

# NW Bicester Masterplan

Flood Risk Assessment



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## A2Dominion

## NW Bicester

## Flood Risk Assessment

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### Masterplan Site

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# EXECUTIVE SUMMARY

The table below provides an overview of the flood risk and drainage strategy for the proposed NW Bicester development.

Item	Response
Site Location	The site of the proposed NW Bicester development is on the north west perimeter of Bicester, Oxfordshire.
Size and Current Land Use	The site has a total site area of approximately 400ha and is existing open agricultural land
Environment Agency Flood Zone	The majority of the site is within Flood Zone 1: Low Probability. Areas of Flood Zone 2 and 3 are located adjacent to watercourses where no development is proposed other than green buffers and blue corridors.
Fluvial Flood Risk	Low risk of fluvial flooding
Tidal Flood Risk	No risk of tidal flooding
Surface Water Flood Risk	Low risk of surface water flooding
Sewer Flood Risk	The site itself is not at risk of flooding from sewers. However, an appropriate drainage strategy is required to ensure that the development does not exacerbate downstream flood risk.
Groundwater Flood Risk	Considered unlikely although further site specific monitoring would confirm this.
Artificial Sources Flood Risk	Low risk of flooding from artificial sources
Historical Flooding	No records of historical flooding
Proposed Development	Up to 6000 new homes houses with employment areas and associated services and infrastructure
NPPF Flood Risk Vulnerability	More vulnerable
Sequential and Exception Tests	The proposed development types are permitted within Flood Zone 1 and therefore pass the Sequential Test. The Exception Test is not required,





# 1 INTRODUCTION

## 1.1 Project Appointment

Hyder Consulting (UK) Limited (HCL) were appointed by A2Dominion to produce a Flood Risk Assessment (FRA) for the NW Bicester development to inform the proposed MasterPlan. The masterplan and related documents sets out the spatial vision to provide up to 6000 new homes at NW Bicester. The FRA assesses the risk of flooding and how the proposals will connect to existing infrastructure.

## 1.2 Development context

NW Bicester is being promoted as a site for up to 6000 new homes, after previously being identified as an Eco-town location within the Planning Policy Statement 1 supplement entitled Eco-Towns A Supplement to Planning Policy Statement 1 (July 2009) (PPS 1 Supplement).

In addition, the development proposal includes non-residential areas comprising commercial floorspace , leisure facilities and social and community facilities.

Planning permission was secured for the Exemplar stage of the development in 2012. The Exemplar stage comprises 393 dwellings. Development of this part of the site is anticipated to commence in 2014.

## 1.3 The Role of this Document

This strategy is one of a number of documents prepared on behalf of A2Dominion in support of the masterplan plan. The Planning Policy Statement: Eco-Towns A Supplement to Planning Policy Statement 1 (July 2009) requires the preparation and submission of a master plan to demonstrate the eco town standards, as set out in the PPS1 supplement, will be addressed.

The master plan will therefore provide the context for the formulation and preparation of subsequent planning applications. It is open to the Council to adopt the master plan for development control purposes.

The role of the FRA is to identify potential flooding mechanisms on and off site, and how these might be affected by climate change; and hence determine appropriate mitigation measures. This will provide a robust evidence base to demonstrate that the NW Bicester development site can be developed with appropriate consideration of flood risk mitigation on site, and without increasing the flood risk to third parties.

## 1.4 Project Context

An FRA was produced for a small portion of the NW Bicester development, termed the Exemplar Site, in June 2011 whereas this FRA is written in relation to the wider NW Bicester development site.

Since the publication of the Exemplar Site FRA in June 2011, Planning Policy Statement 25 (PPS25)<sup>1</sup> has been replaced by the National Planning Policy Framework (NPPF)<sup>2</sup>. This FRA has therefore been written taking into account this revised guidance.

## 1.5 Aims and Objectives

The aim of this FRA is to demonstrate that the NW Bicester development site can be developed safely without exposing the new development to an unacceptable degree of flood risk or increasing the flood risk to third parties. The report presents the findings of a site specific FRA as required by the NPPF which states:

*“This should identify and assess the risks of all forms of flooding to and from the development and demonstrate how these flood risks will be managed so that the development remains safe throughout its lifetime, taking climate change into account.”*

The key objectives are to:

- Identify potential sources of flooding and assess the risks they pose to the site
- Consider the effect of predicted climate change on future flood risk to the site
- Determine the impact of the development on flood risk to third parties
- Determine an appropriate surface water drainage strategy
- Recommend appropriate flood risk mitigation measures as required

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<sup>1</sup> Communities and Local Government (2010) Planning Policy Statement 25 Development and Flood Risk

<sup>2</sup> Communities and Local Government (2012) National Planning Policy Framework

## 2 DEVELOPMENT CONTEXT

### 2.1 Site Description

The site of the proposed NW Bicester development is on the north west perimeter of Bicester, Oxfordshire and has a total site area of approximately 400ha. The site is bounded by the A4095, B4100 and B4030 and bisected approximately north south by the mainline Birmingham to London Marylebone railway and Bucknell Road.

The existing site is predominantly greenfield in nature, encompassing a number of small farms and associated access. Figure 2-1 shows the site location along with the key features referred to in the report. Drawing 7019-UA001881-03 in Appendix B is taken from the Exemplar Site FRA and shows the existing water features on the site in more detail.

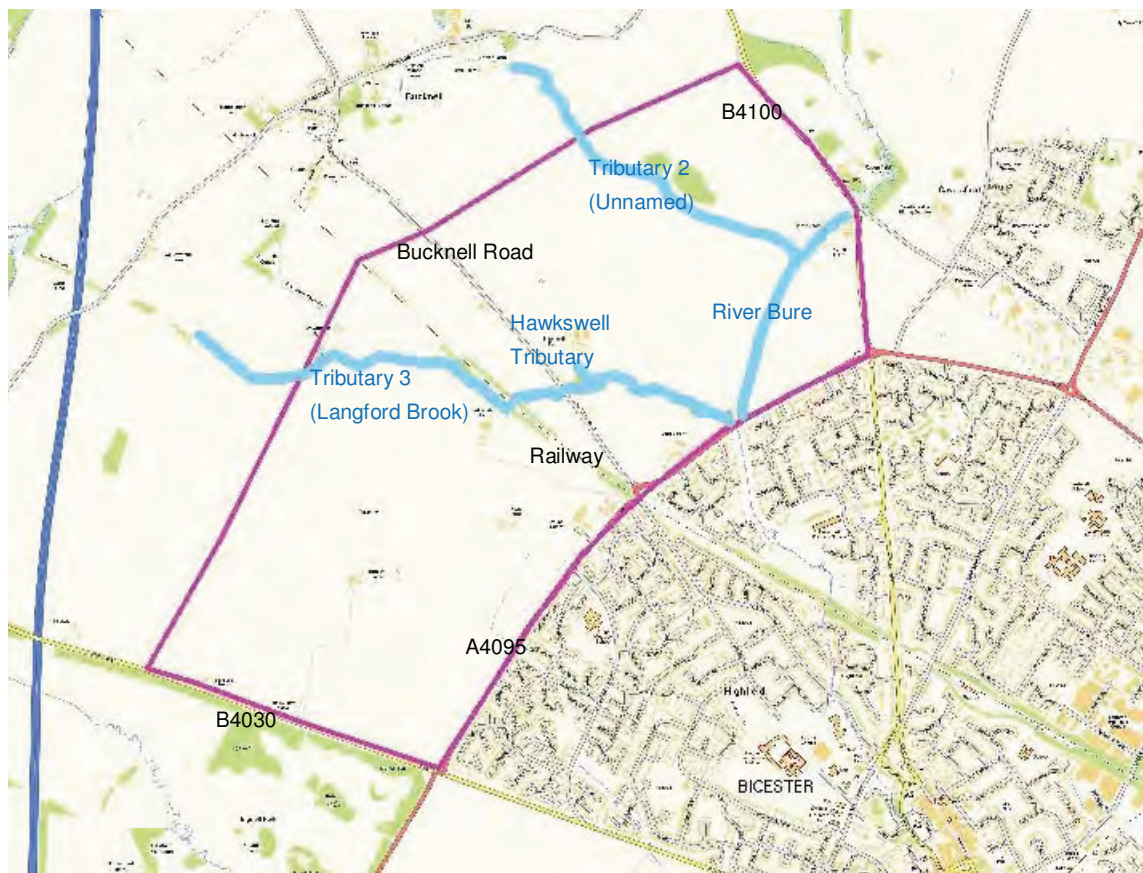


Figure 2-1 Site Location

### 2.2 Site Topography

The NW Bicester development site slopes predominantly from north west to south east with elevations ranging from around 97mAOD to 80mAOD. A detailed topographic survey of the site has not been completed; elevations are based on LiDAR data supplied by Environment Agency Geomatics in September 2013. The main watercourses on the site drain into the River Bure which leaves the site via a culvert under the A4095, flowing towards Bicester town centre.

## 2.3 Existing Drainage Features

The proposed development site contains a number of drainage features; the River Bure and its tributaries, the Langford Brook, Hawkswell Farm and unnamed tributary), field drains, ponds and springs. The main drainage features are described below.

The River Bure flows in a southerly direction from Caversfield House to a culvert beneath the A4095. Downstream of this culvert and outside the development site, the river flows in an open channel between Lucerne Avenue and Purslane Drive before flowing beneath the railway line and through Bicester town centre. The River Bure is classed as 'Main River' from Graham Road in the centre of Bicester, upstream of this point, the river is classed as 'Ordinary Watercourse'.

The Langford Brook, an ordinary watercourse, flows in an easterly direction from Crowmarsh Farm and converges with the River Bure at the A4095 culvert. A small unnamed tributary starts downstream of Hawkswell Farm and joins with Langford Brook. This tributary is referred to as the Hawkswell Tributary in this FRA. One other unnamed tributary flows in an easterly direction from Bucknell to converge with the Bure downstream of Home Farm. This tributary is referred to as Tributary 2 in this FRA.

A field drain south of Gowell Farm flows in a southerly direction to a culvert taking it under the A4095 and into the downstream urban area.

There are several ponds within the site boundaries, most notably at Crowmarsh Farm and south of Himley Farm and a spring is shown to present east of Himley Farm. In addition to these prominent water features, it is likely that a number of ditches and other smaller features drain individual fields and feed in to the network.

It is assumed that the existing properties with the site are likely to discharge runoff from roofs and paved areas to ditches or piped networks discharging to the watercourses.

Highways crossing and adjacent the site shed surface water to their grassed verges, from where it infiltrates the ground.

Information obtained from Thames Water indicates that urban areas surrounding the development site are drained by a positive drainage network of surface water pipes and manholes which discharging to nearby watercourses. The urban areas drain away from the proposed development site.

## 2.4 Ground Conditions

Ground conditions across the entire development site were assessed as part of the Phase 1 work carried out in 2010. A desk study report was produced<sup>3</sup>, which drew the following conclusions:

- The majority of the existing fields are surrounded by drainage ditches 0.5m to 0.75m deep; all were dry during the July 2010 site visit
- There is a thin cover of Superficial Deposits across the site

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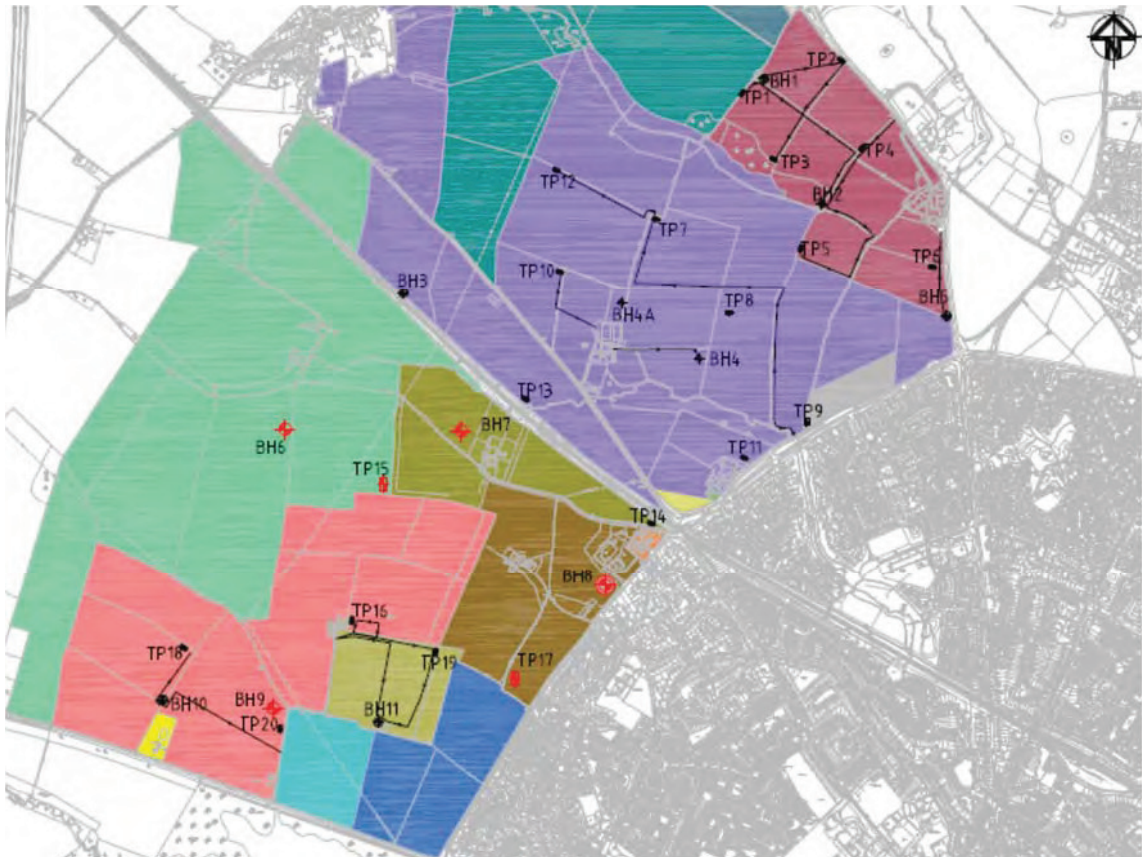
<sup>3</sup> Hyder Consulting (July 2010) NW Bicester Eco-Town - Phase 1 Desk Study, 2501-UA001881-UP33R-01

- Some alluvium is present along stream corridors; this comprises sandy, calcareous clay overlying gravelly clay with limestone clasts and may locally include highly compressible, organic-rich (peaty) layers
- The Solid Geology is dominated by limestones with subordinate mudstone beds
- The site is underlain by:
  - Forest Marble in the floors and sides of the valleys. This may hold small quantities of water in any limestone bands present, but the upper part generally acts as an aquiclude between the Cornbrash Formation and the underlying White Limestone Formation. No boreholes drilled into this formation recorded water strikes.
  - Cornbrash Formation across the majority of the site. This is a local aquifer and water strikes have been recorded in shallow boreholes drilled within the site area. The standing water levels are generally between 0.5m and 4.0m below the ground surface
- White Limestone Formation constitutes a major aquifer in the area, which provides some sources of public supply:
  - A 34m deep borehole at Gowell Farm (SP52/19 at SP 5709 2384), drilled pre-1909 to supply Bicester with water. Water was struck at 28m and 32m below the ground level in the White Limestone Formation. The rest water level rose to the surface after the first strike, and was artesian, with a rest water level about 1m above ground level (about 88m AOD) after the second strike. The yield was over 7 l/s.
  - An 80 m deep borehole at Lords Farm (SP52/18 at SP 5746 2424), struck water in the Cornbrash Formation, which was cased out, and at two levels below the White Limestone Formation. The rest water level was at 11m below ground level (about 68m AOD) and it yielded 1.7 l/s. Other records of water levels at Lords Farm (SP52/17A, B and C at about SP 569

Following the desk study, a targeted, intrusive ground investigation was carried out from the 2<sup>nd</sup> August to 7<sup>th</sup> September 2010 and comprised of dynamic sampling, rotary coring and trial pitting including Standard Penetration Tests (SPTs) and permeability testing. Figure 2-2 shows the locations of the investigations carried out. These investigations drew the following conclusions:

- There was insufficient data to determine a groundwater flow direction, however it was considered that it was likely that locally it would be towards the nearest stream and regionally, down-dip towards the south-east
- Excavations for shallow foundations may encounter some groundwater flow in some areas, particularly after heavy rain. Therefore provision for pumping should be allowed for.
- The groundwater strikes within the trial pits generally coincide with the top of the limestone
- Soakaway testing was undertaken in TP7, TP11 and TP12 within the limestone rock and indicates limited or no soakage.
- No water strikes were recorded within the Cornbrash formation or superficial deposits during drilling. Follow-up groundwater monitoring recorded groundwater standing at in excess of 3m depth on average.
- Following heavy rain, groundwater was encountered as perched water table above the limestone.





**Figure 2-2 Location of Intrusive Site Investigations** (taken from Hyder Consulting Report 507-UA001881-UP33R-01: Geotechnical Interpretive Report – Masterplan Site)

## 2.5 Development Proposals

NW Bicester is being promoted as a site for up to 6,000 homes, after previously being identified as an Eco-town location within the Planning Policy Statement (PPS) 1 supplement.

The development proposal includes non-residential areas comprising commercial floorspace, leisure facilities and social and community facilities.

Development is proposed to start in 2014/15,. The Exemplar Site that involves 393 homes will start first in 2014/15.

The current site MasterPlan is included in Appendix A. Residential development is distributed across the development site with areas of green space located predominantly alongside watercourse corridors. Proposals include for a new primary road across the Langford Brook (Tributary 3), immediately downstream of the Hawkswell Tributary confluence along with a new foot and cycle crossing of Tributary 2. These proposals are in addition to the crossings associated with the Exemplar Site development.

Table 2 of the NPPF Technical Guidance introduces a vulnerability classification for development in order to inform its suitability with respect to flood risk. Table 2-1 summarises the vulnerability associated with the expected development types.

Proposed Development	Vulnerability Classification
Residential Dwellings	More Vulnerable
Education	More Vulnerable
Amenity Open Space	Water Compatible
Outdoor sports and recreation	Water Compatible
Buildings used for shops, financial, professional and other services, offices	Less Vulnerable

**Table 2-1 Flood Risk Vulnerability Classification**

## 2.6 Planning Context

### 2.6.1 Planning Policy

NW Bicester (NWB) is identified in the supplement to PPS1 entitled 'The Planning Policy Statement: Eco-Towns A Supplement to Planning Policy Statement 1' (July 2009) as one of four locations for an Eco Town. The principle of the development is supported by Cherwell District Council ('the Council') and the land to the north west of Bicester ('the Site') is identified in the emerging Local Plan as the area within which a development following eco-town principles and the standards in PPS1 Supplement could be developed.

Planning Policy Statement PPS 1 supplement on Eco Towns contains requirements for both drainage ET 17 (Water) and flood risk management, ET18.

ET17 states that eco-towns should "incorporate measures in the water cycle strategy for improving water quality and managing surface water, ground water and local watercourses to prevent surface water flooding" and "incorporate sustainable drainage systems ...and avoid connection of surface water run-off into sewers".

ET18 states "eco-towns should reduce and avoid flood risk wherever practicable."

It is anticipated that the current Government will cancel the current PPS Supplement in due course. Notwithstanding, the requirements of the Supplement to PPS1 will be carried over by Cherwell (subject to review and amendments as necessary) into the Local Plan. The Council has already set out its policy position in respect of NWB in the emerging Local Plan and granted planning permission for the Exemplar Phase of NWB for 393 new homes, local facilities and land for a primary school.

### 2.6.2 Strategic Flood Risk Assessment

A Level 2 Strategic Flood Risk Assessment (SFRA) was completed for Cherwell District Council in 2012<sup>4</sup>. The NW Bicester development site was assessed as part of this SFRA. Broad scale hydraulic modelling was carried out to inform the assessment of flood risk to the site although the SFRA recommended that more detailed modelling was carried out as part of a site specific FRA.

<sup>4</sup> URS (2012) Cherwell District Council Level 2 SFRA

The SFRA also recommended that development is located away from watercourses, within Flood Zone 1, creating a network of blue corridors.

### 2.6.3 Sequential and Exception Tests

The NPPF requires that development is steered sequentially to sites at lower risk of flooding in preference to developing higher risk sites. In order to comply with this requirement, Local Planning Authorities are required to apply the Sequential Test when allocating sites for development.

Policy ET 18 (Flood Risk Management) within Eco towns, A supplement to Planning Policy Statement 1, expects that all built-up areas are located entirely within Flood Zone 1, with Flood Zone 2 used for open spaces and informal recreation areas.

Cherwell District Council updated their Sequential and Exception Test in October 2013<sup>5</sup>. The NW Bicester development site was identified as being located '*mostly in Flood Zone 1 but with small areas in Flood Zone 2 and 3*'. The results of the Sequential Test concluded that as the majority of the site is within Flood Zone 1, the site is a low risk of flooding and that any development on the site is located in accordance with the SFRA.

Therefore, it is concluded that the Sequential Test has been appropriately completed for Cherwell District Council.

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<sup>5</sup> Cherwell District Council (2013) Sequential and Exception Test (Flooding): Strategic Sites



## 3 SOURCES OF FLOODING

### 3.1 General

The Technical Guidance to NPPF requires that an FRA should 'assess the risks of all forms of flooding to and from the development'; therefore, this section presents a review of all potential sources of flood risk to the proposed development site.

### 3.2 Historical Flooding

As the existing site is undeveloped, it is considered unlikely that any flooding would have been reported. A review of the Oxfordshire Preliminary Flood Risk Assessment (PFRA)<sup>6</sup> did not highlight any flooding within the site boundary although some surface water flooding has occurred within Bicester town.

### 3.3 Flooding From Rivers

The River Bure flows from east to west along the southern site boundary. In addition, two tributaries of the Bure flow approximately north west – south east across the site. The Bure drains out of the site via a culvert under the A4095.

The Environment Agency on-line flood map shows a narrow corridor of Flood Zone 2 associated with the River Bure; however no flood mapping is associated with the tributary watercourses located within the site boundary. Therefore, detailed hydraulic modelling has been undertaken to inform this FRA. This is discussed further in Section 4.1.2.

It is therefore concluded that the site is at risk of flooding from rivers; these risks are discussed further in the following sections of the report.

### 3.4 Flooding from the Sea

The site is located some 150 km from the coast and is therefore not at risk of flooding from the sea.

### 3.5 Flooding from Land

The existing site is Greenfield and used for agricultural purposes, therefore there is no surface water drainage infrastructure associated with the site. It is therefore concluded that the site may be at risk of flooding from the land. This is discussed further in the subsequent sections of this report.

### 3.6 Flooding from Groundwater

Ground investigations were carried out in 2010 to inform the background reports produced to support the Exemplar Site planning application. The results of these investigations indicated that, with the exception of the Forest Marble Formation cropping out in the floors and sides of the valleys, the whole of the Exemplar Site is underlain by the Cornbrash Formation. The

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<sup>6</sup> JBA Consulting (2011) Oxfordshire County Council Preliminary Flood Risk Assessment: Preliminary Assessment Report

Cornbrash Formation is a local aquifer and water strikes were recorded in shallow site investigation boreholes that were drilled as part of the Exemplar Site ground investigation.

Maps of Areas Susceptible to Groundwater Flooding (ASStGWF) were included within the SFRA. These maps were released by the Environment Agency in 2011 and shows the proportion of each 1km grid square where geological and hydrogeological conditions indicate that groundwater might emerge. The maps show that to the north east of the railway line, the percentage of each 1km square that could potentially be subject to groundwater flooding is 25%. To the south west of the railway line, no groundwater flood susceptibility has been defined.

The Environment Agency on line Groundwater Vulnerability Map has been reviewed to determine the vulnerability of the groundwater underlying the Site with the following conclusions:

The superficial deposits are not classified as an aquifer. The underlying Cornbrash Formation is classified as a Secondary A Aquifer, which comprises “permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.”

It is therefore concluded that groundwater flooding cannot immediately be discounted as a risk to the site. This is discussed further in Section 4.4.

### 3.7 Flooding from Sewers

Thames Water Utilities Limited (TWUL) owns assets within and around the development site that are likely to be affected by the proposals. TWUL plans indicate that an existing 150mm foul water rising main and a 150mm standby rising main run south along Bucknell Road which bisects the site. All other sewers shown on the plan serve the existing area of Bicester on the south east side of the A4095. There are no known flooding issues associated with the existing public sewers within the site boundary.

The SFRA highlights a report from Cherwell District Council that there is a known history of sewer flooding in Bicester resulting from a limited capacity within the network. The consultations undertaken with TWU during the preparation of this FRA also confirmed that there is limited capacity is available within the existing sewer network.

It is therefore concluded that known problems and infrastructure in the area may require further consideration in order to prevent potential exacerbation of any existing flooding problems. This issue is discussed further in Section 6.2.

### 3.8 Flooding from Reservoirs, Canals and Other Artificial Sources

Although the site is not located close to any reservoirs, canals or other raised water storage assets, the potential effects of flood risk management infrastructure should also be considered.

The Environment Agency on-line flood map was reviewed and no flood defences were apparent in the vicinity of the development site.

TWUL plans indicate three potable water mains crossing the site following an existing minor track located approximately 600m west of the railway. There is a risk that, should these pipes be damaged during the construction process, flooding to the site could occur as a result.

It is therefore concluded that the site is at risk of flooding from artificial sources, predominantly during the construction phase. Mitigation for this risk is discussed further in Section 6.4.

## 4 FLOOD PROBABILITY

As identified in Section 3, the site is predicted to be at potential risk of flooding from the River Bure and tributaries, surface water, groundwater and the TWUL water mains. This section reviews the probability of flooding from these sources.

### 4.1 Flood Zones

#### 4.1.1 Published

Table 1 of the Technical Guidance to NPPF classifies flood probability into three zones as described in Table 4-1.

Flood Zone	Qualitative Assessment	Probability of Flooding
Flood Zone 1	Low Probability	Less than 1000-year annual probability of flooding (0.1%)
Flood Zone 2	Medium Probability	Between 100-year and 1000-year annual probability of flooding (1% - 0.1%)
Flood Zone 3a	High Probability	Greater than 100-year (1%) annual probability of river flooding
Flood Zone 3b	Functional Floodplain	Land where water <i>has</i> to flow or be stored in times of flood. The extent of Flood Zone 3b should not be defined using rigid probability parameters and should take into account local circumstances.

**Table 4-1 Flood Zone Classification<sup>1</sup>**

The published Environment Agency Flood Zones associated with the River Bure indicate that less than 1% of the site lies within Flood Zone 2. However, no Flood Zones associated with the tributary watercourses have been mapped. Therefore in order to fully assess the flood risk to the site, detailed hydraulic modelling and flood mapping has been carried out for this FRA.

#### 4.1.2 Site Specific

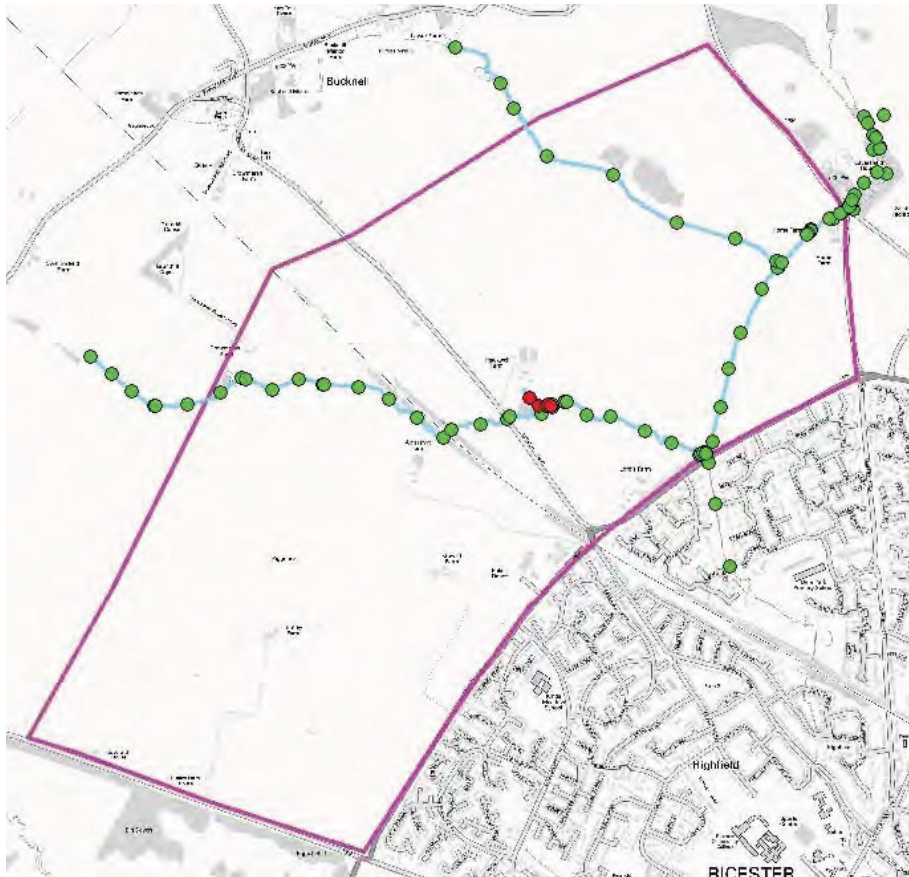
##### Hydraulic Model

A detailed ISIS model of the River Bure and tributaries was constructed to inform the FRA for the Exemplar Site<sup>7,8</sup>. These existing reports are included as Appendix B and should be consulted for full details of the hydrological and hydraulic assessments undertaken.

The Exemplar Site ISIS model extended sufficiently to cover the entirety of the NW Bicester developemt Site as shown in Figure 4-1.

<sup>7</sup> Hyder Consulting (2011) North West Bicester Eco Development: Flood Risk Assessment Exemplar Site

<sup>8</sup> Hyder Consulting (2011) North West Bicester Eco Development: Exemplar Site – Hydraulic Modelling Report



**Figure 4-1 Extent of ISIS Model** (existing model nodes shown in green, additional model nodes added for this study shown in red)

The only change required to the model in order to update the FRA for the entire site was the addition of the Hawkswell Tributary. Following the addition of this tributary, the hydrology was updated to apportion the Tributary 3 inflows between Tributary 3 and Hawkswell. Full details of the hydrology and model build are included in Appendix C.

## Flood Zone Mapping

As the hydraulic model is a one dimensional model, post processing of the model results is required to translate the stage results at a given model node into a two dimensional flood map. A grid of peak water levels was created and overlain onto the site LiDAR data to generate a flood outline. Due to inherent inaccuracies in the LiDAR data, particularly in relation to defining small watercourse channels, further, manual, alteration of the flood outline was carried out to ensure a continuous wet channel, removal of dry islands less than 200m<sup>2</sup> in area and removal of non-contiguous areas of floodplain where separated by ground higher than the peak flood level. Baseline mapped extents for the 1% AEP and 0.1% AEP are included in Appendix D. Table 4-2 summarises the percentage coverage.

Flood Event	% of Site Covered
1% AEP	1%
0.1% AEP	4%

Table 4-2 Percentage of Site Covered by Baseline Mapped Flood Outlines

## 4.2 Climate Change

The NPPF requires that consideration of the impacts of climate change on flood risk is required and sets out a series of recommended sensitivity ranges for rainfall and river flow. These factors are used in hydraulic modelling to assess the likely impact of climate change on water levels and consequently flood risk. The NPPF requires that 20% should be added to the 1% AEP fluvial flows in order to assess the change in fluvial flood risk.

Baseline mapped flood extents for the 1% AEP plus a 20% allowance for climate change are included in Appendix D.

## 4.3 Surface Water Runoff

### 4.3.1 Surface Water Modelling

A direct rainfall model was produced in TUFLOW to represent the existing surface water flow paths across the development site. The existing drainage ditches across the site, along Howes Lane (A4095) and the B4030 were included. Full details of the surface water model development are outlined in Appendix C with the mapped extents in Appendix D.

Surface water model results demonstrate that the key surface water flow routes on the NW Bicester development site follow the existing channels of the River Bure, its tributaries and also existing drainage ditches. Where additional key surface water flow routes have been identified by the model results, these also predominantly fall within the existing and proposed green corridors and have been used to define the location of proposed detention basins, ponds and swales as part of the Drainage Strategy (Section 4.3.2). Modelling outputs have been used to inform the masterplan and direct development away from the areas at significant surface water flood risk and ensure that the drainage features are suitably located. Where existing flow routes always do not follow the green corridors or swales then suitable further measures will be incorporated as part of the site detailed design to intercept and safely convey significant flows to the proposed SuDS features whilst avoiding flood risk to the development. This will be achieved through the effective use of ground reprofiling, intercepting land drainage, road network and positive drainage systems. The baseline surface water modelling outputs should be used for this purpose during the detailed site design and identify specific areas where localised ground reprofiling and intercepting land drainage features would be required as part of site enabling work to effectively manage surface water risk within the development..

### 4.3.2 Drainage Strategy

A drainage concept plan has been prepared for the NW Bicester development and this is included in Appendix E with a summary provided in the paragraphs below. At this stage, attenuation volumes have been derived based on a conservative approach which assumes that no infiltration will occur. This assumption has been made due to the absence of sufficient coverage of soakaway tests results across the site.

As the NW Bicester development site is almost entirely greenfield in its pre development state, the Drainage Strategy is based on the principle of attenuating any additional post development runoff to equivalent greenfield rates. Three hydrological catchments were defined across the NW Bicester development site in order to carry out an assessment of rainfall runoff rates and volumes.

Greenfield runoff rates were estimated using a scaled approach based on the flows supplied by the Environment Agency for the River Bure. A six hour storm duration was used in order to estimate the volume of rainfall runoff

The calculated storage volumes are provided within each catchment using a network of ponds and swales. These attenuated surface water flows are discharged from the site into local watercourses and the adjoining public sewer system as dictated by local constraints.

## 4.4 Groundwater

The SFRA and PFRA indicate some potential for groundwater flooding in the area. The currently available ground investigation (discussed in Section 2.4) suggests that the risk of groundwater flooding is likely to be small. This is also supported by no known previous groundwater flooding incidented within the site.

Additional site specific ground investigations that will be undertaken to inform the general site detailed design process would provide further information necessary to quantify and inform any localised groundwater flooding risk to the site and identify the need for any additional residual risk mitigation measures during the detailed design stage.



## 5 PROPOSED DEVELOPMENT

### 5.1 Description of Proposals

The proposed development includes for one new primary road crossing of Tributary 3 (location A in Figure 5-1) and a new foot and cycle crossing of Tributary 2 (location B in Figure 5-1). These proposals are in addition to the crossings associated with the Exemplar Site development.



**Figure 5-1 Proposed Watercourse Crossings** (Primary road ringed in purple, secondary road ringed in red, existing crossings ringed in blue)

### 5.2 Post Development Flood Risk

The baseline fluvial modelled flood extents for the 0.1% AEP and 1% AEP have been overlain onto the proposed MasterPlan. This will ensure that the flood extents for both events are fully constrained to the areas allocated as a 'water corridor buffer zone' within the MasterPlan. It should be noted however that as a result of a configuration issue related to the underlying OS base mapping and current Masterplan, the modelled fluvial flood outlines shown on figures contained in Appendix D and Appendix E currently do not correctly follow the actual alignment of the existing watercourses. Therefore, the Masterplan and base mapping will need an adjustment when detailed site topographic survey is available to rectify this issue during the detailed design process so that they match with the actual alignment of the watercourses and



the modelled flood outlines. However, the examination of the modelling results using the LiDAR terrain and modelled cross-sections clearly show that the baseline fluvial modelled flood extents for the 0.1% AEP and 1% AEP are much less than 30m in width and therefore fully within the 30m wide 'water corridor buffer zone' that have been incorporated into the masterplan design.

The proposed bridge crossings described above will all be single, clear spanning structures which do not impede in channel or floodplain flows. It is recommended that the bridge soffit is set a minimum of 600mm above the peak 1% AEP plus climate change water level; Table 5-1 summarises the peak modelled water levels at each bridge crossing.

Additionally, as the bridge abutments must not impede floodplain flows, the mapped flood outline drawings supplied in Appendix D have been used to define the bridge span. An estimate of the floodplain width at each proposed bridge is also included in Table 5-1.

Bridge ID	ISIS Node	1% AEP Peak Stage (mAOD)	1% AEP Peak Stage (plus Climate Change) (mAOD)	0.1% AEP Peak Stage (mAOD)	Estimated Span (m)
A	T1-0851	81.37	81.41	81.53	6
B	T2-1545	89.10	89.14	89.22	5

Table 5-1 Peak Modelled Stage at Proposed Bridge Crossings

## 5.3 Flood Protection

Due to PPS1 restrictions on the siting of development, all of the buildings in the proposed NW Bicester development will be sited in Flood Zone 1. Therefore, no specific flood protection or mitigation measures will be necessary on the site to address fluvial flood risk. However Section 6 below discusses the recommended general flood risk management measures.

## 5.4 Third Party Flood Risk

All development will be sited within Flood Zone 1 and all new bridges will be constructed so as to avoid any restriction in channel or floodplain flows. Therefore, there will be no loss of floodplain storage caused by the proposed development. Any increased peak surface water runoff caused by the development will also be attenuated to Greenfield rates (see Section 4). Therefore, there will be no increase in third part flood risk as a result of the development.

## 5.5 Site Access and Egress

As stated in Section 5.4, all development will be sited within Flood Zone 1, and any roads crossing watercourses will be raised above flood levels. Therefore, emergency access routes will not be affected by flooding. Table 5-2 summarises the peak flood levels and dimensions of the existing bridges which demonstrates that the existing bridges will remain operational during all modelled flood events.

Bridge ID	ISIS Node	1% AEP Peak Stage (mAOD)	1% AEP Peak Stage (plus Climate Change) (mAOD)	0.1% AEP Peak Stage (mAOD)	Soffit Level (mAOD)	Deck Level (mAOD)
C	T1-2059b	88.01	88.07	88.20	88.10	88.44

D	T1-1295b	83.37	83.42	83.56	83.74	84.87
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**Table 5-2 Peak Modelled Stage at Existing Bridge Crossings**

## 6 FLOOD RISK MANAGEMENT

This section considers how the proposed development will be protected from flooding over the development lifetime, including the potential impacts of climate change. Management of residual risks is discussed in Section 7.

### 6.1 Fluvial

The proposed development site is almost entirely within Flood Zone 1. All proposed development areas are located in Flood Zone 1 as green and blue corridors have been incorporated within Flood Zone 2 and 3 as part of the Masterplan development. The only elements of the development located outside Flood Zone 1 are the new bridge crossings. However, as discussed in Section 5.2, the abutments will be located outside the modelled 1% AEP plus climate change flood extent.

Climate change is predicted to increase the modelled flood extents by only a small amount as shown in drawings 0008-UA005941-BMD-02 and 0009-UA005941-BMD-02 in Appendix D. Any increase in flood extents is contained within the allocated green and blue corridors and therefore will not increase flood risk to the development.

All new bridge crossings will be designed such that the soffit is a minimum of 600mm above the peak modelled 1% AEP plus climate change water level.

Therefore, the site is not predicted to be at risk of flooding during the development lifetime, including under the potential impacts of climate change.

### 6.2 Surface Water

An appropriate surface water drainage strategy has been produced in order to manage on site surface water flood risk. This is included as Appendix E and should be consulted for specific details on the management of surface water. As highlighted in Section 4.3.1, the surface water modelling outputs have been used to inform the masterplan and direct development away from the areas at significant surface water flood risk and ensure that the drainage features are suitably located.

A review of exceedance flooding has been carried out as part of the conceptual drainage strategy. In locations where the proposed piped drainage system is exceeded for events greater than the 3.33% AEP, there is the potential to channel flood flows to the attenuation features via the road and swales network. Full details of exceedance flow routes should be provided at the detailed drainage design stage once the proposed ground levels and development locations are better defined.

It is also recommended during the detailed design stage that key post-development overland flow routes, which accounts for the proposed ground levels, road network and key drainage features, are modelled and reviewed so that the key flow routes are suitably intercepted and directed to the proposed SuDS features without increasing flood risk to the proposed development.

The Environment Agency have advised that their mapping indicates the presence of a culverted watercourse between NGR SP5688923607 and SP5670823282. There may be opportunities to deculvert this watercourse and any other culverted watercourses within the site and incorporate them within the proposed SUDS network, providing an environmental enhancement. This should be further investigated during the detailed design.

## 6.3 Groundwater

Further investigations into the potential for shallow groundwater flooding (in particular during prolonged periods of rainfall) should be undertaken during the site detailed design before taking any decisions regarding the need for specific mitigation measures (see Section 4.4).

## 6.4 Artificial Sources

In order to mitigate the risk of damaging the existing TWUL water mains during construction, up to date and detailed plans of the locations of these assets should be obtained prior to construction. These plans should be used to identify suitable construction locations and methods to ensure that the pipes are not broken during the construction process.

## 7 RESIDUAL RISKS

### 7.1 Overview

It is essential that the risk of flooding is minimised over the lifetime of the development (100 years) in all instances. It is important to recognise, however, that flood risk can never be fully mitigated, and there will always be a residual risk of flooding. The NPPF states that the residual risks are those remaining after applying the sequential approach and taking mitigation actions.

### 7.2 Residual Risks to the Development

The residual risks to the development site are considered to be:

- A fluvial flood event in excess of those currently modelled
- A storm event which exceeds the capacity of the onsite drainage systems

It is considered that the following measures are adequate during the detailed design process to manage these residual flood risks:

- Flood resistance and resilience measures
- Flood warning and evacuation plans;
- Designing site drainage systems which take into account events which exceed the design standard using the principles set out in 'Designing for Exceedence.'

### 7.3 Finished Floor Levels

In general, it is recommend that the minimum finished floor levels of buildings should be a minimum of 300mm above surrounding ground levels by suitable ground re-profiling, to account for protection against surface water ponding during a storm event that generates runoff which exceeds the design capacity of the drainage system.

## 8 CONCLUSIONS

### Development description and proposals

- A site specific Flood Risk Assessment has been undertaken to accompany the Masterplan for the proposed development of the NW Bicester development site, located on the northern edge of Bicester.
- The proposed development site is identified in the Cherwell District Local Plan.

### Definition of flood probability

- The NW Bicester development site is almost entirely within Flood Zone 1; areas of Flood Zone 2 and 3 are constrained to the watercourse corridor. All development is to be located within Flood Zone 1 other than proposed green and blue corridors.
- All new bridge crossings will be designed such that the soffit is a minimum of 600mm above the modelled peak 1% AEP plus climate change water level. Furthermore, all bridge abutments will be outside the modelled 1% AEP plus climate change floodplain.
- No detailed information is available regarding the risk of groundwater flooding at this stage although the risk is considered to be low based on the currently available information (see recommendations).
- Surface water modelling has been carried out to determine the key routes for surface water flows across the development site. These key flow routes are predominantly constrained to existing green and blue corridors and will be incorporated into the Surface Water Drainage strategy by appropriate location of the proposed SuDS features. Where existing key overland flow routes do not follow the green corridors then ground levels will be re-profiled within the development parcels and/or overland flows will be intercepted and diverted into the proposed SuDS attenuation features.

### Assessment of the impacts of climate change

- An assessment of the potential impacts of climate change has been made by adding 20% to the estimate 1% AEP flows.
- The proposed development is predicted to remain flood free during the 1% AEP plus climate change event.

### Review of existing flood risk management measures

- No existing flood risk management measures are present within, or upstream of the site although some surface water drainage infrastructure is proposed as part of the Exemplar Site development.

### Review of offsite impacts and required mitigation

- No increase in flood risk to third parties is predicted as a result of the NW Bicester development therefore no mitigation is required.

### Assessment of residual risks

- The residual risks to the development site are a fluvial flood event in excess of those currently modelled and a storm event which exceeds the capacity of the onsite drainage systems.
- These residual risks can be adequately managed through flood resilience and resistance measures, provision of a flood warning and evacuation plan and the incorporation of exceedence flow routes in the detailed drainage strategy.

## 9 RECOMMENDATIONS

- All new bridge crossings of watercourses on the development site should be clear spanning with soffits set a minimum of 600mm above the peak modelled 1% AEP plus climate change water level.
- All new bridge abutments should be located outside the modelled 1% AEP plus climate change floodplain in order to prevent any impediment of floodplain flows or loss of floodplain storage.
- The surface water drainage strategy set out in Appendix E (including adoption and maintenance responsibilities of SuDS features) should be further consulted by the key parties and implemented to ensure that the post development runoff rates and volumes are no greater than the pre-development rates. Key post-development overland flow routes, which accounts for the proposed ground levels, road network and key drainage features, should also be modelled and reviewed during the detailed design stage once the proposed ground levels and SuDS features are better defined so that the key flow routes are fully intercepted and/or directed to the proposed system without increasing flood risk to the proposed development.
- The Environment Agency have advised that their mapping indicates the presence of a culverted watercourse between NGR SP5688923607 and SP5670823282. Opportunity to deculvert this watercourse and any other culverted watercourses within the site should be investigated during the detailed design so that they can be incorporated within the proposed SUDS network.
- Additional site specific ground investigations should be used as part of site detailed design to quantify and inform the risk of groundwater flooding to the site (in particular during prolonged periods of rainfall) and the need for any additional mitigation measures.