Groby, Leicestershire- Flood Risk Assessment

A1-C02

December 2025

Prepared for:

Bloor Homes East Midlands

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Contract

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This report describes work commissioned by Bloor Homes East Midlands by an instruction dated 1st August 2024. The Client's representative for the contract was Sally Smith of Bloor Homes East Midlands. Ruth Gale and Megan Cruise of JBA Consulting carried out this work.

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Abbreviations

AEP	Annual Exceedance Probability
AOD	Above Ordnance Datum
BGS	British Geological Survey
CFMP	Catchment Flood Management Plan
DTM	Digital Terrain Model
EA	Environment Agency
FMfP	Flood Map for Planning
FRA	Flood Risk Assessment
ID	Identifier
LiDAR	Light Detection And Ranging
LPA	Local Planning Authority
NaFRA2	National Flood Risk Assessment 2
NGR	National Grid Reference
NPPF	National Planning Policy Framework
OS	Ordnance Survey
OS NGR	Ordnance Survey National Grid Reference
PFRA	Preliminary Flood Risk Assessment
PPG	Planning Policy Guidance
SFRA	Strategic Flood Risk Assessment

1 Introduction

1.1 Terms of reference

JBA Consulting was commissioned by Bloor Homes East Midlands to undertake a Flood Risk Assessment (FRA) for a residential development of up to 180 dwellings at Sacheverall Way, Groby, Leicestershire (hereafter referred to as 'the site').

This FRA provides information on all aspects of flood risk at the site in accordance with the National Planning Policy Framework (NPPF), associated Planning Practice Guidance (PPG) and Local Planning Policy. It also considers the flood risk mitigation relevant to the nature of the proposed development and the identified flood risks.

1.2 FRA requirements

It is a requirement for applications to consider the potential risk of flooding from various sources to a proposed development over its lifetime and any possible impacts on flood risk elsewhere as a result of the development.

Where appropriate, the following aspects of flood risk should be addressed:

- The nature and expected lifetime of the development and the extent to which the development is designed to deal with flood risk.
- The area liable to flood from various sources.
- The probability of the current and future flood risk.
- The extent and standard of existing flood defences and their effectiveness over time.
- The likely depth of flooding.
- The rates of predicted flows.
- The likelihood of impacts on other areas, properties and habitats.
- The effects of climate change.

The level of flood risk to the site has been determined based on a review of the site topography and information provided to us by the client and a review of publicly available information including open licence flood risk datasets provided on the Defra Data Services website by the Environment Agency. This includes the Flood Map for Planning, LIDAR Digital Terrain Model (DTM) and flood history datasets. Site-specific hydraulic modelling has also been undertaken to inform this FRA.

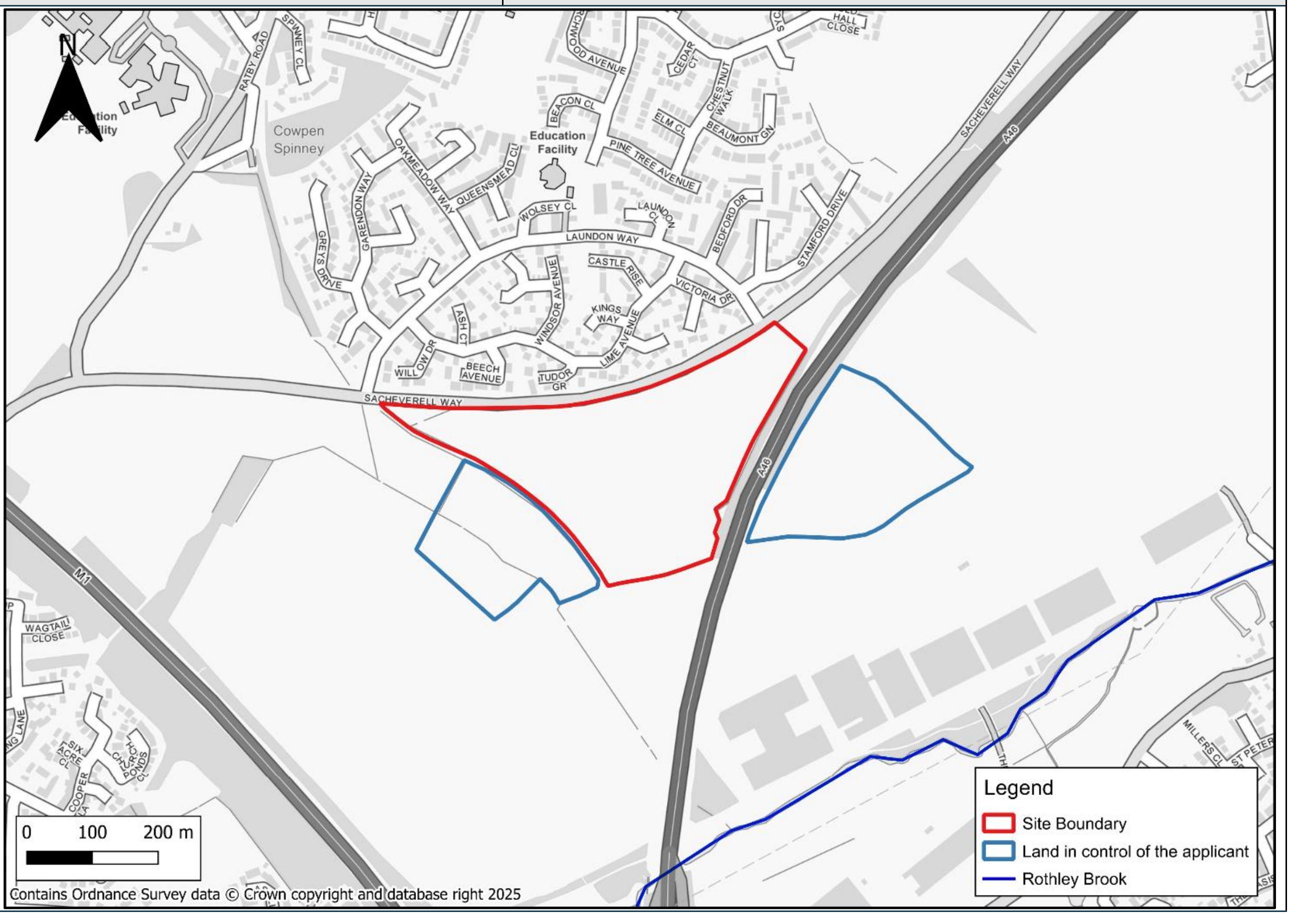
2 Site Details

2.1 Site description

The site is located to the south of Sacheverall Way, Groby and is greenfield in nature. The site is located approximately 400m north of Rothley Brook, an Environment Agency designated Main River.

Table 2-1: Site description

Site descriptors	Site details
Site location	Sacheverall Way, Groby, Leicestershire
Site area	10.55ha
Existing land use	Greenfield land
Proposed land use	Residential development of up to 180 dwellings
OS NGR	SK 52595 06329
County	Leicestershire
Country	England
Local Planning Authority	Hinckley and Bosworth Borough Council
Lead Local Flood Authority	Leicestershire County Council



2.2 Proposed development

The proposed development is for a residential development of up to 180 dwellings within the site boundary. Access is proposed from Sacheverall Way to the north. The proposed high level development concept is shown in Appendix A and an extract is shown in Figure 2-1.

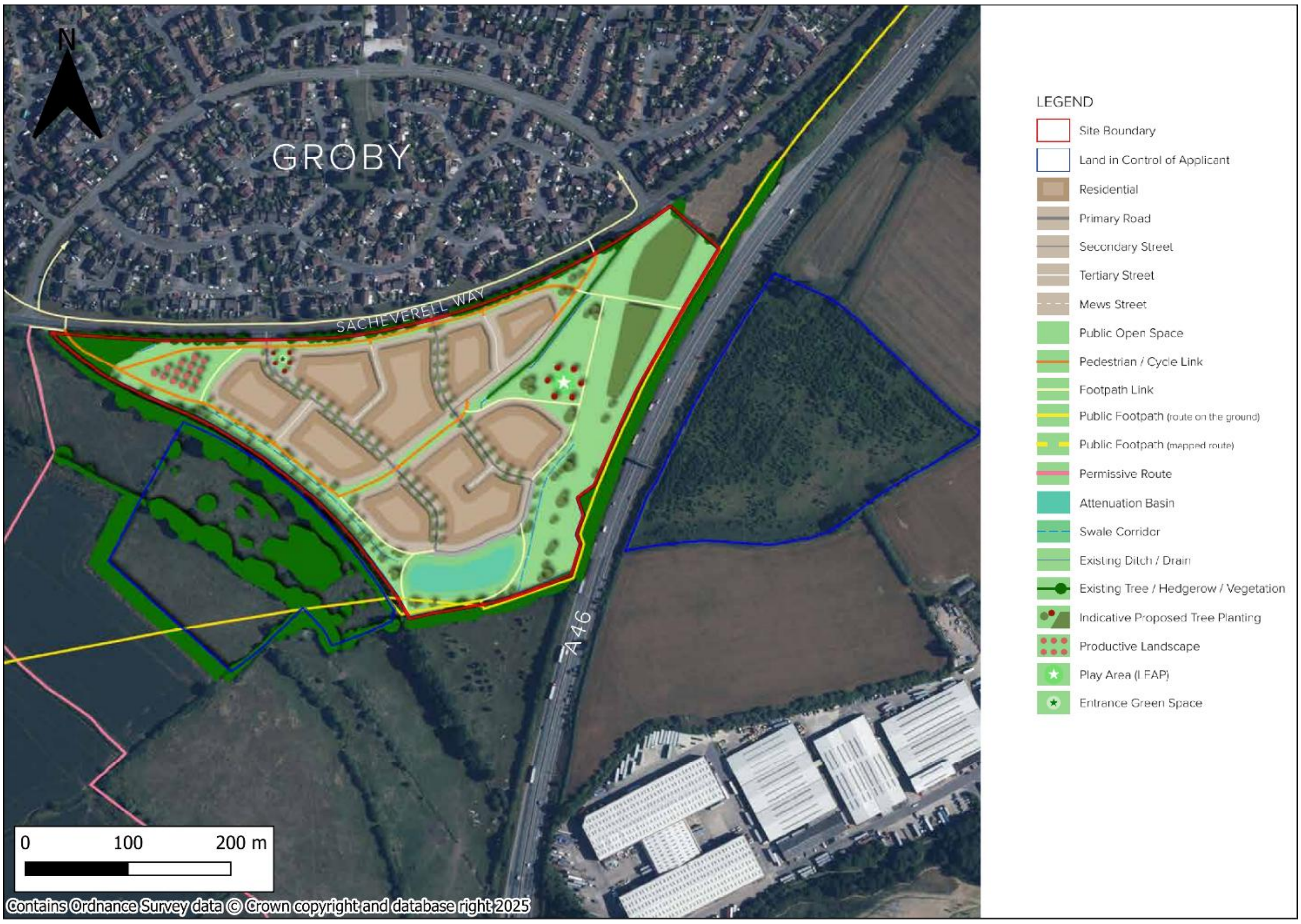


Figure 2-1: Proposed development concept

2.3 Topography

Publicly available LiDAR elevation data shown in Figure 2-2 along with site-specific topographic survey data (included in Appendix B) shows that the north and east of the site have a higher elevation than the west and south of the site with the lowest point of 76m above ordnance datum (AOD) being on the south corner of the site. The elevation increases up to 89.4m AOD in the north-eastern corner of the site. Some of the topographic features in the south-west of the site are likely associated with a dismantled railway shown on the mapping.

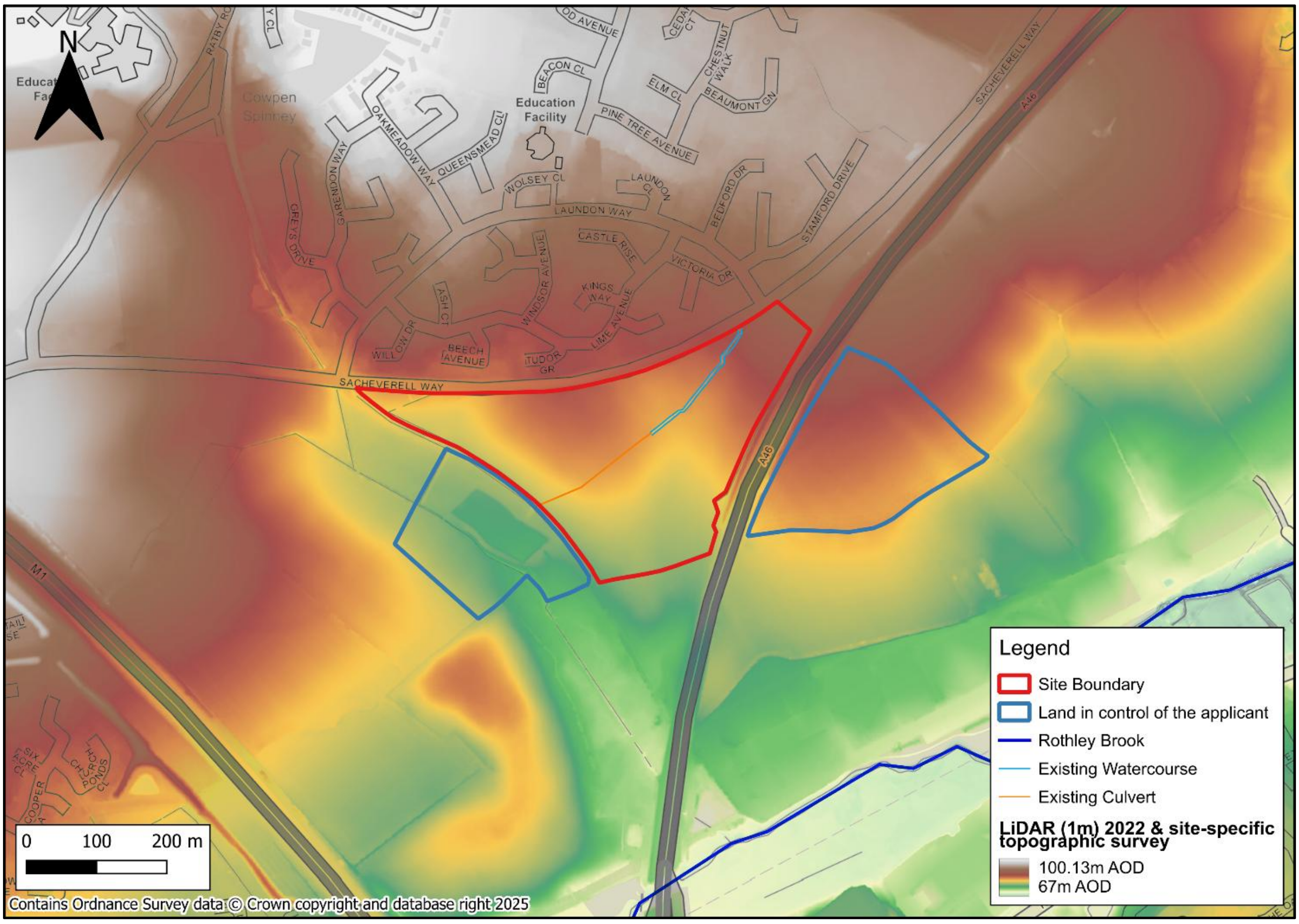


Figure 2-2: Topography (m AOD)

2.4 Geology

The British Geological Survey (BGS) 50k geological mapping[1] indicates the underlying bedrock at the site is Edwalton Member - Mudstone. Soilscapes mapping[2] indicates that the underlying soil types are loamy and clayey soils that are seasonally wet.

2.5 Watercourses

As shown in Figure 2-3, the Rothley Brook, an Environment Agency Main River, flows in a north-easterly direction approximately 400m to the south of the site. Ordinary Watercourses flow through the west of the site and on the eastern site boundary. A 900mm culvert runs across the centre of the site from the existing watercourse shown in Figure 2-3.

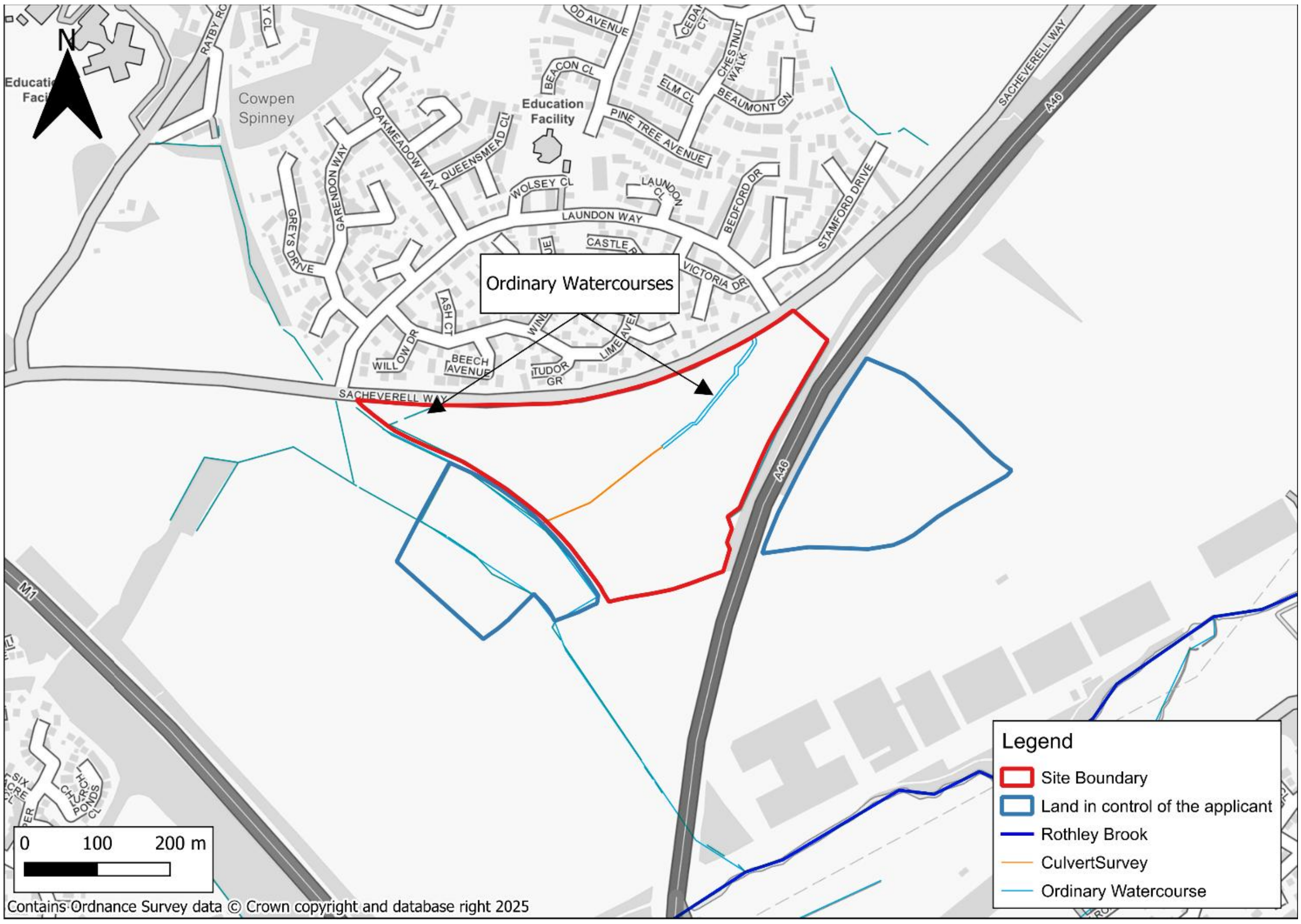


Figure 2-3: Watercourses

1 BGS Geology of Britain viewer: https://mapapps2.bgs.ac.uk/geoindex/home.html?layers=BGSBedrock50,BGSSuperficial50,BGSArtificial50,BGSMass50,BGSLinearFeat50&_ga=2.247862343.1190925926.1671547286-757587520.1671547286

2 Soilscapes: https://www.landis.org.uk/soilscapes/

3 Planning Policy and Flood Risk

3.1 Planning context

The National Planning Policy Framework[3] (NPPF) was issued by the Department for Communities and Local Government in March 2012 and last updated in February 2025. The NPPF is accompanied by the Planning Practice Guidance[4] (PPG) on Flood Risk and Coastal Change, updated in August 2022, which gives further information on the approaches to be adopted in the assessment of flood risk for development. The PPG, in relation to development planning and flood risk, uses a sequential characterisation of risk based on planning zones and the Environment Agency Flood Map for Planning. A principal study requirement is to identify the Flood Zones and vulnerability classification relevant to the proposed development, based on an assessment of current and future conditions.

3.2 Development of sites in Flood Zones

Flood risk is a combination of the probability and the potential consequences of flooding from all sources – including from rivers and the sea, directly from rainfall on the ground surface and rising groundwater, overwhelmed sewers and drainage systems, from reservoirs and, canals, lakes and other artificial sources.

The Environment Agency categorise the fluvial and tidal risk in a series of Flood Zones within the Flood Map for Planning; a definition of such Flood Zones can be found in Table 3-1 (reproduction of Table 1 of the PPG). The Environment Agency's Flood Map for Planning shows the risk of flooding in England for different return period events. This map provides the basis for the assessment of flood risk and development suitability.

It is important to note that the Environment Agency's Flood Map for Planning, in some cases, is based on broad-scale river modelling and provides an indication of the potential flood risk in the area rather than a level of detail suitable for a site-specific assessment. In some areas the Flood Map is informed by historic flood mapping.

3.3 NPPF and PPG Flood Zones and development tables

Table 3-1 shows how the Flood Zones are defined (as based on Table 1 in the PPG). Figure 3-1 shows the Environment Agency's Flood Map for Planning in relation to the site. This shows that the entirety of the site is outside of Flood Zones 2 and 3 and is therefore located within Flood Zone 1. It should be noted that the Flood Map for Planning focuses on the Environment Agency Main Rivers and tidal risk and not the risk from Ordinary Watercourses, which are the responsibility of the Lead Local Flood Authority.

3 National Planning Policy Framework:
https://assets.publishing.service.gov.uk/media/67aafe8f3b41f783cca46251/NPPF_December_2024.pdf

4 Planning Practice Guidance: https://www.gov.uk/government/collections/planning-practice-guidance

Table 2 of the NPPF[5] determines the classification of flood risk vulnerability in relation to a proposed development type. Residential land-uses, such as that proposed, are considered to be 'More Vulnerable' development.

Table 3-2 shows the compatibility of flood zones and vulnerability classifications. This shows that More Vulnerable development is compatible with sites within Flood Zone 1.

Table 3-1: Flood Zones

Flood Zone	Definition
Zone 1 Low Probability	Land having a less than 0.1% annual probability of river or sea flooding. (Shown as 'clear' on the Flood Map for Planning – all land outside Zones 2, 3a and 3b)
Zone 2 Medium Probability	Land having between a 1% and 0.1% annual probability of river flooding; or land having between a 0.5% and 0.1% annual probability of sea flooding. (Land shown in light blue on the Flood Map)
Zone 3a High Probability	Land having a 1% or greater annual probability of river flooding; or Land having a 0.5% or greater annual probability of sea. (Land shown in dark blue on the Flood Map)
Zone 3b The Functional Floodplain	This zone comprises land where water from rivers or the sea has to flow or be stored in times of flood. The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. Functional floodplain will normally comprise: • land having a 3.3% or greater annual probability of flooding, with any existing flood risk management infrastructure operating effectively; or • land that is designed to flood (such as a flood attenuation scheme), even if it would only flood in more extreme events (such as 0.1% annual probability of flooding). Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. (Not separately distinguished from Zone 3a on the Flood Map)
Note: The Flood Zones shown on the Environment Agency's Flood Map for Planning (Rivers and Sea) do not take account of the possible impacts of climate change and consequent changes in the future probability of flooding. Reference should therefore also be made to the Strategic Flood Risk Assessment when considering location and potential future flood risks to developments and land uses. Paragraph: 078 Reference ID: 7-078-20220825 Revision date: 25 08 2022	

5 https://www.gov.uk/guidance/national-planning-policy-framework/annex-3-flood-risk-vulnerability-classification

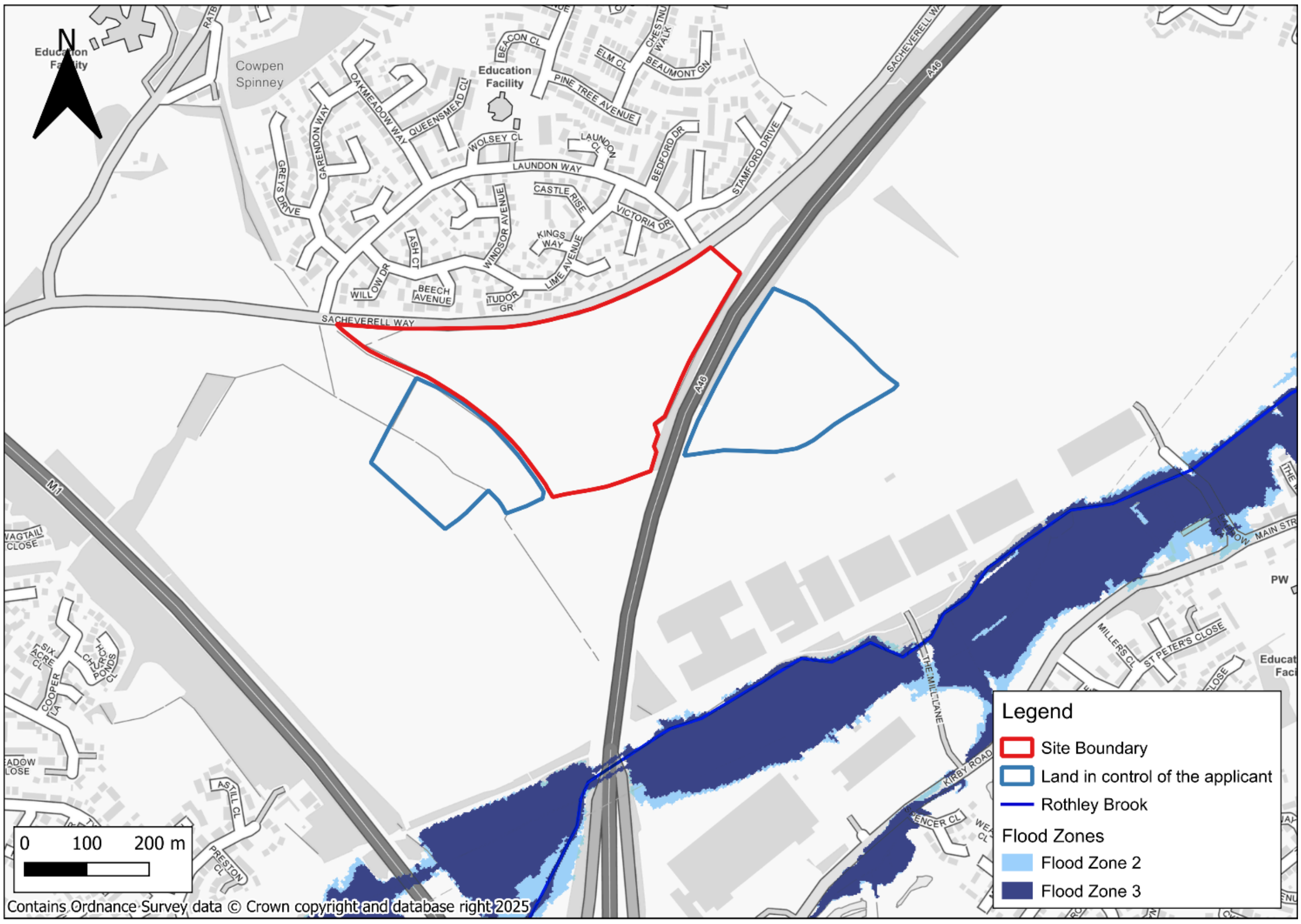


Figure 3-1: Flood Map for Planning

Table 3-2: Flood Risk Vulnerability and Flood Zone 'incompatibility'

Vulnerability Classification (NPPF Table 2)		Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
Flood Zone	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	Exception Test	✓	✓	✓
	Zone 3a	Exception Test	×	Exception Test	✓	✓
	Zone 3b	Exception Test	×	×	×	✓
	Source: Table 3, NPPF Technical Guidance					

✓ Exception test is not required

✗ Development should not be permitted

Notes:

1. Some developments may contain different elements of vulnerability and the highest vulnerability category should be used, unless the development is considered in its component parts.

3.4 Climate change allowances

The NPPF and supporting PPG on Flood Risk and Coastal Change explain when and how flood risk assessments should be used. This includes demonstrating how flood risk will be managed now and over the development's lifetime, taking climate change into account.

In May 2022, the Environment Agency released new guidance on climate change allowances[6] to support the NPPF.

Table 3-3 shows peak river flow allowances[7] for the Soar and tributaries Management Catchment. For 'more vulnerable' development the guidance states the central allowance should be used for the development lifetime i.e. 28%.

Table 3-3: Soar and tributaries Management Catchment peak river flow allowances

Epoch	Central	Higher	Upper End
2020s	14%	18%	28%
2050s	16%	21%	35%
2080s	28%	37%	60%

Table 3-4 shows the peak rainfall allowances[8] for the Soar and tributaries Management Catchment that should be used to assess the impacts of climate change on surface water flood risk. The Upper End 2070s allowance should be used for development proposed with a lifetime beyond 2100.

Table 3-4: Soar and tributaries Management Catchment peak rainfall allowances

	3.3% annual exceedance rainfall event		1% annual exceedance rainfall event	
Epoch	Central	Upper End	Central	Upper End
2050s	20%	35%	20%	40%
2070s	25%	35%	25%	40%

6 Flood Risk Assessments – https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

7 Peak river flow allowances: https://environment.data.gov.uk/hydrology/climate-change-allowances/river-flow

8 Peak rainfall allowances: https://environment.data.gov.uk/hydrology/climate-change-allowances/rainfall?mgmtcatid=3078

3.5 Policy and guidance review

3.5.1 Hinckley and Bosworth Local Plan (2006-2026)

The Hinckley and Bosworth Local Plan[9] sets out the vision and objectives for the growth of the borough up to 2026. The proposed site is located just within the eastern boundary of Hinckley and Bosworth Borough.

The document sets out a series of policies which includes:

- Housing for Everyone: "The focus of development will be in and around the Hinckley urban area, with more limited development in the rural areas to meet local needs. All housing will be high quality, locally distinctive, sustainable developments." (Hinckley and Bosworth Local Plan, 2006-2026)
- Natural Environment and Cultural Assets: " To deliver a linked network of green infrastructure, enhancing and protecting the borough's distinctive landscapes, woodlands, geology, archaeological heritage and biodiversity and encourage its understanding, appreciation, maintenance and development. " (Hinckley and Bosworth Local Plan, 2006-2026)
- Climate Change and Resource Efficiency: " To minimise the impacts of climate change by promoting the prudent use of resources through sustainable patterns of development, investment in green infrastructure, minimising the use of resources and energy, increasing reuse and recycling of natural resources, increasing the use of renewable energy technologies and minimising pollution, including greenhouse gas emissions. " (Hinckley and Bosworth Local Plan, 2006-2026).

3.5.2 Hinckley and Bosworth Level 1 Strategic Flood Risk Assessment (2019)

A Strategic Flood Risk Assessment (SFRA)[10] is undertaken by the Local Planning Authority to assess the current and future flood risk within their administrative boundary and, to determine the impact development may have on flood risk. The current version of the Hinckley and Bosworth Borough Council Level 1 Strategic Flood Risk Assessment was published in July 2019.

The recommendations and policies section relating to flood risk are summarised below:

- Use sustainable flood storage and mitigation schemes to store water and manage surface water runoff in locations that provide overall flood risk reduction as well as environmental benefits.
- In areas where flood risk is being managed effectively, there will be a need in the future to keep pace with increasing flood risk as a result of climate

9 https://www.hinckley-bosworth.gov.uk/localplandocs

10 https://www.hinckley-bosworth.gov.uk/info/1004/planning_policy_and_the_local_plan/1571/strategic_flood_risk_assessment_sfra_2020

change.

- Promote partnership working with all relevant stakeholders in the Tame, Anker and Mease Humber RMP management catchment. This includes working with land managers and farmers to reduce soil erosion from intensively farmed land.
- Assess long-term opportunities to move development away from the floodplain and create green river corridors through Leicestershire.
- Identify opportunities to use areas of the floodplain to store water during high flows, to reduce long term dependence on engineered flood defences located both within the borough (at Witherley) and outside the borough (for instance, in Rothley, Charnwood).
- Safeguard the natural floodplain from inappropriate development.
- Where possible, land management change should be used to reduce run-off rates from the development whilst maintaining or enhancing the capacity of the natural floodplain to retain water. Land management and uses that reduce runoff rates in upland areas should be supported.
- Development should maintain conveyance of watercourses through hamlets and villages (e.g. Sheepy Magna), to help reduce the impact of the more frequently experienced floods and to improve the natural environment.
- Use SFRAs to inform future development and minimise flood risk from all Sources.
- Implement upstream catchment management e.g. slow the flow and flood storage schemes could be implemented in upper catchments to reduce flooding downstream and across neighbouring authority boundaries.
- Promote and consider SUDS at the earliest stage of the development of a site.

3.5.3 Leicestershire County Council Local Flood Risk Management Strategy

Leicestershire's first Local Flood Risk Management Strategy[11] (LFRMS) was published in 2015 and was revised and updated in February 2024. This document sets out the main recommendations for flood risk management in the area in the council's role as the Lead Local Flood Authority (LLFA).

The LFRMS is an important tool to help understand and manage flood risk within the county. Flood risk management is beginning a new stage which will be marked by better knowledge of the risks in the county, better co-operation between organisations involved in flood risk management, and better communication with the public about those risks.

There are 5 objectives for managing local flood risk in Leicestershire. The objectives of the LFRMS include:

1. Assets, Watercourses and catchments: To manage local flood risk through the effective management of flood risk assets, watercourses, and catchments.

11 https://www.leicestershire.gov.uk/sites/default/files/2024-02/Local-Flood-Risk-Management-Strategy-for-Leicestershire.pdf

2. Encouraging Sustainable Development: To manage local flood risk through encouraging sustainable development.
3. Flood Preparedness, Response and Recovery: To manage local flood risk through effective preparedness, response to, and recovery from flood events.
4. Better Understanding Flood Risk: To better understand local flood risk and impacts, informing approaches to managing this risk.
5. Local Projects: To manage local flood risk through developing and or managing local projects for at-risk communities.

4 Assessment of Flood Risk

4.1 Historic flooding

The Environment Agency's Recorded Flood Outlines dataset for the site and surrounding area has been reviewed. The site does not fall within the Environment Agency's historical flood outlines.

4.2 Fluvial flood risk

4.2.1 Flood Map for Planning

Figure 3-1 shows the Environment Agency's Flood Map for Planning. The entirety of the site is outside of Flood Zones 2 and 3. The nearest area within Flood Zone 3 is situated approximately 400m south of the site. The Flood Map for Planning is focused on the risk from Environment Agency Main Rivers so should represent the risk from Rothley Brook. In the event of a breach of Rothley Brook's banks, it is very unlikely flood water will travel towards the site due to the site topography sloping south-west. Therefore, the risk of flooding from fluvial sources is **Very Low**.

4.3 Surface water flood risk

4.3.1 Environment Agency RoFSW mapping

Surface water flooding arises following periods of intense rainfall, or rain falling on saturated soil, that is unable to soak into the ground or where drainage systems are unavailable or unable to manage surface water runoff. This surface water runoff forms overland flow when following the topography of the land, often pooling in topographic low spots. Surface water flooding and subsequent overland flow can also originate from surcharging or blocked sewers and drains.

Figure 4-1 shows the Environment Agency's Risk of Flooding from Surface Water (RoFSW) from the NaFRA2 mapping. The site has areas within the High (3.3% AEP), Medium (1% AEP) and Low (0.1% AEP) surface water flood events, on account of the Ordinary Watercourses which cross the site. However, the NaFRA2 mapping is informed by a generalised mapping approach and does not accurately account for the geometry of the ditches, culverts and structures locally to the site. Therefore, a detailed hydraulic model has been developed to refine the flood risk shown within the NaFRA2 mapping and to provide results suitable for a site-specific assessment of flood risk.

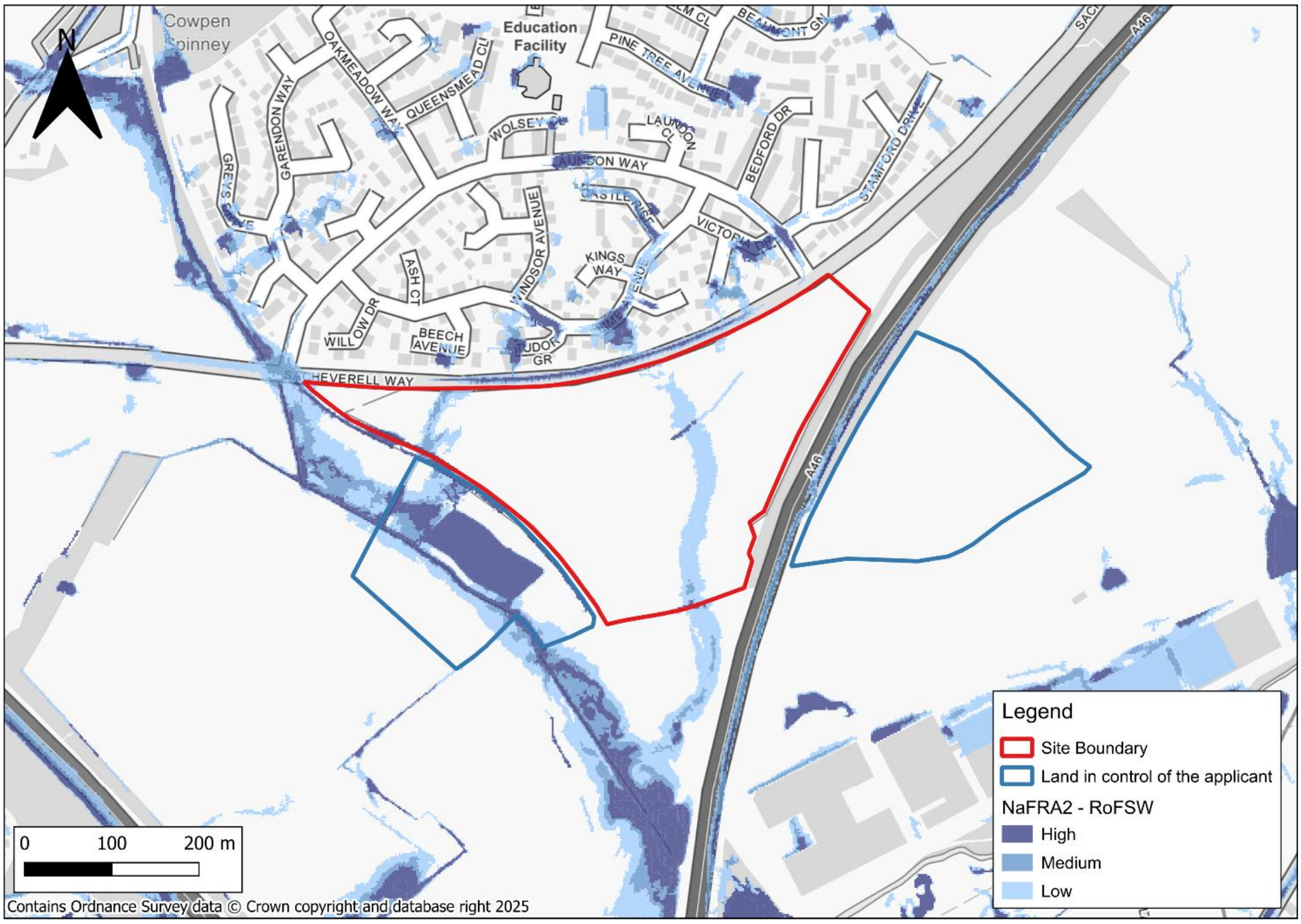


Figure 4-1 Environment Agency's NaFRA2 RoFSW mapping

4.3.2 Hydraulic modelling

4.3.2.1 Baseline modelling

A surface water rainfall-runoff hydraulic modelling study to allow the detailed representation of flood depths, velocity and hazard within the site boundary was undertaken. A 2D InfoWorks-ICM hydraulic model was built, and a hydrological assessment was carried out to derive rainfall hyetographs. The existing culvert which crosses the site was represented within the modelling together with the existing Ordinary Watercourses. Detailed technical reporting is included within Appendix C.

The predicted baseline flood extents during the 3.3%, 1% and 0.1% AEP events are shown in Figure 4-2. Figure 4-2 shows that flooding is predicted to occur on the site during all modelled events. Flow is present through the existing culvert in all modelled events.

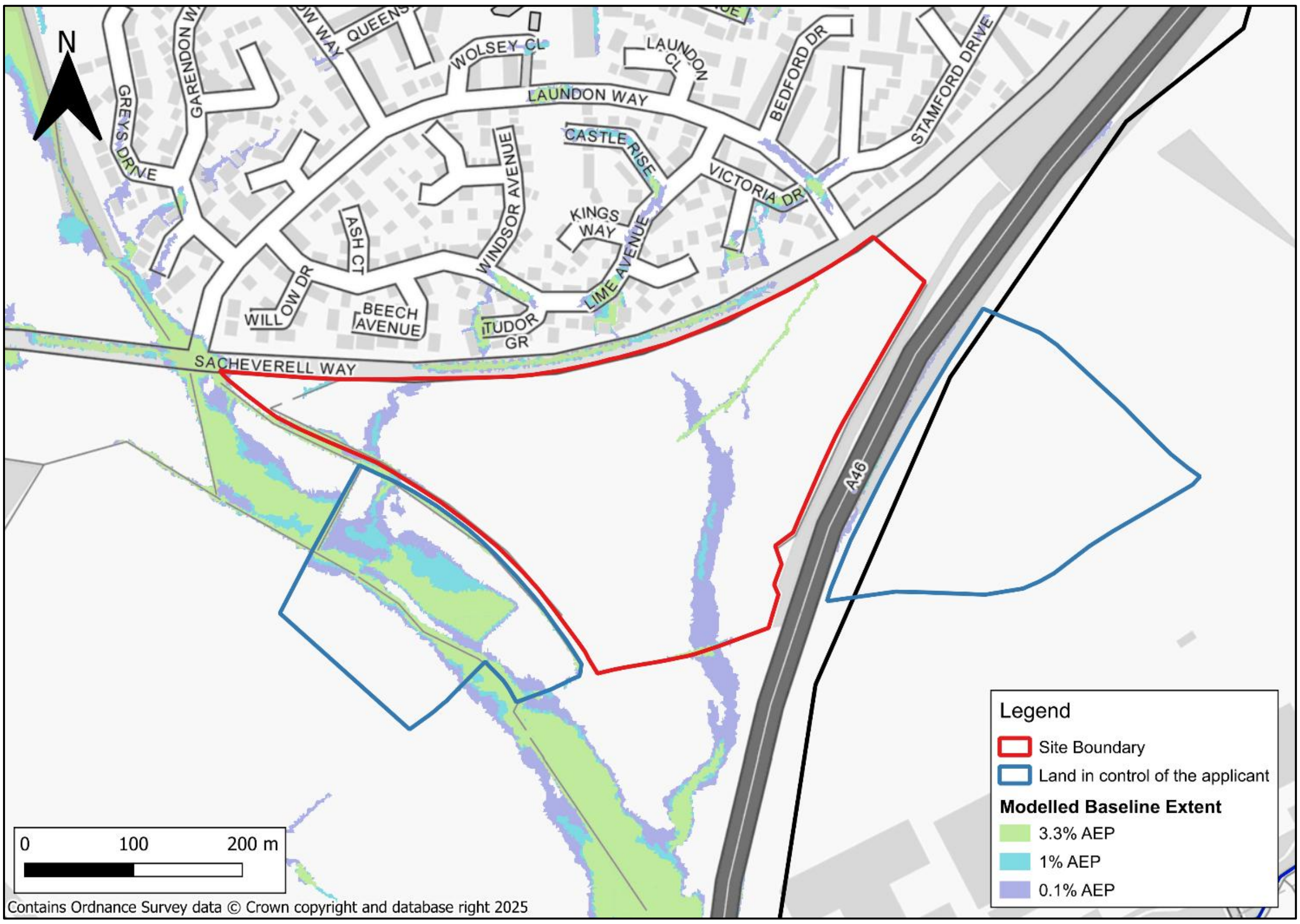


Figure 4-2: Baseline Flood Extents

The allowance used to represent climate change during the design flood event (1% AEP plus climate change) has been set in line with EA guidance for rainfall i.e. 40% (Table 3-4). The modelled flood extents for the baseline climate change events is shown in Figure 4-3. This indicates that flooding is predicted to occur within the site during the 3.3% AEP with (+35%) climate change and 1% AEP with (+40%) climate change event

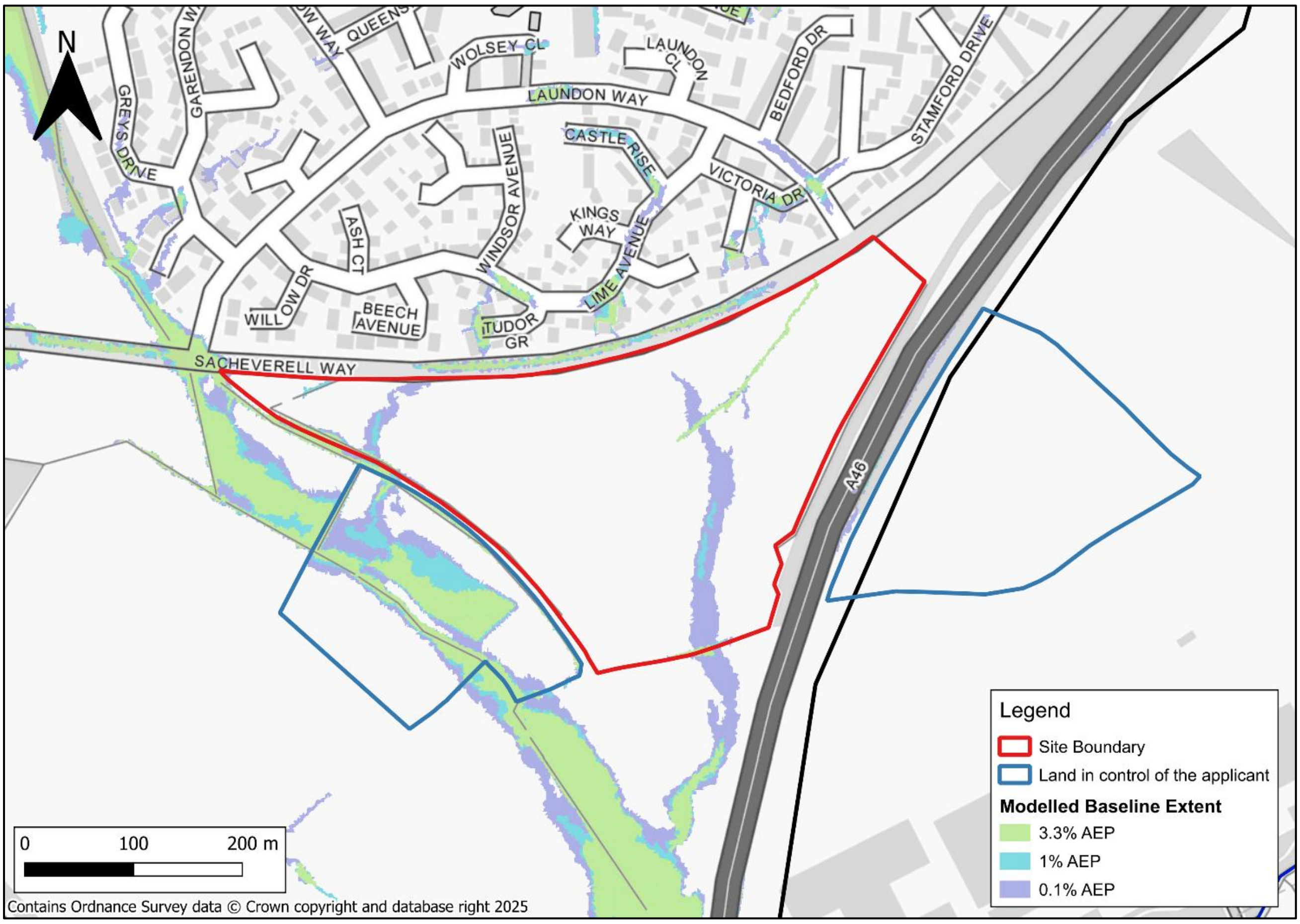


Figure 4-3 Baseline flood extents with climate change uplifts

Figure 4-4 shows the peak flood depths within the site boundary during the 1% AEP plus 40% climate change event for the baseline scenario i.e. the design flood event. Peak modelled flood depths of up to 0.99m are predicted to occur within the site during the 100-year (1% AEP) plus 40% climate change event. However, typical floodplain depths are <0.2m during this event.

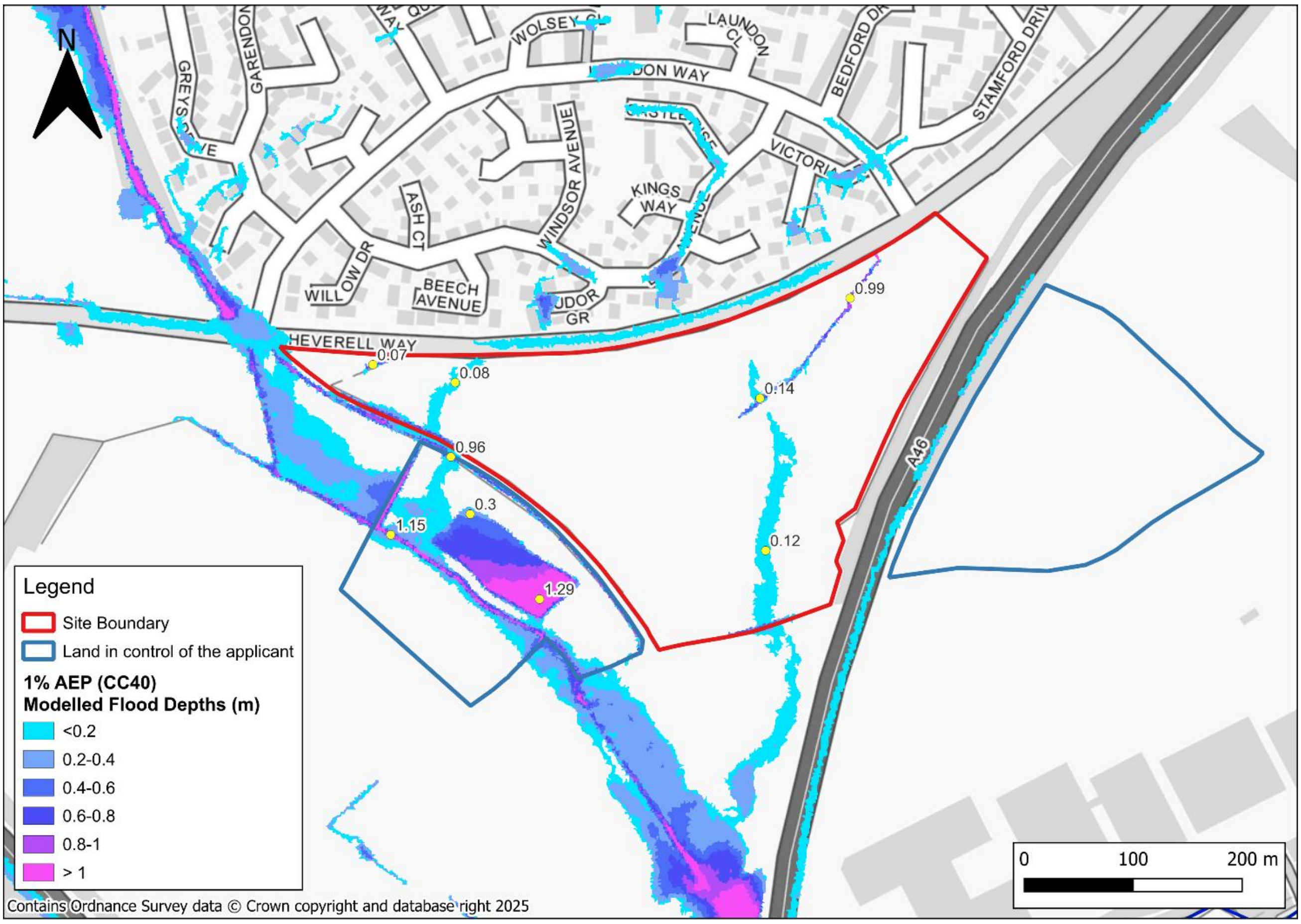


Figure 4-4 Modelled flood depths with 1% AEP +40CC flood event

Figure 4-5 shows the peak flood levels within the site boundary during the 1% AEP plus 40% climate change event for the baseline scenario. Peak modelled flood levels are predicted to range between 84.29m AOD and 78.92m AOD during the 1% AEP plus 40% climate change event.

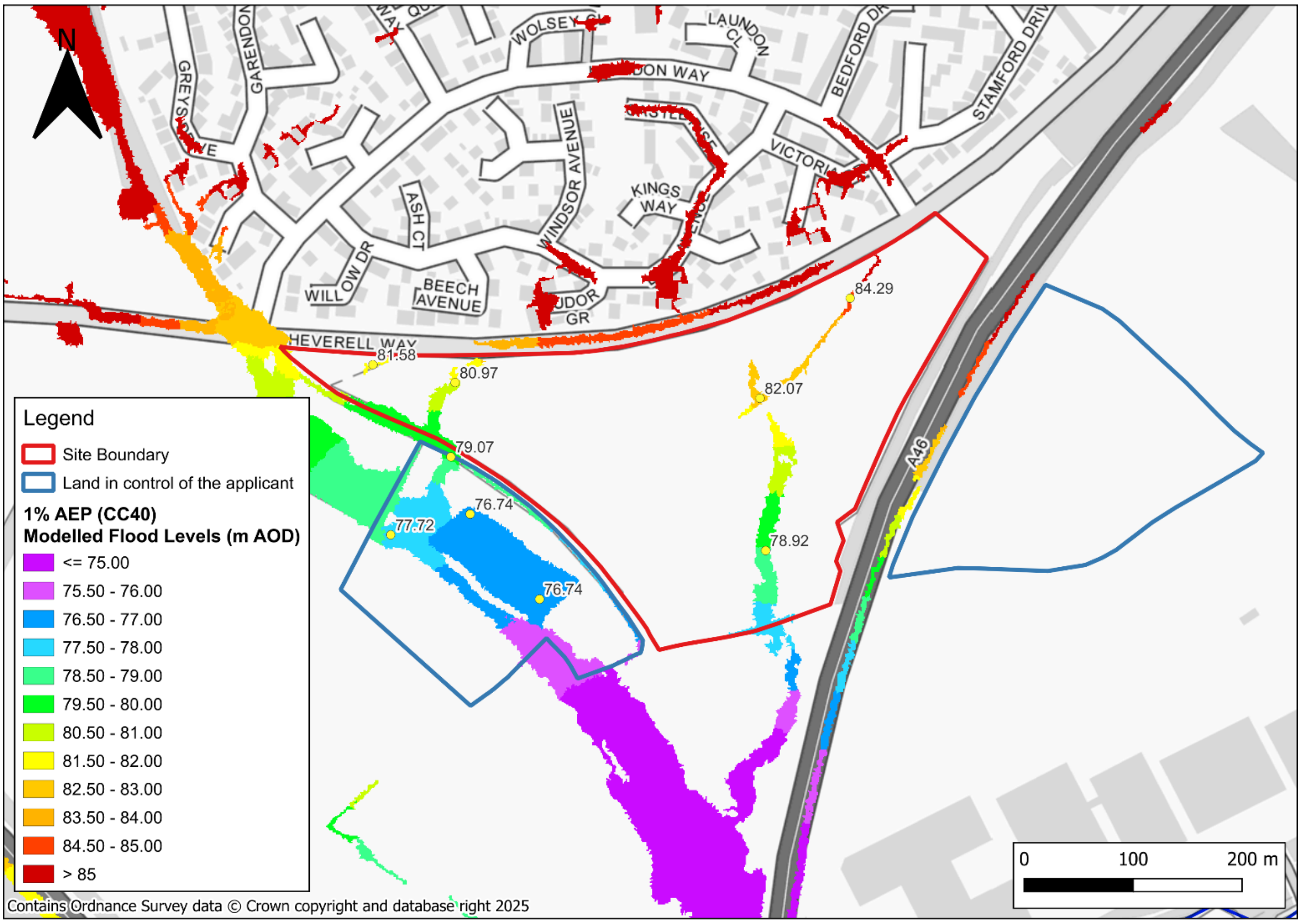


Figure 4-5 Modelled levels in 1% AEP +40% climate change flood event

4.3.2.2 Post development modelling

The baseline model was amended by applying proposed ground level changes including a swale to redirect high flows previously entering the onsite culvert. To facilitate this, ground levels were raised around the culvert inlet, ensuring that when water levels reached 81.6 m AOD, the excess flows could be redirected eastward into a swale designed to channel the water southwards. The existing 900 mm culvert has been reduced to 750 mm to represent the installation of a 750 mm orifice plate at its inlet. This measure aims to lower the proposed downstream flood risk and redirect overland flow through the swale into the drainage ditch along the site's northern boundary.

Further to discussions with the LLFA on the 17th December 2024, it was confirmed that If the existing culvert running through the site was not daylit, the LLFA would not object to the planning application on the basis that the 'status quo if being maintained'.

Indicative development parcels are shown in Figure 4-6. Rainfall inputs were removed from the areas shown to represent the impact of the proposed surface water drainage strategy.

This post-development scenario aimed to redirect off-site generated overland flow paths southwards around Development Zone B.

The proposed drainage basin was represented as at capacity as this feature would be serving the site drainage strategy and would be unavailable for off-site flows.

The post-development scenario was simulated for the 1% AEP plus climate change (40%) event and the post-developed maximum depths are shown in Figure 4-7.

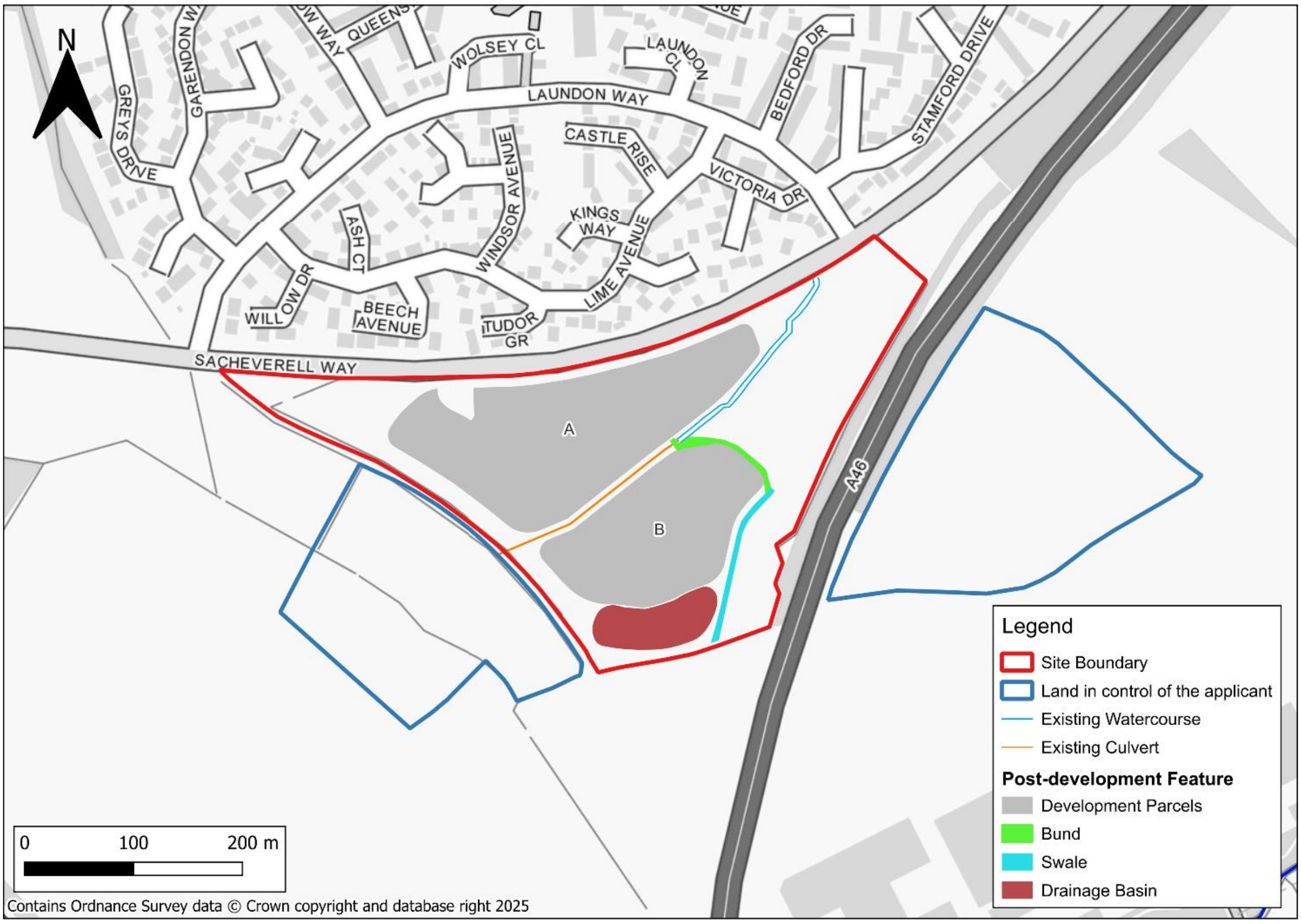


Figure 4-6: Post-development model scenario concept

The results of the post-development modelling for the 1% AEP with (+40%) climate change event shows that maximum flood depths within the eastern part of the site vary between 0m and 0.41m in Figure 4-7. The proposed access from the two parcels and to the north remains operational during the modelled post-developed design flood event.

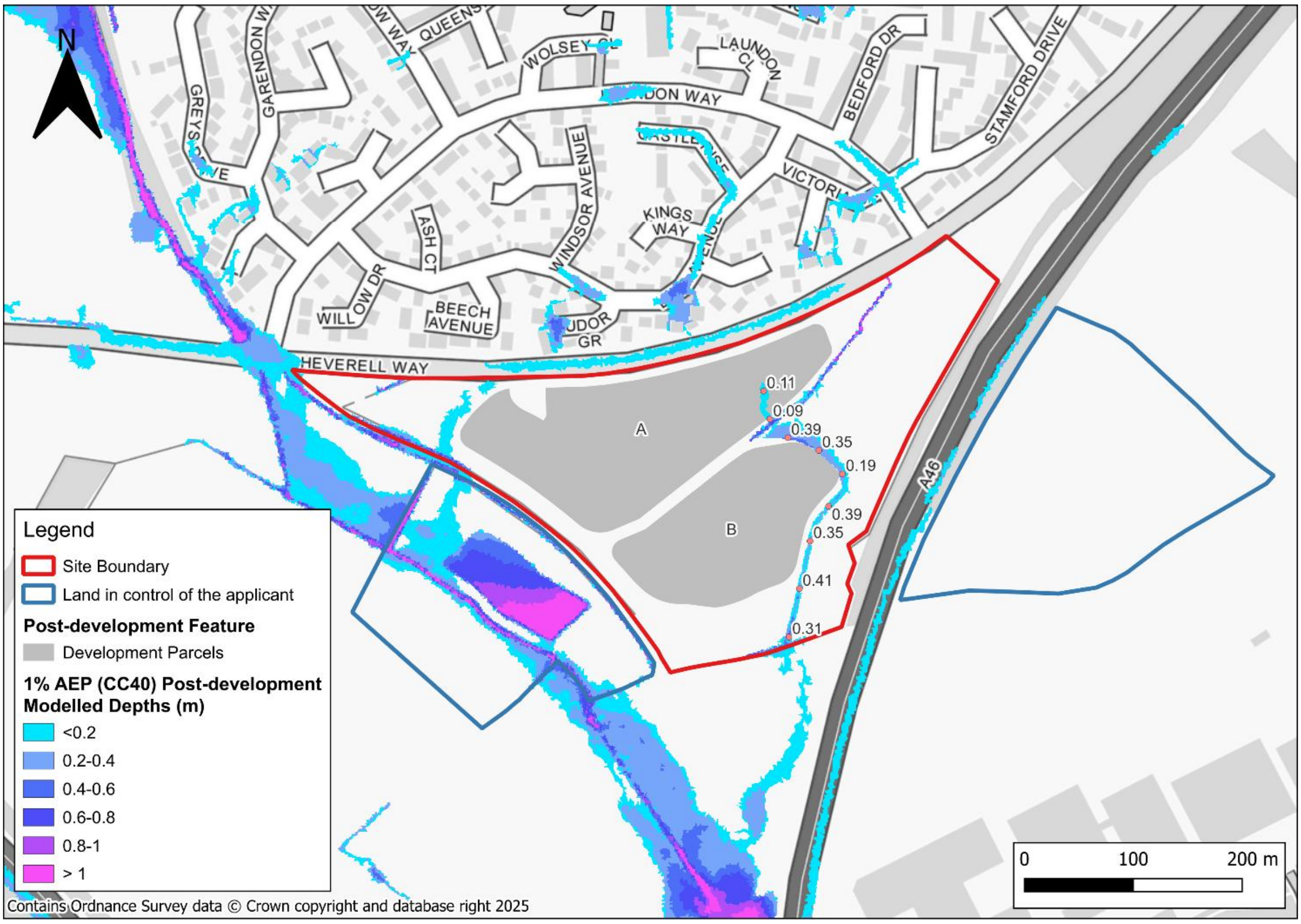


Figure 4-7: Post-developed flood depths for 1% AEP plus 40% climate change event

The post-developed results were then compared with the baseline results to determine any flood risk impacts as a result of the proposed development; this impact assessment is shown in Figure 4-8.

The proposed development does not result in any adverse flood risk impacts to third party land. The northeast of the site, where the proposed ground modification is located, shows a significant increase in depths of +10cm due to ground level changes in order to divert the overland flow paths. There is a significant reduction in peak flood depth by +0.15m south of the modification, which shows the diversion from this area. The reduction in modelled flood depths extends further south of the site.

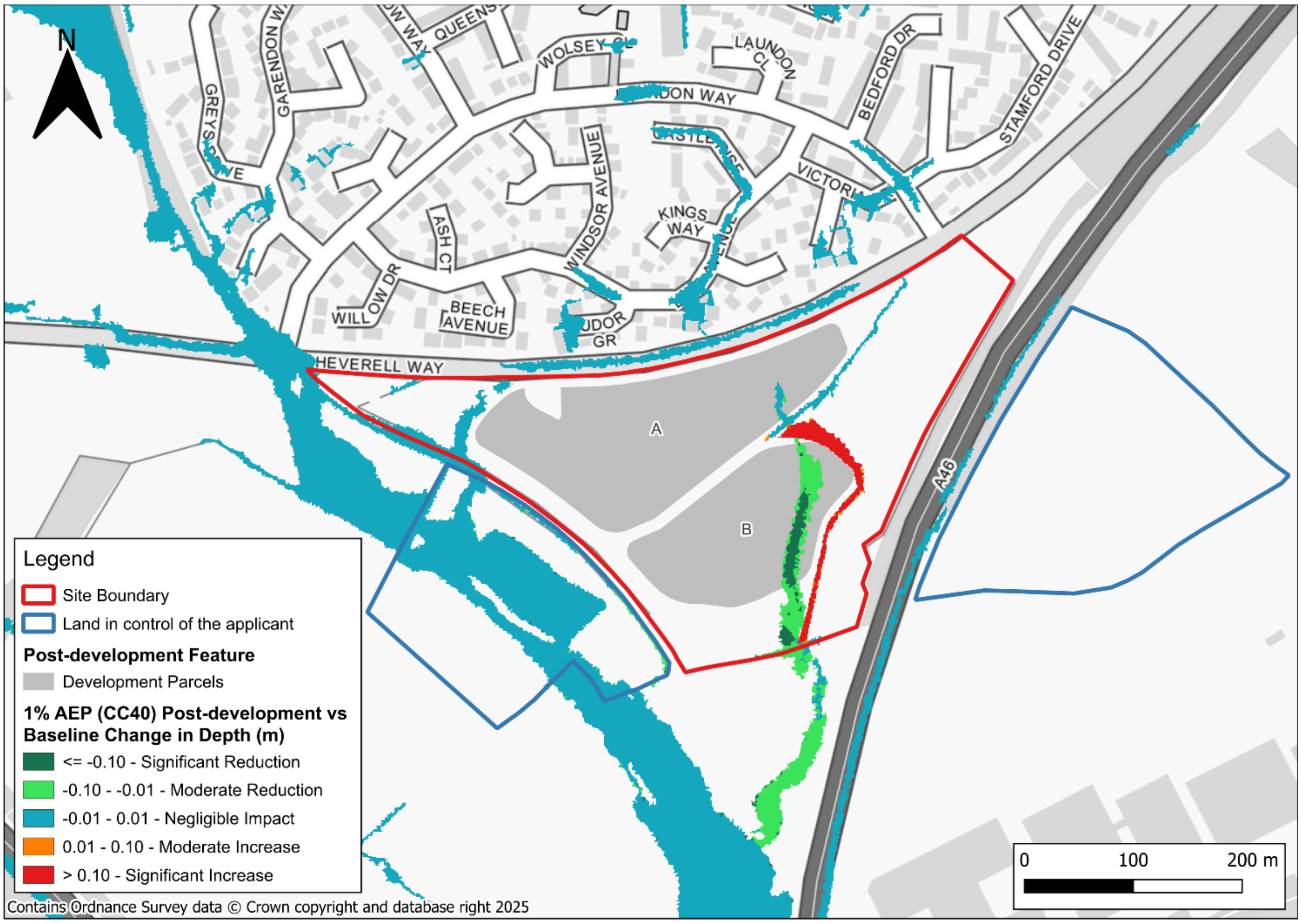


Figure 4-8: Post-developed depth comparison for 1% AEP plus 40% climate change event

The surface water hazard-to-people rating for the post-developed scenario during the 1% AEP plus 40% climate change flood scenario has been mapped using the formula as suggested in Defra's FD2320/TR2 "Flood Risk to People". The different hazard categories are shown in Table 4-1 and the hazard classification for the post-developed scenario during the 1% AEP plus 40% climate change scenario is shown in Figure 4-9.

Table 4-1: Defra's FD2320/TR2 "Flood Risks to People" classifications

Flood hazard rating depth x (velocity+0.5) +DF	Level of Flood Hazard Description	Class label
<0.75	Low	Caution "Flood zone with shallow flowing water or deep standing water"
0.75 to 1.25	Moderate	Dangerous for some (i.e. Children) "Danger: flood zone with deep or fast flowing water"
1.25 to 2.00	Significant	Dangerous for most "Danger: flood zone with deep fast flowing water"
>2.00	Extreme	Dangerous for all "Extreme danger: flood zone with deep fast flowing water"
Using the hazard equation HR = d*(v+0.5) + DF Where d = depth of flooding (m) v = velocity of floodwaters (m/sec) DF = debris factor		

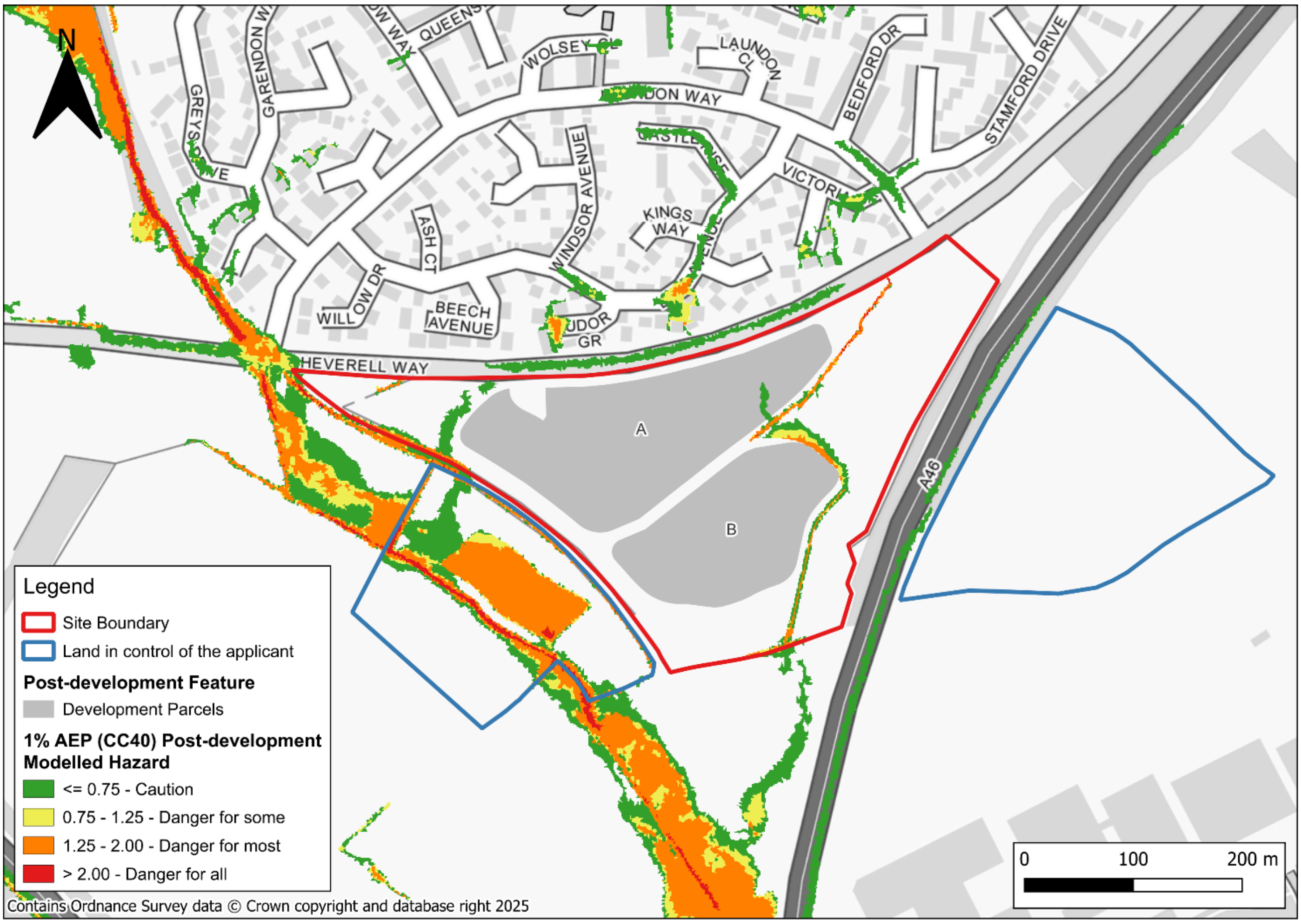


Figure 4-9: Post-developed modelled flood hazard in 1% AEP with (+40%) climate change event

Figure 4-9 shows that the Hazard to People rating for the flooded areas of the site largely falls within the 'Caution' hazard category, with a small area along the southwestern falling into 'Danger for most' hazard category and the southwest ditch falling into the 'Danger for all' category.

The proposed access from the two parcels and to the north along Sacheverall Way remains operational during the modelled post-developed design flood event.

4.4 Groundwater flood risk

Groundwater flooding can occur when the water table rises after prolonged rainfall and emerges above ground level. This is most likely to occur in low-lying areas that are underlain by permeable bedrock and superficial geology. According to Soilscapes[12], the underlying soils are loamy and clayey which are seasonally wet.

The Hinckley and Bosworth Borough Council Level 1 SFRA[13] shows that, in general, the majority of Hinckley and Bosworth borough is within the <25% susceptible classification for

12 Soilscapes soil types viewer - Cranfield Environment Centre. Cranfield University (landis.org.uk)

13 https://www.wokingham.gov.uk/sites/wokingham/files/2023-07/1.%20WBC%20SFRA%202020%20Report.pdf

groundwater flooding (% per km sq). Parts of the borough were identified as higher risk, but the Sacheverall Way site was not included.

Based on the above, the risk of flooding at the site from groundwater sources is considered to be **Low**.

4.5 Sewer flood risk

According to the Hinckley and Bosworth Borough Council SFRA, sewer flooding is one of the main sources of flooding within the borough

However, as the site is greenfield in nature with no existing sewers crossing the site, the risk of flooding from sewers is considered to be **Low.**

4.6 Reservoir flood risk

Figure 4-10 shows the Environment Agency's Reservoir Failure Flood Extents. The mapping shows the site is not at risk of flooding if a reservoir were to fail during both a flood event (wet day) and when river levels are normal (dry day). Based on the above, the risk of flooding at the site as a result of a reservoir failure is considered to be **Very Low.**

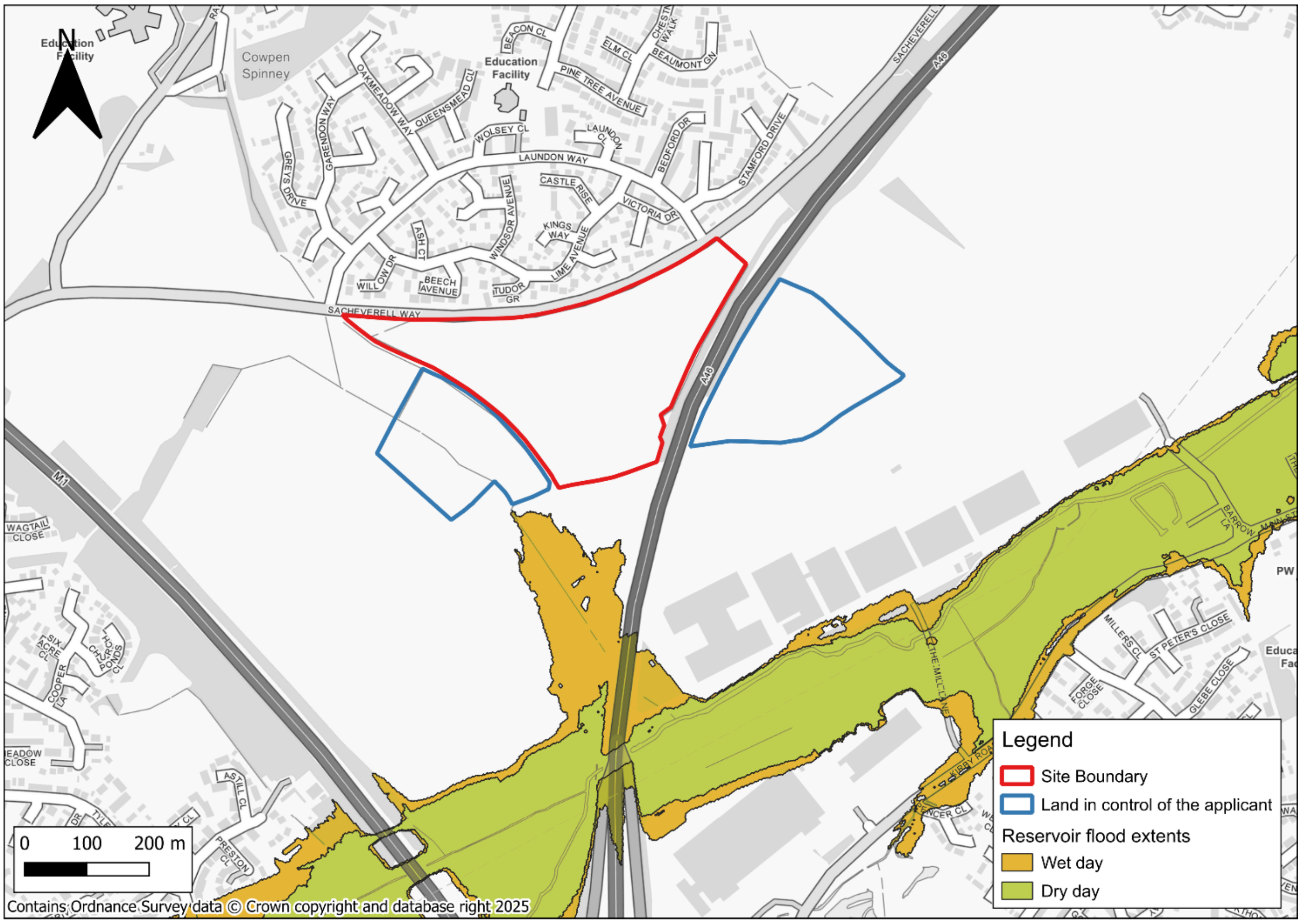


Figure 4-10 Environment Agency's Reservoir Flood Extents

5 Flood Mitigation Measures

In accordance with the NPPF and the associated PPG, it must be demonstrated that the proposed development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

5.1 Site layout

In line with best practice, the development layout has followed a sequential approach to avoid development in areas most at risk of flooding. The surface water flow routes across the site are respected and maintained within the masterplan.

5.2 Finished Floor Levels

The Finished Floor Levels (FFLs) of the proposed residential units should be set above the predicted flood level adjacent to each individual unit in the 1% AEP plus 40% climate change surface water flood event noting that across the site the design flood level ranges from 78.92m AOD to 84.29m AOD. Current Environment Agency guidance states that finished floor levels should be set 600mm above the Design Flood Level.

A detailed site plan was not available at the time of this report and individual FFLs not able to be determined. However, a range of peak water levels for the Design Flood (surface water flood level) is provided in Table 5-1 based on the labels in Figure 5-1. This is provided to give an indication of the range of flood levels in the absence of detail of individual properties. It is recommended that when individual property footprints are known, the flood level adjacent to each property is used to inform its FFL.

Furthermore, in line with part H of the Building Regulations, FFLs and openings (e.g. air bricks) of the proposed buildings should also be set to a minimum of 150mm above the surrounding ground levels

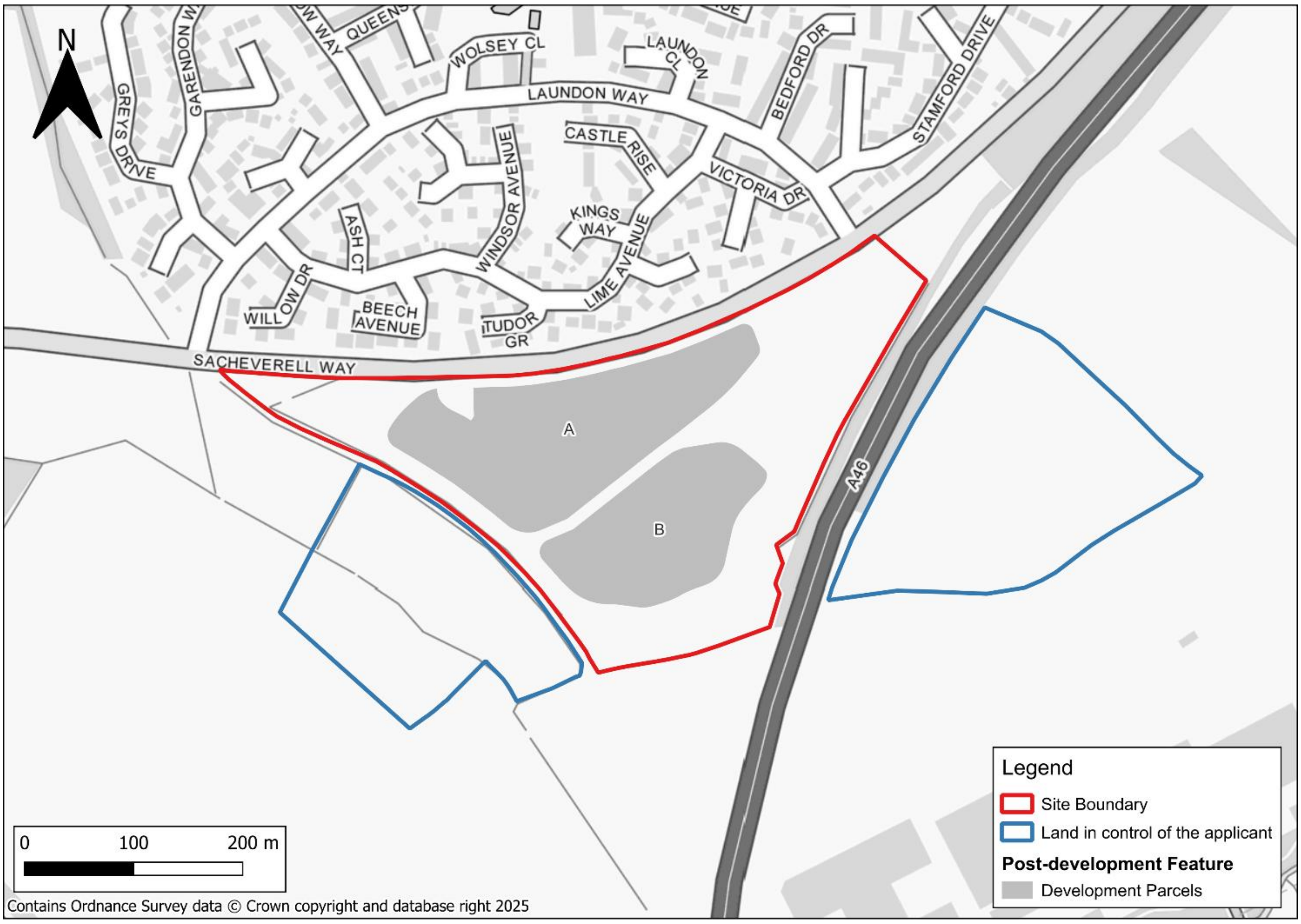


Figure 5-1: Development parcels

Table 5-1: Peak Design Flood level by development parcel

Development Parcel label	Minimum peak flood level (m AOD)	Maximum peak flood level (m AOD)
A	82.16	82.44
B	81.23	82.38

5.3 Surface water management

Surface water runoff from the site will be managed as part of a surface water drainage strategy which will be carried out separately to this FRA. This will ensure that surface flows are managed so that there is no adverse flood risk impact to third parties as a result of increased impermeable surfaces on site.

5.4 Safe access and egress

Where a development or its main route of access is located within a flood risk area, the NPPF recommends that Flood Response Plans are put in place for managing the flood risk to the development and, if necessary, support the evacuation of the site. The site is not served by the Environment Agency's flood warning service, which focuses on fluvial flood risk.

Safe access and egress from the two development parcels and to the north along Sacheverall Way remains operational during the flood events considered within this FRA including the Design Flood.

.

6 Conclusions and Recommendations

6.1 Conclusions

- JBA Consulting was commissioned by Bloor Homes East Midlands to undertake a Flood Risk Assessment (FRA) for a residential development of up to 180 dwellings at Sacheverall Way, Groby, Leicestershire. This FRA has been prepared in accordance with National Planning Policy Framework (NPPF).
- The 10.55ha site is currently greenfield land and falls from an elevation of 89.4m AOD along Sacheverall Way to the north to 76m AOD to the south-west. The Rothley Brook flows in a north-easterly direction approximately 400m to the south of the site. One small ordinary watercourse flows through the west of the site and one on the eastern site boundary. A 900mm culvert runs across the centre of the site.
- The Site is not in Flood Zones 2 or 3 of the Environment Agency's Flood Map for Planning. More Vulnerable development, such as that proposed, is compatible with the site, without the need to apply the Exception Test.
- The site does not fall within the Environment Agency's historical flood outlines and is considered to be at a low risk of flooding from fluvial sources, groundwater, sewers or as a result of a reservoir failure.
- The Environment Agency's NaFRA2 dataset shows significant overland flow paths exist across the Site. However, the NaFRA2 mapping is informed by a generalised mapping approach. Therefore, a detailed rainfall-runoff model (2D InfoWorks-ICM) has been developed to refine the flood risk shown within the NaFRA2 and to provide results suitable for a site-specific assessment of flood risk.
- Results from the rainfall-runoff hydraulic model confirm that overland flow paths are present on site during modelled events.
- During the baseline 1% AEP plus 40% climate change surface water event, typical peak flood depths within the site are predicted to reach up to 0.99m. Peak water levels range from 84.29m AOD down to 78.92m AOD.
- The baseline model was amended by including development parcels, modelling the culvert diameter as 750mm to represent the implementation of a 150mm orifice plate at the inlet and implementing a swale to divert the existing flow path within the 2D model domain to form a post-developed scenario. The post-development scenario was then simulated for the 1% AEP plus climate change event. There is no adverse flood risk impact to third party land as a result of the proposed development. There is a reduction in flood depth to the southeast of the site as a result of the proposed culvert diameter and swale modelled north of Development Zone B.
- Surface water runoff from the site will be managed as part of a surface water drainage strategy which will be carried out by JBA Consulting separately to this FRA.

- Safe access and egress from the two development parcels and to the north along Sacheverall Way remains operational during the flood events considered within this FRA including the Design Flood.
- This FRA report demonstrates that the proposed development may be designed in a sustainable and safe manner without adversely impacting the flood risk either at the Site or to any third-party land.

6.2 Recommendations

Following a review of all sources of flood risk on site, it is recommended to integrate the following mitigation measures as part of the proposal:

- The Finished Floor Levels (FFLs) of the proposed residential units are to be set above the predicted flood level in the 1% AEP plus 40% climate change surface water flood event 84.29m AOD and 78.92m AOD). Current Environment Agency guidance states that finished floor levels should be set 600mm above the Design Flood Level.
- The FFLs and openings (e.g. air bricks) of buildings are set to a minimum of 150mm above surrounding finished ground levels to prevent ingress of surface water.
- The floors of all new buildings should be made of solid construction materials and the ground beneath suspended floors should be sealed to prevent ingress of groundwater should the water table levels increase directly beneath the site.
- At the reserved matter stage, the proposed layout will be refined with detailed topography and building footprints, and the hydraulic model will be updated to confirm there is no adverse impact on flood risk to third-party land.

A Site layout

LEGEND

- Site Boundary
- Land in Control of Applicant
- Residential
- Primary Road
- Secondary Street
- Tertiary Street
- Mews Street
- Public Open Space
- Pedestrian / Cycle Link
- Footpath Link
- Public Footpath (route on the ground)
- Public Footpath (mapped route)
- Permissive Route
- Attenuation Basin
- Swale Corridor
- Existing Ditch / Drain
- Existing Tree / Hedgerow / Vegetation
- Indicative Proposed Tree Planting
- Productive Landscape
- Play Area (LEAP)
- Entrance Green Space

Define.

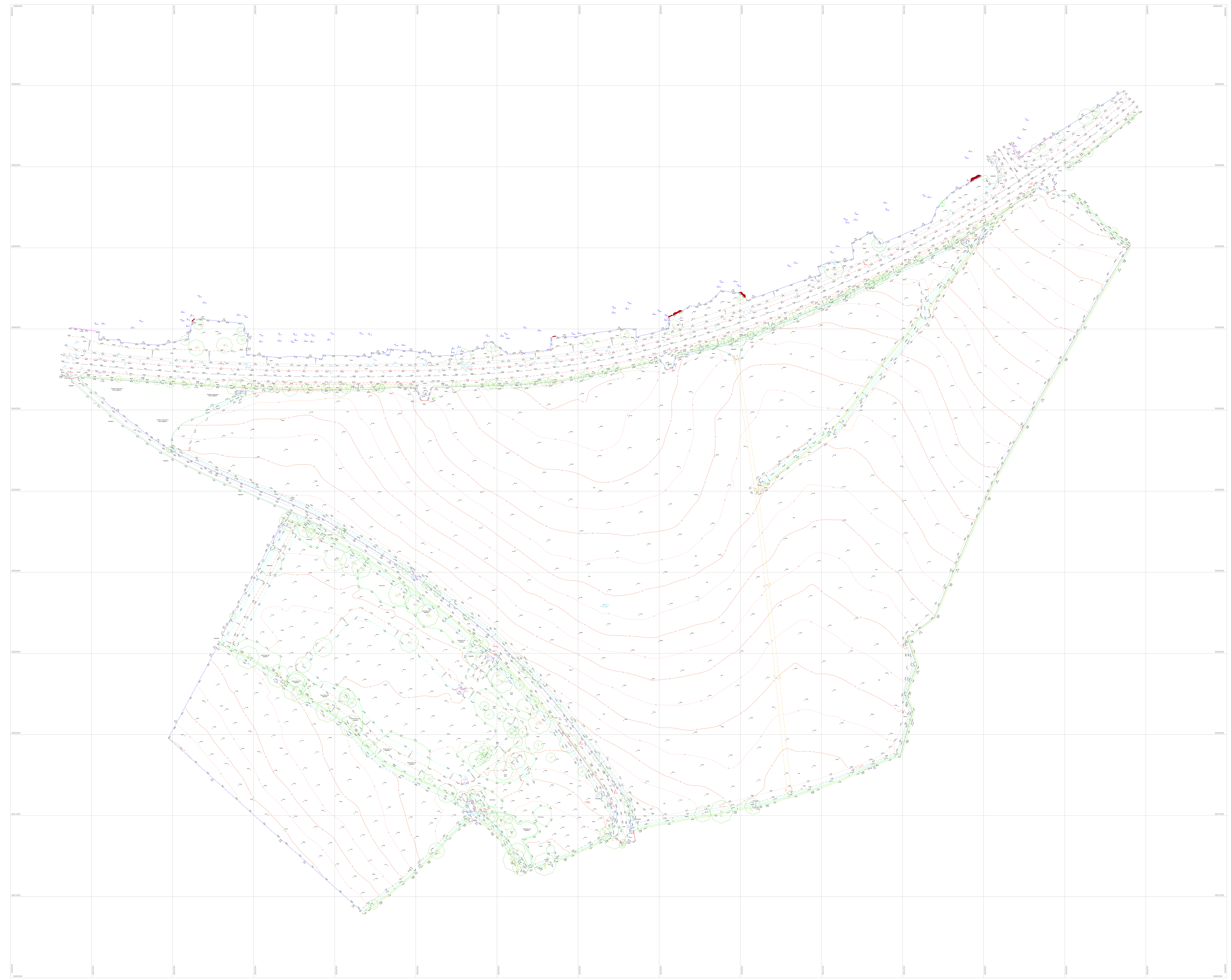
0m 15 25 50 100 150

N

Scale	1:3,500 @ A3
Revision	Rev J
Date	14/08/2025
Prepared by	EHS/KE

Bloor Homes Ltd	Client
Sacheverell Way, Groby	Project
Masterplan	Title
DE.393_SW01	Ref.

B Topographic survey



urban contours

LEGEND -

Buildings		Overhead Cable	
Wall		Concrete edge	
Kerb line		Tarmac edge	
Line marking		Grass verge	
Drop kerb		Canopy/Overhang	
Centre line		Verge	
Top of bank		Bottom of bank	
		Station and Name	

R: Ridge Level
E: Eaves Level
F: Flat Roof Level
Gate

I\R Iron Railings
W\M Wire Mesh
P\R Post & Rail
P\W Post & Wire
C\L Chain Link
W\P Wooden Panels
C\B Close Boarded
S\P Steel Palisade

IC	Inspection chamber	Bo	Bollard
PInv	Pipe invert	IB	Illuminated bollard
Gy	Gully	Bin	Rubbish bin
Bg	Back gully	Vp	Vent pipe
Dp	Down pipe	Grl	Ground light
Pipe	Pipe above ground	Lbox	Letter box
MH	Manhole	Stmp	Tree Stump
WL	Water level	Sty	Stile
Fl	Flood light	IFL	Internal floor level
Lp	Lamp post	THL	Threshold level
Tp	Telegraph post	Sp	Sign post
Ep	Electricity post	TH	Trialhole
Tl	Traffic light	BH	Borehole
Bus	Bus stop	ELC	Electric
Sv	Stop valve	BT	British Telecom
St	Stop tap	C'box	Control box
Er	Earth rod	TT	Tactile
Wm	Water meter	BP	Brick paved
Gas	Gas valve	CPS	Concrete paving slabs
Av	Air valve	CVR	Cover
ICU	Unidentified inspection	R/wall	Retaining wall
Wo	Wash out	TWL	Top of Wall Level
Re	Rodding eye	TCL	Tree canopy level
BB	Belisha beacon	G:	Girth
CTV	Cable tv	MG	Multi girth
Mkr	Marker post	IC	Inspection chamber
Gmkr	Gas marker post	CL:	Cover level
So	Soffit	IL:	Invert level
Fh	Fire hydrant	UTL	Unable to lift

Station Information:

Station	Easting	Northing	Height
C1	452831.001	306538.519	89.546
C2	452725.937	306491.237	85.835
C3	452607.743	306436.487	84.787
C4	452458.287	306427.535	83.790
C5	452331.286	306428.479	82.909
C6	452235.678	306423.566	82.095
C7	452500.364	306253.990	78.969
C8	452551.513	306195.515	77.426
C9	452572.943	306165.358	76.760

Rev	Date	Description	Drawn

PROJECT

Bloor Homes
Sacheverell Way
Groby

TITLE

Topographical Survey
2d

SCALE	DATE	DRAWN	CHECKED BY
1:nts@a1	19.07.20	GY	RH

Level datum	G.P.S OSGB36/15
Job number	

Drawing No.	Rev.
GROBY 001	0

Notes:

This plan has been surveyed to the scale shown.
Caution should be exercised when enlargements are made.

All critical dimensions should be confirmed on site prior to the commencement of any works.

All dimensions have been measured or estimated from ground level.

Tree species shown should be treated with caution and expert identification is advised.

Pipe sizes are estimated from a surface inspection only, Due to Health and Safety requirements.

Every effort is made to identify all visible above ground features, however it should be bourne in mind that there may be items obscured at the time of the survey.

C Hydraulic modelling report

Hydraulic Modelling study at land off Sacheverall Way in Groby, Leicestershire

A1-C02

December 2025

Prepared for:

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Prepared by	Harry Wightman BSc Assistant Analyst Megan Cruise Trainee Technician
Reviewed by	Alistair Clark BSc MSc Senior Flood Risk Analyst
Authorised by	John Panesar BEng (Hons) CEng MICE Technical Director

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Contract

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Address	Suite 1B, First Floor (Front Wing), Coleshill House, 1 Station Road, Coleshill, Warwickshire, B46 1HT
JBA Project Code	2024s1306

This report describes work commissioned by Jenny Brader, on behalf of Bloor Homes East Midlands by an email dated 1st August 2024. Harry Wightman and Megan Cruise of JBA Consulting carried out this work.

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The conclusions and recommendations contained in this Report are based upon information provided by others and upon the assumption that all relevant information has been provided by those parties from whom it has been requested and that such information is accurate. Information obtained by JBA has not been independently verified by JBA, unless otherwise stated in the Report.

The methodology adopted and the sources of information used by JBA in providing its services are outlined in this Report. The work described in this Report was undertaken between August 2024 and December 2025 and is based on the conditions encountered and the information available during the said period. The scope of this Report and the services are accordingly factually limited by these circumstances.

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Where field investigations are carried out, these have been restricted to a level of detail required to meet the stated objectives of the services. The results of any measurements taken may vary spatially or with time and further confirmatory measurements should be made after any significant delay in issuing this Report.

Contents

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Abbreviations

1D	One Dimensional
2D	Two Dimensional
AEP	Annual Exceedance Probability
CC	Climate Change
DTM	Digital Terrain Model
EA	Environment Agency
FEH	Flood Estimation Handbook
FFL	Finished Floor Levels
FRC	Fixed Runoff Coefficient
Ha	Hectares
ICM	Integrated Catchment Modelling
JBA	Jeremy Benn Associates
LIDAR	Light Detection and Ranging
m AOD	Metres Above Ordnance Datum
NaFRA2	National Flood Risk Assessment 2
NGR	National Grid Reference
OS	Ordnance Survey
ReFH	Revitalised Flood Hydrograph

Definitions

Term	Definition
Annual Exceedance Probability	The probability of an event size (often described in terms of peak flow rate) being equalled or exceeded in any one year
Flood risk	A combination of the statistical probability of a flood event occurring and the scale of the consequences if it does. So high risk can include circumstances that might not occur very frequently but have very substantial consequences, and also circumstances that occur relatively frequently and have more moderate consequences, causing relatively frequent but less severe harm
Manning's *n*	This is a roughness coefficient first introduced by Irish Engineer Robert Manning in 1889, which represents the roughness or friction affecting the flow of water by the surface (e.g. channel) over which the water flows. The rougher the surface the greater the effect of friction on the flow.

Executive Summary

JBA Consulting were commissioned by Bloor Homes East Midlands to undertake a detailed hydraulic modelling study in relation to a site located at Sacheverell Way, Groby, Leicestershire.

The purpose of the study is to refine and accurately assess the surface water flood risk to the site. To achieve this, a hydrological assessment was carried out to derive rainfall hyetographs and a 2D InfoWorks-ICM direct runoff hydraulic model was produced to allow the detailed representation of flood depths, flood levels and hazard within the site boundary.

The model was simulated for the following Annual Exceedance Probability (AEP) events: 3.3%, 3.3% with (+35%) climate change, 1%, 1% with (+40%) climate change, and 0.1% storm, for the 60-minute critical (summer) storm duration.

The baseline model results indicate that:

- Flooding is predicted to occur within the site during all modelled design events.
- Flooding is predicted to occur within the site during the 3.3% AEP with (+35%) climate change and 1% AEP with (+40%) climate change events.
- Peak modelled flood depths of up to 1.29m are predicted to occur within the site during the 100-year (1% AEP) plus climate change event.
- Peak modelled flood levels are predicted to range between 84.29m AOD to the north-east and 78.92m AOD towards the southern boundary of the site during the 100-year (1% AEP) plus climate change event.
- Hazard classification areas of ‘caution’ extend across the site, with areas of ‘Danger for most’ to ‘Danger for all’ located within the confines of the formal defences.
- Sensitivity testing of the model found that within the site boundary the model results are insensitive to changes in modelled roughness, and slightly sensitive to changes in the fixed runoff coefficient (runoff percentage) value.

The post-development model results indicate that:

- Raising the ground levels around the culvert inlet and redirecting the overland flow paths into a swale during the 1% AEP with (+40%) climate change event decreases modelled flood depths to third-party land at the south of the site.
- When comparing depths to the baseline scenario, the northeast of the site, where the ground modification is located, shows a significant increase in depths of +10cm due to ground level raising in order to divert the overland flow paths. There is a significant reduction south of the modification, which shows the diversion of overland flow paths from this area.

Recommendations

The results of the hydraulic modelling can be used to inform the Flood Risk Assessment for the site. However, it is recommended that the hydraulic modelling is reviewed and validated by the Lead Local Flood Authority.

It is recommended that the post-development scenario of the model is altered during the detailed layout design and that Finished Floor Levels (FFLs) are set above the modelled design flood level with freeboard is applied. It is recommended that the new levels be re-simulated in the hydraulic model to understand the impact on flood levels and flood hazard within the site, along with the incorporation of a site surface water drainage strategy.

The model results have been prepared for the purpose of quantifying surface water flood risk at the site and surrounding area. If the results are intended to be used for surface water flood risk mapping of the wider catchment, further model refinement is recommended. Additionally, if further data is made available it is recommended that the model is updated to improve the representation of surface water flood risk parameters.

1 Introduction

1.1 Terms of Reference

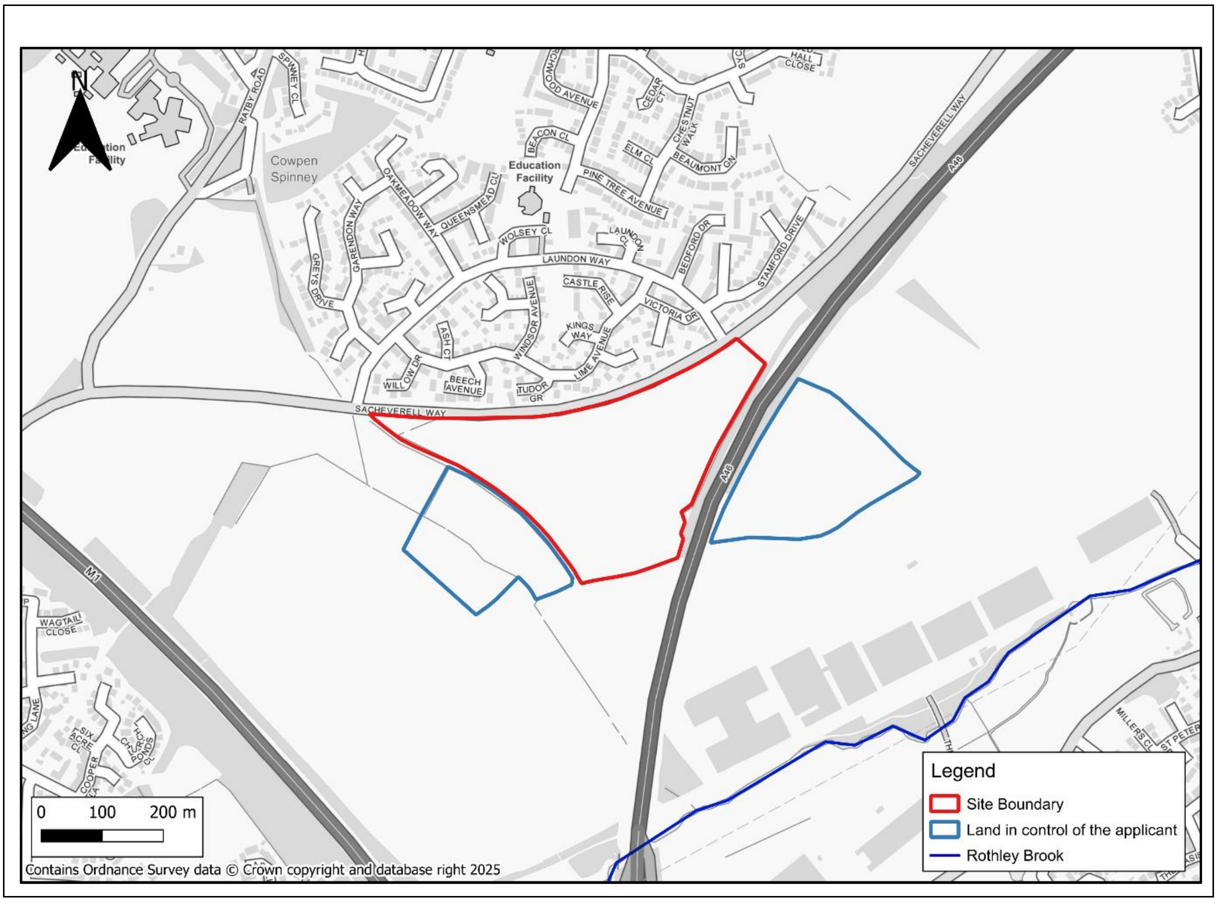
JBA Consulting were commissioned by Bloor Homes East Midlands to undertake a detailed hydraulic modelling study in relation to a site located off Sacheverall Way, Groby, Leicestershire (hereafter referred to as 'the site').

The purpose of the study is to refine and accurately assess the surface water flood risk to the site. To achieve this, a 2D InfoWorks-ICM direct runoff hydraulic model was produced to allow the detailed representation of flood depths, flood levels and hazard within and around the site boundary.

1.2 Site details

Table 1-1: Site details

Site address	Sacheverall Way, Groby, Leicestershire
Site area	10.55ha
Existing land-use	Greenfield land
OS NGR	SK 52595 06329
County	Leicestershire
Country	England



1.3 Site description

The site is located south of Sacheverall Way, Groby. Agricultural land-uses make up the majority of the site. Located north and south-west to the site are large residential areas, which are both bounded by the M1 motorway and the A46. The catchment itself is mostly rural. Analysis of LiDAR elevation data shows the topography of the location slopes from the north-east to the south-west. There are several drainage ditches in the vicinity of the site and a presumed culvert running through the centre of the site. All drainage ditches are presumed to be draining into Rothley Brook, designated as an Environment Agency (EA) Main River, approximately 400m south-east of the site.

Analysis of existing surface water risk mapping, OS mapping and LIDAR elevation data indicates that the site topography slopes south-westerly towards the Rothley Brook tributary as shown in Figure 1-1.

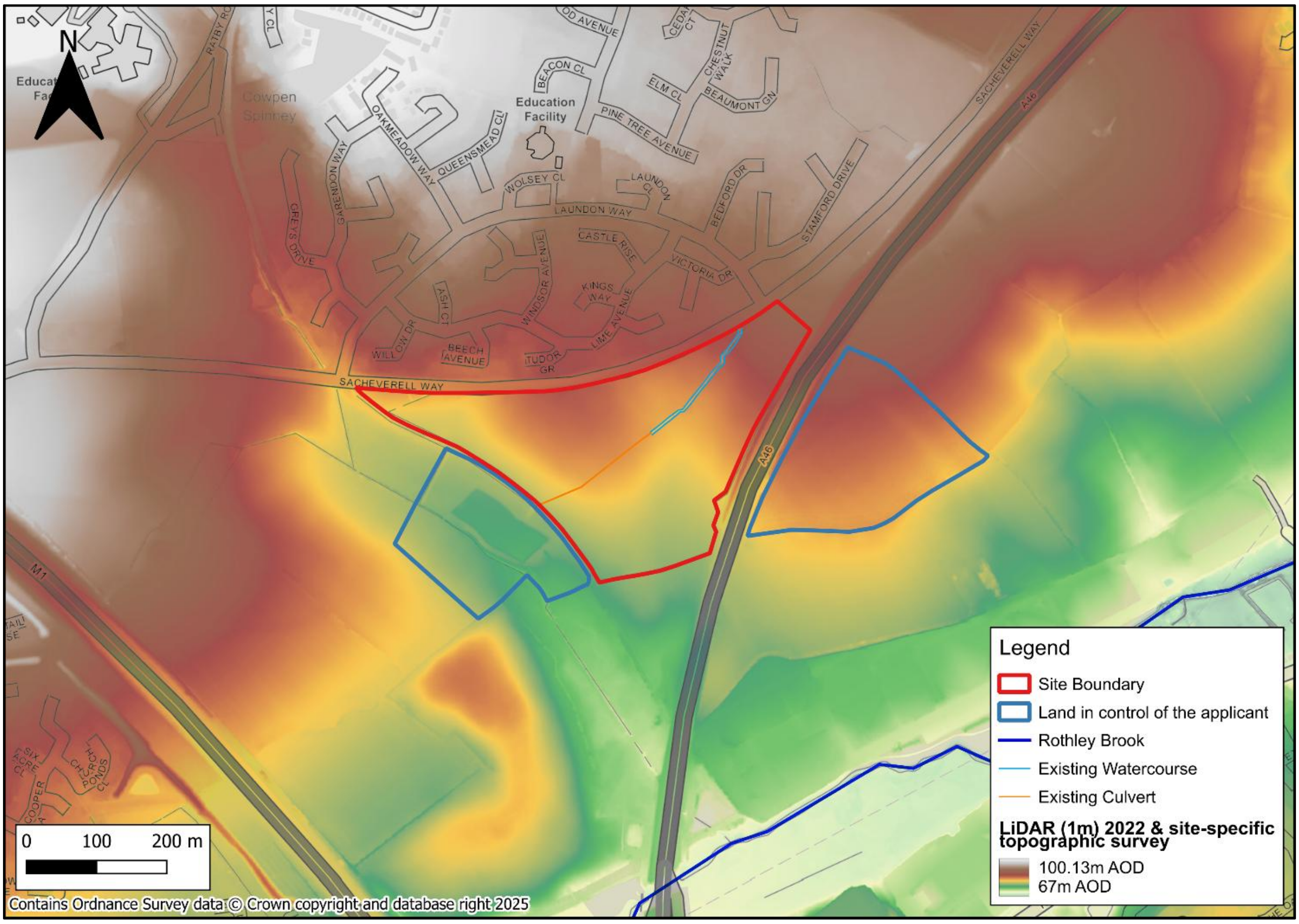


Figure 1-1: Site Topography

1.4 Existing flood data

The EA’s NaFRA2 mapping for the site is shown in Figure 1-2.

The mapping indicates that the site is at risk from surface water flooding in the 3.3% AEP, 1% AEP and 0.1% AEP events. The main cause of flooding is suggested to be flow routes originating from the catchment of Rothley Brook, which is located on the southern boundary. However, these maps originate from broad-scale modelling techniques whereby the capacity public sewers, channel and the structures crossing it is approximated. Key structures including the upstream surface water public sewer network, and surface water features which may allow water to drain away in lower return period events, (such as culverts, drains, gullies, kerbs, etc.) are unlikely to be explicitly represented.

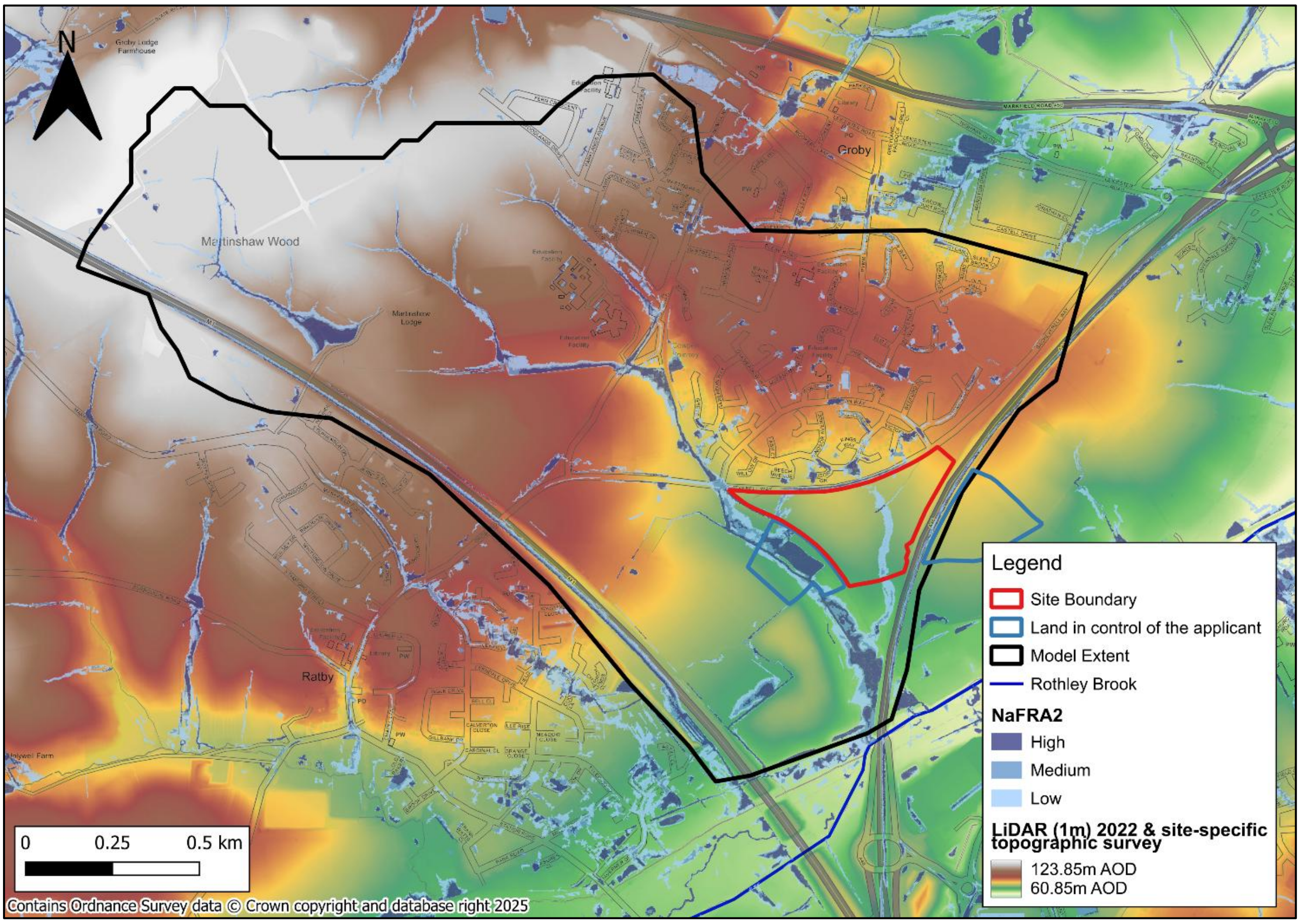


Figure 1-2: Environment Agency’s Risk of Flooding from Surface Water Mapping

1.5 General modelling approach

A direct rainfall-runoff model was developed to refine the understanding of surface water flood risk at the site, incorporating local surface water drainage information and topographic data to improve upon the EA's Risk of Flooding from Surface Water mapping.

A 2D model was developed in InfoWorks ICM covering the study catchment draining towards the site. Rainfall hyetographs were derived for the following storm events:

- 3.3% AEP and 3.3% AEP with (+35%) climate change uplift.
- 1% AEP and 1% AEP with (+40%) climate change uplift.
- 0.1% AEP.

The rainfall hyetographs were applied directly to the model surface to provide baseline model results, including flood depths, flood levels and hazard in the vicinity of the site.

The hydraulic model sensitivity to roughness values and the fixed runoff coefficient was tested to improve confidence in the model results.

2 Approach

2.1 Data availability

Amber Utilities Ltd were commissioned to undertake a culvert information survey report within the vicinity of the site in October 2024 (see Appendix A). The survey consisted of one culvert identified within the vicinity of the site. Sewer maps covering the area around the site were obtained from Severn Trent Water (see Appendix C) and used to inform the representation of the public sewer network, to the north and north-east of the site.

Topographic survey of the site was collected in July 2020 by Urban Contours and was available for use in this study (See Appendix B). The topographic survey was used within the modelling to represent levels throughout the site. Environment Agency LiDAR data was obtained from the Open Data website and used within the modelling to represent ground levels within the wider catchment. The LiDAR data used has a grid resolution of 1m and flown in 2022.

Ordnance Survey (OS) ZoomStack mapping was used to inform land use information in the study catchment.

2.2 Site walkover

A site walkover was carried out by JBA Consulting in September 2024 to improve understanding of drainage features within the site and surrounding area. The visit confirmed the presence of a small watercourse flowing down the western edge of the main field, a flood relief basin in the west of the site and several structures. All structures noted in the topography and drainage drawing, provided by the client, were confirmed on site apart from the culverts along the northern edge of the site which were inaccessible due to heavy vegetation.

2.3 Hydraulic Model Build

The flood modelling approach was based on the "direct rainfall" concept where rainfall is applied to each mesh element in the hydraulic model and routed across the mesh surface, identifying flooding pathways and areas where ponding will occur. A 2D direct rainfall model has been built to refine the EA's NaFRA2 mapping by representing the local drainage network using the available information. The model was built using InfoWorks ICM version 2024.5.

2.4 2D domain

2.4.1 Model extent and topography

The hydraulic model extent encompasses the topographic catchment for the site and that of nearby surface water flow paths identified on the EA's NaFRA2 mapping. It also includes the sewer catchment for the surface water sewer that discharges into the watercourse near the site. The model extent is shown in Figure 2-1.

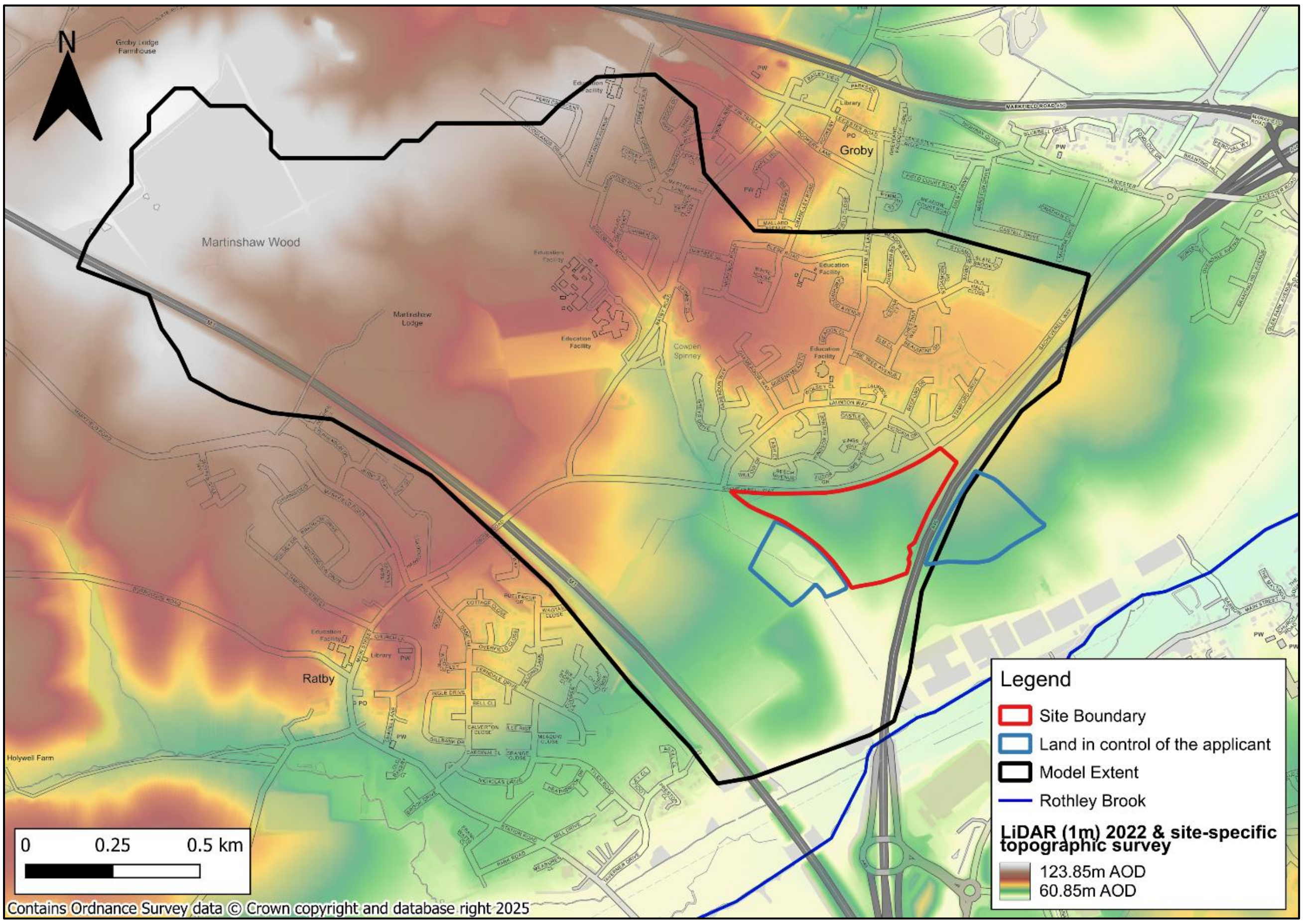


Figure 2-1: Model extent

The 1m Environment Agency 2022 LiDAR has been used to derive the topography throughout the model domain. A maximum triangle size of 10m^2 has been applied to the 2D zone, with terrain sensitive meshing used to increase the resolution in areas of steep topography and improve the representation of changes in the topography. A summary of the key 2D Zone parameters relating to model topography is shown in Table 2-1.

Table 2-1: 2D Zone parameters summary

	Value
Maximum triangle area (m^2)	10
Minimum element area (m^2)	2
Terrain-sensitive meshing	True
Maximum height variation (m)	0.25
Minimum angle (degrees)	25

2.4.2 Model roughness parameters

Manning's *n* roughness values were used to represent the model roughness in the hydraulic model's 2D domain based on land uses across the model extent. Land uses were defined using Ordnance Survey (OS) ZoomStack mapping (see Figure 2-2). Table 2-2 details the range of Manning's *n* values applied to the 2D domain.

Table 2-2: Manning's *n* values within the hydraulic model 2D domain

Land use	Manning's n
General Surface	0.050
Dense woodland	0.100
Roads	0.025
Buildings	0.300
Inland water	0.040

2.4.3 2D features

Mesh zones were used to represent buildings within the 2D domain and raise the mesh to a level 0.125m above the ground level to represent an assumed building threshold. This approach allows buildings threshold levels to be raised above the 2D mesh to account for their impact on overland flows.

Mesh zones were also used to represent roads, enforce kerb lines, and to represent watercourses. Levels were taken from LIDAR with no modifications made.

The 2D features are shown in the 2D model schematic in Figure 3-2.

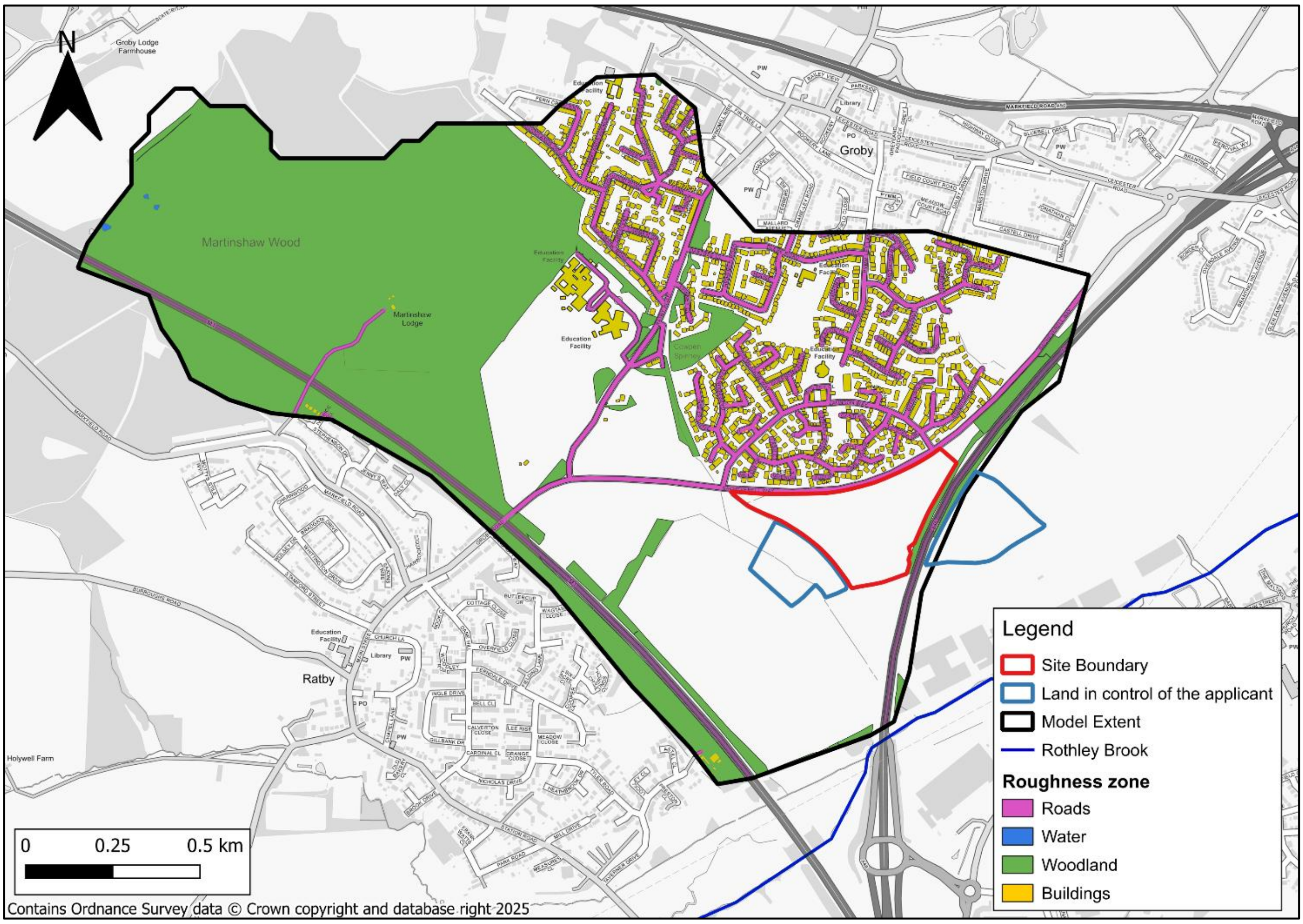


Figure 2-2: 2D model schematic

2.5 1D domain

2.5.1 Representation of sewers

The public surface water sewer network covering the area to the north of the site draining into the modelled drainage ditches via culvert has been represented in the 1D domain with conduits and manholes based on information from the Severn Trent Water sewer maps (see Appendix C).

It was necessary to make some assumptions about data taken from Severn Trent Water sewer mapping including the following:

- Missing pipe dimensions were assumed based on standard pipe sizes and upstream and downstream connections.
- Manholes have been set to have a 2D flood type with those on or close to the highway which uses the weir equation to determine flow between the 1D and 2D domains.
- Ground levels were assumed to be equal to the cover level.
- Manholes were assumed to be unsealed and allowed to surcharge.

- Manholes with unknown dimensions are modelled using the default calculation InfoWorks ICM uses for Chamber plan area: A= $\frac{\pi}{4} \times (Width\ of\ incomming\ pipe + 0.762)^2$

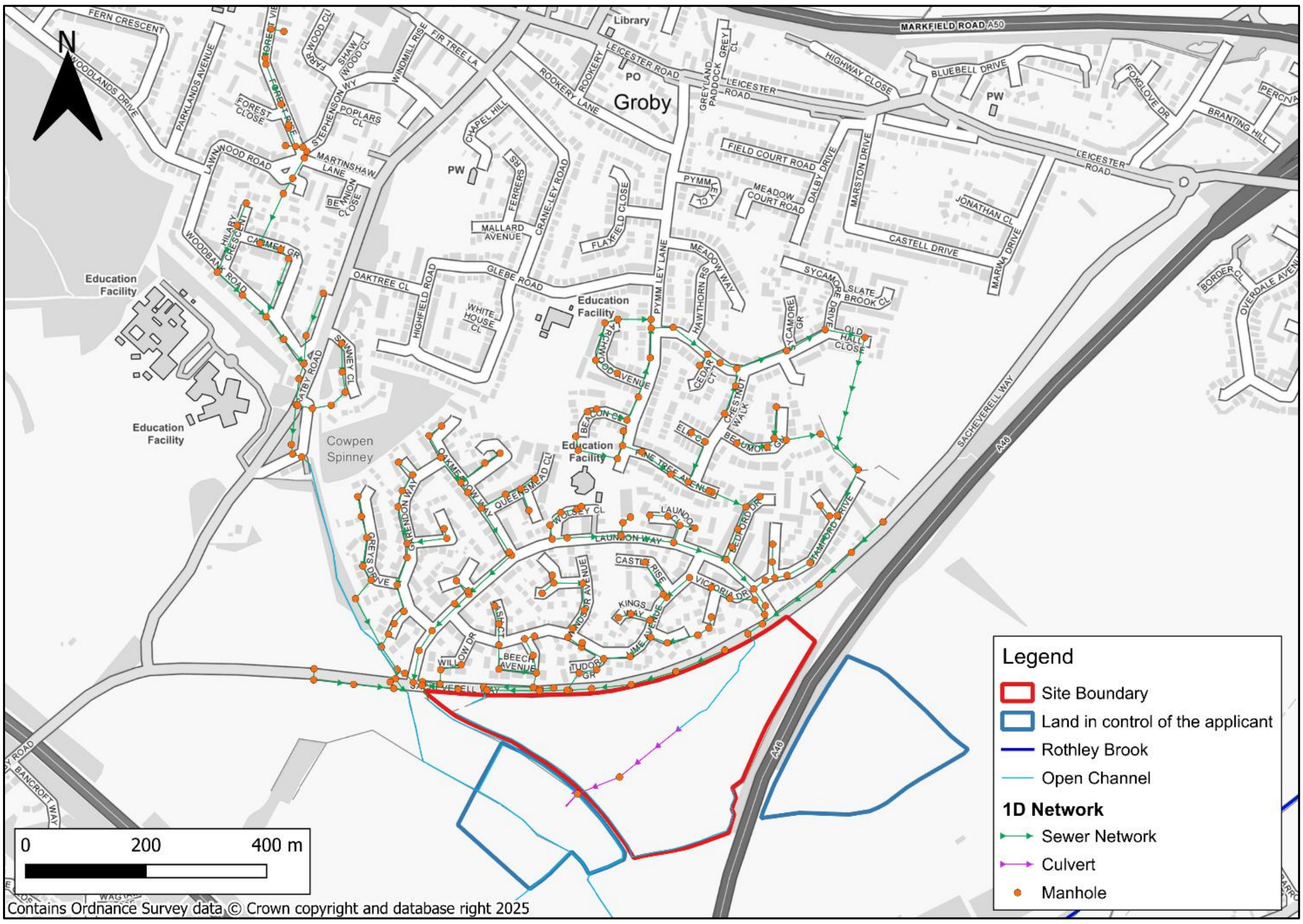


Figure 2-3: 1D model schematic

2.6 Application of hydrology

Rainfall hyetographs were applied directly to the ground model across the catchment using the ReFH2 rainfall generator in InfoWorks-ICM. InfoWorks-ICM allows hyetographs to be automatically generated within the software using catchment rainfall parameters from the FEH service. FEH22 rainfall descriptors were used to generate the rainfall events. An evapotranspiration value of 3mm/day was applied to summer storms to represent summer conditions, and an evapotranspiration value of 1mm/day was applied to winter storms.

Rainfall hyetographs were calculated for the 3.3% AEP (1 in 30-year), 1% AEP (1 in 100-year), and 0.1% AEP (1 in 1000-year) storm events. Storm durations of 1-hour, 3-hours and 6-hours were simulated for each return period with the maximum extent generated for each event determined as the critical storm duration. Winter and summer rainfall were also compared. The results showed that the maximum flood extents at the site occur during the

1-hour storm duration and summer rainfall profile, in all return periods. This event was taken forward as the critical storm duration for all return periods.

The effect of climate change was assessed by increasing the peak rainfall by 35% for the 3.3% AEP event and 40% for the 1% AEP event (upper end allowance for the 2080's epoch from the Loddon and tributaries management catchment).

Rainfall was applied directly to the whole of the 2D model surface, with overland flow routed by surface topography and surface features, such as buildings and roads. Buildings within 50m of the sewer network were represented with subcatchments to route flow into the 1D sewer network, accounting for the drainage of buildings directly into the sewers. Drainage from roads into the sewers was represented using manholes where sewers have been modelled and so were not represented with subcatchments.

Infiltration zones were used to control the volume of rainfall allowed to flow onto the 2D mesh and were also used to account for losses from the 2D domain (e.g. water flowing into the sewer network through subcatchments or water lost through infiltration).

Infiltration surfaces represented in the model are shown in Figure 2-4. Roads and buildings have been given separate infiltration surfaces dependant on whether they have been modelled with a connection to the 1D sewer network or not. If the sewer network draining roads or buildings has not been represented in the model, they have been given a 12mm/hour loss to account for drainage to the sewer network.

In order to prevent any double counting of inflows to the model (by application of rainfall to the 2D mesh and the 1D sewer system using subcatchments) runoff coefficients used to route flows to the sewer system through subcatchments have been reduced based on the 2D runoff coefficient. The fixed runoff coefficients used are shown in Table 2-3.

Table 2-3: Fixed runoff coefficients

Land Use	1D runoff coefficient	2D runoff coefficient	Infiltration surfaces loss (mm/hr)
Roads (No sewer network represented)	-	0.9	12
Buildings (No sewer network represented)	-	1.0	12
Buildings (With sewer network represented)	0.8	0.2	-
Green space	-	0.43	-

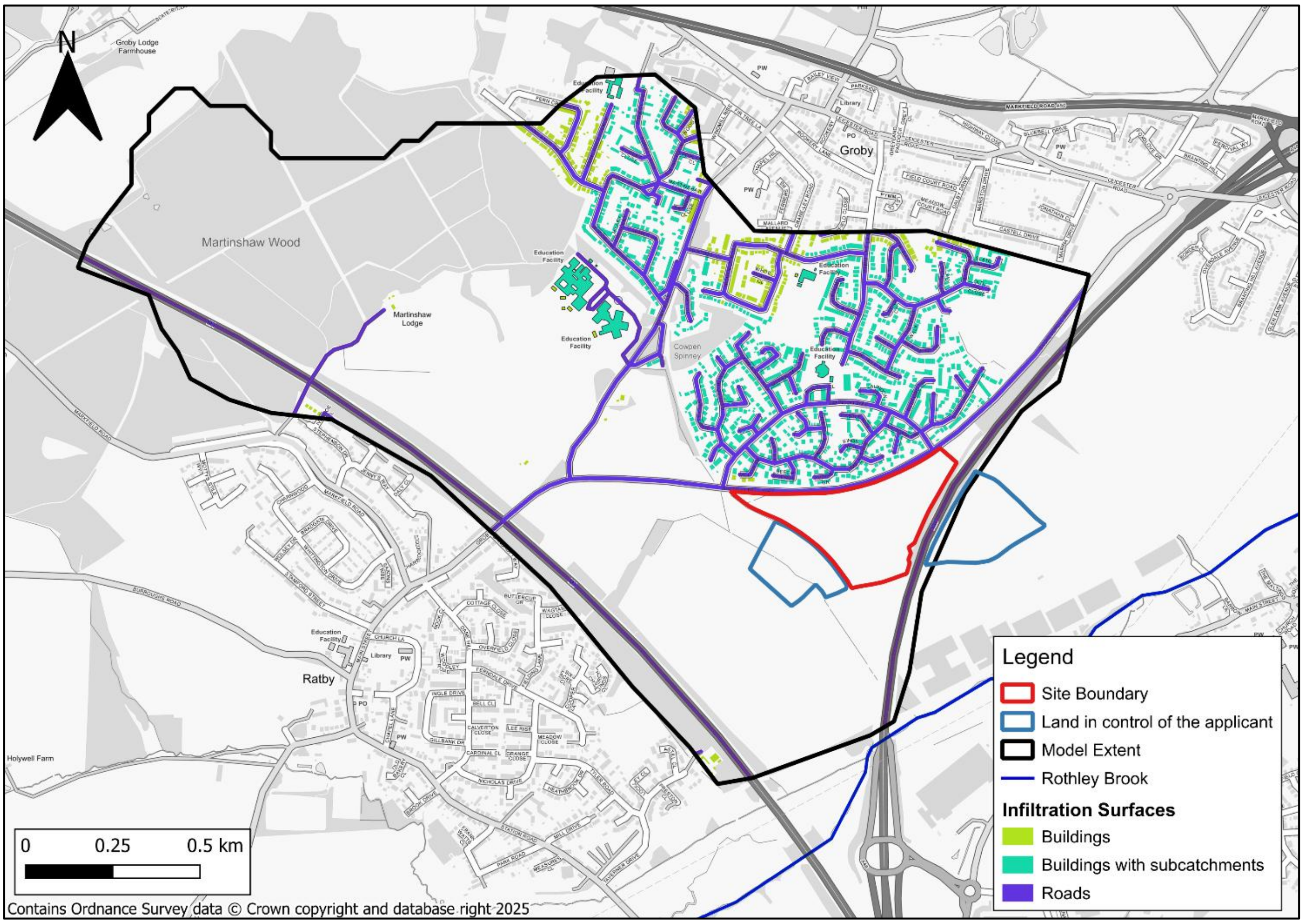


Figure 2-4: Infiltration surfaces

2.7 Calibration

No specific recorded flood levels or flow data were available for the study area. As a result, the model has not been calibrated. Instead, a model validation has been carried out through comparison with the EA's NaFRA2 mapping (see Section 3).

2.8 Model Runs

The following scenarios were simulated within the model:

Scenario	Return period	Description
Baseline scenario	3.3% AEP (30-year)	Existing condition scenario
Baseline scenario	3.3% AEP (30-year) with (+35%) climate change	Existing condition scenario
Baseline scenario	1% AEP (100-year)	Existing condition scenario
Baseline scenario	1% AEP (100-year) with (+40%) climate change	Existing condition scenario
Baseline scenario	0.1% AEP (1,000-year)	Existing condition scenario
Post-development scenario (Option 3)	1% AEP with (+40%) climate change	Post-development modelling
Sensitivity analysis	1% AEP (100-year)	20% increase in roughness
Sensitivity analysis	1% AEP (100-year)	20% decrease in roughness
Sensitivity analysis	1% AEP (100-year)	20% increase in fixed runoff coefficient
Sensitivity analysis	1% AEP (100-year)	20% decrease in fixed runoff coefficient

2.9 Sensitivity analysis

The model's sensitivity to changes in roughness and fixed runoff coefficient were assessed. Further detail on the sensitivity testing is provided in Appendix D.

Sensitivity testing of the model found that within the site boundary the model results are insensitive to changes in modelled roughness, and slightly sensitive to changes in the fixed runoff coefficient (runoff percentage) value.

3 Model validation

To assess the validity of the model results, the surface water modelling results were compared with the EA's NaFRA2 maps for one return period.

3.1 Comparison with the EA 1 in 100-year surface water flood map

Figure 3-1 shows the EA’s 1% AEP NaFRA2 extent compared to the 1% AEP surface water extent modelled as part of this study. The flood extents within the site for the modelled 1% AEP event are predicted to be smaller compared to that of the 1% AEP NaFRA2 in the southwest of the site. The predicted decrease in flooded area within the site can be attributed to the representation of the sewer network, inclusion of site-specific topography and improving the resolution of the modelling.

At the east of the site, it is shown that there is no risk of flooding from surface water however, there is a risk of flooding in the modelled extent. This is due to the inclusion of a culvert immediately downstream of the extent within the model, which the Environment Agency's modelling does not explicitly represent in their NaFRA2 mapping.

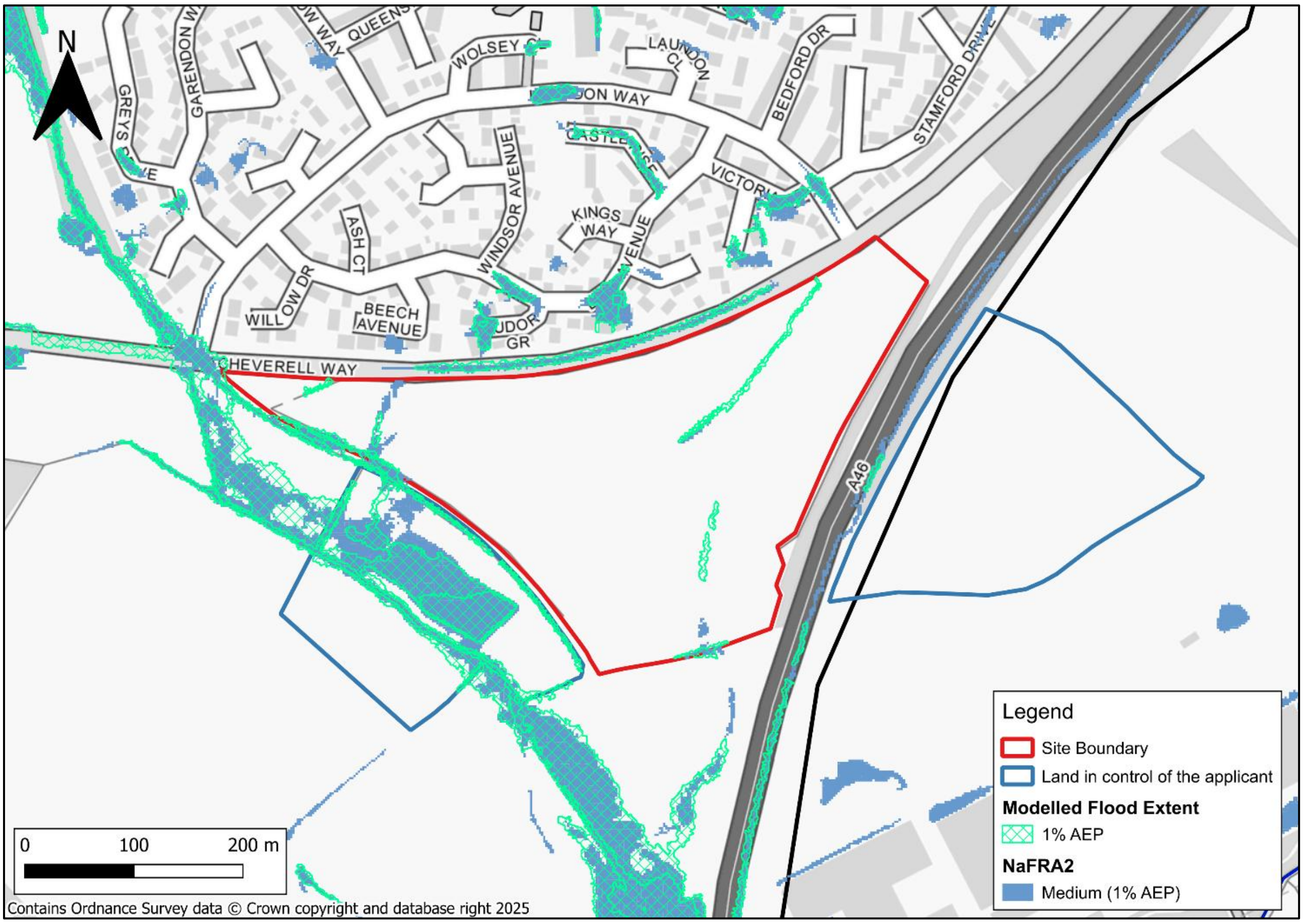


Figure 3-1: 1% AEP comparison with NaFRA2

4 Hydraulic model results

4.1 Processing of hydraulic model results

The following processing steps, aligned with those taken from the EA's National Scale Surface Water Flood Mapping Methodology[1], have been applied to the outputs of all hydraulic modelling results:

- Filtered to remove areas where Hazard to People rating is less than 0.575
- Filled areas with an area less than $50m^2$
- Removal of polygons with an area less than $100m^2$.

Only 2D model results are included in these figures.

4.2 Existing conditions / baseline scenarios

4.2.1 Peak flood extents

Flood extents for the 3.33% AEP, 1% AEP and 0.1% AEP flood events are shown in Figure 4-1, with mapping for the 3.33% AEP with (+35%) climate change and 1% AEP with (+40%) climate change events shown in Figure 4-2.

Figure 4-1 indicates that flooding is predicted to occur within the site during all modelled events.

Figure 4-2 indicates that flooding is also predicted to occur within the site during the 3.3% AEP with (+35%) climate change and 1% AEP with (+40%) climate change events.

1 https://www.gov.uk/government/publications/flood-risk-maps-for-surface-water-how-to-use-the-map/risk-of-flooding-from-surface-water-understanding-and-using-the-map#how-the-rofsw-map-was-created

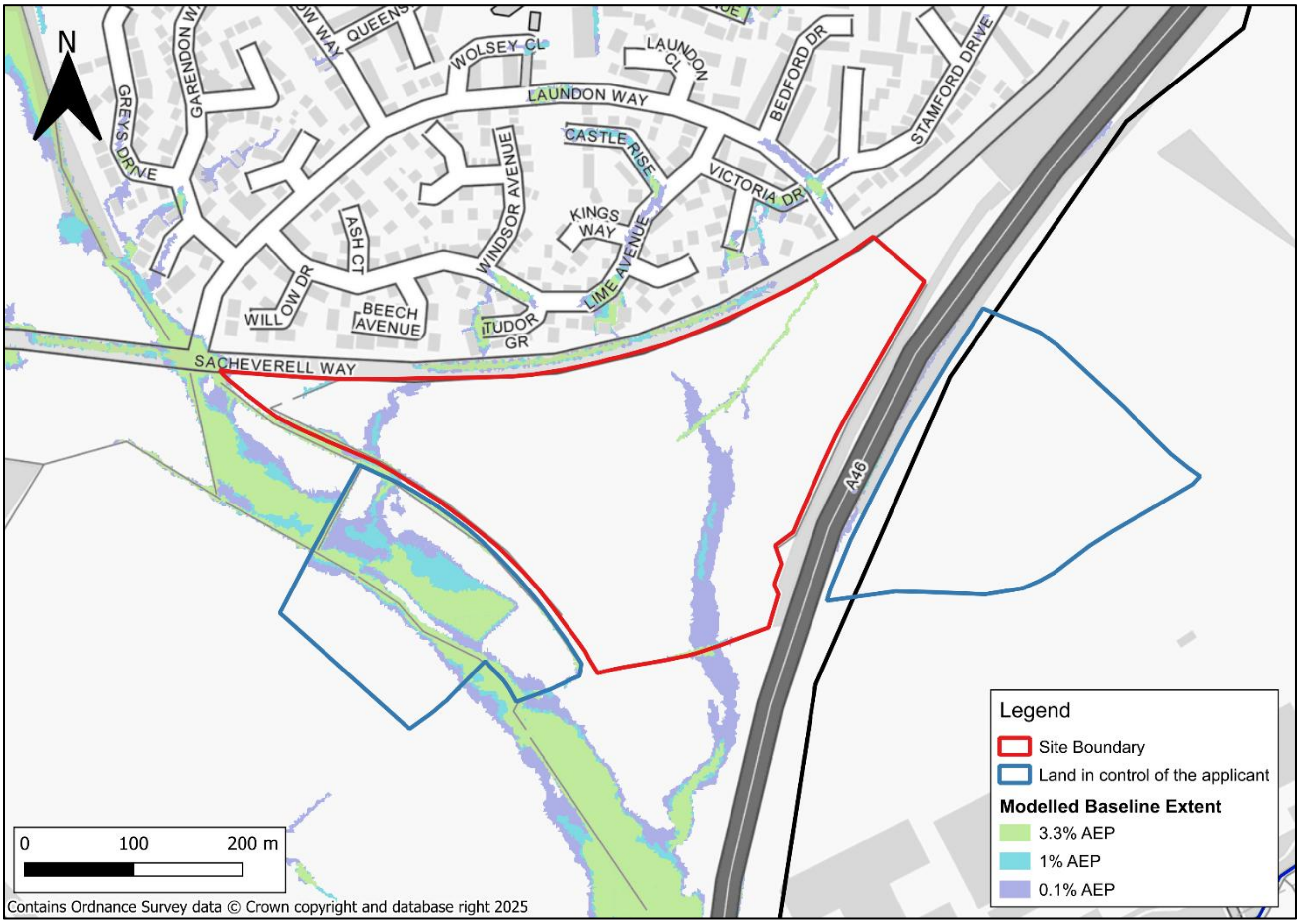


Figure 4-1: Baseline scenario peak flood extents