the 1 in 100 year flood event plus a climate change allowance, resulting in the definition of a suitable floodplain compensation area to the west of the River Derwent (south of the A38). Correspondence with the Environment Agency (EA) in June 2018 has confirmed their contentment with the proposed approach to fluvial flood risk mitigation and compensation proposals at Little Eaton junction, and that residual flood impacts are acceptable.

Surface water flood risk from the Scheme to adjacent areas would increase as a result of highway expansion associated with the Scheme. A road drainage strategy has been developed in parallel with this FRA which demonstrates that surface water risks can be managed appropriately. However, additional hydraulic modelling has been undertaken to assess local surface water flooding risks such that additional measures have been included within the Scheme design as follows:

- Diversion of Dam Brook into a new realigned watercourse that takes account of brook flooding, plus the provision of new ponds that would provide floodwater storage.
- Provision of a flood alleviation channel adjacent to the new A38 that would connect the unnamed surface watercourse downstream of Breadsall Manor with the realigned Dam Brook. A new 600mm diameter culvert would also be provided from the watercourse under the new A38 embankment that would connect into an existing 500mm diameter culvert in order to convey flows from the unnamed watercourse when the flow capacity of the flood alleviation channel is exceeded.

Incorporation of the mitigation measures as detailed herein indicate that flood risks associated with the Scheme at Little Eaton junction can be appropriately managed. Should the Scheme gain development consent, further consultation will be undertaken during the detailed design regarding Little Eaton junction with the EA, Derbyshire County Council (DCC), Severn Trent Water (STW) and other statutory agencies as applicable.

# 1 INTRODUCTION

## 1.1 Commission

1.1.1 AECOM has been commissioned by Highways England to provide design services regarding the development of the A38 Derby Junctions Scheme (referred to herein as "the Scheme"). This Scheme concerns three junctions on the A38 in Derby as follows:

- A38/ A5111 Kingsway junction
- A38/ A52 Markeaton junction
- A38/ A61 Little Eaton junction

1.1.2 AECOM has been requested by Highways England to carry out a Flood Risk Assessment (FRA) for the Scheme at Little Eaton junction. This FRA has been prepared in accordance with the National Policy Statement for National Networks (NPSNN[1]) and the National Planning Policy Framework (NPPF)[2], its associated Planning Practice Guidance (PPG)[3] and the Design Manual for Roads and Bridges (DMRB[4]).

1.1.3 The Road Drainage Strategy (Report Number HE514503-ACM-HDG-A38_SW_PR_ZZ-RP-CD-0002, Highways England 2019) is contained in Appendix 13.4 of the Environmental Statement (ES) (ES Volume 3). It has been developed alongside this report, with the flood risk and drainage assessments informing each other.

## 1.2 Scheme Background

1.2.1 The existing Little Eaton junction is currently an at-grade, five-armed roundabout located along the A38 at Derby and provides a connection between the A38, the A61 Alfreton Road (leading to A61 Frank Whittle Road) and the B6179 Alfreton Road (leading to Little Eaton). A small fifth arm provides access to land adjacent to the eastern part of Ford Lane.

1.2.2 This FRA is based on the best available flood risk information provided by the Environment Agency (EA) and further analysis using hydraulic modelling software. The EA Flood Map[5] shows that the majority of Scheme at Little Eaton junction lies within Flood Zone 2, with the western elements falling within or adjacent to Flood Zone 3.

1.2.3 Areas located within Flood Zone 3 are those that could be affected by flooding, either from rivers or the sea, assuming that there are no flood defences in place. These areas could be affected by a flood that has a 1% (1 in 100) or greater chance of happening each year. Flood Zone 2 shows the additional extent of an extreme flood. These areas are likely to be affected by a major flood, that has between a 1% (1 in 100) and a 0.1% (1 in 1,000) chance of occurring each year. The remaining areas of the Scheme at Little Eaton junction are located within Flood Zone 1 with less than 0.1% annual probability of flood risk (i.e. a very low risk of flooding).

[1] Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/387222/npsnn-print.pdf
[2] Available online: http://planningguidance.planningportal.gov.uk/blog/policy/
[3] Available online: http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/
[4] Available online: http://www.standardsforhighways.co.uk/ha/standards/dmrb/index.htm
[5] Available online: http://apps.environment-agency.gov.uk/wiyby/37837.aspx

1.2.4 Lead Local Flood Authorities (LLFAs)[6], in this case Derbyshire County Council (DCC), have responsibility for managing the risk of flooding from ordinary watercourses, surface water and groundwater. Whilst the Scheme falls within DCC administrative area, the boundary between Derby City Council (DCiC) and DCC falls along the centreline of the River Derwent, and thus DCiC is also a key partner as they are the neighbouring LLFA.

## 1.3 The Scheme

1.3.1 The Scheme entails the provision of grade-separation at Little Eaton junction to enlarge the roundabout at existing ground level with the new mainline A38 passing above the roundabout on two overbridges to the east and south of the existing roundabout (refer to Appendix A which provides details of the Scheme design and Scheme boundary). The existing northbound carriageway would form the northbound slip roads.

1.3.2 From the Scheme tie in at the north end of the River Derwent bridge, the proposed A38 swings slightly to the south of the existing A38 route and passes over a Flood Relief Arch/ Accommodation Bridge which would be extended. Continuing north, the existing railway bridge would be extended to carry the A38 southbound carriageway and southbound merge slip road. The existing northbound carriageway would be retained on the existing part of the railway bridge and to form the northbound diverge slip road.

1.3.3 The A38 would then pass over the two new junction bridges on embankment before continuing to the east of the existing A38 and re-joining the existing A38 alignment immediately south of the Water Treatment underbridge, which would not be affected.

1.3.4 Ford Lane, which joins the existing A38 between the Flood Relief Arch/ Accommodation Bridge and the bridge over the River Derwent, would be closed on safety grounds. The length of Ford Lane to the east of the railway line would tie into the new roundabout between the northbound slip road and the B6179.

1.3.5 During the Scheme construction phase, it is proposed to use an area to the south of the Little Eaton junction for temporary storage of excavated materials (following diversion of Dam Brook). In addition, a construction compound is proposed to the north of the junction accessed off the B6179 Alfreton Road.

## 1.4 Planning Process

1.4.1 The Scheme is a Nationally Significant Infrastructure Project (NSIP) and thus a Development Consent Order (DCO) application is to be made to the Planning Inspectorate (The Inspectorate). The DCO application will be accompanied by an Environmental Impact Assessment (EIA) as reported within an ES.

1.4.2 Given the above, the Scheme is subject to consideration by The Inspectorate rather than being subject to planning control by the Local Planning Authority (LPA). Highways England is the Applicant for the Scheme and upon its completion, Highways England would also be responsible for Scheme maintenance (with the exception of those parts of the Scheme that would be the responsibility of third parties such as the local authority and landowners).

[6] Available online: https://www.gov.uk/government/publications/ordinary-watercourse-regulation-advice-note

## 1.5 Aims and Objectives

1.5.1 This report comprises an FRA of the proposed Little Eaton junction. The assessment has involved evaluating flood risks to the Scheme site, advising on the potential constraints to the Scheme, assessing the potential impacts of the Scheme on flood risks in the wider area and defining applicable mitigation measures and a road drainage strategy. To complete this study the following objectives have been met:

- Review the development plans with respect to flood information in national and local policy documents, strategic flood risk documents and relevant previous and local studies that cover the area of the Scheme.
- Undertake hydraulic modelling to assess the potential Scheme impacts on the River Derwent floodplain i.e. loss of floodplain storage as a result of proposed changes to the junction footprint.
- Assess all other potential sources of flood risk including surface water, drainage infrastructure, groundwater and artificial sources.
- Undertake hydraulic modelling to define a new alignment for Dam Brook which would need to be diverted as part of the Scheme.
- Identify requirements for surface water runoff attenuation from the Scheme site and the implications for storm water attenuation/ storage.
- Propose suitable flood mitigation measures (where applicable) in line with the recommendations of current best practice.
- Produce a report that summarises flood risk at the site and surface water considerations appropriate for the Scheme, in accordance with the NPSNN, NPPF, PPG and DMRB.

# 2 SITE AND SURROUNDING AREA

## 2.1 Site Location

2.1.1 The existing Little Eaton junction is located approximately 3.4km to the north of Derby at Ordnance Survey National Grid Reference 436405, 339995. It forms the intersection of the A38 from the north-east and west with the A61 joining from the south. The B6179 Alfreton Road (access to Little Eaton village) and Ford Lane both join the roundabout to the north on separate arms. The Scheme location is illustrated in Figure 2-1.

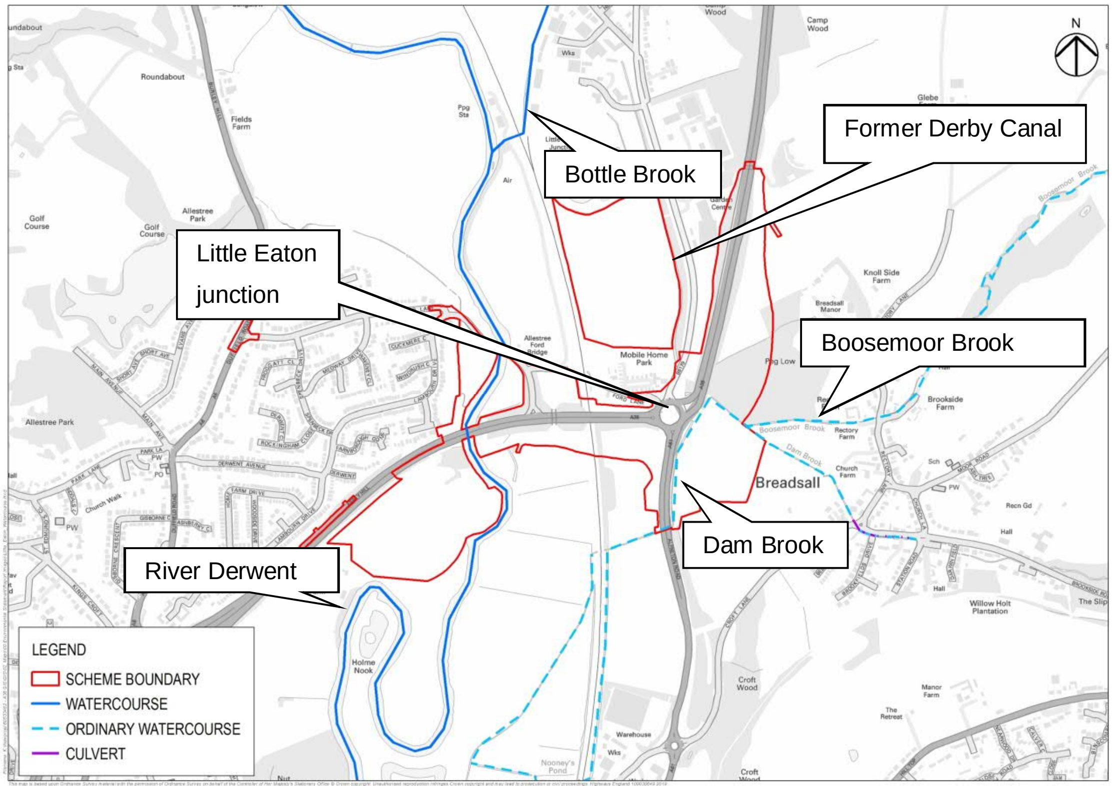


**Figure 2-1: Site Location Map**



## 2.2 Existing Junction

2.2.1 The existing Little Eaton junction is predominantly surrounded by open fields, the majority of which represent the floodplain of the River Derwent and its associated tributaries. The only exception is immediately to the north of the roundabout, where a number of residential and commercial properties are located (including the Ford Farm Mobile Home Park).

2.2.2 Within close proximity to the site are the villages of Breadsall (approximately 0.5km to the east), Allestree (approximately 0.5km to the west) and Little Eaton (approximately 1km to the north). The mainline Sheffield to Derby railway line passes beneath the A38 approximately 150m to the west of the junction.

## 2.3 Topographic Setting

2.3.1 The centre of the existing Little Eaton junction is currently at an elevation of approximately 52.5m above Ordnance Datum (mAOD). The A38 to the north gradually rises, as does the A38 to the west. The highway rises to approximately 58mAOD as it crosses the adjacent railway, but then slopes back to approximately 56mAOD as it crosses over the River Derwent approximately 300m to the west of the junction.

2.3.2 To the south, Alfreton Road (A61) falls away, whilst Alfreton Road (B6179) to the north remains at a similar level to the junction roundabout. Ford Lane, which runs west from the junction roundabout, parallel to the A38 also, falls away to a level of approximately 50.7mAOD where it reaches the edge of the railway line.

## 2.4 Local Water Features

2.4.1 Little Eaton junction is located within the River Derwent catchment. The River Derwent, which is a tributary of the River Trent, flows from north to south and flows beneath the A38 approximately 300m to the west of the junction roundabout (with the river being approximately 25m wide as it passes under the A38).

2.4.2 Other watercourses in the vicinity include Dam Brook, Boosemoor Brook and Bottle Brook (see Figure 3-1). Boosemoor Brook flows from the east and joins Dam Brook approximately 100m to the east of Little Eaton junction. Dam Brook then flows adjacent to the eastern side of the junction roundabout before flowing south adjacent to the A61. Approximately 250m to the south of the roundabout, Dam Brook flows beneath the A61 and the railway line within separate culverts and eventually discharges further downstream into the River Derwent.

2.4.3 Bottle Brook is a small tributary of the River Derwent which flows from north to south, through Little Eaton, before joining the River Derwent approximately 800m to the north of Little Eaton junction.

2.4.4 Sections of the former Derby Canal are located along Alfreton Road (B6179) – however, as this does not convey significant volume of flowing water, it is not considered within this FRA.

## 2.5 Geology/ Hydrogeology

2.5.1 Ground conditions comprise topsoil and Made Ground overlying Alluvium, underlain by rocks of the Millstone Grit Group (Mudstone, Siltstone and Sandstone).

2.5.2 The Made Ground primarily comprises embankment fill of the current road construction, whilst the Alluvium comprises firm silt and clay components to a thickness of up to 2.6m. This is underlain by a predominantly sand and gravel component.

2.5.3 The Millstone Grit Group materials encountered predominantly comprise fissured or laminated hard mudstone overlain further north by weak siltstone. To the north of the junction typically weak sandstone has also been recorded.

2.5.4 According to the EA groundwater mapping[7] and The A38 Derby Junctions Ground Investigation Report (Report Number HE514503-ACM-VGT-A38_SW_PR_ZZ-PR-GE-0003_P02_24, 2018), both the bedrock and superficial deposits areas are classified as a Secondary A aquifer; permeable layers capable of supporting water supplies at a local rather than a strategic scale, and in some cases forming an important source of base flow to rivers.

[7] Available at: http://apps.environment-agency.gov.uk/wiyby/37833.aspx

2.5.5 Groundwater used for drinking water is protected by the EA. The EA classifies zones around potable groundwater abstraction points as Source Protection Zones (SPZs). These are designed to limit potential pollution activities and have implications for how surface water is managed e.g. by infiltration. According to the EA, the majority of the Scheme site at Little Eaton junction lies within SPZ3 (Total Catchment) which has been cross checked with the EA's SPZ Online Map (Updated in October 2018). The SPZ further shows that the site is situated close to SPZ2 and SPZ1 to the east, associated with the River Derwent.

2.5.6 According to the EA, the groundwater SPZs are defined as follows:

- Inner Zone (Zone 1) – Defined as the 50 day travel time from any point below the water table to the source. This zone has a minimum radius of 50m.
- Outer Zone (Zone 2) – Defined by a 400 day travel time from a point below the water table. This zone has a minimum radius of 250m or 500m around the source, depending on the size of the abstraction.
- Total Catchment (Zone 3) – Defined as the area around a source within which all groundwater recharge is presumed to be discharged at the source.

2.5.7 Given the close proximity of the Scheme to the River Derwent, groundwater levels within the floodplain are high. Water strikes and monitoring indicate that groundwater levels of around 0.5m to 3.0m exist below ground levels, principally within the Alluvium.

# 3 REGULATORY POSITION

## 3.1 National Policy Statement for National Networks (NPSNN)

3.1.1 The primary basis for deciding whether or not to grant a Development Consent Order (DCO) is the National Policy Statement for National Networks (NPSNN) which, at Sections 4 and 5, sets out policies to guide how DCO applications will be decided and how the impacts of national networks infrastructure should be considered.

3.1.2 Flood risk paragraphs 5.90 – 5.115 state that the Secretary of State should be satisfied that flood risk will not be increased elsewhere and should only consider development appropriate in areas at risk of flooding where it can be demonstrated that: the most vulnerable development is located in areas of lowest flood risk unless there are overriding reasons to prefer a different location; development is appropriately flood resilient and resistant, including safe access and escape routes where required; that any residual risk can be safely managed, including by emergency planning; and that priority is given to the use of sustainable drainage systems (SuDs). Applications for projects should be accompanied by a flood risk assessment (FRA) to assess all risks of flooding and take climate change into account.

3.1.3 In preparing an FRA an applicant should:

- Consider the risk of all forms 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 lifetime.
- Take the impacts of climate change into account, clearly stating the development lifetime over which the assessment has been made.
- Consider the vulnerability of those using the infrastructure including arrangements for safe access and exit.
- Include the assessment of the remaining (known as ‘residual’) risk after risk reduction measures have been taken in to account and demonstrate that this is acceptable for the particular project.
- Consider if there is a need to remain operational during a worst case flood event over the development’s lifetime.
- Provide the evidence for the Secretary of State to apply the Sequential Test and Exception Test as appropriate.

## 3.2 National Planning Policy Framework (NPPF)

3.2.1 Section 14 of the NPPF (revised in February 2019) and the associated 2014 Planning Practice Guidance (PPG) provides the current guidance for planning with respect to flood risk and meeting the challenges associated with climate change. The NPPF advocates a sequential approach for the planning process in order to steer development to areas with the lowest possible risk of flooding. It is important to note the revision to the 2012 NPPF in 2018 and 2019. The FRA has been completed in accordance with the 2019 revision and the associated 2014 PPG.

3.2.2 As discussed in Section 1.2, the EA Flood Map indicates that the Scheme at Little Eaton junction is located within Flood Zone 2, with the western extent of the Scheme encroaching into Flood Zone 3. According to Table 2 within the PPG, the proposed junction at Little Eaton lies within the 'Essential Infrastructure' vulnerability classification. Table 3, which provides a matrix for the identification of vulnerability classifications, indicates that whilst 'Essential Infrastructure' developments are permitted within Flood Zone 2, the Exception Test must be passed for the development to be considered acceptable within Flood Zone 3.

## 3.3 Design Manual for Roads and Bridges (DMRB)

3.3.1 Highways England and other highway authorities have a responsibility to keep trunk roads and local roads respectively free from flooding (relevant legislation includes the Highways Act 1980 and the Land Drainage Acts 1991 and 1994).

3.3.2 The DMRB primarily refers to the former PPS25 (now superseded by the NPPF) for FRA and flood mitigation guidance, and emphasises the need for consultation with the EA early in the design process.

3.3.3 The DMRB offers guidance on hydraulic design of highway drainage systems, and assessment, and guidance on mitigation techniques for roads (and embankments) that encroach into floodplains.

3.3.4 More detailed discussion of highway surface water management and sustainable drainage is provided in Section 6.

## 3.4 Local Plans

3.4.1 Little Eaton junction falls just outside the DCiC boundary and lies within Erewash Borough Council (EBC) administrative area. The administrative boundary runs along the centre of the River Derwent. Due to the proximity of the Scheme to the administrative boundary, the Local Plans for both DCiC and EBC have been reviewed as part of this FRA (see below).

**Derby City Council (DCiC)**

3.4.2 The current adopted Local Plan for the study area is The City of Derby Local Plan – Part 1 Core Strategy (2017)[8] which sets out the long term strategy for promoting and managing development in the city up to 2028. The plan forms part of a statutory framework to be used in addition to the on-going policies from the City of Derby Local Plan Review (2006)[9].

3.4.3 In terms of flood protection, the Local Plan, 'GP3 Flood Protection' aims to protect important flood plain areas and provides guidance relating to development within these areas. The policy states:

'*Except where satisfactory compensatory measures are provided to off-set any potential adverse effects for development on the water environment and associated lands, planning permission will not be granted for development which:*

a. *Lies within undefended areas at risk of flooding;*

b. *Would create or exacerbate flooding elsewhere;*

[8] Available online: https://www.derby.gov.uk/media/derbycitycouncil/contentassets/documents/policiesandguidance/planning/Core%20Strategy_ADOPTED_DEC%202016_V3_WEB.pdf
[9] Available online: https://www.derby.gov.uk/media/derbycitycouncil/contentassets/documents/policiesandguidance/planning/CDLPR_2017.pdf

c. *Results in the loss of natural floodplain;*

d. *Would impede access to a watercourse for maintenance or flood defence purposes;*

e. *Does not provide for the adequate management of surface run-off using sustainable drainage principles, unless it can be demonstrated that their use is inappropriate.'*

3.4.4 The Scheme is a NSIP and therefore subject to a DCO. In order to obtain development consent, Highways England must demonstrate that flood risk has been adequately managed. Furthermore, planning consent will only be granted where compensating measures are proposed to mitigate potential flood problems.

3.4.5 The draft Core Strategy provides policy and guidance relating to flood risk and water management. It must be ensured that development is flood resilient and resistant and that flood risk is not increased to people or property within the surrounding area. Development must also be designed and laid out to incorporate sustainable drainage systems (SuDS) and ensure that runoff is directed to areas where it does not cause harm to others.

3.4.6 With part of the Scheme encroaching within the River Derwent floodplain, compensatory storage will be required to offset any adverse effects, in line with Local Plan policy discussed above.

**Erewash Borough Council (EBC)**

3.4.7 The policies within the Erewash Core Strategy[10] have been considered. This document sets out the strategy for development across the Borough between 2011 and 2028 guiding development to specific areas.

3.4.8 Under Policy 1: Climate Change, there is a section concerning Flood Risk and Sustainable Drainage where it is stated:

- *Development proposals that avoid areas of current and future flood risk and which do not increase the risk of flooding elsewhere and where possible reduce flood risk, adopting the precautionary principle, will be supported.*
- *Where no reasonable sites within Flood Zone 1 are available, allocations in Flood Zone 2 and Flood Zone 3 will be considered on a sequential basis.*
- *Where it is necessary to apply the Exception Test within the urban areas, it must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk.*
- *All new development should incorporate measures to reduce surface water run-off and the implementation of Sustainable Urban Drainage Systems into all new development will be sought unless it can be demonstrated that such measures are not viable or technically feasible.*

3.4.9 It is also stated within the Erewash Core Strategy that for development on green field sites, the aim should be to reduce or at least maintain run-off levels compared to those prior to development.

[10] Available online: http://www.erewash.gov.uk/media/files/Environment-and-Planning/Planning%20Policy/Core_Strategy_-_Submission_Version/CD01_-_Submission_Version_-_Erewash_Core_Strategy.pdf

## 3.5 Strategic Flood Risk Assessments (SFRA)

3.5.1 DCiC and EBC have both prepared Strategic Flood Risk Assessments for their administrative areas.

3.5.2 In October 2013 DCiC prepared a Level 1 Strategic Flood Risk Assessment (SFRA)[11] to assist the city in meeting the requirements of national policy. The SFRA provides general advice on flood risks and on the principles and application of sustainable drainage.

3.5.3 According to the SFRA, the River Derwent tends to produce high flood flows in proportion to the size of the catchment and the river can also rise rapidly. This is reflected in the June 2007 event (approximately 4 - 5% annual *exceedance probability* (AEP) event) where river levels rose from the 'normal' 700mm (approximately 30m$^2$) to 2,800mm (approximately 300m$^2$) over a 30 hour period.

3.5.4 Although flood defences have been installed around Derby City Centre to mitigate the effects of flooding through the overtopping of river banks, flooding still occurs in other areas along the River Derwent. The SFRA highlights that the River Derwent is channelled under the A38 to the west of the junction roundabout and then spreads over the wash lands either side of the river. On the left bank, flood defences are intermittent therefore water is able to flow outside the main river for approximately 2km. The wash lands in this area act as a conduit for floodwater, however, it is reported that for events up to a 25 year return period, flooding is considered more a nuisance rather than damaging.

3.5.5 The SFRA also states that there are potential flood risks associated with the Dam Brook and Boosemoor Brook due to the number of culverts along each watercourse. The SFRA indicates that the risk to areas other than Breadsall is considered to be low.

3.5.6 The Greater Nottingham SFRA Addendum was prepared by AECOM in September 2017[12] to improve the quality of information available and updates earlier work set out in the Greater Nottingham Strategic Flood Risk Assessment (2010) and the River Leen and Day Brook Strategic Flood Risk Assessment (2008). In relation to the study area, the report mainly focused on flood risk from the River Erewash, Ock Brook, River Derwent (Draycott) and River Trent in areas downstream of the Little Eaton junction. The area around the Little Eaton junction was not explicitly addressed in the SFRA.

## 3.6 Preliminary Flood Risk Assessment (PFRA)

3.6.1 In 2011 DCiC produced its Preliminary Flood Risk Assessment (PFRA)[13] which represented the first stage in recording and monitoring flooding in Derby. The high level assessment addresses flood risk from surface water, groundwater, ordinary watercourses and canals. Main rivers and reservoirs were excluded from the scope as they were covered under a separate assessment. A review of this document has

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[11] Available online: https://www.derby.gov.uk/media/derbycitycouncil/contentassets/documents/policiesandguidance/planning/SFRA_1_Update_Explanation_V3.pdf
[12] Available online: http://www.nottinghamcity.gov.uk/planning-and-building-control/planning-policy/greater-nottingham-strategic-flood-risk-assessment-addendum/
[13] Available online: http://enjoyfreepdf.com/download/derby-city-council-preliminary-flood-risk-assessment/

shown that Little Eaton junction is located outside of the study area associated with this PFRA.

3.6.2 In the same year DCC produced a PFRA which included the Little Eaton junction. Due to the scale of the area covered by the PFRA, there is limited specific information relating to Little Eaton junction. However, figures within the report (based on 1km grids) shows that aside from the fluvial risk from the River Derwent, surface water is also considered a potential risk to the site.

### 3.7 Our City Our River

3.7.1 The Our City Our River Masterplan[14] has been developed jointly by DCiC and the EA since 2012, and sets out a shared vision to reduce flood risk in Derby and transform the City's relationship with the River Derwent by helping to encourage economic regeneration in areas currently at risk of flooding.

### 3.8 Consultation

3.8.1 AECOM has been consulting with DCiC, DCC, EA and STW regarding flooding and highway drainage design issues associated with the Scheme since 2015.

**Derbyshire County Council (DCC) and Derby City Council (DCiC)**

3.8.2 DCC is the LLFA responsible for managing the risk of flooding from surface water, groundwater and ordinary watercourses in the vicinity of the Scheme at Little Eaton junction, and has been consulted regarding local flood risks, available data and the drainage design. DCiC has also been consulted due to their proximity of their boundary to the Scheme at Little Eaton junction and the River Derwent.

3.8.3 DCC is also the Land Drainage Authority for Dam Brook and are responsible for issuing consents for any works requiring approval under the Land Drainage Act.

**Environment Agency (EA)**

3.8.4 With the River Derwent designated as a main river, the EA has been consulted throughout this study, mainly regarding the potential loss of floodplain storage as a result of the increased footprint of the Scheme at Little Eaton junction. The EA provided two hydraulic models (the Milford to Allestree model and the Lower Derwent model) to aid this assessment and has been made aware of the modelling approach. Further to this fluvial aspect, the EA has also emphasised that surface water runoff should be controlled to existing rates or less.

**Severn Trent Water**

3.8.5 Consultation has been undertaken with STW with regard to their assets in the vicinity of the Scheme at Little Eaton junction.

[14] Available at: https://www.derby.gov.uk/media/derbycitycouncil/contentassets/documents/environmentandplanning/OurCityOurRiverMasterplan2013.pdf

# 4 SOURCES OF FLOODING AND FLOOD RISK

## 4.1 Introduction

4.1.1 The NPPF (and the NPSNN for NSIPs) requires that all potential sources of flooding that could affect a development are considered within a FRA. This includes flooding from rivers and the sea, directly from rainfall on the ground surface and rising groundwater, overwhelmed sewers and drainage systems. Flooding from reservoirs, canals, lakes and other artificial sources must also be considered. There should be demonstration of how these should be managed so that the development remains safe throughout its lifetime, taking into account climate change.

## 4.2 Historic Flooding

4.2.1 The Highways England Drainage Data Management System (HE DDMS) database was investigated for records of historic flooding at the Scheme site. There were four flood events reported in the vicinity of the Scheme (ID9929, ID10402, ID10315 and ID10029). The initial action was to unblock gullies with only one incident having a flood severity incident score above 0.0 (ID10315 score 6.3 where gully sucker was required). It was, however, reported that there are no HE DDMS recorded flood events that would have an influence on the Scheme.

## 4.3 Fluvial

4.3.1 Flooding from fluvial sources (rivers) can occur through inundation of floodplains from rivers and watercourses, or inundation of areas outside of the floodplain due to influence of bridges, embankments and other features that can restrict flow.

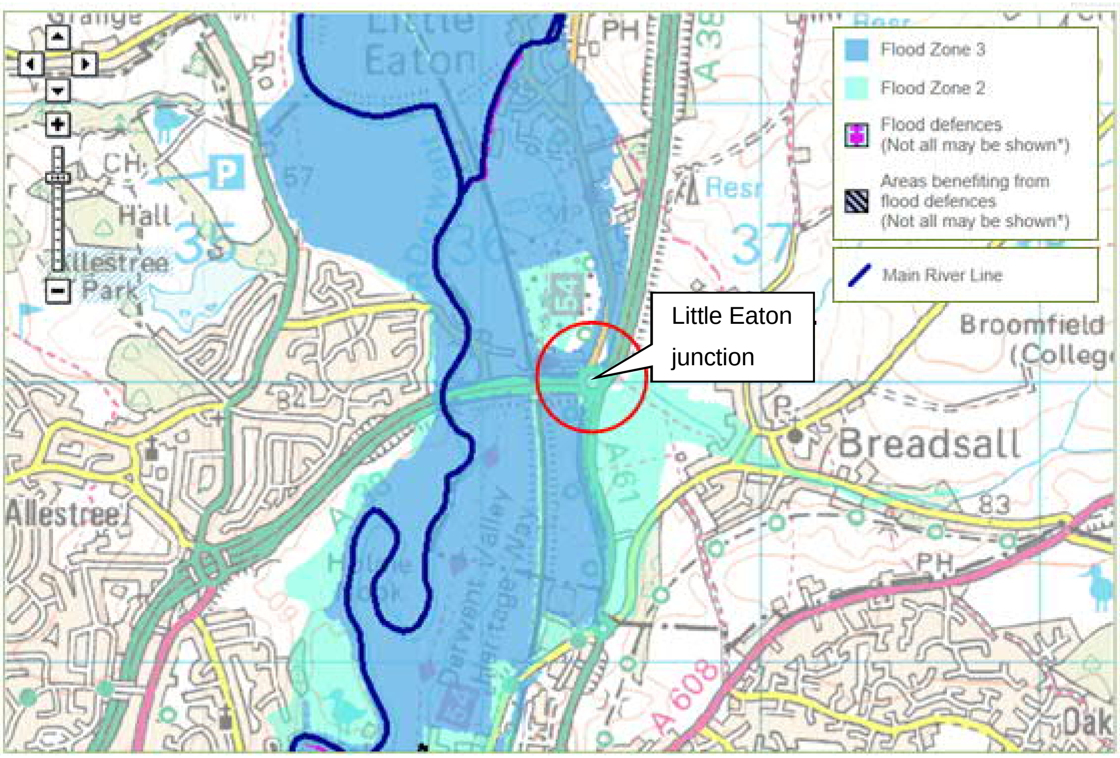



**Figure 4-1: Environment Agency Flood Map**

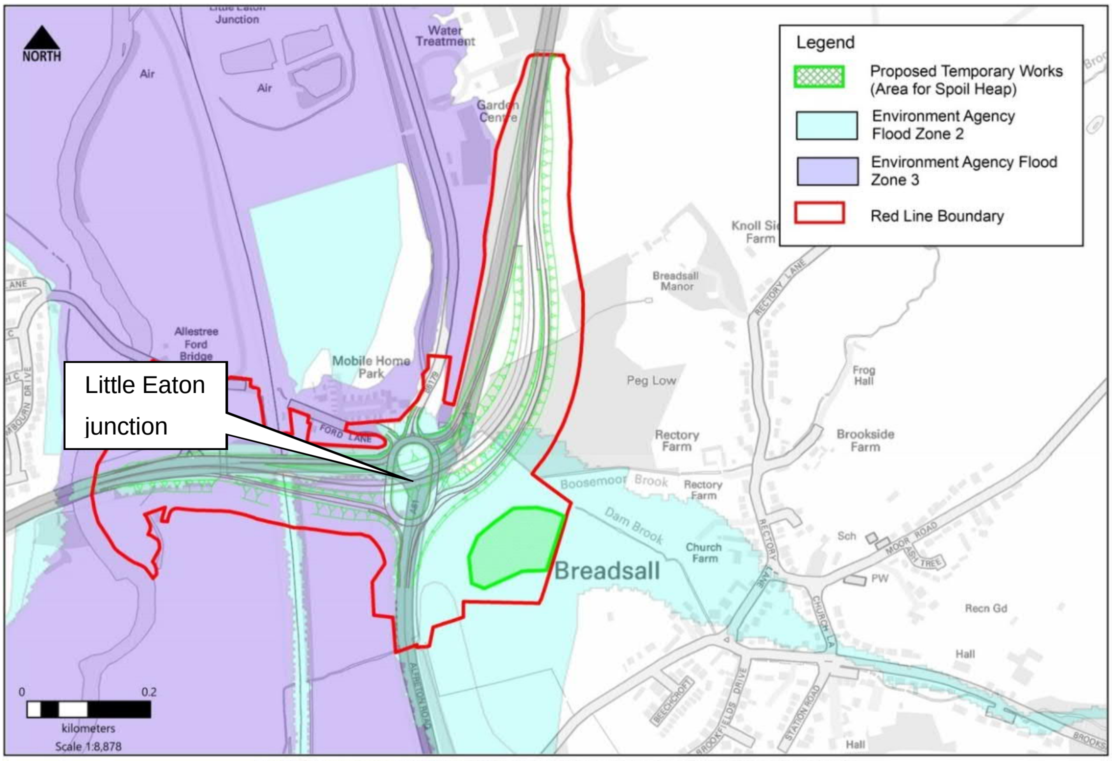


(areas not within Flood Zones 2 and 3 are within Flood Zone 1)

4.3.2 EA fluvial flood maps[15] (see Figure 4-1) show that Little Eaton junction is located within Flood Zone 2, with the western elements falling within or adjacent to Flood Zone 3.

4.3.3 With the changes to the existing junction footprint that would occur as a result of the Scheme, there would be a loss of floodplain storage associated with the River Derwent, and potential increases in flood levels with associated increases in flood risk. Modelling work has, therefore, been undertaken to understand the associated risks and develop suitable compensatory works and any other necessary mitigation measures - this is discussed further in Section 6 and within the Modelling Technical Note provided within Appendix B.

4.3.4 Although the EA Flood Map for Planning shows that the Scheme site for the construction compound at Little Eaton junction is in Flood Zone 2, results from the detailed hydraulic modelling displayed in Little Eaton Flood Modelling Update (April 2018)[16] found in Appendix B, confirms that the area is not susceptible to fluvial flooding at the 1% AEP plus 50% climate change event. The modelling report further notes that the land is raised up in the region, adding confidence to the assertion that the area is not susceptible to fluvial flooding.




Contains Ordnance Survey Data Crown © Copyright and database right 2018

**Figure 4-2: Environment Agency Flood Zones**

(areas not within Flood Zones 2 and 3 are within Flood Zone 1)

4.3.5 Figure 4-2 identifies that the area of the proposed material storage to the south of the junction is located within Flood Zone 2 and has between 0.1% and 1% chance of fluvial flooding in any given year.

15 Available at: https://flood-map-for-planning.service.gov.uk/
16 Technical Note 47071319-URS-05-TN-EN-030

4.3.6 Under Table 2 of the 2014 flood risk and coastal change PPG, the proposed material storage area would be categorised as Less Vulnerable, due to the intended land use being for 'minerals for working and processing'. The development is, therefore, considered to be 'appropriate' under Table 3 of the flood risk and coastal change PPG.

4.3.7 As highlighted in Figure 7 of Appendix B, the proposed material storage area lies outside of the modelled flooding extents of the River Derwent. The proposed material storage area was, therefore, not incorporated into the geometry of the detailed hydraulic model, as there is low fluvial flood risk to the site from the River Derwent. No additional mitigation measures are required in regards to fluvial flood risk for the proposed material storage area or the construction compound to the north of the junction.

## 4.4 Tidal

4.4.1 Little Eaton junction is effectively at no risk of flooding from tidal sources.

## 4.5 Groundwater

4.5.1 Groundwater flooding occurs as a result of water rising up from the underlying aquifer or from water flowing from springs. This tends to occur after long periods of sustained high rainfall, and the areas at most risk are often low-lying where the water table is more likely to be at shallow depth. Groundwater flooding is known to occur in areas underlain by major aquifers, although increasingly it is also being associated with more localised floodplain sands and gravels. It tends to occur sporadically in both location and time, and because of the more gradual movement and drainage of water, tends to last longer than fluvial, pluvial or sewer flooding.

4.5.2 As highlighted in the A38 Derby Junctions Ground Investigation Report (Report Number HE514503-ACM-VGT-A38_SW_PR_ZZ-PR-GE-0003_P02_24, 2018), due to the soils underlying Little Eaton junction being reasonably permeable. Groundwater monitoring was undertaken monthly between November 2016 and October 2017. The average groundwater level from exploratory hole locations screened within the Alluvium ranges between 0.42Mgbl and 3.70Mbgl (48.83 and 50.80Maod).

4.5.3 It should be noted that there are no historical incidents of groundwater flooding at the Scheme site. However, as the site lies over permeable geology and with water strikes encountered below ground level within the vicinity, the risk from groundwater is considered to be medium.

## 4.6 Surface Water

4.6.1 Overland flow results from rainfall that fails to infiltrate the surface and travels over the ground surface; this is exacerbated where the permeability of the ground is low due to the type of soil and geology (e.g. clay soils) or urban development. Surface water flow is also promoted in areas of steep topography which can rapidly convey water that has failed to penetrate the surface.

4.6.2 EA surface water flood maps show that the majority of the area in the vicinity of Little Eaton junction is considered to have a 'Very Low' risk. This means that each year the area has a chance of flooding of less than 1 in 1,000 (0.1%). However, the eastern extent of the Scheme encroaches into an area considered to have a 'High' risk associated with the location of the Dam Brook. 'High' means that each year, the area has a chance of flooding of greater than 1 in 30 (3.3%).

4.6.3 In addition, there is significant attenuation of surface water runoff adjacent to the existing A38 associated with a stream emanating from Breadsall Manor.

4.6.4 The existing drainage of the carriageway east of the railway bridge drains to Dam Brook. Between the railway bridge and the River Derwent the road is on an embankment on the floodplain and the carriageway runoff is collected in a kerb and gully system which discharges to the drainage ditches and is then discharged into the River Derwent. Surface water drainage from other parts of the junction drain to other ditches/ ponds within the vicinity which ultimately discharge to either the Dam Brook or directly to the River Derwent.

4.6.5 As the Scheme at Little Eaton junction would increase the amount of impermeable surface, the amount of surface water runoff from the area would increase if not adequately mitigated. The existing roundabout currently drains to the River Derwent via small drainage channels to the west and Dam Brook to the east. As highlighted in the Road Drainage Strategy (Report Number HE514503-ACM-HDG-A38_SW_PR_ZZ-RP-CD-0002, Highways England 2019), west of Midland Mainline Railway Bridge, and the Scheme would drain to the River Derwent.

4.6.6 Analysis of the EA long term flood risk map shows that surface flood risk is considered low (between 0.1% and 1%) for the majority of the site proposed for use as temporary material storage area to the south of the junction. However, small pockets of high risk (<3.3%) occur on the eastern extent and in a small area in the centre of the site. Medium risk from surface water flooding (between 1% and 3.3%) occurs on the southern extent of site.

4.6.7 At the site of the construction compound to the north of the junction, there is a very low chance of surface water flooding with exception of a small pocket on the western boundary which has a low risk of surface flooding (0.1% to 1%).

4.6.8 Surface water flood risks to the Scheme are considered to be low, but mitigation measures would be required to control surface water flood risks from the proposed junction. These issues are discussed in Section 6.

## 4.7 Sewers

4.7.1 Flooding can occur as a result of infrastructure failure e.g. blocked sewers or failed pumping stations. Sewer flooding can occur when the system surcharges due to the volume or intensity of rainfall exceeding the capacity of the sewer, or if the system becomes blocked by debris or sediment.

4.7.2 No sewer flooding records have been identified in the vicinity of the Scheme at Little Eaton junction.

4.7.3 As described above, the Road Drainage Strategy states that the existing highway pavement and drainage collection systems would be replaced as part of the junction improvements.

4.7.4 Overall, the risk of sewer flooding at Little Eaton junction is considered to be low.

## 4.8 Artificial Sources

4.8.1 Artificial sources include raised channels such as canals or storage features such as ponds and reservoirs. There are several reservoirs in the vicinity of the Scheme at Little Eaton junction and in an unlikely event of a catastrophic dam failure the site could be at risk of inundation.

4.8.2 The EA's Reservoir Flood Map confirms that the Scheme at Little Eaton junction lies within the maximum flood extent with a catastrophic dam failure. However, the EA provides the following explanatory text in relation to the reservoir flood maps:

*'Reservoir flooding is extremely unlikely to happen. There has been no loss of life in the UK from reservoir flooding since 1925. All large reservoirs must be inspected and supervised by reservoir panel engineers. As the enforcement authority for the Reservoirs Act 1975 in England, we ensure that reservoirs are inspected regularly and essential safety work is carried out'*

4.8.3 Based on the information provided by the EA, site specific mitigation measures for this flood source are not considered appropriate. The risk from artificial sources is, therefore, considered to be low.

## 4.9 Climate Change

4.9.1 The United Kingdom Climate Impacts Programme is assessing implications of climate change in the UK. Climate change scenarios for the UK predict that winters will be wetter by up to 15% by the 2020s, summers will possibly be drier by up to 20% by the 2020s, snowfall amounts will decrease significantly, and extreme winter precipitation will become more frequent.

4.9.2 The EA confirmed that 50% allowance for climate change is appropriate for assessing watercourses at the Scheme site and this has been incorporated into the Derby Integrated Catchment Model (DICM) (and subsequent model updates, refer to Section 5). A 40% allowance for climate change has been made with regard to the drainage design.

## 4.10 Summary

4.10.1 The key findings of the flood risk review are as follows:

- The risk of fluvial flooding from the River Derwent to the proposed Little Eaton junction is considered to be high. Hydraulic modelling has been undertaken to assess the impact of the Scheme on the River Derwent i.e. loss of floodplain storage - this is described in Section 5.
- There is no realistic risk of tidal flooding in the vicinity of Little Eaton junction.
- The risk of groundwater flooding is considered to be medium.
- The risk of surface water flooding to Little Eaton junction is low. However, the risk of increased surface water runoff from the Scheme arrangement to surrounding areas is considered to be high. The road drainage strategy has been developed to describe how runoff would be controlled from the Scheme - this is summarised in Section 6. However, the eastern extent of the Scheme encroaches into an area considered to have a 'High' risk associated with the location of the Dam Brook, whilst there is significant attenuation of surface water runoff adjacent to the existing A38 associated with a stream emanating from

Breadsall Manor.

- The risk of sewer flooding is considered to be low.
- The risk of flooding from artificial sources is considered to be low.
- The EA and DCC have confirmed that 50% allowance for climate change is appropriate for assessing watercourses at the Scheme site.

# 5 HYDRAULIC MODELLING AND CONCEPTUAL ASSESSMENT OF FLUVIAL MITIGATION MEASURES

## 5.1 History & Overview

5.1.1 Hydraulic modelling has been used to assess the fluvial flood risk to the existing Little Eaton junction, the effects of the Scheme, and the associated compensatory works required to address the loss of floodplain volume.

5.1.2 The hydraulic modelling has essentially involved merging two separate models of the River Derwent, and then using this combined model to determine the 'baseline' flood risk. Subsequently, the model has been amended to reflect the Scheme design to determine its impact on flood risk.

5.1.3 Modelling undertaken in 2016 concluded that increased flood levels did occur as a result of the Scheme, but could be considered acceptable due to there being no direct impact on property. However, following a meeting with the EA on 17 August 2016, it was stated that the Scheme should aim to achieve zero flood level increase where possible (especially in developed areas of the Derwent floodplain, such as adjacent to Lambourn Drive, Allestree).

5.1.4 Additional flood risk modelling at Little Eaton junction was undertaken in order to further assess flood levels due to the Scheme within the River Derwent floodplain. Details of this modelling and the associated results were reported in a Technical Note 47071319-URS-05-TN-EN-030 (Highways England, November 2016). The modelling, and the associated mitigation optioneering, was targeted on the 1% AEP event plus 20% climate change allowance (in respect of fluvial peak flows). The Technical Note and flood model were submitted to the EA in December 2016, who provided external review comments regarding the model on 27 February 2017.

5.1.5 The results of the modelling and the external review model comments were discussed at a meeting with the EA on 21 March 2017. Subsequently AECOM responded to the EA comments on the model on 16 May 2017, with the EA generally agreeing with our responses on 26 May 2017. In addition, at the meeting with the EA, it was confirmed that the design condition should be the 1% AEP plus 50% climate change event (rather than the previously modelled 20% climate change allowance).

5.1.6 Details of the original modelling, as described above, are not presented in this version of the FRA. It is considered that this has now been sufficiently superseded to not require re-statement. Therefore, this version of the FRA presents the modelling undertaken following agreement of the required updates, along with the associated results and implications for the Scheme.

## 5.2 Little Eaton Flood Model: Updated Baseline

5.2.1 The combined model of the River Derwent, inclusive of the existing A38 Little Eaton junction, was updated to address the external review comments as mentioned in Section 5.1. In addition, new topographic survey and LiDAR DTM data was incorporated into the model. These changes formed an improved baseline model from which the impacts of the Scheme could be assessed.

5.2.2 Full details of the model updates are provided in the modelling Technical Note as supplied in Appendix B.

5.2.3 As the aim of this modelling exercise was to assess the impact of the Scheme on flood levels and floodplain storage, the model was only simulated for the 1% AEP plus 50% climate change event due to impacts of climate changes as assessed by The United Kingdom Climate Impacts Programme.

## 5.3 Little Eaton Flood Model: Proposed Junction

5.3.1 The updated Little Eaton Baseline Flood Model was used to assess the Scheme by replacing the existing junction layout with the proposed junction layout.

5.3.2 As discussed in Section 4.3, an increase in the junction footprint would result in the loss of floodplain storage associated with the River Derwent, and this has the potential to cause an increase in flood risk due to raised flood levels. This is discussed in more detail below.

## 5.4 Modelling Results

5.4.1 Flood risk modelling results are presented in Appendix C for both the existing Little Eaton junction and the Scheme.

5.4.2 As can be seen from the flood depth figures in Appendix C, the flood extents of the existing and proposed Scheme scenarios are practically identical, with the main changes occurring immediately to the south of the junction in the area where the Scheme (i.e. extension of the A38 road embankment) extends. Results show that by encroaching into the floodplain, the Scheme would have some minor impact on flood depths within the Scheme vicinity. This is shown in more detail within Figure 5-1 which shows a depth-difference plot between the existing and proposed Scheme scenario.

5.4.3 Figure 5-1 indicates that changes in flood levels are generally limited to a maximum increase of up to 20mm, although with some areas local to the proposed junction increasing by up to 50mm. There are also some areas where flood levels reduce; these occur immediately to the south of Little Eaton junction, and also to the east of the railway line. It should be noted that this figure does not show the entire flood extent. Where there is no impact, no colour is shown. Thus the Scheme would not affect flood depths in the majority of the surrounding settlements/ developed areas. The coloured areas only show the locations where there has been an impact on flood levels due to the Scheme.

5.4.4 As stated above, and indicated on Figure 5-1, the most significant changes in flood levels occur around the A38 junction. This is due to the changes in hydraulic behaviour of floodplain flow as a result of the proposed junction layout.

5.4.5 Table 5-1 provides further information regarding the changes in flood levels within the vicinity of the junction.

**Table 5-1: Comparison of point-based flood levels between the Updated Baseline Model and Proposed Arrangement Model**

| Flood Assessment Point | 1% AEP event plus 50% climate change allowance | | |
|---|---|---|---|
| | Updated Baseline – Flood Level* (m AOD) | Proposed Arrangement – Flood Level* (m AOD) | Difference* (mm) |
| 1 | 53.08 | 53.08 | +10 |
| 2 | 53.15 | 53.16 | 0 |
| 3 | 53.07 | 53.07 | 0 |
| 4 | 52.56 | 52.57 | +10 |
| 5 | 53.05 | 53.05 | -10 |
| 6 | 51.81 | 51.84 | +30 |
| 7 | 52.45 | 52.48 | +30 |
| 8 | 50.46 | 50.43 | -40 |
| 9 | 50.33 | 50.33 | +10 |
| 10 | 50.31 | 50.29 | -10 |

*Note that differences are calculated from exact model results, whilst calculated levels are rounded to 2 d.p.

5.4.6 The results in Table 5-1 show that for most locations, there are only marginal changes to flood depths. These marginal changes (i.e. ±30mm) are considered to be within the tolerance of the hydraulic model. As such, it is considered that the proposed arrangement would not result in significant changes in flood risk, although mitigation is still required in order to compensate for the loss of River Derwent floodplain.

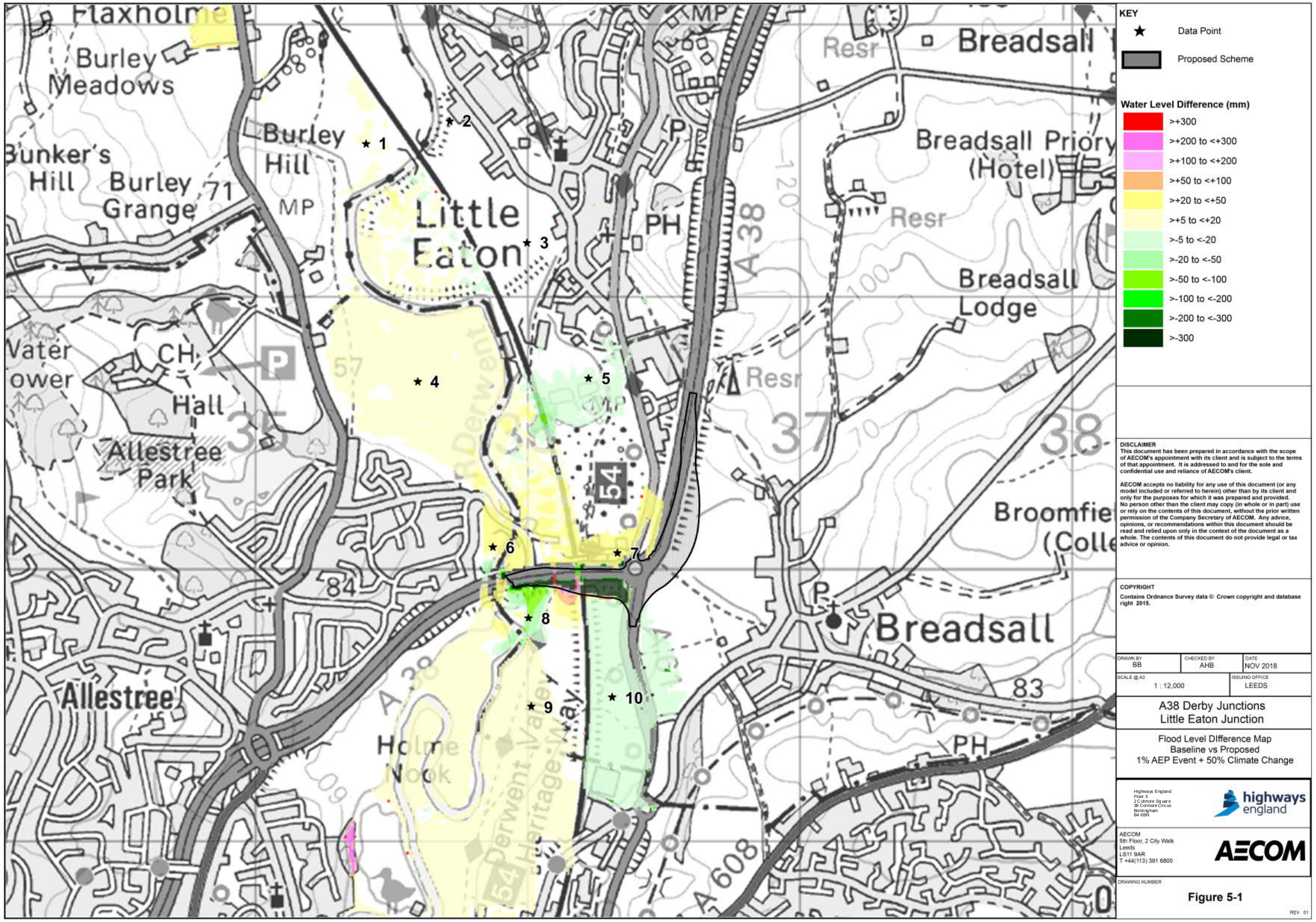



**Figure 5-1: Flood Level/ Depth Difference Map of Updated E … oposed Arrangement Model**

## 5.5 Little Eaton Flood Model: Proposed Junction with Compensatory Works

5.5.1 Several compensatory storage options have been modelled in order to meet the EA's requirement that there be no net loss of floodplain volume as a result of the Scheme.

5.5.2 Following the investigation of several options, a potentially appropriate location for the floodplain compensation works was identified downstream of the Scheme, on the right bank of the River Derwent. Appendix B provides more detail on the method used to determine the required volumes (i.e. volume lost as a result of the Scheme), and the subsequent ground modelling exercise that was undertaken to re-profile the floodplain in order to compensate for the volume lost.

5.5.3 Table 5-2 provides a summary of the compensatory works, in terms of required and provided compensatory volumes.

**Table 5-2: Comparison of required and provide compensatory volumes**

| Lower Level (m AOD) | Upper Level (m AOD) | Cumulative Volume Required ($m^3$) | Cumulative Volume Provided ($m^3$) | Variation ($m^3$) |
|---|---|---|---|---|
| n/a | 49.59 | 0 | 4,291 | +4,291 |
| 49.59 | 49.73 | 18 | 5,619 | +5,601 |
| 49.73 | 49.79 | 405 | 5,913 | +5,508 |
| 49.79 | 49.82 | 609 | 6,484 | +5,875 |
| 49.82 | 49.85 | 873 | 7,056 | +6,183 |
| 49.85 | 49.88 | 1,320 | 7,627 | +6,087 |
| 49.88 | 49.93 | 5,339 | 8,374 | +3,035 |
| 49.93 | 50.19 | 12,439 | 10,853 | -1,586 |
| 50.19 | 50.39 | 12,909 | 12,760 | -149 |
| 50.39 | 50.42 | 12,995 | 13,304 | +309 |

5.5.4 The compensatory works were included in a version of the Scheme model, and found that provision of the compensatory works would not result in unanticipated adverse effects on flood levels. This is confirmed by Figure 5-2 (and also Appendix C), which shows a depth-difference plot between the existing junction scenario and the proposed junction scenario inclusive of the compensatory storage area. The only difference is where the compensatory works have been included, which would flood to provide the level-for-level compensatory volume during some flood events (whereas previously this area was not flooded).

5.5.5 Correspondence with the EA in June 2018 has confirmed their contentment with the proposed approach to flood risk mitigation and floodplain compensation proposals at Little Eaton junction, and that residual flood impacts are acceptable.

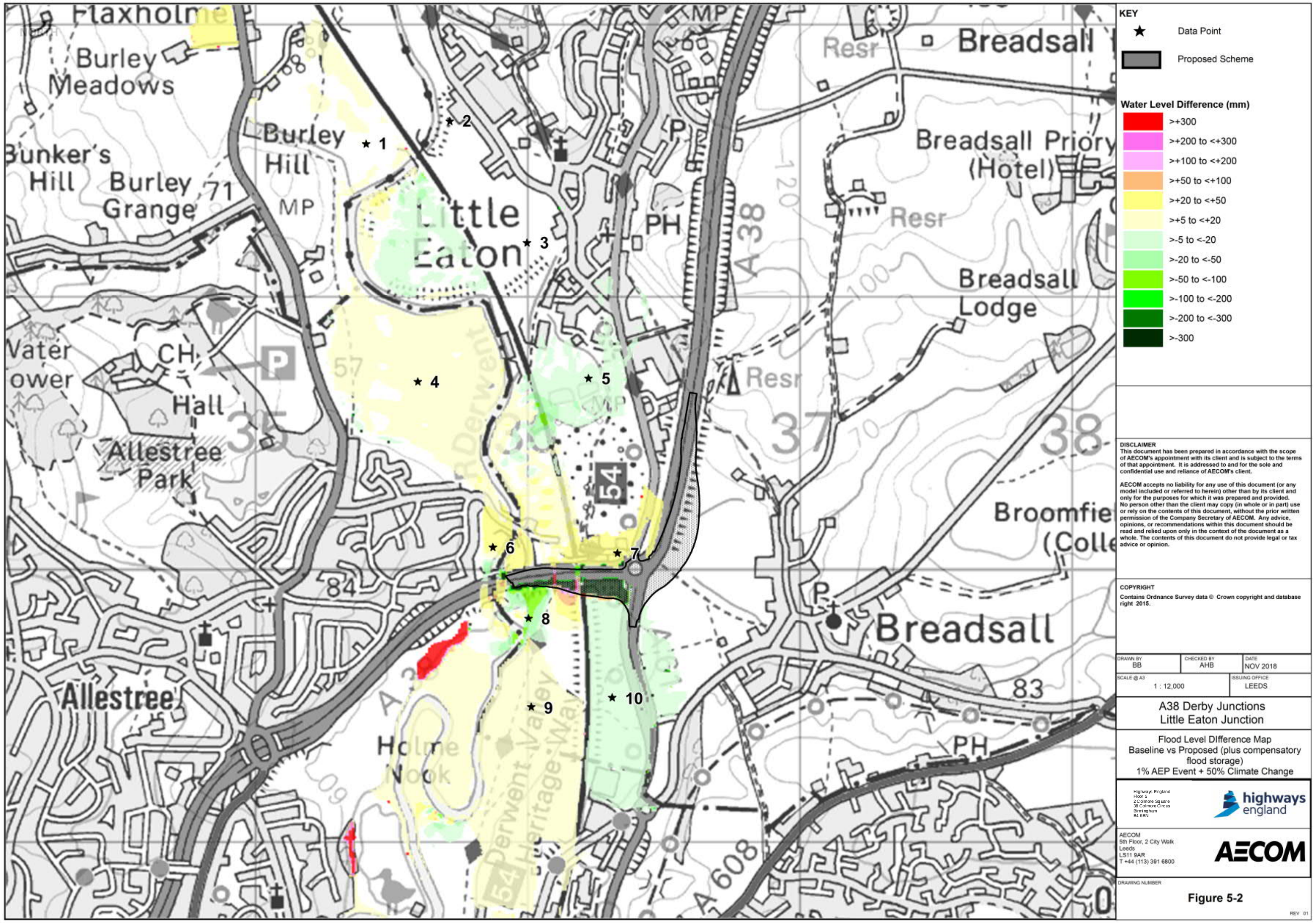



**Figure 5-2: Flood Level/ Depth Difference Map of Updated Ba posed Arrangement Model (with compensatory storage)**

# 6 SURFACE WATER FLOODING AND MITIGATION MEASURES

## 6.1 Overview

6.1.1 In terms of surface water mitigation, there are two elements that require consideration. Firstly, it was necessary to consider the surface water flood risks associated with Dam Brook (noting that the Scheme requires Dam Brook to be diverted) and flooding associated with a stream emanating from Breadsall Manor. Dam Brook is a tributary of the River Derwent which is located near to Breadsall, and which drains under the A61 close to the existing Little Eaton junction. Secondly, an assessment of highway surface water management strategies for the proposed junction and associated drainage was required.

6.1.2 Both of these surface water elements are discussed in the sections below.

## 6.2 Dam Brook and Stream from Breadsall Manor

6.2.1 The eastern extent of the Scheme encroaches into an area considered to have a ‘High’ risk of surface water flooding, according to the EA’s surface water flood maps. This area is associated with the location of the Dam Brook. In addition, further to the north there is significant attenuation of surface water runoff adjacent to the existing A38 associated with a stream emanating from Breadsall Manor.

6.2.2 In order to assess the impact of the Scheme on surface water flood risk, for both the permanent and temporary works (which could entail material storage to the west of Dam Brook) and to identify potential mitigation measures, a surface water hydraulic model was developed. The model was developed using a 2D only direct rainfall approach. Full details of the modelling can be found in Appendix D (Surface Water Modelling Technical Note).

6.2.3 Modelling of the existing situation indicated that the current A38/ A61 alignment causes significant attenuation of surface water within an unnamed watercourse to the south-west of Breadsall Manor. This is related to the channel capacities and culvert networks in vicinity of the existing highway alignment.

6.2.4 For the Scheme scenario, the model was amended to reflect the realigned highway junction, the provision of highway runoff surface water attenuation basins (refer to Section 6.3), the diversion of Dam Brook and the creation of a series of ecological and flood storage ponds. It was also necessary to amend the alignment, length and inverts of the proposed culvert extension beneath the A38 to ensure a positive hydraulic gradient.

6.2.5 Implementation of the Scheme features did not result in an increased risk of surface water flooding to areas south of the proposed A38 alignment. However, attenuation of surface water on the upstream face of the proposed embankments, to the south-west of Breadsall Manor, resulted in an increased risk of flooding outside of the Scheme boundary. Additionally, the model indicated overtopping and inundation of the southernmost proposed attenuation basin during a 1% AEP + 50% climate change design event.

6.2.6 In order to address the surface water flooding issues that resulted from the Scheme, a series of mitigation measures was tested. The solution identified and incorporated into the Scheme comprised a multi-stage flood alleviation channel adjacent to the A38 embankment that would connect the unnamed surface watercourse downstream of Breadsall Manor with the realigned Dam Brook. In addition, a new 600mm diameter culvert would also be provided from the watercourse under the new A38 embankment that would connect into an existing 500mm diameter culvert in order to convey flows from the unnamed watercourse when the flow capacity of the flood alleviation channel is exceeded.

6.2.7 With these mitigation measures, the area to the west of the realigned Dam Brook would be appropriate for temporary material storage during the Scheme construction phase.

## 6.3 A38/ A61 Junction Realignment

6.3.1 The Road Drainage Strategy (Report Number HE514503-ACM-HDG-A38_SW_PR_ZZ-RP-CD-0002, Highways England 2019) is available as a separate report and should be read in parallel with this FRA. The Road Drainage Strategy report indicates that the highway drainage design at Little Eaton junction comprises the following:

- A highway runoff attenuation pond located to the east of the A61 that would be owned and operated by Highways England (pond would receive runoff from Highways England assets).
- A highway runoff attenuation pond located to the east of the A61 that would be owned and operated by DCC (pond would receive runoff from DCC assets).
- Attenuation using oversized pipes.
- Narrow filter drains.
- Combined kerb drainage units.
- Trapped gully pots and road-side linear drains.
- Petrol interceptors at outfalls and connections to existing public sewers.
- By-pass separators.

6.3.2 The surface water management strategy for the Scheme design is summarised as follows:

**Runoff Collection and Conveyance**

6.3.3 Little Eaton junction’s preliminary drainage design has five catchments.

6.3.4 Runoff from the carriageway would be collected via a combination of road edge channels, gullies and combined kerb drainage units (where required). The proposed overbridges allow for bridge drainage/ combined kerb drainage units on the bridge deck.

6.3.5 The use of carrier pipes would ensure that spillages would be contained within the drainage system and would not infiltrate to ground close to source. Subsurface drainage would be provided via narrow filter drains where necessary.

**Attenuation and Pollution Control**

6.3.6 A GRR of 4.6l/s/ha has been agreed for use within the preliminary design calculations.

**Catchment 12**

6.3.7 The runoff from this catchment would outfall into the realigned Dam Brook. Attenuation storage up to and including the 100 year + 40%CC event would be provided by a lined attenuation pond and oversized pipes. The preliminary design allowable discharge rates have been calculated using a GRR of 4.6l/s/ha for the new impermeable areas and restricted to ensure betterment over the existing situation for the site.

6.3.8 Treatment of the runoff prior to discharge would be provided by the lined attenuation pond. The existing highway drainage design includes no vegetative treatment systems, so the Scheme would provide enhancements to runoff water quality. Penstocks would be provided upstream of the attenuation pond to allow cut off in the event of spillage on the highway. The spillage would be contained within the carrier/ system.

6.3.9 The attenuation pond is to be owned and maintained by Highways England, a shared access track with DCC is included within the preliminary design to service the pond.

**Catchment 13**

6.3.10 The runoff from this catchment would outfall into the realigned Dam Brook. Attenuation storage up to and including the 100 year + 40%CC event would be provided by a lined attenuation pond and oversized pipes. The preliminary design allowable discharge rates have been calculated using a GRR of 4.6l/s/ha for the new impermeable areas and restricted to ensure betterment over the existing situation for the site.

6.3.11 Treatment of the runoff prior to discharge would be provided by the lined attenuation pond. The existing highway drainage design includes no vegetative treatment systems, so the Scheme would provide enhancements to runoff water quality. Penstocks would be provided upstream of the attenuation pond to allow cut off in the event of spillage on the highway. The spillage would be contained within the carrier/ system.

6.3.12 The attenuation pond is to be owned and maintained by DCC, a shared access track with Highways England is included within the preliminary design to service the pond.

**Catchment 14**

6.3.13 The discharge from the catchment would be restricted to match existing discharge rates, ensuring no detriment in terms of downstream flood risk. Attenuation would be provided within the pipe network to ensure no flooding from the site in a 1 in 100 year + 40% CC rainfall event. The existing connections (subject to condition assessment) would be retained. No vegetative treatment has been provided within the design due to site constraints, matching existing conditions.

6.3.14 A petrol interceptor would be located upstream of the connection to the proposed discharge point.

**Catchment 15**

6.3.15 The discharge from the catchment would be restricted to match existing discharge rates, ensuring no detriment in terms of downstream flood risk. Attenuation would be provided within the pipe network to ensure no flooding from the site in a 1 in 100 year + 40% CC rainfall event. The existing connections (subject to condition assessment) would be retained. No vegetative treatment has been provided due to site constraints, matching existing conditions.

6.3.16 A petrol interceptor would be located upstream of the connection to the proposed discharge point.

**Catchment 16**

6.3.17 The proposed earthworks drainage would discharge via the existing outfall into Dam Brook. At catchment 16 there would be a reduction in the drained area and consequently a reduction in peak runoff flows.

**Land Drainage**

6.3.18 Dam Brook would be affected by the Scheme and would need to be realigned.

6.3.19 Proposed earthwork drainage would be located at the top of cuttings or at the toe of embankments to capture surface flows from natural catchments. These would outfall into the carrier pipe system.

6.3.20 Due to the areas of high and medium surface water flood risk at the proposed temporary materials storage area, appropriate mitigation measures to reduce risk associated with surface water flooding would be required (surface water attention and management). Mitigation measures are likely to be minimal in nature owing to the limited area of surface water flood risk and the nature of the proposed site use (temporary material storage).

# 7 CONCLUSIONS

7.1.1 This Flood Risk Assessment (FRA) has reviewed the Scheme proposals at Little Eaton junction. Flood risks to, and resulting from, the Scheme were assessed as follows:

- The risk of fluvial flooding from the River Derwent to the proposed junction is high. Hydraulic modelling has been undertaken to investigate the impact on flood risk and loss of floodplain storage as a result of the Scheme and mitigation measures for compensatory floodplain storage have been incorporated into the scheme design.
- There is no risk of tidal flooding.
- The risk of groundwater flooding is considered to be medium which is concluded in the A38 Derby Junctions Ground Investigation Report (Report Number HE514503-ACM-VGT-A38_SW_PR_ZZ-PR-GE-0003_P02_24, 2018).
- The risk of surface water flooding to the site is low, except in the vicinity of an unnamed watercourse to the south-west of Breadsall Manor (east of the proposed junction realignment), as well as an area of ‘High’ risk associated with Dam Brook.
- The risk of sewer flooding is considered to be low.
- The risk of flooding from artificial sources is considered to be low.

7.1.2 Hydraulic modelling has been undertaken to assess the amount of floodplain storage that would be lost as a result of the Scheme. The ISIS-TUFLOW model which has been created for this study was produced by combining the Lower Derwent model (south of the A38) and the Milford to Allestree model (north of the A38), both of which were provided by the EA. The combining of the two models involved updating the LiDAR and also the representation of the floodplain (i.e. changing the area within the vicinity of the junction from 1D to 2D).

7.1.3 Flood modelling demonstrated that the proposed junction encroaches into the River Derwent floodplain causing a loss of storage, and a change in hydraulic conditions around the river crossing. Whilst the impact on flood levels is considered to be minor, there would be a requirement to provide an area of floodplain compensation. Such an area has been identified to the west of the River Derwent and south of the A38, and proposed ground re-profiling would be able to provide the necessary compensation for the floodplain loss on a level-for-level and volume-for-volume basis. Correspondence with the EA in June 2018 has confirmed their contentment with the proposed approach to fluvial flood risk mitigation and floodplain compensation proposals at Little Eaton junction, and that residual flood impacts are acceptable.

7.1.4 Surface water flood risk associated with Dam Brook and an unnamed watercourse to the south-west of Breadsall Manor has been modelled for both the existing and proposed junction arrangement. The resulting increase in surface water flood risk as a result of the Scheme has been addressed by proposing a combination of mitigation measures as follows:

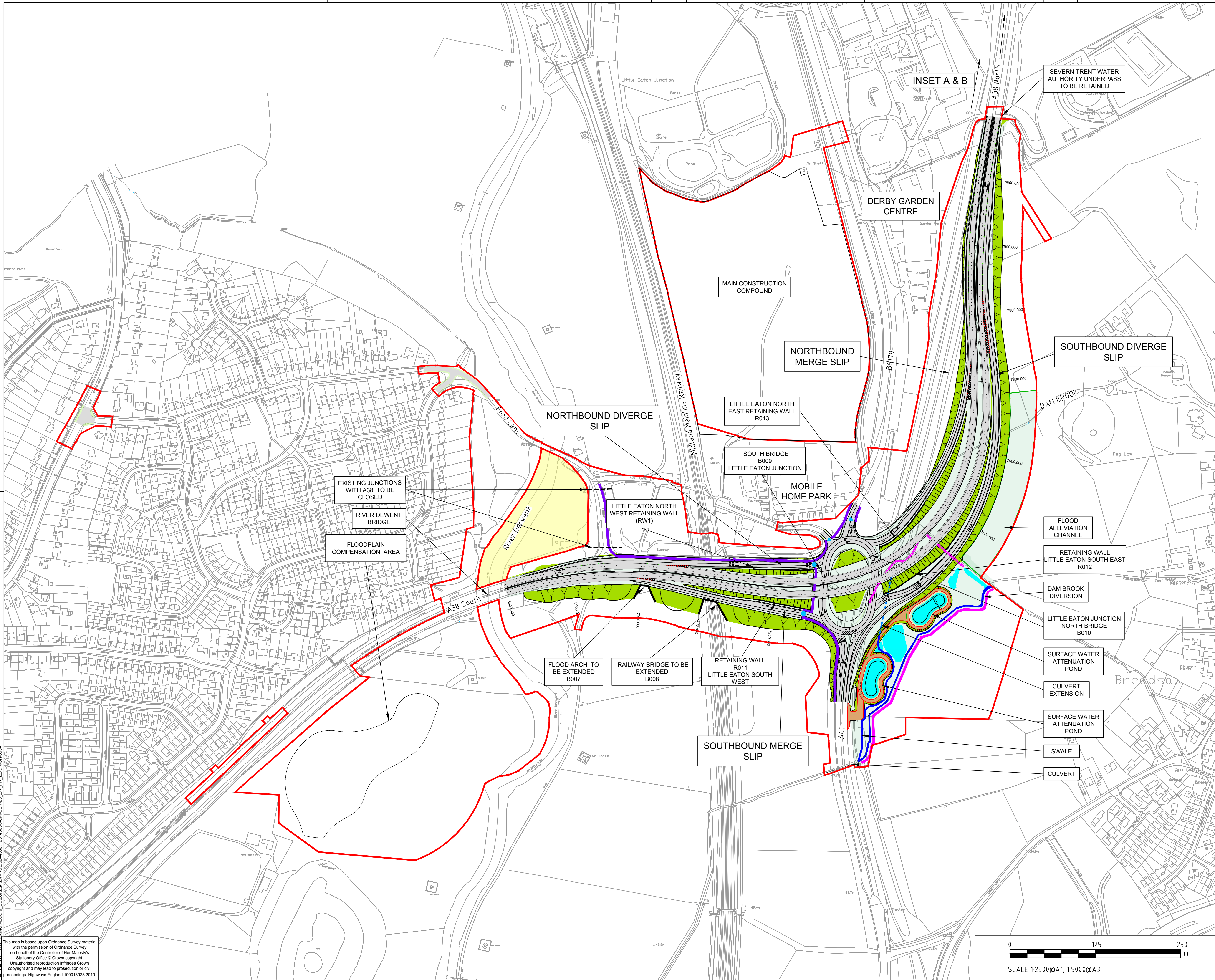
- Diversion of Dam Brook into a new realigned watercourse that takes account of brook flooding, plus the provision of new ponds.

- Provision of a flood alleviation channel adjacent to the new A38 that would connect a surface watercourse downstream of Breadsall Manor with the realigned Dam Brook. In addition, a new 600mm diameter culvert would also be provided from the watercourse under the new A38 embankment that would connect into an existing 500mm diameter culvert in order to convey flows from the unnamed watercourse when the flow capacity of the flood alleviation channel is exceeded.

7.1.5 Surface water flood risks from the Scheme junction itself would be managed through drainage designs as detailed in the Road Drainage Strategy (Report Number HE514503-ACM-HDG-A38_SW_PR_ZZ-RP-CD-0002, Highways England 2019). The main features of the design include two highway runoff attenuation ponds, attenuation using oversized pipes, narrow filter drains, combined kerb drainage units, trapped gully pots and road-side linear drains, petrol interceptors at outfalls and connections to existing public sewers, by-pass separators. The Road Drainage Strategy report is available as a separate report and should be read in parallel with this FRA.

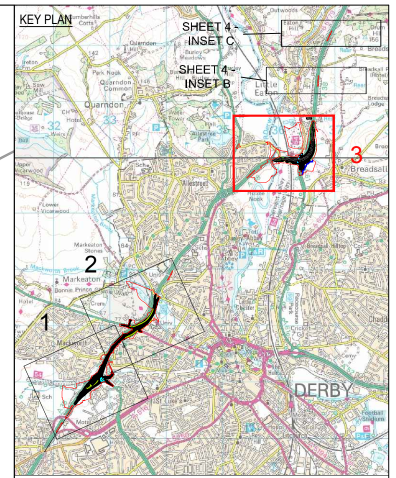
7.1.6 Incorporation of the mitigation measures as detailed herein indicate that flood risks associated with the Scheme at Little Eaton junction can be appropriately managed.

# Appendix A Scheme Design and Boundary Drawings






KEY PLAN




NOTES

PLEASE REFER TO 1:1000 SERIES DRAWINGS FOR:
- MAIN PEDESTRIAN/CYCLE ROUTES AND CROSSING POINTS
- INDICATIVE ROAD MARKINGS
- MAINTENANCE ACCESS AREAS
- FENCING (INCLUDING ENVIRONMENTAL BARRIERS)

KEY:

- The Design
- Limits of Land to be acquired or used permanently or temporarily
- Proposed Footway/Cycleway
- Proposed Footway
- Public Right of Way Diversion
- Existing Right of Way to be stopped up
- Area Not Included within the DCO Boundary
- Proposed Controlled Crossing
- Proposed Un-Controlled Crossing
- Embankment
- Cuttings
- Access Track
- Combined Access track & Footway/C'way
- Environmental Mitigation
- Highway to be stopped up
- Proposed Culvert
- Streams

| Revision Details | By / Check | Date | Suffix |
|---|---|---|---|
| First Issue | LE / GS | 20/02/19 | P01 |
| First Issue | LE / GS | 04/03/19 | P02 |

Purpose of issue
# FINAL

Client
Highways England
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Two Colmore Square
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Development Consent Order Number
TR010022

Project Title
# A38 DERBY JUNCTIONS

Drawing Title
# GENERAL ARRANGEMENT REGULATION 5(2)(O) SHEET 3 OF 4

| Designed | Drawn | Checked | Approved | Date |
|---|---|---|---|---|
| | LE | GS | GS | 04/03/19 |

| Internal Project No. | Suitability |
|---|---|
| 60533462 | S3 |
| Scale @ A1 | Zone |
| 1:2500 | Whole Scheme |



Drawing Number
Highways England PIN | Originator | Volume
HE514503 -ACM -DCO-
A38_SW_PR_ZZ -DR-DC-0023
Location | Type | Role | Number

Rev
P02

# Appendix B Fluvial Modelling Technical Note

# TECHNICAL NOTE

| | | | | | |
|---|---|---|---|---|---|
| **Project:** | **A38 Derby Junctions** | | | | |
| **Title:** | **Little Eaton Flood Modelling Update, April 2018** | | | | |
| **Doc ID:** | **HE514503-ACM-EWE-Z3_ML_PR_ZZ-TN-HF-0001** | | | | |
| **Date:** | **April 2018** | Version: | **P03** | Status: | **S4** |

| Revision | Date | Prepared by | Reviewed by | Approved by |
|---|---|---|---|---|
| P01 | 28.03.2018 | Andrew Heath Brown | Simon Wild | Andy Wilson |
| P02 | 03.04.2018 | Andrew Heath Brown | Simon Wild<br>Gavin Sawyer | Andy Wilson |
| P03 | 10.04.2018 | Andrew Heath Brown | Simon Wild | Andy Wilson |

## 1 Background

1.1 A Level 2 Flood Risk Assessment (FRA) for the proposed A38 Little Eaton junction (referred to herein as the proposed scheme) was undertaken during PCF Stage 2 and reported in 47071319-URS-05-RP-EN-007-2F (Highways England, March 2016). As part of an agreed package of advanced PCF Stage 3 works, additional flood risk modelling at Little Eaton junction was undertaken in order to further lower flood levels due to the proposed scheme within certain areas of the River Derwent floodplain. Details of this modelling and the associated results were reported in a Technical Note 47071319-URS-05-TN-EN-030 (Highways England, November 2016). The modelling, and the associated mitigation optioneering, was targeted on the 1% Annual Exceedance Probability (AEP) event plus 20% climate change allowance (in respect of fluvial peak flows). The Technical Note and flood model were submitted to the Environment Agency in December 2016, who provided external review comments regarding the model on 27 February 2017. The results of the modelling and the external review model comments were discussed at a meeting with the Environment Agency on 21 March 2017. Subsequently AECOM responded to the Environment Agency comments on the model on 16 May 2017, with the Environment Agency generally agreeing with our responses on 26 May 2017.

1.2 Further modelling was undertaken and reported in a Technical Note that was submitted to the Environment Agency on 27 November 2017 (HE514503-ACM-EWE-Z3_JN_J3_ZZ-TN-LE-001), with the Environment Agency providing comments on the 25 January and 2 February 2018. Environment Agency comments included a number of actions needed with regard to the modelling, as well as concerns regarding the absence of floodplain compensation.

1.3 This technical note has been prepared to capture the current status of the Little Eaton junction flood risk modelling taking account of Environmental Agency comments.

# 2 Required Update for PCF Stage 3

2.1 As part of the ongoing PCF Stage 3 works, the associated flood risk modelling at Little Eaton junction has been undertaken to address a number of key factors, as set out below:

- Changes to capture Environment Agency external review comments on the hydraulic model of the Little Eaton A38 junction;
- Changes to capture amendments to the Little Eaton Junction proposed scheme design;
- Changes to capture data generated by an additional topographic survey of the area (including River Derwent cross sections), as well as an updated LiDAR ground model; and,
- Climate change allowances have changed in line with latest Environment Agency guidelines, requiring a 50% increase in peak flows at the 1% AEP event to be mitigated against (as per the Environment Agency request indicated at the meeting held 21 March 2017).

2.2 Full details of the flood risk model update process are presented below.

# 3 Overview

3.1 The process by which the A38 Little Eaton junction hydraulic model has been updated is summarised in **Figure 1**.

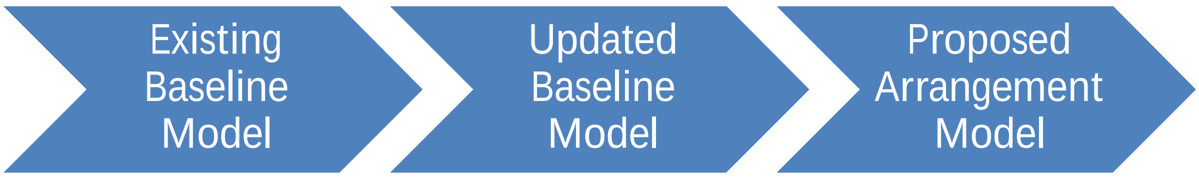



**Figure 1: Process by which A38 Little Eaton junction hydraulic model has been updated**

3.2 An overview of the Existing Baseline Model, followed by a summary of the development of the Updated Baseline Model and the Proposed Arrangement Model (representing the proposed scheme), is given below. The simulation and results of these two models is then discussed and analysed.

# 4 Existing Baseline Model

4.1 The Existing Baseline Model is that developed for the additional modelling investigations as previously described, and subsequently reported in Technical Note 47071319-URS-05-TN-EN-030 (Highways England, November 2016). This model was submitted to the Environment Agency and underwent a third-party review (CH2M Hill, February 2017). AECOM provided a response to this review (16 May 2017) which identified that the Existing Baseline Model had originated from two Environment Agency provided models of the River Derwent, and were therefore assumed to have been approved and suitable for assessing flood risk for the proposed scheme. Although the review was based on the Proposed Arrangement Model (at the time), any comment relating to the existing model set-up was not within AECOM's remit to address. Nevertheless, a series of AECOM actions were identified, some of which did address potential issues with the original models (particularly where it was considered that they may affect levels within the proposed scheme area). Following AECOM's response, the Environment Agency provided further comment on the proposed AECOM actions (26 May 2017). This confirmed that AECOM's proposed actions were acceptable.

# 5 Updated Baseline Model

5.1 The Updated Baseline Model incorporates a number of refinements over the Existing Baseline Model.

*Additional Survey Data*

5.2 Firstly, updated LiDAR data was provided via Highways England at a higher resolution than the previously utilised LiDAR data. The new data has a resolution of 0.25m as opposed to the previously used 2m resolution data. Initially, the new data was 'stamped' onto the original LiDAR; however, for file size/ management reasons, the resulting coverage was trimmed to the extent of the 2D domain. **Figure 2** demonstrates the coverage relative to the 2D domain.

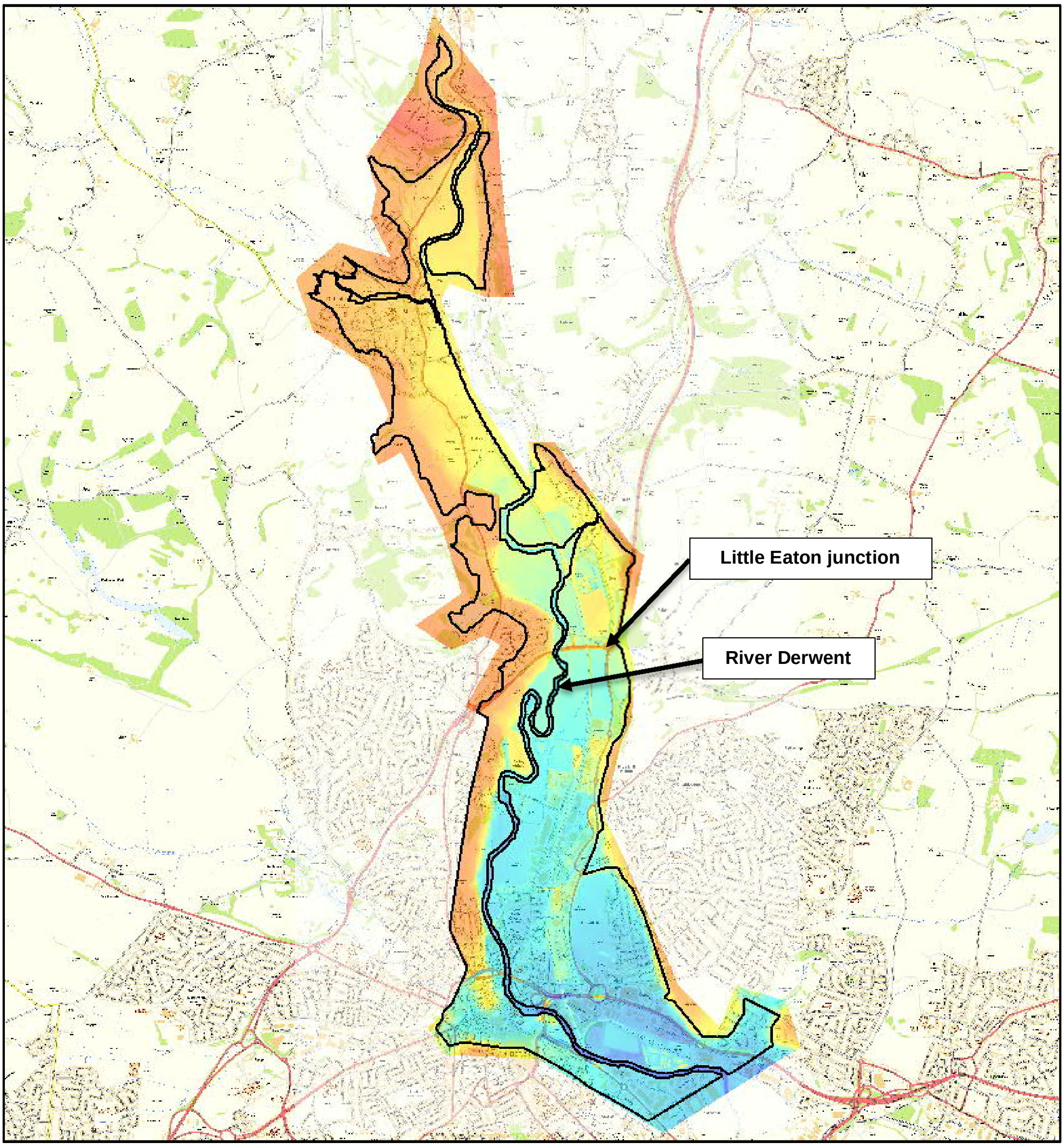



**Figure 2: LiDAR coverage relative to the 2D domain**

5.3 Topographic survey was also undertaken where the original models were joined (i.e. at the existing A38 bridge over the River Derwent). The survey extended downstream from the Ford Lane bridge (upstream face) to approximately 300m downstream of the existing A38 bridge, and included a total of 13 channel cross-sections within the River Derwent.

5.4 The model was updated to incorporate these sections, replacing the existing sections between DE069 and DE067 inclusive. As per the existing model, the A38 bridge was not modelled explicitly. The Ford Lane bridge representation within the model was retained, but with cross-section details amended to reflect those of the updated topographic survey.

5.5 As per the proposed AECOM actions (16 May 2017), the updates as detailed in the sections below have been made to the Existing Baseline Model.

*In-bank Model*

5.6 Following incorporation of the new survey cross-sections, the 1D in-bank model was reviewed:

- Panel markers and bank markers were added to the new cross-sections, and were also added to the existing cross-sections where missing or incorrectly placed;
- Additional panel markers were added where necessary;
- A review of panel marker placement was undertaken based on plotting the conveyance properties of each cross-section and ensuring the resultant stage-conveyance curve was reasonably smooth;
- A 1D model 'Health Check' was undertaken to confirm that panel markers and bank markers were not missing at any locations.

5.7 Manning's 'n' values were reviewed and are considered sensible for the modelled reach, particularly within the vicinity of the A38.

5.8 Although the external review identified the use of further interpolates, particularly due to some instances of large cross-section spacing, it was considered that the current 1D model (following the above amendments) was sufficiently stable to not require use of additional interpolates.

*Out-of-bank Model*

5.9 Environment Agency comments received 27 February 2017 regarding the out-of-bank model were more specific, and were addressed individually. For those where actions were required, these are discussed below.

5.10 The external review noted that the 2D domain was 'glass-walling' at North Parade Road during the 1% AEP event plus 20% climate change. Although AECOM stated that glass walling in this area is unlikely to have an effect on flood levels within the vicinity of the proposed scheme when considering the 1% AEP event plus 20% climate change event, it was conceded that this could be more problematic at higher flows (i.e. a 50% climate change event). As such, the 2D domain was extended at this point.

5.11 The external review noted that "*It is not recommended to use the Z flag without first checking that the reason for discrepancy in elevations between 1D and 2D domains is appropriate. 'f' is assigned a value of two and six for the HX lines. This should be further explained/ justified*". AECOM's response was that this set-up was as per the received models, and based on the assumption that these z flags/ 'f' values have been appropriately used, they did not need to be changed. However, the Environment Agency indicated that AECOM should be satisfied that the Z flag and f values are appropriate in the vicinity of the proposed scheme. As such, the following additional comments are provided:

- It was not clear why 'f' values of two and six had been applied to the HX lines; this was a legacy of the original Environment Agency model, and was not commented on in associated reports. A test of the baseline model was undertaken in which the f-values were set to zero, and it was determined that the impact was negligible;

- The survey data used to set the culvert inverts within the ESTRY part of the model was not available, so each culvert arrangement and their associated elevations/ inverts cannot be verified. The model grid resolution of 10m x 10m is large, and therefore it is necessary to use z-flags to reset ground levels locally for modelling purposes. AECOM consider that the culverts where z-flags have been applied are not critical in terms of the overall results and their impact on assessing the proposed scheme. The z-flag approach is appropriate, but further detailed analysis might indicate that a better resolution to this issue (such as revising the location of the 1D/2D connection) would be preferable.

5.12 The external review suggested that the source of data for defence levels was included in the accompanying report. AECOM's response was that since such data related to the original modelling, this information could only be extracted from the original modelling reports. For the Milford to Allestree model, the accompanying report entitled Lower Derwent PAR – Hydraulic Modelling Report (Black & Veatch, July 2010) stated that "*additional detail on the crest levels of minor flood banks along the river and flood defences at Little Eaton and Bottle Brook were obtained from topographic survey*". This topographic survey was referenced as being provided by CSL Survey (2003 and 2006), undertaken for the Environment Agency Derby Strategy. The banks (and associated defences) were modelled using z-lines (thick). No other information was provided in the Black & Veatch report. For the Lower Derwent model, the accompanying report entitled River Derwent Trent Confluence Flood Mapping – Final Hydraulic Modelling Report (JBA Consulting, November 2010) stated that "*The underlying topography was created from LIDAR data…" but that a "…'finer' representation of key structures (e.g. flood defences, river bank levels, localised ground raising, etc.) was required in various locations*". The report purported to give further detail within the appendices; however, this only stated which z-lines had been included to represent particular defences, but not how the data to define those z-lines had been sourced. No further information can therefore be provided.

5.13 As part of the 1D model update, the extents of the deactivated cross-sections were exported, and the boundary of the inactive area was adjusted accordingly. This addresses the external review recommendation to check the extent of the 2D inactive area against the extent of the 1D domain, and ensures no double-counting or exclusion of flow areas. A further concern raised by the Environment Agency was that there was some 'glass-walling' in sections around DE077 because there is no 1D-2D linking. In this area, the model set-up is as per the Environment Agency approved model received at the start of this project. The figure in **Appendix A** has been extracted from the Black & Veatch report, which accompanied the model passed to AECOM from the Environment Agency. It confirms that the area around DE077 is modelled in 1D only, with connections to 1D reservoir units. The Black & Veatch report confirms this was done to improve model stability. AECOM consider that the conveyance within this area of 1D only model will be appropriately calculated, since the railway embankment to the west and road to the east will contain the flows. AECOM also consider that the study area would not be significantly affected by this representation. It is not clear why section DE077 has not been connected to the 1D reservoir units, but again it is considered that this would not impact model results within the study area.

5.14 The external review concluded that Manning's 'n' roughness values used for floodplains were reasonable, but noted that a value of 1.0 was used to stabilise parts of the model. According to the River Derwent Trent Confluence Flood Mapping –

Final Hydraulic Modelling Report (JBA Consulting, November 2010), "*some high velocity areas were 'manually' allocated a roughness value of 1.0 in order to improve model stability locally*". AECOM has removed these roughness stability patches, and successfully run the model as a result.

*Structures*

5.15 There are no structures within the vicinity of the proposed scheme that have not been represented, with the exception of the A38 bridge itself. This has been excluded on the basis that it does not cause any significant restriction to River Derwent flow. The bridge is shown in **Figure 3**.

**Figure 3: Existing A38 bridge opening (viewed from upstream)**

5.16 The Environment Agency external review noted that the "*A601 bridge and footbridges are missing*". The A601 bridge is not in the vicinity of the proposed scheme, but it is assumed that it was originally excluded for the same reasons as the A38 bridge, particularly given that the Sowter Road/ St Mary's bridge immediately upstream is the main restriction at this location, and is included in the model.

5.17 The Ford Lane bridge did not have an in-line spill in the original model to represent flow over the parapet and onto the deck, nor was this included within the 2D domain. A spill has been added to represent this, based on a typical crest level of the parapet wall as obtained from the latest topographic survey (which only provided spot levels along the wall crest). The variation was not significant enough to warrant greater detail in the geometry. In reality, flow is unlikely to spill over the parapet wall as the adjacent floodplains are at a much lower elevation, and therefore all out-of-bank flow will go around the structure. No other structures were identified that would require an inline spill to represent flow over the deck.

*Model Boundaries*

5.18 Previously, the downstream boundary of the 2D domain caused water to back-up, since the boundary defaults to a vertical wall if no other boundary type is specified. The Environment Agency external review recommended that an HQ boundary should be applied at the downstream boundary of the 2D domain. This has been done, based on the typical slope of the adjacent floodplain.

# 6 Proposed Arrangement Model

6.1 The Proposed Arrangement Model has been developed from the Updated Baseline Model. The amendments were essentially to include representation of the proposed scheme junction design (March 2018), which was provided in a CAD drawing (LE FORD LANE STRINGS.dwg). This was converted into TUFLOW Z-Shape and Z-Line files, with associated elevations.

# 7 Model Simulation and Results

7.1 All model simulations have been undertaken for the 1% AEP event plus 50% climate change allowance (as per the model run done as a sensitivity check, and reported on within the previous Technical Note - 47071319-URS-05-TN-EN-030).

7.2 The Updated Baseline Model was originally run with the same simulation parameters applied as part of previous modelling work at Little Eaton junction (as reported in the Level 2 FRA - 47071319-URS-05-RP-EN-007-2F, and the follow-up Technical Note - 47071319-URS-05-TN-EN-030). However, it was necessary to change the Matrix Dummy Coefficient from a default of 0 to 0.0001 (does not impact on results). However, during early iterations of the Proposed Arrangement Model, some mass balance errors were identified. As such, a lower model time-step was used to reduce this error; this meant a reduction of the 2D time-step from 5 seconds to 2 seconds, and a reduction of the 1D time-step from 2.5 seconds to 1 second.

7.3 To ensure a like-for-like comparison against the results of the Proposed Arrangement Model, the Updated Baseline Model was run using these revised time-steps. The cumulative mass balance error was within the accepted 1% tolerance (see **Figure 4**).

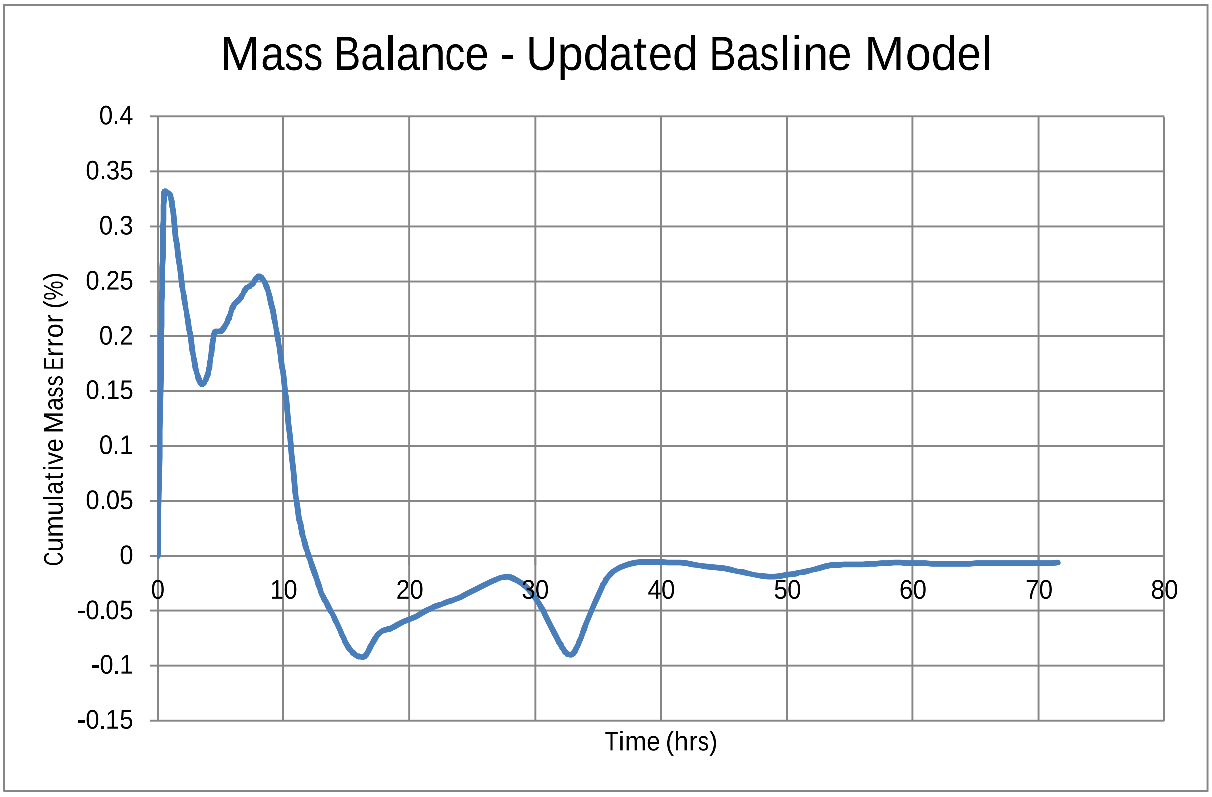



**Figure 4: Cumulative mass error plot for Updated Baseline Model**

7.4 The Proposed Arrangement Model was run with the same simulation parameters as the Updated Baseline Model (including the changes to time-steps). In addition, it was necessary to change the Matrix Dummy Coefficient from 0.0001 to 0.00001. The cumulative mass balance error was within the accepted 1% tolerance (see **Figure 5**).

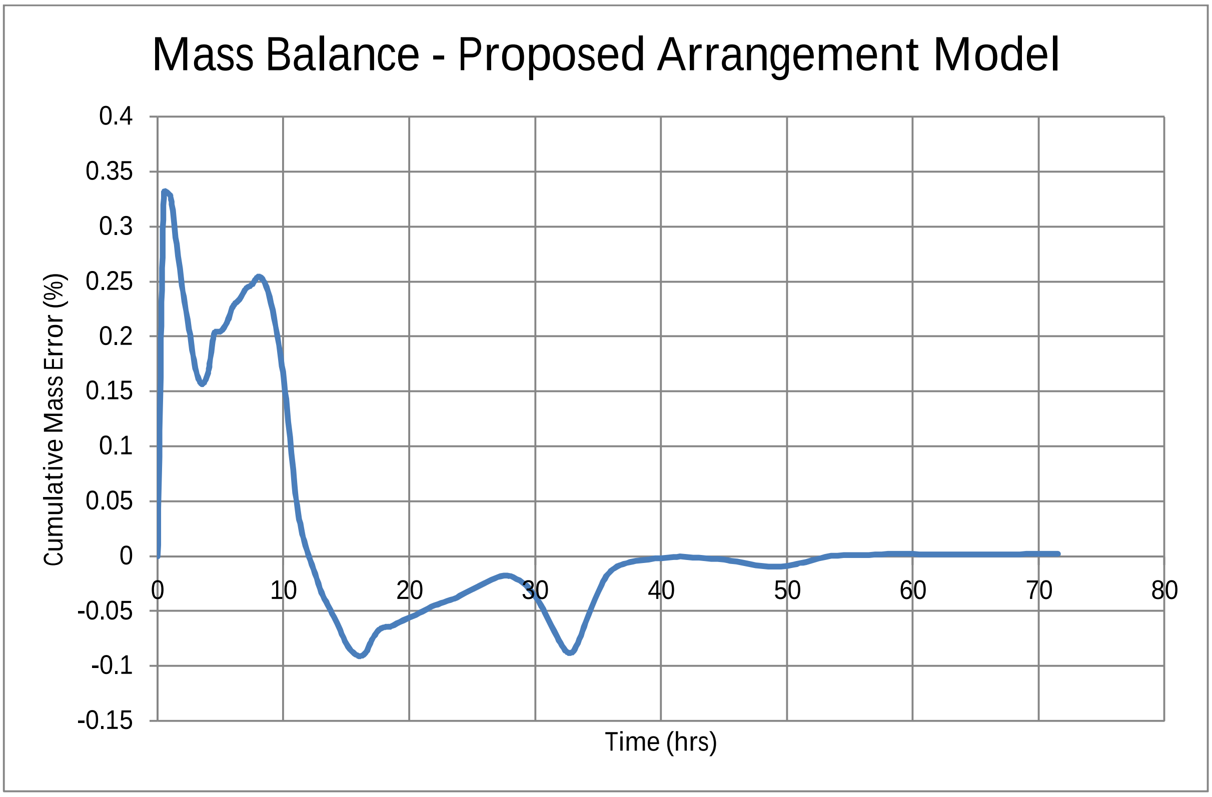



**Figure 5: Cumulative mass error plot for Proposed Arrangement Model**

7.5 Comparison of results between the Updated Baseline Model and the Proposed Arrangement Model has been undertaken as per previous reporting; a depth-difference map has been created (see **Figure 6)** as well as a point-inspection comparison, the results of which are presented in **Table 1**.

**Table 1: Comparison of point-based flood levels between the Updated Baseline Model and Proposed Arrangement Model (also refer to Figure 6)**

| Flood Assessment Point | 1% AEP event plus 50% climate change allowance | | |
|---|---|---|---|
| | Updated Baseline – Flood Level* (m AOD) | Proposed Arrangement – Flood Level* (m AOD) | Difference* (mm) |
| 1 | 53.08 | 53.08 | +10 |
| 2 | 53.15 | 53.16 | 0 |
| 3 | 53.07 | 53.07 | 0 |
| 4 | 52.56 | 52.57 | +10 |
| 5 | 53.05 | 53.05 | -10 |
| 6 | 51.81 | 51.84 | +30 |
| 7 | 52.45 | 52.48 | +30 |
| 8 | 50.46 | 50.43 | -40 |
| 9 | 50.33 | 50.33 | +10 |
| 10 | 50.31 | 50.29 | -10 |

*Note that differences are calculated from exact model results, whilst calculated levels are rounded to 2 decimal places

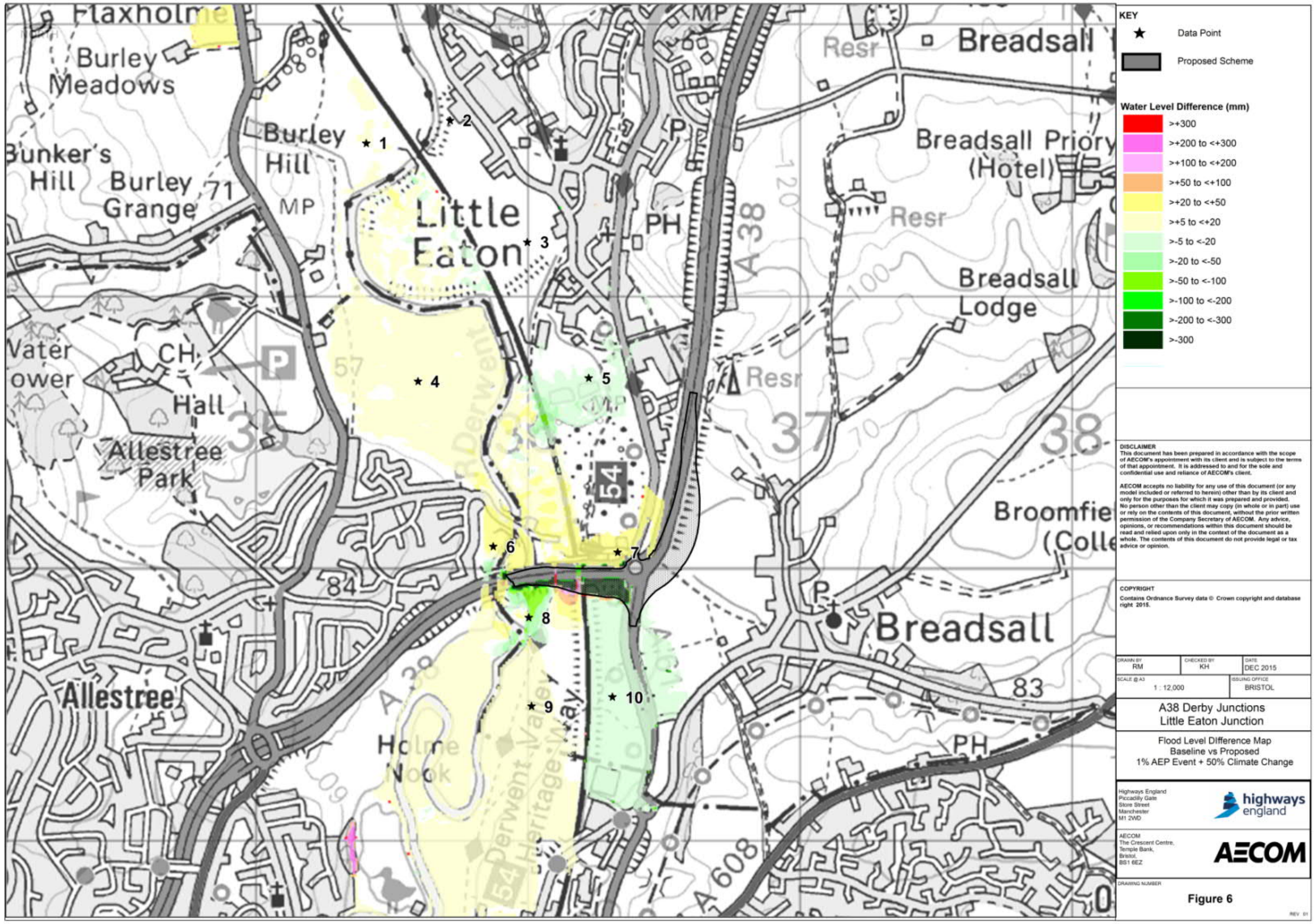



**Figure 6: Flood Level/ Depth Difference Map of Updated Baseline Model against Proposed Arrangement Model**

7.6 The results in **Table 1** show that for most locations, there would only be marginal changes to flood depths. These marginal changes (i.e. ±300mm) are considered to be within the tolerance of the model. As such, it is concluded that the proposed arrangement would not result in significant changes in flood risk that would require any mitigation strategies to be employed.

# 8 Floodplain Compensation

8.1 The Environment Agency reviewed the AECOM Technical Note results as submitted on 27 November 2017, with comments being provided on the 25 January and 2 February 2018. Environment Agency comments included a number of actions needed with regard to the modelling (as actioned herein), as well as concerns regarding the absence of floodplain compensation given that the proposed scheme would result in the removal of existing floodplain volume. Although modelling has shown that the proposed scheme would not have a significant impact on flood levels locally, the Environment Agency consider that floodplain compensation is required to mitigate against cumulative impacts of volumetric floodplain loss.

8.2 Given the above, an assessment of the volumetric loss in floodplain as a result of the proposed scheme was undertaken using the 2D grid representation of the resulting topography, as defined by the TUFLOW model. Volumetric losses were only calculated where there was an increase in existing ground levels, and there was flooding in the baseline (existing) scenario (for the 1% AEP event plus 50% climate change).

8.3 In practice, floodplain compensation is preferably provided on a level-for-level basis. Since floodplain compensation works cannot be provided immediately adjacent to the proposed scheme, an alternative location was identified downstream of the A38, within the right bank floodplain (refer to **Figure 7**). The following approach to calculating the volumetric loss was applied:

- Calculated volumetric losses below flood levels at 4-hour intervals throughout 1% AEP event plus 50% climate change;
- Calculated equivalent flood level for the same 4-hour intervals at the location of proposed compensatory works; and
- Determined the required volume to be provided between these flood level intervals.

8.4 Essentially, the approach used time as a proxy for level in determining the form of the compensation works. **Table 3** summarises the outcome of the assessment.

**Table 3: Required compensatory volumes based on time, and the levels between which they need to be provided at the proposed compensatory works location**

| Time (hours) | Cumulative Volume Required ($m^3$) | Interval Volume Required ($m^3$) | Lower Level (m AOD) | Upper Level (m AOD) |
|---|---|---|---|---|
| 8 | 0 | 0 | n/a | 49.59 |
| 12 | 18 | 18 | 49.59 | 49.73 |
| 16 | 405 | 386 | 49.73 | 49.79 |
| 20 | 609 | 205 | 49.79 | 49.82 |
| 24 | 873 | 264 | 49.82 | 49.85 |
| 28 | 1,320 | 447 | 49.85 | 49.88 |
| 32 | 5,339 | 4,019 | 49.88 | 49.93 |
| 40 | 12,439 | 7,099 | 49.93 | 50.19 |
| 44 | 12,909 | 471 | 50.19 | 50.39 |
| Max | 12,995 | 86 | 50.39 | 50.42 |

8.5 Based on this information, a ground modification exercise was undertaken utilising the same LiDAR data as used in the hydraulic model. The exercise sought to determine how the proposed area of compensatory works could be amended to provide the required interval volumes (as per **Table 3**). An additional consideration was that the land to be modified would need to retain a slope that would enable the landowner to retain the use of farm vehicles. The outcome of this was that there was significant over provision of required volume at the majority of intervals. There was some under provision at the higher flood levels, but the overall cumulative volume provided would be greater than that required - this is demonstrated in Table 4.

**Table 4: Comparison of required and provided compensatory volumes**

| Time (hours) | Cumulative Volume Required ($m^3$) | Cumulative Volume Provided ($m^3$) | Variation ($m^3$) | Lower Level (m AOD) | Upper Level (m AOD) |
|---|---|---|---|---|---|
| 8 | 0 | 4,291 | +4,291 | n/a | 49.59 |
| 12 | 18 | 5,619 | +5,601 | 49.59 | 49.73 |
| 16 | 405 | 5,913 | +5,508 | 49.73 | 49.79 |
| 20 | 609 | 6,484 | +5,875 | 49.79 | 49.82 |
| 24 | 873 | 7,056 | +6,183 | 49.82 | 49.85 |
| 28 | 1,320 | 7,627 | +6,087 | 49.85 | 49.88 |
| 32 | 5,339 | 8,374 | +3,035 | 49.88 | 49.93 |
| 40 | 12,439 | 10,853 | -1,586 | 49.93 | 50.19 |
| 44 | 12,909 | 12,760 | -149 | 50.19 | 50.39 |
| Max | 12,995 | 13,304 | +309 | 50.39 | 50.42 |

8.6 The proposed compensatory works were represented in a version of the proposed model using a z-shape, which applied a TIN in which contour lines representing the proposed ground profile were enforced as break lines. The resulting grid was checked to confirm that the z-shape had been applied correctly.

8.7 This model was run and it was found that there was negligible impact on flood levels as a result. The depth-difference map, shown in **Figure 7**, indicates that aside from the increased depths where the flood compensatory works would be located, there is generally an improvement in flood risk compared to the proposed arrangement model without compensatory work (i.e. no difference compared to baseline). Peak flood levels at the sample locations, in comparison to the baseline scenario, were as per the results presented in **Table 1**.

8.8 It is, therefore, concluded that the proposed compensatory works are appropriate from a flood risk viewpoint and would mitigate against cumulative impacts of floodplain loss.

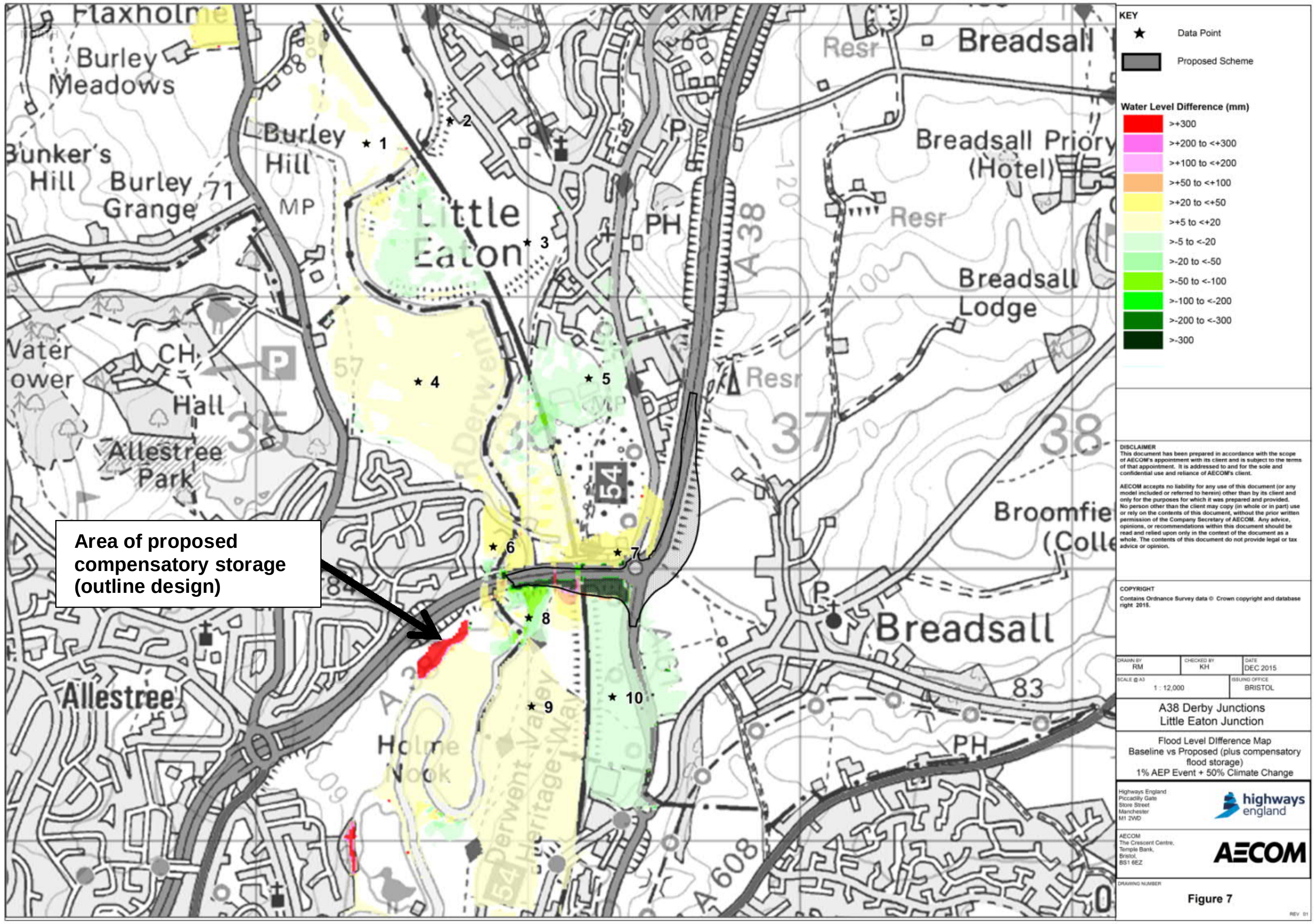



**Figure 7: Flood Level/ Depth Difference Map of Updated Baseline Model against Proposed Arrangement Model (with outline compensatory storage)**

# 9 Conclusions

***Modelling***

9.1 The existing baseline model has been updated with new channel survey, and refined in response to comments received from the Environment Agency and associated external reviewers. The updated baseline model is considered to be an improvement, and a suitable basis upon which the impacts resulting from the proposed scheme could be assessed.

9.2 The proposed arrangement model has been developed to include a suitable representation of the proposed scheme, and the resulting model outputs have been compared against the updated baseline results.

***Flood Risk***

9.3 The results of the modelling indicate that the proposed scheme would not result in any significant increase in flood risk, and that all localised increases in flood levels are within the model tolerances.

9.4 The Environment Agency stated that there should be no increase in flood levels to any of the properties located to the north of the proposed scheme on the western fringe of Little Eaton. The depth-difference maps confirm that this is the case.

***Flood Compensation***

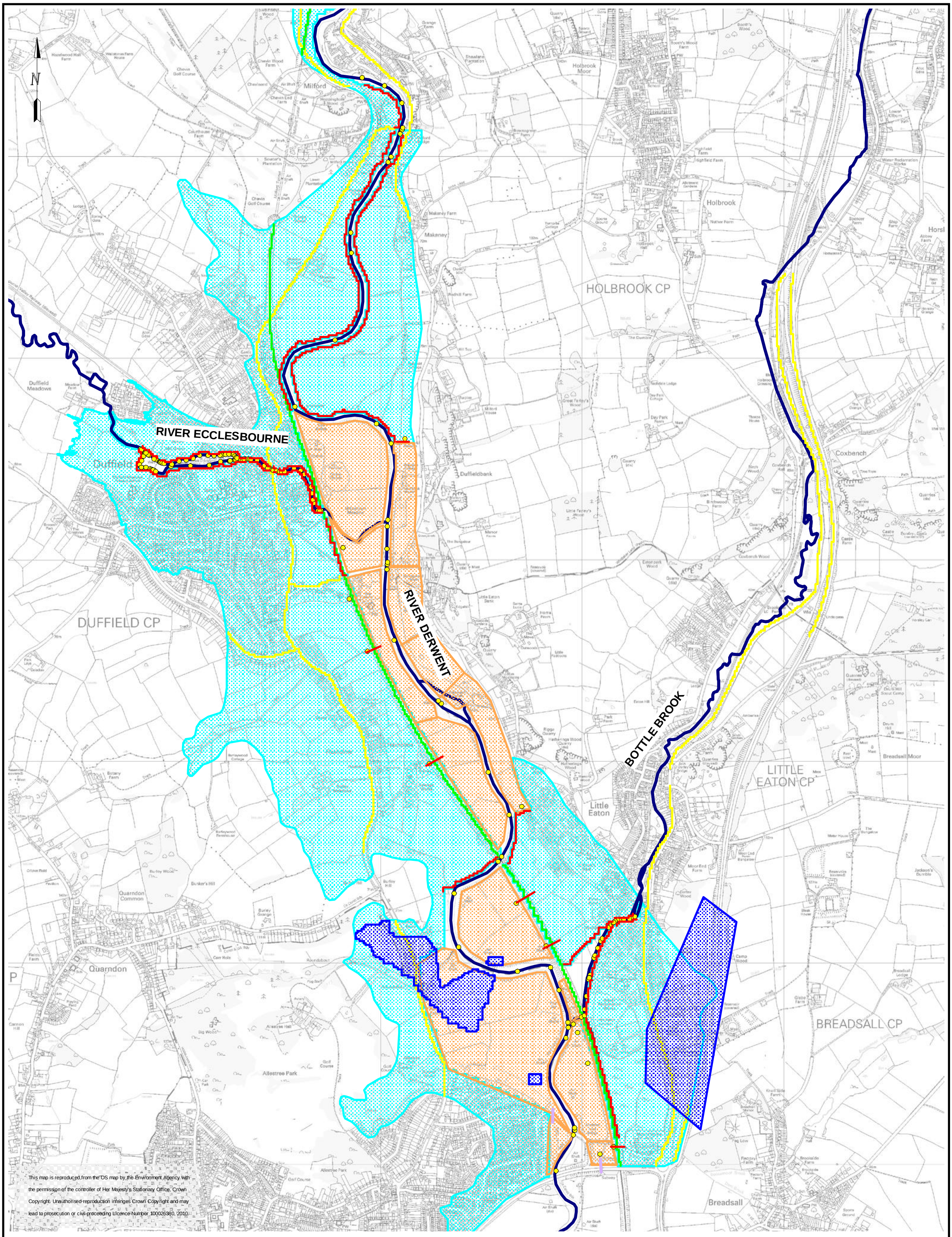
9.5 Whilst flood levels have been found to be acceptable for the proposed scheme, there would still be a volumetric loss in floodplain. The total area of land being raised is approximately 13,500m$^2$ with ground levels increasing from between 49.0m AOD - 49.5m AOD to 57.0m AOD. In terms of floodplain volumes, it has been estimated that approximately 13,000m$^3$ would be lost below existing flood levels.

9.6 The Environment Agency considers that floodplain compensation is required to mitigate against cumulative impacts of volumetric floodplain loss.

9.7 Provision of such compensatory storage volume could be achieved by re-profiling the floodplain downstream of the A38, on the right bank of the River Derwent. The outline proposals for ground re-profiling have been designed in such a way as to enable continued operation of farm vehicles and to avoid removing existing trees. The outline ground profiling proposals would over-provide the required volumes at lower flood levels, and although there would be some under-provision at higher flood levels, the overall volume provided would be in excess of that required during a 1% AEP event plus 50% climate change allowance. The modelling results obtained indicate that the outline compensatory works would be appropriate from a flood risk viewpoint and mitigate against cumulative impacts of floodplain loss. The outline ground re-profiling proposals may be subject to alteration during further design stages, noting that the model will need to be amended as such to confirm that the proposals continue to provide appropriate level-for-level compensatory volume, and do not increase flood risks elsewhere.

9.8 We request that the Environment Agency review the details as presented herein and pass comment as to whether the proposed outline flood mitigation strategy and the residual flood risks are acceptable.

**Appendix A: Extract from the Lower Derwent PAR – Hydraulic Modelling Report (Black & Veatch, July 2010)**




## Key

- Tuflow Domain - HXE
- Railway - ZLN
- Road - ZLN
- ISIS Nodes
- LiDAR Correction Layer - ZSH
- ISIS Reservoir Units
- ISIS TUFLOW Join - HXI
- Grid Correction Layer - ZPLG
- ISIS Floodplain Culverts
- Main River

**Lower Derwent PAR**
**Hydraulic Modelling Report**

## Model Layers

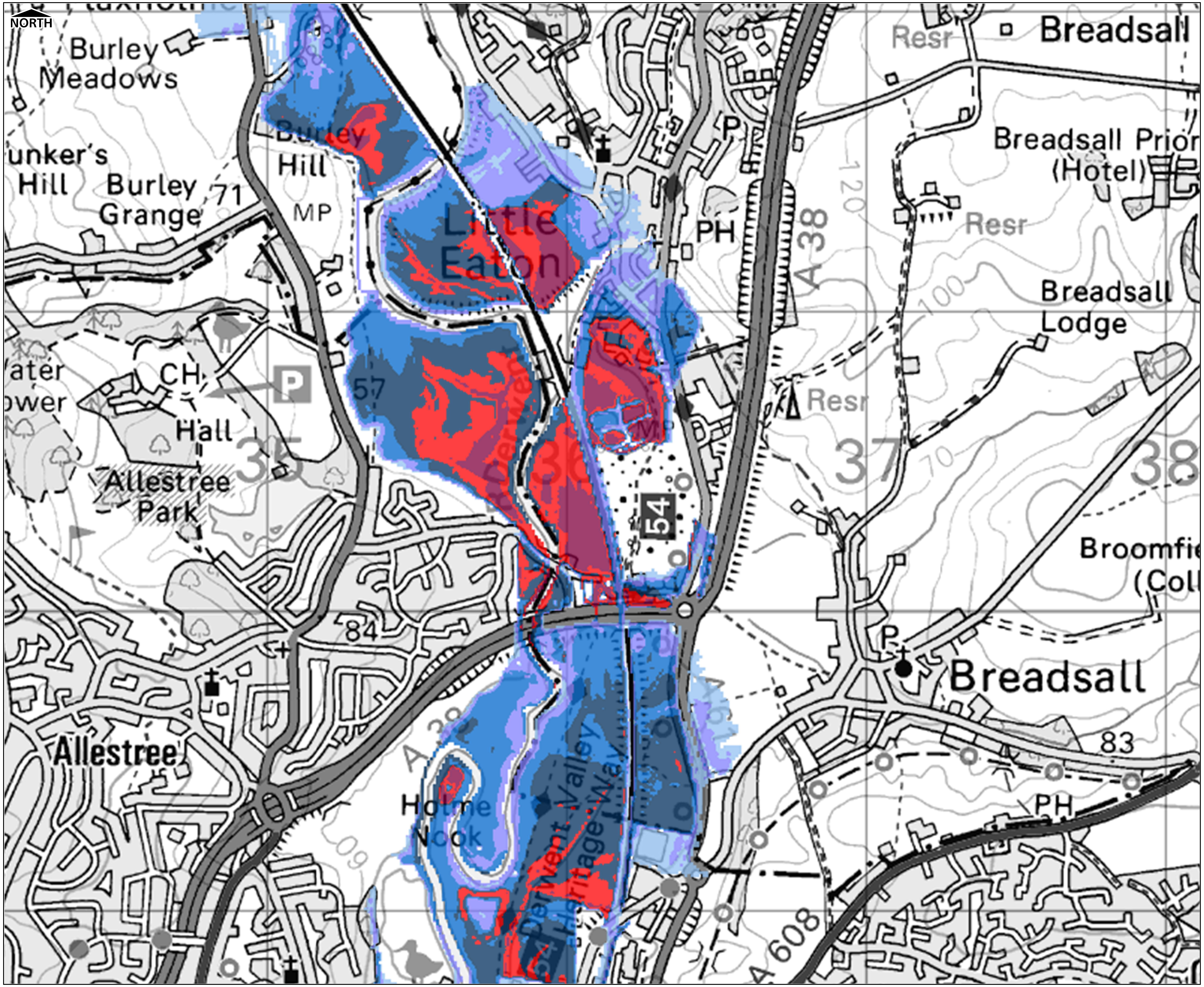
Environment Agency

| | | | | | |
|---|---|---|---|---|---|
| Scale: 1:17,500 (at A3) | Contract No: 108907 | Designed: NG | Date: July 2010 | | |
| Date: July 2010 | Drawing No.: Figure 3.1 | Checked: MDR | Date: July 2010 | | |
| BLACK & VEATCH | ROYAL HASKONING | Drawn: NG | Date: July 2010 | | |
| | | Checked: TPMP | Date: July 2010 | | |



P:\108907 Lower Derwent\MapInfo\Modelling Layers\Report Figures\3d Lines.wor - NG - CHE - July 2010 - (c)BVCs

# Appendix C Fluvial Modelling Flood Depth Maps




**KEY**

Maximum Flood Depth (m)

- 0m - 0.50m
- 0.50m - 1.00m
- 1.00m - 1.50m
- 1.50m - 2.00m
- 2.00m - 2.50m
- >2.50m

**TECHNICAL NOTE**



| DRAWN BY | CHECKED BY | DATE |
|---|---|---|
| RM | KH | DEC 2018 |

| SCALE @ A3 | ISSUING OFFICE |
|---|---|
| 1 : 12,000 | BRISTOL |

A38 Derby Junctions
Little Eaton Junction

Flood Depth Map
Existing Scenario
1% AEP Event + 50% Climate Change

Highways England
Floor 5
2 Colmore Square
38 Colmore Circus
Birmingham
B4 6BN

highways england

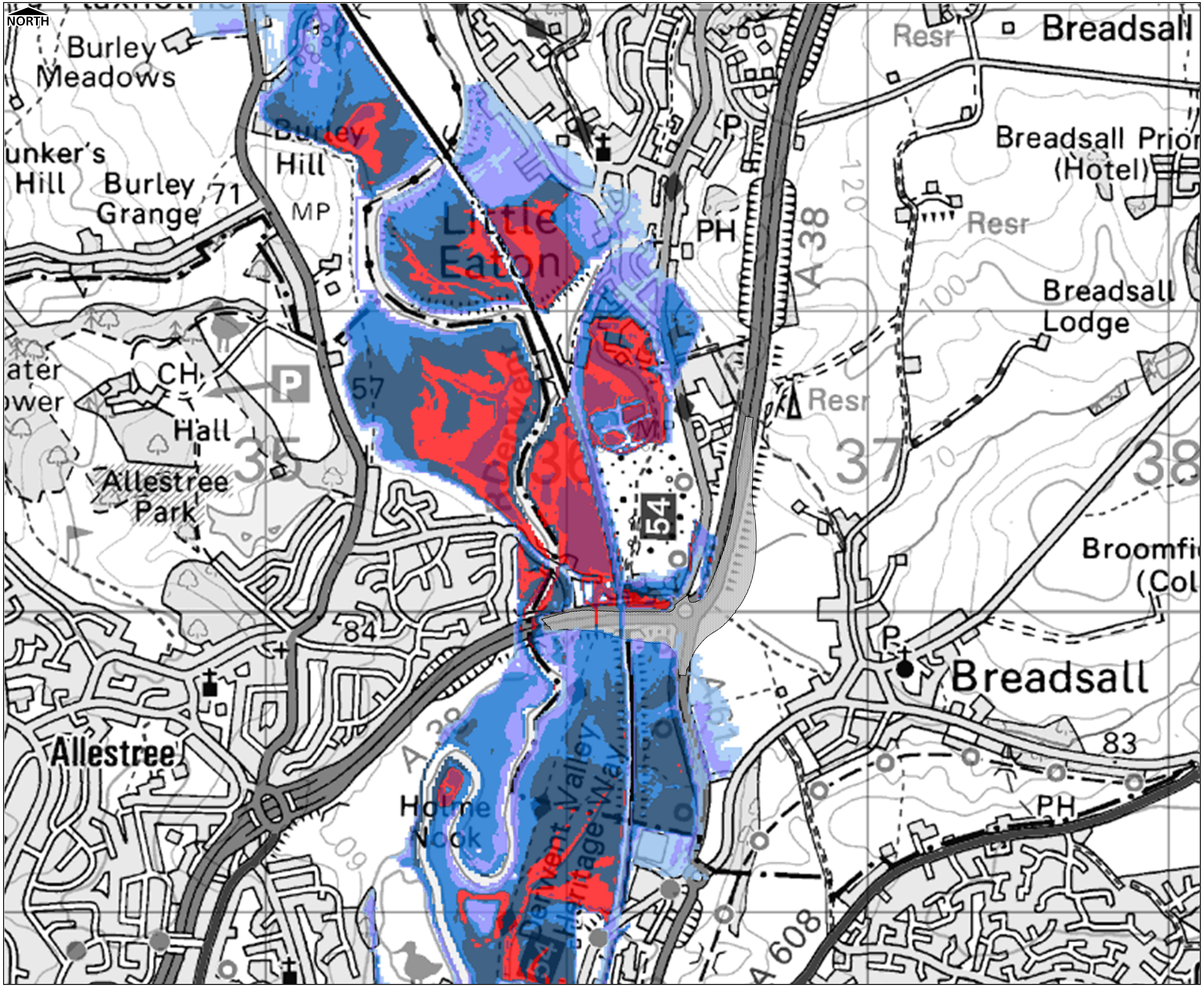
AECOM
The Crescent Centre,
Temple Bank,
Bristol,
BS1 6EZ

AECOM

DRAWING NUMBER

**Appendix C1**

REV 01




**KEY**

Proposed Scheme

Maximum Flood Depth (m)

- 0m - 0.50m
- 0.50m - 1.00m
- 1.00m - 1.50m
- 1.50m - 2.00m
- 2.00m - 2.50m
- >2.50m

**TECHNICAL NOTE**



| DRAWN BY | CHECKED BY | DATE |
|---|---|---|
| RM | KH | DEC 2018 |

| SCALE @ A3 | ISSUING OFFICE |
|---|---|
| 1 : 12,000 | BRISTOL |

A38 Derby Junctions
Little Eaton Junction

Flood Depth Map
Proposed Scenario
1% AEP Event + 50% Climate Change

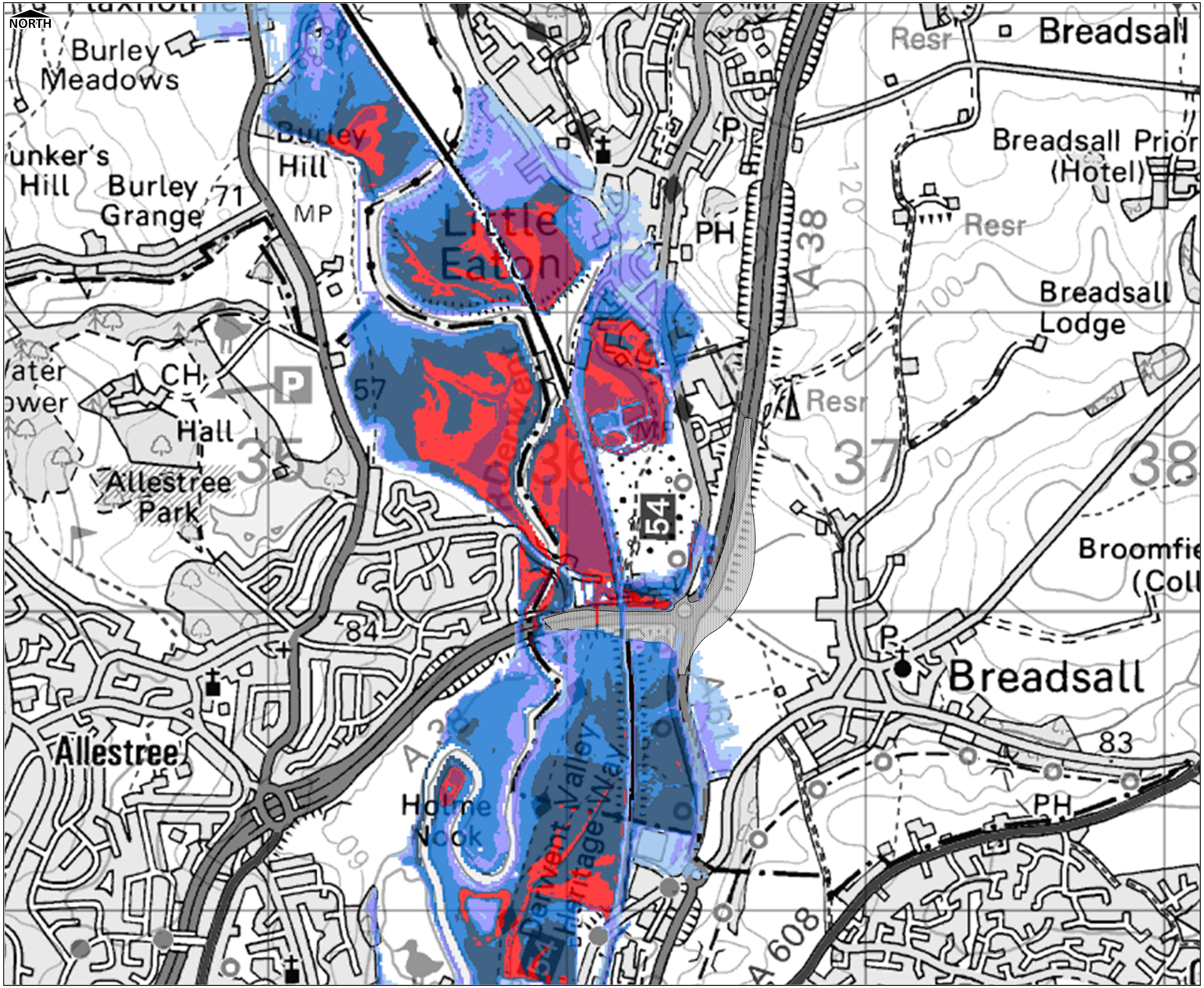
Highways England
Floor 5
2 Colmore Square
38 Colmore Circus
Birmingham
B4 6BN

AECOM
The Crescent Centre,
Temple Bank,
Bristol,
BS1 6EZ

DRAWING NUMBER

**Appendix C2**

REV 01




**KEY**

| | |
|---|---|
| | Proposed Scheme |

Maximum Flood Depth (m)

| | |
|---|---|
| | 0m - 0.50m |
| | 0.50m - 1.00m |
| | 1.00m - 1.50m |
| | 1.50m - 2.00m |
| | 2.00m - 2.50m |
| | >2.50m |

**TECHNICAL NOTE**

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|---|---|
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A38 Derby Junctions
Little Eaton Junction

Flood Depth Map
Proposed Scenario + Compensatory Storage
1% AEP Event + 50% Climate Change

Highways England
Floor 5
2 Colmore Square
38 Colmore Circus
Birmingham
B4 6BN

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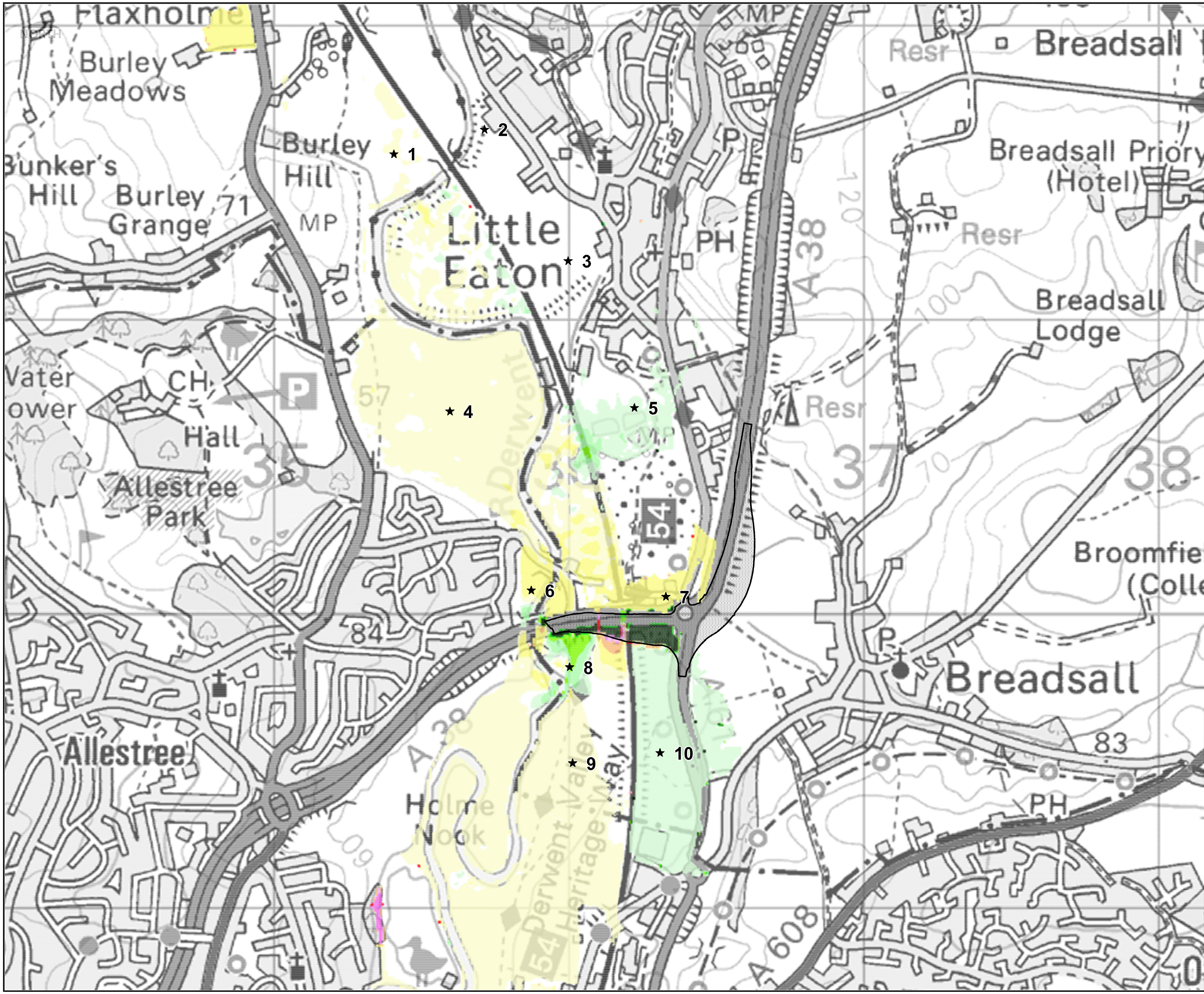
Temple Bank,
Bristol,
BS1 6EZ

DRAWING NUMBER

**Appendix C3**

REV 01




KEY

★ Data Point

Proposed Scheme

**Water Level Difference (mm)**

- >+300
- >+200 to <+300
- >+100 to <+200
- >+50 to <+100
- >+20 to <+50
- >+5 to <+20
- >-5 to <-20
- >-20 to <-50
- >-50 to <-100
- >-100 to <-200
- >-200 to <-300
- >-300



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|---|---|
| 1 : 12,000 | BRISTOL |

A38 Derby Junctions
Little Eaton Junction

Flood Level DIfference Map
Baseline vs Proposed
1% AEP Event + 50% Climate Change

Highways England
Floor 5
2 Colmore Square
38 Colmore Circus
Birmingham
B4 6BN

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Bristol,
BS1 6EZ

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**Appendix C4**

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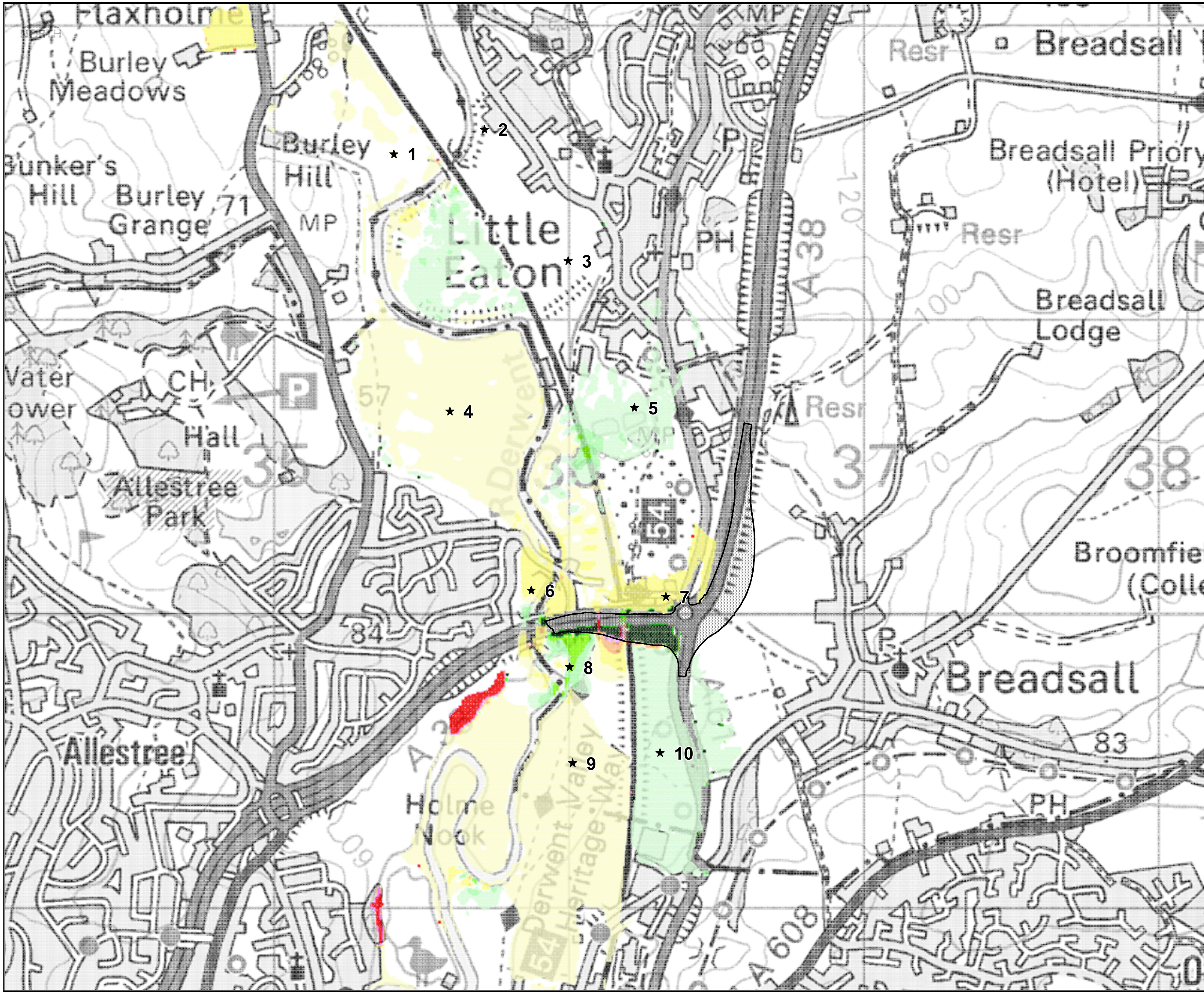


**KEY**

★ Data Point

Proposed Scheme

**Water Level Difference (mm)**

- >+300
- >+200 to <+300
- >+100 to <+200
- >+50 to <+100
- >+20 to <+50
- >+5 to <+20
- >-5 to <-20
- >-20 to <-50
- >-50 to <-100
- >-100 to <-200
- >-200 to <-300
- >-300



| DRAWN BY | CHECKED BY | DATE |
|---|---|---|
| RM | KH | DEC 2018 |

| SCALE @ A3 | ISSUING OFFICE |
|---|---|
| 1 : 12,000 | BRISTOL |

A38 Derby Junctions
Little Eaton Junction

Flood Level DIfference Map
Baseline vs Proposed (plus compensatory flood storage)
1% AEP Event + 50% Climate Change


Highways England
Floor 5
2 Colmore Square
38 Colmore Circus
Birmingham
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BS1 6EZ

AECOM


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**Appendix C5**

REV 01

# Appendix D Surface Water Modelling Technical Note

| | | |
|---|---|---|
| **Project Name:** | A38 Little Eaton Junction | |
| **AECOM Project Number:** | 60533462 | |
| **Title:** | Little Eaton Surface Water Modelling Technical Note | |
| **Date:** | 05th February 2019 | |
| **Author:** | William Madge/ Fiona Ryall | Consultant/ Graduate Consultant |
| **Reviewer:** | Katie Pearson | Associate |
| **Approver:** | Simon Wild | Regional Director |

# 1. Introduction

This technical note outlines the methodology used to produce a surface water flood model for the Dam Brook ordinary watercourse, located east of the proposed A38 Little Eaton scheme near Breadsall, Derby (Figure 1-1).

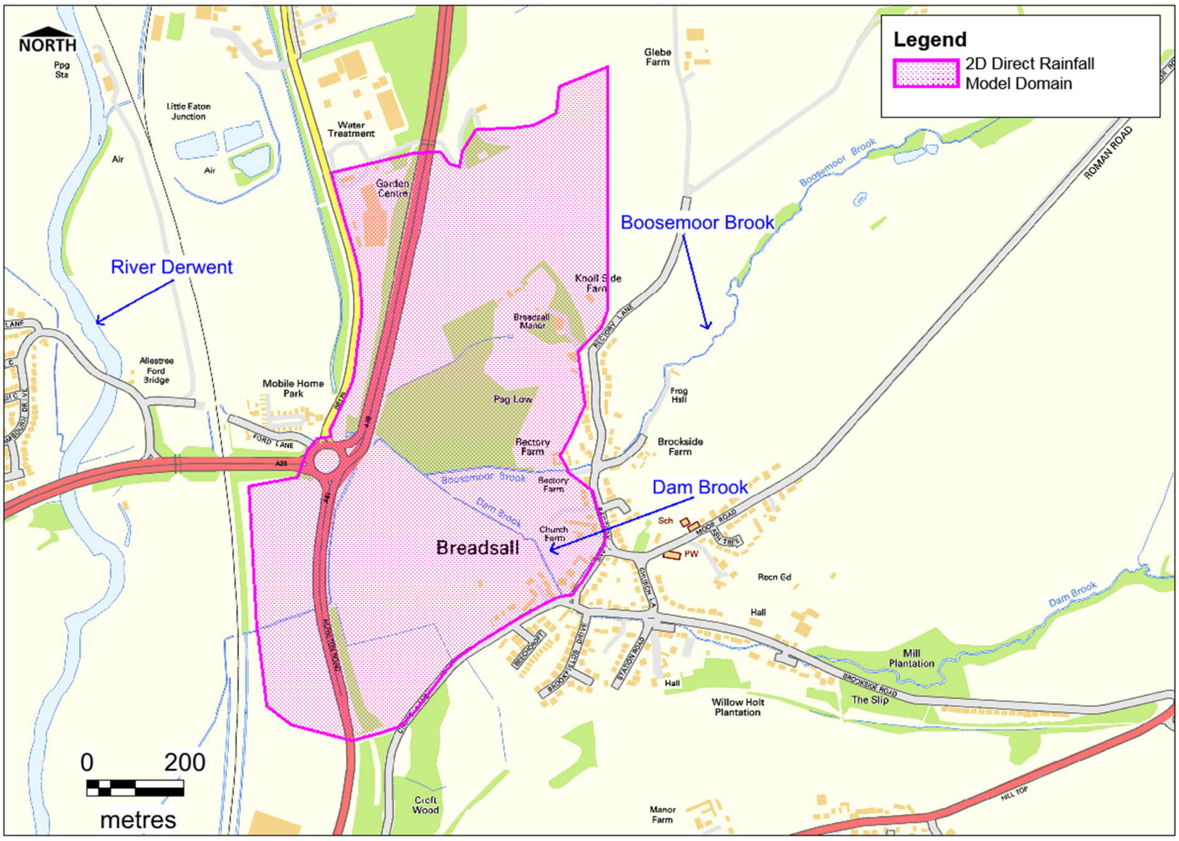


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**Figure 1-1: Study Area**

The aim of this work is to understand the risks of surface water flooding to and resulting from the Scheme, by undertaking direct rainfall modelling of the upstream catchment area. In particular, the following points have been addressed:

- Assessment of an area identified as posing a high risk of surface water flooding within the Scheme boundary;

- Assessment of an area proposed to be used for temporary spoil storage during Scheme construction; and
- Recommendation of mitigation measures.

# 2. Data Collection

## 2.1. Site Walkover

A site walkover was undertaken by AECOM in June 2018 to undertake site observations of critical assets and identify key hydrological features within the study area. This included identification of structures, such as the small 500mm diameter culvert conveying surface water runoff beneath the existing A38 alignment, downstream of Breadsall Manor (Figure 2-1).


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**Figure 2-1: Culvert beneath Existing A38 Alignment**

## 2.2. Topography

A topographic survey was undertaken as part of the Scheme and has been used to determine the unnamed watercourse channel and culvert alignments in the model. It should be noted that no detailed watercourse cross sections or bank top survey were provided, though topographic spot points were used to inform channel bed elevations, culvert diameters and invert levels.

Floodplain levels were informed by open source LiDAR data, despite sparse coverage of 1m and 2m DTMs (Figure 2-2). In order to utilise the most accurate and available data, both 1m and 2m LiDAR DTMs were merged to define the 2D model domain (with the 1m resolution data taking precedent where applicable).

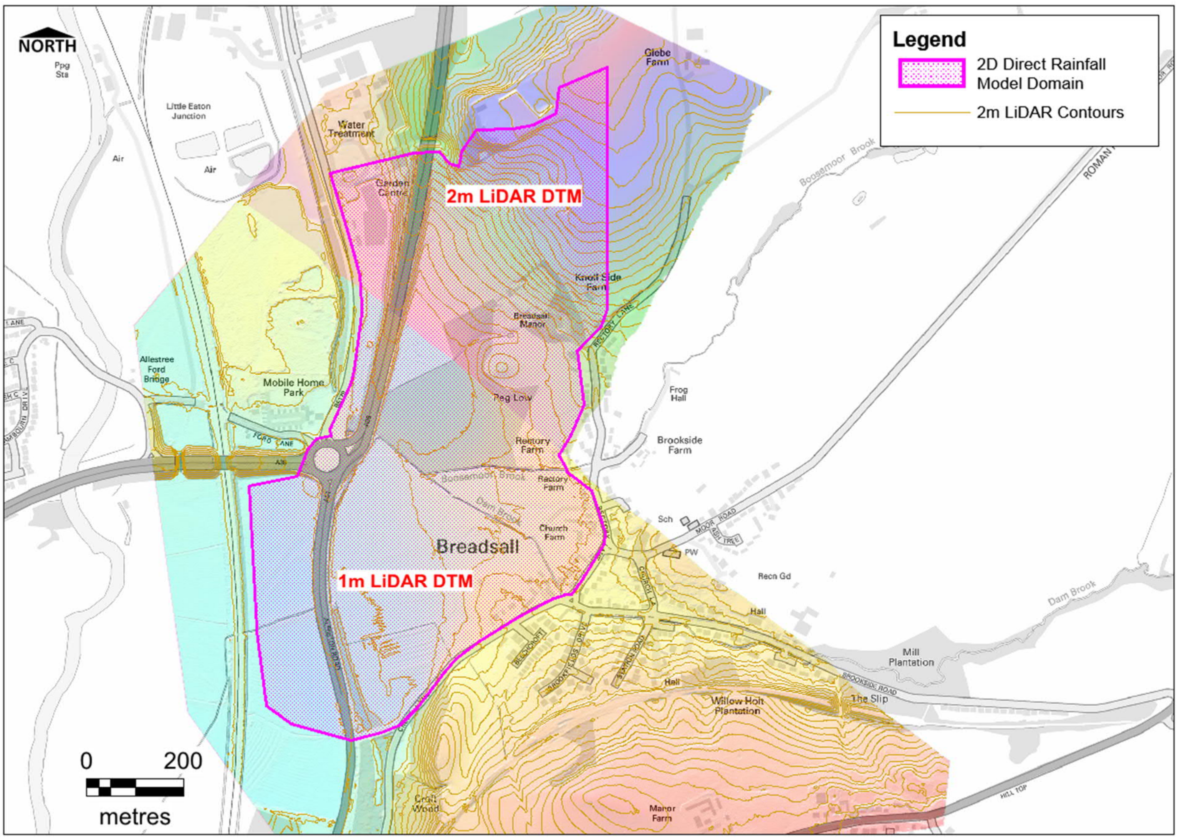


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**Figure 2-2: LiDAR Coverage in Study Area**

# 3. Hydrological Analysis

## 3.1. Introduction

Two Flood Estimation Points (FEPs) were selected based on the locations that would represent upstream boundary conditions for the Dam Brook and Boosemoor Brook watercourses. Catchment descriptors were downloaded from the Flood Estimation Handbook (FEH) Web Service to inform the hydrological analysis (Figure 3-1).

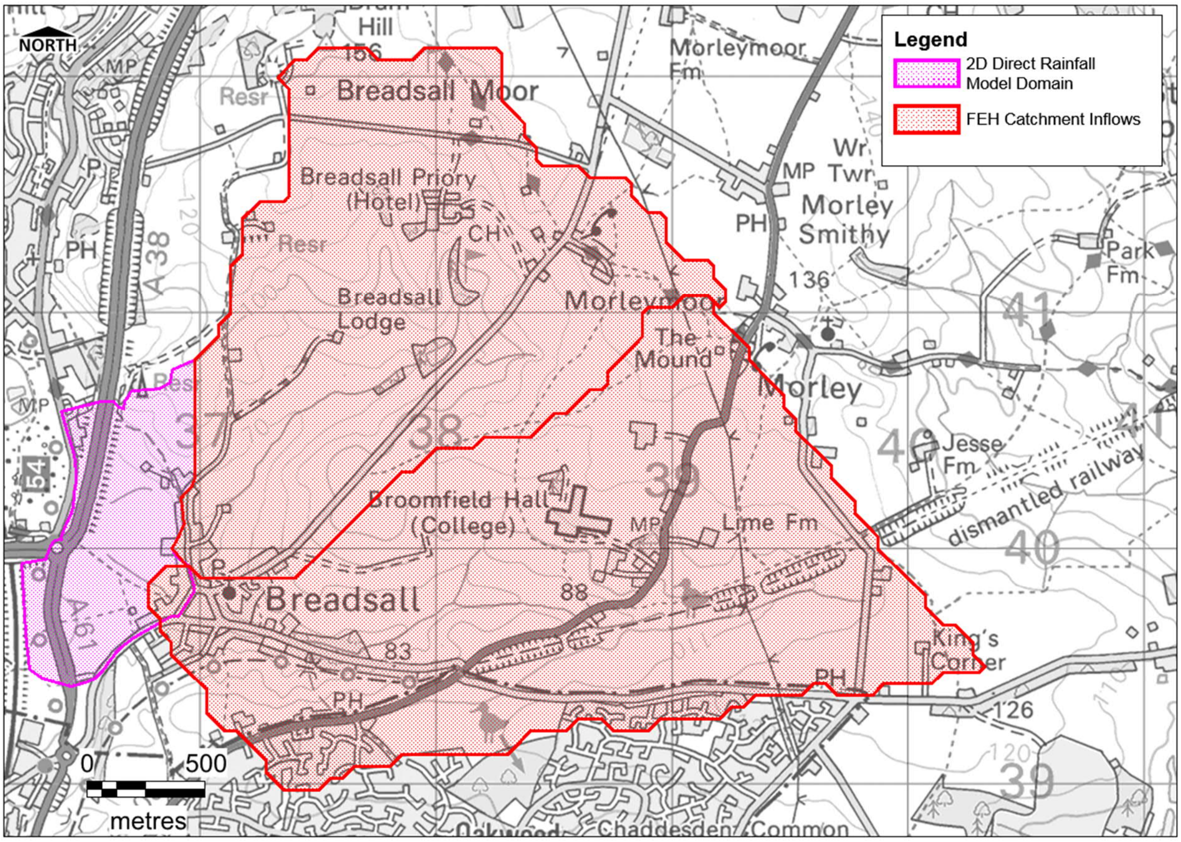


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**Figure 3-1: Catchment Areas and Model Extent**

## 3.2. Choice of Method for FEPs

The FEH Statistical and ReFH2 methodologies were undertaken to generate flow estimates at the two FEPs, which were defined by the following key catchment characteristics (Table 3-1).

**Table 3-1: FEH Catchment Descriptors**

| Catchment Descriptor | Dam Brook FEP | Boosemoor Brook FEP |
|---|---|---|
| CATCHMENT X | 436800 | 436650 |
| CATCHMENT Y | 339850 | 339950 |
| AREA ($km^2$) | 3.73 | 2.96 |
| DPLBAR (km) | 2.26 | 1.81 |
| DPSBAR ($m\ km^{-1}$) | 52.40 | 68.30 |
| URBEXT (2000) | 0.07 | 0.00 |

There were no suitable donor stations available to improve peak flows estimated by the FEH Statistical methodology, through QMED adjustment or enhanced single site analysis. Additionally Table 3-1 shows that the Dam Brook catchment is urbanised (URBEXT>0.03), so ReFH2 urban hydrographs could be expected to represent improved routing of surface water through the catchment to the FEP.

In summary, and to provide a consistent approach across all FEPs, ReFH2 urban hydrographs were used to represent upstream boundary conditions for the Dam Brook and Boosemoor Brook watercourses.

## 3.3. Design Rainfall Profiles

LiDAR analysis was undertaken to define watershed boundaries and thus determine the intermediate catchment areas that also drain towards the existing and proposed A38 alignments. Although open source LiDAR coverage is relatively sparse in the area, catchment delineation was not limited, and sufficient coverage of contributing catchment areas was achieved (Figure 2-2).

Once the 2D model domain had been defined the domain area and location was compared against the already captured FEP catchment descriptors. It was concluded that the Boosemoor Brook catchment descriptors were representative of the intervening catchment, and so the ReFH2 urban design rainfall profiles were extracted and applied as total direct rainfall across the 2D model domain using 2d_rf polygons.

OS MasterMap data was used to differentiate between 2d_rf polygons, both in terms of spatial extent and also by application of discrete interception ratios to each polygon (Table 3-2).

**Table 3-2: Interception Ratios**

| OS MasterMap Description | Interception Ratio |
|---|---|
| Natural surface | 0.50 |
| Inland water | 1.00 |
| Structure | 0.90 |
| Scrub | 0.50 |
| Multiple surface (garden) | 0.50 |
| Road | 0.90 |
| Railway | 0.35 |
| Manmade surface or step | 0.80 |
| Nonconiferous trees | 0.20 |
| Coniferous trees | 0.20 |
| Path or track | 0.75 |
| Building | 0.90 |
| Unclassified (or broken) | 0.50 |
| Orchard | 0.20 |
| Marsh reeds or saltmarsh | 0.20 |

# 4. Little Eaton Surface Water Flood Model

## 4.1. Model Software

A 2D only direct rainfall model was built using TUFLOW software (TUFLOW_2016_03_AE-w64.exe) to assess the impact of the existing and proposed A38 alignments on surface water runoff within the Dam Brook catchment.

## 4.2. Model Extent and Schematisation

The Little Eaton surface water flood model accounts for flows generated throughout the Dam Brook and Boosemoor Brook catchments, including intervening catchment areas, and extends to the downstream side of the existing A38 alignment (Figure 3-1).

The model comprises a single 2D domain with a grid resolution of 2m. This is a suitable resolution considering the average watercourse channel width, available LiDAR data and the need to work with practical model run times. The Little Eaton surface water model has a total simulation duration of 20hrs.

The existing watercourse channels and culverts are schematised in the 2D domain using levels picked up in the topographic survey (Figure 4-1).

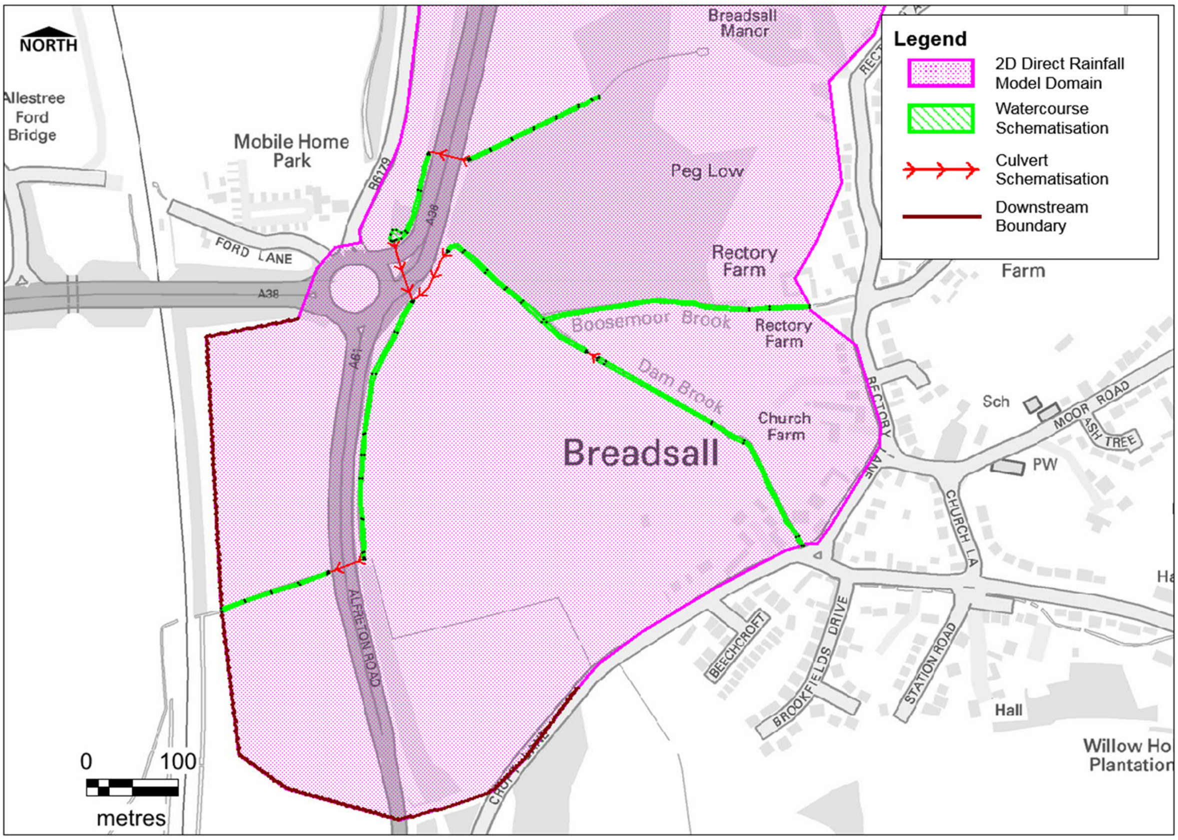


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**Figure 4-1: Model Schematisation**

Although the general watercourse alignment and gradient could be estimated from the available drawings, it was not possible to provide a detailed representation of in-channel capacity or conveyance in the absence of detailed watercourse survey. 2d_zshp files were used to define the channel bed elevations in the model; these were read from the available topographic spot levels and then interpolated between those values. Channel bank elevations were read in from the underlying LiDAR DTM.

## 4.3. Roughness Coefficients

Manning's n roughness values were assigned based on OS MasterMap feature codes. In addition to the interception ratios discussed in Section 3.3, this provided a detailed representation of rainfall runoff response within the study area.

## 4.4. Boundary Conditions

Upstream boundary conditions for Dam Brook and Boosemoor Brook were applied at the eastern edge of the 2D model domain using 2d_bc layers. Hydrograph inflows to each watercourse were generated by the hydrological analysis undertaken as part of this study (Section 3).

Initially it was considered whether rising levels on the River Derwent in flood would affect the ability of floodwater to drain out of the study area, and whether this should be represented in the downstream boundary of the model. However, considering the size of the study catchment compared to the River Derwent catchment, it is reasonable to assume that a peak flood flow on Dam Brook is unlikely to coincide with a peak flood flow on the River Derwent.

For a 4.5h duration rainfall event, the Little Eaton surface water flood model has a total simulation duration of 20 hrs and a peak flow at 5.25 hrs during the 1% AEP + 50% climate change event. The critical storm duration for the River Derwent is significantly longer and in the River Derwent the total simulation time is 72 hrs with a peak flow at 44.5 hrs in vicinity of the study area. Analysis of the River Derwent model results shows that floodwater begins backing up underneath the railway line at approximately 14 hrs, significantly later than the modelled peak flow on Dam Brook. Even at a simulation time of 20 hrs, flood levels on the River Derwent would not be high enough to result in locking of the downstream boundary and backing up of floodwater into the red line boundary (**Error! Reference source not found.**).

To consider potential interaction between the floodplain of the River Derwent and the smaller surface water catchments to the east, the 2D domain of the existing River Derwent model was expanded to include the Dam Brook catchment. The inclusion of the Dam Brook in the Derwent model shows an apparent increase in flood volumes in places where water could not flow, as it was outside the model extents. Depths upstream of the proposed A38 alignment were reduced, while a marginal increase in flood depths downstream of the proposed highway was also noted. These differences appear to be relatively minor and are the result of changes to the hydraulics of the system brought about through expansion of the model extents.

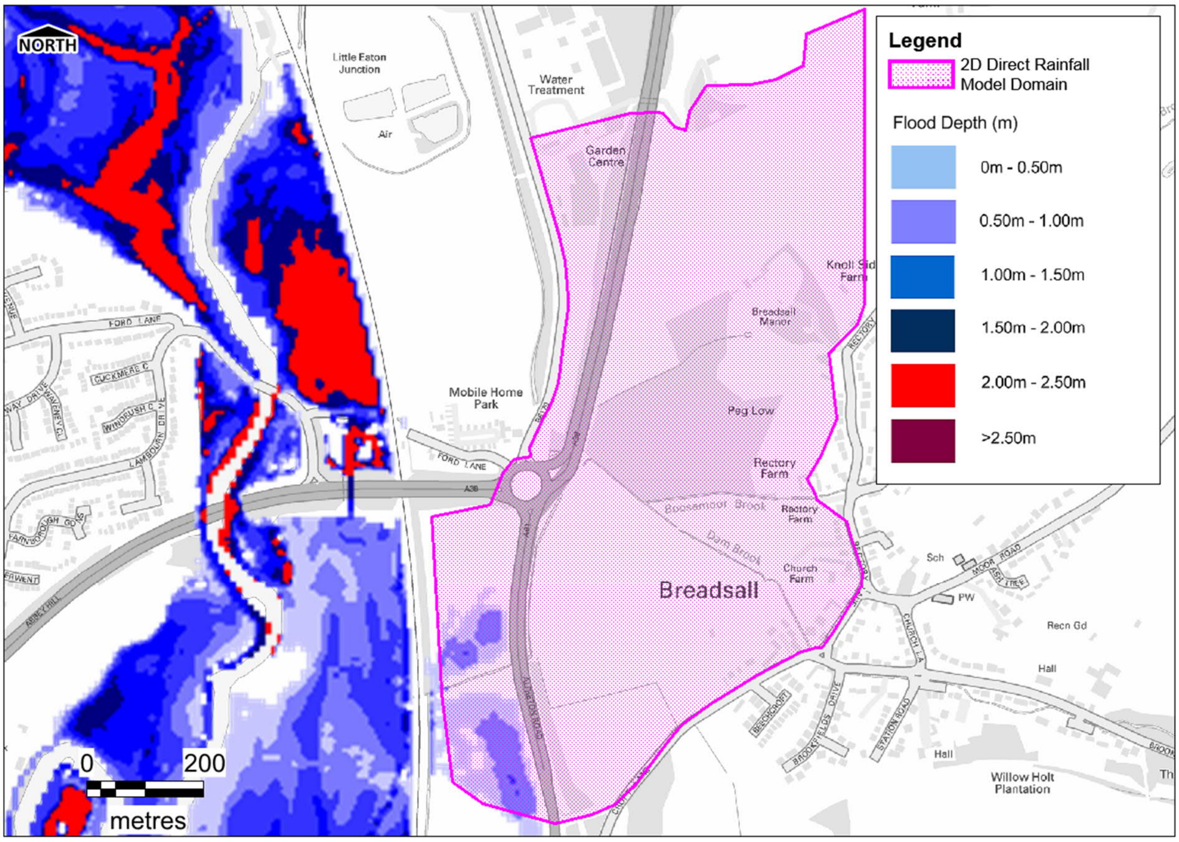


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**Figure 4-2: River Derwent Flood Depths at t=20 hrs, Proposed Scenario, 1% AEP + 50% Climate Change**

Therefore, a 2d_bc HQ boundary based on the channel bed gradient was used as the model downstream boundary.

## 4.5. Model Stability

The TUFLOW 2D Mass Balance output (Cumulative Mass Error %) mostly remains within +/-1% for all simulations, which is considered the normal criteria for a 'healthy' model. An exception would be for the first two hours of each simulation. However, this is not of concern because instability is often experienced at the start of direct rainfall model simulations, in response to the rapid wetting and drying of cells throughout the 2D domain.

# 5. Model Results

A number of model simulations were run for the baseline and proposed scenarios, but this technical note solely focusses on discussing the results associated with the 1% AEP + 50% climate change design flood event.

## 5.1. Existing Scenario

The baseline model highlights a significant attenuation of surface water runoff on the upstream face of the existing A38 alignment, downstream of Breadsall Manor (Figure 5-1). For reference, several point inspections are provided to illustrate the modelled depth of floodwater in vicinity of the Scheme boundary.

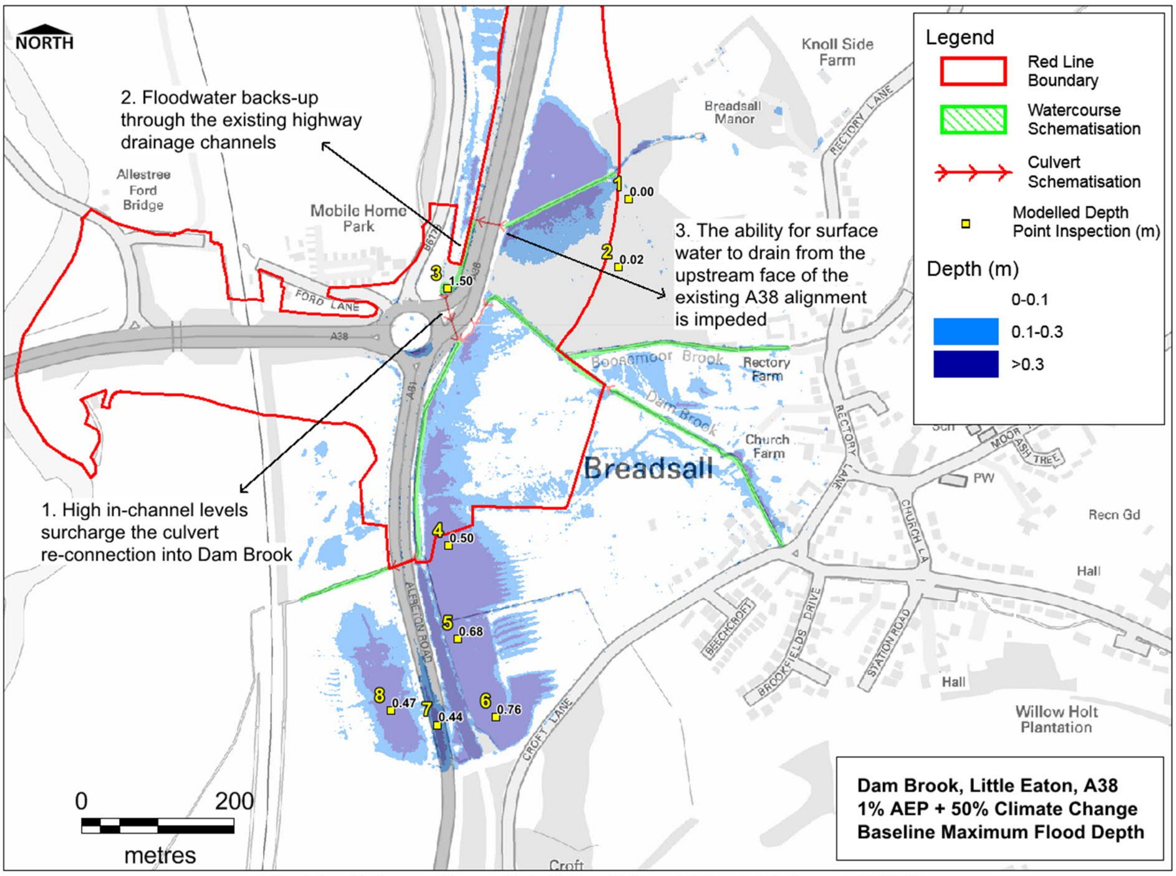

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**Figure 5-1: Dam Brook 1% AEP + 50% Climate Change Baseline Maximum Flood Depths**

Surface water attenuation appears to be predominantly caused by backing up of floodwater from the main Dam Brook channel. High in-channel flood levels are predicted to surcharge the culvert re-connection into Dam Brook, resulting in backing-up of floodwater through the existing highway drainage channels. The ability for surface water to drain from the upstream face of the existing A38 alignment is therefore impeded. The small diameter of the existing culvert in this location is also likely to cause a flow restriction (Figure 2-1).

The capacity of the main Dam Brook channel downstream of the Boosemoor Brook confluence is limited by the shallow bed gradient and the number of existing culvert structures. In times of flood, the model shows that the culvert structures surcharge, resulting in channel capacity exceedance and propagation of flow onto the floodplain. This mechanism contributes to a significant accumulation of surface water along the upstream face of Alfreton Road, to the south of the Scheme boundary. Once the available floodplain storage in this area is surpassed, floodwater overtops the existing embankment and flows across Alfreton Road, ponding in a depression immediately west of the highway.

## 5.2. Surface Water Management – Development of the Proposed Scenario

Between October 2018 and January 2019, the proposed design of surface water management measures has evolved, taking into account highway drainage, Water Framework Directive (WFD) requirements and ecological constraints which has been shown (see results below) to work in principle. A series of modelling tests has been undertaken to support the design evolution, but to aid clarity in the report, only the results of the final modelling scenario are reported in Section 5.3 of this report.

The existing culvert under the A38 would be retained for highway drainage of the proposed realigned roundabout and carriageway. Initially the proposals included an extension of this culvert in a straight line, between the two highway runoff attenuation basins to connect into the realigned Dam Brook channel. However, the invert level of the existing culvert outfall is 48.9m AOD and the proposed level of the realignment channel is 49.9m AOD. In order to provide a positive outfall in this location, the realignment channel levels would need to be reduced by at least 1m. Doing so would be detrimental to the morphological status of the channel and so this is not an option that has been tested in the model.

An alternative option to create a positive outfall was investigated with an extended culvert connecting into the base of the southernmost highway runoff attenuation basin. Whilst this option presented a viable gradient, the River Derwent hydraulic model simulations are shown to inundate the area north of the existing junction, before flowing through this culvert and into the study area (**Error! Reference source not found.**). It is therefore not possible to directly connect this culvert into an attenuation basin, due to the risk of fluvial inundation from the River Derwent. This flood mechanism would also require that highway drainage was adequately treated prior to entering the culvert.

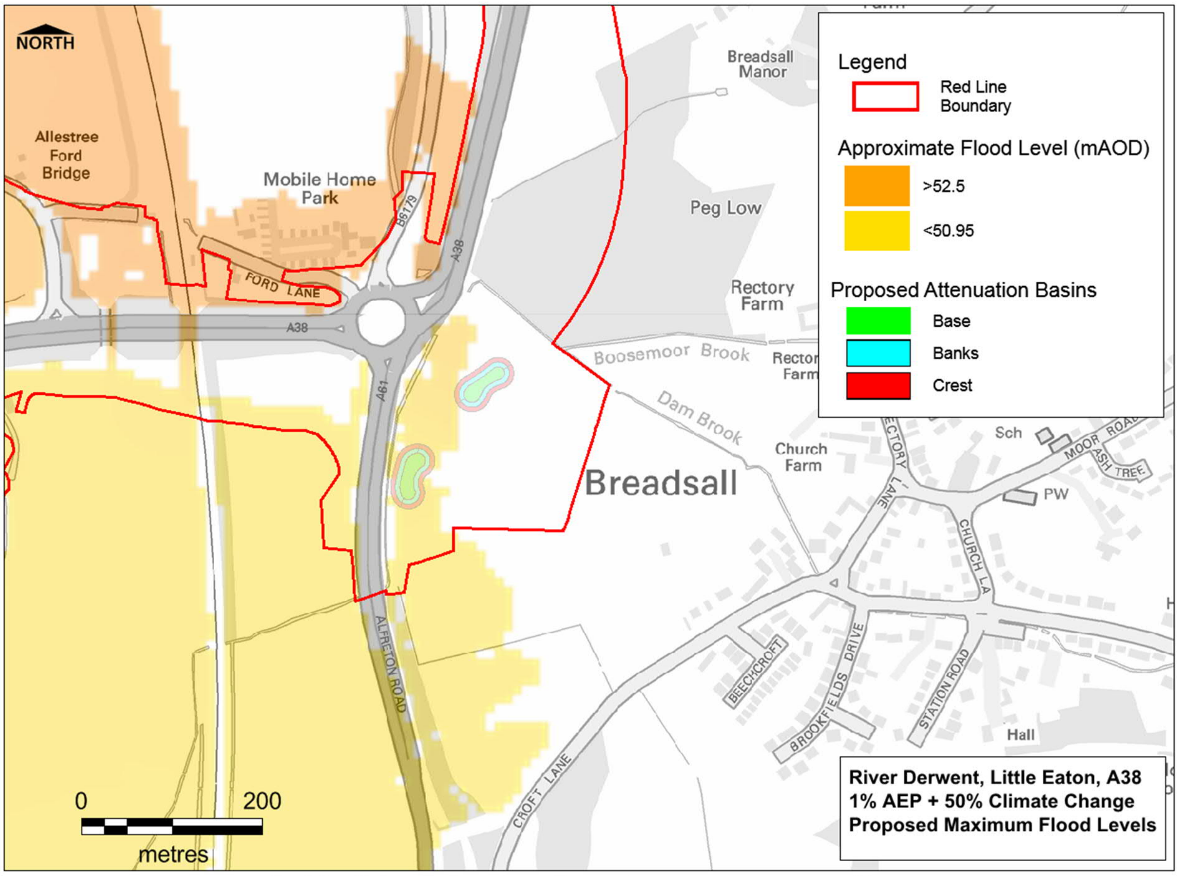


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**Figure 5-2: River Derwent 1% AEP + 50% Climate Change Maximum Flood Levels**

To reconcile the various topographic and hydraulic constraints, it was necessary to extend the existing culvert to connect into a new pond at the southernmost extent of the study area. This facilitates a positive outfall through the culvert to the pond, and from the pond back into the Dam Brook realignment channel. The culvert extension assumed an additional 209m of 900mm diameter pipe, with invert levels at the upstream and downstream faces of 48.90m AOD and 48.70m AOD, respectively.

## 5.3. Modelling of the Preferred Proposed Scenario

There are a number of elements to the Scheme design and surface water management measures for this junction which have the potential to influence or be influenced by surface water flood risk. For this reason, the hydraulic model has been modified to incorporate the Scheme design so that the potential impacts can be assessed and understood. To represent the Scheme design the 'proposed scenario' version of the hydraulic model includes representation of these design elements within the Scheme boundary (Figure 5-2):

- Realignment of the existing A38 Little Eaton junction into a new island and main line flyover;

*Proposed levels were supplied to the modelling team in .xyz format. Ztin polygons were created for both the main line and junction arrangements, then stamped onto the baseline DTM.*

- Construction of two runoff surface water attenuation basins to treat and attenuate highway drainage;

*Proposed drawings were supplied to the modelling team. Zshape polygons were created to represent the base, banks and crest levels of the proposed attenuation basins.*

- Extension of the existing culvert under the A38, which currently connects highway drainage channels (north of the island) to span the width of the proposed A38 alignment;

*The existing culvert geometry was supplied as part of the baseline topographic survey. No design levels for the proposed culvert extension were supplied, so an alignment that could satisfy the various topographic and hydraulic constraints was assumed (see below).*

- Watercourse realignment of Dam Brook to a new two-stage channel;

*Proposed design levels were supplied to the modelling team in zshape format. These design levels were copied into the "proposed" model.*

- Construction of new ecology ponds to replace habitat loss and provide floodwater storage.

*Proposed design levels were supplied to the modelling team in zshape format. These design levels were copied into the "proposed" model.*

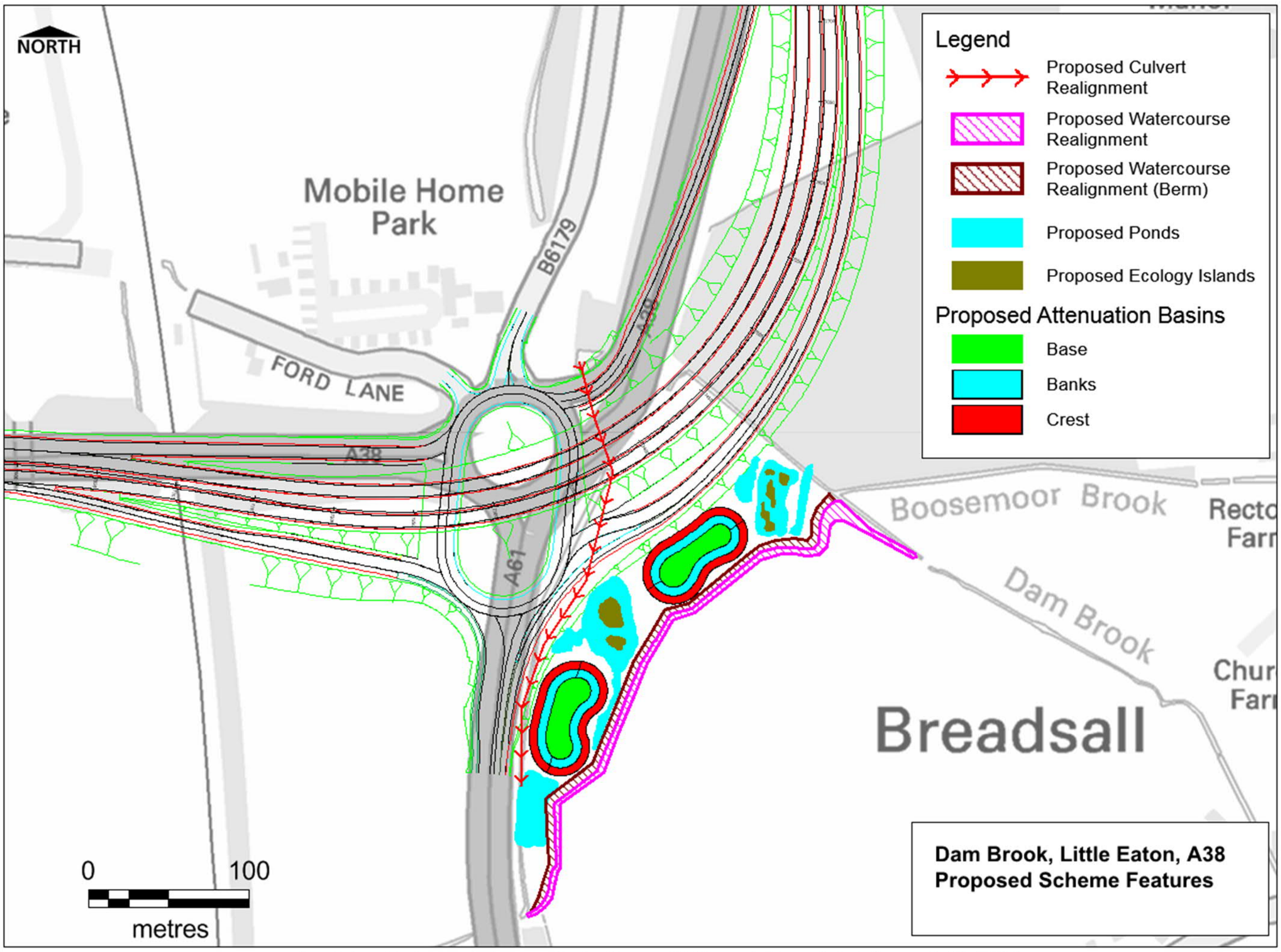


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**Figure 5-2: Proposed Scheme Features**

## 5.4. Model Results

The results of the hydraulic model with the Scheme design in place (as in Figure 5-2) are shown in Figure 5-3.

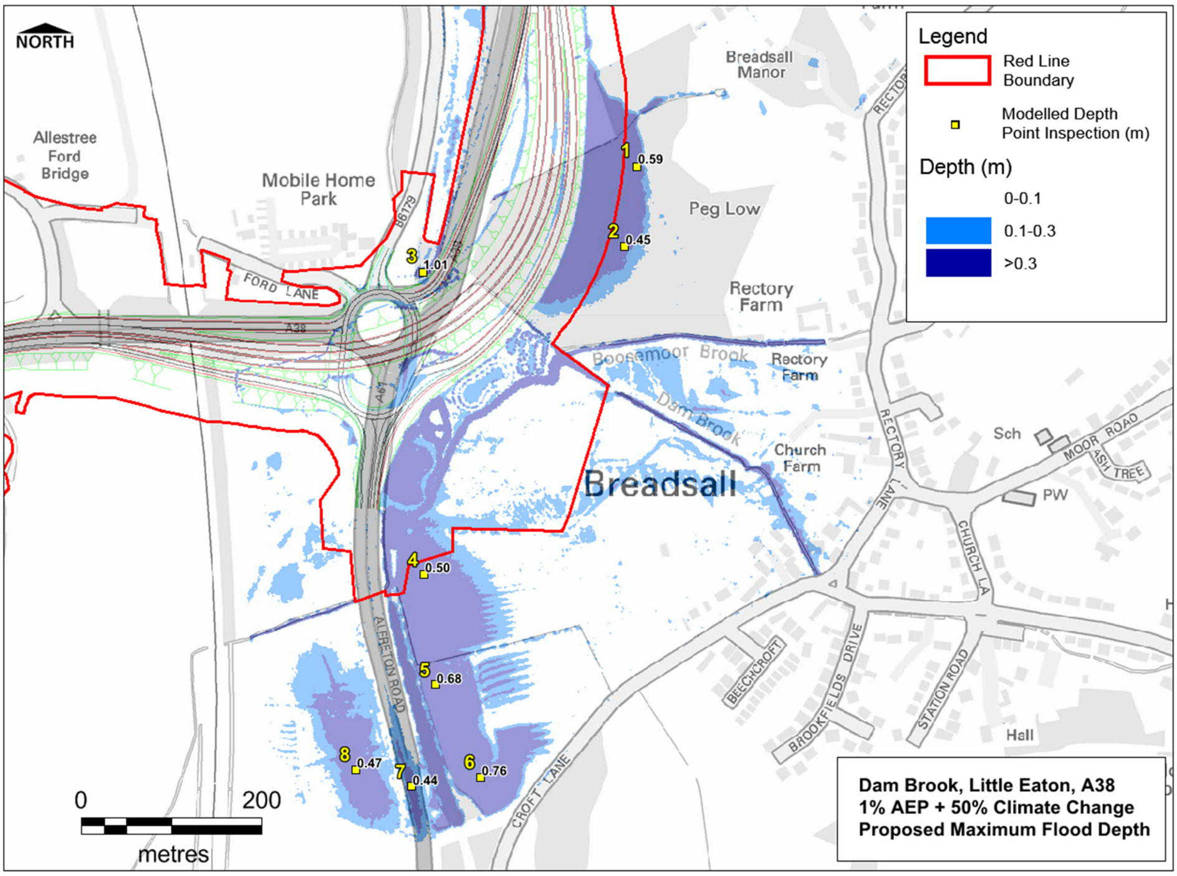


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**Figure 5-3: Dam Brook 1% AEP + 50% Climate Change Proposed Maximum Flood Depths**

Implementation of the proposed scheme features did not result in an increased risk of surface water flooding to areas south of the proposed A38 alignment. However, attenuation of surface water on the upstream face of the proposed embankments, beneath Breadsall Manor, resulted in an increased risk of flooding outside of the red line boundary. Mitigation options to resolve this issue were subsequently investigated (Section 5.5).

Additionally, the model indicated overtopping and inundation of the southernmost proposed attenuation basin during a 1% AEP + 50% climate change design event. The design team were consulted to determine whether this basin could be re-located, however this was not deemed viable at this stage of the project due to other constraints governing the highway drainage design. Mitigation options to resolve this issue were subsequently investigated (Section 5.5).

## 5.5. Mitigation Measures

Implementation of the Scheme features resulted in unacceptable impacts within and outside of the Scheme boundary. The two identified issues were resolved through iterative and model testing of potential mitigation measures as detailed below.

**Surface Water Flooding Downstream of Breadsall Manor**

Numerous model iterations were undertaken to resolve the surface water flooding impacts downstream of Breadsall Manor associated with an unnamed watercourse. This included modelling of a flood alleviation channel to connect the existing surface water flow paths directly into Dam Brook; the orientation, layout, levels and connections into Dam Brook were varied between model runs to maximise available storage. However, an alleviation channel alone did not provide sufficient storage within the Scheme boundary. Similarly, a new culvert under the proposed A38 alignment, combined with the existing A38 culvert and drainage channel arrangement, also did not provide enough capacity. Ultimately, a combined solution comprising both new culverts and a flood alleviation channel was tested and resulted in a positive outcome (refer to Figure 5-4).

In order to accommodate an alteration to the design of the proposed A38 alignment, it was necessary to culvert a previously open section of channel of the unnamed channel (see Figure 5-5). This section (approximately 14m in length) is located to the north of the proposed island, west of the main line alignment. The removal of the short open channel allows the connection of the new 600mm culvert (under the proposed main line alignment) with the existing culvert which carries flow beneath the A61.

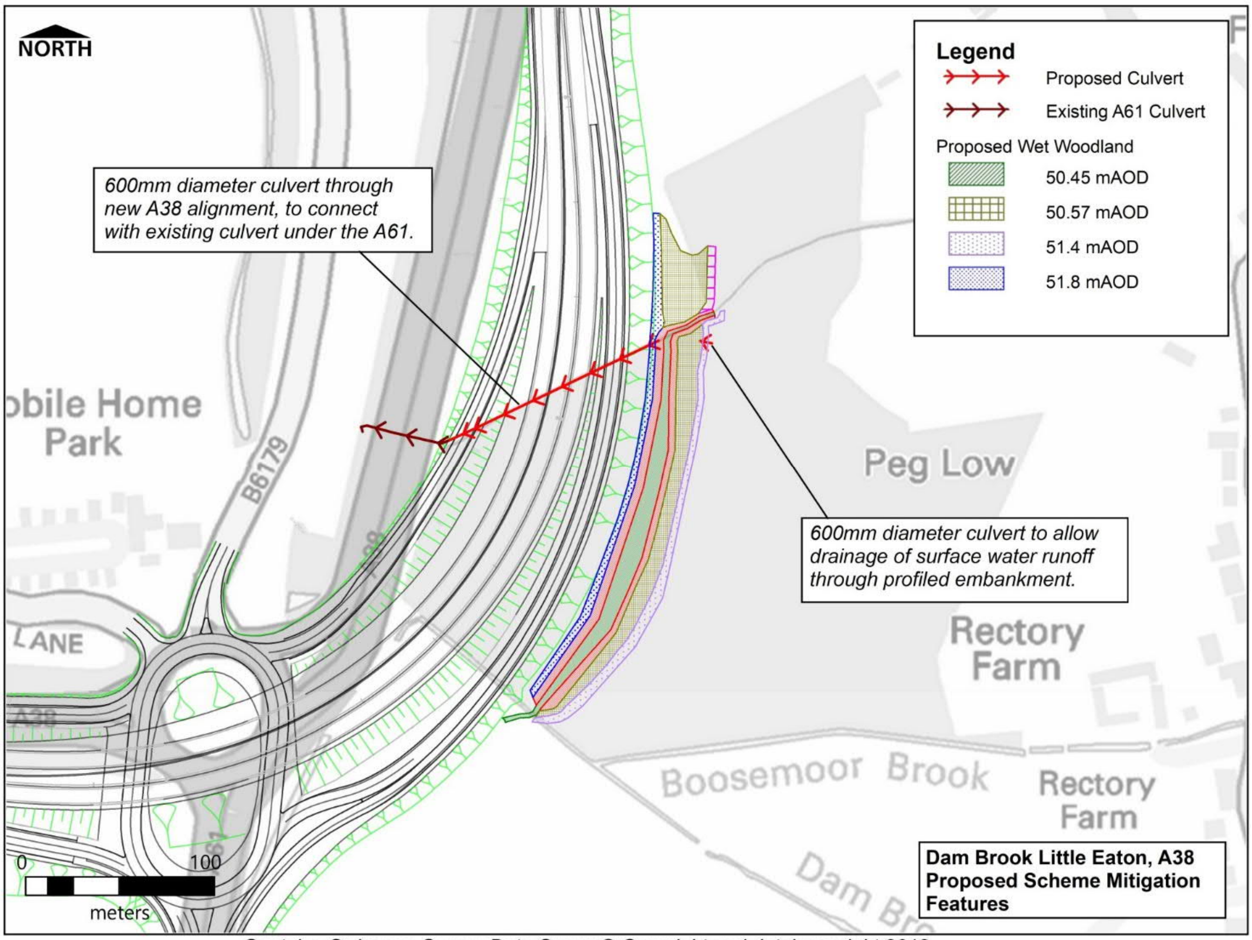


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**Figure 5-4: Proposed Scheme Mitigation Features**

The identified solution required:

- **A multi-staged flood alleviation channel:**
  - The AECOM ecology team were consulted on a suitable arrangement, because the potential for installation of a new wet woodland habitat was identified in this area.
- **Two new 600mm diameter culverts:**
  - The 600mm diameter culvert under the new A38 alignment was required to alleviate storage capacity issues during the 1% AEP + 50% climate change scenario.
  - The invert level was raised above the flood alleviation channel bed to 50.90 mAOD. This was chosen to allow regular filling of the channel during typical, frequent storm events, which would be required to best support a wet woodland habitat.
  - Both culverts were modelled with a flap valve, to prevent backing-up of floodwater through the system.
- **Raising of ground levels along the proposed A38 embankment toe to 51.80 mAOD**:
  - This would alleviate loading of floodwater against the embankment and could also help to achieve a more favourable cut-fill balance.
- **Change in layout of the ecology ponds to create a positive outfall for the realignment channel:**
  - The proposed ecology ponds were re-positioned to accommodate the open channel and swale alignment. The addition of open channel length means that overall bank length exceeds the 'existing + >50%' requirement outlined by the WFD. The ecology team were consulted, and the same proposed bank length for water vole habitat was maintained, together with pond bases that would be flush with the realigned Dam Brook channel bed. To sustain populations of fish such as the lamprey, the ponds are to have connectivity with the Dam Brook, acting as backwaters.

**Southernmost Attenuation Basin Inundation**

Similarly, multiple model simulations were undertaken to resolve the issues of surface water attenuation basins flooding from overtopping of the proposed crest levels. The two main constraints in this area were the maximum flood levels modelled on Dam Brook (50.95 mAOD) and the maximum flood levels modelled on the River Derwent (50.45 mAOD); these levels were established from the water height grids of each respective model. In order to prevent inundation of the southernmost highway runoff attenuation basin and provide a small degree of freeboard, it was necessary to raise the crest levels at the perimeter of each pond from 50.35 mAOD to 51.00 mAOD.

The proposed model was adapted to include all listed mitigation measures and then run as a "proposed mitigation" scenario. Additionally, an area of approximately 13,000$m^2$ was raised to simulate the temporary storage of spoil within the study area during the Scheme construction phase (Figure 5-5). For reference, a number of point inspections are provided to illustrate the modelled depth of floodwater in vicinity of the development proposals.

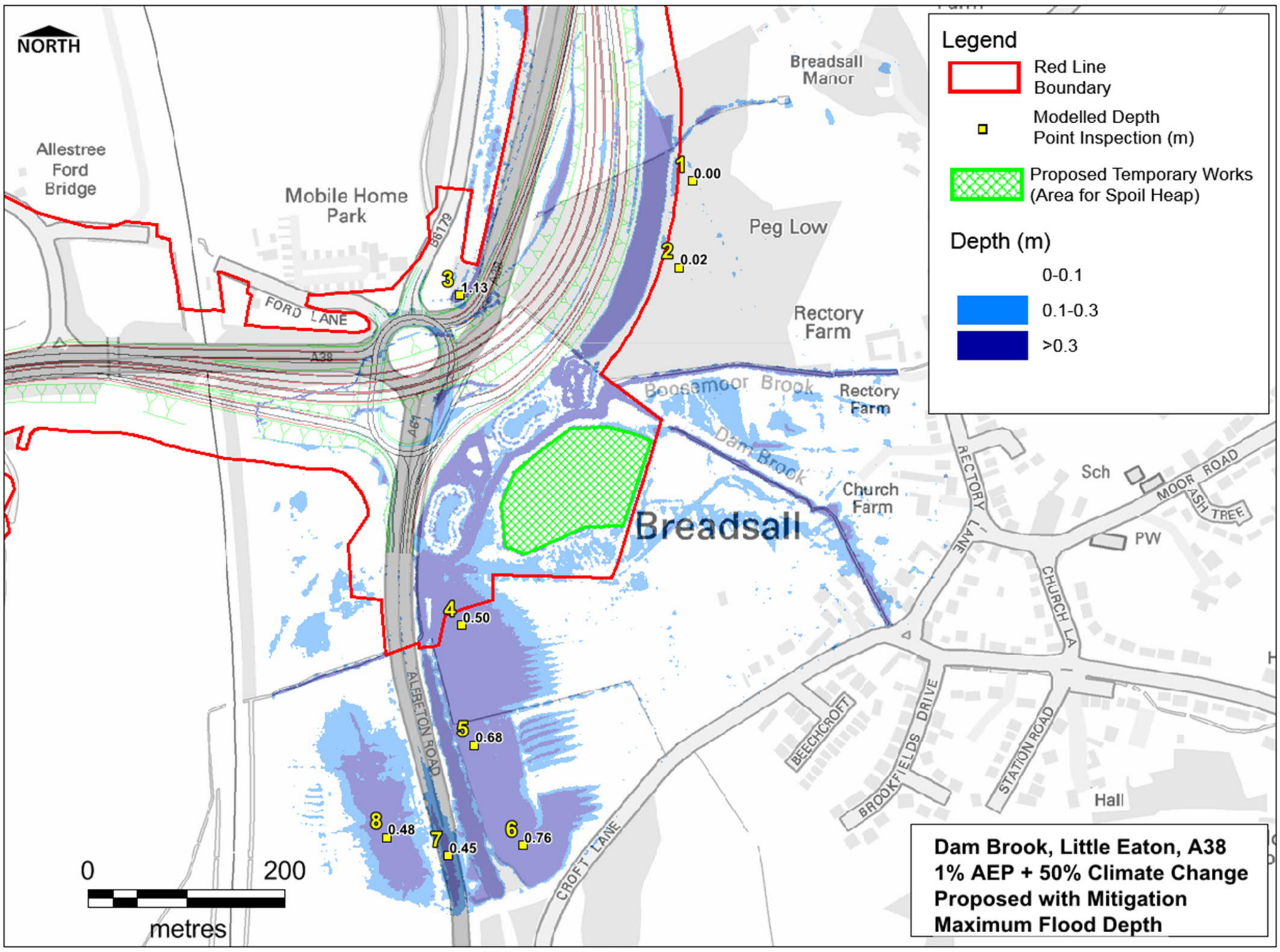


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**Figure 5-5: Dam Brook 1% AEP + 50% Climate Change Proposed Mitigation Maximum Flood Depths**

Comparison of the scenario results indicates that if the Scheme was implemented with the mitigation measures as modelled, then the risk of surface water flooding would not be increased within or outside of the Scheme boundary (refer to Table 5-1).

**Table 5-1: Comparison of Baseline and Proposed Mitigation Peak Flood Levels**

| Flood Point | Baseline Scenario – Flood Level (m AOD) | Proposed Mitigation Scenario – Flood Level (m AOD) | Flood Level Difference (m) |
|---|---|---|---|
| 1 | n/a | n/a | n/a |
| 2 | n/a | n/a | n/a |
| 3 | 51.15 | 50.78 | - 0.37 |
| 4 | 50.61 | 50.62 | + 0.01 |
| 5 | 50.60 | 50.60 | 0.00 |
| 6 | 50.59 | 50.59 | 0.00 |
| 7 | 50.29 | 50.29 | 0.00 |
| 8 | 48.92 | 48.92 | 0.00 |

In summary, the layout of the "proposed mitigation" hydraulic model is illustrated in Figure 5-6.

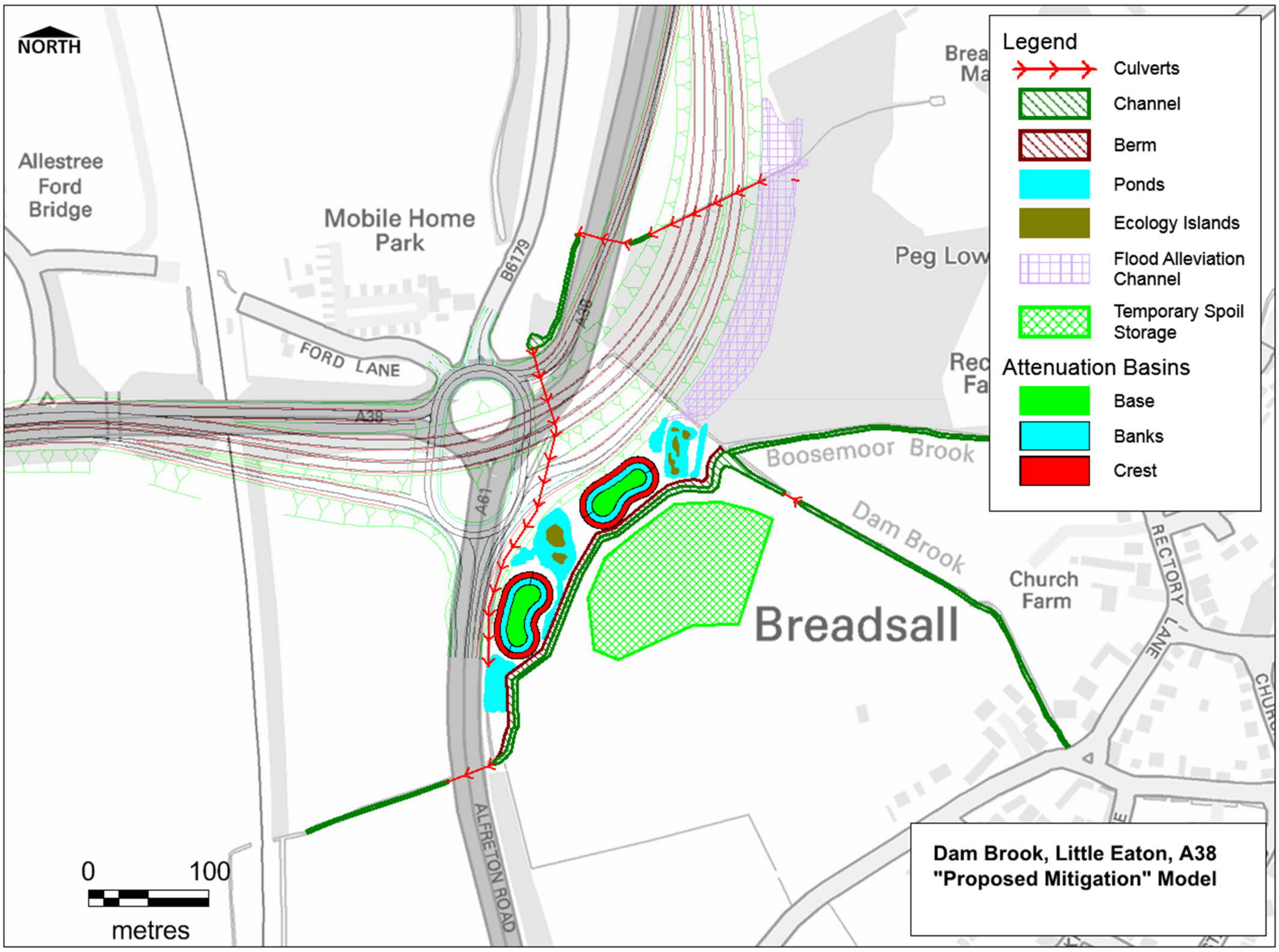


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**Figure 5-6: "Proposed Mitigation" Hydraulic Model Layout**

## 5.6. Refinements to the Proposed Scheme & Mitigation

A further constraint affecting the viability of a culverted solution is that the culvert passing to the north of the junction, as designed, would intersect the position of the highway drainage network to carry flows from the proposed mainline to the attenuation pond. The necessary invert levels would not allow the two systems to cross without issue. The alignment of the proposed culvert was therefore re-designed. Constraints of shallow gradient, minimum depth to cover levels required and site vehicle access requirements resulted in a revised proposal of an open channel swale to convey flows, rather than a culverted channel. This open channel swale had initially been proposed to outfall at the same location as the original extended culvert, namely the southernmost ecology pond. In an effort to improve conveyance, the swale channel was extended as far downstream as the Scheme boundary would allow, improving the overall gradient of the watercourse. In adding this open channel swale to the proposed design, it was necessary to amend the layout of the ecology ponds. The changes made to the ecology ponds in adding the open swale channel can be seen in Figure 5-8. Several solutions were tested as part of the modelling process. The newly proposed open channel swale, as shown in Figure 5-8, however, offered the most beneficial solution in terms of gradient, site access, water quality and an increase in open channel/ bank lengths which comply with the WFD minimum of 'Existing + >50%.'This is the final design which has been tested in the model and as reported in this Technical Note.

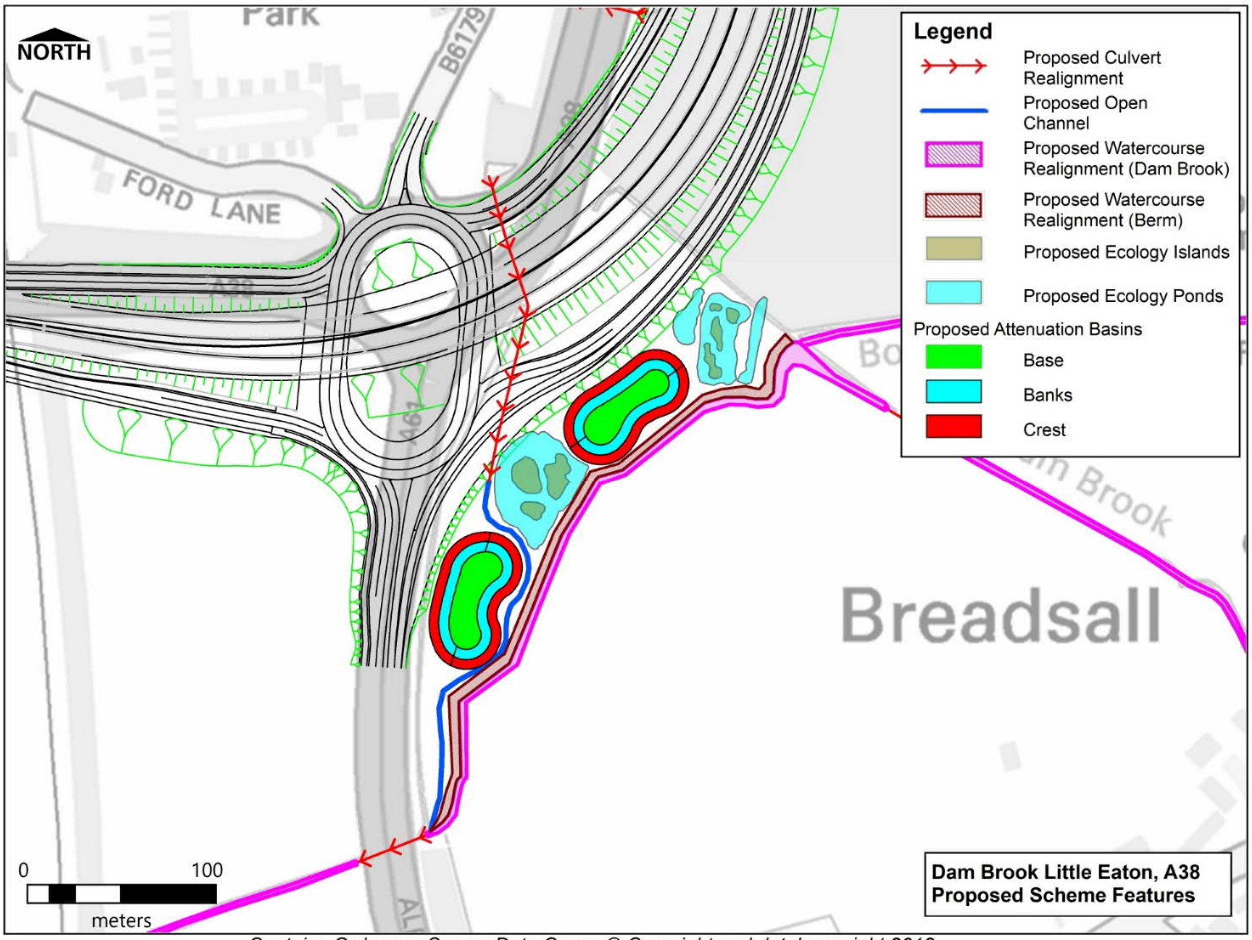

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**Figure 5-8: "Refined Proposed Mitigation" Hydraulic Model Layout**

## 5.7. Final Proposed Scheme and Mitigation

The final proposed design comprises the following:

- **A multi-stage flood allevition channel/ wet woodland area** to the east of the proposed A38 alignment, which would convey flows from the unnamed watercourse from Breadsall Manor south, into an ecology pond and subsequently into Dam Brook.

- **Two new 600mm culverts** to carry flows to and from the flood alleviation channel to the west, under the A38, in the event of the storage capacity in the flood alleviation channel being exceeded. Flows from this culvert would then spill into the open channel north of the island.

- **A 900mm culvert** under the proposed A38 alignment, to take flows from the open channel to the north of the island. This new culvert then discharges into an approximate 216m swale where the road embankment ends. This swale then narrows and continues as a open channel between the southernmost attenuation pond and the re-aligned Dam Brook. The open channel would then join the Dam Brook immediately upstream of the existing culvert under the A61.

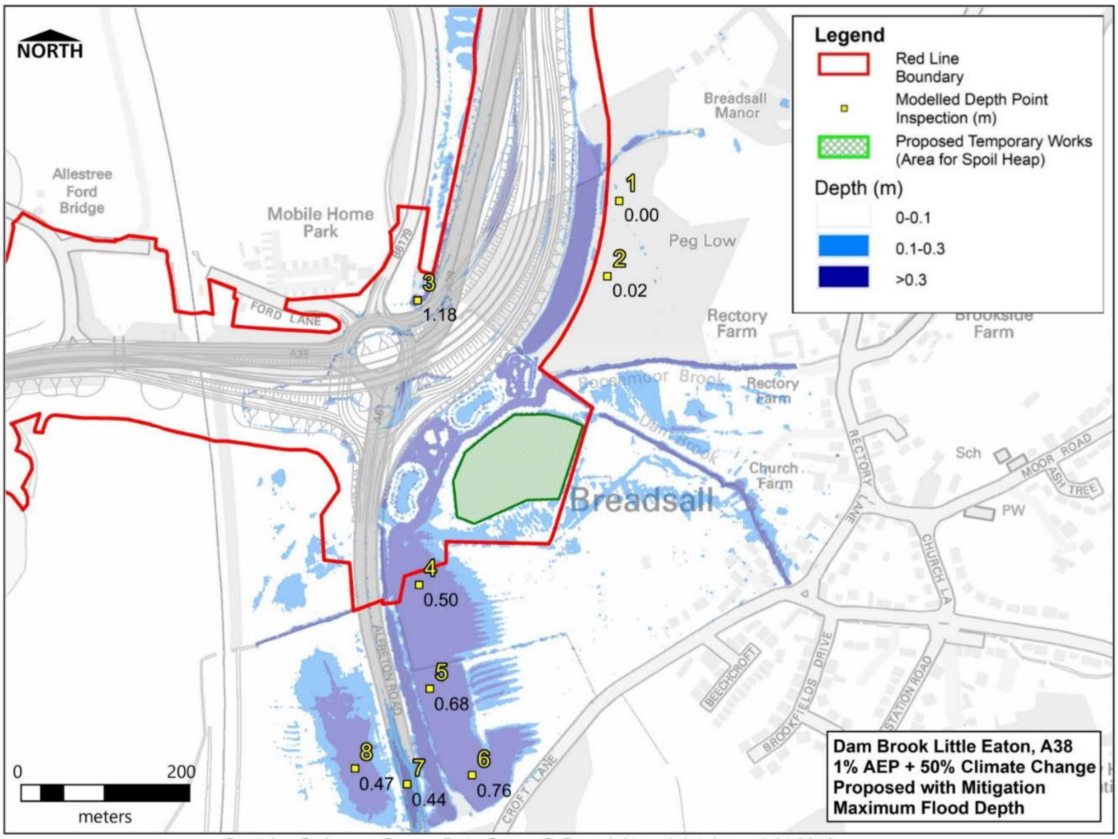


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**Figure 5-8: Dam Brook 1% AEP + 50% Climate Change Final Proposed Mitigation Maximum Flood Depths**

Comparison of the scenario results indicates that if the proposed design was implemented with the mitigation measures as modelled, then the risk of surface water flooding would not be increased significantly within or outside of the Scheme boundary (refer to Table 5-2).

**Table 5-2: Comparison of Baseline and Proposed Mitigation Peak Flood Levels**

| Flood Point | Baseline Scenario – Flood Level (m AOD) | Proposed Mitigation Scenario – Flood Level (m AOD) | Flood Level Difference (m) |
|---|---|---|---|
| 1 | n/a | n/a | n/a |
| 2 | n/a | n/a | n/a |
| 3 | 51.15 | 50.83 | - 0.32 |
| 4 | 50.61 | 50.62 | + 0.01 |
| 5 | 50.60 | 50.60 | 0.00 |
| 6 | 50.59 | 50.60 | + 0.01 |
| 7 | 50.29 | 50.30 | + 0.01 |
| 8 | 48.92 | 48.93 | + 0.01 |

# 6. Model Limitations

The Little Eaton surface water modelling has been based on the best available data, although the main study limitations should be considered when interpreting the results:

- A lack of detailed watercourse survey including channel cross sections and bank top survey throughout the entire study area.
- Uncertainty regarding the geometry of the existing 500mm diameter culvert under the existing A38 alignment, downstream of Breadsall Manor.

# 7. Conclusions

This technical note presents a solution to appropriately manage the risks of surface water flooding as part of the Scheme development in line with the requirements of the National Planning Policy Framework (NPPF). The solution included within the Scheme design comprises:

- **A multi-stage flood allevition channel/ wet woodland area** to the east of the proposed A38 alignment, which would convey flows from the unnamed watercourse from Breadsall Manor south, into an ecology pond and subsequently into Dam Brook.

- **Two new 600mm culverts** to carry flows to and from the flood alleviation channel to the west, under the A38, in the event of the storage capacity in the flood alleviation channel being exceeded. Flows from this culvert would then spill into the open channel north of the island.

- **A 900mm culvert** under the proposed A38 alignment, to take flows from the open channel to the north of the island. This new culvert then discharges into an approximate 216m swale where the road embankment ends. This swale then narrows and continues as a open channel between the southernmost attenuation pond and the re-aligned Dam Brook. The open channel would then join the Dam Brook immediately upstream of the existing culvert under the A61.