BROOKBANKS

10633 Land at North West Bicester

Technical Note 11 Rv0: Hydraulic Modelling

26th July 2024

Document Status

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1 Introduction

1.1 Brookbanks is appointed by Hallam Land Management Ltd to complete a Flood Study Report (FSR) for a proposed mixed use development at Land at North West Bicester.

1.2 An outline planning application (Ref 21/04275/OUT), including a Flood Risk Assessment and Surface Water drainage Strategy, was submitted to the LPA who consulted with the Environment Agency. Comments on the application was received on the 20th April 2022 and 9th January 2023, which required that a detailed flood model to be developed.

1.3 Brookbanks upload the model to the EA for review and the Red-Amber-Green (RAG) response (see **Appendix A**) was received on April 12th 2024 for the Hydrology and Hydraulic modelling -Mo, mainly detailing some areas of clarification.

1.4 Since then, there has been a need to consider some culvert removals and new bridges over the watercourses.

1.5 Therefore, the purpose of this TN clarify some of the queries and assumptions made for the modelling and the current fluvial flood risk across the Site and to demonstrate that the development is acceptable once a mitigation strategy has been established.

1.6 This TN will therefore, summarise the findings of the modelling and specifically address the following:

- Existing Flooding Risk – Baseline,
- Proposed Development with Mitigation

2 Hydrology

Methodology

2.1 Brookbanks has undertaken a detailed hydrology study for the study area, which focused on the storm events outlined below.

- 1 in 100-year (1% AEP)
- 1 in 100-year + 15% allowance for climate change (1% AEP + 15%CC) Central Estimate
- 1 in 100-year + 25% allowance for climate change (1% AEP + 25%CC) Higher Estimate
- 1 in 100-year + 49% allowance for climate change (1% AEP + 49%CC) Upper end Estimate
- in 1000-year (0.1% AEP)

2.2 The climate change allowances that have been applied correspond to the those identified for the Cherwell and Ray Management Catchment peak river flow allowances, which is the catchment in which Bicester is located.

2.3 The methodology for the hydrological assessment was determined by the requirements of the work for LLFA/EA which required robust estimates of inflows for use in the modelling. The assessment included:

- A review of all available data allowing for detailed response for catchment response,
- The update of flood peak data to provide updated flood estimates,
- An assessment of the critical storm duration for the catchment.

2.4 All FEH catchments were compared against available information with respect to ‘key’ descriptors that influence calculated flows. These included AREA, SPRHOST, and URBEXT amongst others. For these, checks have been undertaken against the FEH data and topographical information to confirm the areas are correct, soil plans to ensure the classification of the site (i.e. permeable, non-permeable etc) is considered as being correct and aligned, and $URBAN_{50k\ mapping}$ to ensure the URBEXT values remain correct and reflect any updated/new development within the study catchments.

2.5 The hydrology of the FEH catchment has been analysed at 3 Flood Estimation Points (FEPs) using the Flood Estimation Handbook (FEH) statistical analysis and Revitalised Flood Hydrograph (ReFH). Each of the identified watercourses hydrological calculations were required to derive peak flow estimates and design hydrographs for input into the hydraulic model.

2.6 The FEH catchments are illustrated on **Figure 2-1**.

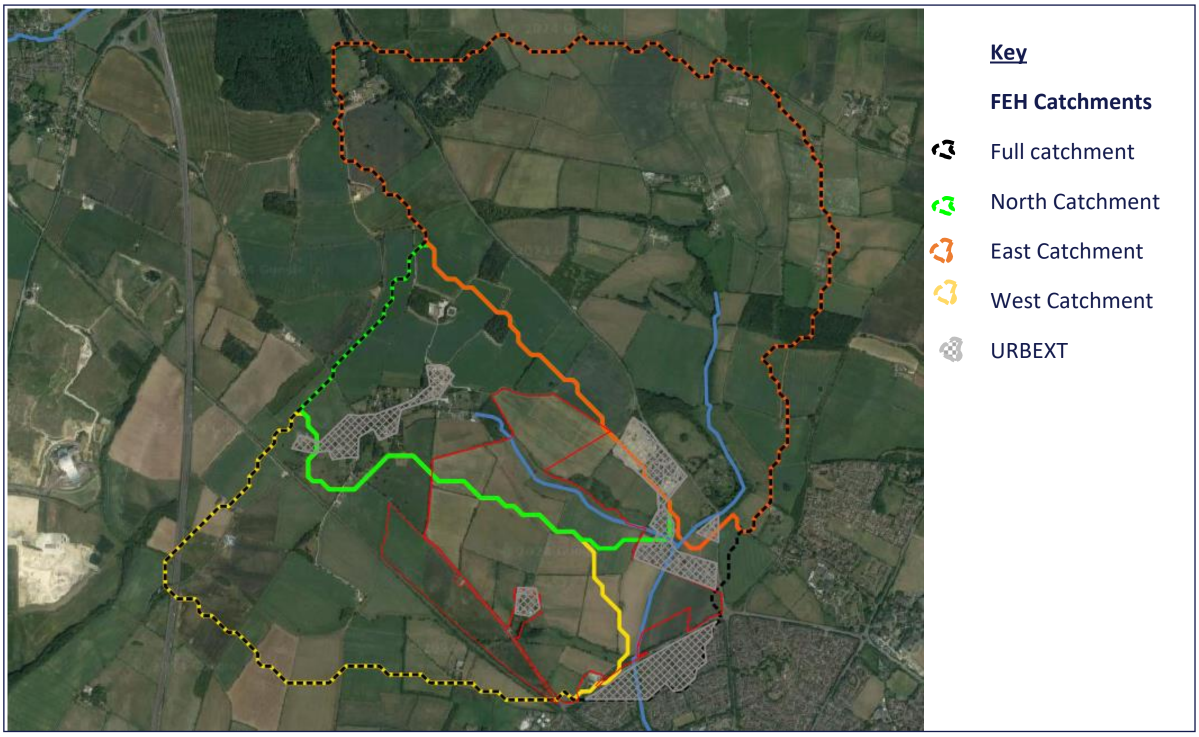

Figure 2-1: FEH Catchment Areas

2.7 Important catchment descriptors at each subject site are presented in **Table 2-1**.

Site Code	AREA	FARL	PROPWET	BFIHOST19	DPLBAR (km)	DPSBAR (m/km)	SAAR (mm)	SPRHOST	URBEXT
East	5.26	0.949	0.32	0.770	2.64	17.5	654	17.09	0.0062
West	2.79	1.0	0.32	0.845	1.72	14.2	639	6.65	0.0040
North	1.89	1.0	0.32	0.799	1.63	18.4	647	13.92	0.0251

* Note: No changes have been made to the catchment descriptors

Table 2-1: Catchment Descriptors at Each FEP

2.8 The final choice of method is to use peak flows derived from the FEH Statistical method as this makes most use of the observed flow data within the catchment and is consistent with guidance.

2.9 To obtain hydrographs and the design storm needed to run the hydraulic Flood Modelled model, the ReFH2 rainfall runoff analysis was used and scaled to fit the FEH Statistical peak flows as outlined in **Table 2-2**.

2.10 The latest FEH peak flow estimates reflecting the most up to date rainfall event data have been used when inputting the hydrology information. The peak flow from all FEP's are shown in the **Table 2-2**.

2.11 The ReFH2 hydrograph for the and example catchment is shown in **Figure 2-2**.(note this is a theoretical assessment for the combined catchment and therefore does not reflect values in **Table 2-2**).

Site Code	Flood peak (m3/s) for the following return periods (in years)				
	100	100+15%CC	100+25%CC	100+49%CC	1000
East	0.754	0.868	0.943	1.130	1.676
West	0.244	0.280	0.305	0.365	0.541
North	0.360	0.414	0.450	0.539	0.799
DS	1.358	1.562	1.697	2.023	2.221

Table 2-2: BCL Modelled Inflow at each FEP

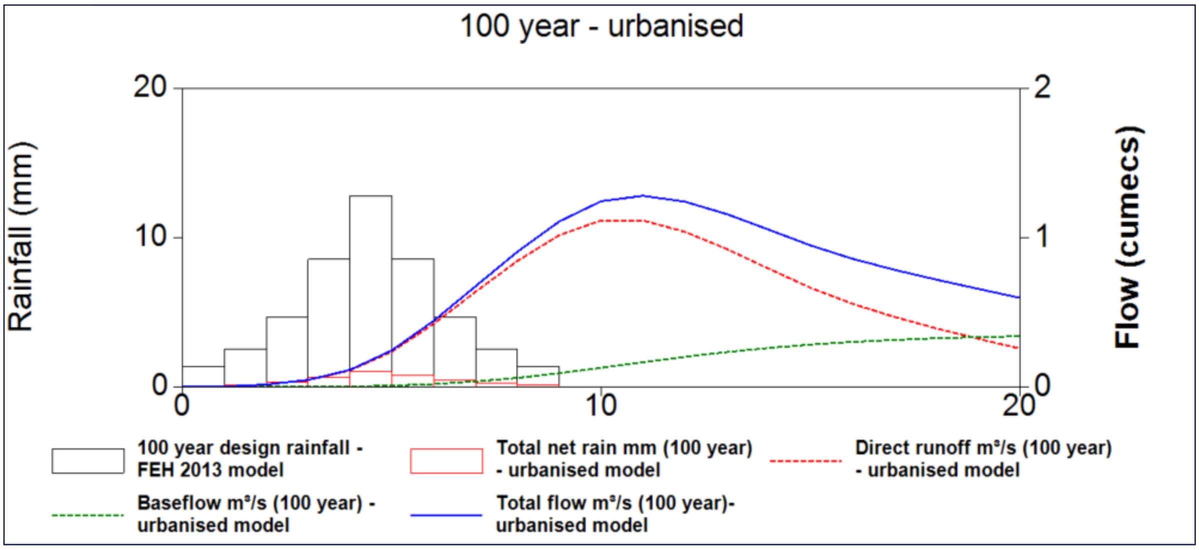

Figure 2-2: ReFH2 urbanised 1 in 100yr hydrograph, DS catchment

2.12 The method of scaling statistical peak flows to fit ReFH2 hydrograph is in line with good modelling practice and guidance.

2.13 An allowance of climate change has been applied to the peak inflows in line with current guidelines provided by EA. The development site lies within the Cherwell and Ray Management Catchment area therefore, the EA required that a 15% allowance (central estimate), 25% allowance (higher estimate) and 49% allowance (Upper estimate) be tested.

2.14 FEH calculation record **Appendix B**.

3 Hydraulic Modelling

3.1 From both the information received from the topographic survey and a Site walkover it was found that the northern watercourse is known to be dry for long periods of time. Therefore, this section of watercourse has been built with using ESTRY (1d). The 1d_nwke ESTRY feature has been linked to the upstream section of the Flood Modeller East watercourse with X1DH connection and Head-Time to the upstream cross section.

3.2 In order to run a stable model within Flood Modeller Pro 7.0, the East and West watercourses were run with the minimum baseflow.

3.3 For this model three upstream boundaries have been used, one at the start of each stretch of watercourse.

3.4 The boundary conditions (bc_dbase.csv) have been located at; East of Manor Farm for the North watercourse, between the railway line and Bucknell Road for the West watercourse and at Caversfield for the East watercourse. Where flows were input in Flood Modeller these were done so via ReFH boundaries.

3.5 Peak flows were taken with statistical analysis and shaped with ReFH2 to create the bc_dbase and the hydrographs units at the Flood Modeller section.

3.6 Bank levels have been calculated from the topographic survey cross sections and 2d_zpt points extracted connected vie 2d_zpt lines representing both banks, bank levels where reviewed with Tuflow check files to analyse any Z values out of range, as this is one the main sources of mass balance errors in any model.

3.7 The hydraulic model extent is illustrated on **Figure 3-1**.

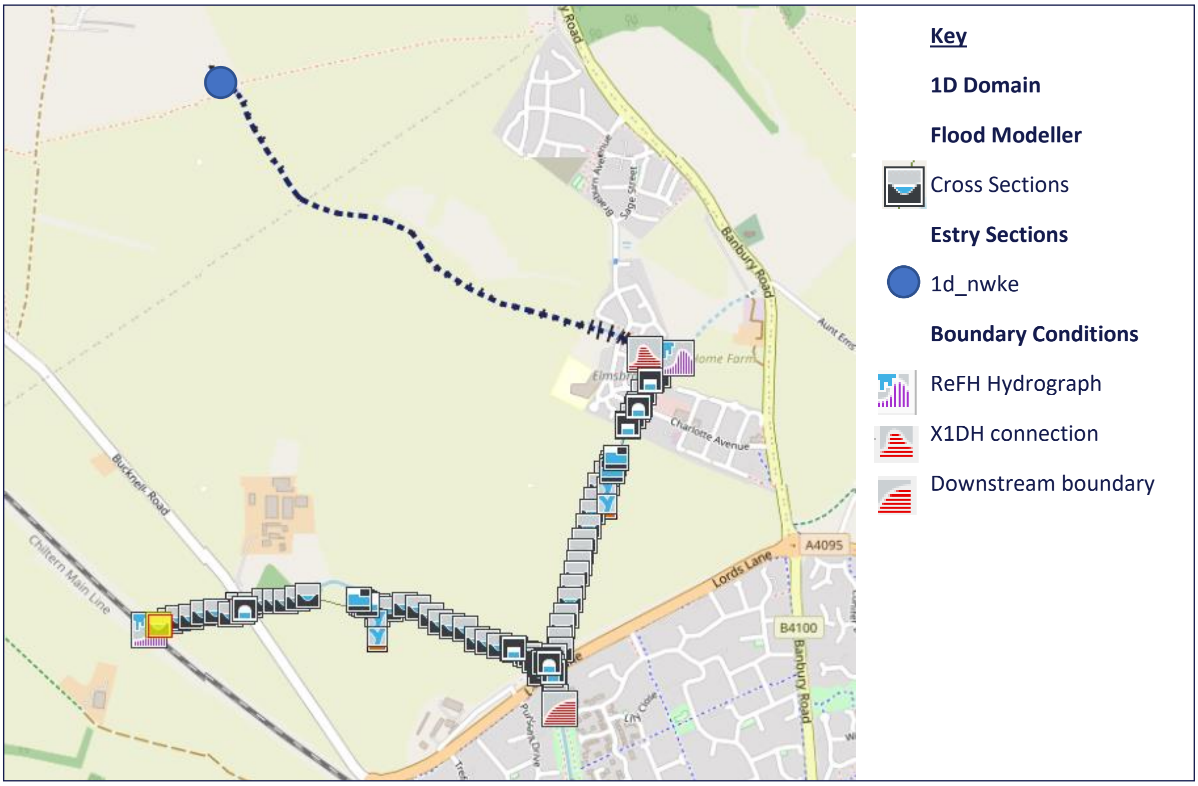

Figure 3-1: 1D Hydraulic Model Extent

3.8 The spill from the 1D channel into the floodplain over the left and right banks is defined by (Head External) HX lines. The HX lines are defined along the banks of the channel. As requested by EA, HX features where added to the culverts and bridges, perpendicular to the flow direction in order to allow overtop if water level reach deck levels. Spill unit in 1D are set to ZERO (OFF) for the linked 1D-2D model.

3.9 Bed, bank and flood plain materials have been represented in the hydraulic model using Manning's roughness values. The Manning's roughness values are based on site visit, topographical survey data, photographic evidence and OS map.

3.10 The Manning's roughness coefficient was set at 0.054 for the floodplain. Within the 2D model, buildings are set with an elevated roughness value to slow the movement of water. Roads, tracks, and pavements were set with lower roughness value to reflect the smoother surfaces that would act as preferential flow routes during an event. Ven Te Chow (Chow, 1959) Manning's n for channels has been used to select roughness parameters.

4 Baseline Results

4.1 A baseline model was built to establish the "As Existing" scenario, the benchmark for the proposed development scheme.

4.2 The amended flows and the arch bridge in Estry was also modelled with different representation with 1d_tab feature that allows to build the bed, soffit and deck levels of the structure.

4.3 The baseline model was built as per the description, some of the assumptions and notes to take into consideration are as follows:

- The roughness coefficient values were selected to represent the reality at the 1D and 2D domain,
- The inflows added to the 1d domain (Estry) were hydrographs calculated with ReFH2 fitted to the statistical values, the hydrographs at the Flood Modeller are ReFH2 fitted to statistical values.
- LiDAR is 1m resolution. However, the 2d domain grid cell size was selected to be 2m resolution,
- The initial water level of the watercourses used are those measured the day of the topographic survey.
- The North watercourse is linked to the FMP 1d domain with X1DH connection.

4.4 The baseline results shows that:

- Water overtops the watercourse right bank at the North watercourse, flowing parallel to the watercourse, this is due to the existence of 3 culverts upstream which act as a restriction to in channel flows due to a lack of capacity for all modelled events. This occurs with events of 1% AEP (1 in 100yr) and above.
- At the junction between the West and East watercourses, flows exceed channel capacity and result in ponding in an existing lower elevated section of the site. This happens for all modelled events.

4.5 The baseline maximum flood depth is illustrated on **Figure 4-1**.

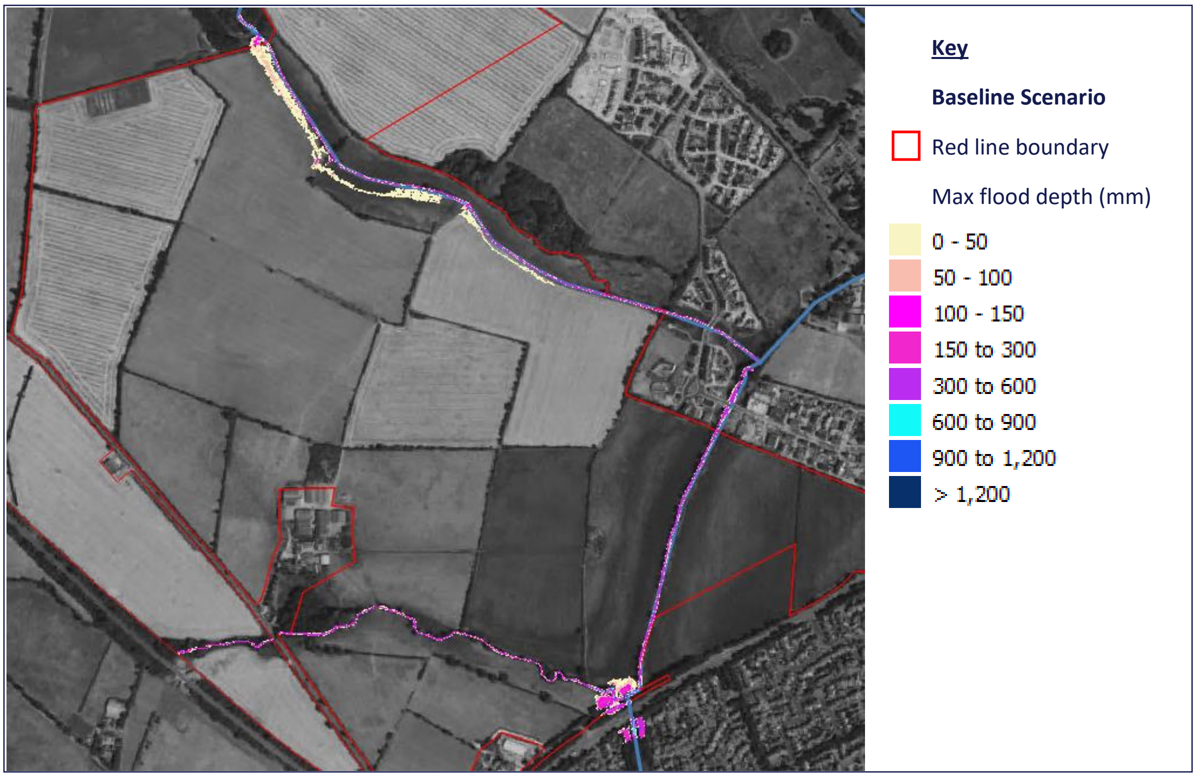

Figure 4-1: Baseline scenario, maximum flood depth 1 in 100yr +25%CC (higher estimate)

4.6 Baseline results at **Appendix C**.

5 Development Results

5.1 This section shows the changes proposed for de development scenario.

5.2 North to the A4095 road (it is located a site access) due to the new road to be design the two bridges currently located at the West watercourse and after the junction of the East and bending south another arch bridge is going to be redundant. Therefore, remove both bridges is proposed.

5.3 The West watercourse has some culverts at Hawkwell Farm access and a small arch bridge at Bucknell Road crossing, shown in **Figure 5-3**.

Figure 5-2: Hydraulic structures at West watercourse

5.4 Both structures above are proposed to be removed, since the track passing over is made redundant from the 'Strategic Link Road (SLR)' at the site.

5.5 **Figure 5-3** below show the location of the new structures and the location of the structures to be removed.

5.6 In summary, the new development includes for:

- Two new access road culverts for 'Main Link Road (MLR)'.
- Five bridges as part of the 'Active Travel Route (ATR)', which is a 3m wide combined pavement and cycle path.
- The removal of an access culvert near Hawkwell Farm.
- The removal of two culverts near the SLR.

5.7 The size of new bridges and, therefore, the new culverts for the MLR have yet to be determined, so the model has provided the smallest culvert possible that allows flow through without surcharge. However, due to ecology issues, the culverts will be larger, as each culvert will need to facilitate safe travel of animals at all times. Therefore, each size will require 1m either side of the maximum flood extent at the two locations.

5.8 The minimum proposed culvert dimensions without creating surcharge for the MLR are as follows:

- East 4.0m wide X 1.2m height
- West 1.5m wide X 1.0m height

5.9 The new structures have been modelled over the FMP baseline section, adding the structures with inlet and outlet losses and spill units at the deck levels, the spill units have been deactivated for the linked model in 2d domain.

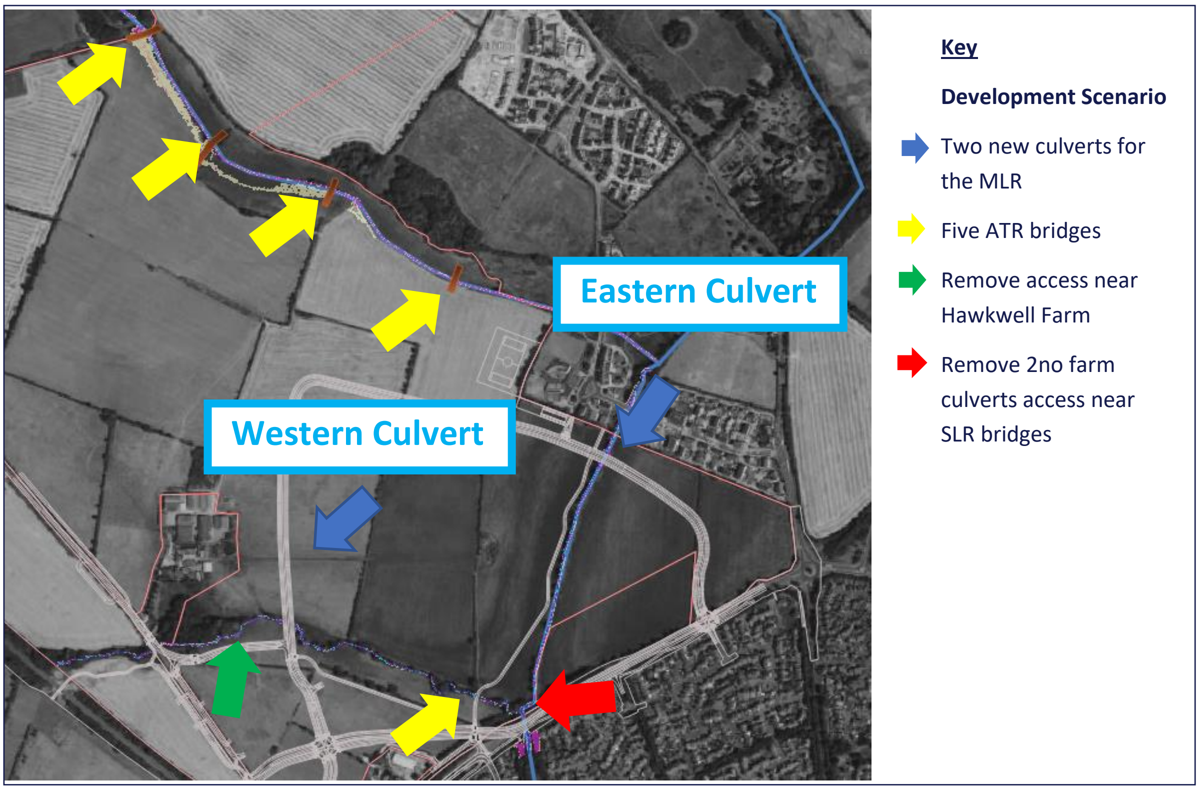

Figure 5-3: Proposed Development Scenario

5.10 The proposed development includes a buffer green zone along the watercourses without any development. This extends to 30m either side of the banks. Only SuDS basin features are present within this, although they are not located within 10m of either side of the banks or in any flood area.

5.11 The proposed culverts comply with the CIRIA (C786) freeboard allowance.

5.12 The Development maximum flood depth is illustrated on **Figure 5-4**.

5.13 The proposed development scenario show that at the north watercourse the flooding patterns remain the same as no changes at the watercourse.

5.14 The modelling also show that due to the removal of the downstream bridges no flooding occur at the junction section for events up to 1 in 100yr +CC (Higher estimate).

Figure 5-4: Development scenario, maximum flood depth 1 in 100yr +25%CC (higher estimate)

5.15 Development results at **Appendix D**.

6 Mitigation Results

6.1 This section shows the changes proposed for de development with mitigation scenario.

6.2 The proposed development scenario replaces and removes two arch bridges at the downstream section, at the junction between west and east watercourses. The initial calculations show a slightly increase in flows downstream.

6.3 In order to mitigate the impact of the removal of both bridges it is proposed to create a flood mitigation area north of the junction of east and west watercourses.

6.4 The watercourse north is also proposed to be amended, the existing culverts ~450mm diameter replaced with flat ATR bridges crossings to the north section. Additionally increase the wetland area increasing flow retention and storing some of the excess.

6.5 The Development with mitigation illustrated on **Figure 6-1**.

Figure 6-1: Development with mitigation proposal

6.6 All the changes above mentioned are set within the 2D domain for the proposed ground levels and the new bridges a the north section set with propose deck levels.

6.7 Bridges at the 1D domain have been amended accordingly, removing existing culverts and adding the structures at the proposed location. No additional changes to the channel morphology is applied.

6.8 The Development maximum flood depth is illustrated on **Figure 6-2**.

Figure 6-2: Development with mitigation scenario, maximum flood depth 1 in 100yr +25%CC (higher estimate)

6.9 Downstream analysis show that with the proposed development with mitigation the peak flow is reduced up to three percent (3%).

6.10 **Figure 6-3** below show the hydrograph at the downstream section of the model.

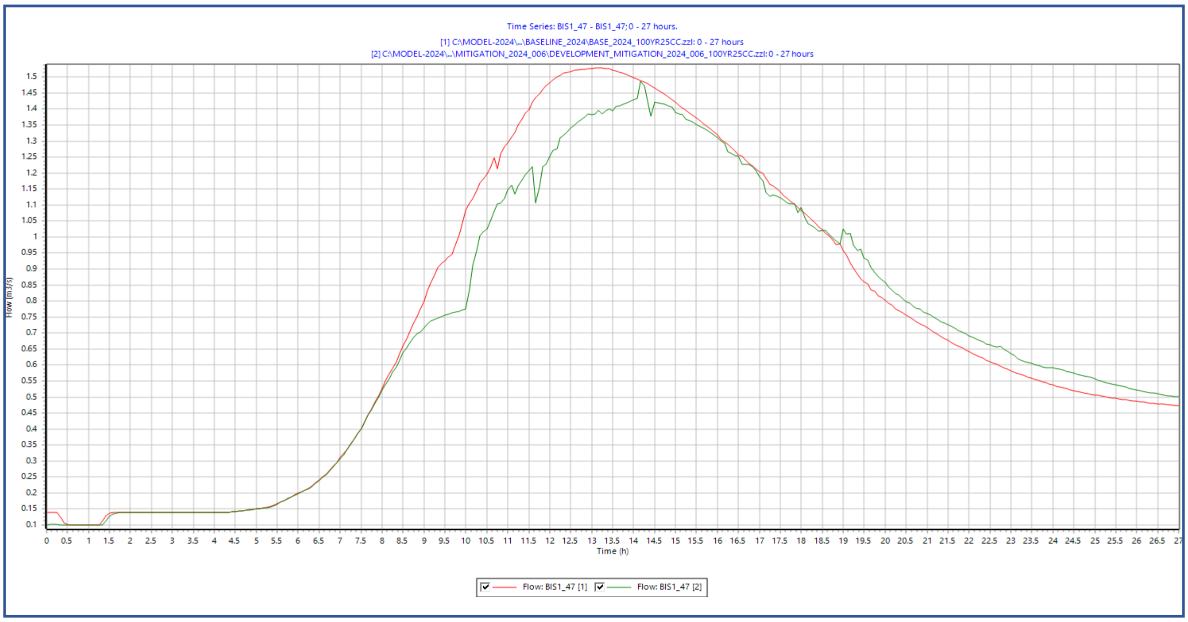

Figure 6-3: Downstream section -Red baseline vs Green Mitigation hydrographs

6.11 Mitigation results at **Appendix D**.

7 Summary

7.1 The baseline modelling shows that the proposed residential development and Site access is not affected by flooding from the onsite watercourses.

7.2 The proposed development is located outside the flood risk areas.

7.3 The proposed mitigation measures show that the implementation does not affect third party land and reduce flows and levels at the downstream section towards Bicester town.

7.4 The modelling work completed demonstrates that the development can be delivered safely in line with best practice without any increase in downstream or upstream flood risk.

Appendix A: EA RAG Comments and Responses

Separate Excel Spreadsheet

Appendix B: FEH Calculation Record

Appendix C: Baseline Scenario

Appendix D: Mitigation Scenario