



**UK Flood Risk**  
**Flood Risk Consultants**

# ***Flood Risk Assessment & Hydraulic Modelling Report***

**White House, Ashwell Road, Newnham,  
Baldock, Hertfordshire SG7 5JU**

**Development of Hydraulic Model for watercourse**

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## **UK Flood Risk**

Unit 044 The Base  
Dartford Business Park  
Victoria Road  
Dartford DA1 5FS

Tel: 020 3797 6380

[ukfloodrisk@gmail.com](mailto:ukfloodrisk@gmail.com)  
[www.ukfloodrisk.co.uk](http://www.ukfloodrisk.co.uk)

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| Prepared by | SG | Senior Flood Risk Consultant | 20/10/2025 |
|-------------|----|------------------------------|------------|

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**UK Flood Risk**  
Unit 044 The Base  
Dartford Business Park  
Victoria Road  
Dartford DA1 5FS

## Executive Summary

A hydraulic model has been developed for a section of a watercourse (Cat Ditch) located in Newnham, Baldock, Hertfordshire.

The purpose of the model is to support the Flood Risk Assessment (FRA) for a proposed residential development comprising a new residential dwelling on the site located at White House, Ashwell Road, Newnham, Baldock, Hertfordshire SG7 5JU.

The model has been developed in accordance with current guidance from the Environment Agency and relevant planning policies and is intended to assess the fluvial flood risk associated with the watercourse under existing and design flood conditions, including the effects of climate change.

An assessment of the hydraulic modelling outputs indicated that the site is not at risk of flooding during the 1 in 5 year, 1 in 30 year, 1 in 100 year, and 1 in 100 year plus climate change flood events from the watercourse. Based on the model outputs, the site is considered suitable for the proposed residential development from a fluvial flood risk perspective.

The modelling outputs provide information on maximum flood levels for a range of events to inform the site layout, floor levels, and appropriate flood mitigation measures.

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## 1.0 Introduction

A hydraulic model has been developed for the Cat Ditch located near the proposal site- White House, Ashwell Road, Newnham, Baldock, Hertfordshire SG7 5JU. The purpose of the model is to support the Flood Risk Assessment (FRA) for a proposed residential development comprising one new residential dwelling on the site.

The model has been prepared in accordance with current guidance from the Environment Agency and relevant planning policies and is intended to assess the fluvial flood risk associated with the watercourse under existing and design flood conditions, including the effects of climate change. The modelling outputs provide information on maximum flood levels for a range of events to inform the site layout, floor levels, and appropriate flood mitigation measures.

## 2.0 General Description of the Site and the Watercourse

The watercourse (Cat Ditch) is a small watercourse that runs adjacent to the site within a predominantly rural setting. The watercourse is narrow and heavily vegetated with dense growth along both banks and within the channel (**Figure 1**). This vegetation may influence flow resistance and conveyance capacity, and has been considered in the hydraulic modelling by assigning appropriate roughness coefficients.

The contributing catchment is rural in character, comprising primarily agricultural fields and open grassland, with minimal impermeable surfaces. Surface runoff is generally slow due to the natural permeability of the ground and the vegetation cover, although intense or prolonged rainfall may still generate some flows towards the watercourse.

Importantly, there is a road culvert within the immediate vicinity of the site (**Appendix A**). Upstream of the culvert, the watercourse flows freely in an open channel, and the hydraulic conditions are predominantly governed by natural features such as vegetation, channel slope, and ground conditions.

**Figure 1 Dense vegetated watercourse near the road culvert.**



## **3.0 Data Collection**

### **3.1. Topographic Data and Watercourse Sections**

The site and the surrounding area are generally flat, with only minor undulations typical of a rural landscape. There is no significant gradient across the site, which may limit natural surface water runoff and result in slow drainage or localised ponding during heavy rainfall. The flat topography also means that any exceedance flows from the

nearby field drain could potentially spread across the wider floodplain, depending on ground conditions and surface cover.

To support the hydraulic assessment, a topographic survey was undertaken for the site and the watercourse (**Appendix B**). The survey provides a reliable representation of the existing ground levels and has been used to extract the cross-sectional profiles of the watercourse adjacent to the site. These profiles are critical for understanding the channel geometry, identifying low points, and evaluating the potential flow paths and flood extents under various scenarios. The survey provides a sufficiently accurate baseline for preliminary hydraulic modelling and flood risk assessment purposes.

## **3.2. Hydrological Data**

### **River flow gauging data**

There are no flow gauging stations located within the immediate vicinity of the site or the contributing catchment. As such, observed flow records are not available for direct use in the hydrological assessment or model calibration.

### **Rainfall data sources**

As there are no rain gauge stations located in close proximity to the site, FEH (Flood Estimation Handbook) Rainfall Data has been utilised to inform the hydrological inputs for the modelling and assessment. The FEH data, obtained via the FEH Web Service, provides statistically derived rainfall estimates for a range of storm durations and return periods, accounting for local catchment characteristics. SAAR (Standard Average Annual Rainfall) in mm is the average annual rainfall which has been used for hydrological assessment. This approach ensures that the rainfall inputs used are consistent with national best practice and are suitable for use in flood risk assessments and hydraulic modelling, as recommended by the Environment Agency.

### **Catchment Characteristics**

The catchment area of the watercourse at the site is approximately 24.88km<sup>2</sup>. Due to the undeveloped nature of the catchment, the hydrological response is expected to be more gradual compared to urban areas, although the watercourse may still be susceptible to exceedance during extreme rainfall events, particularly where vegetation or debris obstructs the flow.

### **Historical flood event data**

There were no records of flooding events at the site or in the vicinity.

## **3.3. Information on Hydraulic Structures**

There is a road culvert adjacent to the site.

## **4.0 Hydrological Analysis**

### **Model Coverage Plan**

A Model coverage plan is provided in **Appendix A**.

### **Method of Flow Inflow Estimation**

The FEH Statistical (2025) method refers to the Flood Estimation Handbook Statistical Method, which is one of the standard hydrological for estimating greenfield runoff rates and peak flow estimation at ungauged sites. The FEH Statistical (2025) method has been used to calculate the peak flow rates from the catchment. This approach uses rainfall and catchment descriptors derived from the Flood Estimation Handbook (FEH) Web Service, incorporating updated datasets and improved statistical models to provide robust and accurate runoff rate estimates for design and planning purposes.

The calculation requires input parameters including:

- Total site Area,
- Base Flow Index derived using the UK Hydrology of Soil Types (HOST) classification.
- Standard Annual Average Rainfall (SAAR) 9120.

Details of the input parameters are derived from catchment descriptors are provided in **Appendix E**.

### **Design storm events and return periods**

When the FEH statistical equation is used to derive  $Q_{med}$ , a conversion factor is applied to obtain  $Q_{bar}$ , as  $Q_{bar}$  can then be factored to achieve other return periods using the growth curves, which can then be used to derive runoff rates for different return periods, typically the 1 in 1-year, 1 in 2-year, 1 in 10-year, 1 in 30-year, and 1 in 100-year events, with appropriate climate change allowances applied.

Details about the parameters used in the estimation are provided in **Appendix E**. Estimation of flow rates for a range of events are provided in **Appendix F** and the results are summarised in **Table 1** below.

**Table 1 – Peak flow rates**

| Events        | Peak flow rates (Litres/Sec) |
|---------------|------------------------------|
| 1 in 1 year   | 255.8                        |
| 1 in 2 year   | 261.6                        |
| 1 in 10 year  | 485.2                        |
| 1 in 30 year  | 720.5                        |
| 1 in 100 year | 1046.9                       |

## Climate change allowances

The proposal site is located within the Upper Ouse and Bedford Management Catchment and within the Anglian River Basin District. The relevant climate change allowances are summarised in **Table 2** below.

**Table 2 - Peak river flow allowances by Management Catchment and River Basin District**

| Management Catchment Name / River Basin District | Climate Change allowance | Total potential change anticipated for the '2020s' (2015 to 2039) | Total potential change anticipated for the '2050s' (2040 to 2069) | Total potential change anticipated for the '2080s' (2070 to 2115) |
|--------------------------------------------------|--------------------------|-------------------------------------------------------------------|-------------------------------------------------------------------|-------------------------------------------------------------------|
| Upper Ouse and Bedford / Anglian                 | Upper end                | 24%                                                               | 30%                                                               | 58%                                                               |
|                                                  | Higher central           | 10%                                                               | 11%                                                               | 30%                                                               |
|                                                  | Central                  | 5%                                                                | 4%                                                                | 19%                                                               |

## Using peak river flow allowances for flood risk assessments

The guideline suggests to consider the flood zone and the appropriate flood risk vulnerability classification to decide which allowances applies to the development or plan.

In flood zones 2 or 3a for:

- essential infrastructure – use the higher central allowance
- highly vulnerable – use central allowance (development should not be permitted in flood zone 3a)
- more vulnerable – use the central allowance
- less vulnerable – use the central allowance

- water compatible – use the central allowance

In flood zone 3b for:

- essential infrastructure – use the higher central allowance
- highly vulnerable – development should not be permitted
- more vulnerable – development should not be permitted
- less vulnerable – development should not be permitted
- water compatible – use the central allowance

### **Assessment of Climate Change Impact for the Site**

The proposal site is located within the Upper Ouse and Bedford Management Catchment and within the Anglian River Basin District. As the proposed development is categorised as ‘more vulnerable’ and part of the site is located within a flood zone, the guideline recommends to use the Central allowance for assessing the impact of climate change. The Central allowance for the Upper Ouse and Bedford/Anglian River Basin District is 19% for the period between 2070 and 2115 (**Table 2**). Therefore, a 19% climate change allowance factor has been used for the hydraulic modelling assessment for the site. Accordingly, The peak flow discharge rates for the 1 in 100 year plus climate change are provided in **Table 3**.

**Table 3 – 1 in 100 year Plus Climate Change runoff rates**

| <b>Events</b>                                 | <b>Greenfield runoff rates<br/>(Litres/Sec)</b> |
|-----------------------------------------------|-------------------------------------------------|
| 1 in 100 year                                 | 1,046.9                                         |
| 1 in 100 year + 19%<br>Central Climate Change | 1,245.8                                         |

## 5.0 Hydraulic Model Set Up

### 6.1. Modelling Software

The use of a simple and computationally efficient hydraulic model is critical for simulating water surface profiles across a range of flood events, particularly when assessing small or moderately complex watercourses.

The hydraulic modelling of the watercourse has been undertaken using HEC-RAS, a widely accepted and industry-standard software developed by the U.S. Army Corps of Engineers for simulating water surface profiles and assessing flood risk in open channel flow systems. HEC-RAS 6.6 (September 2024) has been selected for this study as it is well-suited for simulating one-dimensional steady and unsteady flow conditions within open channel watercourses, allowing for accurate assessment of water levels and flow dynamics. The model allows for rapid scenario testing, sensitivity analysis, and incorporation of site-specific data without excessive processing time or resource demands. It strikes a balance between analytical accuracy and practical usability, enabling timely and cost-effective flood risk assessments that support planning and design decisions while maintaining reliability and regulatory compliance.

### 6.2. Model Extents and Domains

The extent of the hydraulic model has been defined based on the location and context of the proposed development site. This extent ensures that all relevant flow dynamics affecting the site are captured within the modelled reach. The model extents and domains are provided in **Appendix C**.

There are no tributaries or significant lateral inflows within the modelled reach; therefore, these have not been included in the hydraulic model. This approach ensures that the model remains focused on the primary watercourse influencing the site, maintaining both accuracy and computational efficiency.

### 6.3. Model Components

- Cross-sections

The cross-sectional profiles of the watercourse used in the hydraulic model have been derived from the topographic and channel cross-sectional survey. The locations of the watercourse cross-sections are provided in **Appendix B**.

- Structures and hydraulics

There is a road culvert near the site, which has been included in the model domain (**Appendix B**).

- Inflows and boundary conditions

The flow rates in **Table 1 and Table 3** have been used as inflows to the model. The downstream boundary condition has been defined using normal flow depth, calculated based on the average slope gradient of the channel in the downstream reach. This approach is appropriate for representing gradually varied flow conditions where no backwater effects or downstream control structures are present.

- Roughness coefficients

A Manning's roughness coefficient appropriate for natural channels with dense vegetation has been applied to the watercourse in the hydraulic model. A roughness value of 0.060 has been used for the watercourse. This reflects the resistance to flow introduced by the vegetation and ensures a more accurate representation of flow dynamics within the channel.

- Model schematics/diagrams

The model schematic is provided in **Appendix D**. It illustrates the catchment area, upstream model boundary, channel alignment, location of cross-sections, and the downstream model boundary, providing a clear overview of the hydraulic model layout and its key components.

#### **6.4. Assumptions and Limitations**

Several simplifications have been applied in the modelling process due to data limitations and the nature of the site. Notably, there are no tributaries or lateral inflows included in the model, as no significant sources of additional flow were identified. Furthermore, the hydraulic model relies on the survey data for the cross-sectional profiles, which, while highly accurate, may not fully capture fine-scale topographic variations in certain areas.

Any gaps in the data, such as the absence of local flow gauging stations or historical high-resolution rainfall data, have been addressed using the best available alternative data sources, such as FEH rainfall data. These assumptions and simplifications are acknowledged and accounted for in the model results.

Model stability has been carefully considered throughout the hydraulic modelling process. The assumptions made to ensure model stability include the use of steady-state flow conditions for the majority of the simulations, with a focus on normal flow depth boundary conditions at the downstream limit. The model has been used with appropriate time steps and grid resolutions to avoid computational instability, particularly for the one-dimensional flow in the watercourse. The chosen Manning's roughness coefficient and cross-sectional data have been verified to be consistent with typical conditions for natural channels with dense vegetation. Sensitivity analyses have been conducted to assess the effect of variations in roughness and slopes, ensuring that the model produces stable and reliable results within the parameters set by the available data.

## 6.0 Hydraulic Model Runs and Outputs

The baseline model has been developed using design flows applied at the most upstream channel cross-section (i.e. Cross Section 21). The downstream boundary condition is defined using a Normal Depth approach, based on the average slope gradient of the downstream channel reach. The downstream slope used for calculating normal depth is 0.00087, derived from the longitudinal gradient of the channel in the downstream sections. A Manning's roughness coefficient of 0.060 has been applied uniformly across all cross-sections to reflect the dense vegetative cover observed along the watercourse. A summary of the baseline model is provided in **Table 4**.

Table 4 – Baseline Model

| Model Events | Model Plan | Model Geometry | Model Steady Flow | Remarks                                                                                                                         |
|--------------|------------|----------------|-------------------|---------------------------------------------------------------------------------------------------------------------------------|
| Baseline     | Plan01     | Whitehouse     | Catditch          | Baseline model with Roughness Coefficient N 0.060, Normal Depth as D/S boundary condition and range of design flows as inflows. |

### Sensitivity Tests

Sensitivity tests have been undertaken to assess the robustness and stability of the hydraulic model. These tests focused on key parameters, including the Manning's roughness coefficient and inflow discharge rates. The results of the Sensitivity Tests are included in **Appendix G**.

#### *Sensitivity Test for Roughness Coefficient*

A summary of the Sensitivity Test for Roughness Coefficient is provided in **Table 5**. A range of model outputs for the sensitivity test for Roughness Coefficient are provided in **Appendix G**. The model sensitivity test indicates that the predicted maximum water levels are not highly sensitive to slight variations in the roughness coefficient.

Table 5 – Sensitivity Test for Roughness Coefficient N

| Roughness Coefficient (N) | Model Plan | Model Geometry | Model Steady Flow | Remarks                  |
|---------------------------|------------|----------------|-------------------|--------------------------|
| N=0.060                   | Plan01     | Whitehouse     | Catditch          | Baseline model as above. |
| N=0.070                   | Plan02     | WhitehouseN070 | Catditch          | N=0.070 used.            |
| N=0.080                   | Plan03     | WhitehouseN080 | Catditch          | N=0.080 used.            |
| N=0.050                   | Plan04     | WhitehouseN050 | Catditch          | N=0.050 used.            |
| N=0.040                   | Plan05     | WhitehouseN040 | Catditch          | N=0.040 used.            |

#### *Sensitivity Test for Inflow Discharge Rates*

A summary of the Sensitivity Test for Inflow discharge (1/100 year plus CC) is provided in **Table 6**. A range of model outputs for the sensitivity test for the inflow discharges are provided in **Appendix G**. The sensitivity test indicated that the predicted maximum water levels are not highly sensitive to slight variations in the inflow discharge rates.

Table 6 – Sensitivity Test for Inflows (1/100 year plus CC)

| Inflows         | Model Plan | Model Geometry | Model Steady Flow | Remarks                  |
|-----------------|------------|----------------|-------------------|--------------------------|
| Q (1/100yr +CC) | Plan01     | Whitehouse     | Catditch          | Baseline model as above. |
| Q (+10%)        | Plan06     | Whitehouse     | Catditchplus10p   | 10% increase in flow.    |
| Q (+20%)        | Plan07     | Whitehouse     | Catditchplus20p   | 20% increase in flow.    |
| Q (- 10%)       | Plan08     | Whitehouse     | Catditchminus10p  | 10% reduction in flow.   |
| Q (- 20%)       | Plan09     | Whitehouse     | Catditchminus20p  | 20% reduction in flow.   |

### **Prediction of peak water levels for a range of events**

The hydraulic model (i.e. Baseline Model) has been used to simulate and predict peak water levels along the watercourse for a range of design flood events, including the 1 in 30-year, 1 in 100-year, and 1 in 100-year plus climate change scenarios. Summary of the predicted peak water levels for a range of events are provided in **Appendix H**.

### **Modelling of culvert blockage scenarios**

Two scenarios are modelled, one with 50% blockage and another 90% blockage of the culvert opening. The model outputs for the blockage scenarios are provided in **Appendix I**.

From the model results, the site is not subject to flooding from the extreme events when 50% and 90% blockage conditions are considered.

## **7.0 Assessment of Flood Risk to the Site**

The predicted peak water levels have been extracted at key cross-sections within the model domain, with particular focus on those in proximity to the proposed development site. These predictions provide valuable insights into the flood risk associated with various return periods and are used to inform the flood risk assessment, define potential flood extents, and support the development of appropriate mitigation measures.

The modelled water levels have been compared against the site levels for a range of events in **Table 8, 9 and 10**. The model cross-sections near the site are Sections 5 to 8 which have been used for this assessment.

Table 8 Comparison of modelled water levels against the Site Levels  
(1/30 year event) (See Appendix H)

| X-Sections | 1/30 year maximum water levels, mAOD | Site Levels mAOD | Max flood depth, m |
|------------|--------------------------------------|------------------|--------------------|
| 8          | 51.01                                | 52.37-52.60      | No flooding        |
| 7          | 50.85                                | 51.79-51.90      | No flooding        |
| 6          | 50.49                                | 51.73-52.69      | No flooding        |
| 5          | 50.19                                | 51.39-52.19      | No flooding        |

Table 9 Comparison of modelled water levels against the Site Levels  
(1/100 year event) (See Appendix H)

| X-Sections | 1/100 year maximum water levels, mAOD | Site Levels mAOD | Max flood depth, m |
|------------|---------------------------------------|------------------|--------------------|
| 8          | 51.12                                 | 52.37-52.60      | No flooding        |
| 7          | 50.96                                 | 51.79-51.90      | No flooding        |
| 6          | 50.61                                 | 51.73-52.69      | No flooding        |
| 5          | 50.32                                 | 51.39-52.19      | No flooding        |

Table 10 Comparison of modelled water levels against the Site Levels  
(1/100 year + Climate Change event) (See Appendix H)

| X-Sections | 1/100 year plus CC maximum water levels, mAOD | Site Levels mAOD | Max flood depth, m |
|------------|-----------------------------------------------|------------------|--------------------|
| 8          | 51.18                                         | 52.37-52.60      | No flooding        |
| 7          | 51.02                                         | 51.79-51.90      | No flooding        |
| 6          | 50.68                                         | 51.73-52.69      | No flooding        |
| 5          | 50.40                                         | 51.39-52.19      | No flooding        |

Table 11 Comparison of modelled water levels against the Site Levels  
(1/100 year + Climate Change event), 90% culvert blockage (See Appendix I)

| X-Sections | 1/100 year plus CC with<br>90% blockage maximum<br>water levels, mAOD | Site Levels<br>mAOD | Max flood<br>depth, m |
|------------|-----------------------------------------------------------------------|---------------------|-----------------------|
| 8          | 51.18                                                                 | 52.37-52.60         | No flooding           |
| 7          | 51.02                                                                 | 51.79-51.90         | No flooding           |
| 6          | 50.68                                                                 | 51.73-52.69         | No flooding           |
| 5          | 50.40                                                                 | 51.39-52.19         | No flooding           |

## 8.0 Conclusions

The hydraulic modelling assessment indicates that the site is not at risk of flooding during the 1 in 30 year, 1 in 100 year, and 1 in 100 year plus climate change flood events from the watercourse. Also, the site is not at risk of flooding during the 1 in 30 year, 1 in 100 year, and 1 in 100 year plus climate change flood events under the most critical scenario of culvert blockage scenarios.

Based on the model outputs, the site is considered suitable for the proposed residential development from a fluvial flood risk perspective.

From the assessment of the modelling output, it is concluded that the development will not give rise to backwater affects or divert water towards other properties.

This report demonstrates that the proposal will be safe, in terms of flood risk, for its design life and will not increase the flood risk elsewhere.

## **Appendix A Model Coverage Plan**

## **Appendix B Topographic and Channel Sectional Survey**

## **Appendix C Model Extents and Domain Details**

## **Appendix D Model Schematics in Hec Ras**

## **Appendix E Catchment Descriptors**

## **Appendix F Estimation of Flow Discharges**

## **Appendix G Sensitivity Tests**

## **Appendix H Predicted Peak Water Levels**

# **Appendix I Modelling of Culvert Blockage Scenarios**