Appendix B - Modelling Technical Notes

JBA Project Code	2022s0447
Contract	NBBC Level 2 SFRA
Client	Nuneaton and Bedworth Borough council
Day, Date and Time	August 2023
Author	Arran Bright
Reviewer / Sign-off	Louise Goode/Paul Redbourne
Subject	Updated Modelling

1 Introduction

1.1 Updating the SFRA modelling

The Coventry and Warwickshire Level 2 Strategic Flood Risk Assessment (SFRA) provides a comprehensive and robust evidence base on flood risk issues to investigate 22 proposed development sites which have been identified by Nuneaton and Bedworth Borough Council (NBBC). The use of comprehensive and robust evidence will support the replacement of the current Nuneaton and Bedworth Borough Plan. This will cover a period between 2024 - 2039. The Environment Agency's 'Flood Map for Planning' is used to represent the flood zones and levels of flood risk and incorporates updates modelled data where available.

The Planning Practice Guidance on Flood Risk and Coastal Change was updated on the 25th August 2022 which resulted in the need to update the SFRA. These updates include the requirement for:

- Updated climate change modelling for all sources of flood risk
- Definition of the functional floodplain (Flood Zone (3b)) based around the 3.3% AEP event, rather than the 5% AEP event under previous guidance.

2 The River Sowe

The hydraulic modelling of the River Sowe has been updated to simulate the 3.3% AEP, 1% AEP and 0.1% AEP with updated Central, Higher and Upper end climate change allowances for the management catchment (as quoted in Table 2-1).

Appendix B - Modelling Technical Notes

JBA Project Code	2022s0447
Contract	NBBC Level 2 SFRA
Client	Nuneaton and Bedworth Borough council
Day, Date and Time	August 2023
Author	Arran Bright
Reviewer / Sign-off	Louise Goode/Paul Redbourne
Subject	Updated Modelling

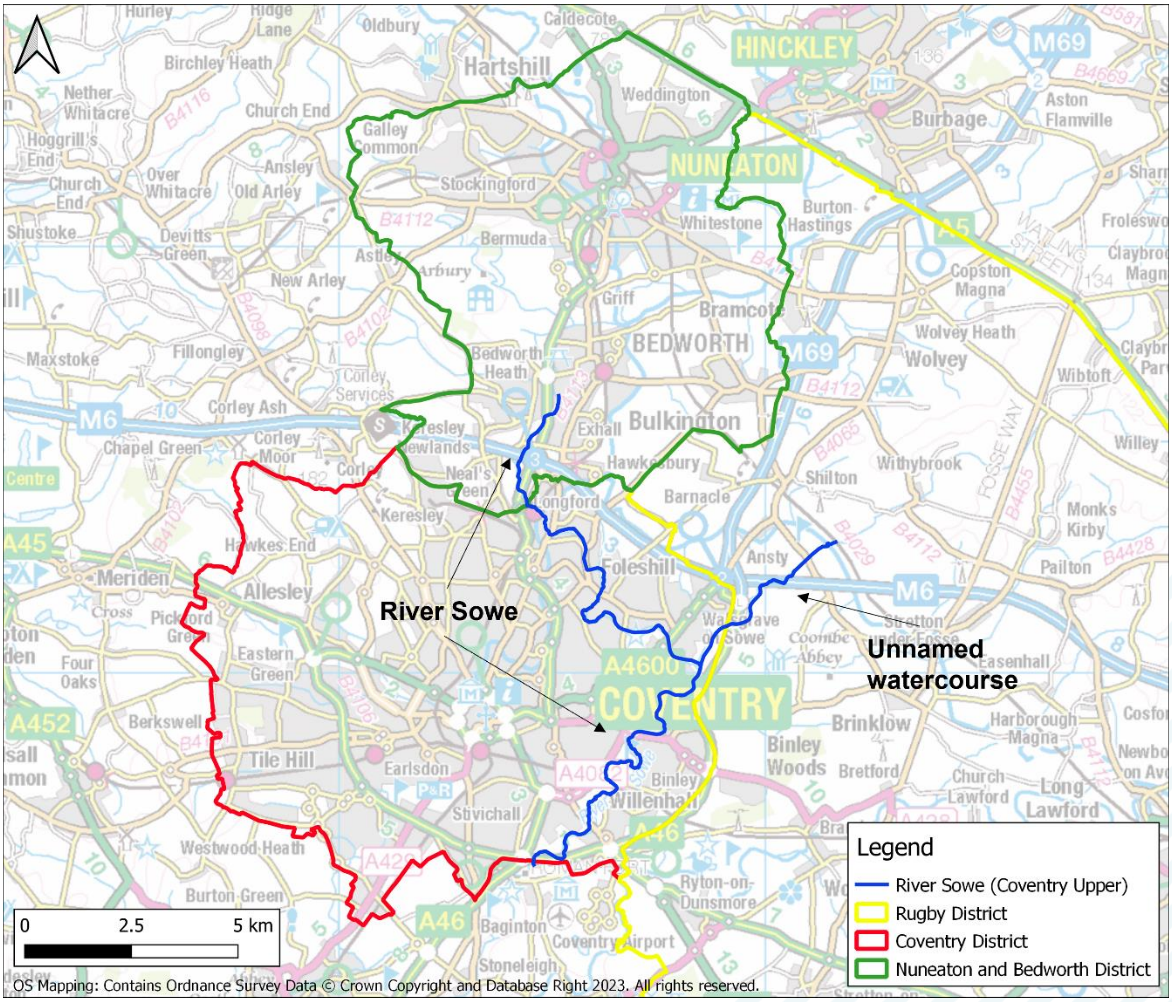

Figure 2-1: River Sowe (Coventry Upper) model extent

The Coventry Upper is a modelled as a 1D-2D FM-TUFLOW model which covers the River Sowe and a smaller, unnamed watercourse. The River Sowe flows from the north-west from the Nuneaton and Bedworth District through the Coventry District. The smaller, unnamed tributary flows from the north-east through the Rugby District and joins the River Sowe within the Coventry District.

JBA Project Code	2022s0447
Contract	NBBC Level 2 SFRA
Client	Nuneaton and Bedworth Borough council
Day, Date and Time	August 2023
Author	Arran Bright
Reviewer / Sign-off	Louise Goode/Paul Redbourne
Subject	Updated Modelling

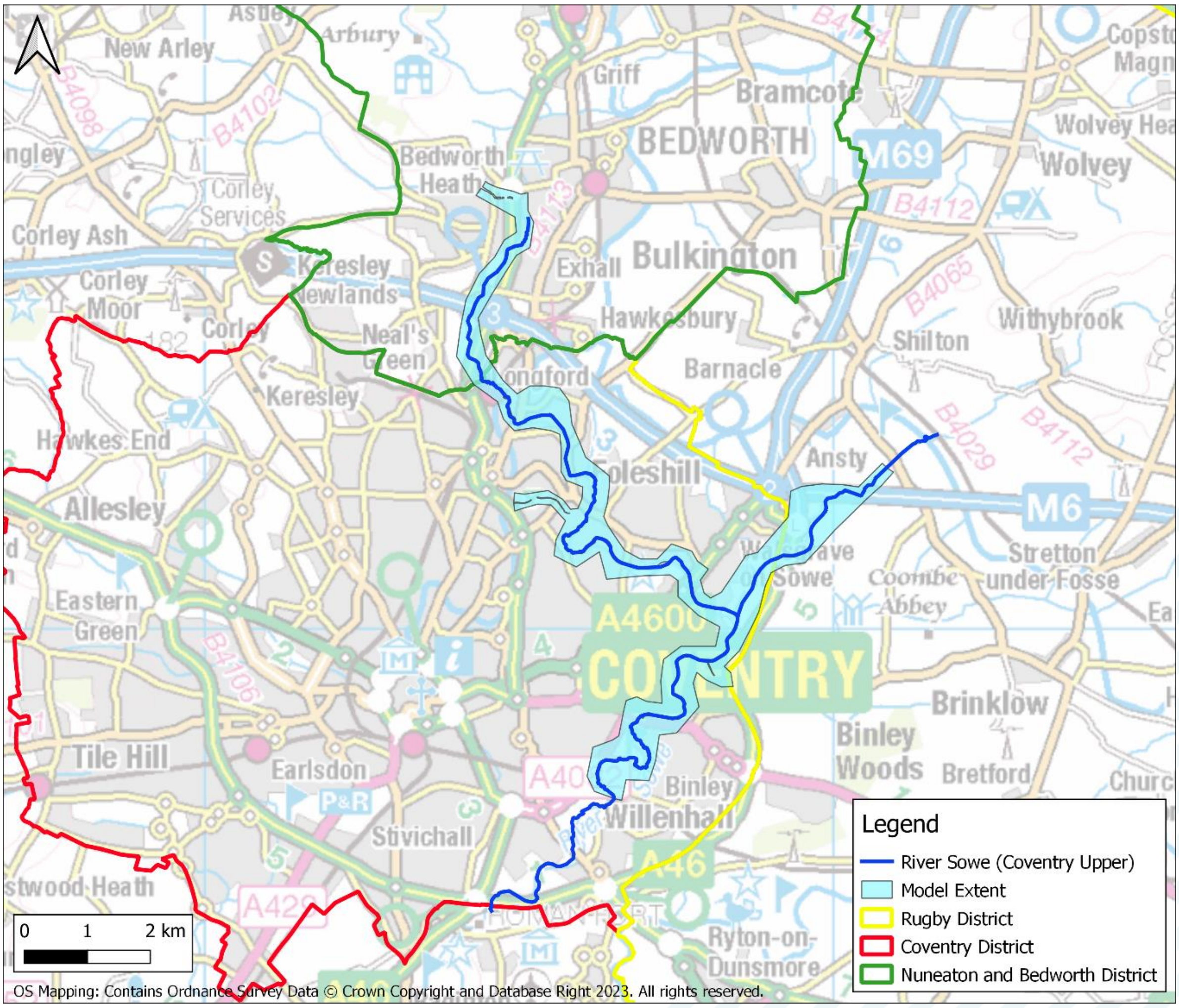

Figure 2-2: Extents of 1D-2D linked model

The following events were simulated for the model:

- 3.3% AEP
- 3.3% AEP + CC - Central, Higher and Upper end allowances
- 1% AEP
- 1% AEP + CC - Central, Higher and Upper end allowances
- 0.1% AEP
- 0.1% AEP + CC - Central, Higher and Upper end allowances

JBA Project Code	2022s0447
Contract	NBBC Level 2 SFRA
Client	Nuneaton and Bedworth Borough council
Day, Date and Time	August 2023
Author	Arran Bright
Reviewer / Sign-off	Louise Goode/Paul Redbourne
Subject	Updated Modelling

2.1 Method

2.1.1 Estimating the 3.3% AEP flood flow

Flows for the 3.3% AEP event were not available with the existing model files and had not been derived in the existing hydrological study. The model though is schematised with FEH Boundaries as inflows, meaning appropriate flows can be derived by adjusting the Flood Return Period in the boundary unit to 30 years.

From the FEH Rainfall data a flow hydrograph for each inflow point is then calculated by Flood Modeller and applied to the hydraulic model. The flow hydrographs produced for each inflow point are consistent with the shape of the respective 20 and 50 year flow hydrographs. Checks for consistency have shown that the 30-year hydrographs are reasonable and fit between the 20 and 50 year hydrographs.

A more comprehensive updating of the hydrology for the River Sowe is considered to be beyond scope of the project as this modelling is strategic and in nature and aims to derive datasets that can be used consistently with existing flood risk datasets. Furthermore, there are complexities in re-running the model and the age of the model which means updating the model hydrology may become a more complex and expensive undertaking.

2.1.2 Applying the climate change guidance

In 2018, the government published new UK Climate Projections (UKCP18). The Environment Agency used these projections to update their climate change guidance for new developments with regards to updated fluvial and rainfall allowances which were released in July 2021.

Table 2-1 shows the updated peak river flow allowances that apply in Nuneaton/Coventry for fluvial flood risk for the River Sowe within the Avon Warwickshire Management Catchment (last updated in July 2021). Table 2-1 shows the updated Central, Higher and Upper end climate allowances for the 2020s, 2050 and 2080 epochs. The red highlighted box shows the relevant climate change allowances used in the SFRA and model.

Appendix B - Modelling Technical Notes

JBA Project Code	2022s0447
Contract	NBBC Level 2 SFRA
Client	Nuneaton and Bedworth Borough council
Day, Date and Time	August 2023
Author	Arran Bright
Reviewer / Sign-off	Louise Goode/Paul Redbourne
Subject	Updated Modelling

Table 2-1: Peak river flow allowances for the Avon Warwickshire Management Catchment

Allowance category	Total potential change anticipated for '2020s' (2015 to 39)	Total potential change anticipated for '2050s' (2040 to 2069)	Total potential change anticipated for '2080s' (2070 to 2115)
Central	7%	8%	21%
Higher	12%	14%	32%
Upper	22%	31%	59%

JBA Project Code	2022s0447
Contract	NBBC Level 2 SFRA
Client	Nuneaton and Bedworth Borough council
Day, Date and Time	August 2023
Author	Arran Bright
Reviewer / Sign-off	Louise Goode/Paul Redbourne
Subject	Updated Modelling

3 Nuneaton Model (River Anker and Tributaries)

The hydraulic modelling of the River Anker and its tributaries (Figure 3-1), which form the WCC (Warwickshire County Council) Nuneaton model, have been updated to simulate the 3.3% AEP and 0.1% AEP with updated Central, Higher and Upper end climate change allowances for the management catchment.

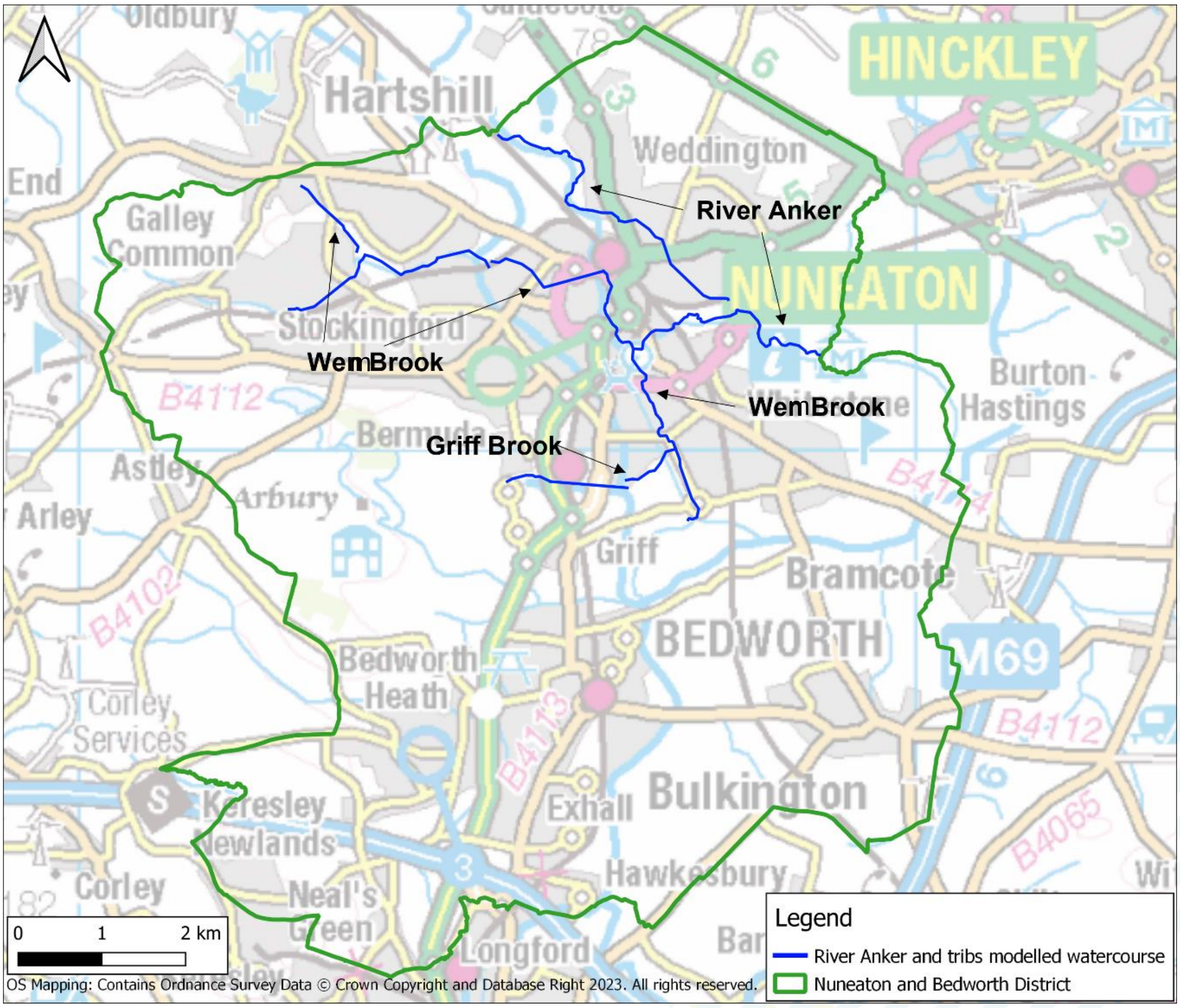

Figure 3-1: Extent of Nuneaton modelled watercourse

The WCC Nuneaton model is a 1D-2D FM-TUFLOW model which covers the River Anker and a number of tributaries which flow through the Nuneaton and Bedworth District. Modelled watercourses include The River Anker, which flows from the east through the centre of Nuneaton and the Wem and Griff brooks flow from the south-east (Figure 3-2).

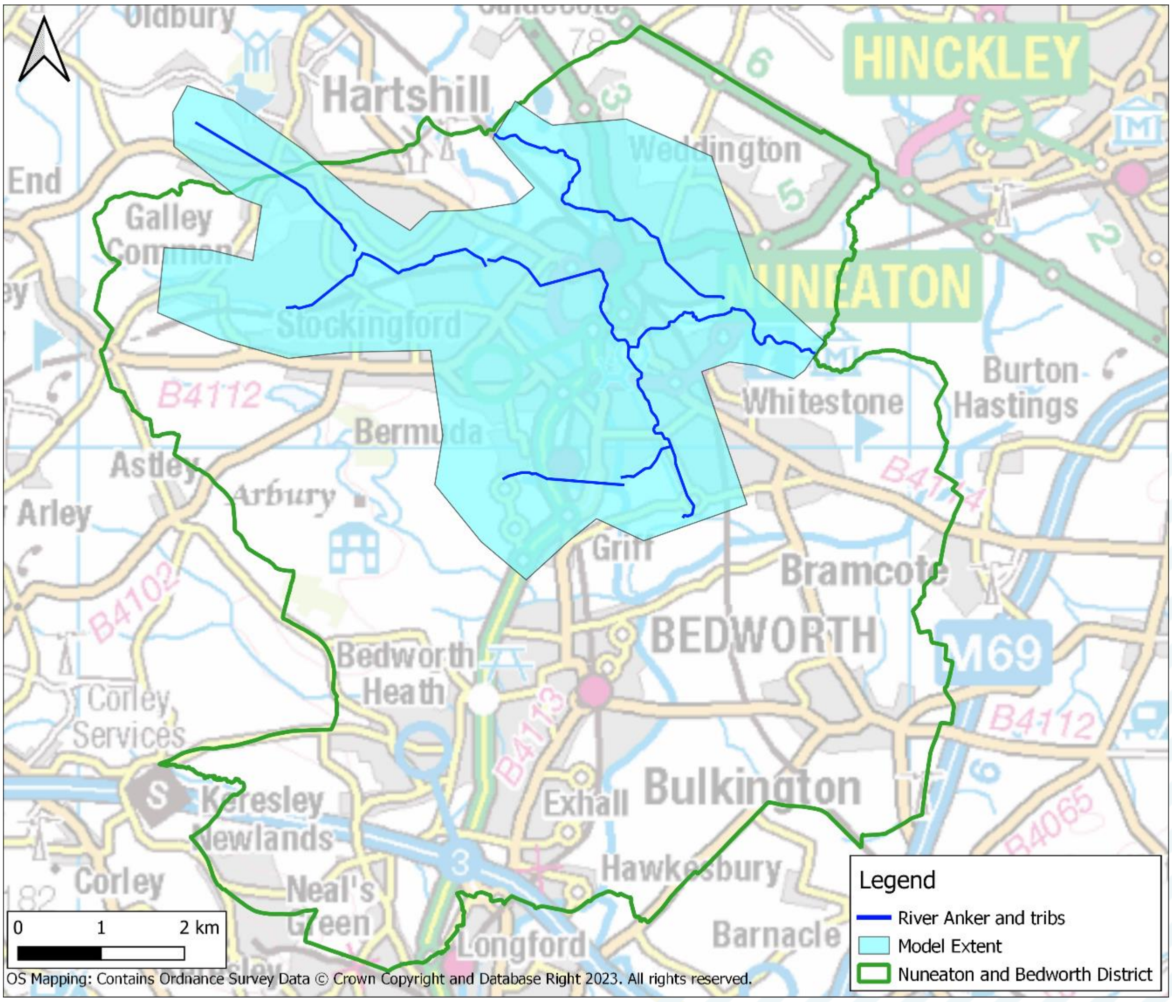

Figure 3-2: Extents of 1D-2D linked model

The following events were simulated for the model:

- 3.3% AEP
- 3.3% AEP + CC - Central, Higher and Upper end allowances
- 1% AEP
- 1% AEP + CC - Central, Higher and Upper end allowances
- 0.1% AEP

- 0.1% AEP + CC - Central, Higher and Upper end allowances

3.1 Method

3.1.1 Estimating the 3.3% AEP flood flow

Flows for the 3.3% AEP event were not available with the existing model files and had not been derived in the existing hydrological study. The model though is schematised with FEH Boundaries as inflows, meaning appropriate flows can be derived by adjusting the Flood Return Period in the boundary unit to 30 years.

From the FEH Rainfall data a flow hydrograph for each inflow point is then calculated by Flood Modeller and applied to the hydraulic model. The flow hydrographs produced for each inflow point are consistent with the shape of the respective 20 and 50 year flow hydrographs. Checks for consistency have shown that the 30 year hydrographs are reasonable and fit between the 20 and 50 year hydrographs.

A more comprehensive updating of the hydrology for the Rivers in the model is considered to be beyond scope of the project as this modelling is strategic and in nature and aims to derive datasets that can be used consistently with existing flood risk datasets. Furthermore, there are complexities in re-running the model and the age of the model which means updating the model hydrology may become a more complex and expensive undertaking.

3.1.2 Applying the climate change guidance

In 2018, the government published new UK Climate Projections (UKCP18). The Environment Agency used these projections to update their climate change guidance for new developments with regards to updated fluvial and rainfall allowances which were released in July 2021.

Table 3-1 shows the updated peak river flow allowances that apply in Nuneaton/Coventry for fluvial flood risk for the Rivers in the model are within the Tame, Anker and Mease Management Catchment (last updated in July 2021). Table 3-1 shows the updated Central, Higher and Upper end climate allowances for the 2020s, 2050 and 2080 epochs. The red highlighted box shows the relevant climate change allowances used in the SFRA and model.

JBA Project Code	2022s0447
Contract	NBBC Level 2 SFRA
Client	Nuneaton and Bedworth Borough council
Day, Date and Time	August 2023
Author	Arran Bright
Reviewer / Sign-off	Louise Goode/Paul Redbourne
Subject	Updated Modelling

Table 3-1: Peak river flow allowances for the management catchment in Nuneaton (Tame, Anker and Mease)

Allowance category	Total potential change anticipated for '2020s' (2015 to 39)	Total potential change anticipated for '2050s' (2040 to 2069)	Total potential change anticipated for '2080s' (2070 to 2115)
Central	10%	15%	22%
Higher	11%	17%	30%
Upper	22%	30%	51%

JBA Project Code	2022s0447
Contract	NBBC Level 2 SFRA
Client	Nuneaton and Bedworth Borough council
Day, Date and Time	August 2023
Author	Arran Bright
Reviewer / Sign-off	Louise Goode/Paul Redbourne
Subject	Updated Modelling

4 The River Anker

The hydraulic modelling of the River Anker has been updated to simulate the 3.3% AEP, 1% AEP and 0.1% AEP with updated Central, Higher and Upper End climate change allowances for the management catchment.

Figure 4-1 shows the location of the modelled watercourses for the River Anker study in relation to the wider Nuneaton and Bedworth Borough Council boundary.

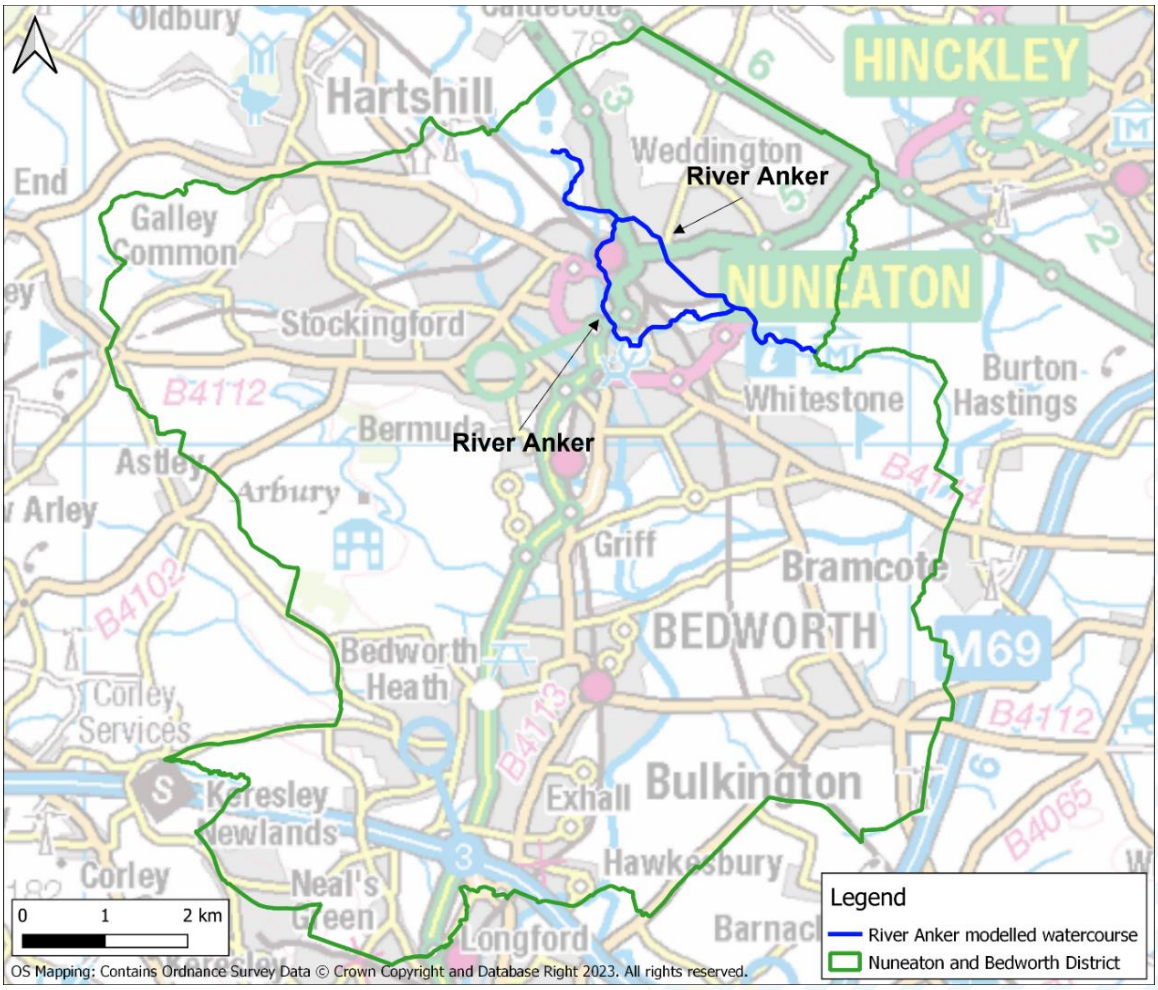

Figure 4-1: Extent of River Anker modelled watercourse

The River Anker is modelled as a 1D-2D linked Flood Modeller (FM) - TUFLOW model covering the River Anker watercourse which flows from the south-east through the Nuneaton and Bedworth District.

The model was originally developed by Capita Aecom in 2015 for the Nuneaton Hazard Mapping study for the Environment Agency as part of the Water and Environmental

Management (WEM) Lot 1 package of works. Figure 4-2 shows the location of the model extent that has been simulated for this study.

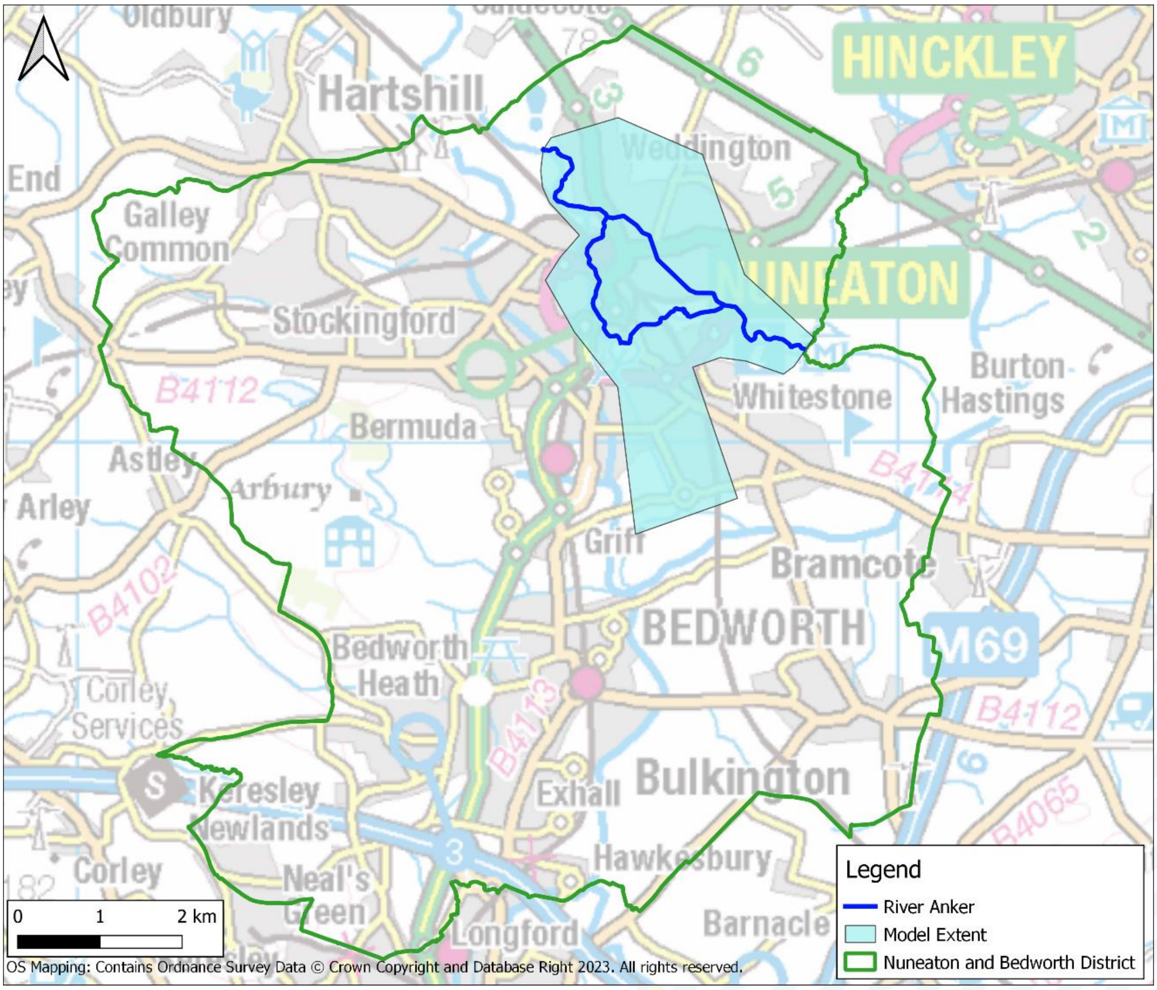

Figure 4-2: Extents of 1D-2D linked model

The following events were simulated for the model:

- 3.3% AEP + CC - Central, Higher and Upper End allowances
- 1% AEP + CC - Central, Higher and Upper End allowances
- 0.1% AEP
- 0.1% AEP + CC - Central, Higher and Upper End allowances

Appendix B - Modelling Technical Notes

JBA Project Code	2022s0447
Contract	NBBC Level 2 SFRA
Client	Nuneaton and Bedworth Borough council
Day, Date and Time	August 2023
Author	Arran Bright
Reviewer / Sign-off	Louise Goode/Paul Redbourne
Subject	Updated Modelling

4.1 Method

There have been no significant changes to the Environment Agencies River Anker model. The scope of works has focused on the simulation of new climate change uplifts, but some minor updates have been undertaken including the use of an updated TUFLOW version (202-10-AD) and an updated version of Flood Modeller (v5.0). Both of software executables have received further updates since the completion of these model runs but the changes are not expected to have any significant impact on the results and importantly represent an improvement compared to the 2015 model.

The following section summarise the updates applied to the model inflows to represent the changes to the climate change allowances.

4.1.1 Applying the climate change guidance

In 2018, the government published new UK Climate Projections (UKCP18). The Environment Agency used these projections to update their climate change guidance for new developments with regards to updated fluvial and rainfall allowances which were released in July 2021.

Table 3-1 shows the updated peak river flow allowances that apply in Nuneaton/Coventry for fluvial flood risk for the River Anker within the Tame, Anker and Mease catchment (last updated in July 2021). Table 3-1 shows the updated Central, Higher and Upper end climate allowances for the 2020s, 2050 and 2080 epochs. The red highlighted box shows the relevant climate change allowances used in the SFRA and model.

JBA Project Code	2022s0447
Contract	NBBC Level 2 SFRA
Client	Nuneaton and Bedworth Borough council
Day, Date and Time	August 2023
Author	Arran Bright
Reviewer / Sign-off	Louise Goode/Paul Redbourne
Subject	Updated Modelling

5 Site specific SHA1 Model

This section summarises the new flood modelling work for the SHA1 site. A new flood modelling approach has been required as no detailed modelling of the study area currently exists. Figure 5-1 shows the location of the modelled watercourses for the SHA1 study in relation to the wider Nuneaton and Bedworth Borough Council boundary.

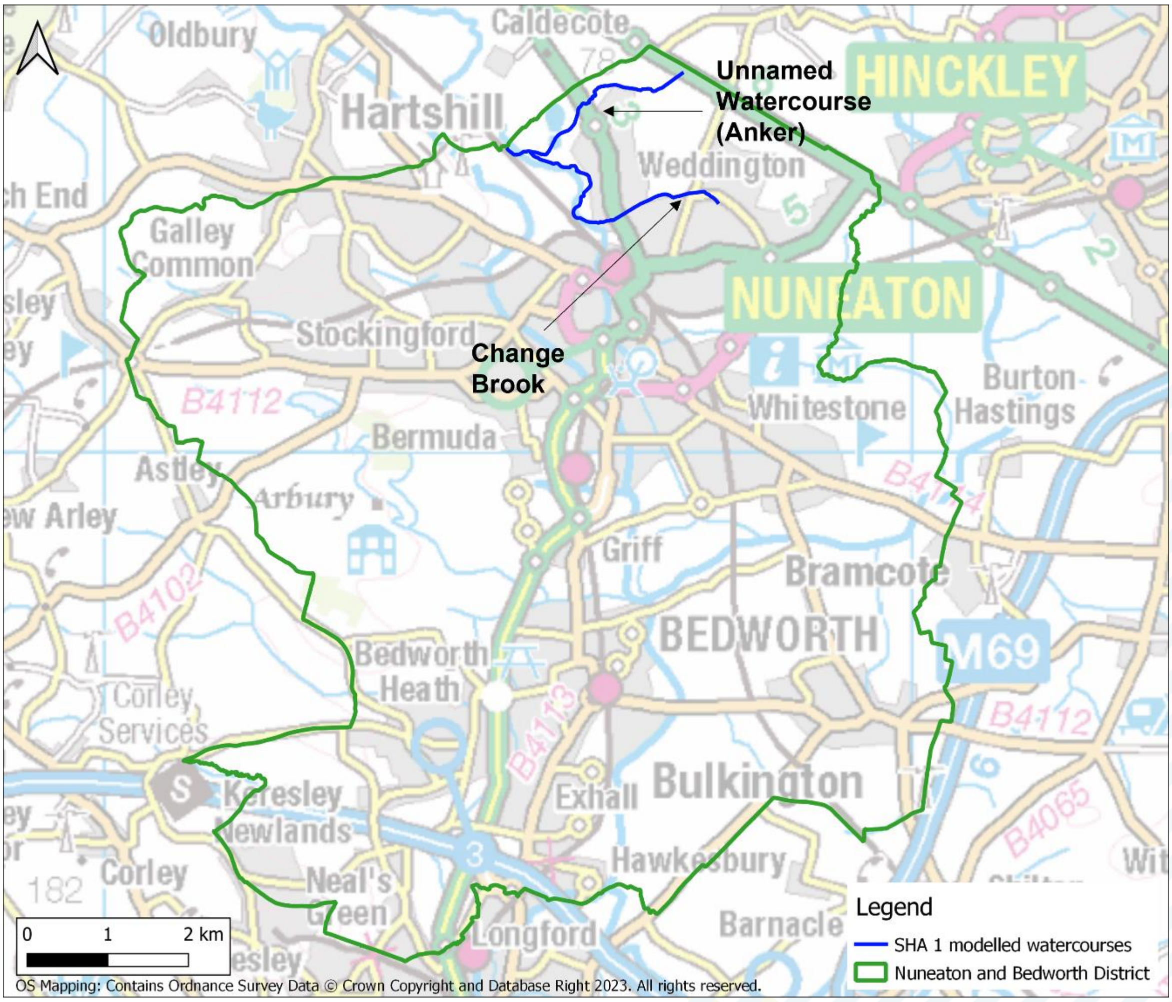

Figure 5-1: SHA 1 modelled watercourses

5.1 Method

5.1.1 Overview

As Part of this SFRA, a new 2D TUFLOW hydraulic model was built by JBA Consulting. This was comprised of a 1m resolution DTM, material layers created from open-source

OS Vector Mapping, upstream and downstream boundary conditions and 2D topographical edits to represent the watercourses through the study area.

One of the watercourses modelled was the Change Brook which flows westwards around the southern boundary of the site and eventually discharges into the River Anker. The second watercourse is an unnamed tributary which flows southwards past the western boundary of the site and eventually also joins the River Anker. For this study, the watercourse has been named the Anker.

5.1.2 Model extent

The model extent of the SHA 1 study area covers 3.71km² and is shown in Figure 5-2.

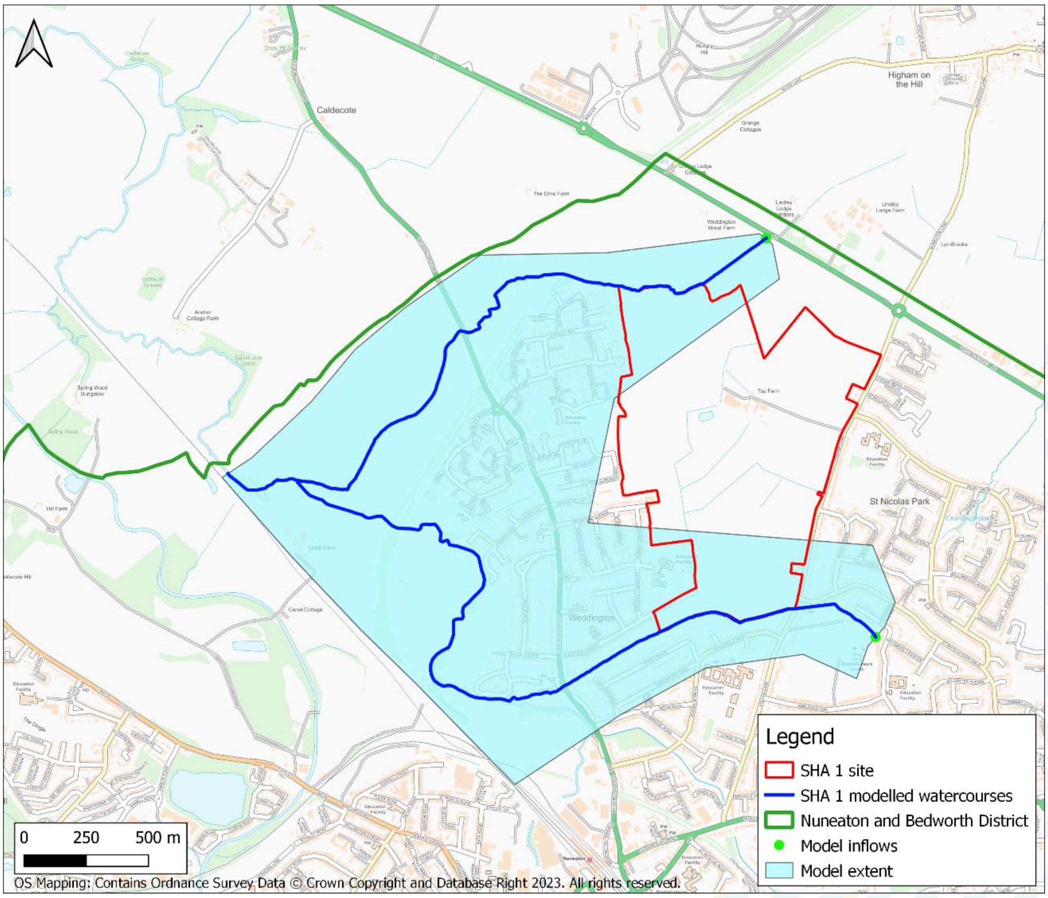

Figure 5-2: SHA 1 model extent

5.1.3 Software used

The flood model was developed using TUFLOW version 2023-03-AB, which is the most recent version of the software at the time of this study. TUFLOW is a 2D hydrodynamic modelling package used widely throughout the industry.

There are no 1D elements within this model as no river channel survey data is available. Therefore, there is no requirement for a separate 1D solver.

5.1.4 Grid size selection

The model has been simulated using a 3m grid resolution. This resolution was found to provide an acceptable balance between the representation of overland flow routes and the management of acceptable model run times. A 2D timestep of 1s has been used which falls within the recommended tolerances as set by TUFLOW which recommends between 1/2 and 1/5 of the grid resolution.

5.1.5 Data availability

The latest 1m-resolution composite EA LiDAR Digital Terrain Model (DTM) was used as the base topography for the models. The LiDAR data used was flown in 2022 and represents the current ground topography. OS Vector map data was acquired to represent the land use within the modelled study area. This was processed to set the material and roughness values of the 2D domain.

No river channel survey data was available and therefore, a simplified 2D modelling approach has been adopted to represent the watercourses within the modelled study area. No data was available to represent the structure constrictions and therefore all structures have been cut through to reflect a continuous open channel. This approach can lead to the underestimation of flood risk but without survey data, this was the only method available.

5.1.6 Boundary conditions

Upstream and downstream boundary conditions have been applied to the model. At the upstream extents of both watercourses, a single Flow-Time (QT) point inflow has been applied.

At the downstream extent, a 2D Stage-Discharge (HQ) line boundary condition has been applied. The channel gradient was applied to the 'b' attribute of the HQ boundary to allow TUFLOW to generate a Stage-Discharge relationship for the downstream boundary conditions. This allows water to leave the model and prevent glass walling.

5.1.7 Hydrology

Given the small hydrological catchment area impacting the modelled study area and the high-level nature of the study, the ReFH2 approach only has been used to derive peak flow estimates and inflow hydrographs. The catchment has been treated as rural, as research into flood estimation in small catchments[1] revealed that flood frequency

1 1 Stewart, Lisa, Duncan Faulkner, Giuseppe Formetta, Adam Griffin, Tracey Haxton, Ilaria Prosdocimi, Gianni Vesuviano and Andy Young (2021). Estimating flood peaks and hydrographs for small catchments (Phase 2). Report – SC090031/R0, Environment Agency.

estimates on catchments of this size would be more accurate if they were treated as such.

The British Geological Survey (BGS) Geology of Britain viewer was used to assess the geology of the catchments and was found to be predominantly sedimentary beds of Mercia Mudstone deposited in the Triassic Period. Soils[2] of the catchments are predominantly slightly acid, loamy, and clayey soils with impeded drainage.

Due to the lack of hydrometric data available, the default ReFH2 parameters have been used unaltered. The peak flow estimates derived for this study and applied to the model are shown in Table 5-1

Table 5-1: Flood peaks for each modelled watercourse

AEP Event	Flood Peaks for model inflows (m^3/s)	
	Change Brook Inflow	Anker Watercourse Inflow
50% AEP	1.18	0.61
20% AEP	1.54	0.81
10% AEP	1.81	0.96
5% AEP	2.11	1.12
3.3% AEP	2.31	1.23
3.3% AEP + Central CC	2.82	1.51
3.3% AEP + Higher CC	3.01	1.61
3.3% AEP + Upper CC	3.49	1.86
2% AEP	2.61	1.40
1.3% AEP	2.90	1.55
1% AEP	3.13	1.68
1% AEP + Central CC	3.82	2.05
1% AEP + Higher CC	4.07	2.18

2 2 http://www.landis.org.uk/soilscapes/index.cfm

JBA Project Code	2022s0447
Contract	NBBC Level 2 SFRA
Client	Nuneaton and Bedworth Borough council
Day, Date and Time	August 2023
Author	Arran Bright
Reviewer / Sign-off	Louise Goode/Paul Redbourne
Subject	Updated Modelling

AEP Event	Flood Peaks for model inflows (m³/s)	
	Change Brook Inflow	Anker Watercourse Inflow
1% AEP + Upper CC	4.72	2.54
0.5% AEP	3.76	2.03
0.1% AEP	5.47	2.99
0.1% AEP + Central	6.68	3.65
0.1% AEP + Higher	7.12	3.88
0.1% AEP + Upper	8.27	4.51

5.1.8 Climate Change

This SFRA has utilised the latest EA guidance on climate change allowances. Peak river flow allowances were acquired from DEFRA's data service platform. The modelled watercourses are situated within the Tame, Anker and Mease catchment. The climate change allowances are shown in Table 3-1.

5.1.9 Topographic adjustments

LIDAR data at 1m resolution has been used to represent the base topography in the modelled study area. To help better define the watercourses in the study area, 2d_zsh lines and snapped 2d_zsh points were used to 'burn' the channel into the 2D domain. The channel bed elevations for the 2d_zsh points, were extracted from the base LIDAR data.

There was no river channel survey data available and the approach to burn the channel into the 2D domain is considered appropriate to ensure a continuous watercourse enabling conveyance downstream.

5.1.10 Hydraulic roughness values used

A generalised manning's roughness value of 0.05 was applied as the base 2D roughness coefficient across the study area, representing 'Greenspace'. Key features affecting roughness in each model were identified using OS Vector Map data and were included in the model using a 2d_mat file coupled with a .tmf (TUFLOW materials) file. The Manning's n values for the features that are included in the .tmf file are provided below in Table 5-2.

Table 5-2: 2D roughness values

2D Roughness Value	Feature
0.05	Greenspace
0.1	Buildings
0.15	Woodland
0.045	Inland Water
0.025	Roads

5.2 Assumptions and limitations

Developing a hydraulic model requires the application of simplifications and generalisations. As such, several assumptions are made when building the model, which can lead to model uncertainties and subsequent limitations of the results. This section summarises some of the outstanding assumptions and limitations with the model.

The 2D only approach is limited in that it may not accurately represent the channel capacity or the constrictions provided by in-line structures. Without the availability of survey data, these features cannot be represented accurately. The 2D only approach completed for this study is considered an improvement on existing broad scale mapping of the area, but future site-specific assessments may require more detailed flood modelling that adopt a 1D-2D linked approach that can more accurately represent the watercourses within the study area.

The model performance is generally considered stable but the Mass Error (ME%) which provides an indication on model stability reports a peak ME% of 3% - 4% in each of the design event simulations. This seems to be linked to the 2D approach with pockets of high ME reported in the channel and at bank locations. Typically, a ME% of +/-1% is the recommended tolerance but for 2D only models, this is more difficult to achieve. Attempts have been made to improve the model mass error reporting by amending the 2D loc orientation and localised amendments to the 2D roughness coefficients, but this has not been fully resolved. Importantly, there are no 2D negative depths being reported which indicates no significant oscillations in water levels.

The approach taken to derive the inflow estimates is considered appropriate for the scale of this study, but the use of ReFH2 only is considered a limitation. Future more detailed modelling of the study may be required for site specific assessments and therefore, the FEH statistical approach should also be considered for the derivation of peak flow estimates.

Appendix B - Modelling Technical Notes

JBA Project Code	2022s0447
Contract	NBBC Level 2 SFRA
Client	Nuneaton and Bedworth Borough council
Day, Date and Time	August 2023
Author	Arran Bright
Reviewer / Sign-off	Louise Goode/Paul Redbourne
Subject	Updated Modelling

6 Site specific SHA2 model

This section summarises the new flood modelling work for the SHA2 site. A new flood modelling approach has been required as no detailed modelling of the study area currently exists. Figure 6-1 shows the location of the modelled watercourses for the SHA2 study in relation to the wider Nuneaton and Bedworth Borough Council boundary.

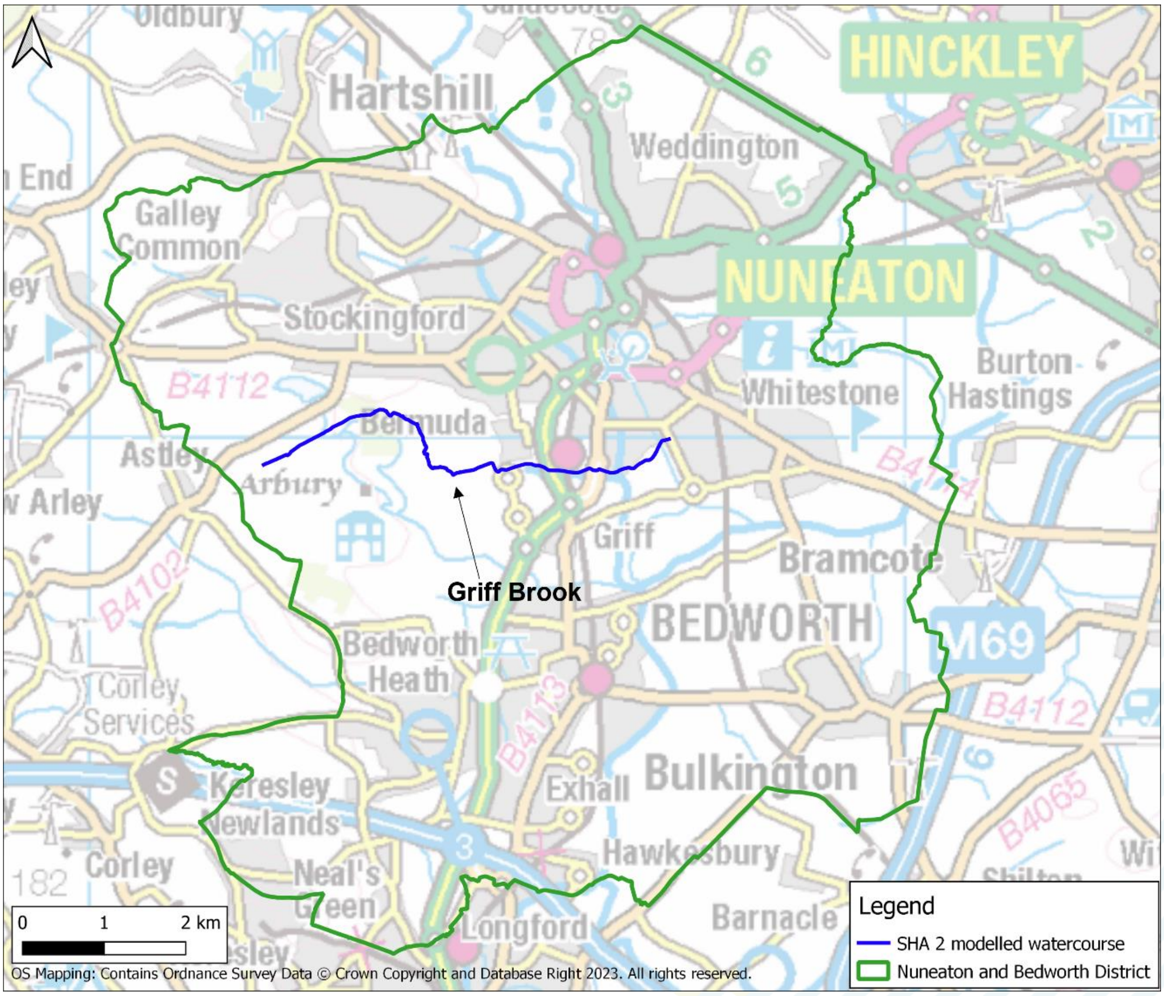

Figure 6-1: SHA2 modelled watercourse

6.1 Method

6.1.1 Overview

As Part of this SFRA, a new 2D TUFLOW hydraulic model was built by JBA Consulting. This was comprised of a 1m resolution DTM, material layers created from open-source

OS Vector Mapping, upstream and downstream boundary conditions and 2D topographical edits to represent the watercourse within the study area.

The modelled watercourse is the Griff brook which flows westwards around the southern boundary of the site and eventually discharges into the Coventry Canal.

6.1.2 Model extent

The model extent of the SHA 2 study area covers 4.80km² and is shown in Figure 6-2.

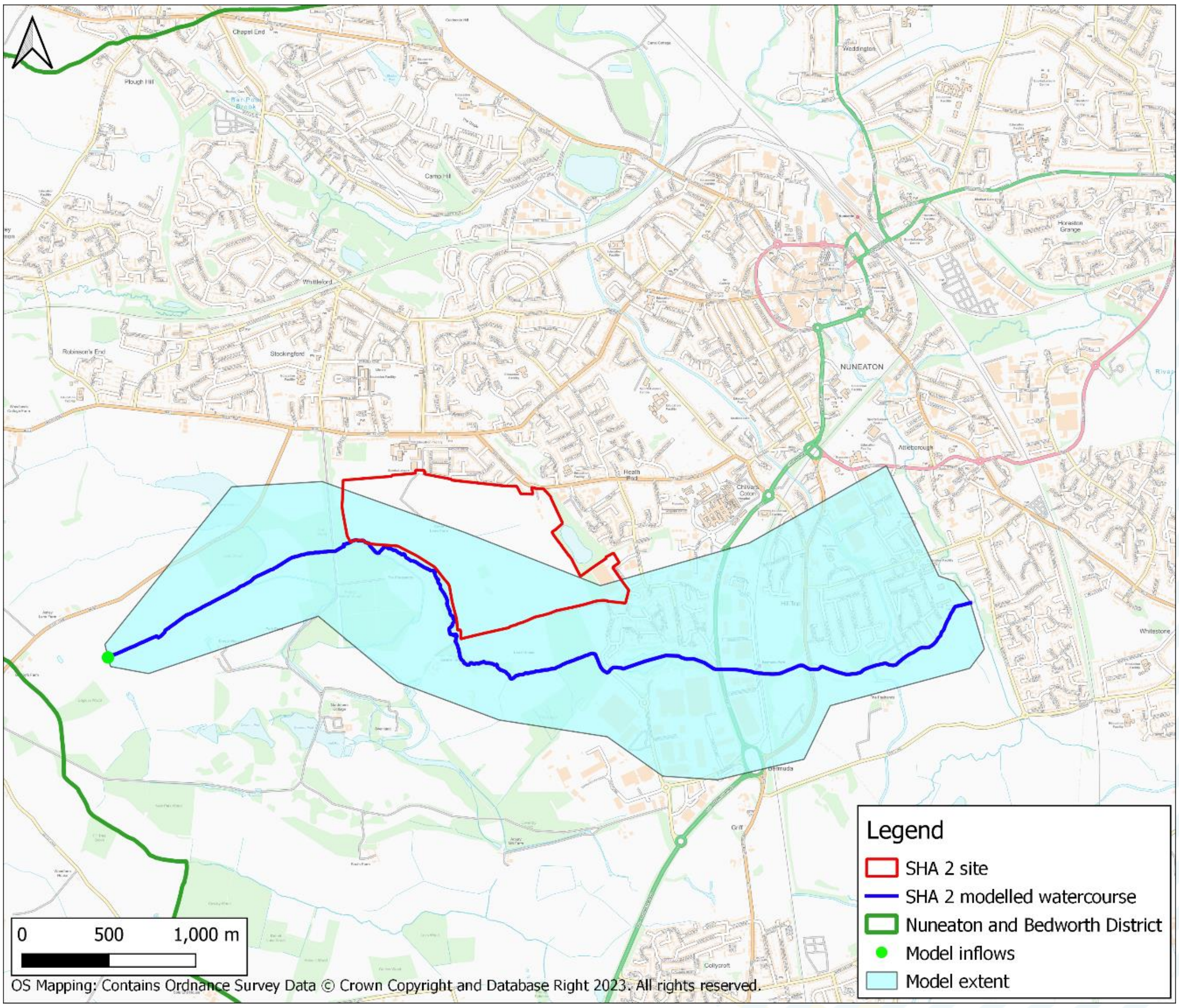

Figure 6-2: SHA2 model extent

6.1.3 Software used

The flood model was developed using TUFLOW version 2023-03-AB, which is the most recent version of the software at the time of this study. TUFLOW is a 2D hydrodynamic modelling package used widely throughout the industry. This model has used double precision due to ground elevations within the modelled study area exceeding 100mAOD.

There are no 1D elements within this model as no river channel survey data is available. Therefore, there is no requirement for a separate 1D solver.

6.1.4 Grid size selection

The model has been simulated using a 3m grid resolution. This resolution was found to provide an acceptable balance between the representation of overland flow routes and the management of acceptable model run times. A 2D timestep of 1s has been used which falls within the recommended tolerances as set by TUFLOW which recommends between 1/2 and 1/5 of the grid resolution.

6.1.5 Data availability

he latest 1m-resolution composite EA LiDAR Digital Terrain Model (DTM) was used as the base topography for the models. The LiDAR data used was flown in 2022 and represents the current ground topography. OS Vector map data was acquired to represent the land use within the modelled study area. This was processed to set the material and roughness values of the 2D domain.

No river channel survey data was available and therefore, a simplified 2D modelling approach has been adopted to represent the watercourses within the modelled study area. No data was available to represent the structure constrictions and therefore all structures have been cut through to reflect a continuous open channel. This approach can lead to the underestimation of flood risk but without survey data, this was the only method available.

6.1.6 Boundary conditions

Upstream and downstream boundary conditions have been applied to the model. At the upstream of the watercourse, a single Flow-Time (QT) point inflow has been applied. At the downstream extent, a 2D Stage-Discharge (HQ) line boundary condition has been applied. The channel gradient was applied to the 'b' attribute of the HQ boundary to allow TUFLOW to generate a Stage-Discharge relationship for the downstream boundary condition. This allows water to leave the model and prevent glass walling.

6.1.7 Hydrology

Given the small hydrological catchment area impacting the modelled study area and the high-level nature of the study, the ReFH2 approach only has been used to derive peak flow estimates and inflow hydrographs. The catchment has been treated as rural, as research into flood estimation in small catchments[3] revealed that flood frequency estimates on catchments of this size would be more accurate if they were treated as such.

The British Geological Survey (BGS) Geology of Britain viewer was used to assess the geology of the catchments and was found to be predominantly sedimentary beds of Mercia Mudstone deposited in the Triassic Period. Soils[4] of the catchments are predominantly slightly acid, loamy, and clayey soils with impeded drainage.

Due to the lack of hydrometric data available, the default ReFH2 parameters have been used unaltered. The peak flow estimates derived for this study and applied to the model are shown in Table 6-1.

Table 6-1: Flood peaks for each modelled watercourse

AEP Event	Flood Peaks for model inflows (m³/s)
	Griff Watercourse Inflow
50% AEP	2.32
20% AEP	2.99
10% AEP	3.48
5% AEP	4.03
3.3% AEP	4.11
3.3% AEP + Central CC	5.38
3.3% AEP + Higher CC	5.74
3.3% AEP + Upper CC	6.66
2% AEP	4.97
1.3% AEP	5.50
1% AEP	5.92
1% AEP + Central CC	7.22

3 3Stewart, Lisa, Duncan Faulkner, Giuseppe Formetta, Adam Griffin, Tracey Haxton, Ilaria Prosdocimi, Gianni Vesuviano and Andy Young (2021). Estimating flood peaks and hydrographs for small catchments (Phase 2). Report – SC090031/R0, Environment Agency.

4 4 http://www.landis.org.uk/soilscapes/index.cfm

JBA Project Code	2022s0447
Contract	NBBC Level 2 SFRA
Client	Nuneaton and Bedworth Borough council
Day, Date and Time	August 2023
Author	Arran Bright
Reviewer / Sign-off	Louise Goode/Paul Redbourne
Subject	Updated Modelling

AEP Event	Flood Peaks for model inflows (m³/s)
	Griff Watercourse Inflow
1% AEP + Higher CC	7.69
1% AEP + Upper CC	8.94
0.5% AEP	7.06
0.1% AEP	10.13
0.1% AEP + Central	12.36
0.1% AEP + Higher	13.17
0.1% AEP + Upper	15.30

6.1.8 Climate Change

This SFRA has utilised the latest EA guidance on climate change allowances. Peak river flow allowances were acquired from DEFRA's data service platform. The modelled watercourses are situated within the Tame, Anker and Mease catchment. The climate change allowances are shown in Table 3-1.

6.1.9 Topographic adjustments

LIDAR data at 1m resolution has been used to represent the base topography in the modelled study area. To help better define the watercourses in the study area, 2d_zsh lines and snapped 2d_zsh points were used to 'burn' the channel into the 2D domain. The channel bed elevations for the 2d_zsh points, were extracted from the base LIDAR data.

There was no river channel survey data available and the approach to burn the channel into the 2D domain is considered appropriate to ensure a continuous watercourse enabling conveyance downstream.

6.1.10 Hydraulic roughness values used

A generalised manning's roughness value of 0.05 was applied as the base 2D roughness coefficient across the study area, representing 'Greenspace'. Key features affecting roughness in each model were identified using OS Vector Map data and were included in the model using a 2d_mat file coupled with a .tmf (TUFLOW materials) file. The Manning's n values for the features that are included in the .tmf file are provided below in Table 6-2.

Table 6-2: 2D roughness values

2D Roughness Value	Feature
0.05	Greenspace
0.1	Buildings
0.15	Woodland
0.045	Inland Water
0.025	Roads

6.2 Assumptions and limitations

Developing a hydraulic model requires the application of simplifications and generalisations. As such, several assumptions are made when building the model, which can lead to model uncertainties and subsequent limitations of the results. This section summarises some of the outstanding assumptions and limitations with the model.

The 2D only approach is limited in that it may not accurately represent the channel capacity or the constrictions provided by in-line structures. Without the availability of survey data, these features cannot be represented accurately. The 2D only approach completed for this study is considered an improvement on existing broad scale mapping of the area, but future site-specific assessments may require more detailed flood modelling that adopt a 1D-2D linked approach that can more accurately represent the watercourses within the study area.

The model performance is generally considered stable but the Mass Error (ME%) which provides an indication on model stability reports a peak ME% exceeding 5% in some of the design event simulations. This is occurring at 0 hours into the simulation and is therefore attributed to the initial wetting in the 2D domain. The model quickly resolves itself and the mass error is within tolerable limits for the remainder of the simulation. The model is therefore considered to be stable which is further emphasised by the omission of any 2D negative depths within the model. The high mass error reported at the start of the simulation is considered an acceptable limitation.

The approach taken to derive the inflow estimates is considered appropriate for the scale of this study, but the use of ReFH2 only is considered a limitation. Future more detailed modelling of the study may be required for site specific assessments and therefore, the FEH statistical approach should also be considered for the derivation of peak flow estimates.

Appendix B - Modelling Technical Notes

JBA Project Code	2022s0447
Contract	NBBC Level 2 SFRA
Client	Nuneaton and Bedworth Borough council
Day, Date and Time	August 2023
Author	Arran Bright
Reviewer / Sign-off	Louise Goode/Paul Redbourne
Subject	Updated Modelling

C GeoPDF User Guide

This appendix details the datasets used within each site-specific GeoPDF map.

1.1 Historical flooding

The Environment Agency provided the Historic Flood Map dataset which details incidents of flooding in the area.

1.2 Fluvial flooding

1.2.1 Flood Zones

Flood Zones (FZ) are derived from the EA's Flood Map for Planning. The Flood Zones are defined as:

Flood Zone 3a: Locations in flood zone 3a have a high probability of flooding. This means in any year land has a 1% or more chance of flooding from rivers, or a 0.5% or more chance of flooding from the sea.

Flood Zone 2: Locations in flood zone 2 have a medium probability of flooding. This means in any year land has between a 1% and 0.1% chance of flooding from rivers and between a 0.5% and 0.1% chance of flooding from the sea.

1.2.2 Modelled Flood extents

Where available, detailed hydraulic model outputs have been used within this mapping to more accurately represent flood risk. Modelled flood extents include the 0.1% AEP, 1% AEP and 3.3% AEP extents*. Figure B-1 shows the coverage of these models.

*Areas within the modelled 3.3% extent should be considered as FZ3b. Where modelled results aren't available, FZ3a should be considered as FZ3b.

Table B-1 below details the models used to represent fluvial flood risk for each site.

The Environment Agency's Flood Map for Planning Flood Zones 2 and 3 have been used to represent fluvial flood risk in and around each site where detailed model outputs are not available.

Table B- 1: Hydraulic model used to represent fluvial flood risk for each site

Site name	Model used to represent fluvial flood risk	Software used
ABB-4	River Anker model (2015) River Anker portion of the WCC Nuneaton model (2023)	ISIS-TUFLOW ISIS-TUFLOW
ABB-7	River Anker model (2015) River Anker portion of the WCC Nuneaton model (2023)	ISIS-TUFLOW ISIS-TUFLOW
ABB-8 & ABB8-1	River Anker model (2015) River Anker portion of the WCC Nuneaton model (2023)	ISIS-TUFLOW ISIS-TUFLOW
BUL-9	Flood Map for Planning	-
CAM-1	Bar Pool Brook portion of the WCC Nuneaton model (2023)	ISIS-TUFLOW
EXH-1	River Sowe model (2010)	ISIS-TUFLOW
GAL-7	Bar Pool Brook portion of the WCC Nuneaton model (2023)	ISIS-TUFLOW
SEA-1	Griff Brook portion of the WCC Nuneaton model (2023)	ISIS-TUFLOW
SEA-2	River Sowe model (2010)	ISIS-TUFLOW
SEA-4	Griff Brook portion of the WCC Nuneaton model (2023)	ISIS-TUFLOW
SEA-5	River Sowe model (2010)	ISIS-TUFLOW
SEA-6 & SEA6-1	River Sowe model (2010)	ISIS-TUFLOW
SHA-1	Site-specific model of Change Brook and unnamed tributary of the River Anker (2023)	TUFLOW
SHA2-1, SHA2-2 & ARB-1	Site-specific model of two unnamed watercourses converging to form Griff Brook (2023)	TUFLOW
SHA-5	Flood Map for Planning	-
SHA3-4	River Anker portion of the WCC Nuneaton model (2023)	ISIS-TUFLOW
SHA3-1 & SHA3-2	River Anker model (2015) River Anker portion of the WCC Nuneaton model (2023)	ISIS-TUFLOW ISIS-TUFLOW
SHA-6	River Sowe model (2010)	ISIS-TUFLOW
ABB-6	River Anker model (2015) River Anker portion of the WCC Nuneaton model (2023)	ISIS-TUFLOW ISIS-TUFLOW

Please note: WCC stands for Warwickshire County Council

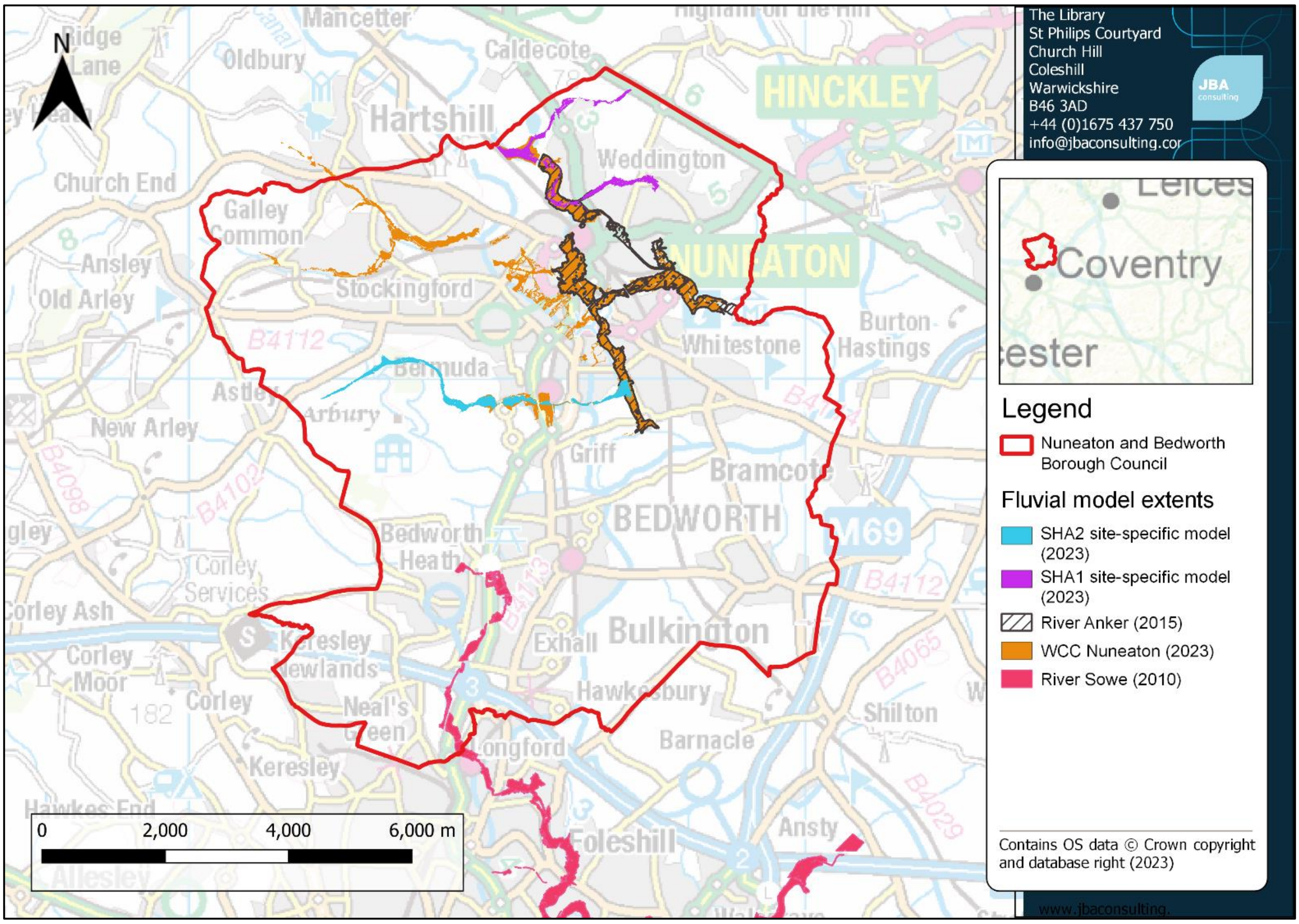

Figure B- 1: Hydraulic model extents coverage in Nuneaton and Bedworth Borough Council

1.3 Climate change

Detailed Environment Agency hydraulic models were obtained under licence for the SFRA. Where climate change simulations undertaken for the past projects were within +/- 10% of the updated climate change allowances, these were deemed suitable to use. This was the case for the following models:

- River Sowe
    i. 3.3% AEP +22%, 30%, 59% CC (latest climate change allowances: +21%, 32%, 59%)
    ii. 1% AEP +22%, 30%, 59% CC (latest climate change allowances: +21%, 32%, 59%)

Where previous climate change runs were not suitable, these models were re-run as part of this SFRA. This was the case for the following models:

- River Anker
    i. 3.3% AEP +22%, 30%, 51% CC
    ii. 1% AEP +22%, 30%, 51% CC

The WCC Nuneaton model and the two site-specific models (SHA1 and SHA2) were also run with the latest climate change allowances as detailed below:

- WCC Nuneaton model
    i. 3.3% AEP +22%, 30%, 51% CC
    ii. 1% AEP +22%, 30%, 51% CC
- SHA1 site-specific model
    i. 3.3% AEP +22%, 30%, 51% CC
    ii. 1% AEP +22%, 30%, 51% CC
- SHA2 site-specific model
    i. 3.3% AEP +22%, 30%, 51% CC
    ii. 1% AEP +22%, 30%, 51% CC

Surface Water Climate Change uplifts were modelled for the Risk of Flooding from Surface Water (RoFSW) dataset for the following events and scenarios:

- 3.3% AEP +25% CC
- 3.3% AEP +35% CC
- 1% AEP +25% CC
- 1% AEP +40% CC

1.4 Surface water flooding

Mapping of surface water flood risk in the study area has been from the Risk of Flooding from Surface Water (RoFfSW) maps published online by the Environment Agency. These maps are intended to provide a consistent standard of assessment for surface water flood risk across England and Wales in order to help LLFAs, the Environment Agency and any potential developers to focus their management of surface water flood risk.

The RoFfSW is derived primarily from identifying topographical flow paths of existing watercourses or dry valleys that contain some isolated ponding locations in low lying areas. They provide a map which displays different levels of surface water flood risk depending on the annual probability of the land in question being inundated by surface water (Table B- 2).

Table B- 2: RoFfSW EA risk categories

Category	Definition
High	Flooding occurring as a result of rainfall with a greater than 1 in 30 chance in any given year (annual probability of flooding 3.3%).
Medium	Flooding occurring as a result of rainfall of between 1 in 100 (1%) and 1 in 30 (3.3%) chance in any given year.
Low	Flooding occurring as a result of rainfall of between 1 in 1,000 (0.1%) and 1 in 100 (1%) chance in any given year.

Although the RoFfSW offers improvement on previously available datasets, the results should not be used to understand flood risk for individual properties. The results should be used for high level assessments such as SFRAs for local authorities. If a site is indicated in the Environment Agency mapping to be at risk from surface water flooding, a more detailed assessment should be considered to illustrate the flood risk more accurately at a site-specific scale.

1.5 Groundwater

Mapping of groundwater flood risk has been based on the JBA Groundwater Flood Map 5m Resolution GW5 V2.3. The Groundwater Flood Risk Map is based on detailed source datasets and also represents the relationship between peak groundwater levels and return period. The map should be interpreted as an initial indicative tool to assess groundwater flood risk.

The Environment Agency's Areas Susceptible to Groundwater Flooding (AStGWF) dataset has also been provided to represent groundwater flood risk.

1.6 Reservoirs

The risk of inundation because of reservoir breach or failure of reservoirs within Nuneaton and Bedworth Borough Council has been mapped using the outlines produced as part of the National Reservoir Flood Mapping (RFM) study, and are shown online on the Long-Term Risk of Flooding website at the time of publication.

The Environment Agency provide two flooding scenarios for the reservoir flood maps: a ‘dry-day’ and a ‘wet-day’. The ‘dry-day’ scenario shows the predicted flooding which would occur if the dam or reservoir fails when rivers are at normal levels. The ‘wet-day’ scenario shows the predicted worsening of the flooding which would be expected if a river is already experiencing an extreme natural flood.

1.7 Flood Defences

The Environment Agency supplied the location of all flood defences within Nuneaton and Bedworth Borough Council in their AIMS database, including information relating to the type of flood defence and their standard of protection.

1.8 Overview of supplied data

Overview of supplied data for the Nuneaton and Bedworth Borough Council GeoPDF mapping from stakeholders is as follows:

Source of flood risk	Data used to inform the assessment	Data supplied by
Historic (all sources)	Historic Flood Map	Environment Agency
Fluvial (including climate change where available)	River Anker (2015) 1D-2D ISIS-TUFLOW model (re-run by JBA Consulting in 2023) River Sowe (2010) ID-2D ISIS-TUFLOW model (re-run by JBA Consulting in 2023)	Environment Agency
	Warwickshire County Council Nuneaton (2023) 1D-2D ISIS-TUFLOW model SHA1 site-specific (2023) 2D TUFLOW model SHA2 site-specific (2023) 2D TUFLOW model	Warwickshire County Council JBA Consulting JBA Consulting
	Flood Map for Planning Flood Zones	Environment Agency
Surface Water	Risk of Flooding from Surface Water dataset	Environment Agency
Groundwater	Areas Susceptible to Groundwater Flooding (AStGWF)	Environment Agency
	Groundwater Flood Risk Map	JBA Consulting
Reservoirs	National Inundation Reservoir Mapping (long term flood risk map)	Environment Agency
Flood defences	Location and description of flood defences	Environment Agency

Source of flood risk	Data used to inform the assessment	Data supplied by
Other datasets	Partner Data Catalogue: - AIMS asset bundle - LIDAR Composite DTM 2020 1m - Risk of Flooding from Rivers and Sea - Risk of Flooding from Rivers and Sea (properties in areas at risk) - Reduction in Risk of Flooding from Rivers and Sea due to Defences - Reservoir Inundation Maps - Risk of Flooding from Surface Water - Spatial Flood Defences Including AIMS - Detailed River Network - Flood Alert Areas - Flood Warning Areas - Flood Maps for Planning - Historic Flood Map	Environment Agency

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Appendix D: RAG Summary

KEY		
	(pink)	Site table required, significant flood risk
	(yellow)	Minor issue mentioned in main report

Sites	New Site Code	Label	Allocation	Area (Ha)	% of site in in FZ2	% of site in FZ3	% of site in RoFSW 0.1% AEP event	% of site in RoFSW 1% AEP event	% of site in RoFSW 3.3% AEP event	% of site in 3.3% AEP fluvial	% of site in 1% AEP fluvial	% of site in 0.1% AEP fluvial
EXH-1		NSHA-2	NON-STRATEGIC	3.7	4.1	0.0	2.3	0.7	0.5	0.0	0.0	0.0
SHA1			STRATEGIC	94.2	1.0	0.3	10.0	4.1	1.8	1.5	1.8	2.8
ABB-8		NSHA-5	NON-STRATEGIC	1.0	0.9	0.0	9.1	0.0	0.0	0.0	0.0	0.9
SEA-1			SEA (employment sites)	26.4	0.3	0.0	3.6	1.1	0.5	0.0	0.0	0.7
SEA-2			SEA (employment sites)	18.3	0.7	0.3	12.4	6.2	4.5	5.3	5.6	6.3
SEA-4			SEA (employment sites)	9.6	0.7	2.2	4.4	1.5	1.2	0.0	1.9	2.6
SHA3	SHA3-4		STRATEGIC	8.4	13.0	7.0	12.5	1.3	0.8	13.3	14.5	19.4
SEA-5			SEA (employment sites)	2.1	0.0	0.0	18.1	5.6	2.5	0.0	0.0	0.0
SEA-6			SEA (employment sites)	19.9	0.0	0.0	6.3	3.0	2.0	0.0	0.0	0.0
BUL-9		NSHA-12	NON-STRATEGIC	0.3	0.0	0.0	26.3	6.1	0.0	N/A	N/A	N/A
ARB-1		NSHA-13	NON-STRATEGIC	0.8	0.0	0.0	22.5	3.1	0.6	0.0	0.0	0.0
GAL-7		NSHA-11	NON-STRATEGIC	2.2	5.1	2.4	54.4	38.2	28.8	38.6	40.9	46.0
ABB-8	ABB8-1		NON-STRATEGIC	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SHA2	SHA2-1		STRATEGIC	85.0	0.0	0.0	8.4	3.5	2.3	0.1	0.1	0.2
SHA2	SHA2-2		STRATEGIC	0.8	0.0	0.0	5.6	3.4	0.0	0.0	0.0	0.0
SHA-5			STRATEGIC	18.8	0.0	0.0	13.7	4.2	1.9	N/A	N/A	N/A
SHA-3	SHA3-1		SHA	40.1	0.0	0.0	6.0	1.6	0.7	0.0	0.0	0.0
SHA-3	SHA3-2		SHA	15.0	0.0	0.0	11.0	4.7	1.4	0.0	0.0	0.0
SEA-6	SEA6-1		STRATEGIC	6.4	0.0	0.0	4.0	0.2	0.0	0.0	0.0	0.0
CAM-1		NSHA-7	NON-STRATEGIC	1.9	0.0	0.0	6.4	2.9	0.6	0.0	0.0	0.0
ABB-4		NSHA-4	NON-STRATEGIC	2.3	4.1	2.5	1.9	0.0	0.0	0.0	0.0	0.8
ABB-6		NSHA-9	NON-STRATEGIC	2.4	18.6	12.0	6.3	1.2	0.0	0.0	0.4	3.9
SHA-6			SHA	29.0	0.0	0.0	12.9	4.9	2.9	0.0	0.0	0.0
ABB-7		NSHA-17	NON-STRATEGIC	0.5	100.0	78.6	87.5	47.6	6.5	0.2	41.4	87.7
ABB-5		NSHA-14	NON-STRATEGIC	0.3	0.0	0.0	3.0	2.2	0.0	0.0	0.0	0.0
EXH-8		NSHA-10	NON-STRATEGIC	1.6	0.0	0.0	3.6	0.0	0.0	0.0	0.0	0.0
EXH-2		NSHA-25	NON-STRATEGIC	0.4	0.0	0.0	2.4	0.1	0.0	0.0	0.0	0.0
EXH-3		NSHA-3	NON-STRATEGIC	3.0	0.0	0.0	5.2	1.6	0.7	0.0	0.0	0.0
SHA3		SHA3-3	SHA	8.2	0.0	0.0	5.9	2.0	0.5	0.0	0.0	0.0
SHA-4			STRATEGIC	23.2	0.0	0.0	2.0	0.4	0.2	0.0	0.0	0.0

Sites	New Site Code	Label	Allocation	Area (Ha)	% of site in in FZ2	% of site in FZ3	% of site in RoFSW 0.1% AEP event	% of site in RoFSW 1% AEP event	% of site in RoFSW 3.3% AEP event	% of site in 3.3% AEP fluvial	% of site in 1% AEP fluvial	% of site in 0.1% AEP fluvial
KIN-2		NSHA-15	NON-STRATEGIC	0.6	0	0	0	0	0.04	0	0	0
EXH-14		NSHA-22	NON-STRATEGIC	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SEA-3			SEA (employment sites)	5.3	0.0	0.0	4.6	3.0	2.2	0.0	0.0	0.0