BEACON FEN ENERGY PARK

Planning Inspectorate Reference: EN010151

Appendix 11.1 Flood Risk Assessment

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~~December 2025~~

January 2026

The Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 - Regulation 5(2)(a)

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 - Regulation 5(2)(e)

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| | | |

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# 1. INTRODUCTION

## 1.1 General

1.1.1 This Flood Risk Assessment has been prepared by SLR Consulting Ltd ('SLR') – formerly Wardell Armstrong – on behalf of Beacon Fen Energy Park Ltd (the 'Applicant') in support of an application for a Development Consent Order (DCO) for Beacon Fen Energy Park (the 'Proposed Development').

1.1.2 This Flood Risk Assessment (FRA) Report forms an Appendix to the Environmental Statement (ES) Chapter 11: Water Resources and Flood Risk (Document Ref: 6.2 ES Vol.1, 6.2.11) and covers the construction, operation and maintenance and decommissioning of a proposed renewable energy generating project, incorporating ground-mounted solar photovoltaic (PV) arrays and an onsite battery energy storage system (BESS), with associated infrastructure and cable connection to the existing Bicker Fen Substation.

1.1.3 The FRA has been prepared to accompany the ES that is to be submitted as part of the Development Consent Order (DCO) application for the Proposed Development.

1.1.4 The FRA has been carried out in accordance with guidance set out in the following:

- National Planning Policy Framework (NPPF), December 2024[1];
- National Planning Practice Guidance (NPPG): Flood Risk and Coastal Change, September 2025[2];
- Planning Practice Guidance (PPG): Water supply, wastewater and water quality, July 2019[3];
- Overarching National Policy Statement for Energy (EN-1), November 2023 (last updated January 2024)[4];
- National Policy Statement for Renewable Energy Infrastructure (EN-3), November 2023 (last updated January 2024)[5];
- Central Lincolnshire Local Plan 2018 to 2040, adopted in April 2023[6]:
  - Policy S21: Flood Risk and Water Resources;
  - Policy S56: Development on Land Affected by Contamination Development.
- South East Lincolnshire Local Plan 2011-2036, adopted March 2019[7]:
  - Policy 3: Design of New Development; and
  - Policy 4: Approach to Flood Risk.

[1] Available: National Planning Policy Framework Accessed December 2024
[2] Available: Flood risk and coastal change - GOV.UK Accessed December 2024
[3] Available: Water supply, wastewater and water quality - GOV.UK Accessed January 2025
[4] Available: EN-1 Overarching National Policy Statement for Energy Accessed January 2025
[5] Available: National Policy Statement for renewable energy infrastructure (EN-3) Accessed January 2025
[6] Available: Local Plan for adoption Approved by Committee.pdf Accessed January 2025
[7] Available: Local-Plan-text-March-2019.pdf Accessed January 2025

## 1.2 Report Structure

1.2.1 This FRA report is split into a number of sections. A summary of the content of each section of the report is provided in Table 1 below.

**Table 1: Summary of FRA Content**

| SECTION | SUMMARY OF SECTION CONTENT |
|---|---|
| Section 1 | Provides an introduction to the Flood Risk Assessment and outlines the methodology. Also provides a definition for each distinct area of the Proposed Development. |
| Section 2 | Discusses the national and local planning policies relevant to the assessment, and the Sequential and Exception Tests. |
| Section 3 | Details the site location and setting, hydrological setting and existing drainage and ground conditions. |
| Section 4 | Provides a description of the Proposed Development |
| Section 5 | Assesses the risk of flooding to the Site covering fluvial, pluvial, sewers, groundwater, and artificial sources. Flood risk to each area of the Proposed Development (as defined in Section 1) is discussed separately. The results of the flood modelling study are also summarised here. This section identifies if any flood risk mitigation measures will be required. |
| Section 6 | Assesses the post-development flood risk scenario (ie any impacts the Proposed Development may have on flood risk) including surface water runoff. This section identifies if any flood risk mitigation measures will be required. |
| Section 7 | Following the assessments in Section 6 and 7 where the need for flood risk mitigation measures is identified, this Section discusses the proposed Mitigation Measures and assesses the residual risk. |
| Section 8 | Provides an Outline Surface Water Drainage Strategy for the Proposed Development. This is a measure designed to mitigate the increased surface water runoff as a result of the Proposed Development, as identified in the assessment in Section 6. |
| Section 9 | Conclusions of the assessment. |

## 1.3 Methodology

1.3.1 The methodology for this FRA has comprised a desktop study and review of site information, and relevant local and national planning policy documents. The comments issued by the Environment Agency in their Section 42 response (see Appendix 3) have also been reviewed and accommodated within the assessment.

1.3.2 A hydraulic modelling study has also been undertaken to provide a robust assessment of the fluvial flood risk at the Site. This has involved the creation of a 1D-2D linked model and analysis for a range of return periods and scenarios, including appropriate climate change allowances. A Breach Assessment has also been undertaken as part of this study. The methodology for the modelling was agreed with the Environment Agency prior to the modelling being undertaken. Further details are provided in Appendix 1 of this report.

1.3.3 The Proposed Development will be located within the DCO Order Limits ('Order Limits') as shown on **Site Boundary Plan** (**Document Ref: 6.4.2 ES Figure 1.2**).

1.3.4 For the purposes of this FRA Report, six terminologies will be used (note: b and c are specific definitions used in the FRA):

a) **Proposed Development/the Site**: all areas of the development including the PV solar panels, substation, associated infrastructure, Bespoke Access Road and the route of the cable connection to the Bicker Fen Substation;

b) **Solar Array Area:** the main site area comprising the solar panels, substation and associated infrastructure (excluding the cable route);

c) **The BESS and Onsite Substation site:** the area within the Solar Array Area which houses the Battery Energy Storage Systems (BESS) area and the Onsite Substation.

d) **Cable Route Corridor:** the route of the cable connecting the Solar Array Area to the Bicker Fen Substation.

e) **Bespoke Access Road:** The physical development i.e. the road itself, to be located within the Bespoke Access Corridor.

f) **Bespoke Access Corridor:** The land within the Order Limits within which the Bespoke Access Road will be located.

g) **Bicker Fen Substation:** The National Grid Substation to which the Proposed Development will connect.

1.3.5 The exact route of the Bespoke Access Road is also yet to be finalised and will be confirmed as part of future works. Bespoke Access Corridor, therefore, refers to the redline boundary of the route.

1.3.6 Each of the above areas within the Site have been assessed individually in relation to existing flood risk (all sources) and post-development flood risk (ie impacts of the Proposed Development on flood risk). Where flood risk has been identified, mitigation measures are proposed and the residual risk assessed. For each source of flooding, the risk to the Site, and from the Proposed Development, as a whole, has also been assessed.

1.3.7 In undertaking the assessment, a 40 year operational lifetime for the Proposed Development has been used. Appropriate climate change allowances based on the latest Environment Agency guidance for a development with a 40 year lifespan have been accounted for in the assessments.

## Embedded Mitigation

1.3.8 The design of the Proposed Development has incorporated mitigation measures with respect to flood risk. The options chosen with respect to certain construction methods (e.g. trenchless cable installation) also provide mitigation against particular identified flood risks. Furthermore a sequential approach to the layout of the Proposed Development has been taken, whereby more vulnerable electrical infrastructure such as the BESS and Onsite Substation has been located in areas of the Site at a lower risk of flooding.

1.3.9 The Proposed Development incorporates raised solar panel tables supported on piles, access tracks at existing ground levels, raised electrical components such as transformer stations, and freeboard allowances on critical electrical infrastructure to reduce the risk of flooding to the development to ensure it can remain operational, and to avoid increasing flood risk off-site. These features are embedded into the design of the Site. These embedded mitigation measures are assessed within Sections 5 and 6 of the report and discussed alongside any additional mitigation measures such as floodplain compensation, in Section 7.

## 1.4 Information Sources

1.4.1 Reference has been made to plans and documents relevant to the site location, including:

- Lincolnshire County Council (2011) Preliminary Flood Risk Assessment[8];
- Lincolnshire County Council (2017) Preliminary Flood Risk Assessment Addendum[9];
- North Kesteven District Council (2009) Strategic Flood Risk Assessment ('SFRA')[10];
- Central Lincolnshire (2015) Level 1 Strategic Flood Risk Assessment[11]; and
- Central Lincolnshire (2015) Level 2 Strategic Flood Risk Assessment[12].

## 1.5 Data Sources

1.5.1 The following datasets have been utilised in undertaking the assessments herein:

- Environment Agency; Flood Map for Planning (Rivers and Sea).
- Environment Agency; Risk of Flooding from Surface Water datasets.
- Environment Agency; Reservoir Flood Extents dataset.
- Environment Agency; Spatial Flood Defences dataset
- Environment Agency; LIDAR Composite Digital Terrain Model (DTM) - 1m.
- British Geological Survey; GeoIndex (Onshore).
- Cranfield Soilscapes Viewer.
- Natural England; Magic Map.

[8]Available:https://www.lincolnshire.gov.uk/downloads/file/4382/preliminary-flood-risk-assessment-report Accessed: January 2025
[9]Available: PFRA_Lincolnshire_County_Council_2017.pdf Accessed January 2025
[10]Available: Adobe PDF - The Strategic Flood Risk Assessment Report 2009 Accessed: January 2025
[11]Available: Flood Risk Assessment Template Accessed January 2025
[12]Available: Flood Risk Assessment Template Accessed January 2025

# 2. FLOOD RISK AND PLANNING POLICY

## 2.1 National Planning Policy

2.1.1 The ~~2024~~2025 National Policy Statement ('NPS') for Energy (EN-1) sets out the national planning policy for Nationally Significant Infrastructure Projects (NSIPs), specifically energy infrastructure. Section 5.8 of NPS EN-1 sets the policy in relation to flood risk, with paragraph 5.8.13 outlining the need for an FRA. This FRA has been produced in accordance with paragraph 5.8.15 which lists the minimum requirements of the FRA and demonstrates that this Project is compliant with section 5.8 of NPS EN-1.

2.1.2 NPS EN-3 (~~2024~~2025) covers 'significant onshore renewable energy infrastructure projects' and the latest version of NPS EN-3 (~~2024~~2025) specifically addresses solar PV generation. NPS EN-3 refers to Section 5.8 EN-1 in relation to flood risk and provides specific policy for solar PV development. ~~Paragraphs~~Paragraph 2.10.~~84~~76 of NPS EN-3 (~~2024) refer~~2025) refers to the impact of drainage within solar developments.

2.1.3 The National Planning Practice Guidance ('NPPG') is referenced in the NPSs and has also been considered in preparing this FRA. The NPPG aims to ensure that flood risk is taken into consideration at all stages of the planning process and advocates the use of a risk-based 'Sequential Test' to preferentially locate development in areas with a low risk of flooding. Where development is necessary in high risk areas, the NPPG aims to ensure that the development is safe without increasing flood risk through the application of the Exception Test.

2.1.4 The NPPG defines the levels of flood risk within England as follows.

- Flood Zone 1 - Low Probability - Land having less than a 1 in 1,000 annual probability of river or sea flooding;
- Flood Zone 2 - Medium Probability - Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding;
- Flood Zone 3a - High Probability - Land having a 1 in 100 or greater annual probability of river flooding; or having a 1 in 200 or greater annual probability of sea flooding; and
- Flood Zone 3b - Functional Floodplain - Land where water has to flow or be stored in times of flood.

2.1.5 The NPPG states that a site-specific FRA should be provided for all energy projects located within Flood Zones 2 and 3, areas at risk of flooding from sources other than river/tidal sources and for any proposal of 1 hectare (ha) or greater regardless of its flood zone classification. This is as stated in paragraph 5.8.13 of NPS EN-1. The extent of Flood Zones 1, 2 and 3, as described above are shown on the Environment Agency's (EA) Flood Map for Planning, available online.

2.1.6 The EA Flood Map for Planning, however, does not differentiate between areas of Flood Zone 3a and 3b. The definition Flood Zone 3b is determined by individual Lead Local Flood Authorities and this definition is typically confirmed in the Strategic Flood Risk Assessment.

2.1.7 Table 2 of the NPPG classifies development types based on their vulnerability to flooding, ranging from 'Essential Infrastructure' that has to be operational in times of flood, through 'Highly Vulnerable' (e.g. emergency service stations), 'More Vulnerable' (e.g. residential dwellings and establishments), 'Less Vulnerable' (e.g. offices/retail), to 'Water Compatible' development (e.g. open space, docks, marinas, and wharves).

2.1.8 Based on Table 2 of the NPPG, the Proposed Development is classified as Essential Infrastructure, defined as "essential utility infrastructure which has to be located in a flood risk area for operational reasons, including electricity generating power stations and grid and primary substations; and water treatment works that need to remain operational in times of flood". Table 3 of the NPPG indicates which vulnerability classes are acceptable in each of the Flood Zones, and when the Exception Test should be applied. This is reproduced as Table 2 below.

**Table 2. Flood Risk Vulnerability and Flood Zone Capacity**

| FLOOD ZONE | ESSENTIAL INFRASTRUCTURE | HIGHLY VULNERABLE | MORE VULNERABLE | LESS VULNERABLE | WATER COMPATIBLE |
|---|---|---|---|---|---|
| 1 | ✓ | ✓ | ✓ | ✓ | ✓ |
| 2 | ✓ | Exception Test | ✓ | ✓ | ✓ |
| 3a | Exception Test | × | Exception Test | ✓ | ✓ |
| 3b | Exception Test | × | × | × | ✓ |

2.1.9 This FRA has been produced in compliance with the NPS EN-1, NPS EN-3, the NPPG and confirms that the Sequential and Exception Tests are passed.

## 2.2 Application of the Sequential and Exception Test

2.2.1 As stated in Paragraph 5.8.21 of the NPS EN-1, the Sequential Test aims to steer developments to areas with the lowest risk of flooding (i.e. Flood Zone 1), wherever possible.

2.2.2 The Site is shown on the Environment Agency (EA) Flood Map for Planning[13] to extend across a number of Flood Zones (see Drawing No. ST19595-441 'Flood Map for Planning (Sheets 1-4)'). The eastern and central areas of the Solar Array Area lie within Flood Zone 3, including the area adjacent to Hodge Dike. The proposed BESS and Onsite Substation will, however, be located almost wholly within Flood Zone 1, based on the Flood Map for Planning.

2.2.3 The boundary of the Cable Route Corridor also extends through areas of Flood Zone 3 (see Drawing No. ST19595-441).The majority of the works in this area are underground, with exceptions being the temporary construction compounds and the extension works to the Bicker Fen Substation which would be above ground.

[13]Available: https://flood-map-for-planning.service.gov.uk/ Accessed October 2025

2.2.4 The Bespoke Access Corridor is located in Flood Zone 1 (see Drawing No. ST19595-441) and would provide access to the Solar Array Area from the A17 for construction, operation and decommissioning. **Appendix 3.2: Bespoke Access Road Appraisal (Document Ref: 6.3 ES Vol.2, 6.3.10**) references other route options considered for this component of the development, some of which were located partly in areas of flood risk.

2.2.5 The Proposed Development will connect to the Bicker Fen Substation, which is located within Flood Zone 3 (as shown on Drawing No. ST19595-441). The Cable Route will also cross through areas of Flood Zone 3 to connect to Bicker Fen substation. The Proposed Development could, therefore, not be wholly located within Flood Zone 1.

2.2.6 The location of the Solar Array Area was selected as part of a staged process undertaken by the Applicant to identify potential development sites within 10km of the Bicker Fen Substation which would be suitable for a solar development of 400-600 MW generation capacity (see **Chapter 3: Alternatives and Design Evolution (Document Ref: 6.2 ES Vol.1, 6.2.3**)). Flood risk was taken into consideration in the site selection process and the Sequential Test applied, as detailed in the Site Selection Report **(Appendix 2 of Document 5.5 Planning Statement),** an updated version of which is submitted into examination in December 2025**.**

2.2.7 A sequential approach has also been taken when designing the layout of the Site, with the most vulnerable infrastructure located in parts of the site at a lower risk of flooding. Owing to the size (i.e. 529ha) of the Solar Array Area, it would not be feasible to locate all panels and infrastructure solely within areas of Flood Zone 1 and 2.

2.2.8 Section 5 of this FRA confirms that no parts of the development will be impacted by flooding from any source that would render it inoperable. It is considered, therefore, that the Sequential Test has been passed.

2.2.9 The Exception Test, detailed in paragraph 5.8.10 of NPS EN-1, should be applied only after the Sequential Test has been applied and when Essential Infrastructure cannot be located within Flood Zone 1 or 2.

2.2.10 To pass the Exception Test, it should be demonstrated that the development:

- Would provide wider sustainability benefits to the community that outweigh the flood risk; and
- 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.

2.2.11 It is considered that the nature of the Proposed Development, which will provide a source of renewable energy to the National Grid and contribute to the meeting the UK's urgent need for new low-carbon electricity infrastructure as established in NPS EN-1, would outweigh the flood risk. Further detail on the overall need and benefits for the Proposed Development is provided in **Chapter 3: Alternatives and Design Evolution (Document Ref. 6.2 ES Vol.1, 6.2.3)** as well as the Planning Statement (**Document Ref. 5.5**).

2.2.12 The Proposed Development will be located outside of the defended 1 in 100 year plus climate change flood extent, or alternatively, appropriate mitigation measures will be provided for this design event, ensuring that the Proposed Development will remain safe and operational at all times. Further detail is provided within Section 6.2 and 7.2.

2.2.13 Where there is built development or associated ground level raising within areas at risk of flooding in the defended 1 in 100 year plus climate change design event, compensatory floodplain storage will be provided to ensure that there is no net loss of floodplain storage as a result of the Proposed Development. This is secured through requirement 5 of the **Draft DCO (Document Ref: 3.1)** which secures that no part of the Proposed Development may commence until details of (among other things) the proposed finished ground levels have been submitted to and approved in writing by the relevant planning authority. The details submitted must accord with the **Works Plan (AS-006)** and the outline design principles (contained in Appendix 1 of the **Design and Access Approach Document (AS-019)**).

2.2.14 Safe access and egress routes will be incorporated into the layout of the site. The primary access to the Solar Array Area is at the western boundary, via the Bespoke Access Road or local roads. Secondary access is via the southern boundary off Howell Fen Drove.

2.2.15 Fluvial flooding in this area is due primarily to the overtopping of small watercourses at field boundaries rather than a single larger river. Due to the extensive land drainage network, areas of land within the extent of the defended 1 in 100 year event are widespread, and it is not possible to have an access and egress route located solely outside of these areas.

2.2.16 Flood depth modelling data shows that whilst local roads are within the extent of the defended 1 in 100 year event, any flooding would be safely passable by vehicle and on foot at all times. Further detail is provided within Section 7.6.

2.2.17 Surface water runoff generated within the development will be managed sustainably within the Site, and necessary fluvial floodplain compensation will be provided to ensure that the risk of flooding elsewhere is not increased as a result of the Proposed Development. It is considered, therefore, that the Exception Test has been passed.

# 3. SITE SETTING AND BASELINE

## 3.1 Site Description and Location

3.1.1 A summary of the Site and its characteristics is provided in Table 3 below.

**Table 3. Site Location Summary**

| | |
|---|---|
| **SITE NAME** | Beacon Fen Energy Park |
| **SITE ADDRESS** | Ewerby Thorpe, near Sleaford, Lincolnshire |
| **SOLAR ARRAY AREA** | Circa 529 ha (excluding Cable Route Corridor and Bespoke Access Corridor) |
| **NATIONAL GRID REFERENCE** | TF 14921 48576 (centred upon the Solar Array Area) |
| **EXISTING LAND USE** | Agricultural |
| **PROPOSED LAND USE** | Energy Park |
| **LOCAL PLANNING AUTHORITIES** | Solar Array Area and Bespoke Access Corridor: North Kesteven District Council and Lincolnshire County Council<br>Cable Route Corridor: North Kesteven District Council, Lincolnshire County Council and Boston Borough Council |

3.1.2 The Solar Array Area is situated to the north of Heckington, between the small villages of Howell, Ewerby Thorpe and South Kyme as shown on **Figure 1.2 Site Boundary Plan** (**Document Ref: 6.4 ES Vol.3, 6.4.2**), covering a total area of approximately 529 ha. The approximate National Grid Reference for the centre of the Solar Array Area is TF 14921 48576, and the nearest postcode is LN4 4AA. The proposed Cable Route Corridor will connect to the Bicker Fen Substation extension at Bicker Fen, close to the village of Bicker, approximately 9.5km to the south-east of the substation.

3.1.3 The Solar Array Area is irregular in shape and comprises agricultural land and areas of woodland. The Solar Array Area is surrounded by further agricultural land, with dwellings and farm buildings adjacent to the northern, southern and western boundaries.

3.1.4 Black Drove (named Howell Lane to the south of Ewerby Thorpe) extends along the western and northern boundaries of the Site before diverting southwards into the Solar Array Area to one of the dwellings along the northern boundary (Gashes Barn). Howell Fen Drove extends along the majority of the southern boundary of the Solar Array Area to join Howell Lane. No highways run adjacent to the eastern boundary.

3.1.5 The proposed Cable Route Corridor extends southwards from the Solar Array Area, through agricultural land, diverting around nearby settlements and dwellings. The redline boundary for the Cable Route Corridor is c. 50-100m wide and irregular in shape, comprising a total area of 183ha.

3.1.6 A Bespoke Access Road will also be constructed as part of the Proposed Development. The road will extend from the western boundary of the Solar Array Area to Sleaford Road (A17), approximately 3km to the south-west, comprising a total area of 45ha. The 'corridor' of the Bespoke Access Corridor is approximately 0.3km wide at its widest point. Following removal of the Bespoke Access Road, the land will be restored to agricultural use.

3.1.7 A Change Request was accepted by the Examining Authority into examination in a procedural decision dated 19 December 2025 (PD-015). This relates to a new design of the proposed extension to the Bicker Fen substation. This includes the construction of a new overhead line (OHL) tower of up to 56.2 metres (m) in height, and new 400kV cabling and associated works, which henceforth form part of the Application.

## 3.2 Existing Watercourses, Waterbodies and Flood Defences

3.2.1 The locations of the existing watercourses in the vicinity of the Site are shown on Drawing No. ST19595-198, ST19595-199 and ST19595-200 'Watercourse Network (Sheets 1 to 3)'. See Section 11.5 of **Chapter 11: Water Resources and Flood Risk** (**Document Ref: 6.2 ES Vol.1, 6.2.11**) for further details of existing watercourses and waterbodies.

### Solar Array area

3.2.2 The Hodge Dike Main River flows north-eastwards through the southern half of the Solar Array Area, towards the eastern boundary. The Car Dyke Ordinary Watercourse (referred to as the Midfodder Dyke further upstream) forms the eastern Solar Array Area boundary, flowing south-eastwards. The Hodge Dike joins Car Dyke at the eastern boundary of the Solar Array Area.

3.2.3 Car Dyke joins Heckington Eau, a Main River located approximately 1.4km to the south-east of the Solar Array Area. Heckington Eau continues to flow south-eastwards to join the South Forty Foot Drain, approximately 7km to the south-east of the Site.

3.2.4 The Solar Array Area is located within the Black Sluice Internal Drainage Board (IDB) region.

3.2.5 The IDB's Ewerby Fen Pumping Station is located adjacent to the eastern boundary of the Solar Array Area, which controls the flows within the Midfodder Dike and by extension the downstream section of the Hodge Dike.

3.2.6 The River Slea (sometimes referred to as Kyme Eau), also a Main River, is located adjacent to the north-eastern corner of the Solar Array Area, along the eastern boundary. This watercourse flows north-eastwards away from the Site.

3.2.7 The Solar Array Area is also crossed by a number of Ordinary Watercourses, with land drains present along the majority of field boundaries. This is a typical characteristic of the area.

3.2.8 The Ordinary Watercourses are aligned either north-eastwards flowing towards Car Dyke, or south-eastwards flowing towards Hodge Dike. The most significant of these watercourses are the Catchwater Drain, which flows south-eastwards through the centre of Solar Array Area to Hodge Dike, and the Twelve Drain, which flows north-eastwards in the northern corner of the Solar Array Area.

3.2.9 A small reservoir is situated in the southern central section of the Solar Array Area, adjacent to the Hodge Dike. There are also several small ponds located to the east of the reservoir, south of the Hodge Dyke.

## Cable Route Corridor

3.2.10 The boundary for the Cable Route Corridor crosses the Heckington Eau and Old Sixteen Foot Drain, both of which are Main Rivers. A number of unnamed Ordinary Watercourses are also crossed by the proposed Cable Route Corridor. These generally form parts of wider land drainage networks which flow south-eastwards to the Old Sixteen Foot Drain.

3.2.11 The Cable Route Corridor is also located within the Black Sluice Internal Drainage Board (IDB) region.

## Bespoke Access Corridor

3.2.12 The proposed Bespoke Access Corridor crosses several unnamed Ordinary Watercourses. These are generally situated at field boundaries and aligned north-eastwards.

3.2.13 A second reservoir is located 1.2km south-west of the southern boundary of the Bespoke Access Corridor.

3.2.14 The Bespoke Access Corridor is located within the Black Sluice IDB region.

## Bicker Fen Substation

3.2.15 The Bicker Fen Substation site is bounded on all sides by unnamed Ordinary Watercourses. These are part of a wider network of land drains which surround all fields in the vicinity of the substation. It is considered that these ~~ultimately~~land drains currently discharge to Hammond Beck, located approximately 0.3km to the south-east of the substation.

3.2.16 Small drainage channels cross the substation site, aligned generally north-west to south-east. These drainage channels ultimately discharge into Hammond Beck.

## Flood Defences

3.2.17 The Environment Agency's 'Spatial Flood Defences' dataset (as included in Drawing No. ST19595-441 'Flood Map for Planning (Sheets 1-4)') provides information regarding fluvial flood defences, including location, design standard of protection and condition. The defences in the vicinity of the Site consist of earth embankments. According to the EA, these defences are in a 'fair' to 'good' condition.

3.2.18 The earth embankment along Hodge Dike (within the Site boundary) has a design standard of protection of up to 1 in 75 years on the northern embankment and 1 in 25 years on the southern embankment.

3.2.19 An existing ramp is present on the southern side of the Hodge Dike flood defence within the Solar Array Area. It is understood that this ramp provides access for the Environment Agency Asset Management team to undertake inspections of the flood defence asset. This ramp, and access to it will be retained as part of the Proposed Development.

3.2.20 The earth embankment along the River Slea to the north of the Site has a design standard of protection of up to 1 in 1000 years with an effective crest height of 5.23mAOD.

3.2.21 The earth embankment along Midfodder Dyke to the south-east of the Site has a design standard of protection of up to 1 in 200 years on the eastern bank and 1 in 50 years on the western bank.

3.2.22 The earth embankment along Heckington Eau to the south of the Site has a design standard of protection of up to 1 in 200 years on the northern bank and 1 in 50 years on the southern bank. Howell Fen Drove to the south of the Site, Heckington Road to the west and Halfpenny Toll Lane to the north of the Site are raised approximately 1m above the ground level relative to the adjacent fields and these can also be assumed to provide a degree of protection to the Site.

## 3.3 Existing Drainage

### Solar Array Area

3.3.1 Liaison with Anglian Water confirmed that there are no public sewers within the Solar Array Area. Owing to the rural, agricultural setting of the Site, it is assumed that there are no private sewer networks within the Solar Array Area.

3.3.2 As shown on Drawing No. ST19595-138 ‘Existing Drainage’, the fields are underlain by land drains installed at regular spacing. Records show that these are typically 1m deep, 80mm in diameter and filled with porous material. The land drains discharge directly to the watercourses at field boundaries or form part of a wider network of land drains.

3.3.3 It is assumed that surface water runoff disperses naturally either via evaporation, infiltration into the field drainage network or draining via overland flow following the Site topography.

### Cable Route Corridor

3.3.4 It is also assumed that similar underground land drainage will be present in some areas of agricultural land crossed by the Cable Route Corridor. Liaison with Anglian Water confirmed that there are no public sewers within the vicinity of the Cable Route Corridor.

3.3.5 The Cable Route Corridor will also pass beneath a number of roads and close to dwellings. Private sewers or highway drainage may, therefore, be present in these areas.

### Bespoke Access Corridor

3.3.6 The Bespoke Access Corridor is also likely to have similar underlying land drainage that discharges to the adjacent Ordinary Watercourses. Liaison with Anglian Water confirmed that there are no public sewers within the vicinity of the Bespoke Access Corridor. The route crosses Heckington Road and Asgarby Road where highway drainage may be present.

3.3.7 The route does not pass close to dwellings, and it is unlikely, therefore, that any private sewers will be present in the vicinity of the Bespoke Access Road.

### Bicker Fen Substation

3.3.8 The Bicker Fen Substation site has a formal surface water drainage network which includes a c.2,000m$^2$ attenuation pond located to the south of the substation. It is understood that surface water is discharged from this attenuation pond into a nearby watercourse or drainage channel, the locations of which are described above.

## 3.4 Ground Conditions

### Solar Array Area

3.4.1 The online British Geological Survey (BGS) GeoIndex Onshore viewer (see **Figure 11.4 Bedrock Geology (Document Ref: 6.4 ES Vol.3, 6.4.65**) indicates that the majority of the Solar Array Area is underlain by mudstone of the Oxford Clay Formation. Land in the far east of the Solar Array Area is underlain by mudstone and siltstone of the West Walton Formation. Both types of bedrock are classified as a 'unproductive' aquifers defined as 'rock layers or drift deposits with a low permeability that have negligible significance for water supply or river base flow.' The Lincolnshire Limestone Formation, a Principal Aquifer, is present at depths of around 100 m beneath the Site.

3.4.2 The Solar Array Area is wholly underlain by superficial deposits, (see **Figure 11.3 Superficial Geology (Document Ref: 6.4 ES Vol.3, 6.4.64)** with tidal flat clay and silt deposits in northern and eastern areas and mid-Pleistocene till deposits in southern and western areas. A narrow section of clay, silt and sand alluvium deposits is present in central areas of the Solar Array Area, aligned along the route of the Hodge Dike, with a narrow section of 'ice contact' sand and gravel deposits in the south-western corner of the Solar Array Area.

3.4.3 The tidal deposits are classified as an unproductive aquifer. The alluvium, and sand and gravel deposits are classified as Secondary A aquifers (permeable layers capable of supporting water supplies at a local rather than strategic scale). The till deposits are classified as an undifferentiated Secondary aquifer (cases where it has not been possible to attribute either category A or B to a rock type due to the variable characteristics of the rock).

3.4.4 The Solar Array Area is not located with a groundwater Source Protection Zone (SPZ).

3.4.5 The Cranfield Soilscapes map records the soils at the Solar Array Area as 'loamy and clayey soils of coastal flats with naturally high groundwater' within the eastern portion of the Solar Array Area, 'slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils' within the west and 'freely draining lime-rich loamy soils' central to the Solar Array Area.

3.4.6 Further details on the soils at the site are contained in Chapter 14: Soils and Agricultural Land (Document Ref: 6.2 ES Vol.1, 6.2.14).

### Cable Route Corridor

3.4.7 Approximately 2.5km of the Cable Route Corridor, located immediately to the south of the Solar Array Area, extends through the West Walton Formation. The remainder of the route extends through the Oxford Clay formation.

3.4.8 The northern section of the Cable Route Corridor extends through superficial till deposits with smaller areas of sand and gravel deposits (Secondary B and undifferentiated Secondary aquifers). The southern section extends through clay and silt tidal flat deposits (unproductive aquifers).

3.4.9 The Cable Route Corridor does not cross through any groundwater Source Protection Zones.

3.4.10 The Soilscapes viewer shows that the northern most 2.2km of the Cable Route Corridor crosses areas of 'Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils', 'Freely draining lime-rich loamy soils' and 'Loamy and clayey soils of coastal flats with naturally high groundwater'. The next 4km of the route then extends back to the area of slowly permeable loamy clayey soils, with the remaining 4.5km of the route extending back into the area of coastal flats soil.

### Bespoke Access Corridor

3.4.11 The full Bespoke Access Corridor is underlain by the Oxford Clay Formation.

3.4.12 Superficial deposits are present along the majority of the corridor, with northern sections underlain by superficial till deposits (Secondary Undifferentiated aquifer) and southern sections of the corridor underlain by areas of sand and gravel deposits (Secondary B aquifer).

3.4.13 The Soilscapes viewer shows that the majority of the Bespoke Access Corridor crosses slowly permeable loamy and clayey soils. The southern extent of the route, adjacent to the A17, crosses freely draining loamy soils.

### Bicker Fen Substation

3.4.14 The bedrock geology underlying the Bicker Fen Substation is the Oxford Clay Formation, and superficial deposits of clay and silt tidal flat deposits (unproductive aquifers) are also present.

3.4.15 The Soilscapes viewer indicates that the Bicker Fen Substation is underlain by 'clayey soils of coastal flats with naturally high groundwater'.

# 4. DEVELOPMENT PROPOSALS

## 4.1 Description of the Proposed Development

4.1.1 The Proposed Development would comprise of above ground solar PV and BESS infrastructure, connected by the Cable Route Corridor to Bicker Fen Substation situated to the west of the village of Bicker (with further detail provided in **Chapter 2: Proposed Development (Document Ref: 6.2 ES Vol.1, 6.2.2)**. The Proposed Development includes the following key infrastructure:

- Solar Arrays;
- Power Conversion Units;
- Inverters;
- Transformers;
- Battery Energy Storage System (BESS);
- Onsite Substation;
- Onsite Cabling;
- Fencing;
- Water supply and drainage infrastructure;
- Cable Route; and
- Bespoke Access Road.

4.1.2 The PV arrays are fixed panels mounted on metal frames (i.e. tables), with a maximum height of 3.9m above ground level. Panels will have a maximum dimension of 2.5m long and 1.5m wide. These will be supported by galvanised steel poles, driven approximately 1.0 to 2.5m into the ground.

4.1.3 The supporting infrastructure consists of inverters, transformers and high-voltage switchgear and control equipment.

4.1.4 Access tracks will be constructed around the Solar Array Area, generally adjacent to field boundaries to provide access for maintenance and operational purposes. Transformers will be constructed adjacent to the access tracks.

4.1.5 Access tracks located adjacent to drainage ditches will incorporate the necessary ecological; Environment Agency (EA) and/or Internal Drainage Board (IDB) buffers where required. A buffer width of 9m measured from the top of the watercourse banks has been provided. Furthermore, a 9m buffer strip has been provided adjacent to formal flood defences along Main Rivers such as the Hodge Dike. This has been measured from the toe of the flood defence embankment. The buffer strips will be unfenced, allowing access for maintenance.

4.1.6 There are a total of 79 temporary and permanent, vehicular and pedestrian watercourse crossings and cable crossings proposed, these are detailed in **Appendix 11.3 Summary of Watercourse Crossings and Photographs (Document Ref: 6.3 ES Vol.2, 6.3.83)** and are identified on **Figure 11.6 Watercourse Crossings (Document Ref: 6.4 EA Vol.3, 6.4.67)**, which provides an indication of the type of crossing.

4.1.7 The majority of these crossings are over/under Ordinary Watercourses, with only three crossings affecting Main Rivers. The three Main River crossings comprise trenchless techniques (including Horizontal Directional Drilling) to install the Cable Route. These crossings will be under Hodge Dike, Heckington Eau and the South Forty Foot Drain. There are no permanent or temporary bridge crossings or culverts affecting Main Rivers.

4.1.8 All other crossings, including culverts, vehicular and pedestrian bridges, and cable crossings will affect Ordinary Watercourses only, as summarised in Table 4 below.

**Table 4. Summary of Watercourse Crossings**

| TYPE OF CROSSING | MAIN RIVER | ORDINARY WATERCOURSE |
|---|---|---|
| Cable – HDD | 3 | 0 |
| Cable – trenched or trenchless | 0 | 32 |
| Bridge – Vehicular (new) | 0 | 2 |
| Bridge – Pedestrian (new) | 0 | 8 |
| Culvert (new) | 0 | 28 |
| Culvert (upgrade) | 0 | 6 |

4.1.9 The Proposed Development will also include an associated BESS within a larger compound area close to the centre of the Solar Array Area. Batteries will be placed within individual enclosures arranged regularly within the compound area with vehicular access available to each unit. The compound will also include the Onsite Substation area containing a 33 kV switchroom and a control building to include office space and welfare facilities.

4.1.10 An indicative layout of the proposed Solar Array Area is shown on Illustrative Layout Plan of BESS and On-Site Substation (Document Ref: 2.6).

4.1.11 The Cable Route Corridor will extend south-eastwards from the Onsite Substation to the Bicker Fen substation as shown on **Works Plan (Document Ref: 2.4)**. The cable will be situated below ground, primarily using trenched methods within infilled trenches measuring approximately 2m (width) by 2.5m (depth). Where the cable crosses beneath Main Rivers (Hodge Dike, Heckington Eau and South Forty Foot Drain), the cable will be installed using trenchless methods such as Horizontal Directional Drilling (HDD). Such crossings will be at sufficient depth to avoid interaction with any flood defence foundations, the locations and depths of which will be determined via intrusive investigations (eg trial pits) at the detailed design stage. For simplicity in the FRA, the term HDD is used interchangeably with the term 'trenchless methods.'

4.1.12 Where the cable crosses beneath Ordinary Watercourses it is proposed to use either traditional trenched methods including open cut trenching (with water within the channel either temporarily dammed and pumped or the channel temporarily diverted) or trenchless methods. The works are referred to in the **Draft DCO (Document Ref: 3.1)** as Work No. 4A ('works in connection with electrical cabling')

4.1.13 As part of the Proposed Development, the existing Bicker Fen Substation will be extended. The works are referred to in the **Draft DCO (Document Ref: 3.1)** as Work No. 5 and are depicted on the **Works Plan (AS-006)**. A summary is provided below.

1) Work No. 5A: the creation of a new generation bay and associated works to the south of the existing substation;
2) Work No. 5B: Extension to the existing substation,
3) Work No. 5C: Cabling works in connection with the extension of the existing substation including overhead line tower and cabling;
4) Work No. 5D: Temporary laydown area to the north of the existing substation;
5) Work No. 5E: Further works in connection with the extension to the existing substation including landscaping and biodiversity mitigation and enhancement measures including planting, and laying and construction of drainage infrastructure.

4.1.14 During the construction phase, six temporary construction compounds will be situated along the Cable Route Corridor. These will contain site offices, containerised storage areas, bunded fuel storage and areas of parking. The works are referred to in the **Draft DCO (Document Ref: 3.1)** as Work No. 4B ('construction compounds in connection with Work No. 4A').

4.1.15 A Bespoke Access Road will be constructed to provide access to the Solar Array Area via the A17 located to the south-west for the duration of the construction, operation and decommissioning of the Solar Array Area.

4.1.16 It is important to note that the majority of the works associated with the extension of Bicker Fen Substation have already been consented in the **Heckington Fen Solar Park Order 2025**. The only difference between the Proposed Development and the approved works relates to an additional circa 0.3 hectares of land to be developed to accommodate the generation bay required to connect the Proposed Development into the Bicker Fen Substation and the impacts are considered to be broadly the same.

# 5. FLOOD RISK ASSESSMENT

## 5.1 Flood Risk to the Development

5.1.1 The main sources of flooding identified within the NPPF are rivers, tidal waters and the sea, surface water, groundwater, sewers and drains, and artificial sources (e.g. canals and reservoirs). The presence of a potential flooding source does not necessarily translate into a high risk of flooding. Table 5 below summarises the potential flood sources and the related flood risk posed to the Site.

**Table 5. Summary of flood risk to the Development from different Flood Sources**

| FLOOD SOURCE | AREA | PRESENCE WITHIN THE AREA | POTENTIAL RISK IN THE AREA | DESCRIPTION |
|---|---|---|---|---|
| Rivers (fluvial) flooding | Solar Array Area | Y | Low to High | Western areas of the Solar Array Area are within Flood Zone 1. Eastern areas within Flood Zones 2 and 3.<br><br>The modelled defended 1 in 100 year flood extent is generally constrained to watercourses and adjacent low-lying ground. |
| | Cable Route Corridor | Y | High (cable route – construction phase)<br><br>Very Low (cable route – operational phase)<br><br>Low to High (construction compounds)<br><br>High (Bicker Fen substation) | Large sections of the Cable Route Corridor are located within Flood Zones 2 and 3, including three temporary construction compounds. Sections in the northern part of the Cable Route Corridor are located within Food Zone 1.<br><br>The modelled defended 1 in 100 year flood extent in northern sections is smaller and generally constrained to watercourses and adjacent low-lying ground. The southern sections of the cable route are outside the extent of the fluvial flood model.<br><br>Cable will be installed underground and would only be impacted by flooding during construction. |
| | Bespoke Access Corridor | Y | Low to High | The route is shown to be located wholly within Flood Zone 1, however, eastern and western sections of the route are located within the modelled defended 1 in 100 year flood extent. |
| | Bicker Fen Substation | Y | High | The Bicker Fen Substation is located entirely within Fluvial Flood Zone 3. |

| | | | | |
|---|---|---|---|---|
| | | | | Flood defences along the South Forty Foot Drain reduce the risk of flooding, however, the Bicker Fen Substation is still located within the 1 in 100 year defended flood extent.<br><br>The Bicker Fen Substation is outside of the extent of the fluvial flood model. |
| Tidal | Solar Array Area | N | N/A | The EA has agreed that the Solar Array Area is not located within an area at risk of tidal flooding. |
| | Cable Route Corridor | N | N/A | The EA has agreed that the Cable Route Corridor is not located within an area at risk of tidal flooding. |
| | Bespoke Access Corridor | N | N/A | The EA has agreed that the Access Road Corridor is not located within an area at risk of tidal flooding. |
| | Bicker Fen Substation | N | N/A | The EA has confirmed that the Bicker Fen Substation is not located within an area at risk of tidal flooding. |
| Surface Water (Pluvial) Flooding | Solar Array Area | Y | Very Low to High | Risk Very Low or Low for majority of the area and Medium to High risk adjacent to Hodge Dike. |
| | Cable Route Corridor | Y | Very Low | Cable route crosses overland flow routes. Cable will be installed underground and would only be impacted by flooding during construction.<br><br>One construction compound at a High Risk. Isolated areas within existing Bicker Fen substation at increased risk. |
| | Bespoke Access Corridor | Y | Very Low to High | Majority of the route at Very Low risk and areas of Medium/High risk at southern end of route. |
| | Bicker Fen Substation | Y | Low | There are areas considered at Low to High risk of surface water ponding associated with isolated topographical depressions There are no surface water flow routes travelling through the site. Depths are generally below 0.2m, with some small areas reaching depths of up to 0.9m. |
| Groundwater | Solar Array Area | Y | Medium | Areas of the Solar Array Area potentially vulnerable to groundwater flooding. |
| | Cable Route Corridor | Y | Low to High | Sections of the route are potentially vulnerable to flooding. during the operational phase, the risk of flooding is Low. During the construction phase there is a Medium to High risk of |

| | | | | |
|---|---|---|---|---|
| | | | | groundwater emergence to the construction compounds and cable trenches. |
| | Bespoke Access Corridor | Y | Medium | Areas of the route potentially vulnerable to flooding.<br><br>During the construction phase, the construction compounds may be impacted by groundwater emerging above ground level. |
| | Bicker Fen Substation | Y | Low | The Bicker Fen Substation is situated on land with minimal susceptibility to groundwater flooding. |
| Sewer | Solar Array Area | N | N/A | No sewers within area. |
| | Cable Route Corridor | Y | Very Low | Potentially crosses/runs close to sewers. Cable will be installed underground and would only be impacted by sewer flooding during construction.<br>Above ground sewer flooding would not impact on construction compounds.<br>Any public/private sewer networks within Bicker Fen substation assumed to be sufficient capacity with minimal risk of flooding. |
| | Bespoke Access Corridor | Y | Low | Access track extends to highways where sewers may be present. Limited pathways for any flooding to affect track due to the surrounding topography. |
| | Bicker Fen Substation | Y | Very Low | Any private sewers within the Bicker Fen Substation will be suitably sized and not prone to flooding in order to ensure the site can remain operational at all times. |
| Artificial (Reservoirs) | Solar Array Area | Y | Very Low | Eastern and northern areas at risk of reservoir flooding only when flooding from rivers is also occurring. This scenario is considered unlikely. Majority of area at no risk. |
| | Cable Route Corridor | Y | Very Low | Areas at risk of flooding from reservoirs at all times. Assumed reservoirs are maintained in accordance with Reservoirs Act 1975 and risk of failure is minimal. Cable will be installed underground and would only be impacted by flooding during construction. |
| | Bespoke Access Corridor | Y | Very Low | Small area at southern end of route at risk of reservoir flooding when river levels are normal. |

| | | | |
|---|---|---|---|
| Bicker Fen Substation | Y | Low | The entire area of the Bicker Fen Substation is shown to be at risk of reservoir flooding when there is also a risk of fluvial flooding. |

## 5.2 Historical Flooding Incidents

5.2.1 Historical flood mapping in the 2009 North Kesteven Strategic Flood Risk Assessment (SFRA)[10] does not show any flooding incidents in the vicinity of the Solar Array Area, the closest area shown to be affected being land to the west of Sleaford in 1977. The Cable Route Corridor and the Bespoke Access Corridor also do not extend through any areas affected by historical flooding incidents.

5.2.2 The Lincolnshire Preliminary Flood Risk Assessment (PFRA)[9] does not refer to any historical flooding incidents in the vicinity of the Solar Array Area, Cable Route Corridor or the Bespoke Access Corridor.

5.2.3 The LCC database (Section 19 Flood Investigations)[14] shows that there are no ongoing or completed investigations within the Solar Array Area, Cable Route Corridor or the Bespoke Access Corridor. The closest ongoing or completed investigation was within the village of South Kyme completed in 2019, located approximately 2.1km to the north-east of the Site. It was concluded that the incident was the result of rainfall entering the foul public sewer causing surcharging and flooding.

5.2.4 The EA state in their correspondence that they have no record of any historical flood events within the Solar Array Area (see Appendix 1).

## 5.3 Fluvial Flooding

### Solar Array Area – Present Day and Future Climate Change Scenario

5.3.1 The EA Flood Map for Planning for the present day scenario, as shown on Drawing No. ST19595-441 'Flood Map for Planning (Sheets 1-4)', indicates that western areas of the Solar Array Area are located in fluvial Flood Zone 1, with an annual probability of flooding of less than 1 in 1,000 (<0.1%). Eastern areas of the Solar Array Area are located within Flood Zone 3 with an annual probability of flooding of greater than 1 in 100 (>1%). Small areas in the south-west of the site are shown to be within Flood Zone 2, with an annual probability of flooding of between 1 in 100 and 1 in 1000 (0.1% – 1%).

5.3.2 The Flood Map for Planning for the climate change scenario (2070 – 2125) shows that there is no climate change data available for the majority of the Solar Array Area. Climate change data is available for two small areas in the south-west of the Solar Array Area and shows that the extent of Flood Zone 2 increases slightly.

5.3.3 The EA provided Product 4 modelled flood level data for the Solar Array Area, taken from the 2009 Lower Witham model for the River Slea and Kyme Eau,

[14] Available: Flood investigations – Lincolnshire County Council Accessed January 2025

and the 2016 South Forty Foot model for Hodge Dike, Car Dyke and Heckington Eau. The flood levels at the most relevant model node points are summarised in Table 6. The full dataset, including node locations, is included in Appendix 1.

5.3.4 The modelling, however, does not incorporate the impact of the IDB pumping stations within the river network. The pumping stations are designed to provide approximately 1m of freeboard within the watercourses during the 1 in 10 year return period and during storm events these would be providing some reduction in flood levels.

5.3.5 The capacity and maximum design water levels of pumping stations within each catchment are listed on the Black Sluice IDB website[15]. The Ewerby pumping station (grid reference: 515947, 348363) in the south-eastern corner of the Solar Array Area contains three gravity pumps with capacity of 2,237 l/s and a design water level of –0.3m AOD.

**Table 6. Environment Agency Modelled Flood Levels (Undefended)**

| NODE | RETURN PERIOD | | | | |
|---|---|---|---|---|---|
| | 1 IN 10 | 1 IN 100 | 1 IN 100 (+20% CC) | 1 IN 1000 | 1 IN 1000 (+20% CC) |
| Lower Witham Model (River Slea) – Flood Level (mAOD) | | | | | |
| KE_07650 | 3.90 | 3.94 | 3.95 | 3.98 | 4.07 |
| *KE_09720* | *3.96* | *4.01* | *4.01* | *4.07* | *4.23* |
| KE_12000 | 4.01 | 4.05 | 4.06 | 4.13 | 4.34 |
| South Forty Foot (Heckington Eau, Hodge Dike, Car Dyke) – Flood Level (mAOD) | | | | | |
| *HO103000* | *2.63* | *2.80* | *2.85* | *3.00* | *3.09* |
| HO101835d | 2.63 | 2.80 | 2.85 | 3.00 | 3.09 |
| MD101000 | 2.63 | 2.80 | 2.85 | 3.00 | 3.09 |
| HK110198 | 2.64 | 2.80 | 2.85 | 3.02 | 3.12 |
| HK109108d | 2.63 | 2.80 | 2.85 | 3.00 | 3.09 |

*Italics* show modelled node used for calculating flood depths

5.3.6 The Lower Witham model for the 1 in 100+20%CC storm event estimates the flood level within the Kyme Eau at 4.01m AOD. Transposing this flood level across the floodplain using LiDAR data, results in a maximum flood depth of 2.7m close to the north-eastern boundary of the Solar Array Area. Areas in the south and west of the Solar Array Area would generally be unaffected.

5.3.7 The South Forty Foot model for the same storm event, estimates a flood level of 2.85m AOD within the Hodge Dike. Transposing this across the floodplain using LiDAR data, results in a maximum flood depth within the Solar Array Area of over 1.52m, in the east of the Site. Both models, however, provide data for the defended scenario only. This accounts for the presence of existing flood defences, thereby considering the protection offered by existing defences.

5.3.8 Furthermore, the modelled flood levels represent 1D ‘in-channel’ levels which are built on the assumption that water can rise up within the confines of the raised flood defences and beyond, often referred to as the ‘glass-wall’ effect. The 1D model methodology is not sufficiently detailed to represent flooding across the floodplain.

[15] Available: Pumping Stations | Black Sluice Internal Drainage Board Accessed January 2025

5.3.9 The modelled in-channel flood levels could, therefore, be higher than the realistic level across the adjacent ground. Extrapolating the modelled in-channel flood levels across the adjacent ground to determine flood depth (as above), therefore, has limitations in accuracy. The EA data does not provide information on the crest height of the raised flood defences.

5.3.10 Fields to the north and south of Hodge Dike are situated several metres below raised flood defence embankments adjacent to the watercourse. There are also raised embankments along Car Dyke and the upstream Midfodder Dyke. If there is no pathway for water to exit the confines of these embankments, water levels within the channels could rise above the level of the adjacent ground without causing flooding to the Solar Array Area.

5.3.11 Owing to the considered inaccuracies in the Lower Witham and South Forty Foot models, additional fluvial flood modelling has been undertaken by Aegaea Ltd in order to confirm the extent, levels and depths of fluvial flood risk more accurately within the Solar Array Area.

5.3.12 The Aegaea fluvial flood model for the baseline scenario (contained as Appendix 2 Ref: AEG2934_LN4_Fen_Hydraulic Model Report_003) is a 1D-2D linked model based on LiDAR elevation data, land use, visual surveys, ditch and watercourse bed levels, the locations and level of protection of flood defences and location of pumping stations. The modelling estimates the flood levels and depths across the floodplain for the defended scenario.

5.3.13 For the purposes of this FRA, it is considered that the bespoke fluvial flood model is the best available data and provides the most realistic representation of fluvial flood risk at the Site and has been considered ahead of the Flood Map for Planning and EA Product 4 data where relevant.

5.3.14 This model was run for a range of return periods and scenarios. For this FRA, the key return periods are:

- Defended 1 in 100 year present day;
- Defended 1 in 1000 year present day;
- Defended 1 in 100 year +32% climate change;
- Defended 1 in 100 year +32% climate change breach scenario;
- Credible Maximum Scenario;
- Tidal H++ scenario.

5.3.15 Drawing No. ST19595-444 ‘Modelled Flood Extents for the Baseline Defended 1 in 100 and 1 in 1000 year return periods’ shows the defended flood extents for each return period. When compared to the EA Flood Map for Planning (i.e the undefended scenario), the modelled flood extent is considerably less than the extent of Flood Zone 3 and is generally constrained to the watercourses and the adjacent land in immediate proximity. The modelled flood extents show flooding is, however, more extensive within several fields in the south and west of the Solar Array Area than is shown on the Flood Map for Planning.

5.3.16 Overall, the proportion of the Solar Array Area shown to be within Flood Zone 3 on the Flood Map for Planning is approximately 47.5%. The modelled defended 1 in 100 year present day flood extent, however, only affects 15.2% of the Solar Array Area.

5.3.17 Flooding in the modelled defended 1 in 1,000 year present day scenario is more extensive in the north-east of the site and to the south of Hodge Dike. The increase in flood extents is less significant in areas of land to the north of Hodge Dike and in western and south-western areas of the Solar Array Area..

5.3.18 In comparison to the outline of Flood Zone 2 (ie the 1 in 1000 year undefended scenario) on the Flood Map for Planning, the modelled flood extent within the north-eastern fields is significantly smaller. The modelled flood extent in the south-western fields is, however, larger than is shown on the Flood Map for Planning.

5.3.19 Overall, 50.3% of the Solar Array Area is shown to be within Flood Zone 2 on the Flood Map for Planning, and 25.4% is within the extent of the modelled defended 1 in 1,000 present day scenario.

5.3.20 The modelled extent of fluvial flooding in the defended 1 in 100 year climate change scenario, as shown on Drawing No. ST19595-445 'Modelled Flood Extent for the 1 in 100 year + 32% CC return period', is similar to the modelled extent of the defended 1 in 100 year present day scenario. Flooding is generally constrained to the watercourse and land immediately adjacent in both scenarios.

5.3.21 Based on the latest flood modelling, it is considered that the risk of flooding in the defended, present day and future scenarios is Low to Medium, with south-western areas of the Solar Array Area considered to be at a High risk.

## Cable Route Corridor – Present Day and Future Climate Change Scenario

5.3.22 The Aegaea flood model boundary to the south of the site extends to the A17 which is a maximum distance of approximately 3.8km from the southern boundary of the Solar Array Area. Only northern sections of the Cable Route Corridor are, therefore, within the extent of the flood model. For central and southern sections of the Cable Route Corridor outside of the extent of the modelling, the Environment Agency Flood Map for Planning and Product 4 modelled flood levels are considered to be the best available data.

5.3.23 As shown in Drawing No. ST19595-445 'Modelled Flood Extent for the 1 in 100 Year +32% CC Return Period', the majority of the northern section of the Cable Route Corridor is outside of the extent of the modelled flood event, with only isolated areas at risk of flooding.

5.3.24 As shown in Drawing No. ST19595-441 'Flood Map for Planning (Sheets 1-4)', the majority of the initial 1km section of the Cable Route Corridor to the south of the A17 is within Flood Zone 1. The remainder of the Cable Route Corridor extending towards the Bicker Fen Substation is within Flood Zones 2 and 3.

5.3.25 Product 4 in-channel flood level data from the 2016 South Forty Foot model includes two node points in the vicinity of the crossing point beneath the South Forty Foot Drain. The modelled flood levels included in Appendix 1. The closest node to the Cable Route Corridor boundary is Node SF113000, which is located approximately 0.3km to the north of the Cable Route Corridor boundary. The in-channel flood levels at the node in the 1 in 100 year scenario and 1 in 100 year +20% scenario are 2.92mAOD and 2.94mAOD respectively.

5.3.26 Ground levels in the vicinity of Node SF113000 range between approximately 1.5mAOD and 2.5mAOD based on LiDAR data, with no ground levels exceeding the 2.92mAOD 1 in 100 year flood level. It is noted, however, that all sections of the embankments adjacent to Node SF113000 exceed the 2.92mAOD flood level.

5.3.27 As the Cable Route will be installed below ground, impacts of fluvial flooding would only be seen during the installation of the cable when open trenches are present and/or trenchless methods are being followed.

5.3.28 The risk of fluvial flooding to the Cable Route Corridor is, therefore, considered to be High during installation of the cable and Very Low during the operational phase.

5.3.29 Six temporary construction compounds will be located along the Cable Route Corridor. The two compounds to the north of the A17 are located outside of the defended 1 in 100 year + 32% climate change flood extent. The Flood Map for Planning shows the compound between the A17 and the railway is located partially within Flood Zone 3, and the three compounds further south are wholly within Flood Zone 3. The overall risk of fluvial flooding, therefore, ranges from Low to High.

5.3.30 The Flood Map for Planning climate change scenario (2070 – 2125) shows that there is no climate change data available for the Cable Route Corridor.

### Bespoke Access Corridor – Present Day and Future Climate Change Scenario

5.3.31 As shown in Drawing No. ST19595-445 , the majority of the Bespoke Access Corridor crosses areas considered not at risk of flooding in the defended 1 in 100 year + 32% climate change scenario. The eastern end of the corridor along with two narrow sections adjacent to watercourses at the western end of the corridor close to Asgarby are, however, located within the flood extent.

5.3.32 The modelled flood depth data shows that the maximum depth of flooding would be 0.3m in one topographical depression adjacent to Heckington Road. The depth of flooding along the remainder of the route would be less than 0.1m. The general safety guidelines for driving in floods advises against driving in moving flood water or water more than 0.1m deep[16].

5.3.33 Ordinary Watercourses at field boundaries are assumed to provide land drainage. These also are generally at the upstream end of larger drainage networks and any catchment areas are likely to be minimal.

5.3.34 During the construction phase, there will be two temporary construction compounds. The compound adjacent to Heckington Road is within the extent of the defended 1 in 100 year + 32% climate change scenario event, with a maximum depth of flooding of less than 0.1m. The compound adjacent to the A17 is unaffected by flooding in this return period.

[16] AA 'Driving Through Floodwater' Available: https://www.theaa.com/driving-advice/seasonal/driving-through-flood-water Accessed 01 December 2025

5.3.35 The risk of fluvial flooding to the Bespoke Access Corridor is considered, therefore, to be Low with areas of High risk.

### Bicker Fen Substation - Present Day and Future Climate Change Scenario

5.3.36 The bespoke fluvial model does not cover the Bicker Fen Substation site and, therefore, EA flood mapping and Product 4 flood level data are considered to be the best available data.

5.3.37 As shown on Drawing No. ST19595-441 the Bicker Fen Substation is located wholly within fluvial Flood Zone 3. The Flood Map for Planning climate change scenario (2070 – 2125) shows that there is no climate change data available for Bicker Fen Substation.

5.3.38 Product 4 flood level data from the South Forty Foot 2016 model shows in-channel flood levels in the 1 in 100 year scenario and 1 in 100 year +20% scenario are 3.06mAOD and 3.08mAOD respectively at Node SF117000 (the closest node to the Bicker Fen Substation site).

5.3.39 Ground levels within the Substation site range between approximately 1.5mAOD and 2.5mAOD, with the main substation infrastructure situated on a platform set at 2mAOD. Based on LiDAR data, however, the level of the embankments in the vicinity of the node exceed the 3.08mAOD flood level.

5.3.40 The EA 'Rivers and Sea Defended Flood Extent' mapping indicates that flood defences along the South Forty Foot Drain, located to the west of the Bicker Fen Substation reduce the risk of flooding to the substation and the surrounding area. Large areas of the Bicker Fen Substation are, however, located within the defended 1 in 100 year and 1 in 1000 year fluvial flood extents.

5.3.41 Based on the available data, the risk of fluvial flooding to the Bicker Fen Substation is considered, to be High.

### Overall Fluvial Flood Risk

5.3.42 The risk of fluvial flooding varies across the Proposed Development. Fluvial flood modelling for the Solar Array Area shows that flood risk is greatest in low-lying areas adjacent to watercourses, particularly in the south-west of the site. The extent of fluvial flooding for the modelled defended 1 in 100 year return period is less extensive than the area of undefended Flood Zone 3 shown on the EA Flood Map for Planning. The modelled extent of flooding in the climate change scenario is generally similar to the modelled present day scenario.

5.3.43 The fluvial flood modelling also shows that the majority of the Bespoke Access Corridor and northern extent of the Cable Route Corridor is outside of the extent of the modelled defended 1 in 100 year (plus climate change) flood extent.

5.3.44 The central and southern extents of the Cable Route Corridor are within Flood Zones 2 and 3 on the EA Flood Map for Planning. Bicker Fen Substation is located wholly within fluvial Flood Zone 3.

5.3.45 Overall there are areas of the Proposed Development that are at a High risk (> 1% annual exceedance probability) of fluvial flooding primarily adjacent to existing watercourses. Eastern areas of the Site are at a Medium risk (ie between 1% and 0.1% annual exceedance probability) of fluvial flooding with the remainder of the Site at Low risk (ie < 0.1% annual exceedance probability).

## 5.4 Tidal Flooding

### Solar Array Area

5.4.1 The Environment Agency states in their Product 4 package for the Solar Array Area (see Appendix 1) 'whilst the Site is within a tidal flood zone, ie assuming no tidal defences exist, it is **not** at risk of tidal flooding in either an overtopping or breaching of defences scenario, today or with an allowance for climate change'.

5.4.2 The risk of tidal flooding to the Solar Array Area can, therefore, be discounted.

### Cable Route Corridor

5.4.3 The EA Flood map for Planning indicates the Cable Route Corridor is not located within a tidal Flood Zone and is at risk from fluvial flooding only. The risk of tidal flooding can, therefore, be discounted.

### Bespoke Access Corridor

5.4.4 The Flood Map for Planning shows that the Bespoke Access Road is not located within a tidal Flood Zone. The risk of tidal flooding to the Bespoke Access Road can, therefore, be discounted.

### Bicker Fen Substation

5.4.5 The EA Flood map for Planning indicates the Bicker Fen Substation is not located within a tidal Flood Zone. The risk of tidal flooding to the Bicker Fen Substation can, therefore, be discounted.

## 5.5 Surface Water Flooding (Pluvial Flooding)

5.5.1 Surface water flooding often occurs during intense rainfall when water is unable to infiltrate into the ground or enter drainage systems and runs quickly overland resulting in local flooding. The EA classifies the risk of surface water flooding as:

- Very Low - an annual probability of less than 1 in 1,000 (<0.1%);
- Low - an annual probability of between 1 in 1,000 and 1 in 100 (0.1% - 1.0%);
- Medium - an annual probability of between 1 in 100 and 1 in 30 (1.0% - 3.3%); and
- High - an annual probability of greater than 1 in 30 (>3.3%).

5.5.2 The National Flood Risk Assessment 2 (NaFRA2) dataset, published in early 2025, provides details of the predicted extent and depth of surface water flooding. The EA surface water flood extent mapping, which is based on the

NaFRA2 dataset, for the present day scenario is included on Drawing No, ST19595-510-1 (sheets 1 – 4). Surface water flood depth mapping is included on Drawing No: ST19595-511-1 (sheets 1 – 4) and surface water flood flow velocities for the present day scenario are included on Drawing No. ST19595-524-1 (Sheets 1 – 4).

5.5.3 The NaFRA2 dataset also includes the extent and depths of surface water flooding in the 2040 – 2060 scenario to demonstrate the effects of climate change. Climate change modelling is based on the latest UK Climate Change Projections (UKCP18).

5.5.4 The EA 'Risk of Flooding from Surface Water' dataset only includes the 2040 – 2060 climate change scenario and whilst the Proposed Development has an operational life of 40 years (i.e. beyond 2060) it is considered that this data is the best available data to determine the impacts of climate change on surface water flood risk at the Site.

5.5.5 Surface water extent mapping for the 2040-2060 climate change scenario is included on Drawing No: ST19595-512-P0.02 (sheets 1 – 4). Depth and Velocity mapping for the 2040-2060 Climate Change scenario is included on Drawing No: ST19595-513-P0.02 (sheets 1 – 4) and Drawing No. ST19595-525-1 (sheets 1 – 4), respectively.

## Solar Array Area - Present Day Scenario

5.5.6 The EA Extent of Surface Water Flooding map shows that the majority of the Solar Array Area (70.7%) is at Very Low Risk of flooding.

5.5.7 Land in the north-east of the Solar Array Area is generally at a Low risk of surface water flooding, with areas of Medium and High risk, particularly in the north and adjacent to Hodge Dike.

5.5.8 There are areas of Medium to High risk in the south-west of the Solar Array Area at the upstream extent of Hodge Dike. It is considered that these areas are where overland flows are obstructed by a raised embankment adjacent to the unnamed watercourses in this vicinity, with surface water backing up behind the embankment.

5.5.9 Other areas shown to be at risk of surface water flooding are generally consistent with the alignment of watercourse corridors or localised topographical depressions causing ponding within the Solar Array Area, and are not associated with overland flow routes coming from outside the Order Limits.

5.5.10 The BESS and Onsite Substation site is generally shown not to be at risk of surface water flooding. There are several long, narrow sections within the proposed BESS and Onsite Substation area that are shown to be at a Low to High risk. Due to the arable land use of the Site, these are considered to be a result of tramlines or plough lines associated with farming machinery.

5.5.11 The EA surface water velocity mapping for the medium risk scenario (1 in 100 year event) shows three overland flow pathways extending eastwards into south-western areas of the Solar Array Area to converge at the upstream extent of Hodge Dike. The combined flows then continue north-eastwards along the route of the Hodge Dike. The velocity of the flows and the width of the pathway generally reduce as the flows progress north-eastwards across the Solar Array Area.

5.5.12 A second overland flow pathway follows the route of the River Slea and Catchwater Drain to the north-west of the Solar Array Area. The overland flows then extend south-eastwards into the Site to discharge to Hodge Dike.

5.5.13 EA surface water flood depth mapping shows that the area considered at risk of surface water flooding in the Solar Array Area for the 1 in 100 year event (i.e. the medium risk scenario) would generally not exceed depths of 300mm.

5.5.14 In several areas, depths are indicated at between 300mm and 900mm, notably, in the south-western area, adjacent to Hodge Dike.

5.5.15 Based on the available information, it is considered that the risk of surface water flooding is Very Low to Low for the majority of Solar Array Area, with small areas at a Medium to High risk adjacent to Hodge Dike in the south-west of the Solar Array Area.

### Solar Array Area - Future Climate Change Scenario

5.5.16 The areas at risk of surface water flooding are shown to be slightly more extensive in the climate change scenario when compared to the present day scenario. Notwithstanding this, there are no significant new areas of the Solar Array Area affected, and no new overland flow routes shown to be present.

5.5.17 The minimum depth of flooding in the Medium likelihood climate change scenario is also greater than in the present day scenario. There are, however, no additional areas of the Solar Array Area where flooding would exceed 0.6m when compared to the present day scenario.

### Cable Route Corridor - Present Day Scenario

5.5.18 The majority of the Cable Route Corridor (81.8%) is at a Very Low risk of surface water flooding.

5.5.19 The majority of surface water flooding affecting the Cable Route Corridor is considered to be associated with ponding caused by isolated topographical depressions.

5.5.20 Northern and central sections of the proposed Cable Route Corridor are situated within overland flow routes in the vicinity of Heckington Eau and to the east of the village of Great Hale. These pathways generally flow from north-west to south-east across the Cable Route Corridor.

5.5.21 There are no significant overland flow pathways in the vicinity of southern sections of the Cable Route Corridor.

5.5.22 The construction compound proposed immediately to the east of Great Hale is at a High risk of surface water flooding. Surface water depth mapping indicates depths in this area of up to 600mm in the 1 in 100 year event. The southern-most compound also has isolated areas of surface water flooding at Low to High risk. In the Medium risk scenario, flooding in this area is shown to reach a maximum depth of 300mm, with the majority of the flood risk area having flood depths less than 200mm. All other compounds are at a Very Low risk.

5.5.23 It is considered, therefore, that the risk of flooding to the Cable Route Corridor and proposed construction compounds is Very Low with areas of Low to High risk.

### Cable Route Corridor – Future Climate Change Scenario

5.5.24 The extent of surface water flooding and depth of flooding increases along the Cable Route Corridor in the future climate change scenario. As with the Solar Array Area, no new overland flow routes are anticipated. Furthermore, surface water flooding does not encroach into any of the proposed construction compounds that are unaffected in the present day scenario.

### Bespoke Access Corridor – Present Day Scenario

5.5.25 The majority of the Bespoke Access Corridor is at a Very Low risk of surface water flooding, with approximately 82% of the route extending through areas of land at a Very Low risk.

5.5.26 The southern section, adjacent to the A17 is, however, located within an area of High risk. This forms part of an overland flow pathway flowing eastwards towards Heckington Eau, located to the south of the boundary of the Solar Array Area.

5.5.27 Depth mapping indicates that in the 1 in 100 year event, flood depths in this area would be less than 600mm.

5.5.28 A narrow section of land in the northern part of the corridor is at a Low to High risk of flooding. This forms part of a series of overland flow routes which converge within the Solar Array Area upstream of Hodge Dike.

5.5.29 Temporary construction compounds will be located adjacent to the A17 and Heckington Road during the construction phase. Portions of both of these areas are shown to be at a High risk of surface water flooding.

5.5.30 There are several areas of the Bespoke Access Corridor shown to be at a Low to High risk of surface water flooding as a result of ponding associated isolated depressions with the topography.

5.5.31 Based on the available information it is considered that the risk of surface water flooding to the proposed Bespoke Access Corridor is Very Low, with a High risk adjacent to the A17.

### Bespoke Access Corridor – Future Climate Change Scenario

5.5.32 As with other areas of the Site, the climate change scenario mapping does not show any new overland flow routes or surface water flooding encroaching into new areas of the Bespoke Access Corridor when compared to the present day scenario. The depth of flooding away from watercourses is sufficiently shallow to be passable on foot for the purposes of emergency access and egress.

### Bicker Fen Substation – Present Day Scenario

5.5.33 There are no surface water flow pathways extending through the Bicker Fen Substation. There are, however, areas of surface water ponding associated with isolated topographical depressions.

5.5.34 Depths of surface water flooding in the medium risk scenario are indicated on EA mapping to be up to 0.2m, with some small areas associated with existing drainage ditches with depths of between 0.2m and 0.9m.

5.5.35 The risk of surface water flooding within the Bicker Fen Substation is considered to be Low.

### Bicker Fen Substation – Future Climate Change Scenario

5.5.36 In the climate change scenario the extent of surface water flooding in the Medium and High risk scenarios remains generally the same as the present day scenario; however an increase in the extent of surface water flooding in the Low Risk scenario is shown.

5.5.37 As with other areas of the Site, the climate change scenario mapping does not show any new overland flow routes.

### Overall Surface Water Flood Risk

5.5.38 The EA mapping shows that the majority of the Solar Array Area is at a Very Low risk of surface water flooding. Overland flow routes are present in the south-west of the Solar Array Area, where the risk is High. North-eastern and central areas of the Site are at a Low risk of flooding. The majority of the Cable Route Corridor and Bespoke Access Corridor is at a Very Low risk of surface water flooding. The southern extent of the Bespoke Access Corridor is, however, situated within an overland flow route where the risk is High.

5.5.39 The overall risk of surface water flooding to the Proposed Development is, therefore, considered to be Low, with isolated areas at High risk.

## 5.6 Groundwater Flooding

5.6.1 Groundwater flooding can occur when prolonged rainfall causes the groundwater table to rise above ground level. Groundwater flooding can occur at the same time as flooding from other sources, such as surface water flooding. The LCC PFRA states that the Sleaford and Bourne areas are susceptible to flood risk due to high groundwater levels in the underlying aquifer. The Susceptibility to Groundwater Flooding mapping within the PFRA divides the region into 1km grid squares and assigns a percentage based on the proportion of that area in which hydrogeological conditions are such that groundwater flooding could occur and does not refer to the risk of flooding.

### Solar Array Area

5.6.2 Mapping shows that south-western areas of the Solar Array Area have a greater than 75% 'susceptibility' to groundwater flooding. The susceptibility decreases with distance from Sleaford and north-eastern areas of the Solar Array Area have a less than 25% susceptibility.

5.6.3 This corresponds with BGS mapping, which shows that south-western areas are underlain by bedrock and superficial deposits classified as Secondary aquifers, and north-eastern areas are underlain by unproductive bedrock and superficial deposits. Cranfield 'Soilscapes' Viewer states that the loamy and clayey soils in the east of the Solar Array Area have naturally high groundwater.

5.6.4 As there will be minimal development below ground level, it is unlikely that groundwater would be encountered except during pile installation. Below ground structures such as basements are not proposed. Also, due to the nature of a solar farm development, it is considered unlikely that elevated groundwater would impact on its operations.

5.6.5 Based on the available information it is considered that the risk of groundwater flooding to the Solar Array Area is Medium.

### Cable Route Corridor

5.6.6 The northern sections of the Cable Route Corridor are situated within land with a susceptibility to groundwater flooding of over 75%. Central and southern sections are situated on land with minimal susceptibility to groundwater flooding.

5.6.7 The cable itself would be unaffected by high groundwater levels and would remain operational. Groundwater flooding would only be a risk during the installation of the cables as the cable trenches will generally be up to 2m deep and it is possible that they will intersect the groundwater table.

5.6.8 The construction compounds will be constructed at ground level and could, therefore, be impacted by groundwater emergence.

5.6.9 It is considered that the risk of flooding to the Cable Route Corridor from groundwater is Low during the operational phase. During the construction phase, the risk to the cable trenches and construction compounds is Medium to High.

### Bespoke Access Corridor

5.6.10 The northern section of the Bespoke Access Corridor crosses areas with a susceptibility of over 75%. The susceptibility decreases with distance from the Solar Array Area, with southern sections of the corridor having a 25% - 50% susceptibility.

5.6.11 The Bespoke Access Road will, however, be surfaced with asphalt and groundwater would, therefore, only emerge within areas of open ground adjacent. As shown on the surface water extent mapping (see Drawing No. ST19595-510), there are limited areas where water could ‘pond’ to any significant depth and the road would be fully passable. The construction compounds will be constructed at ground level and could, therefore, be impacted by any groundwater emerging above ground level.

5.6.12 Based on the available information it is considered that the risk of groundwater flooding to the Bespoke Access Road is Medium.

### Bicker Fen Substation

5.6.13 The Bicker Fen Substation is situated on land with minimal susceptibility to groundwater flooding. Based on the clayey nature of the tidal deposits and soils, it is assumed that the groundwater would have limited pathways to rise above ground level.

5.6.14 Groundwater flooding would, therefore, only pose a risk during the installation of below ground infrastructure such as foundations, pipework and cables.

5.6.15 Any existing below ground infrastructure such as pipework and cables within the Bicker Fen Substation will also not be impacted by raised groundwater levels. As this is an operational substation, it is assumed any mitigation required is already in place. It is considered, therefore, that the risk of flooding from groundwater is Low.

### Overall Groundwater Flood Risk

5.6.16 Land in the vicinity of Sleaford has a high susceptibility to groundwater flooding, which would affect south-western areas of the Solar Array Area, the northern sections of the Cable Route Corridor and Bespoke Access Corridor. The vulnerability of ground to flooding does not translate into the risk of flooding, however, and the overall risk of groundwater flooding is considered to be Medium.

## 5.7 Sewer Flooding

### Solar Array Area

5.7.1 Consultation with Anglian Water confirmed that there are no public sewers within the Solar Array Area. It is also assumed that there are no private sewers in the vicinity of the Solar Array Area and this potential source of flooding is, therefore, not applicable.

### Cable Route Corridor

5.7.2 Consultation with Anglian Water confirmed that there are no public sewers within the Cable Route Corridor. Where the route passes close to properties there may be private sewers present, and highway drainage may be present within highways.

5.7.3 The cable will be, however, be below ground and not affected by sewer flooding. Where the Cable Route Corridor crosses highways or runs close to built-up areas, sewers will be identified along with other services prior to excavation to ensure no damage is caused during the works.

5.7.4 The temporary construction compounds will be located within open agricultural fields, and it is assumed that there will be no private sewers within these areas.

5.7.5 The risk of sewer flooding will, therefore, be Very Low.

### Bespoke Access Corridor

5.7.6 The route extends between Heckington Road and Asgarby Road; and Asgarby Road and the A17. Temporary construction compounds will be situated immediately adjacent to the road junctions. There may be sewers or highway drainage present within these carriageways.

5.7.7 Based on ground levels around these crossing points and junctions, there are limited pathways for any flooding to extend onto the access road. Furthermore, the flat ground will mean any flooding would likely be shallow with no ponding and would be passable. It is assumed that the Bespoke

Access Road will not cross any public or private sewers within areas of agricultural land and the overall risk of flooding will, therefore, be Low.

### Bicker Fen Substation

5.7.8 The Bicker Fen Substation is served by a private surface water drainage network. It is assumed that the existing network is suitably sized to ensure the substation is not prone to flooding and can remain operational at all times. The proposed extension works would, therefore, not be vulnerable to sewer flooding. The overall risk of flooding will, therefore, be Very Low.

### Overall Flooding risk from Sewers

5.7.9 The rural nature of the Proposed Development means that there are anticipated to be few public and private sewers across the Site and within its immediate vicinity. On this basis, the overall risk of sewer flooding to the Proposed Development is, therefore, considered to be Very Low.

## 5.8 Artificial Sources

5.8.1 Artificial sources of flooding include reservoirs, canals and any other impounded water body that is elevated above the level of the Solar Array Area. Flooding can occur when the impounding structures (such as dams and embankments) fail, when culverts become blocked, when flow controls (eg pumps) fail, or during extreme rainfall events when the waterbodies overflow.

5.8.2 The EA Maximum Extent of Flooding from Reservoirs map is shown of Drawing No. ST19595-454 ‘Environment Agency Reservoir Flooding Extents (Sheets 1-4)’.

### Solar Array Area

5.8.3 The EA Maximum Extent of Flooding from Reservoirs map shows that the northern and eastern areas of the Solar Array Area are at risk of flooding from reservoirs when there is also flooding from rivers.

5.8.4 The extent of the area of risk generally follows the outline of Flood Zone 3 on the Flood Map for Planning (see Drawing No. ST19595-441 ‘Flood Map for Planning (Sheets 1-4)’). The Aegaea fluvial flood modelling suggests that the EA Flood Map for Planning provides a conservative representation of flood risk. It can, therefore, be assumed that the extent of reservoir flooding also shows a conservative representation of the flood risk to the proposed site.

5.8.5 Based on mapping, the risk of flooding relates to an unnamed impounded reservoir located approximately 4.5km to the south-west of the Solar Array Area at Grid Reference 510468, 344125. Flooding from this source could affect large areas in the vicinity of the Site. It is assumed that raised embankments surrounding the reservoir are well-maintained in accordance with the Reservoirs Act 1975.

5.8.6 It is considered that the probability of a breach of the reservoir coinciding with a fluvial flooding event is minimal.

5.8.7 A small reservoir is present in the south of the Solar Array Area (location can be seen on Drawing No. ST19595-198 ‘Watercourse Network (Sheet 1 of 3)’), adjacent to Hodge Dike. It is considered that any flooding from this waterbody would continue north-eastwards along the route of Hodge Dike without risk to the wider Site.

5.8.8 Water levels within the Black Sluice Internal Drainage Board area are artificially managed via pumps to allow the land to be farmed. There is the potential, therefore, for one or more of the pumps to fail and result in flooding to the Site. The fluvial flood modelling assumes no water level management, and, therefore, represents a conservative representation of the flood risk. It can, therefore, be considered that the modelled flood levels give an indication of the flood extent in a 'no pump' scenario.

5.8.9 There are no other potential sources of artificial flooding within the vicinity of the Solar Array Area and, based on the available information, it is considered that the risk of flooding from this source is Very Low.

## Cable Route Corridor

5.8.10 As shown on Drawing No.ST19595-454 sections of the Cable Route Corridor would only be at risk from reservoir flooding when there is also fluvial flooding.

5.8.11 Two temporary construction compounds and the Bicker Fen substation are located in areas at risk of reservoir flooding when there is also fluvial flooding. The source of flooding to southern sections of the Cable Route Corridor is an unnamed reservoir in Culverthorpe approximately 16km to the west. The size of the reservoir would mean it is covered by the Reservoir Act 1975. As all reservoirs covered under the Act must be well-maintained it is considered that risk of the reservoir failure is minimal.

5.8.12 As stated in Section 5.8.7, there is the potential for the Black Sluice IDB pumps to fail which may result in flooding to the Cable Route Corridor. Since it is assumed that the EA modelling does not account for the water level management within the IDB network, it is considered that the Flood Map for Planning is representative of this scenario.

5.8.13 The risk of flooding to developments within the Cable Route Corridor from artificial sources would, therefore, be Very Low.

## Bespoke Access Corridor

5.8.14 A small area in the southern section of the Bespoke Access Corridor, adjacent to the A17, is at risk of reservoir flooding, even when river levels are normal. During the construction phase, a temporary construction compound will be located in this area. The source of flooding is the aforementioned unnamed reservoir in Culverthorpe, located approximately 1km to the south-west of the A17.

5.8.15 There is the potential for the Black Sluice IDB pumps to fail which may result in flooding to the Bespoke Access Road. Since it is assumed that the EA modelling does account for the water level management within the IDB network, it is considered that the Flood Map for Planning, is representative of this scenario.

5.8.16 The remainder of the route is not at risk of flooding from reservoirs and there are no canals or impounded water bodies in the vicinity. As the area of the route at risk of reservoir flooding is minimal, the overall risk from artificial sources is considered to be Very Low.

### Bicker Fen Substation

5.8.17 As shown on Drawing No.ST19595-454 the Bicker Fen Substation would only be at risk from reservoir flooding when there is also fluvial flooding.

5.8.18 As stated in Section 5.8.8, there is the potential for the Black Sluice IDB pumps to fail which may result in flooding to the Cable Route Corridor. Since it is assumed that the EA modelling does not account for the water level management within the IDB network, it is considered that the Flood Map for Planning is representative of this scenario.

5.8.19 The overall risk of flooding from artificial sources is, therefore, considered to be Low.

### Overall Flood Risk from Artificial Sources

5.8.20 Reservoir flooding would affect the eastern portion of the Solar Array Area and Cable Route Corridor when fluvial flooding is also present. The risk relates to two reservoirs to the south-west of the Site. The bespoke fluvial flood modelling shows that in the defended scenario, flooding during the 1 in 100 year +32% Climate Change scenario would be less extensive than shown on the Flood Map for Planning. It could be expected, therefore, that the overall extent of the site which would be affected by reservoir flooding in times of river flooding would be less extensive than EA mapping shows.

5.8.21 Furthermore, it can be assumed that the reservoirs will be well-maintained in accordance with the Reservoir Act 1975 and, therefore, the risk to the site would be minimal. Overall, the risk of flooding from reservoirs to the Proposed Development is considered to be Very Low.

# 6. POST DEVELOPMENT FLOOD RISK ASSESSMENT

6.1.1 New development can pose a risk of flooding to neighbouring properties and areas downstream of a site, often as a result of an increase in impermeable area which has the effect of increasing the rate and volume of surface water runoff. In addition, climate change can be expected to cause an increase in rainfall intensity and surface water runoff over the lifetime of a development. Flood risk can also be increased as a result of new development if the development reduces the floodplain storage area or alters flood flow paths, ultimately displacing flood water and resulting in an increased risk to the surrounding area.

6.1.2 Based on Section 5, it can be considered that the Proposed Development could have an impact on fluvial flooding and pluvial flooding. The Proposed Development would have no impact on groundwater flooding or sewer flooding and the layout does not include provision of any new artificial sources.

## 6.2 Fluvial Flooding

### Solar Array Area

6.2.1 The Solar Array Area will have a negligible impact on fluvial flooding. It is considered that the solar panel tables will have no direct impact on flood routing or floodplain storage. Land raising associated with the transformers and debris accumulation associated with the fence could have minor impacts and are considered further below.

6.2.2 During a flood event there is the risk that debris will accumulate against the fences. As the Site and its vicinity generally comprise open farmland with minimal areas of woodland, the source of large scale debris is considered to be relatively minimal, however, there is still the risk of smaller-scale debris accumulating against the fence lines and potentially impeding the flow of flood water. Mitigation measures will need to be implemented to prevent this.

6.2.3 Transformers will be located on raised ground (platforms) extending 600mm above the maximum depth of flooding. Based on the proposed layout plans, 74No. transformers are located within the flood extent and would need to be constructed on raised platforms for protection. The exact elevation of each individual platform is to be confirmed with the Environment Agency at the detailed design stage.

6.2.4 The transformer structures will stand in isolation from other structures and flood flows would not be impeded or diverted to areas previously unaffected by fluvial flooding. As the individual transformers will have a footprint of approximately 21m$^2$, any losses in floodplain storage will be minimal when compared to the overall size of the Solar Array Area. Any losses of floodplain storage will, however, require mitigation.

6.2.5 Access tracks will be constructed at existing ground level to avoid diverting or impeding fluvial flood flows or affecting floodplain storage.

6.2.6 A small area in the north-eastern corner of the proposed BESS and Onsite Substation site is also shown to be affected by fluvial flooding in the defended 1 in 100 year + 32% climate change scenario. Any ground raising associated with the construction of the flat plateau for the BESS and Onsite Substation site may result in a minor loss of floodplain storage, which will require mitigation.

6.2.7 All proposed bridge crossings, temporary and permanent, will be constructed in accordance with all relevant secondary consents to ensure that water and debris within the watercourse is able to flow freely as per the existing scenario without causing blockages and in turn increased flood risk upstream or to the Site itself.

6.2.8 Losses of floodplain storage as a result of any bridge access ramps will also require mitigation.

6.2.9 Mitigation measures for the impacts detailed above are discussed in Section 7.

## Cable Route Corridor

6.2.10 Sections of the proposed Cable Route Corridor will cross areas at a High risk of fluvial flooding (see Drawing No. ST19595-441 and ST19595-445). The cable will be located below ground within a trench and as stated previously, the only time the cable would be prone to flooding would be during installation when sections of cable are exposed within open trenches. Appropriate management/mitigation will, therefore, be required.

6.2.11 During construction, stockpiled arisings from the trench excavations could result in the loss of floodplain storage and impede existing flood flow routes. Mitigation measures during the construction phase will, therefore, be required.

6.2.12 The trenches will be reinstated with arisings to the existing ground level and there will, therefore, be no areas of raised ground that could result in a loss of floodplain storage or diversion of flood flow routes in the operational phase.

6.2.13 Where the cable crosses larger watercourses (Main Rivers), this will be done using trenchless methods and, therefore, there will be no impact on flows within the watercourses. The crossings will be made at sufficient depth to avoid interaction with the foundations of any flood risk management asset that may be present, the locations and depths of which will be determined via intrusive investigations (eg trial pits) at the detailed design stage.

6.2.14 Where the cable crosses smaller Ordinary Watercourses, the cable may be installed via trenchless methods or within an open cut channel. Where an open cut channel is used the watercourse may either be dammed temporarily with water pumped downstream or the watercourse itself be temporarily diverted. Appropriate management/mitigation will, therefore, be required.

6.2.15 Four of the temporary construction compounds are located partially or fully within Flood Zone 3. It is proposed that office and welfare cabins will be raised above ground on stilts where feasible allowing flood water to pass beneath with no impact on flood flows or floodplain storage. Other storage containers and structures will be small standalone units which flood waters could pass between. In comparison to the scale of the development and the floodplain, the footprint of these structures will be minimal, and any losses of floodplain storage would, therefore, be negligible.

## Bespoke Access Corridor

6.2.16 Small sections of the proposed Bespoke Access Road will be located within the defended 1 in 100 year +32% climate change flood extent (see Drawing No. ST19595-445), however, the road will be constructed at ground level and there will be no impact on any existing flood flow routes or loss of floodplain storage.

6.2.17 A temporary construction compound will also be located within the defended 1 in 100 year +32% climate change flood extent. Compounds will generally contain temporary office structures and storage containers, and these could, therefore, impact on flood flow routes or result in a loss of floodplain storage.

6.2.18 The depth of flooding will generally be less than 0.1m and it is proposed that office and welfare cabins will be raised above ground on stilts where feasible allowing flood water to pass beneath with no impact on flood flows or floodplain storage. Any structures which cannot be raised will not be grouped closely together allowing flood waters to pass between. In comparison to the scale of the development and the floodplain, the footprint of these structures will be minimal, and any losses of floodplain storage would, therefore, be negligible.

6.2.19 There is a requirement to stockpile excavated materials for the 40 year duration of the proposed development. These stockpiles, therefore, have the potential to impact on floodplain storage and flood flows if situated within the defended 1 in 100 year +32% climate change flood extent. In this situation flood risk mitigation will be required.

6.2.20 ~~The~~Figure 6.31 Landscape Strategy Plan (**Document Ref: 6.4.42 ~~ES Figure 6.31~~**) provides indicative locations for the ~~permanent~~ stockpiles ~~along~~which will be present within the Bespoke Access Corridor. These stockpiles will be present for the duration of the Proposed Development and will be removed upon decommissioning of the Bespoke Access Road. The indicative stockpile locations do not encroach into the modelled 1 in 100 year + 32% climate change flood extent, nor interface with the surface water flood risk extents.

## Bicker Fen Substation

6.2.21 The existing Bicker Fen Substation is situated within Flood Zone 3 and any new structures could, therefore, cause a reduction in floodplain storage and potentially impact on flood flow routes.

6.2.22 The proposed substation extension (Work No. 5B) will comprise either ~~an~~ outdoor Air Insulated Switchgear (AIS) or indoor Gas Insulated Switchgear (GIS) ~~structure~~infrastructure. The AIS infrastructure would have a total external footprint of approximately 0.9ha and the GIS building would have a footprint of less than 0.15ha. Further detail is provided in Section 2.13 **Chapter 2: Proposed Development (Document Ref: 6.2 ES Volume 1, 6.2.2).**

6.2.23 A worst-case estimate of the potential loss of floodplain storage, and the potential off-site impact, associated with the Bicker Fen Substation works has been undertaken The estimate is based on the assumption that any new infrastructure is built at/above the existing ground level of 2mAOD. The 1 in 100 year plus 20% climate change flood elevation on the South Forty Foot Drain (in-channel level at node SF117000) is 3.08mAOD (see Appendix 1), resulting in a flood depth of 1.08m. This is an 'in-channel' level on the South Forty Foot Drain and is therefore likely to be a considerable over-estimation of flood depth at the existing substation site. Furthermore, the substation extension is subject to detailed design, however the GIS option is considered to represent a worst case scenario with respect to floodplain displacement as it involves a building rather than external infrastructure supported on poles/legs. It has been further assumed that the GIS building will result in full displacement of floodwater, albeit the structure will allow flood water to enter.

6.2.24 On this basis, the estimated floodplain loss is 1,600m$^3$ (approximately). To understand the impact of this displacement, the extent of the 1 in 100 year flood cell surrounding the Bicker Fen Substation has been estimated. The flood volume displacement has been divided by this extent to estimate the average increase in flood depth. The flood cell is estimated to be 1,161ha. This results in a flood depth increase of approximately 0.00013m (0.13mm). The impact is, therefore, considered to be negligible.

6.2.25 The floodplain associated with the South Forty Foot Drain is extensive with flood flows emerging from the channel and crossing a large area of flat ground. As the AIS will comprise a number of small, raised structures in isolation, it is considered that flood flows would be able to pass between the structures unimpeded.

6.2.26 The GIS building will be separate from the other existing infrastructure within the substation site, generally allowing flood flows to pass through the area unimpeded. When compared to the scale of the floodplain it is considered, that the impact the GIS building would have on flood flows will be relatively minimal and localised.

## Floodplain Loss

6.2.27 It is acknowledged that certain elements of the Proposed Development will be placed within, and/or raised above the defended 1 in 100 year + 32% climate change flood extent and, therefore, have the potential to displace floodplain storage. This includes solar panel piles; transformers; a small area of the BESS and Onsite Substation; bridge crossings; the proposed extension to Bicker Fen Substation, temporary stockpiles of material associated with the installation of the cable routeCable Route; and, the permanent stockpiles of material associated with the Bespoke Access Road which will be present for the duration of the Proposed Development.

6.2.28 The bespoke fluvial flood modelling has been used to make an assessment of the potential volume of floodplain storage that could be lost. The assessment has considered the loss of floodplain storage in 200mm depth bands across the site for the defended 1 in 100 year + 32% climate change event.

6.2.29 In undertaking this assessment a number of assumptions have been made with respect to the footprint of particular elements of the Proposed Development listed above, with the intention of assessing a worst case scenario.

6.2.30 Transformer stations are assumed to be on raised platforms with 600mm freeboard above the design flood level. The platforms have an assumed side slope of 1 in 3, and the footprint has been determined accordingly. In assessing the loss of flood storage volume, vertical sides have been assumed.

6.2.31 For assessing floodplain loss due to solar panel pile placement, a maximum flood depth within each field has been determined, and this has been multiplied by the pile footprint and number of piles estimated within the flood extent for each field.

6.2.32 The assessment of floodplain loss from bridge crossings has considered vehicular bridges only. In determining the footprint of each bridge, an access ramp with a gradient of 1 in 20 has been assumed. The height of the bridge, and hence length of access ramp, has been determined using the maximum flood elevation at each locality and applying a 600mm freeboard allowance. It has also been assumed that the entire footprint of the bridge access ramps and abutments will be within the floodplain, albeit in reality this is unlikely to be the case.

6.2.33 The BESS platform partially encroaches into the design flood extent. To determine flood storage loss, the flood extent has been measured and multiplied by the maximum flood depth in that locality to provide a conservative estimate.

6.2.34 It has been assumed that the floodplain extents within the Bespoke Access Corridor are entirely covered by the ~~permanent~~ stockpiles, and that the stockpiles have vertical sides. This assumption has been made to provide a worst-case estimate of floodplain loss. It is highly unlikely that the stockpiles will be this extensive within the design flood extent.

~~6.2.34~~6.2.35 The existing topography in this locality ranges from 7.2m AOD to 12.4mAOD and hence the flood elevation is equally variable. The flood depths have, therefore, been analysed. This has identified a small, isolated topographical low spot at the eastern end of the Bespoke Access Corridor, which results in a maximum flood depth greater than 0.4m. This is considered to be an outlier and not an accurate representation of the flood depths across the majority of the flood extent at the eastern end of the Bespoke Access Corridor. With this outlier excluded, the average flood depth has been estimated as 0.12m. This has been multiplied by the flood extent to obtain a conservative estimate of the volume of floodplain loss.

~~6.2.35~~6.2.36 It should be noted that the estimation of floodplain loss resulting from the ~~permanent~~ stockpiles within the Bespoke Access Corridor, as detailed above, represents a worst-case scenario. The indicative stockpile locations as shown on ~~the~~Figure 6.31 Landscape Strategy Plan (**Document Ref: 6.4.42 ES Figure 6.31**) represent a more realistic scenario of stockpile locations and extents. This Figure shows that the stockpiles do not encroach into the modelled 1 in 100 year + 32% climate change flood extent, nor interface with the surface water flood risk extents~~.~~ and, therefore, result in no net loss of floodplain storage.

~~6.2.36~~6.2.37 A summary of the total loss of floodplain storage is provided in Table 7 below. An indication of the elevations at which this storage is lost is also provided.

**Table 7. Floodplain Storage Loss**

| AREA | FLOODPLAIN LOSS (m3) | APPROXIMATE ELEVATION RANGE (mAOD) |
|---|---|---|
| Solar Panels | 6 | Variable |
| Transformers | 275 | 1.2 up to 6.8 |
| BESS Plateau | 33 | 3.4 to 3.6 |
| ~~Permanent~~ Stockpiles within Bespoke Access Corridor | 5,322 | Majority 7.4 to 12.2 |
| Bridge Crossings | 4 | 4.8 to 5.2 |
| **TOTAL** | **5,640** | |

~~6.2.37~~6.2.38 The figures in Table 7 above are illustrative only, intended to provide a worst-case estimation of floodplain loss based on a set of assumptions, and illustrative designs for the proposed infrastructure. The figures are, therefore, subject to detailed design and hence subject to change.

~~6.2.38~~6.2.39 To mitigate the loss of floodplain storage, floodplain compensation will be provided within the Order Limits on a level-for-level and volume-for-volume basis. Please refer to Section 7.2 of this report for further detail.

### Overall Impact of Proposed Development on Fluvial Flood Risk

~~6.2.39~~6.2.40 Overall there are elements of the Proposed Development that individually could have a minor effect on fluvial flood risk, generally through displacement of floodplain storage or impeding flood flow routes. Cumulatively these minor impacts could result in a more significant impact on fluvial flood risk and, therefore, mitigation measures are required. Fluvial flood risk mitigation measures are discussed in Section 7.2.

## 6.3 Surface Water (Pluvial) Flood Risk

### Solar Array Area

6.3.1 The EA surface water velocity mapping (see Drawing ST19595-524 and ST19595-525) shows that an overland flow route crosses the south-eastern area of the Solar Array Area and extends eastwards towards Hodge Dike. This will pass through areas of proposed solar panels.

6.3.2 As all solar panels will be situated above ground level on piles, it is considered that they would not cause any diversion of existing overland flow routes and there would be no increased risk to areas previously unaffected by surface water flooding. The BESS and Onsite Substation is not located within an area affected by overland flow routes.

6.3.3 There is an area in the eastern section of field 1.26 where EA mapping shows surface water flood depths may reach up to 0.9m in the medium risk (1 in 100 year) scenario. The deepest area is located adjacent to the embankment of the watercourse and associated with a localised topographic depression. This area coincides with the fluvial flood extent for the defended 1 in 100 year +32%

climate change breach scenario. The solar panel tables will, therefore, be raised in this location, and it is considered that the mitigation provided for the fluvial flood risk is sufficient to allow unimpeded continuation of pre-development surface water (pluvial) flows without causing damage to electrical equipment or increasing flood risk off-site.

### Cable Route Corridor

6.3.4 The cable will be installed within trenches which will be infilled to ground level meaning that there will be no impact on overland flows. When the cable is being installed within trenches, excavated material will be stored alongside the trench. These stockpiles could obstruct or divert local overland flow paths. Mitigation will, therefore, be required.

6.3.5 The proposed construction compounds will be constructed at ground level and structures within the compound will be spaced sufficiently to allow any overland flow to pass through the compound without being impeded or diverted. In areas at risk of fluvial flooding in the 1 in 100 year scenario, structures will be raised above ground level where feasible and, therefore, overland flows will be able to pass beneath the structures unimpeded.

### Bespoke Access Road

6.3.6 The Bespoke Access Road will be constructed at the existing ground level and will, therefore, not obstruct or divert any existing overland flow routes. During construction of the Bespoke Access Road excavated soils will be stored in stockpiles which will be present for the 40 year lifespan of the development.

6.3.7 Sections of the Bespoke Access Road are situated along overland flow routes which originate from higher land to the west. Stockpiled material therefore has the potential to divert or impede surface water runoff and mitigation will be required. ~~The~~Figure 6.31 Landscape Strategy Plan (**Document Ref: 6.4.42 ES Figure 6.31**) provides indicative locations for the ~~permanent~~ stockpiles along the Bespoke Access Corridor. The stockpiles will be present for the duration of the Proposed Development and will be removed upon decommissioning of the Bespoke Access Road. The indicative stockpile locations do not interface with the surface water flood risk extents.

6.3.8 The proposed construction compounds will be constructed at ground level and structures within the compound will be spaced sufficiently to allow any overland flow to pass through the compound without being impeded or diverted.

### Bicker Fen Substation

6.3.9 Surface water flood mapping shows that there are isolated areas at risk of flooding associated with topographical depressions within the Bicker Fen Substation. There are, however, no overland flow routes extending through the substation site. It is considered, therefore, that any new permanent structures or any temporary stockpiled materials from excavations will have no impact on pluvial flooding.

### Overall Impact of Proposed Development on Pluvial Flood Risk

6.3.10 Overall, there are elements of the Proposed Development that individually could have a minor effect on pluvial flood risk. Cumulatively these minor impacts could result in a more significant impact on pluvial food risk and, therefore, mitigation measures are required. Pluvial flood risk mitigation measures are discussed in Section 7.2.41.

## 6.4 Surface Water Runoff

### Solar Array Area

6.4.1 The solar panels will be supported on piles driven into the ground without any form of concrete base. This would occupy minimal ground surface area, and their presence would not affect the present character of the ground. Rain falling on the panels will run off onto the ground and disperse naturally, mimicking the existing greenfield characteristics.

6.4.2 There is limited empirical evidence of the effect of solar development on surface water runoff. The research paper 'Hydrologic Response of Solar Farms'[17] , however, found that, with well-maintained grass underneath the panels, the solar panels themselves did not have a significant impact on the runoff volumes and peak runoff rates. There will, therefore, be a negligible increase in runoff reaching the Site boundary as a result of the solar panels.

6.4.3 There are a number of structures associated with the BESS units, Onsite Substation, and transformers located across the Solar Array Area that will act as impermeable surfaces.

6.4.4 The proposed access tracks will be constructed from crushed aggregate which will generally act as a semi-permeable surface, retaining some surface water during a storm event.

6.4.5 As a result of the increased impermeable area, the rate and volume of surface water runoff may increase and mitigation measures will, therefore, be required.

### Cable Route Corridor

6.4.6 The proposed cabling will be installed underground, and the trench backfilled with arisings. There will, therefore, be no increase in impermeable area. There will also be no increase in impermeable area where trenchless methods are used.

6.4.7 The proposed cable route will, therefore, have no impact on the risk of surface water flooding.

6.4.8 The proposed temporary compounds will be constructed on open agricultural land and will be surfaced with crushed aggregate. There will also be a number of access routes for plant which will also comprise impermeable surfacing. There will, therefore, be an increase in the rate and volume of surface water

[17] Cook L. M. (2013) *Hydrologic Response of Solar Farms* (J. Hydrol. Eng., 2013, 18(5): 536-541)

runoff as a result of these temporary works during the construction phase which will require mitigation.

### Bespoke Access Road

6.4.9 The surface materials include a stone surfaced road, with asphalt surface within 10m of public highways (see **Appendix 2.2: Bespoke Access Road Construction Method Statement (Document Ref: 6.3 ES Vol.1, 6.3.5)** for more detail). Due to the amount of traffic on the road, the stone will be compacted and, therefore, it is likely to act as an impermeable surface. There will, therefore, be an increase in surface water runoff and mitigation measures will be required.

6.4.10 The soil stockpiles adjacent to the access tracks will be placed on existing flat ground. The rate and volume of runoff from the sloped sides of the stockpiles would be higher than the current runoff rate from the flat ground. Slopes will be vegetated to minimise runoff; however, further mitigation measures may be required to manage runoff.

### Bicker Fen Substation

6.4.11 The proposed extension works to the Bicker Fen Substation will result in an increase in impermeable ground cover during the construction and operational phases. It is recognised, therefore, that the existing rate and volume of surface water runoff may increase as a result of the proposed extension works.

6.4.12 Appropriate mitigation is proposed, as detailed in Sections 7 and 8, to ensure the risk of flooding to surrounding areas is not increased as a result of the proposed extension works.

### Overall Impact of Proposed Development on Surface Water Runoff

6.4.13 Overall there are elements of the Proposed Development that could increase the rate and volume of surface water runoff significantly. Cumulatively these impacts could result in a significant increase in off-site flood risk and, therefore, mitigation measures are required. Flood risk mitigation measures are discussed in Section 7.2.41 and a surface water management plan is outlined in Section 8.

## 6.5 Groundwater Flooding

### Solar Array Area

6.5.1 Solar panel piles may extend up to 2.5m below ground level, subject to ground conditions. The existing field underdrainage, as shown on Drawing No. ST19595-138 ‘Existing Drainage’, is to be retained and will remain operational. Groundwater levels will, therefore, continue to be well-managed and the piles will have no impact on the risk of groundwater flooding. Mitigation measures will, therefore, not be required.

6.5.2 If works to install the foundations of the BESS and Onsite Substation and other structures encounter groundwater, mitigation during construction may, therefore, be required. Once the foundations are installed, however, groundwater will return to a pre-development level and there will be no impact. Long term mitigation will, therefore, not be required.

### Cable Route Corridor

6.5.3 The cable trenches will generally be up to 2m deep and it is possible that they will intersect the groundwater table where groundwater levels are high, causing ingress into the cable trench. This will require mitigation (see Section 7.5).

### Bespoke Access Corridor

6.5.4 The proposed works for the Bespoke Access Road will be at ground level and, therefore, there will be no below ground works that will interact with the groundwater table. Mitigation measures will not be required.

### Bicker Fen Substation

6.5.5 As part of Work No. 4A, underground electrical cables will be installed within the substation site. The cable trenches will generally be up to 2m deep and it is possible that they will intersect the groundwater table where groundwater levels are high, causing ingress into the cable trench. This will require mitigation (see Section 7.5).

6.5.6 If works to install the foundations of the substation extension and other structures encounter groundwater, mitigation will be required. Once the foundations are installed, groundwater will return to a pre-development level and there will be no impact. Long term mitigation will, therefore, not be required.

## 6.6 Climate Change

6.6.1 Climate change can be expected to cause an increase in rainfall intensity during the lifetime of the Proposed Development, resulting in an increase in surface water runoff rates and volumes.

6.6.2 The Proposed Development comprises a temporary structure with a modelled operational lifespan of up to 40 years (being the expected operational life of the solar PV modules). As per the Environment Agency guidance[18], the climate change allowances for peak rainfall intensity, for Essential Infrastructure located in Flood Zone 3 within the Witham Management Catchment, are 35% for the 1 in 30 year and 40% for the 1 in 100 year return period events. These are the Upper End allowances.

6.6.3 It is considered, therefore, that the risk of surface water flooding could increase as a result of climate change and that mitigation measures are required. Mitigation measures are discussed in detail in Section 7, and surface water management is discussed in Section 8.

[18] Available: https://environment.data.gov.uk/hydrology/climate-change-allowances/rainfall Accessed December 2024

# 7. FLOOD RISK MITIGATION MEASURES

7.1.1 The assessment has indicated that mitigation measures are required for:

- The impact of the Proposed Development on fluvial flooding;
- The impact of the Proposed Development on surface water flooding;
- The anticipated increase in surface water runoff due to increased impermeable area and climate change.

7.1.2 Furthermore, the assessment has identified that the Site may be at risk of groundwater flooding and/or flooding from reservoirs when also impacted by fluvial or other forms of flooding. It is considered that the mitigation measures detailed below for fluvial and surface water flooding will also provide mitigation for flooding from these sources.

## 7.2 Fluvial Flooding

7.2.1 The fluvial flood modelling shows that certain areas within the Site are at a High risk of fluvial flooding. As stated in the EA Section 42 response (see Appendix 3), to ensure that the development is appropriately resilient to flood risk and remains operational, a freeboard allowance must be incorporated into the design of the Site and, therefore, "*any operational elements of the proposal must be located 600mm above the 1% annual probability (plus climate change) flood event*".

7.2.2 Whilst the design storm event is the defended 1 in 100 year + 32% climate change return period event, the freeboard allowance for the solar panels is based on the 1 in 100 year + 32% climate change 'breach' scenario to provide a worst-case estimate of panel heights for the purposes of the Environmental Impact Assessment.

7.2.3 The defended 1 in 100 year + 32% climate change return period event is used as the design flood event for all other aspects of the Proposed Development to determine appropriate mitigation measures such as floodplain compensation.

### Solar Array Area

7.2.4 The Site design has allowed for the leading edge of the solar panel tables to be raised by 600mm in areas shown to be affected by flooding in the 100 year + 32% climate change 'breach' event.

7.2.5 By raising the height of the solar panel tables rather than raising ground levels, the loss of floodplain storage will be minimal and any fluvial flood flows would be able to pass beneath the panels unimpeded with no diversion.

7.2.6 The solar panel tables to be used within the Proposed Development are shown on **Illustrative Solar Table Cross Section and Elevation (Document Ref: 2.7)**. The standard panel structure will have a maximum height of 3.5m with a minimum leading edge of 0.8m above ground level. This will provide sufficient freeboard for all areas of the Solar Array Area unaffected by flooding or where flooding is less than 0.2m in depth.

7.2.7 Where flood depths are deeper than 0.2m, panels will be taller, with a maximum height of 3.9m, and a minimum leading edge of 1.3m above ground level. This allows for 600mm freeboard above the maximum modelled flood depth of 0.69m for the 1 in 100 year + 32% climate change 'breach' scenario.

7.2.8 Drawing No. ST19595-457 'Required Minimum Panel Heights' identifies the areas of the Solar Array Area where standard and raised solar panels are required.

7.2.9 In order to reduce the risk of debris accumulating at the fence panels during a flood event and impeding flood flows, the mesh spacing at the base of the fence will be widened.

7.2.10 Transformers will be constructed on raised ground to provide 600mm freeboard above the defended 1 in 100 year +32% climate change flood depth. The height that the transformers will need to be raised by is location dependant due to the variation in the depth of flooding across the Solar Array Area. The final elevation of the individual raised platforms is to be confirmed with the Environment Agency at the detailed design stage.

7.2.11 It is proposed to lower areas of higher ground adjacent to the flood extent in order to provide additional storage in continuity with the existing floodplain.

7.2.12 Approximately 3.5% of the total BESS and Onsite Substation area, in the north-eastern corner, is shown to be located within the defended 1 in 100 year +32% climate change scenario flood extent. It is necessary to ensure that the electrical infrastructure remains operational in the event of a flood and to provide appropriate freeboard. It is proposed, therefore, that the electrical infrastructure is either raised or protected by a wall for the defended 1 in 100 year + 32% climate change flood event, plus a 600mm freeboard allowance.

7.2.13 The construction of the 'plateau' will result in a minor loss of floodplain storage where ground levels are raised as discussed further below. Shallow scrapes, located immediately outside of the flood extent, will provide this compensation.

## Cable Route Corridor

7.2.14 During construction, stockpiled arisings from the trench excavations could result in a loss of floodplain storage and impede existing flood flow routes. It is proposed, therefore, that stockpiles are located outside of the extent of the defended 1 in 100 year flood event.

7.2.15 Where this is not feasible, floodplain compensation will be required. In order to minimise the impact on floodplain storage, the construction methodology will ensure that large sections of trench are not exposed at any one time, thereby reducing the volume of material placed within the floodplain. Details of the location and extent of any temporary stockpiles will be determined post-consent at which stage it will be determined if any flood risk mitigation measures are required. Such measures ~~will be~~are secured via the outline Construction Environmental Management Plan (oCEMP) ~~-~~and associated DCO Requirement 12.

7.2.16 Limiting the extent of the temporary stockpiles will also ensure that potential impacts on flood flow routes are also kept to a minimum. The excavated materials will be placed to ensure a 1m gap is provided at 10m intervals for any linear stockpiles. Furthermore, the stockpiling of materials within the floodplain will not be undertaken during periods of prolonged wet weather or when flood warnings are in place.

7.2.17 Where an open cut channel is used to install the cable across a watercourse, the watercourse may either be dammed temporarily with water pumped downstream or the watercourse itself be temporarily diverted. To mitigate any increased risk of flooding associated with this construction methodology appropriately designed over pumping and/or diversion systems will be put in place to ensure continuity of flows.

## Bespoke Access Corridor

7.2.18 The ~~permanent~~ stockpiling of materials within the Bespoke Access Corridor for the duration of the Proposed Development has the potential to impede existing flood flow routes and could result in a loss of floodplain storage, as detailed in Section 6.2. The stockpiled materials will be removed upon decommissioning of the Bespoke Access Road.

7.2.19 In the first instance, stockpiled materials will not be located within the 1 in 100 year + 32% climate change design flood extent. ~~The~~Figure 6.31 Landscape Strategy Plan (**Document Ref: 6.4.42 ES Figure 6.31**) indicates that the stockpile locations do not encroach into the modelled 1 in 100 year + 32% climate change flood extent. However, where this is not feasible, the stockpiles will be placed to ensure a 1m gap is provided at 10m intervals. Should it be necessary to place ~~permanent~~ stockpiles within the design flood extent, floodplain compensation will be provided as detailed below.

7.2.20 Offices and welfare cabins located within the temporary construction compounds and within the 1 in 100 year flood extent will be raised above ground on stilts to ensure flood water does not enter the cabins and to allow flood flows to pass beneath without diversion or displacement.

## Bicker Fen Substation

7.2.21 The majority of the proposed works to the existing substation during the construction and operational phases of the Proposed Development will have no impact on floodplain storage. The work to install the underground cable (Work No. 4A) will result in stockpiled arisings, which will be placed adjacent to the cable trench within the floodplain. As per stockpiles within the wider Cable Route Corridor, the length of the stockpiles will be kept to a minimum and regular 1m gaps will be included at 10m intervals.

7.2.22 The proposed substation extension (Work No. 5B) will comprise either an outdoor Air Insulated Switchgear (AIS) or indoor Gas Insulated Switchgear (GIS) structure. The AIS infrastructure would have a total external footprint of approximately 0.9ha and the GIS building would have a footprint of less than 0.15ha. Further detail is provided in Section 2.13 **Chapter 2: Proposed Development (Document Ref: 6.2 ES Volume 1, 6.2.2).**

7.2.23 As detailed in Section 6.2 of this report, the proposed works at Bicker ~~fen substation~~Fen Substation have the potential to result in a minor loss of floodplain storage (c. 1600m$^3$). To provide true floodplain compensation, ground levels would need to be lowered in areas in continuity with the existing floodplain in the catchment where the ~~proposed development~~Proposed Development would be situated. The Bicker Fen Substation is, however, located within an extensive area of flat low-lying ground. The existing infrastructure is situated on a platform set at approximately 2mAOD. Approximately 2.3ha of land within the substation site lies at elevations greater than 2mAOD and, with the exception of temporary stockpiles at the entrance, the maximum ground level within the substation site is approximately 2.6mAOD.

7.2.24 The EA Product 4 flood level data (see Appendix 10 shows that the flood level in the South Forty Foot Drain in the 1 in 100 year +20% return period would be 3.08mAOD adjacent to the site. The 1 in 1000 +20% return period flood level will be 3.12mAOD.

7.2.25 There would, therefore, be no means of providing level-for-level floodplain compensation within the substation site area for any development raised above the 1 in 100 year +20% climate change flood level. The closest area of land above 3.08mAOD is located over 1km to the south of the substation.

7.2.26 For this reason, it was agreed with the Environment Agency that providing floodplain compensation so distant from where floodplain storage is lost, would not provide the intended benefit (ie compensation). Instead, the Environment Agency have advised that mitigation should ensure that new Essential Infrastructure (ie the critical electrical infrastructure associated with the AIS/GIS) within the Bicker Fen Substation is raised above the flood level to ensure it remains operational, and without impacting existing fluvial flood flow routes.

7.2.27 As the AIS will comprise a number of small structures in isolation, it is considered that flood flows would be able to pass between the structures unimpeded. By raising the critical equipment above the 1 in 100 year plus climate change flood level with 600mm freeboard, the substation will remain operational.

7.2.28 The GIS building would comprise a single building containing the switchgear. If it is not feasible to raise the floor level of the building above the design flood level, the critical equipment within the building will be raised above the 1 in 100 year plus climate change flood level with 600mm freeboard to ensure it remains operational.

## Other

7.2.29 Temporary and permanent watercourse crossings are designed so the soffit level of the bridge complies with the requirements of the Environment Agency and IDB to ensure that there is no increase in the risk of flooding. ~~The Environment Agency has requested that the~~The soffit level of any bridges across Main Rivers, ~~is~~will be set at 600mm above the 1 in 100 year flood level for temporary crossings; and the 1 in 100 year + climate change flood level for permanent crossings. It should be noted, however, that ~~here~~there are no bridge crossings (permanent or temporary) proposed across Main Rivers.

7.2.30 Bridge abutments are set back a minimum of 1m from the bank top as requested by the Environment Agency and this will provide opportunity for out of channel flood flows to pass unimpeded and retain riparian connectivity.

7.2.31 Typical cross sections for the proposed bridge crossings are shown on Illustrative Temporary Bridge designs for Bridges over Watercourses (Document Ref: 2.17) and Illustrative Permanent bridge designs for Bridges over Watercourses (Document Ref: 2.18).

7.2.32 Open span crossings are used wherever feasible to do so. In situations where culverts are used, the watercourse crossing hierarchy will be followed favouring arched culverts over single or double-piped culverts. The most appropriate design will be selected based on ground investigations for each proposed culvert and the design will ensure that the capacity of all culverts is sufficient for the design storm event. The watercourse crossing hierarchy will also be followed where existing crossings are upgraded.

7.2.33 To ensure that the EA flood defence asset along Hodge Dike remains operational and able to protect the Proposed Development and wider area, a 9m buffer has been provided from the toe of the flood defence embankment. This will be unfenced and there will be no built infrastructure within the buffer zone, to ensure access for maintenance and emergency responses is unimpeded.

7.2.34 Where the proposed cable crosses beneath flood risk management assets such as flood defence embankments on Main Rivers, it will be installed at sufficient depth to ensure that any foundations are not affected. All proposed bridge crossings are subject to detailed design, which is secured via requirement 5 in the **Draft DCO (Document Ref: 3.1)**, and the appropriate licences and consents will be sought from the relevant parties as set out in the Consents and Licenses Statement (**Document Ref 5.4**).

## Floodplain Compensation

7.2.35 NPS EN-1, at paragraph 5.8.~~41~~12, states that *"~~energy projects~~Development should ~~not normally~~ be ~~consented within Flood Zone 3b….., or on land expected~~designed to ~~fall within these zones within its~~ ensure there is no increase in flood risk elsewhere, accounting for the predicted impacts of climate change throughout the lifetime~~. This may also apply where land is subject to other sources of flooding (for example surface water). However, where essential energy infrastructure has to be located in such areas, for operational reasons, they should only be consented if~~ of the development ~~will not result in a~~. There should be no net loss of floodplain storage~~,~~ and ~~will not impede water flows~~any deflection or constriction of flood flow routes should be safely managed within the site. Mitigation measures should make as much use as possible of natural flood management techniques."*

7.2.36 It is acknowledged in Section 6.2 of this report that there will be a loss of floodplain storage as a result of the Proposed Development.

7.2.37 Section 6.2 of this report provides a worst-case estimate of the potential loss of floodplain storage resulting from the Proposed Development. This has been assessed using 200mm depth bands which indicates that the elevation at which the floodplain storage is lost is quite variable.

7.2.38 The largest potential loss is associated with the ~~permanent~~ stockpiles of material within the Bespoke Access Corridor; and minimal losses are anticipated from the installation of the BESS plateau, transformer stations, vehicular bridges and solar panel piles.

7.2.39 To ensure there is no net loss of floodplain storage, and to accord with NPS EN-1, it is proposed to provide level-for-level and volume- for-volume floodplain compensation within the Order Limits. Analysis of ground levels outside of the defended 1 in 100 year + 32% climate change flood extent has been undertaken to identify suitable areas where ground levels could be lowered to provide the required compensation on a level-for-level basis.

7.2.40 To determine the approximate plan area required to provide the floodplain compensation, the volume has been divided by 0.2m (the depth banding). This is an illustrative exercise to demonstrate that there is sufficient space available within the Order Limits to provide compensation for the worst-case estimate of floodplain storage loss. As such, in determining the plan areas, certain elevation bands have been grouped together to avoid individual and isolated compensation areas in so far as possible.

7.2.41 The 'Indicative Floodplain Compensation Areas' drawing (Drawing No ST19595-542) indicates the areas where level-for-level and volume-for-volume floodplain compensation could be provided, and the approximate plan areas associated with the grouped elevation bands. This demonstrates that there is sufficient space within the Order Limits to provide the necessary floodplain compensation. It should be noted, however, that this is illustrative only and subject to change following detailed design. There are other areas within the Solar Array Area that are large enough and at the correct elevations to provide level-for-level floodplain compensation, that could be used as an alternative to those areas shown on Drawing No ST19595-542.

7.2.42 A comparison between the floodplain storage loss, and the compensation provided on a level-for-level basis is provided in Table 8 below. This demonstrates that the compensation provided is equal to or greater than the floodplain storage loss. It should be noted that these figures are based on the floodplain compensation areas shown on Drawing No ST19595-542. All floodplain compensation details are illustrative only and subject to change following detailed design.

**Table 8 Comparison of Floodplain Storage Loss vs. Floodplain Compensation on Level-for-Level basis (Illustrative Only)**

| 200mm Ground Elevation Bands (mAOD) | Floodplain Loss ($m^3$)[Note 2] | Floodplain Compensation Required ($m^3$)[Note 3] | Total Floodplain Compensation Provided ($m^3$)[Note 1] | Difference ($m^3$) |
|---|---|---|---|---|
| 1.2-1.4 | 79 | 95 | 134 | +39 |
| 1.4-1.6 | 13 | | | |
| 1.6-1.8 | 3 | | | |
| 2.2-2.4 | 26 | 71 | 121 | +50 |
| 2.6-2.8 | 42 | | | |
| 2.8-3.0 | 3 | | | |
| 3.4-3.6 | 33 | 33 | 42 | +9 |
| 3.8-4.0 | 37 | 41 | 55 | +14 |
| 4.0-4.2 | 5 | | | |

| | | | | |
|---|---|---|---|---|
| 4.4-4.6 | 16 | 26 | 190 | +164 |
| 4.6-4.8 | 6 | | | |
| 4.8-5.0 | 4 | | | |
| 5.0-5.2 | 2 | 24 | 51 | +27 |
| 5.4-5.6 | 15 | | | |
| 5.6-5.8 | 6 | | | |
| 6.2-6.4 | 3 | 1260 | 2285 | +1025 |
| 6.4-6.6 | 389 | | | |
| 6.6-6.8 | 35 | | | |
| 6.8-7.0 | 24 | | | |
| 7.0-7.2 | 18 | | | |
| 7.2-7.4 | 51 | | | |
| 7.4-7.6 | 66 | | | |
| 7.6-7.8 | 675 | | | |
| 7.8-8.0 | 384 | 1353 | 1626 | +273 |
| 8.0-8.2 | 288 | | | |
| 8.2-8.4 | 246 | | | |
| 8.4-8.6 | 117 | | | |
| 8.6-8.8 | 132 | | | |
| 8.8-9.0 | 186 | | | |
| 9.0-9.2 | 408 | 2403 | 3300 | +897 |
| 9.2-9.4 | 228 | | | |
| 9.4-9.6 | 252 | | | |
| 9.6-9.8 | 93 | | | |
| 9.8-10 | 96 | | | |
| 10-10.2 | 90 | | | |
| 10.2-10.4 | 84 | | | |
| 10.4-10.6 | 168 | | | |
| 10.6-10.8 | 213 | | | |
| 10.8-11.0 | 156 | | | |
| 11.0-11.2 | 114 | | | |
| 11.2-11.4 | 132 | | | |
| 11.4-11.6 | 168 | | | |
| 11.6-11.8 | 60 | | | |
| 11.8-12.0 | 126 | | | |
| 12.0-12.2 | 15 | | | |
| 12.6-12.8 | 9 | 78 | 78 | 0 |
| 12.8-13.0 | 66 | | | |
| 13.0-13.2 | 3 | | | |
| 14.0-14.2 | 12 | 84 | 126 | +42 |
| 14.2-14.4 | 36 | | | |
| 14.4-14.6 | 36 | | | |
| 19.8-20.0 | 108 | 123 | 165 | +42 |
| 20.0-20.2 | 15 | | | |
| 20.8-21.0 | 39 | 42 | 45 | +3 |
| 21.0-21.2 | 3 | | | |
| **TOTAL** | **5633** | **5633** | **8218** | **+2585** |

NOTES:
1. As shown on Drawing No. ST19595-542 Indicative Floodplain Compensation Areas

2. Floodplain storage loss for solar panel piles (6m$^3$) is excluded; however floodplain compensation provided is greater than required by more than 6m$^3$. Floodplain storage loss for solar panel piles occurs across a wide range of elevations due to spatial extent of solar arrays.
3. Floodplain compensation required/provided has been grouped into bands greater than 200mm due to volumes being relatively minimal and associated land requirement being relatively small. Volume losses within each 200mm band for any particular group are of the same order of magnitude. In all cases, compensation is greater than, or equal to, the loss. Figures are indicative only and aim to demonstrate there is sufficient area within the Order Limits to provide compensation.
4. All figures in this Table are indicative only and subject to detailed design.

7.2.43 It is acknowledged that there will be a net loss of floodplain storage resulting from the proposed extension works at Bicker Fen Substation. However, the impact of this loss has been assessed as negligible, with flood depths estimated to increase by approximately 0.13mm in the worst-case scenario estimate (details are provided in Section 6.2 of this report). It is considered, therefore, that flood risk will not increase as result of the estimated floodplain storage loss associated with the proposed extension works at Bicker Fen Substation. This is compliant with NPS EN-1.

## 7.3 Surface Water Flooding

### Solar Array Area

7.3.1 Solar panel tables will also be a sufficient height to allow surface water to pass beneath the panels without risking damage to any electrical equipment. The maximum depth of surface water flooding for the 1 in 100 year event is 0.9m in an isolated area in the south-west of the Solar Array Area (see Drawing No. ST19595-511 'Environment Agency Surface Water Flood Depths (Sheets 1-4)'). Raised panel tables will be used in this area to mitigate the risk of fluvial flooding, and the leading edge of 1.3m above ground level would ensure that the panels are not affected by surface water flooding.

7.3.2 Furthermore, solar PV panels themselves can tolerate being submerged without any detriment to their ability to operate once floodwaters have receded. This is subject to the electrically sensitive components such as the junction box being raised above the flood level. There would, therefore, be minimal impact from localised surface water flooding on the overall operation of the Solar Array Area.

7.3.3 As shown in Drawing No. ST19595-510 'Environment Agency Surface Water Flooding Extents (Sheets 1-4)', the western extent of the Bespoke Access Corridor adjacent to the A17 is situated within an overland flow route extending south-eastwards from higher ground, giving the risk of deep ponding water across the access point during extreme storm events. To mitigate this risk, it is proposed to install additional drainage to allow the continuation of the existing overland flow routes and/or install storage to retain these flows away from the junction.

### Cable Route Corridor

7.3.4 During the construction phase of the Cable Route, open trenches and stockpiled material may impede or divert overland flow routes. In order to ensure flood risk is not increased or overland flows diverted, the construction methodology will ensure that large sections of trench are not exposed at any one time, thereby reducing the volume of material placed above existing ground level.

7.3.5 The excavated materials will be placed to ensure a 1m gap is provided at 10m intervals for any linear stockpiles. Furthermore, the stockpiling of materials will not be undertaken during periods of prolonged wet weather or when flood warnings are in place.

7.3.6 Arisings where trenchless methods are used will also be stored so that flood flow routes are not impeded.

7.3.7 Offices and welfare cabins located within the temporary construction compounds will the raised above ground on stilts to ensure flood water does not enter the cabins and to allow overland flood flows to pass beneath without diversion.

### Bespoke Access Corridor

7.3.8 Where excavated soils are stockpiled adjacent to the road, these will be stored such that overland flows are not impeded, with material located away from major overland flow routes. ~~The~~Figure 6.31 Landscape Strategy Plan (**Document Ref: 6.4.42 ES ~~Figure 6.31~~**) provides indicative locations for the ~~permanent~~ stockpiles ~~along~~of material associated with the Bespoke Access Corridor for the duration of the Proposed Development. The indicative stockpile locations do not interface with the surface water flood risk extents.

7.3.9 The excavated materials will be placed to ensure a 1m gap is provided at 10m intervals for any linear stockpiles that intersect existing overland flow routes.

7.3.10 As stockpiles ~~may~~will be present for the ~~40 year lifespan~~duration of the Proposed Development, and then removed upon decommissioning of the Bespoke Access Road, the climate change scenario for surface water flooding have been used to confirm appropriate flood risk mitigation measures.

7.3.11 Offices and welfare cabins located within the temporary construction compounds ~~will the~~and within the areas at risk of surface water flooding will be raised above ground on stilts to ensure flood water does not enter the cabins and to allow overland flood flows to pass beneath without diversion.

### Bicker Fen Substation

7.3.12 Mapping shows that there are no significant overland flow routes extending through the substation site and, therefore, no mitigation is required.

## 7.4 Surface Water Management

7.4.1 To mitigate the potential increase in flood risk due to increased surface water runoff from the impermeable surfaces within the Proposed Development, and the predicted effects of climate change during the operational lifetime of the Proposed Development, an outline Surface Water Management Plan for the Site is proposed. This aims to mimic the existing greenfield characteristics of the Site.

7.4.2 Discharge of surface water runoff from the proposed drainage networks within the BESS and Onsite Substation site have been restricted to Greenfield rates for all storm events up to and including the 1 in 100 year event, including an allowance for climate change. For flows in excess of this rate, sufficient attenuation has been provided up to and including the 1 in 100 year plus 40% climate change allowance.

7.4.3 Surface water runoff from proposed access tracks and the Bespoke Access Road will be managed to ensure that increased volumes of runoff generated during the 1 in 100 (+40%) year storm event are retained within the Proposed Development.

7.4.4 Soil stockpiles adjacent to the Bespoke Access Road have the potential to cause minor increases in the rate and volume of surface water runoff when compared to the existing scenario. This can be managed with the use of small precautionary drainage ditches at the toe of the stockpiles to intercept and retain runoff.

7.4.5 Runoff from the proposed temporary construction compounds and access roads within the Cable Route Corridor will also need to be managed during the construction phase.

7.4.6 It is considered that with an appropriate Surface Water Management Plan in place that mimics the pre-development characteristics, there will be no increase in flood risk off-site as a result of the development proposals.

7.4.7 The Surface Water Management Plan is discussed in further detail in Section 8.

## 7.5 Groundwater Flooding

7.5.1 Groundwater ingress may occur where below ground works are being carried out. This would primarily affect works to install underground cables, and building foundations. Where any groundwater ingress is encountered within cable trenches and around foundations, this will be dispersed by pumping to adjacent ground. Water will then infiltrate to ground with no impact on groundwater volumes.

7.5.2 The temporary construction compounds will be constructed at ground level and could, therefore, be impacted by groundwater emergence.

7.5.3 To mitigate this risk, offices and welfare cabins located within the temporary construction compounds will be raised above ground on stilts to ensure flood water does not enter the cabins and to allow groundwater flooding to pass beneath without diversion.

## 7.6 Residual Risk

7.6.1 Areas of the Site are shown to be at risk of flooding from fluvial, surface water and artificial sources. Areas of the Site are also susceptible to groundwater flooding. Similarly, climate change and increases in impermeable area are likely to result in increased surface water runoff rates and volumes.

7.6.2 Residual risk is the risk remaining once the mitigation measures (detailed above) have been implemented. Whilst there is always a possibility that the design standards of any proposed flood risk mitigation measures will be exceeded by an extreme storm event, any mitigation will be designed in accordance with the EA guidelines and it is, therefore, considered that the residual risk will be minimal.

## Credible Maximum Scenario

7.6.3 As part of the model sensitivity testing and in accordance with the requirements for Nationally Significant Infrastructure Projects, a credible maximum scenario was simulated within the fluvial model. This is based on the Upper End climate change allowances of a 57% peak river flow uplift and a 40% increase in rainfall. The credible maximum scenario has been used to test the resilience of the Proposed Development and associated flood risk mitigation measures.

7.6.4 The extent of the modelled credible maximum scenario is shown on Drawing No. ST19595-541 'Modelled Flood extent for the Credible Maximum Scenario (~~Fluvail~~Fluvial extreme event) Compared to the Defended 1 in 100 year +32% CC Baseline Scenario'.

7.6.5 Comparing the modelled flood depths for the defended 1 in 100 year 'credible maximum scenario' with the modelled flood depths for the defended 1 in 100 year +32% climate change scenario at 9no. locations across the Solar Array Area shows that the depth of flooding was between 0.01m and 0.13m higher in the credible maximum scenario. Further detail is contained within Aegaea report 'Extreme Event Model Report Ref: 'AEG2934_LN4_Fen_Extreme Event Model Report_001' (see Appendix 2).

7.6.6 The flood extent of the modelled credible maximum scenario is slightly greater than the defended 1 in 100 year +32% climate change scenario flood extent (design event). Therefore, the flood depths within the additional flood extent have been analysed. This has indicated that approximately 26 transformer stations are situated within the credible maximum scenario flood extent, but are unaffected by the design event. The depth of flooding ranges from 5mm to 186mm, with only 4No transformers subject to flood depths greater than 100mm.

7.6.7 The increase in flood depths in the credible maximum scenario is less than the freeboard allowance of 600mm on solar panel heights, transformers and the BESS and Onsite Substation. It is considered, therefore, that the Proposed Development remains resilient in the credible maximum scenario.

## Tidal H++ Scenario

7.6.8 In addition to the requested fluvial extreme climate change event, an extreme tidal event has also been tested within the hydraulic model. The H++ extreme event was requested by the Environment Agency to understand the impact from the extreme tidal event.

7.6.9 It is noted, however, that the Proposed Development is not designed to the H++ scenario. The likelihood of an H++ event is considered negligible given the presence of tidal defences, including the Boston Barrier.

7.6.10 The results of the H++ model scenario show that flooding extends across the majority of the Solar Array Area. Depths within the site range from 1.43m to 6.33m at the sample locations. Depths fall from east to west as expected with flooding originating from the coast and reducing as the flood wave progresses inland. Further detail is contained within 'Extreme Event Model Report Ref: 'AEG2934_LN4_Fen_Extreme Event Model Report_001' (see Appendix 2).

## Breach Scenario

7.6.11 There is a residual risk of a breach in the existing flood defences, which could result in the Proposed Development being inundated. A breach scenario has therefore been included in the fluvial flood modelling. The purpose is to assess the impact of a breach event and test the resilience of the Proposed Development should such an event occur.

7.6.12 Details of the breach event modelling, including the methodology agreed with the Environment Agency, are included in Appendix 2 'Breach Model Report' (Ref 'AEG2934_LN4_Fen_Breach Model Report_003').

7.6.13 The 1 in 100 year +32% climate change breach scenario considers the impact of flooding during a breach in the flood defence on the River Slea, with the breach location centred around 513506.63, 349578.62. The breach extends 20m along the bank each side of this point to generate the 40m wide breach (this location was agreed by the Environment Agency).

7.6.14 As shown on Drawing No. ST19595-446 'Modelled Flood Extent for the 1 in 100 year +32% CC Breach scenario', the extent of flooding in the 1 in 100 year +32% climate change breach scenario would affect fields to the north-east and south-east of Gashes Barn and north of Hodge Dike, and within watercourse channels. Flooding would extend along the Hodge Dike, however, western areas and the majority of central areas of the Solar Array Area would be unaffected.

7.6.15 Drawing No. ST19595-447 'Modelled Flood Depths for the 1 in 100 year +32% CC Breach Scenario' shows that the depth of flooding during the 1 in 100 year +32% climate change breach scenario within the Solar Array Area would be up to 0.69m. Depths are, however, generally below 0.35m on average. Depths greater than 0.35m are coincident with localised, isolated topographical depressions predominantly within the area to the north-east and south-east of Gashes Barn and north of Hodge Dike, and within the watercourse channels.

7.6.16 The height of the leading edge of the solar panel tables has been determined using the modelled flood depths for the 1 in 100 year +32% CC breach scenario to ensure resilience. The flood mitigation measures proposed for the transformer stations in the design flood event, will provide adequate mitigation in a breach event. Furthermore, there are no transformers proposed in locations where the modelled flood depths for the 1 in 100 year +32% climate change breach scenario are greater than 0.6m. The BESS and Onsite Substation area is situated outside the extent of a flooding during a breach event and would not be affected in the breach scenario. It is considered, therefore, that the Proposed Development remains resilient in the modelled breach scenario.

## Exceedance Flows

7.6.17 If the capacity of any proposed drainage features is exceeded during a storm event that exceeds the design return period, it is considered that exceedance flows would follow the existing topography with no risk to areas previously unaffected by surface water flooding. Where these routes extend beyond the Site boundary, this would only impact agricultural land with no risk to dwellings or developed areas.

7.6.18 Where ground levels have been modified within the Solar Array Area, it will be ensured that existing overland flow routes are retained, and exceedance flows would not be diverted to areas previously unaffected.

7.6.19 The Solar Array Area benefits from fluvial flood defences along Hodge Dike and Car Dyke. The condition of the earth embankments is generally shown to be Fair in the EA data. Notwithstanding this, the embankments should be regularly inspected during the operational period and any necessary repairs made to minimise the risk of a breach.

## Safe Access and Egress

7.6.20 Safe access and egress arrangements need to be considered to ensure that operational staff and visitors on site are safe during periods of flooding.

7.6.21 Modelling shows that in the defended 1 in 100 year +32% climate change event (the design storm event), areas within the Proposed Development and its vicinity would be affected by flooding.

7.6.22 The nature of the flooding within the area is generally the result of the widespread overtopping of smaller watercourses along field boundaries within a larger network of land drainage rather than flooding from a single larger river.

7.6.23 This means that there are widespread areas of flooding within the Proposed Development and surrounding areas and, therefore, it is not possible to have an access and egress route from local roads to the BESS and Onsite Substation site solely outside of the defended 1 in 100 year +32% climate change flood event.

7.6.24 The general guidance from the AA, states that vehicles should not pass through water deeper than 0.1m. Based on the Defra/Environment Agency ‘Flood Risks to People Phase 2’ report[19], flood depths of less than 0.25m at velocities of less than 0.5m/s would not pose a risk to people on foot. The guidance states that flooding would pose a ‘danger to some’ at velocities of greater than 2m/s.

7.6.25 Other than small isolated topographical depressions, however, modelled data shows that flood depths on access tracks between the BESS and Onsite Substation site and the primary entrance point in the west of the Solar Array Area, are generally less than 0.1m and do not exceed 0.25m in the defended 1 in 100 year +32% climate change event.

7.6.26 The EA surface water depth mapping (see Drawing No. ST19595-513) shows that the depth of surface water flooding along the route of the access track between the eastern extent of the Bespoke Access Corridor and the BESS and Onsite substation will be less than 0.3m in the 1 in 100 year (Medium Risk) 2040 – 2060 return period.

7.6.27 Velocity modelling undertaken as part of the fluvial flood modelling shows that the velocity of flooding along open ground within the Solar Array Area, outside

[19] Defra/Environment Agency (2006) Flood Risks to People Phase 2 FD2321/TR2 Guidance Document

of watercourses, would generally be less than 0.4m/s in the defended 1 in 100 year +32% climate change event. Along the route of the access track between the eastern extent of the Bespoke Access Corridor and the BESS and Onsite substation, the velocity of flooding will not exceed 0.4m/s.

7.6.28 The EA surface water velocity mapping (see Drawing No. ST19595-525) shows that the velocity will be less than 0.5m/s in the 1 in 100 year (Medium Risk) 2040 – 2060 return period.

7.6.29 This would mean, therefore, that the egress route would be passable by vehicle and/or persons on foot during this return period.

7.6.30 In the event of a flood where access and exit arrangements are not considered safe, safe refuge may be provided for staff and visitors within the control room facilities within the BESS and Onsite Substation site development platform which will be located outside the 1 in 100 year +32% climate change flood extent, with finished floor levels constructed above the design flood level for this scenario.

7.6.31 As a matter of good practice, all buildings and infrastructure will incorporate flood resilient design and construction principles where practical. Exact details will be confirmed at the detailed design stage.

7.6.32 A flood warning and evacuation plan will be prepared for the Energy Park. The plan will provide detail on the Environment Agency Flood Warning service and what actions should be taken following the notification of a potential flood event such as establishing safe access and egress routes, and safe refuge locations.

# 8. OUTLINE DRAINAGE STRATEGY

## 8.1 Surface Water Drainage Rationale

8.1.1 Surface water runoff from the Proposed Development will be controlled on the Site to ensure that there is no increase in risk of flooding to areas downstream of the Site and the Proposed Development itself.

8.1.2 Surface water runoff will be managed separately within the Solar Array Area, the BESS and Onsite Substation site, Bespoke Access Road and Cable Route Corridor areas.

8.1.3 The Planning Practice Guidance stipulates a hierarchy for the disposal of surface water that should be followed as part of any surface water drainage design. This hierarchy is as follows:

1) into the ground (infiltration);
2) to a surface water body;
3) to a surface water sewer, highway drain or another drainage system;
4) to a combined sewer.

8.1.4 In accordance with the hierarchy, it is proposed that surface water runoff will be discharged via infiltration, where feasible to do so. The infiltration rate of the soils and subsoils within the Site area will be confirmed with percolation testing undertaken in accordance with Building Research Establishment (BRE) Digest 365 guidelines[20].

8.1.5 Where it is not feasible to discharge via infiltration alone, surface water runoff will be discharged to the adjacent watercourses, in accordance with item 2 of the hierarchy.

## 8.2 Outline Surface Water Drainage Strategy: BESS and Onsite Substation Site

8.2.1 In accordance with the drainage hierarchy, Soilscapes mapping describes the underlying soil at this location of the Site as 'Loamy and clayey soils of coastal flats with naturally high groundwater.' It is unlikely, therefore, that infiltration will be viable. Furthermore, due to the need to provide firewater runoff management within the development (see Section 8.3), all areas within the BESS and Onsite Substation site will need to be lined with impermeable geomembrane to prevent the infiltration of small amounts of potentially contaminated fire water to the ground.

8.2.2 It is proposed, therefore, to discharge surface water runoff to the drainage ditch located to the south of the BESS and Onsite Substation site. Discharge has been restricted to the greenfield runoff rate of 1.44l/s/ha as calculated using the HR Wallingford UK SuDS 'Greenfield runoff rate estimation' tool (see Appendix 4).

[20] Available: productattachments_files_b_r_bre_digest_365.pdf Accessed January 2025

8.2.3 Impermeable areas will consist of the roof areas and concrete bases of the BESS units, roof areas of all other structures and the internal Access Roads. Structures will be surrounded by semi-permeable aggregate, although this has also been considered 100% impermeable for the purposes of this assessment.

8.2.4 The proposed outline surface water management plan for the BESS and Onsite Substation site is shown on Drawing No. ST19595-342 'BESS and Onsite Substation Surface Water Management Plan'.

8.2.5 For the purposes of surface water management, the area (based on Illustrative Layout Plan of BESS and Onsite Substation (Document Ref: 2.6)) has been divided into three sub-catchments as shown on Drawing No. ST19595-342The proposed impermeable areas for each sub-catchment and the resulting required attenuation for the 1 in 30 year +35% climate change and 1 in 100 year +40% climate change storm events are detailed in Table 9 below, with full calculations provided in Appendix 5. Climate change allowances are based on the most recent UKCP18 climate change data.

**Table 9. Required Attenuation BESS Area and Onsite Substation**

| CATCHMENT | CONTRIBUTING AREA (HA) | DISCHARGE RATE (L/S) | REQUIRED ATTENUATION (M3) | |
|---|---|---|---|---|
| | | | 1 IN 30 +35%CC | 1 IN 100 +40% CC |
| 1 (BESS Area; North) | 5.65 | 11.12 | 3576 | 4897 |
| 2 (BESS Area; South) | 2.15 | 2 | 1482 | 1986 |
| 3 (Substation) | 2.7 | 2 | 1889 | 2522 |
| Total | 10.5 | 15.12 | 7594 | 9405 |

8.2.6 It has been assumed that there will be two separate discharge points into the drainage ditch which have been restricted to a total of 15.12l/s based on the total impermeable area. Discharge from Catchments 2 and 3 will, accordingly, be restricted to 2l/s to ensure the available space for attenuation is utilised efficiently.

8.2.7 Surface water flows in excess of the restricted discharge rates will be retained within the Site. The aggregate surrounding the BESS units and Onsite Substation will provide the primary form of attenuation. Table 10 details the attenuation provided within the aggregate for each sub-catchment based on an assumed 0.3 void ratio and 0.5m depth of aggregate.

**Table 10. Provided Attenuation for the BESS Area and Onsite Substation**

| CATCHMENT | REQUIRED ATTENUATION (M3) | AREA OF AGGREGATE (M2) | ATTENUATION PROVIDED WITHIN AGGREGATE (M3) | ADDITIONAL ATTENUATION REQUIRED (M3) |
|---|---|---|---|---|
| 1 (BESS Area; North) | 4897 | 27120 | 4068 | 829 |

| | | | | |
|---|---|---|---|---|
| 2 (BESS Area; South) | 1986 | 10320 | 1548 | 438 |
| 3 (Onsite Substation) | 2522 | 17550 | 2633 | 0 |

8.2.8 The 829m$^3$ of additional attenuation required for Catchment 1 has been provided within a 6m wide grass lined swale, located east of the BESS platform. This swale will provide 907m$^3$ of attenuation at 0.7m depth with 0.3m freeboard, with a 1 in 3 side slope and total length of 255m, also accounting for the additional attenuation required from the adjacent access track.

8.2.9 The additional attenuation for Catchment 2 has been provided within a detention basin located to the south of the BESS units. The basin will provide 450m$^3$ of attenuation at 0.7m depth with 0.3m freeboard, and 825m$^2$ area at surface level.

8.2.10 No additional attenuation is required for Catchment 3; however, flows will be discharged via the detention basin in Catchment 2 in order to provide water quality treatment.

## 8.3 Outline Firewater Management Strategy

8.3.1 Requirement 6 in the **Draft DCO (Document Ref: 3.1)** secures that a Battery Safety Management Plan ('BSMP') must be prepared, substantially in accordance with the Outline Battery Safety Management Plan. This will be prepared in consultation with the Lincolnshire Fire & Rescue Service and approved by LCC. The firefighting strategy will form part of the emergency response plan within this document and its exact contents will depend on a range of factors including battery technology, prevailing guidance, suppression, spacing, and the comments of Lincolnshire Fire & Rescue Service. It is not the intention of the FRA to duplicate the BSMP, rather, the Outline Firewater Management Strategy intends to reflect the anticipated (i.e. outline) emergency response, and to describe how the resultant water runoff will be managed. Should the approved BSMP propose non water strategies or reduced water strategies, there would be no or reduced water management requirements.

8.3.2 The BESS is designed to allow storage of all firefighting runoff with the BESS platform area, with an allowance for a heavy rainfall event coinciding. Automatic shutoff valves will be installed at outfall points into the wider drainage network to retain any potentially contaminated firewater close to the affected area to minimise any mixing with uncontaminated water. The automatic shutoff valves will have a manual override in case the automation fails and an appropriate maintenance programme will be put in place to ensure these remain operational. The BESS platform will also be lined to prevent firewater from infiltrating to the underlying ground. There is, therefore, no pathway for potentially contaminated water to discharge to downstream watercourses or infiltrate to the ground.

8.3.3 After the fire has been managed, pollution analysis including laboratory testing of water samples to a UKAS/MCERTS or equivalent standard will always be conducted before removing from site (if polluted) for treatment and disposal at an appropriately licensed facility or releasing into drainage systems, if safe to do so. Any contaminated sediment within the aggregate in the vicinity of the affected area will also be removed and disposed of off-site. In the instance that water is released into the environment, following confirmation that it contains no pollutants, the relevant water discharge permits will be applied for.

8.3.4 A worst-case scenario of a four hour firefighting water discharge event of 1,500 litres per minute (i.e. 360m$^3$ in total) within a single section of BESS units, coinciding with a 1 in 10 year (+35%CC) storm event has been assumed for the purposes of estimating the required storage capacity for potentially contaminated firewater runoff.

8.3.5 Based on Drawing No. ST19595-383, an individual section of BESS units will have an impermeable area of 0.31ha. A 1 in 10 year (+35% CC) storm event onto this area would generate approximately 185m$^3$ of runoff. Including the 360m$^3$ of firewater, a total of approximately 545m$^3$ storage would therefore be required.

8.3.6 Assuming a depth of aggregate of 0.5m, approximately 465m$^3$ of storage will be provided within the aggregate surrounding the BESS units in a single section. In a scenario where automatic shutoff valves are installed at the outfall from each section additional storage would, therefore, be required outside of the section.

8.3.7 The lined central lagoon in the centre of the BESS and Onsite Substation site will, however, provide a further 360m$^3$ of storage. Sufficient capacity would, therefore, be available to attenuate the 545m$^3$ of potentially contaminated firewater runoff generated in a worst case scenario event.

8.3.8 There will, therefore, be no risk to downstream areas in the event of a fire within the BESS platform area. The attenuation calculations are contained in Appendix 5.

8.3.9 The full firewater management strategy will be confirmed as part of the detailed design and in the BSMP.

## 8.4 Outline Surface Water Drainage Strategy: Solar Array Area

8.4.1 The drainage network within the Solar Array Area will manage runoff from:

- Solar panel arrays
- Transformers and other structures
- Access tracks

8.4.2 The solar panels themselves occupy minimal ground surface area, and their presence would not affect the current character of the ground. The research paper 'Hydrologic Response of Solar Farms'[17] concludes that, with well-maintained grass underneath the panels, the solar panels themselves would not have a significant impact on the runoff volumes and peak runoff rates. There is considered to be a negligible increase in runoff reaching the Site boundary as a result of the solar panels and, therefore, no formal drainage is required. Precautionary swales could be implemented on field boundaries to account for any increase in runoff, although considered to be minimal.

8.4.3 Surface water runoff from buildings (transformers) and access tracks will drain to adjacent swales implemented downslope to capture runoff. These will follow the topography of the Site and ultimately discharge to the existing land drainage network. The swales will be unlined to allow runoff to disperse naturally via infiltration where soil type allows. To maximise attenuation on sloped ground, check dam structures will be constructed within the swales at regular intervals. During more intense storm events, where surface water runoff exceeds the infiltration capacity of the ground within the swales, check dams will be overtopped by surface water runoff with flows continuing towards the outfall to the existing drainage ditch network. The relevant water discharge permits will be obtained from the appropriate approving body prior to any discharge occurring.

8.4.4 To ensure there is no increase in the risk of flooding to downstream areas as a result of the Proposed Development, swales will have sufficient capacity to retain the additional runoff volume generated from the impermeable surface during the 1 in 100 year plus 40% climate change 6-hour storm event, compared to the pre-development greenfield surface.

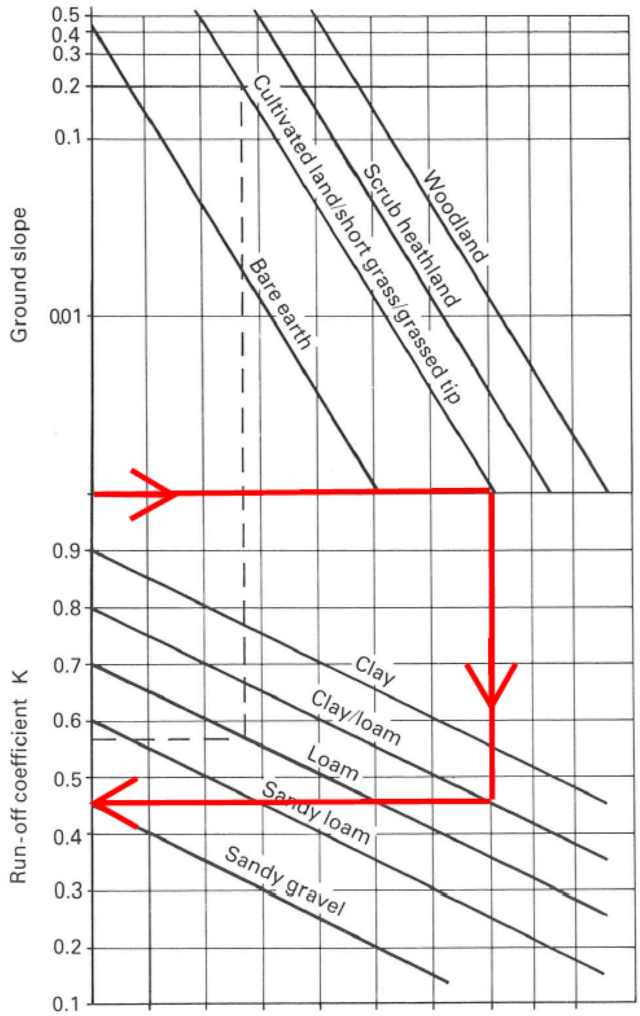
8.4.5 Under the existing 'greenfield' scenario, any rain falling on the fields will disperse naturally via infiltration or would form overland flow. The proportion of rainfall that runs off the land is dependent upon the underlying soil conditions, vegetation cover and the gradient of the field.

8.4.6 There are various methods to estimate the runoff percentage from a greenfield Site. The 1982 National Coal Board ‘Technical Management of Water in the Coal Mining Industry’[21] report contains a nomogram to determine the runoff coefficient for coal tips based on the ground slope, vegetation cover and soil conditions. This is considered an appropriate method for estimating runoff from any sloped ground.

8.4.7 The existing Site is relatively flat with little fall on ground levels and based on this method (see Figure 1), the runoff coefficient for short grass, with a clay loam soil type would be a minimum of 45%.

[21] NATIONAL COAL BOARD (1982) *Technical Management of Water in the Coal Mining Industry*

**Figure 1. Runoff Coefficient Nomogram (from Technical Management of Water in the Coal Mining Industry report)**




8.4.8 The Greenfield Runoff Estimation UK SuDS Tool shows the Standard Percentage Runoff for the soil type would be 30%. This has been used in the attenuation calculations.

8.4.9 The typical dimensions of the swales have been calculated based on the required attenuation for a 100m length of access track at 5m width with 100% runoff. Table 11 below summaries the existing and post-development runoff volumes and the required attenuation for the 1 in 100 year +40% climate change, 6 hour storm event, see Appendices 6 to 8 for full calculations and required swale dimensions.

**Table 11. Required Attenuation for 100m Length of Access Track**

| | CONTRIBUTING AREA (M2) | PERCENTAGE RUNOFF (%) | RUNOFF VOLUME (M3) |
|---|---|---|---|
| Existing | 500 | 30 | 13.1 |
| Post-development | 500 | 100 | 43.8 |
| Required attenuation for 1in100(+CC) year, 6 hour storm event for 100m length of Access Track at 5m wide. | | | 30.7 |
| Calculations assume no infiltration and no discharge as worst case scenario estimates | | | |

Required attenuation = Post-development Runoff Volume – Existing scenario Runoff Volume

8.4.10 In order to store the required 30.7m$^3$ attenuation for the 100m length of access track, the swale would need to be 0.35m deep and 2.3m wide bank-to-bank, with 1:3 side slopes and a longitudinal gradient of 1 in 1000. A 100m length of swale at this dimension will provide 33.2 m$^3$, sufficient storage for a 100m length of access track.

8.4.11 The required attenuation and swale dimensions have also been calculated for 1No. individual transformer unit (21m$^2$ impermeable area). Table 12 12 below summaries the existing and post-development runoff volumes and the required attenuation for the 1 in 100 year +40% CC, 6 hour storm event, see Appendices 9-11 for full calculations and required swale dimensions.

**Table 12 12. Required Attenuation for 1No. Transformer**

| | CONTRIBUTING AREA (M2) | PERCENTAGE RUNOFF (%) | RUNOFF VOLUME (M3) |
|---|---|---|---|
| Existing | 21 | 30 | 0.6 |
| Post-development | 21 | 100 | 1.8 |
| Required attenuation for 1in100(+CC) year, 6 hour storm event for 1No. Transformer | | | 1.2 |

Calculations assume no infiltration and no discharge as worst case scenario estimates

Required attenuation = Post-development Runoff Volume – Existing scenario Runoff Volume

8.4.12 A 6m length swale would provide the required attenuation for the transformer at 0.35m deep and 2.3m wide bank-to-bank, with 1:3 side slopes, and a longitudinal gradient of 1 in 1000.

8.4.13 Drawing No.ST19595-383 ‘Typical Surface Water Management Plan for Solar Array Area’ shows the typical placement of swales adjacent to the access tracks and transformers along with cross sections of the swales.

## 8.5 Outline Surface Water Drainage Strategy: Cable Route

8.5.1 The proposed cable will be located underground and will not, therefore, alter existing ground levels. There will be no additional impermeable area created as a result of the cable installation. As a result the cable is not considered to result in any increase in surface water runoff or flood risk. It is considered, therefore, that no permanent formal drainage is required for the proposed cable route.

8.5.2 During the construction phase, a temporary haul road will be required for access. Small construction compounds will also be required at strategic locations along the route. Temporary surface water management will, therefore, be required to account for the additional impermeable ground during this time. It is proposed, therefore, to include precautionary swales adjacent to the haul road to capture and attenuate any additional surface water runoff generated**. Plan of Cable Route Working Width (Document Ref: 2.23)** shows the cross section for the temporary haul route, cable trench and the proposed precautionary swales.

## 8.6 Outline Surface Water Drainage Strategy: Bespoke Access Road

8.6.1 Using a similar rationale as used for the access tracks for the Solar Array Area, the required swale dimension for the proposed Bespoke Access Road has been calculated based on the attenuation required for a 6m wide road of 100m length, for the 1 in 100 +40% climate change 6 hour storm event. Table 1313 below summaries the existing and post-development runoff volumes, see Appendix 12-15 for full calculations and required swale dimensions.

**Table 1313. Required Attenuation for 100m Length of Bespoke Access Road**

| | CONTRIBUTING AREA (HA) | PERCENTAGE RUNOFF (%) | RUNOFF VOLUME (M3) |
|---|---|---|---|
| Existing | 0.06 | 30 | 15.8 |
| Post-development | 0.06 | 100 | 52.5 |
| Required attenuation for 1in100(+CC) year, 6 hour storm event for 100m length of Access Road at 6m wide | | | 36.7 |
| Calculations assume no infiltration and no discharge as worst case scenario estimates<br><br>Required attenuation = Post-development Runoff Volume – Existing scenario Runoff Volume | | | |

8.6.2 The Illustrative Bespoke Access Road cross-section single slope **(Document Ref: 2.13)** and Illustrative Bespoke Access Road cross-section dual slope **(Document Ref: 2.15)** show cross sections for the Bespoke Access Road. For the single slope road, a single swale will be required, located down slope of the road. A minimum bank-to-bank width of 2.6m, and a depth of 0.35m will be required to provide the necessary attenuation volume. Where the dual slope roads are proposed, a swale will be required either side of the access track to ensure all runoff is captured. Each swale would need to be a minimum of 1.9m wide bank-to-bank, and of 0.25m depth to provide the required attenuation volume. All swales are subject to detailed design in collaboration with a specialist agricultural drainage contractor.

8.6.3 The swale will also retain runoff from the soil stockpiles extending along the track. For the side of the stockpile facing away from the track, it is proposed to use precautionary swales along the toe of the sideslope.

## 8.7 Outline Surface Water Drainage Strategy: Bicker Fen Substation

8.7.1 The Bicker Fen Substation is served by a surface water drainage network which is assumed to discharge to the surrounding watercourse network, with attenuation primarily provided within a pond feature. This strategy will be retained as part of the proposed works to extend the substation site.

~~8.7.2~~ During the construction phase, aggregate or matting will be used across ~~the entire area~~all landscaped areas of Work No.'s 5A, 5B, 5C and 5D~~. For the purposes of this assessment, it is assumed that this is wholly impermeable with a total impermeable area of 4.62ha.~~

8.7.2 ~~The 400kV circuit will be installed as part of Work No. 4A. Where this extends into, this~~. Whilst the matting and aggregate will provide some permeability and will ~~create an area of impermeable surfacing. The associated~~ reduce the rate and volume of runoff, in order to provide a worst case estimate of the required attenuation volumes, it has been assumed that all areas will be 100% impermeable.

8.7.3 The cable trench, haul road and laydown area for the Cable Route within Work No. 4A will be confined to a 30m working width. The 2.5ha area of land to the east of the existing substation allocated to Work No. 4A is also utilised for Work No. 5C which, as detailed above, is assumed to be 100% impermeable during the construction phase for the purposes of estimating the required surface water attenuation volumes.

8.7.4 For the purposes of this assessment, it is estimated that the total impermeable area associated with the proposed extension works during the construction phase will be 7.57ha.

8.7.5 Following the completion of the construction phase, all aggregate and matting required for construction within the work areas for Work No. 4A, 5A, 5B, 5C and 5D will be removed. The operational work areas will comprise the following surfacing:

- Work No. 4A and 5C: the area will be revegetated with the exception of the new OHL tower foundations for each leg (which will comprise impermeable concrete approximately 7m by 7m in dimension per leg (of which there are 4 in total)).
- Work No. 5A and 5B: it is assumed, as a worst case scenario, that 2.2ha of permeable and semi permeable surfacing will be retained as part of Work No. 5B. This will comprise the AIS/GIS structure plus surrounding concrete surfacing and aggregate-surfaced compound area(s).
- Work No. 5D: it is assumed that the 0.29 ha of existing aggregate will be retained as a compound serving the wider Bicker Fen Substation site. The existing access road will also be retained. It is assumed that all other areas will be revegetated.

8.7.6 The total impermeable area associated with the proposed extension works during the operational phase will, therefore, reduce to 2.49ha.

8.7.7 The Bicker Fen Substation in the current scenario (ie pre-extension) has an existing impermeable area of 7.14ha. This will be retained during the construction phase and operational phases of the proposed extension works.

8.7.48.7.8 It is proposed that the surface water runoff generated from the substation extension and associated work during the construction and operational phases will be discharged to the watercourse network at the QBAR rate of 1.44 l/s/ha. The relevant water discharge permits will be obtained from the appropriate approving body prior to any discharge occurring.

8.7.58.7.9 Table 14 shows the estimated discharge rates and required attenuation for each Work Number areaArea during the construction phase. Since the construction phase is when the majority of impermeable surfacing will be present, these calculations are considered to show the 'worst case' scenario. The calculations are contained in Appendix 5 of this report.

8.7.10 The attenuation feature(s) will remain in place following the completion of the construction phase, with the discharge rates at the outfall points modified to suit the new contributing impermeable areas during the operational period. There will, therefore, be sufficient attenuation to manage runoff during the operational phase.

**Table 14. Required Attenuation – Construction Phase**

| WORK NUMBER AREA | EFFECTIVE IMPERMEABLE AREA | DISCHARGE RATE (PRO-RATA)[1] | REQUIRED ATTENUATION (M3) | |
|---|---|---|---|---|
| | | | 1 IN 30 +35%CC | 1 IN 100 +40% CC |
| 4A, 5A, 5B and 5C | 3.15ha5.41 ha | 4.54l7.79 l/s | 2,084m³3,579m³ | 2,821m³5,033m³ |
| 4A5D | 0.69ha2.16 ha | 0.99l3.11 l/s | 457m³1,429m³ | 618m³1,935m³ |
| 5DExisting Substation | 1.47ha7.14 ha | 2.12l10.28 l/s | 973m³4,724m³ | 1,316m³6,394m³ |
| Total | 5.3114.71 ha | 7.6521.18 l/s | 3,514m³9,732m³ | 4,755m³13,362m³ |

1. Based on a QBAR rate of 1.44 l/s/ha

Following completion of the construction phase all aggregate and matting will be removed, and the only impermeable surfacing will be the new substation extension and the surrounding aggregate and hardstanding within Work No. 5B. This will have a total impermeable area of approximately 2.25ha. This would require approximately 2,005m³ of attenuation.

8.7.68.7.11 Any amendments to the existing drainage network at the Bicker Fen Substation to manage runoff from the proposed extension works, such as increasing the size and location of attenuation features, will be confirmed at the detailed design stage.

## 8.8 Outline Surface Water Drainage Strategy: Decommissioning

8.8.1 During decommissioning, all surface water drainage and attenuation will remain in place until all associated structures and impermeable surfacing contributing to surface water runoff within the sub-catchment have been removed. If drainage and attenuation components are to be removed ahead of this, temporary surface water management will be implemented.

8.8.2 There will, therefore, be no increase in the risk of flooding during the decommissioning phase.

## 8.9 Water Quality: Simple Index Approach

8.9.1 Sustainable drainage should ensure that there is no negative impact on water quality to downstream watercourses or groundwater as a result of the Proposed Development. The SuDS features should, therefore, also ensure that the pollution risk is sufficiently managed within the Proposed Development.

8.9.2 With regards to the areas of solar development, grass will be reinstated following construction and will intercept runoff from the solar panels, limiting the rate of erosion by reducing the kinetic energy of the runoff as it falls to the ground. The grass will also impede any overland flow, lessening any 'scouring' effect that overland flow may have. This will minimise the concentration of silt and suspended solids within the runoff. The grass cover will also filter surface water runoff removing silts and suspended solids.

8.9.3 The proposed SuDS features will provide treatment for runoff generated during the construction and operational phases of the Site and will be constructed prior to commencement of the construction phase.

8.9.4 The SuDS features will retain runoff from storm events on site, this control can help to reduce total discharge of silt and sediment off site. Swales and detention basins can also treat residual runoff, by removing course to medium sediments and associated pollutants by filtration via surface vegetation. Fine particles will be filtered via infiltration through underlying soil.

8.9.5 The Simple Index Approach outlined in the CIRIA SuDS Manual[22] is used to demonstrate that appropriate treatment will be provided within the proposed outline drainage strategy to ensure that there is no negative impact on water quality.

8.9.6 The Simple Index Approach assigns ‘Pollution Hazard Indices’ for suspended solids, metals and hydrocarbons, and an overall ‘pollution hazard level’ to several types of land use. These are summarised in Table 1515 below (based on Table 26.2 of the SuDS Manual).

[22] Ciria (2015) ‘C753 The SuDS Manual’

**Table 1515. Pollution Hazard Indices for Land Use Classifications**

| LAND USE | POLLUTION HAZARD LEVEL | TOTAL SUSPENDED SOLIDS | METALS | HYDROCARBONS |
|---|---|---|---|---|
| Residential roofs | Very Low | 0.2 | 0.2 | 0.05 |
| Commercial/ industrial roofs | Low | 0.3 | 0.2 | 0.05 |
| Individual property driveways, residential car parks, non-residential car parks with infrequent change (ie schools, offices), low traffic roads (ie homezones and general access roads) ie less than 300 traffic movements per day | Low | 0.5 | 0.4 | 0.4 |
| Commercial yard/delivery areas, non-residential car parking with frequent changes (ie retail, hospitals), all roads (except low traffic/trunk roads/motorways). | Medium | 0.7 | 0.6 | 0.7 |
| Haulage yards, industrial estates, areas, trunk roads, motorways. | High | 0.8 | 0.8 | 0.9 |

8.9.7 It is considered that all areas of the Site would have a 'Low' pollution hazard level. Few vehicles will access the Site and there will be less than 300 traffic movements per day during the operational lifetime of the development. All access tracks would, therefore, comprise 'low traffic roads'/'general access roads' and areas of parking would comprise 'non-residential car parking with infrequent changes.' The pollution hazard indices, therefore, would be:

- Total suspended solids: 0.5
- Metals: 0.4
- Hydrocarbons: 0.4

8.9.8 The Simple Index Approach then assigns mitigation indices for suspended solids, metals and hydrocarbons to the various types of SuDS . To ensure that water quality standards are met, the Pollution Mitigation Indices provided by the sustainable drainage features need to be greater than or equal to the Pollution Hazard Indices for the proposed land use.

8.9.9 In order to account for the reduced performance of secondary SuDS features associated with already reduced inflow concentrations, a factor of 0.5 should be applied to the second stage of treatment within a 'treatment train' (ie the detention basin), following the below formula taken from the CIRIA SuDS manual.

Total SuDS mitigation index = mitigation index + 0.5 (mitigation index)

8.9.10 During the construction phase, traffic movements will likely be higher than the 300 per day stated above. Section 11.7.6 of **Chapter 11: Water Resources and Flood Risk (Document Ref: 6.2 ES Vol.1, 6.2.11,),** discusses a number of appropriate measures that will be adopted during the construction phase to prevent and control the release of sediment and polluting substances into the watercourses.

## BESS and Onsite Substation Area

8.9.11 It is envisaged, water quality treatment within the BESS and Onsite Substation site will primarily be provided via the aggregate for all sub-catchment areas. For catchment 1 treatment will also be provided via the swale, and for Catchment 2 a second stage of treatment will be provided via the detention basin.

8.9.12 The treatment indices are summarised in Table 1616 (based on Table 26.3 of the SuDS Manual).

**Table 1616. CIRIA Simple Index Approach Assessment**

| | TOTAL SUSPENDED SOLIDS | METALS | HYDROCARBONS |
|---|---|---|---|
| Pollution Hazard Indices – Low<br>low traffic roads (ie homezones and general access roads) ie less than 300 traffic movements per day | 0.5 | 0.4 | 0.4 |
| **CATCHMENT 1** | | | |
| Pollution Mitigation Indices – Aggregate (described as Filter Drain in Table 26.3) | 0.4 | 0.4 | 0.4 |
| Pollution Mitigation Indices - Swale | 0.5÷2 | 0.6÷2 | 0.6÷2 |
| Total SuDS mitigation index | 0.65 | 0.7 | 0.7 |
| Sufficient or Additional Treatment Required | Sufficient | Sufficient | Sufficient |
| **CATCHMENT 2 AND CATCHMENT 3** | | | |
| Pollution Mitigation Indices – Aggregate (described as Filter Drain in Table 26.3) | 0.4 | 0.4 | 0.4 |
| Pollution Mitigation Indices – Detention Basin | 0.5÷2 | 0.5÷2 | 0.6÷2 |
| Total SuDS mitigation index | 0.65 | 0.65 | 0.7 |
| Sufficient or Additional Treatment Required | Sufficient | Sufficient | Sufficient |

Treatment indices are halved for the second stage of treatment in a ‘treatment train’

## Solar Array Area

8.9.13 Treatment within the Solar Array Area will be required for the runoff from the transformers and access tracks. Treatment will be provided by the vegetated swales discharging to the adjacent watercourses as well as via infiltration. The mitigation indices for the swales will, therefore, be based on both discharges to groundwater and surface waters, as detailed in Table 1717 below (based on Table 26.3 and Table 26.4 of the SuDS manual).

**Table 1717. Indicative SuDS Mitigation Indices for a Swale (Discharging to Surface water and Groundwater)**

| | TOTAL SUSPENDED SOLIDS | METALS | HYDROCARBONS |
|---|---|---|---|
| Pollution Hazard Indices – Low<br>Other roofs (commercial and industrial) | 0.3 | 0.2 | 0.05 |
| Pollution Hazard Indices – Low | 0.5 | 0.4 | 0.4 |

| | TOTAL SUSPENDED SOLIDS | METALS | HYDROCARBONS |
|---|---|---|---|
| low traffic roads (ie homezones and general access roads) ie less than 300 traffic movements per day, | | | |
| **Discharge to Surface Water** | | | |
| Pollution Mitigation Indices- **Swale** (as detailed in Table 26.3) | 0.6 | 0.5 | 0.5 |
| Sufficient or Additional Treatment Required | Sufficient | Sufficient | Sufficient |
| **Discharge to Groundwater** | | | |
| Pollution Mitigation Indices**- Swale** (as described in Table 26.4 as '**Dense vegetation underlain by minimum 300mm depth of soil with good contaminant attenuation potential'** | 0.5 | 0.5 | 0.6 |
| Sufficient or Additional Treatment Required | Sufficient | Sufficient | Sufficient |

8.9.14 Soil mapping shows that the majority of the Site is underlain by 'loamy clayey soils.' It is considered, therefore, that infiltrating flows will be retained for a time and some breakdown of contaminants will occur. The soil is considered, therefore, to have 'good contaminant attenuation potential.'

8.9.15 It is, therefore, considered that there will be no impact on surface water quality as a result of the Proposed Development.

8.9.16 During the construction phase, if vehicle movements within the Solar Array Area are higher than 300 per day, additional temporary mitigation may be required. Further details on management of water quality during the construction phase can be found in Section 11.8 of **Chapter 11: Water Resources and Flood Risk** (**Document Ref: 6.2 ES Vol.1, 6.2.11**).

## Cable Route Corridor

8.9.17 There will be no permanent water quality treatment along the route of the proposed cable. During the construction phase, the swales adjacent to the temporary haul road will provide treatment for any runoff generated. The hazard and treatment indices will be as outlined in Table 1717 above.

8.9.18 Where trenchless methods are used to install the cable beneath watercourse crossings, all arisings will be temporarily retained within the drilling area with no pathway for sediment-laden surface water runoff to flow to downstream watercourses. Further details on management of water quality during the construction phase can be found in Section 11.8 of **Chapter 11: Water Resources and Flood Risk** (**Document Ref: 6.2 ES Vol.1, 6.2.11**).

## Bespoke Access Road

8.9.19 The proposed Bespoke Access Road will comprise a low trafficked road and water quality treatment will be provided by the adjacent swales. The hazard and treatment indices will be as outlined in Table 1717 above. Further details on management of water quality during the construction phase can be found in Section 11.8 of **Chapter 11: Water Resources and Flood Risk** (**Document Ref: 6.2 ES Vol.1, 6.2.11**).

### Bicker Fen Substation

8.9.20 It is understood that attenuation within the Bicker Fen Substation is provided primarily by a pond feature, with runoff discharged to watercourses. This will provide sufficient treatment to surface water runoff as shown in Table 18 below. The existing pond may be infilled as part of the proposed works and would, therefore, be reinstated elsewhere within the substation site. There would also be an option to incorporate detention basins within the drainage network to provide attenuation. Table 18 confirms that these would also provide sufficient treatment for surface water runoff.

8.9.21 It is considered that the attenuation feature(s) will be retained following the construction phase and, therefore, that treatment will continue to be provided throughout the operational period.

**Table 18. Indicative SuDS Mitigation Indices for a Pond (Discharging to Surface Water)**

| | TOTAL SUSPENDED SOLIDS | METALS | HYDROCARBONS |
|---|---|---|---|
| Pollution Hazard Indices – Low<br>Other roofs (commercial and industrial) | 0.3 | 0.2 | 0.05 |
| Pollution Hazard Indices – Low<br>low traffic roads (ie homezones and general access roads) ie less than 300 traffic movements per day, | 0.5 | 0.4 | 0.4 |
| **Discharge to Surface Water** | | | |
| Pollution Mitigation Indices- **Pond** (as detailed in Table 26.3) | 0.7 | 0.7 | 0.5 |
| Sufficient or Additional Treatment Required | Sufficient | Sufficient | Sufficient |
| Pollution Mitigation Indices – Detention Basin | 0.5 | 0.6 | 0.6 |
| Sufficient or Additional Treatment Required | Sufficient | Sufficient | Sufficient |

## 8.10 SuDS Management and Maintenance

8.10.1 In order to ensure the successful continued management of surface water runoff, the proposed SuDS features must be regularly maintained. Table 19, Table 20 and Table 21 below outline the typical maintenance requirements for the proposed SuDS features based on guidance within the CIRIA SuDS Manual (C753).

**Table 19. Operation and Maintenance Requirements for Swales**

| Maintenance Schedule | Required Action | Typical Frequency |
|---|---|---|
| Regular Maintenance | Remove litter and debris | Monthly, or as required |
| | Cut grass – to retain grass height within specified design range | Monthly (during growing season), or as required |
| | Manage other vegetation and remove nuisance plants | Monthly at start, then as required |

| Maintenance Schedule | Required Action | Typical Frequency |
|---|---|---|
| | Inspect inlets, outlets, and overflows for blockages, and clear if required | Monthly |
| | Inspect infiltration surfaces for ponding, compaction, silt accumulation, record areas where water is ponding for > 48hrs | Monthly, or when required |
| | Inspect vegetation coverage | Monthly for 6 months, quarterly or 2 years, then half yearly |
| | Inspect inlets and facility surface for silt accumulation, establish appropriate silt removal frequencies | Half yearly |
| Occasional Maintenance | Reseed areas of poor vegetation growth, alter plant types to better suit conditions, if required | As required or if bare soil is exposed over 10% or more of the swale treatment area |
| Remedial Actions | Repair erosion or other damage by re-turfing or reseeding | As required |
| | Relevel uneven surfaces and reinstate design levels | As required |
| | Scarify and spike topsoil layer to improve infiltration performance, break up silt deposits and prevent compaction of the soil surface | As required |
| | Remove build-up of sediment on upstream gravel trench, flow spreader or at top of filter strip | As required |
| | Remove and dispose of oils or petrol residues using safe standard practices. | As required |

Reproduced from the CIRIA SuDS Manual Table 17.1

8.10.2 The ideal length of grass within each swale is specified by the CIRIA SuDS Manual to be in the range of 75-150mm in order to assist proper infiltration of pollutants and sediments that may accumulate in the swale and to reduce the risk of flattening during larger events such as the 1 in 30 and 1 in 100-year storm events. Maintaining this length will require regular maintenance activities such as mowing when dry.

**Table 20. Operation and Maintenance Requirements for Detention Basins**

| Maintenance Schedule | Required Action | Typical Frequency |
|---|---|---|
| Regular Maintenance | Remove litter and debris | Monthly (or as required) |
| | Cut grass – for spillways and access routes | Monthly (during growing season) or as required |
| | Cut grass- meadow grass in and around basin | Half yearly; Spring (before nesting season, and Autumn) |
| | Manage other vegetation and remove nuisance plants | Monthly (at start, then as required) |
| | Inspect inlets, outlets and overflows for blockages and clear if required | Monthly |
| | Inspect banksides, structures, pipework for evidence of physical damage | Monthly |
| | Inspect inlets and facility surface for silt accumulation. Establish appropriate silt removal frequencies. | Monthly (for first year), then annually or as required |
| | Check any penstock and other mechanical devices | Annually |

| Maintenance Schedule | Required Action | Typical Frequency |
|---|---|---|
| | Tidy all dead grass growth before growing season | Annually |
| | Remove sediment from inlets, outlet and forebay | Annually (or as required) |
| | Manage wetland plants in outlet pool- were provided | Annually |
| Occasional Maintenance | Reseed areas of poor vegetative growth | As required |
| | Prune and trim any trees and remove cuttings | Every 2 years, or as required |
| | Remove sediment from inlets, outlets, forebays and main basin when required | Every 5 years, or as required (likely to be minimal requirements where effective upstream source control is provided) |
| Remedial Actions | Repair erosion or other damage by reseeding or re-turfing | As required |
| | Realignment of riprap | As required |
| | Repair/ rehabilitation of inlets, outlets and overflows | As required |
| | Relevel uneven surfaces and reinstate design levels. | As required |

Reproduced from the CIRIA SuDS Manual Table 23.1

### Table 21. Operational and Maintenance Requirements for Aggregate Storage

| Maintenance Schedule | Required Action | Typical Frequency |
|---|---|---|
| Regular Maintenance | Remove litter and debris | Monthly (or as required) |
| | Inspect surface, inlet/outlet pipework and control systems for blockages, clogging, standing water and structural damage | Monthly |
| | Inspect inlets and perforated pipework for silt accumulation and establish appropriate silt removal frequencies | Six Monthly |
| Occasional Maintenance | At locations with high pollution loads, wash or replace aggregate | Every 5 years, or as required |
| | Clear perforated pipework of blockages | As required |

Modified from the CIRIA SuDS Manual Table 16.1

# 9. SECURING THE MITIGATIONS

## 9.1 Construction Phase Mitigations

9.1.1 During the construction phase of the Cable Route placement of temporary stockpiles will avoid, where feasible, areas at risk of fluvial and surface water flooding. Where this is not possible, construction methodologies and programming will ensure that the volume of stockpiled material within the flood risk areas is limited. Furthermore, any linear stockpiles within the flood risk areas will be placed with 1m gaps at 10m intervals. These measures will ensure flood risk is not increased and flood flows are not diverted.

9.1.2 Where construction compounds are located in areas at risk of surface water or fluvial flooding, it is proposed that office and welfare cabins are raised above ground on stilts, where feasible, allowing flood water to pass beneath, ensuring minimal impact on flood flows or floodplain storage. Other storage containers and structures will be small standalone units which flood waters could easily pass between. Any structures which cannot be raised will not be grouped closely together allowing flood waters to pass between.

9.1.3 The construction phase mitigations as detailed above, and surface water runoff management and pollution control for construction related activities will be secured via the Construction Environmental Management Plan (CEMP). The CEMP ~~will be~~is secured ~~by a~~under DCO requirement 12.

## 9.2 Operational Phase Mitigations

9.2.1 To ensure the development remains operational and there is no risk to electrical equipment, all electrical infrastructure (with the exception of the solar panel tables – see below) will be raised above the 1 in 100 year +32% climate change flood level (the design event) or otherwise located outside of the respective flood extent.

9.2.2 With regards to the Solar Array Area, the solar panels themselves are considered to have a negligible impact on fluvial flooding or surface water flow paths. The panels will be raised with flood water able to flow freely beneath them. Furthermore, the solar panels themselves are not at risk should they come into contact with water and can, therefore, remain operational.

~~9.2.2~~9.2.3 The design has allowed for the leading edge of the panel tables to be raised by 600mm above the 1 in 100 year + 32% climate change flood depth for the breach scenario. The standard solar panel table will have a leading edge of 0.8m above ground level, proving sufficient freeboard for areas where flood depths are less than 0.2m. Where flooding is deeper than 0.2m, panel tables will be raised with a leading edge of up to 1.3m above ground level, to provide 600mm freeboard above the maximum flood depth of 0.69m in the 1 in 100 year + 32% climate change breach scenario. There will be no ground raising to achieve this and, therefore, the impact on floodplain storage and flow routes will be minimal.

~~9.2.3~~9.2.4 Where proposed transformer units are located within the modelled 1 in 100 year + 32% climate change flood extent, minor ground raising will be required to provide protection to the electrical infrastructure. A 600mm freeboard allowance above the modelled 1 in 100 year + 32% climate change flood level at individual transformer locations will be provided. Ground raising to achieve this is considered to have a minimal impact on existing overland flow pathways and floodplain storage. Floodplain compensation will, however, be provided on a level-for-level and volume-for-volume basis.

~~9.2.4~~9.2.5 The north-eastern corner of the BESS and Onsite Substation site encroaches into the modelled 1 in 100 year + 32% climate change flood extent. Electrical infrastructure will be protected against flooding in the 1 in 100 year + 32% climate change scenario, including a 600mm freeboard allowance.

~~9.2.5~~9.2.6 The construction of a level plateau for the BESS and Onsite Substation will displace a small volume of floodplain storage. Floodplain compensation in the form of shallow scrapes/ground lowering in areas currently unaffected by flooding in the design storm event will, therefore, be provided within the Site on a level-for-level and volume-for-volume basis.

~~9.2.6~~9.2.7 ~~Permanent stockpiles~~Stockpiles of excavated materials along the Bespoke Access Corridor will avoid, where feasible, areas at risk of fluvial and surface water flooding. ~~The~~Figure 6.31 Landscape Strategy Plan (**Document Ref: 6.4.42 ES Figure 6.31**) provides indicative locations for the ~~permanent~~ stockpiles ~~along~~of material associated with the Bespoke Access Corridor which will be present for the duration of the Proposed Development. The indicative stockpile locations do not encroach into the modelled 1 in 100 year + 32% climate change flood extent, nor interface with the surface water flood risk extents. However, if this is not feasible, any linear stockpiles within the flood risk areas will be placed with 1m gaps at 10m intervals and floodplain compensation will be provided on level-for-level and volume for volume basis.

~~9.2.7~~9.2.8 New and upgraded permanent watercourse crossings will be designed to ~~comply with the requirements of the Environment Agency and Black Sluice Internal Drainage Board to~~ ensure that there is no increase in the risk of flooding. ~~Appropriate~~Where appropriate, Ordinary Watercourse Consents and/or Flood Risk Activity Permits will be obtained from the relevant approving bodies prior to construction.

~~9.2.8~~9.2.9 Where new, permanent bridges are proposed within the design flood extent, there is potential for the abutments and ramps to result in a minor loss of flood storage. Floodplain compensation will, therefore, be provided on level-for-level and volume for volume basis

~~9.2.9~~9.2.10 Fencing within the Proposed Development has the potential to cause a barrier to flood flows, especially if debris accumulates against the fencing causing a blockage. The mesh spacing at the base of any fencing within the design flood extent will, therefore, be widened in order to reduce debris accumulation.

~~9.2.10~~9.2.11 The proposed works at Bicker Fen Substation are unlikely to have any significant effect on fluvial or pluvial flood risk. There is potential for the works to result in a loss of floodplain storage and have a minor and localised effect on flood flow routes at site scale. However, relative to the current floodplain extent and level of flood risk these impacts are considered to be

~~minor~~negligible. Furthermore, the Environment Agency has confirmed that providing floodplain compensation for the loss of flood storage would provide little benefit due to the distance between the Bicker Fen Substation (ie where flood storage is lost) and areas of land that are currently outside of the flood extent (ie where floodplain compensation could be provided). Mitigation is, therefore, focussed on protecting the new electrical infrastructure by raising it sufficiently above the design flood level.

### Floodplain Compensation

~~9.2.11~~9.2.12 Floodplain compensation is proposed on a level-for-level and volume-for-volume basis to account for the loss of floodplain resulting from the raising of ground levels and from development placed within the floodplain, including the ~~permanent~~ stockpiles of material that will be present within the Bespoke Access Corridor for the duration of the Proposed Development, transformers, solar panel piles, new permanent vehicular bridges, and the BESS and Onsite Substation plateau. Compensation will be provided via shallow scrapes, located immediately outside of the design flood extent. Indicative locations for floodplain compensation extents have been provided on Drawing No ST19595-542 to demonstrate that there is sufficient space available within the Order limits to provide the required compensation. Detailed floodplain loss and compensation assessments will be carried out at the detailed design stage in consultation with the Environment Agency.

~~9.2.12~~9.2.13 The mitigations detailed above for the Operational phase ~~will be~~is secured by a DCO Requirement.

## 9.3 Outline Surface Water Drainage Strategy

9.3.1 The Outline Surface Water Drainage Strategy for the operational and decommissioning phases, as detailed in Section 8 of this report, ~~will be~~is secured via DCO Requirement 10.

# 10. SUMMARY AND CONCLUSIONS

## 10.1 Sequential and Exception Tests

10.1.1 The proposed Solar Array Area, Cable Route Corridor and Bespoke Access Corridor are located within Flood Zones 1, 2 and 3. The site was selected as part of a staged process undertaken by environmental and planning specialists to identify potential development sites, and it is considered that the development passes the Sequential Test (Section 2.2).

10.1.2 The vulnerability class of the Proposed Development is Essential Infrastructure. Table 3 of the NPPG indicates that such developments are suitable for sites within Flood Zone 3a if it is confirmed, with the Exception Test, that the benefits to the community outweigh the risk of flooding, and that the development and surrounding area will be safe from flooding. As the Proposed Development will provide a source of renewable energy to the National Grid, it will provide significant benefits to the UK, and it is considered that this benefit outweighs the flood risks that the Proposed Development will be subject to. Furthermore, this Flood Risk Assessment demonstrates that the Proposed Development will be safe form flooding for its lifetime, and with appropriate mitigation measures, will not increase flood risk elsewhere. It is considered that the Exception Test is passed.

## 10.2 Flood Risk to the Proposed Development

10.2.1 The risk of flooding to the Proposed Development from fluvial, surface water, groundwater and artificial sources varies across the Site. Eastern areas of the Solar Array Area, southern portions of the Cable Route Corridor and the Bicker Fen Substation are located within areas at a High risk of fluvial flooding. These areas are also at risk of reservoir flooding.

10.2.2 Detailed fluvial flood modelling has been undertaken in order to confirm the risk of fluvial flooding to the Proposed Development. This shows that flooding in the 1 in 100 year defended scenario is less extensive in the Solar Array Area and Bespoke Access Corridor than the undefended scenario shown on the EA Flood Map for Planning (ie Flood Zone 3). With the exception of the solar panels, a number of transformers and a small portion of the BESS and Onsite Substation, the majority of structures within the Solar Array Area will be outside of the modelled 1 in 100 year flood extent.

10.2.3 Southern sections of the Cable Route Corridor and Bicker Fen Substation are outside of the extent of the bespoke fluvial model and the Flood Map for Planning shows that sections of the Cable Route Corridor and the full Bicker Fen Substation site are located within Flood Zone 3.

10.2.4 The risk of surface water flooding to the majority of the Site is considered to be Very Low to Low. Some areas of the Site are at High risk of surface water flooding with overland flow pathways extending through central areas of the Solar Array Area and sections of the Bespoke Access Corridor and Cable Route Corridor. The Bicker Fen Substation is affected by isolated ponding of surface water runoff only with no overland flow pathways crossing the substation area.

10.2.5 The Solar Array Area is considered to have a 'Medium' susceptibility to groundwater flooding. The Cable Route Corridor, Bespoke Access Corridor and Bicker Fen Substation have a Very Low to Low susceptibility to groundwater flooding.

10.2.6 The Solar Array Area is not affected by sewer flooding and the risk is considered to be Very Low in the Cable Route Corridor, Bespoke Access Corridor and at the Bicker Fen Substation.

10.2.7 Artificial flooding from reservoirs is considered to be Very Low in all areas of the Site, with the majority of areas at risk only when there is flooding from rivers. In addition, owing to the water levels in the Black Sluice Internal Drainage Board watercourses being artificially managed, there is the remote potential for the pumps to fail. The bespoke fluvial flood modelling is based on a 'no pump' scenario. It can, therefore, be considered that the modelled flood levels give an indication of the flood extent in a 'no pump' scenario. The majority of the Solar Array Area and Bespoke Access Corridor would, therefore, be unaffected.

10.2.8 The fluvial flood modelling includes a scenario where flood defences fail (the 'Breach' scenario). This shows flood depths vary significantly across the north-eastern portion of the Solar Array Area; however the maximum flood depth (excluding within watercourse channels) in the event of a breach is estimated to be 0.69m in the 1 in 100 year +32% climate change return period.

## 10.3 Post-Development Flood Risk and Residual Risk

10.3.1 It is considered that with appropriate flood risk mitigation measures in place (see Section 9 for summary), the Proposed Development will not increase flood risk and will be safe for its lifetime.

10.3.2 There is always a possibility of a flood event that exceeds the design standards of the proposed flood risk mitigation measures, or as a result of an event such as a breach in the existing flood defences. As such, the resilience of the Proposed Development has been tested against a Credible Maximum Scenario. It is considered that the Proposed Development is resilient in such an event.

10.3.3 Furthermore, the resilience of the Proposed Development has been tested against a potential breach in the flood defence on the River Slea in the 1 in 100 year +32% climate change event. This sensitivity test also concluded that the Proposed Development remains resilient.

## 10.4 Surface Water Drainage Strategy

10.4.1 There will be a negligible increase in impermeable ground at the Site as a result of the Proposed Development. The management of surface water runoff will ensure that flood risk from the Site is not increased as a result of the Proposed Development. This will be achieved by ensuring that any offsite discharges of surface water from the BESS and ~~OnSite~~Onsite Substation and the Bicker Fen Substation extension are restricted to pre-development greenfield runoff rates. Any flows in excess of this will be attenuated on site for all storm events up to an including the 1 in 100 year plus 40% climate change return period.

10.4.2 The proposed drainage strategy within the BESS and Onsite Substation area will also include firewater management to ensure that potentially contaminated firewater is retained safely on site and not discharged to downstream watercourses or groundwater in the unlikely event of a fire.

10.4.3 The additional volume of surface water runoff from the access tracks and Bespoke Access Road, for events up to the 1 in 100 year plus 40% climate change 6-hour storm event, will be stored in swales located adjacent to the tracks/roads.

10.4.4 SuDS will be utilised within the Site to provide conveyance and storage for surface water runoff, as well as water quality treatment and enhancing biodiversity.

## 10.5 FRA Conclusions

10.5.1 This FRA has been carried out in accordance with the NPS EN-1 and NPS EN-3 and associated NPPG.

10.5.2 The findings of this assessment, which has been based on the data available at the time of writing, confirm that from a flood risk perspective the Site is suitable for the Proposed Development, the Proposed Development will remain safe for its lifetime (~~ie~~i.e. taking into account the potential effects of climate change) and will not increase flood risk elsewhere. This is subject to appropriate flood risk mitigation measures being implemented, which are to be secured via an appropriate Requirement.

10.5.3 In terms of the mitigation to be incorporated in the design of the Proposed Development as set out above in Section 9.2, the DCO Requirement secures the inclusion of such mitigation in the detailed design of the Proposed Development. Whilst the anticipation is that the design will incorporate those measures, the requirement does allow some flexibility by providing that any alternative design measures will include mitigation that will not result in conclusions for flood risk that are worse than those set out above in Section 10.3.

10.5.4 In terms of the inclusion of floodplain compensation in the final design of the Proposed Development, the detail of this is required to be approved and must accord with Section 9.2 and such compensation must not result in conclusions for flood risk and floodplain storage that are worse than those in Section 10.3 above. In each case, the details must be approved by the relevant planning authority in consultation with the Environment Agency.

# Appendices

# Appendix 1. Environment Agency Modelled Flood Levels

[redacted]

**Our ref:** CCN-2023-317303

**Date:** 17/07/2023

[redacted]

**Provision of Flood Risk Information for Bicker Fen, Lincolnshire**

Thank you for your request for our flood risk information for the above site. The information is set out below and attached. It is important you read any contextual notes on the maps provided.

If you are preparing a Flood Risk Assessment (FRA) for this site, please note this information may not be sufficient by itself to produce an adequate FRA to demonstrate the development is safe over its lifetime. Additional information may be required to carry out an appropriate assessment of all risk, such as consequence of a breach in defences.

We aim to review our information on a regular basis, so if you are using this data more than twelve months from the date of this letter, please contact us again to check it is still valid.

Please read the letter in full as the information covered has been updated in **June 2023.**

## 1. Flood Map for Planning

The attached map includes the current Flood Map for Planning for your area. The map indicates the area at risk of flooding, **assuming no flood defences exist**, for a flood with a 0.5% chance of occurring in any year for flooding from the sea, or a 1% chance of occurring for fluvial (river) flooding. It also shows the extent of the Extreme Flood Outline which represents the extent of a flood with a 0.1% chance of occurring in any year, or the highest recorded historic extent if greater.

In some locations, such as around the fens and the large coastal floodplains, showing the area at risk of flooding assuming no defences may give a slightly misleading picture in that if there were no flood defences, water would spread out across these large floodplains. This flooding could cover large areas of land but to relatively shallow depths and could leave pockets of locally slightly higher land as isolated dry islands. It is important to understand the actual risk of the flooding to these dry islands, particularly in the event of defence failure.

The Flood Map for Planning also shows the location of formal raised flood defences and flood storage reservoirs. It represents areas at risk of flooding for present day only and does not take account of climate change.

The Flood Map for Planning only indicates the extent and likelihood of flooding from rivers or the sea. It should also be remembered flooding may occur from other sources such as surface water sewers, road drainage, etc.

The Flood Map has been supplied at a 1:10,000 scale and also at a 1:35,000 scale in order to show the main river channel and node points.

## 2. Recorded Flood Outlines

With regards to the history of flooding I can advise we do not have any records of flooding in this area. It is possible recent flooding may have occurred which we are currently investigating, therefore this information may be subject to change. It is possible other flooding may have occurred which other risk management authorities, such as the Lead Local Flood Authority (ie top tier council) or Internal Drainage Board (where they exist) have responsibility.

## 3. Schemes in the area

There are no ongoing capital projects to reduce or sustain the current flood risk to this site.

## 4. Fluvial Flood Risk Information

This site is considered to be at risk of flooding from main rivers.

The site may also be at risk from local ordinary watercourses for which other risk management authorities, such as the Lead Local Flood Authority (ie top tier council) or Internal Drainage Board (where they exist) have responsibility.

### 4.1 Fluvial Defence Information

The existing fluvial defences reducing the risk of flooding from Kyme Eau to this site consist of earth embankments. They are in fair condition and reduce the risk of flooding (at the defence) to a 1% (1 in 100) chance of occurring in any year. We inspect these defences routinely to ensure potential defects are identified.

The existing fluvial defences reducing the risk of flooding from Midfodder Dyke to this site consist of earth embankments and concrete floodwalls. They are in fair condition and reduce the risk of flooding (at the defence) to a 2% (1 in 50) chance of occurring in any year. We inspect these defences routinely to ensure potential defects are identified.

The existing fluvial defences reducing the risk of flooding from Heckington Edu to this site consist of earth embankments. They are in fair condition and reduce the risk of flooding (at the defence) to a 1% (1 in 100) chance of occurring in any year. We inspect these defences routinely to ensure potential defects are identified.

There are no formal flood defences reducing the risk of flooding to this site from Hodge Dyke.

Refer to paragraph 3 for details of any ongoing capital projects to reduce the flood risk to this site.

### 4.2 Fluvial Modelled Levels and Flows

Available modelled fluvial flood levels and flows for the model nodes shown on the attached map are set out in the data table attached. This data is taken from the model named on the data table, which is the most up-to-date model currently available.

Please note these levels are “in-channel” levels and therefore may not represent the flood level on the floodplain, particularly where the channel is embanked or has raised defences.

Our models may not have the most up to date climate change allowances. In time we will update our models for the latest allowances. You should refer to 'Flood risk assessments: climate change allowances' to check if the allowances modelled are appropriate for the type of development you are proposing and its location. You may need to undertake further assessment of future flood risk using different allowances to ensure your assessment of future flood risk is based on best available evidence.

### 4.3 Fluvial Modelled Flood Extents

Please find attached a map showing available modelled flood extents, taking into account flood defences, for your area. This data is taken from the model named on the map, which is the most up-to-date model currently available.

In some cases the flood extents shown may not be from main river, but may be from other sources such as IDB lowland drainage networks.

### 4.4 Fluvial Hazard Mapping

For certain locations we have carried out modelling to map the maximum values of flood depth, velocity and hazard rating (danger to people) resulting from overtopping and / or breaching of defences at specific locations for a number of scenarios.

At present this information is available for fluvial flood risk in Northampton, Lincoln, Wainfleet and some isolated rural locations.

The number of locations we have this information for is expected to increase in time.

At present this site is not covered by any fluvial hazard mapping.

## 5. Tidal Flood Risk Information

Whilst the site is within a tidal flood zone, ie assuming no tidal defences exist, it is not at risk of tidal flooding in either a overtopping or breaching of defences scenario, today or with an allowance for climate change.

## 6. Development Planning

If you would like local guidance on preparing a flood risk assessment for a planning application, please contact our Sustainable Places team at LNplanning@environment-agency.gov.uk. It will help if you mention this data request and attach your site location plan.

We provide free preliminary advice; additional/detailed advice, review of draft FRAs and meetings are chargeable at a rate set to cover our costs, currently £100 (plus VAT) per hour of staff time. Further details are available on our website at
https://www.gov.uk/guidance/developers-get-environmental-advice-on-your-planning-proposals.

General advice on flood risk assessment for planning applications can be found on GOV.UK at https://www.gov.uk/guidance/flood-risk-assessment-for-planning-applications

Climate change will increase flood risk due to overtopping of defences. Please note, unless specified otherwise, the climate change data included has an allowance for 20% increase in flow. Updated guidance on how climate change could affect flood risk to new development - 'Flood risk assessments: climate change allowances' was published on GOV.UK in **July 2021**. The appropriate updated climate change allowance should be applied in a Flood Risk Assessment.

You should also consult the Strategic Flood Risk Assessment produced by your local planning authority.

## 7. Data Licence and Other Supporting Information

We respond to requests for recorded information we hold under the Freedom of Information Act 2000 (FOIA) and the associated Environmental Information Regulations 2004 (EIR).

This information is provided in accordance with the Open Government Licence which can be found here: http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/

Further information on flood risk can be found on the GOV.UK website at:
https://www.gov.uk/browse/environment-countryside/flooding-extreme-weather

## 8. Other Flood Risk Management Authorities

The information provided with this letter relates to flood risk from main river or the sea. The Flood Map for Surface Water can be viewed at https://www.gov.uk/check-long-term-flood-risk

Additional information may be available from other risk management authorities, such as the Lead Local Flood Authority (ie top tier council) or Internal Drainage Board (where they exist).

I hope we have correctly interpreted your request. If you have any queries or would like to discuss the content of this letter further please contact [redacted] using the email address below and quoting our CCN reference number above.

[redacted]

[redacted]

[redacted]

Enc.
Flood Map for Planning
Modelled Node Points Map
Modelled Fluvial Levels and Flows Data Sheet
Modelled Flood Extent Maps

# Flood Map for Planning centred on TF1472048139 - created July 2023 [Ref: CCN-2023-317303]


Environment Agency

Scale 1:10,000

N E S W

**Legend**

- Main River
- Raised Defences
- Flood Storage Areas
- Areas at Risk of Flooding from Rivers or The Sea
- Extreme Flood Outline

Dark blue shows the area that could be affected by flooding, either from rivers or the sea, if there were no flood defences. This area could be flooded:

- from the sea by a flood that has a 0.5% (1 in 200) or greater chance of happening each year.

- or from a river by a flood that has a 1% (1 in 100) or greater chance of happening each year.

Light blue shows the extent of the Extreme Flood Outline, which represents the extent of a flood event with a 0.1% chance of occurring in any year, or the highest recorded historic extent if greater.

These two colours show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements. Sites outside the two extents, but behind raised defences, may be affected by flooding if the defences are overtopped or fail.

**Contact Us:** National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

# Flood Map for Planning with Nodes centred on TF1472048139 - created July 2023 [Ref: CCN-2023-317303]


Environment Agency

Scale 1:35,000

N W E S

**Legend**

- Modelled_Nodes
- Main River
- Raised Defences
- Flood Storage Areas
- Areas at Risk of Flooding from Rivers or The Sea
- Extreme Flood Outline

Dark blue shows the area that could be affected by flooding, either from rivers or the sea, if there were no flood defences. This area could be flooded:

- from the sea by a flood that has a 0.5% (1 in 200) or greater chance of happening each year.

- or from a river by a flood that has a 1% (1 in 100) or greater chance of happening each year.

Light blue shows the extent of the Extreme Flood Outline, which represents the extent of a flood event with a 0.1% chance of occurring in any year, or the highest recorded historic extent if greater.

These two colours show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements. Sites outside the two extents, but behind raised defences, may be affected by flooding if the defences are overtopped or fail.

**Contact Us:** National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

## Fluvial Flood Levels (mODN)

The fluvial flood levels for the model nodes shown on the attached map are set out in the table below. They are measured in metres above Ordnance Datum Newlyn (mODN).

| | | | Annual Exceedance Probability - Maximum Water Levels (mODN) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Node Label | Easting | Northing | 50% (1 in 2) | 20% (1 in 5) | 10% (1 in 10) | 5% (1 in 20) | 4% (1 in 25) | 2% (1 in 50) | 1.33% (1 in 75) | 1% (1 in 100) | 1% (1 in 100) inc 20% Climate Change | 0.5% (1 in 200) | 0.1% (1 in 1000) | 0.1% (1 in 1000) inc 20% Climate Change |
| KE_07650! | 516752 | 349656 | 3.72 | 3.88 | 3.90 | 3.93 | 3.93 | 3.94 | 3.94 | 3.94 | 3.95 | 3.95 | 3.98 | 4.07 |
| KE_09720 | 515133 | 350248 | 3.77 | 3.93 | 3.96 | 3.99 | 4.00 | 4.00 | 4.00 | 4.01 | 4.01 | 4.01 | 4.07 | 4.23 |
| KE_12000 | 513100 | 349360 | 3.81 | 3.96 | 4.01 | 4.04 | 4.04 | 4.05 | 4.05 | 4.05 | 4.06 | 4.06 | 4.13 | 4.34 |

## Fluvial Flood Flows ($m^3/s$)

The fluvial flood flows for the model nodes shown on the attached map are set out in the table below. They are measured in metres cubed per second ($m^3/s$).

| | | | Annual Exceedance Probability - Maximum Flows ($m^3/s$) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Node Label | Easting | Northing | 50% (1 in 2) | 20% (1 in 5) | 10% (1 in 10) | 5% (1 in 20) | 4% (1 in 25) | 2% (1 in 50) | 1.33% (1 in 75) | 1% (1 in 100) | 1% (1 in 100) inc 20% Climate Change | 0.5% (1 in 200) | 0.1% (1 in 1000) | 0.1% (1 in 1000) inc 20% Climate Change |
| KE_07650! | 516752 | 349656 | 5.97 | 7.96 | 8.82 | 8.84 | 8.86 | 9.05 | 9.11 | 9.14 | 9.30 | 9.22 | 9.98 | 11.79 |
| KE_09720 | 515133 | 350248 | 5.73 | 7.96 | 8.70 | 8.75 | 8.77 | 8.96 | 9.03 | 9.06 | 9.18 | 9.13 | 9.95 | 12.33 |
| KE_12000 | 513100 | 349360 | 5.74 | 7.94 | 8.60 | 8.67 | 8.69 | 8.89 | 8.98 | 9.25 | 9.50 | 9.42 | 10.17 | 12.31 |

## Fluvial Flood Levels (mODN)

The fluvial flood levels for the model nodes shown on the attached map are set out in the table below. They are measured in metres above Ordnance Datum Newlyn (mODN).

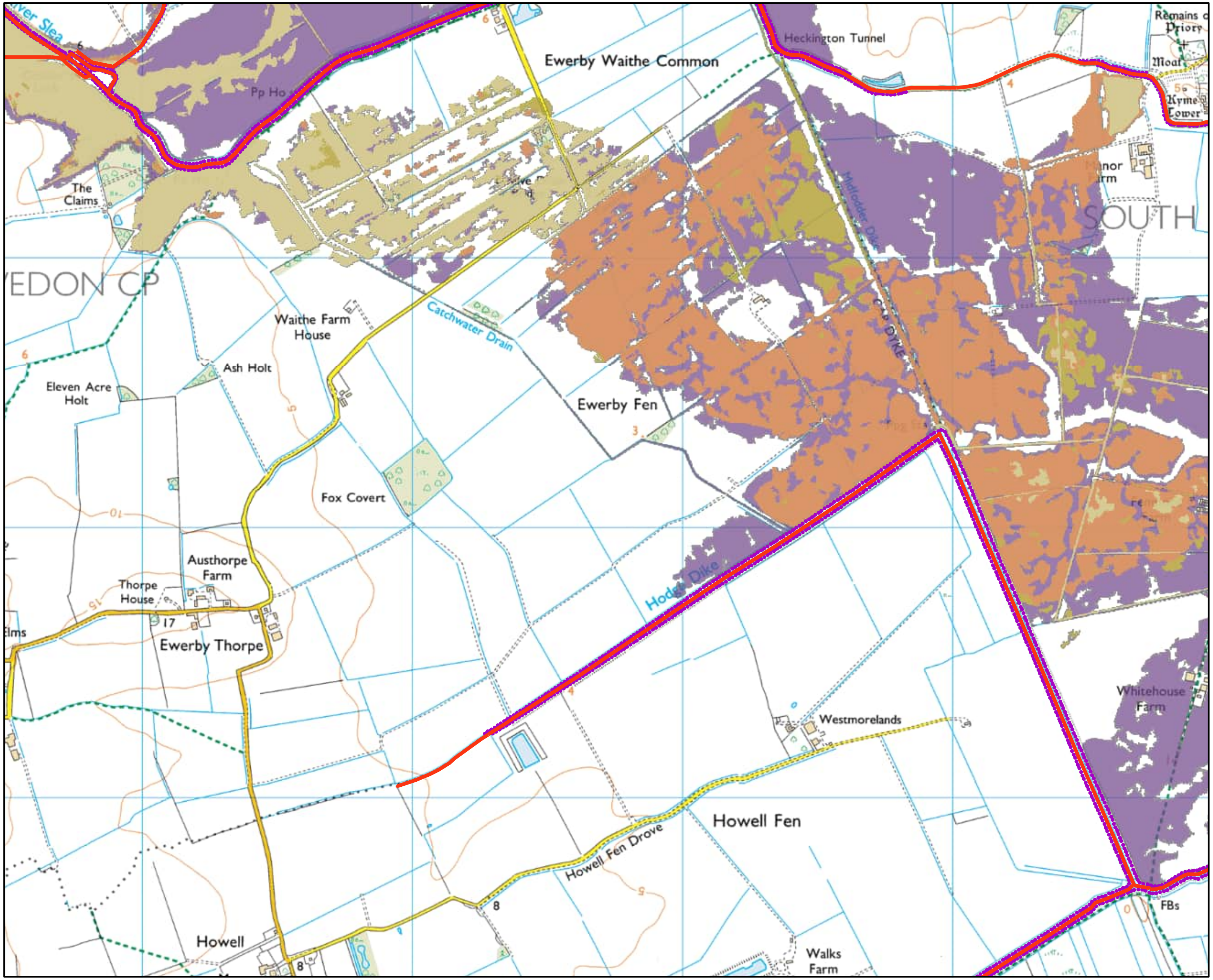
| | | | Annual Exceedance Probability - Maximum Water Levels (mODN) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Node Label** | **Easting** | **Northing** | **50% (1 in 2)** | **20% (1 in 5)** | **10% (1 in 10)** | **5% (1 in 20)** | **2% (1 in 50)** | **1.33% (1 in 75)** | **1% (1 in 100)** | **1% (1 in 100) inc 20% Climate Change** | **0.5% (1 in 200)** | **0.1% (1 in 1000)** | **0.1% (1 in 1000) inc 20% Climate Change** |
| HK109108d | 516683 | 346670 | 2.18 | 2.54 | 2.63 | 2.64 | 2.73 | 2.78 | 2.80 | 2.85 | 2.85 | 3.00 | 3.09 |
| HO101835d | 515967 | 348320 | 2.19 | 2.55 | 2.63 | 2.64 | 2.73 | 2.78 | 2.80 | 2.85 | 2.85 | 3.00 | 3.09 |
| HO103000 | 514981 | 347695 | 2.19 | 2.55 | 2.63 | 2.64 | 2.74 | 2.78 | 2.80 | 2.85 | 2.85 | 3.00 | 3.09 |
| MD101000 | 516277 | 347602 | 2.18 | 2.54 | 2.63 | 2.64 | 2.73 | 2.78 | 2.80 | 2.85 | 2.85 | 3.00 | 3.09 |
| HK110198 | 515744 | 346102 | 2.19 | 2.54 | 2.64 | 2.65 | 2.74 | 2.78 | 2.80 | 2.85 | 2.85 | 3.02 | 3.12 |
| HK112000 | 514238 | 345212 | 2.19 | 2.55 | 2.65 | 2.67 | 2.80 | 2.86 | 2.89 | 2.99 | 2.99 | 3.34 | 3.54 |

## Fluvial Flood Flows (m³/s)

The fluvial flood flows for the model nodes shown on the attached map are set out in the table below. They are measured in metres cubed per second (m³/s).

| | | | Annual Exceedance Probability - Maximum Flows (m³/s) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Node Label** | **Easting** | **Northing** | **50% (1 in 2)** | **20% (1 in 5)** | **10% (1 in 10)** | **5% (1 in 20)** | **2% (1 in 50)** | **1.33% (1 in 75)** | **1% (1 in 100)** | **1% (1 in 100) inc 20% Climate Change** | **0.5% (1 in 200)** | **0.1% (1 in 1000)** | **0.1% (1 in 1000) inc 20% Climate Change** |
| HK109108d | 516683 | 346670 | 2.78 | 4.16 | 4.83 | 5.17 | 6.29 | 7.21 | 7.60 | 9.02 | 8.97 | 13.78 | 16.75 |
| HO101835d | 515967 | 348320 | 1.47 | 2.63 | 3.19 | 3.24 | 3.30 | 2.71 | 2.65 | 3.06 | 3.06 | 4.35 | 5.08 |
| HO103000 | 514981 | 347695 | 0.89 | 1.19 | 1.56 | 1.98 | 2.47 | 2.81 | 2.91 | 3.42 | 3.42 | 4.82 | 5.60 |
| MD101000 | 516277 | 347602 | 1.78 | 2.51 | 3.54 | 3.55 | 3.62 | 2.69 | 2.58 | 3.01 | 2.97 | 3.94 | 4.67 |
| HK110198 | 515744 | 346102 | 1.29 | 2.39 | 3.23 | 3.85 | 4.89 | 5.59 | 5.95 | 7.07 | 7.01 | 10.64 | 12.67 |
| HK112000 | 514238 | 345212 | 1.43 | 2.58 | 3.40 | 4.01 | 5.08 | 5.81 | 6.19 | 7.35 | 7.30 | 10.93 | 12.95 |

# Modelled Flood Extents (with defences) Model: Lower Witham 2009 [CCN-2023-317303]




Environment Agency

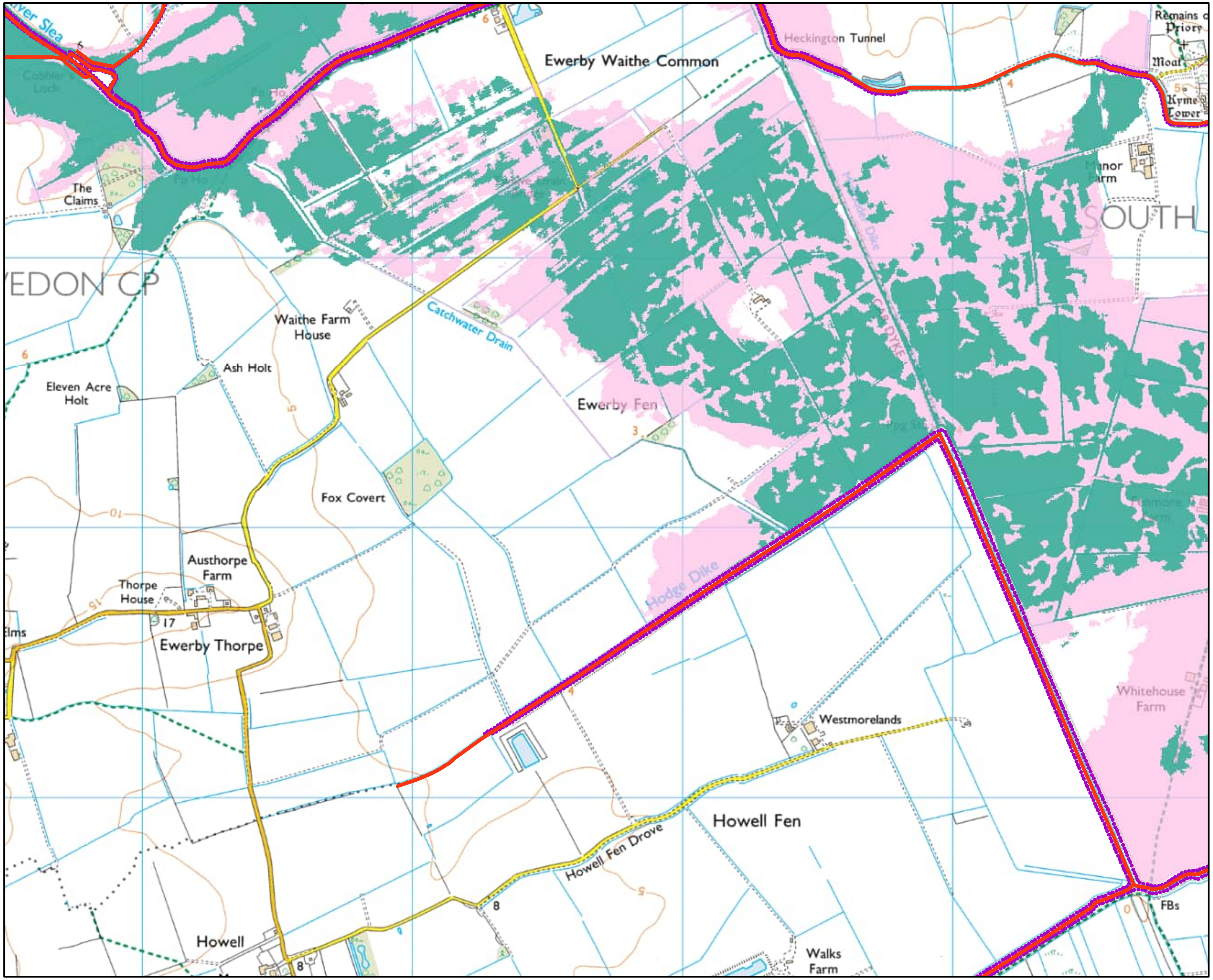
Scale 1:20,000

N W E S

**Legend**

- Main River
- Raised Defences
- Flood Storage Areas
- 2009_LW_Defended_Baseline_1in25
- 2009_LW_Defended_Baseline_1in50
- 2009_LW_Defended_Baseline_1in100
- 2009_LW_Defended_Baseline_1in1000

# Modelled Flood Extents Climate Change (with defences) Model: Lower Witham 2009 [CCN-2023-317303]




Scale 1:20,000

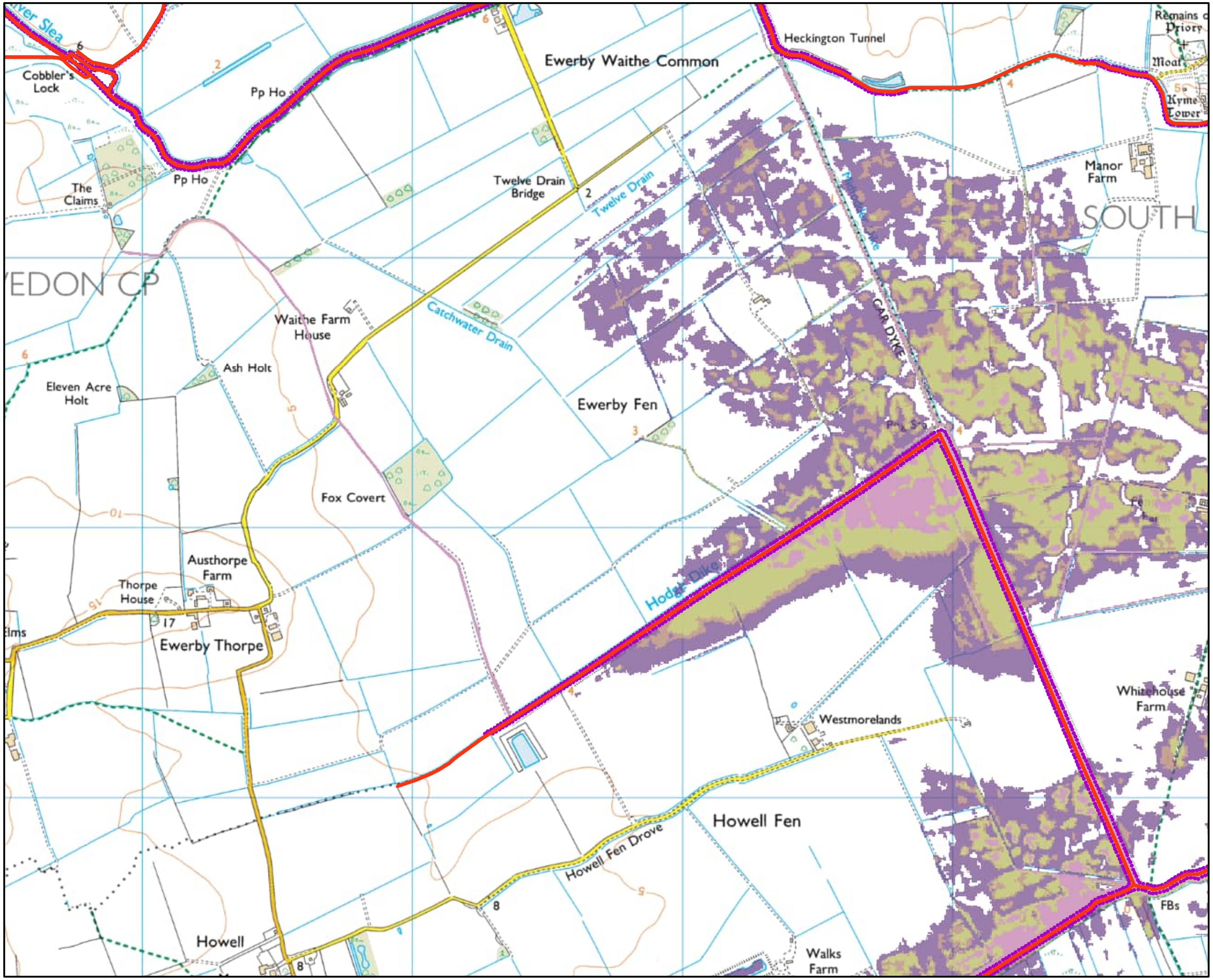
N / S / E / W

**Legend**

- Main River
- Raised Defences
- Flood Storage Areas
- 2009_LW_Defended_Baseline_1in100_CC20pc
- 2009_LW_Defended_Baseline_1in1000_CC20pc

**Contact Us:** National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

# Modelled Flood Extents (with defences) Model: South Forty Foot 2016 [CCN-2023-317303]




Scale 1:20,000

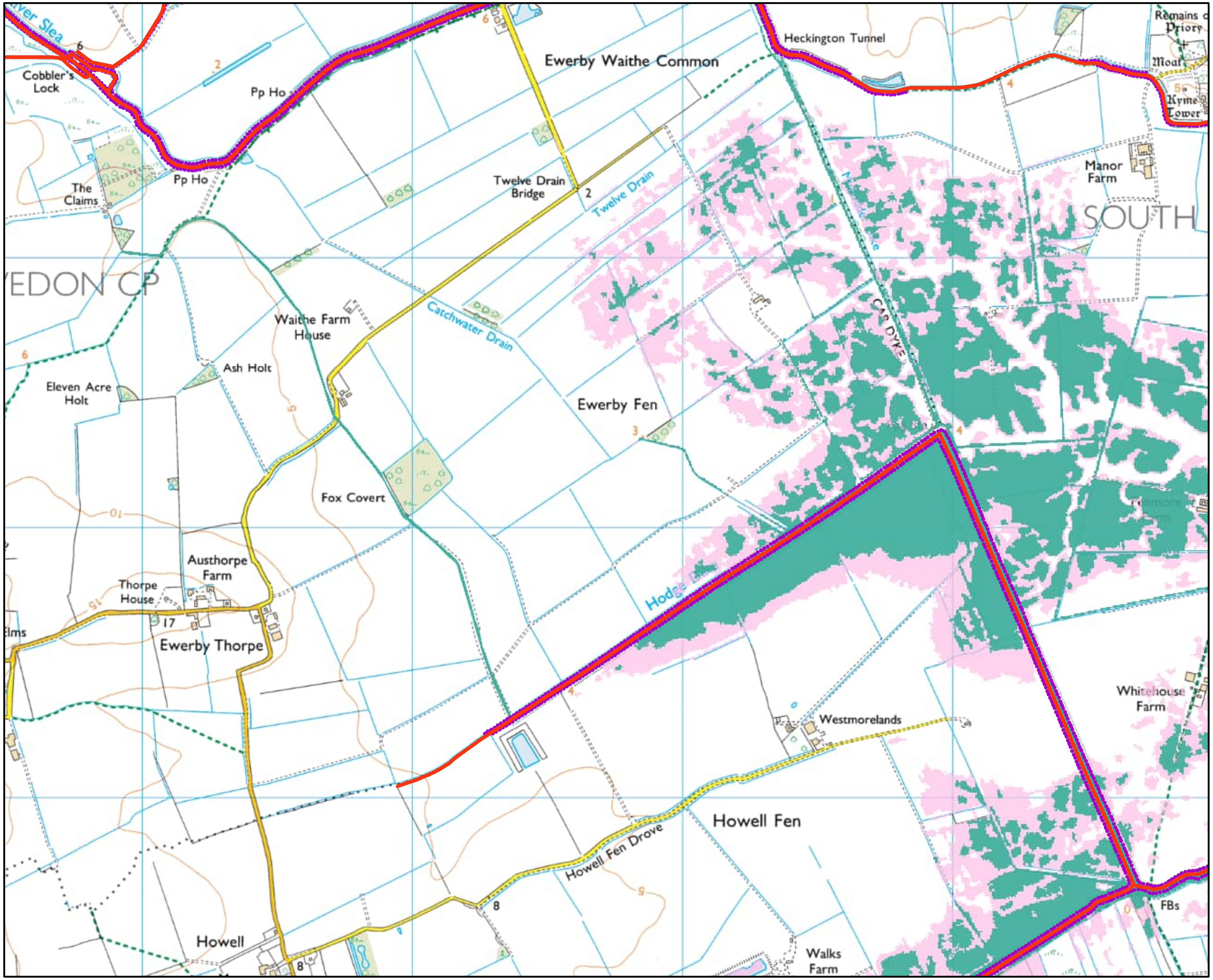
N W E S

**Legend**

- Main River
- Raised Defences
- Flood Storage Areas
- 2016_SFFC_Defended_Baseline_1in10
- 2016_SFFC_Defended_Baseline_1in50
- 2016_SFFC_Defended_Baseline_1in100
- 2016_SFFC_Defended_Baseline_1in1000

**Contact Us:** National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

# Modelled Flood Extents Climate Change (with defences) Model: South Forty Foot 2016 [CCN-2023-317303]




Scale 1:20,000

N
W E
S

**Legend**

- Main River
- Raised Defences
- Flood Storage Areas
- 2016_SFFC_Defended_Baseline_1in100_CC20pc
- 2016_SFFC_Defended_Baseline_1in1000_CC20pc

**Contact Us:** National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

creating a better place
for people and wildlife

Environment Agency

[redacted]
[redacted]@slrconsulting.com

Our ref: EIR2025/42430
Your ref:
Date: 15 December 2025

Dear Bryn,

**Flood Risk Information for S/E of Heckington**

The flood risk information for the above site is set out below and attached. It is important you read any contextual notes on the maps provided.

If you are preparing a Flood Risk Assessment (FRA) for this site, please note this information may not be sufficient by itself to produce an adequate FRA to demonstrate the development is safe over its lifetime. Additional information may be required to carry out an appropriate assessment of all risks, such as the consequences of a breach in the flood defences.

We aim to review our information on a regular basis, so if you are using this data more than twelve months from the date of this letter, please contact us again to check it is still valid.

Please read the letter in full as the information covered has been updated in **August 2025.**

## 1. Flood Map for Planning

The attached map includes the current Flood Map for Planning for your area. The map indicates the Area at Risk of Flooding (Flood Zone 3) and the Extreme Flood Outline (Flood Zone 2) **assuming no flood defences exist.**

The Area at Risk of Flooding shows the land that could be impacted from a flood with a 0.5% or greater chance of occurring in any year for flooding from the sea, or a 1% or greater chance of occurring in any year for fluvial (river) flooding.

The Extreme Flood Outline shows the land that could be impacted from a flood which has between a 1% and 0.1% chance of occurring in any year for fluvial (river) flooding, or between a 0.5% and 0.1% annual probability of sea flooding, or the highest recorded historic extent if greater.

In some locations, such as around the fens and the large coastal floodplains, showing the area at risk of flooding assuming no defences may give a slightly misleading picture in that if there were no flood defences, water would spread out across these large floodplains. This flooding could cover large areas of land but to relatively shallow depths and could leave pockets of locally slightly higher land as isolated dry islands. It is important to understand the actual risk of the flooding to these dry islands, particularly in the event of defence failure.

The Flood Map for Planning also shows the location of formal raised flood defences and flood storage reservoirs. It represents areas at risk of flooding for present day only and does not take account of climate change.

The Flood Map for Planning only indicates the extent and likelihood of flooding from rivers or the sea. It should also be remembered flooding may occur from other sources such as surface water sewers, road drainage, etc.

## 2. <u>Recorded Flood Outlines</u>

With regards to the history of flooding I can advise we do not have any records of flooding in this area. It is possible recent flooding may have occurred which we are currently investigating, therefore this information may be subject to change.

It is possible other flooding may have occurred which other risk management authorities, such as the Lead Local Flood Authority (i.e. top tier council) or Internal Drainage Board (where they exist) have responsibility.

## 3. Schemes in the area

There are no ongoing capital projects to reduce or sustain the current flood risk to this area.

## 4. Fluvial Flood Risk Information

This site is considered to be at risk of flooding from main rivers.

The site may also be at risk from local ordinary watercourses for which other risk management authorities, such as the Lead Local Flood Authority (i.e. top tier council) or Internal Drainage Board (where they exist) have responsibility.

### 4.1 Fluvial Defence Information

The existing fluvial defences reducing the risk of flooding from main river to this site consist of earth embankments. They are in good to poor condition and reduce the risk of flooding (at the defence) to a 10% (1 in 10) chance of occurring in any year. We inspect these defences routinely to ensure potential defects are identified.

The site may be at risk from local ordinary watercourses for which other risk management authorities, such as the Lead Local Flood Authority (i.e. top tier council) or Internal Drainage Board (where they exist) have responsibility.

### 4.2 Fluvial Modelled Levels and Flows

Available modelled fluvial flood levels and flows for the model nodes shown on the attached map are set out in the data table attached. This data is taken from the model named on the data table, which is the most up-to-date model currently available.

Please note these levels are “in-channel” levels and therefore may not represent the flood level on the floodplain, particularly where the channel is embanked or has raised defences.

Our models may not have the most up to date climate change allowances. In time we will update our models for the latest allowances. You should refer to 'Flood risk assessments: climate change allowances' to check if the allowances modelled are appropriate for the type of development you are proposing and its location. You may need to undertake further assessment of future flood risk using different allowances to ensure your assessment of future flood risk is based on best available evidence.

### 4.3 Fluvial Modelled Flood Extents

Please find attached a map showing available modelled flood extents, taking into account flood defences, for your area. This data is taken from the model named on the map, which is the most up-to-date model currently available.

In some cases the flood extents shown may not be from main river, but may be from other sources such as IDB lowland drainage networks.

There may still be a residual risk of fluvial flooding to your site due to the failure of flood management infrastructure such as a breach of a raised flood defence. You may need to undertake further assessment of this residual risk using the data provided.

### 4.4 Fluvial Hazard Mapping

For certain locations we have carried out modelling to map the maximum values of flood depth, velocity and hazard rating (danger to people) resulting from overtopping and / or breaching of defences at specific locations for a number of scenarios.

At present this information is available for fluvial flood risk in Northampton, Lincoln, Wainfleet and some isolated rural locations.

The number of locations we have this information for is expected to increase in time.

At present this site is not covered by any fluvial hazard mapping.

## 5. Tidal Flood Risk Information

This site is considered to be at risk from tidal flooding.

## 6. Development Planning

If you would like local guidance on preparing a flood risk assessment for a planning application, please contact our Sustainable Places team at LNplanning@environment-agency.gov.uk. It will help if you mention this data request and attach your site location plan.

We provide free preliminary advice; additional/detailed advice, review of draft FRAs and meetings are chargeable at a rate set to cover our costs, currently £115 (plus VAT) per hour of staff time. Further details are available on our website at https://www.gov.uk/guidance/developers-get-environmental-advice-on-your-planning-proposals.

General advice on flood risk assessment for planning applications can be found on GOV.UK at https://www.gov.uk/guidance/flood-risk-assessment-for-planning-applications

We have provided information on risk of breach where it is available. If you are intending on using this information to prepare a Flood Risk Assessment you will need to check if the data meets your requirements. You may need to carry out further assessment (or modelling) for sites that are at residual risk (including from breach of defences), or additional locations or scenarios.

Climate change will increase flood risk due to overtopping of defences. Please note, unless specified otherwise, the climate change data included has an allowance for 20% increase in flow. Updated guidance on how climate change could affect flood risk to new development - 'Flood risk assessments: climate change allowances' was published on GOV.UK in **July 2021**. The appropriate updated climate change allowance should be applied in a Flood Risk Assessment.

You should also consult the Strategic Flood Risk Assessment produced by your local planning authority.

## 7. Permitting Information

Under the Environmental Permitting (England and Wales) Regulations 2016, permission must be obtained from the Environment Agency for any proposed activities which will take place:

- in, over, under or within 8 metres of a main river (16 metres if tidal)
- on or within 8 metres of a flood defence structure or culvert (16 metres if tidal)
- on or within 16 metres of a sea defence
- within 16 metres of any main river, flood defence (including a remote defence) or culvert for quarrying or excavation
- in a flood plain more than 8 metres from the river bank, culvert or flood defence structure (16 metres if tidal) if planning permission has not already been granted for the works

For further guidance and advice please visit our website: https://www.gov.uk/guidance/flood-risk-activities-environmental-permits or contact our local Partnerships and Strategic Overview team by email at psolincs@environment-agency.gov.uk. The team will be able to advise if an environmental permit or exemption registration is required and the fee applicable.

Please note that a permit is separate to and in addition to any planning permission granted. The applicant should not assume that such a permit will automatically be forthcoming once planning permission has been granted, and we would advise them to consult with us at the earliest opportunity.

## 8. Data Licence and Other Supporting Information

We respond to requests for recorded information we hold under the Freedom of Information Act 2000 (FOIA) and the associated Environmental Information Regulations 2004 (EIR).

This information is provided in accordance with the Open Government Licence which can be found here: http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/

Further information on flood risk can be found on the GOV.UK website at:
https://www.gov.uk/browse/environment-countryside/flooding-extreme-weather

**Rights of appeal**

If you are not satisfied with our decision, you can contact us within two calendar months to ask for the decision to be reviewed. We will then conduct an internal review of our response to your request and give you our decision in writing within 40 working days.

If you are not satisfied with the outcome of the internal review, you can then make an appeal to the Information Commissioner Office, the statutory regulator for EIR and the Freedom of Information Act 2002. The address is: Information Commissioner's Office, Wycliffe House, Water Lane, Wilmslow, Cheshire. SK9 5AF.

Tel: 0303 123 1113 (local rate) or 01625 545 745 (national rate) | Fax: 01625 524 510
Email: casework@ico.org.uk | Website: www.ico.org.uk

## 9. Other Flood Risk Management Authorities

The information provided with this letter relates to flood risk from main river or the sea. The Flood Map for Surface Water can be viewed at https://www.gov.uk/check-long-term-flood-risk

Additional information may be available from other risk management authorities, such as the Lead Local Flood Authority (ie top tier council) or Internal Drainage Board (where they exist).

I hope we have correctly interpreted your request. If you have any queries or would like to discuss the content of this letter further please contact PSOLincs@environment-agency.gov.uk and quoting our EIR reference number above.

Yours sincerely,

[redacted]

[redacted]
**Flood and Coastal Risk Management Officer**
Witham Partnerships and Strategic Over Team

**for** [redacted]
**Witham Partnerships and Strategic Overview Team Leader**
e-mail PSOLINCS@environment-agency.gov.uk

Enc.

Flood Map for Planning

Modelled Node Points Map

Modelled Fluvial Levels and Flows Data Sheet

Modelled Flood Extent Maps

# Flood Map for Planning centred onS/E heckington - created December 2025 [Ref: EIR2025/42430]




Environment Agency

Scale 1:25,000

N
W E
S

**Legend**

- Main River
- Raised Defences
- Flood Storage Areas

**Flood Zones 2 and 3 Rivers and Sea**

**Flood Zone**

- Flood Zone 2
- Flood Zone 3

Dark blue shows the area that could be affected by flooding, either from rivers or the sea, if there were no flood defences. This area could be flooded:

- from the sea by a flood that has a 0.5% (1 in 200) or greater chance of happening each year.

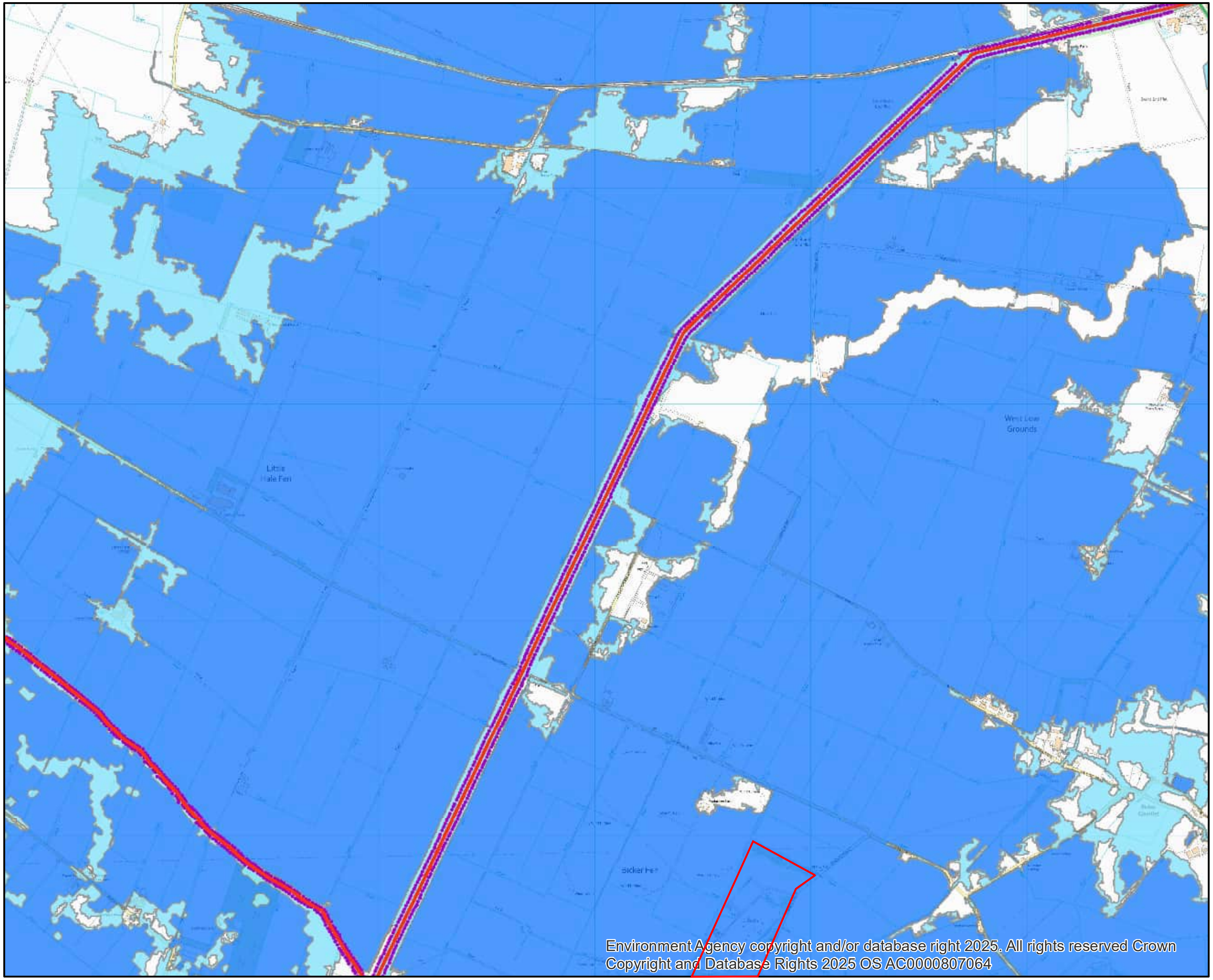
- or from a river by a flood that has a 1% (1 in 100) or greater chance of happening each year.

Light blue shows the extent of the Extreme Flood Outline, which represents the extent of a flood event with a 0.1% chance of occurring in any year, or the highest recorded historic extent if greater.

These two colours show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements. Sites outside the two extents, but behind raised defences, may be affected by flooding if the defences are overtopped or fail.

**Contact Us:** National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

# Flood Map for Planning centred onS/E Heckington - created December 2025 [Ref: EIR2025/42430]




Scale 1:25,000

N
W E
S

**Legend**

- Main River
- Raised Defences
- Flood Storage Areas

**Flood Zones 2 and 3 Rivers and Sea**

**Flood Zone**

- Flood Zone 2
- Flood Zone 3

Dark blue shows the area that could be affected by flooding, either from rivers or the sea, if there were no flood defences. This area could be flooded:

- from the sea by a flood that has a 0.5% (1 in 200) or greater chance of happening each year.

- or from a river by a flood that has a 1% (1 in 100) or greater chance of happening each year.

Light blue shows the extent of the Extreme Flood Outline, which represents the extent of a flood event with a 0.1% chance of occurring in any year, or the highest recorded historic extent if greater.

These two colours show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements. Sites outside the two extents, but behind raised defences, may be affected by flooding if the defences are overtopped or fail.

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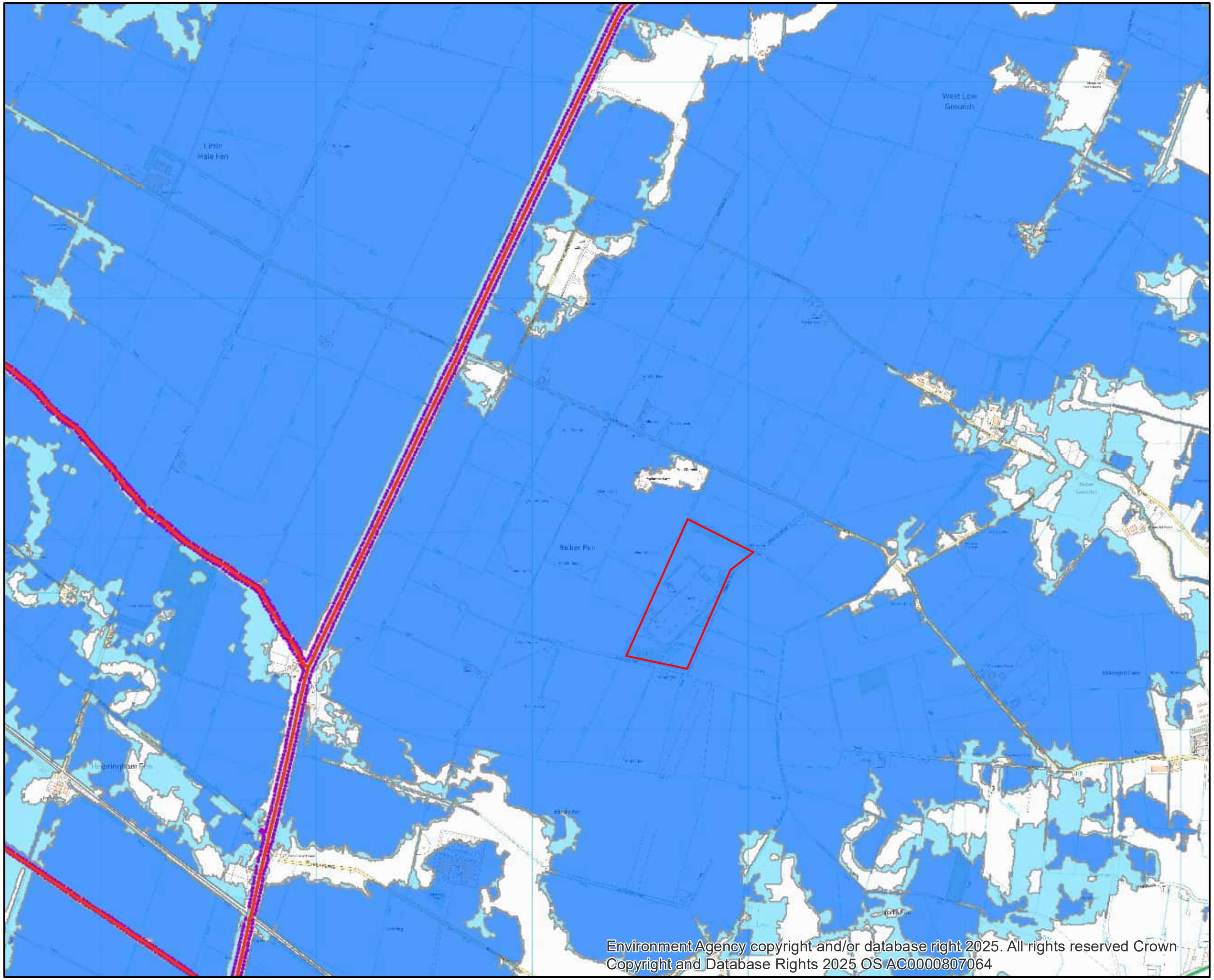
# Flood Map for Planning centred onS/E Heckington - created December 2025 [Ref: EIR2025/42430]




Environment Agency

Scale 1:25,000

N
W E
S

**Legend**

- Main River
- Raised Defences
- Flood Storage Areas

**Flood Zones 2 and 3 Rivers and Sea**

**Flood Zone**

- Flood Zone 2
- Flood Zone 3

Dark blue shows the area that could be affected by flooding, either from rivers or the sea, if there were no flood defences. This area could be flooded:

- from the sea by a flood that has a 0.5% (1 in 200) or greater chance of happening each year.

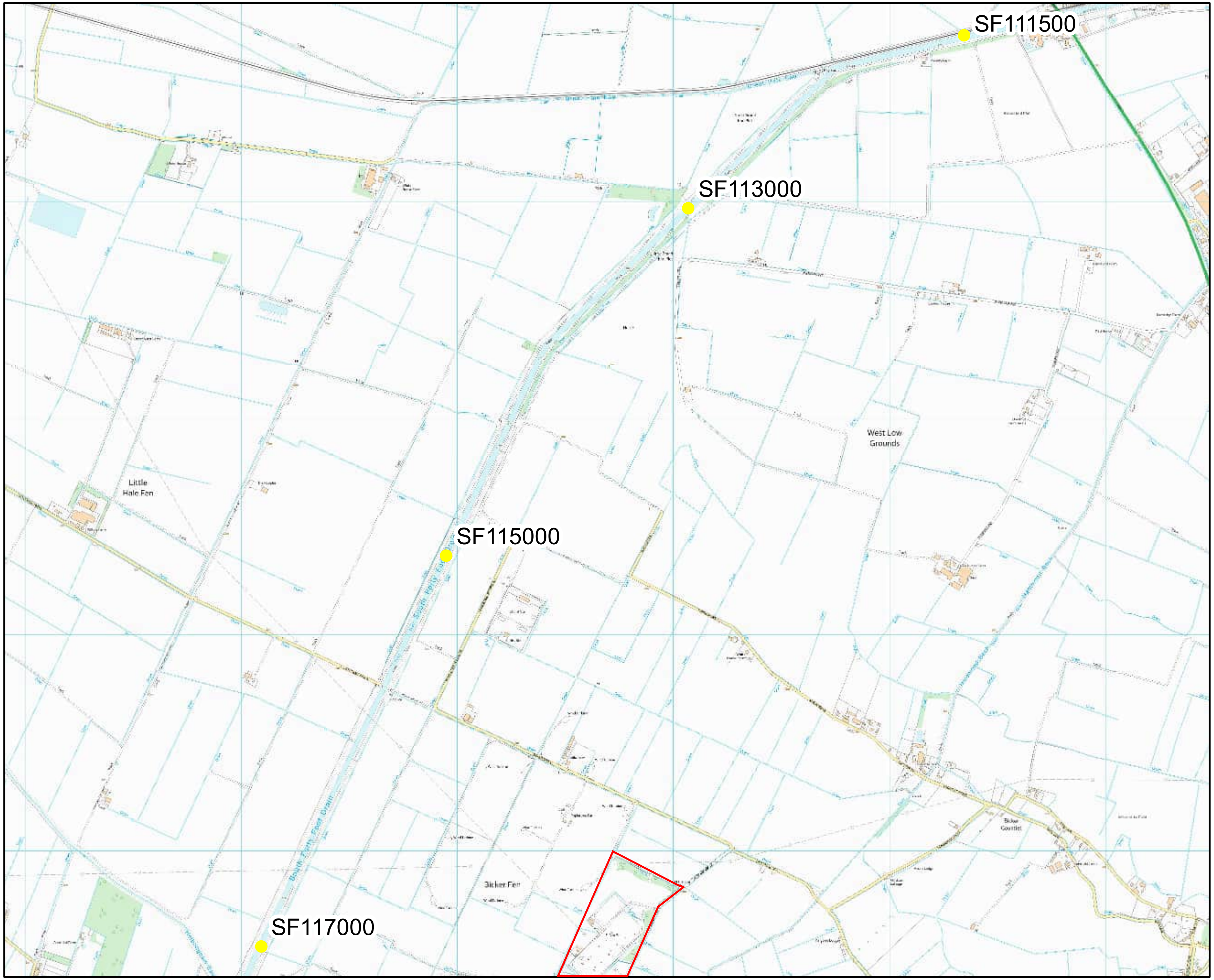
- or from a river by a flood that has a 1% (1 in 100) or greater chance of happening each year.

Light blue shows the extent of the Extreme Flood Outline, which represents the extent of a flood event with a 0.1% chance of occurring in any year, or the highest recorded historic extent if greater.

These two colours show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements. Sites outside the two extents, but behind raised defences, may be affected by flooding if the defences are overtopped or fail.

**Contact Us:** National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

# Model Nodes Map    Model: Lower Witham 2009 EIR2025/42430]




Scale 1:25,000

N
W
E
S

**Legend**

SFF_Nodes

**Contact Us:** National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Environment Agency

**Datasheet [Ref: EIR2025/42430]** **Model Name: South Forty Foot** **Model Date: 2016**

## Fluvial Flood Levels (mODN)

The fluvial flood levels for the model nodes shown on the attached map are set out in the table below. They are measured in metres above Ordnance Datum Newlyn (mODN).

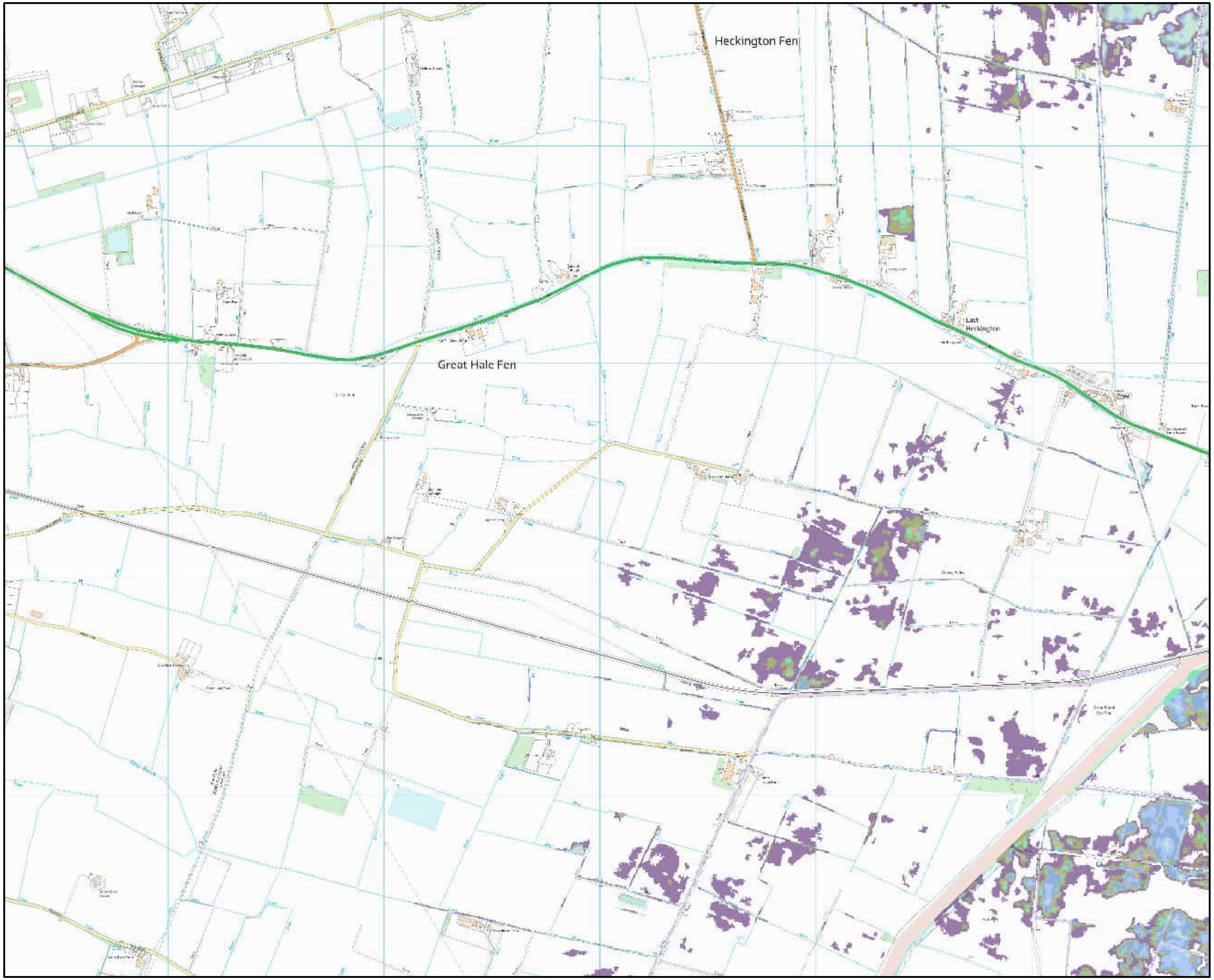
| | | | Annual Exceedance Probability - Maximum Water Levels (mODN) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Node Label | Easting | Northing | 50% (1 in 2) | 20% (1 in 5) | 10% (1 in 10) | 5% (1 in 20) | 2% (1 in 50) | 1.33% (1 in 75) | 1% (1 in 100) | 1% (1 in 100) inc 20% Climate Change | 0.5% (1 in 200) | 0.1% (1 in 1000) | 0.1% (1 in 1000) inc 20% Climate Change |
| SF111500 | 521344 | 342772 | 2.16 | 2.55 | 2.64 | 2.67 | 2.81 | 2.85 | 2.86 | 2.89 | 2.89 | 2.91 | 2.92 |
| SF113000 | 520068 | 341973 | 2.17 | 2.56 | 2.64 | 2.72 | 2.87 | 2.91 | 2.92 | 2.94 | 2.94 | 2.97 | 2.98 |
| SF115000 | 518948 | 340366 | 2.17 | 2.58 | 2.65 | 2.79 | 2.94 | 2.98 | 2.99 | 3.01 | 3.01 | 3.04 | 3.05 |
| SF117000 | 518091 | 338556 | 2.18 | 2.60 | 2.73 | 2.87 | 3.02 | 3.05 | 3.06 | 3.08 | 3.08 | 3.11 | 3.12 |

## Fluvial Flood Flows (m³/s)

The fluvial flood flows for the model nodes shown on the attached map are set out in the table below. They are measured in metres cubed per second (m³/s).

| | | | Annual Exceedance Probability - Maximum Flows (m³/s) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Node Label** | **Easting** | **Northing** | **50% (1 in 2)** | **20% (1 in 5)** | **10% (1 in 10)** | **5% (1 in 20)** | **2% (1 in 50)** | **1.33% (1 in 75)** | **1% (1 in 100)** | **1% (1 in 100) inc 20% Climate Change** | **0.5% (1 in 200)** | **0.1% (1 in 1000)** | **0.1% (1 in 1000) inc 20% Climate Change** |
| SF111500 | 521344 | 342772 | 19.96 | 32.32 | 35.77 | 37.58 | 40.58 | 40.98 | 40.94 | 41.31 | 41.25 | 42.93 | 43.29 |
| SF113000 | 520068 | 341973 | 19.12 | 31.44 | 35.16 | 36.98 | 39.76 | 40.16 | 40.13 | 41.85 | 41.21 | 43.56 | 43.47 |
| SF115000 | 518948 | 340366 | 19.20 | 31.99 | 36.54 | 38.52 | 40.78 | 41.44 | 41.55 | 43.60 | 42.95 | 44.34 | 43.72 |
| SF117000 | 518091 | 338556 | 18.82 | 32.70 | 37.70 | 39.89 | 42.13 | 42.76 | 43.34 | 45.27 | 44.71 | 45.02 | 43.95 |

# ModelledFlood Extents (with defences)  Model: Lower Witham 2009 EIR2025/42430]




Scale 1:25,000

N
W E
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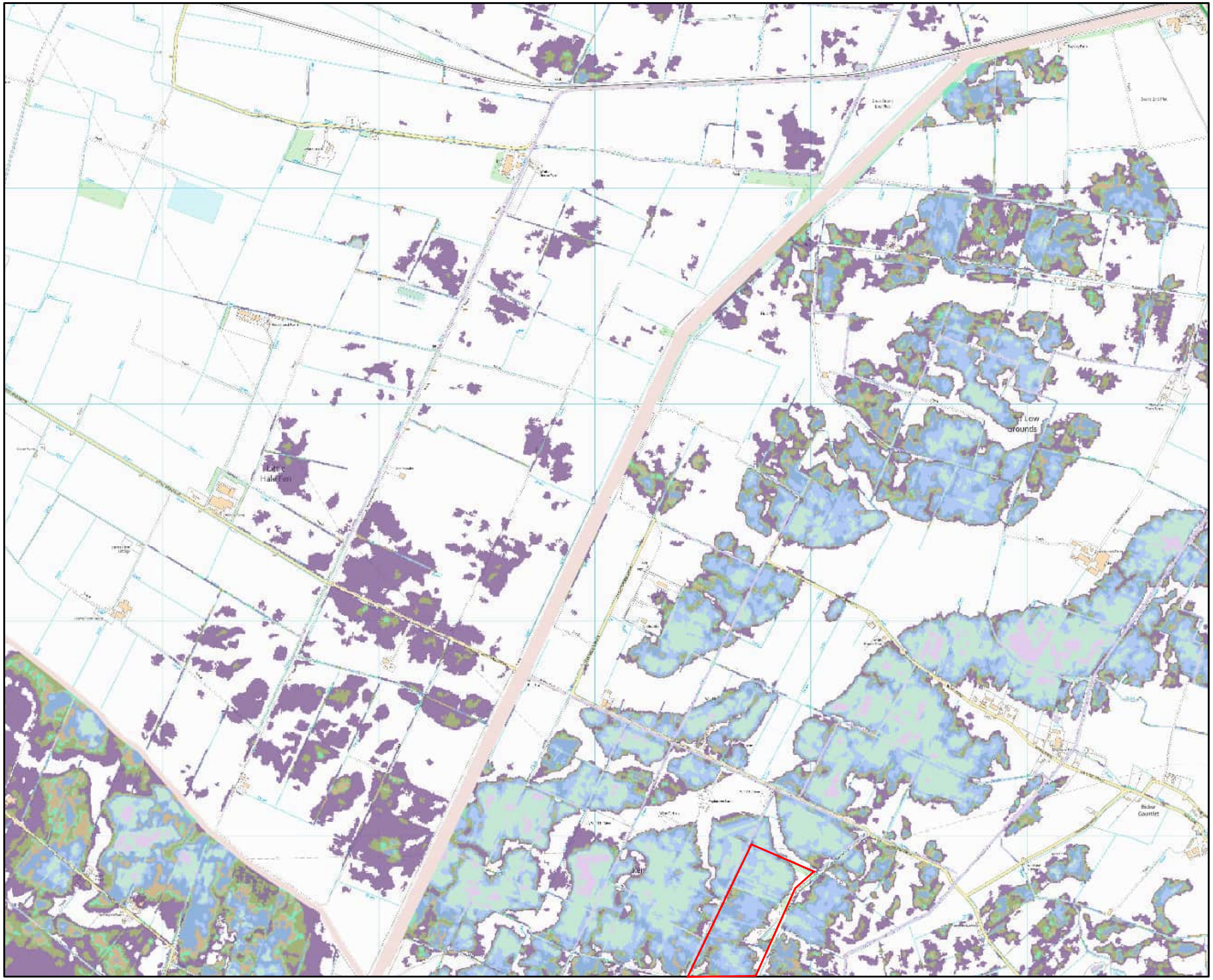
**Legend**

- 2016_SFFC_Defended_Baseline_1in2
- 2016_SFFC_Defended_Baseline_1in5
- 2016_SFFC_Defended_Baseline_1in10
- 2016_SFFC_Defended_Baseline_1in20
- 2016_SFFC_Defended_Baseline_1in50
- 2016_SFFC_Defended_Baseline_1in75
- 2016_SFFC_Defended_Baseline_1in100
- 2016_SFFC_Defended_Baseline_1in200
- 2016_SFFC_Defended_Baseline_1in1000

**Contact Us:** National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

# ModelledFlood Extents (with defences)  Model: Lower Witham 2009 EIR2025/42430]




Environment Agency

Scale 1:25,000

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**Legend**

- 2016_SFFC_Defended_Baseline_1in2
- 2016_SFFC_Defended_Baseline_1in5
- 2016_SFFC_Defended_Baseline_1in10
- 2016_SFFC_Defended_Baseline_1in20
- 2016_SFFC_Defended_Baseline_1in50
- 2016_SFFC_Defended_Baseline_1in75
- 2016_SFFC_Defended_Baseline_1in100
- 2016_SFFC_Defended_Baseline_1in200
- 2016_SFFC_Defended_Baseline_1in1000

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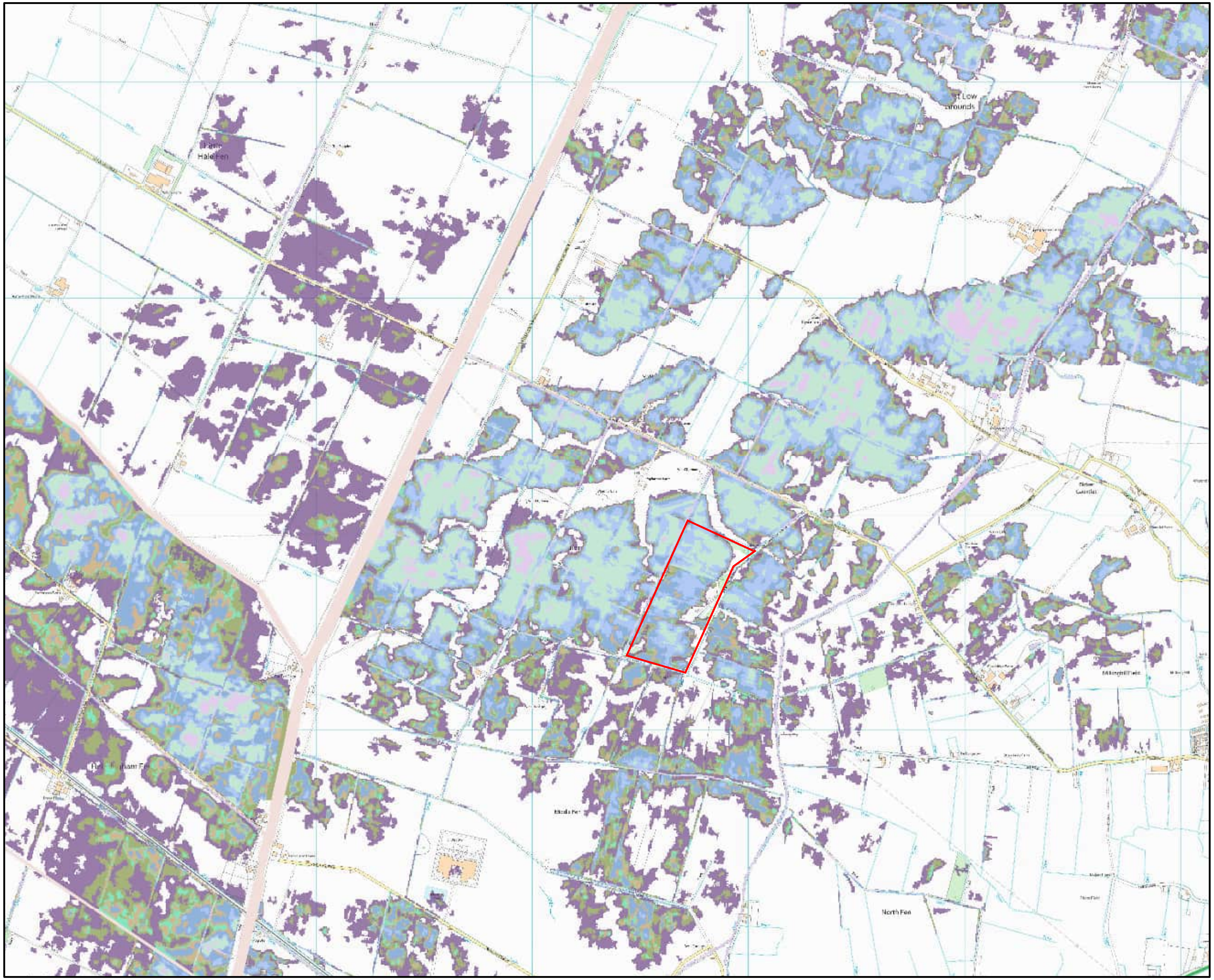
# ModelledFlood Extents (with defences)  Model: Lower Witham 2009 EIR2025/42430]



Environment Agency

Scale 1:25,000

N
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**Legend**

- 2016_SFFC_Defended_Baseline_1in2
- 2016_SFFC_Defended_Baseline_1in5
- 2016_SFFC_Defended_Baseline_1in10
- 2016_SFFC_Defended_Baseline_1in20
- 2016_SFFC_Defended_Baseline_1in50
- 2016_SFFC_Defended_Baseline_1in75
- 2016_SFFC_Defended_Baseline_1in100
- 2016_SFFC_Defended_Baseline_1in200
- 2016_SFFC_Defended_Baseline_1in1000

Dark blue shows the area that could be affected by flooding, either from rivers or the sea, if there were no flood defences. This area could be flooded:

- from the sea by a flood that has a 0.5% (1 in 200) or greater chance of happening each year.

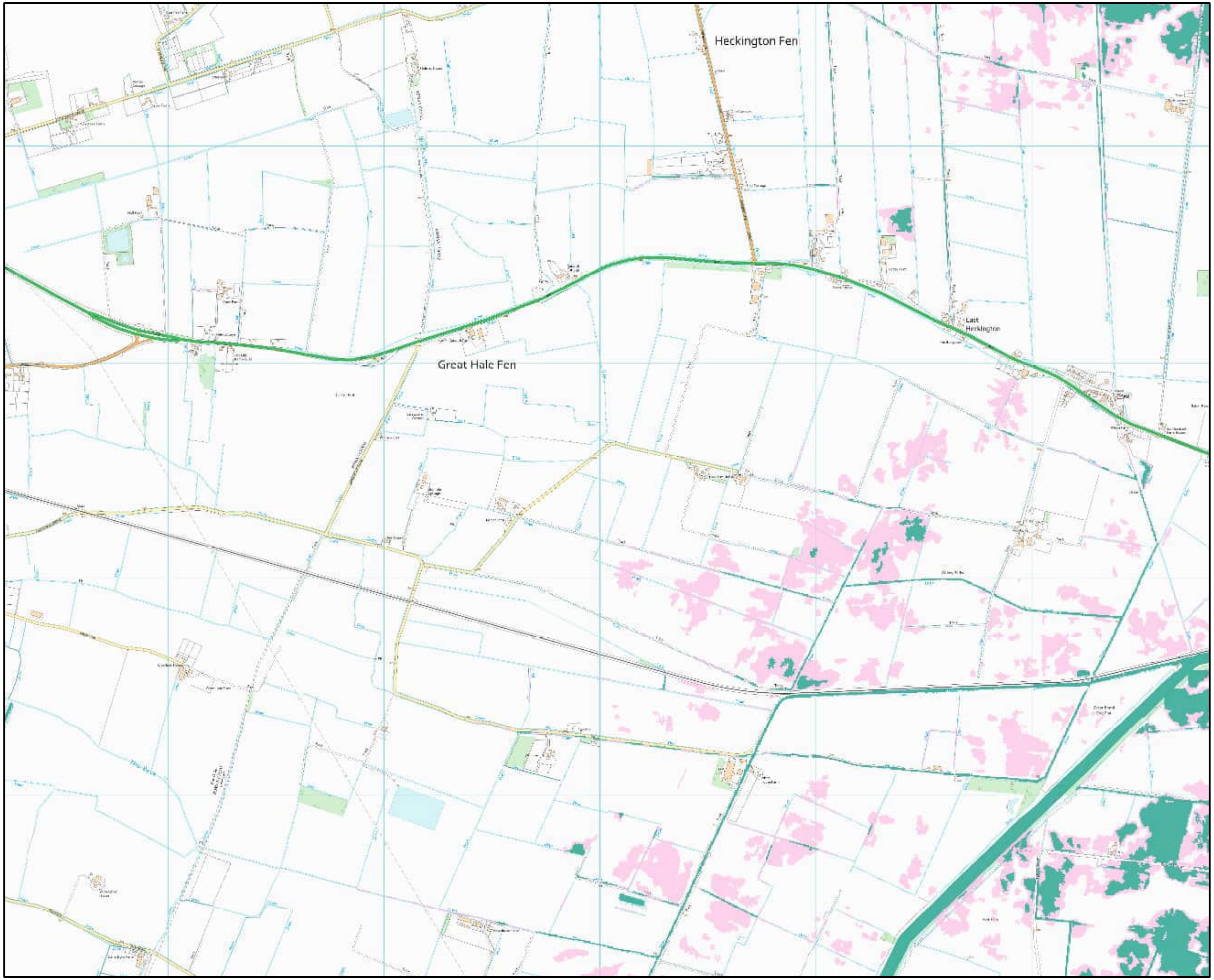
- or from a river by a flood that has a 1% (1 in 100) or greater chance of happening each year.

Light blue shows the extent of the Extreme Flood Outline, which represents the extent of a flood event with a 0.1% chance of occurring in any year, or the highest recorded historic extent if greater.

These two colours show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements. Sites outside the two extents, but behind raised defences, may be affected by flooding if the defences are overtopped or fail.

**Contact Us:** National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

# ModelledFlood Extents (with defences)  Model: Lower Witham 2009 EIR2025/42430]




Environment Agency

Scale 1:25,000

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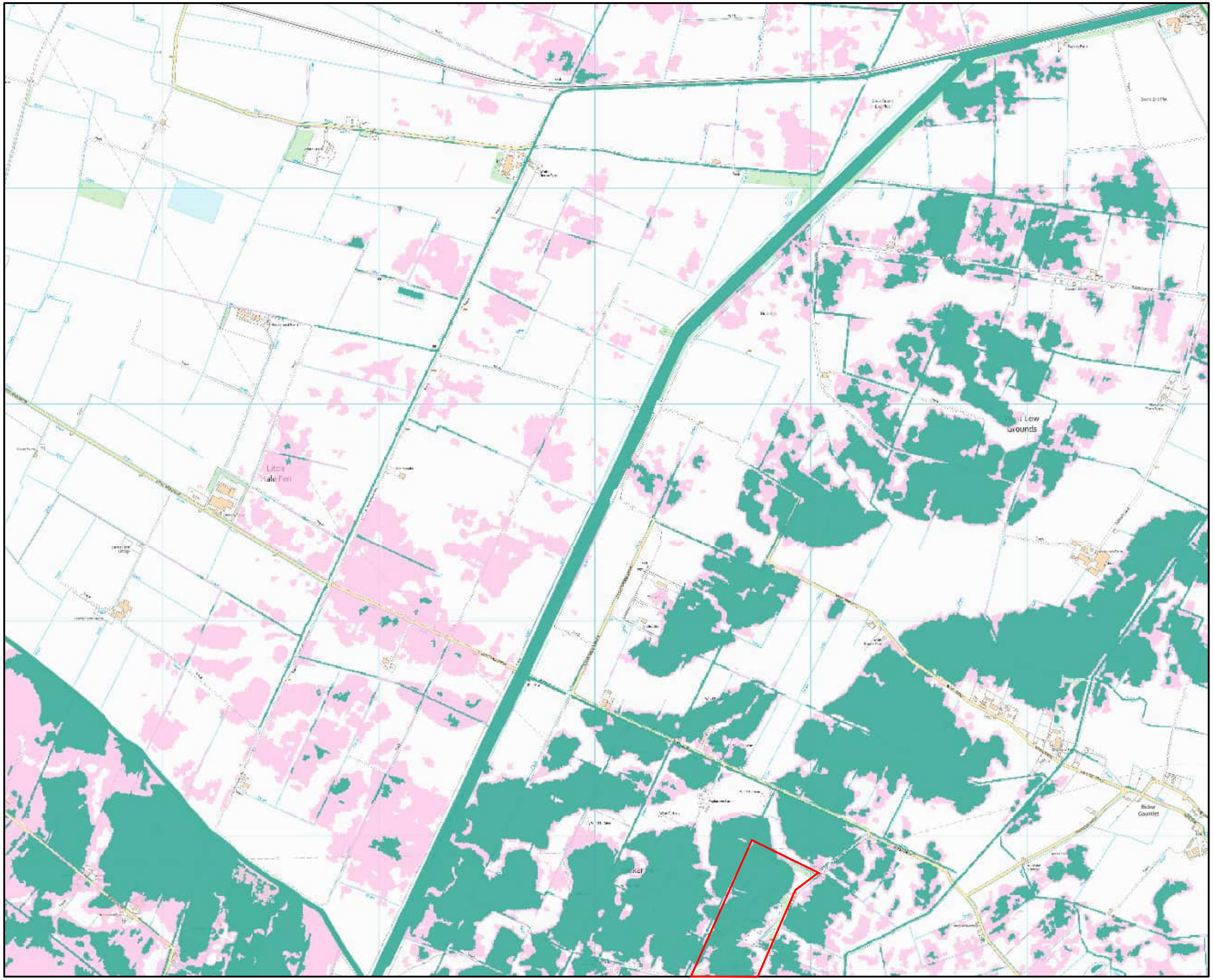
**Legend**

2016_SFFC_Defended_Baseline_1in100_CC20pc

2016_SFFC_Defended_Baseline_1in1000_CC20pc

**Contact Us:** National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

# Modelled Flood Extents Climate Change (with defences) Model: Lower Witham 2009 EIR2025/42430]



Scale 1:25,000

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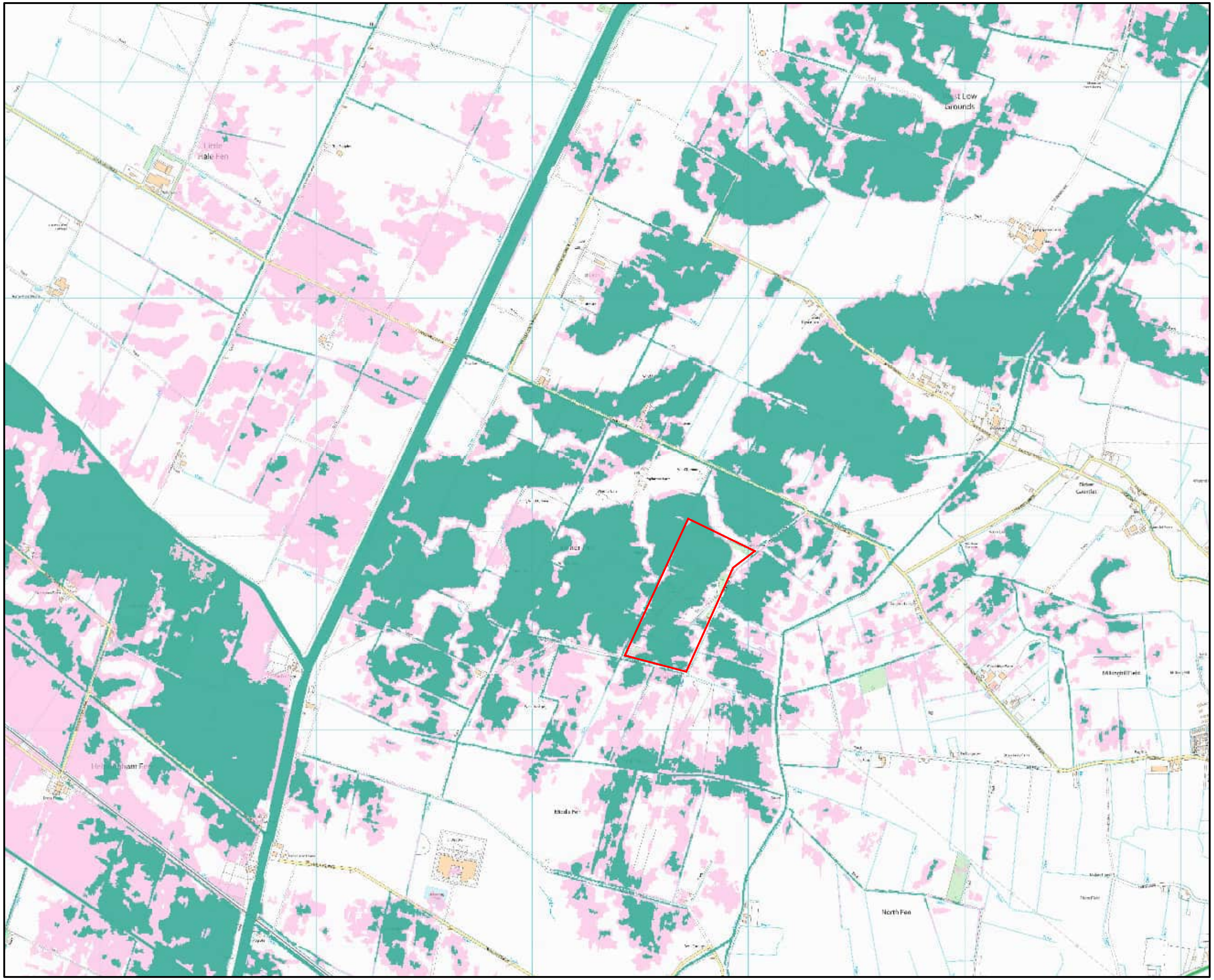
**Legend**

- 2016_SFFC_Defended_Baseline_1in100_CC20pc
- 2016_SFFC_Defended_Baseline_1in1000_CC20pc

# Modelled Flood Extents Climate Change (with defences) Model: Lower Witham 2009 EIR2025/42430]



Environment Agency

Scale 1:25,000

N
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**Legend**

2016_SFFC_Defended_Baseline_1in100_CC20pc

2016_SFFC_Defended_Baseline_1in1000_CC20pc

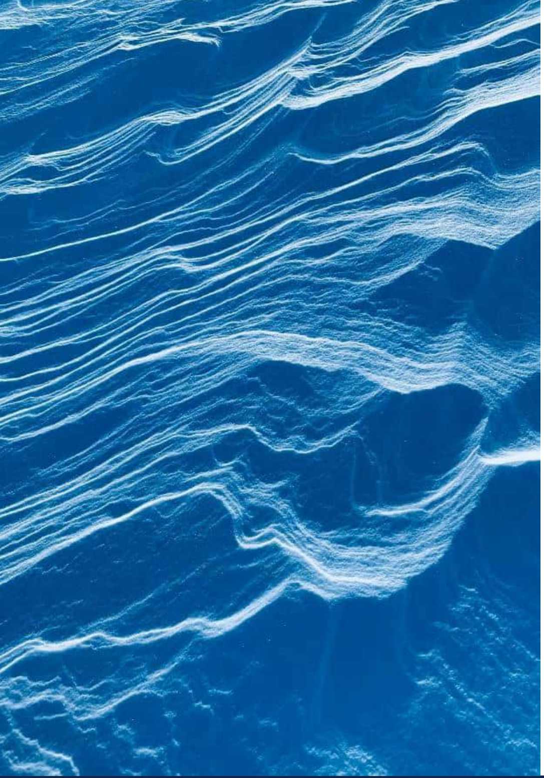
**Contact Us:** National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

# Appendix 2. Aegaea Hydraulic Model Reports

## Baseline Model: Ref AEG2934_LN4_Fen_Hydraulic Model Report_003

## Extreme Event Model: Ref AEG2934_LN4_Fen_Extreme Event Model Report_001

## Breach Model: Ref AEG2934_LN4_Fen_Breach Model Report_003



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# Hydraulic Model Report

## AEG2934_LN4_Fen_03

Site Address:
Land at Westmoorland Farms,
Fen,
Lincolnshire,
LN4 4AA

**UK Experts in Flood Modelling, Flood Risk Assessments, and Surface Water Drainage Strategies**

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# Document Issue Record

**Project:** AEG2934_LN4_Fen_03

**Prepared for:** Beacon Fen Energy Park Limited

**Reference:** AEG2934_LN4_Fen_Hydraulic_Model_Report_003

**Site Location:** Land at Westmoorland Farms, Fen, Lincolnshire, LN4 4AA

**Revision:** 003

| Consultant | | Date |
|---|---|---|
| Author | Rebecca Thirkell | 07/02/2025 |
| Document Check | Calum Park | 11/02/2025 |
| Authorisation | Chris Cameron-Hann | 12/02/2025 |
| Revision 001 | | |
| Author | Rebecca Thirkell | 31/03/2025 |
| Document Check | Calum Park | 31/03/2025 |
| Authorisation | Chris Cameron-Hann | 31/03/2025 |
| Revision 002 | | |
| Author | Paige Sanders | 01/09/2025 |
| Document Check | Calum Park | 01/09/2025 |
| Authorisation | Nick Darling-Drewett | 01/09/2025 |
| Revision 003 | | |
| Author | Paige Sanders | 11/11/2025 |
| Document Check | Calum Park | 11/11/2025 |
| Authorisation | Nick Darling-Drewett | 11/11/2025 |

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## Revision 001

Revision 001 has been updated to account for a change in red line boundary around the proposed solar array at the request of Low Carbon. No other updates were made.

## Revision 002

Revision 002 incorporates updates made in response to the Environment Agency's model review comments. All results and sensitivity testing outputs have been updated, with the addition of the Downstream Boundary Sensitivity Test, undertaken to assess the model's sensitivity to elevated downstream water levels.

## Revision 003

Revision 003 of this report incorporates updates made in response to the Environment Agency's model review comments. Additional text has been added to 1.5, 1.6, 3.14 - 3.19, 3.27, 3.28, 4.17, 4.18, 4.34, 4.49, 4.50, 6.28 and 6.34.

# Table of Contents





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# 1. Introduction

1.1. Aegaea have been commissioned by Beacon Fen Energy Park Limited to undertake a fluvial hydraulic modelling exercise of watercourses within the vicinity of the study site at Land at Westmoorland Farms, Fen, Lincolnshire, LN4 4AA. This is to identify the potential fluvial flood risk posed by the watercourses.

1.2. The project is being undertaken in a staged approach as detailed below.

- **Stage 1:** Acquisition and review of existing EA models.
- **Stage 2:** Combining and updating the existing EA models to include a 2D domain and topographic survey
- **Stage 3:** Defence breach and extreme event modelling
- **Stage 4:** Reporting

1.3. This report details the combination and update to the existing Environment Agency models as part of Stage 2 of the project. The work was undertaken in accordance with the agreed modelling methodology as approved by the Environment Agency. The modelling methodology and comments are provided in Appendix A.

1.4. The hydraulic modelling is based on two existing hydraulic models provided by the Environment Agency. The first covers the River Slea and Kyme Eau (Lower Witham network) while the second covers Head Dike and Skerth Drain (Black Sluice network). The models were provided to Aegaea with the purpose of updating them to be suitable for a site-specific flood risk assessment.

1.5. The baseline modelling presented in this report has since been supplemented by two addendum assessments:

- **Extreme Event Modelling Report:** AEG2934_LN4_Fen_Extreme Event_Model_Report_001, which assessed the fluvial and tidal credible maximum scenarios;
- **Breach Modelling Report:** AEG2934_LN4_Fen_Breach_Model_Report_003, which assessed the potential impact of defence breach scenarios.

1.6. These addendums build upon the baseline model presented herein and were undertaken to further evaluate residual and extreme flood risk to the site.

1.7. The site location is shown within Figure 1 below, along with nearby watercourses.

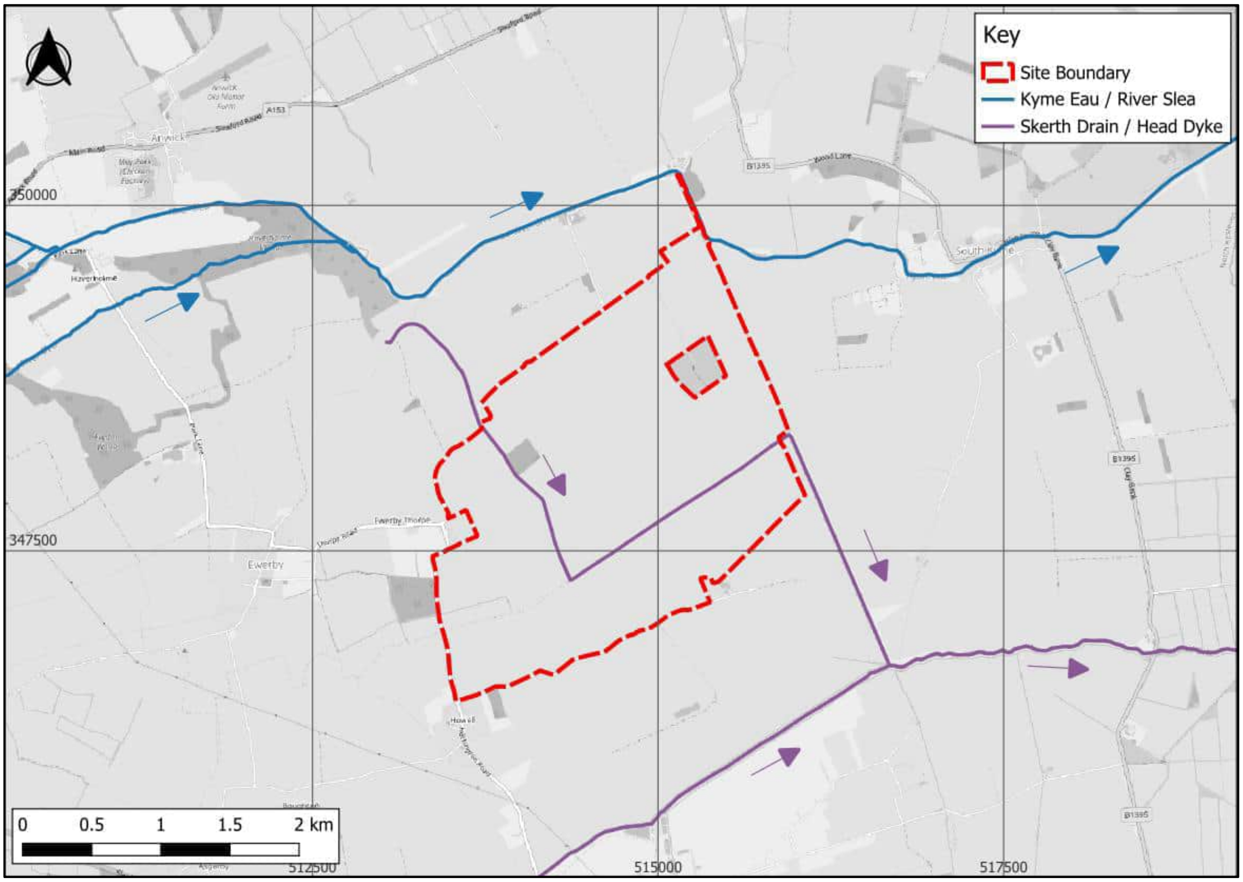


Figure 1: Area of Interest (Base map and data from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

## Aims and Objectives

1.8. The aim of this exercise is to establish an accurate hydraulic representation of the existing fluvial flooding mechanisms within the study site.

1.9. To achieve this aim, the following objectives have been identified:

- Obtain existing hydraulic models for the two watercourses within close proximity to the study site.
- Convert and combine the two existing hydraulic models into a single model using suitable software and the most recent version at the time of construction.
- Update the hydraulic models to be a combined 1D-2D model and incorporate new survey of structures not currently represented in the existing hydraulic models.
- Simulate flood events with the combined 1D-2D model to establish the current fluvial flood risk extent.

# 2. Available Data

## Flood Map for Planning

2.1. The watercourses near to the study site are represented within the Environment Agency Flood Map for Planning dataset (as shown on Figure 2). Both the River Slea/Kyme Eau (Lower Witham network) and Head Dike/Skerth Drain (Black Sluice network) are classified as an Environment Agency Main River. There are also flood defences present along much of the watercourses designated as main rivers.

2.2. The east of the site is shown on Figure 2 to be located within Flood Zone 3, this area is designated as having a 1 in 100 year or greater annual probability of river flooding or a 1 in 200 year or greater annual probability of tidal flooding. A small area of the site is in Flood Zone 2 while the remainder is in Flood Zone 1. The Flood Zones displayed on Figure 2 do not take into account the presence of flood defences.

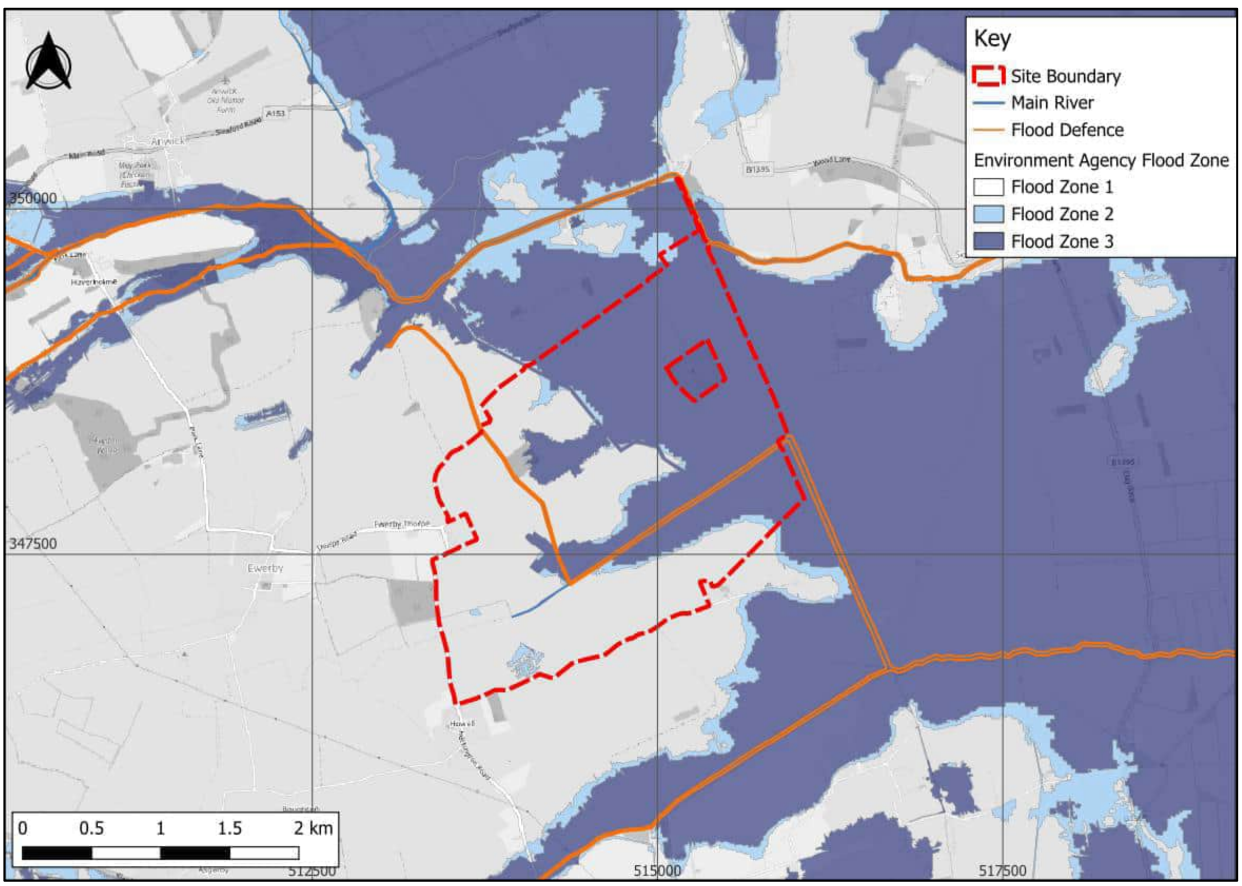


Figure 2: Flood Map for Planning (Base map and data from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors, © EA copyright and/or database right 2015)

2.3. The fluvial flood extents associated with the Flood Map for Planning are understood to be based on the Environment Agency's Lower Witham and Black Sluice models. These models were reviewed in detail by Aegaea in December 2023 (AEG02934_LN4_Fen_03_TechNote). A summary of this review is provided below.

## Existing Hydraulic Models

2.4. The study site is covered by two Environment Agency models (Black Sluice and Lower Witham) with the very western boundary being located outside of the extent of the models. Therefore, the combined hydraulic model requires extending to cover the full site area.

2.5. Initially both Environment Agency models were provided in InfoWorks RS format. After the first model review had been completed an earlier version of the Black Sluice model was provided in Flood Modeller format. A review of the older Black Sluice model found it was constructed in an outdated ISIS (early Flood Modeller) version of the software which would require updating. Spills within the model generated errors where the spill was lower than the structure soffit and some structures were found to be missing from the network. The remainder of the model was considered suitable for use once connected to a 2D domain. Hydrology input files were provided with this model. The hydrology was original calculated in the original model build in 2003. An update was made to the InfoWorks RS model however the associated hydrology files were not provided in this data share. Therefore, the hydrology was considered not fit for use due to the age of the study.

2.6. The Lower Witham InfoWorks RS model was converted to InfoWorks ICM (2024) as the RS software is no longer supported. Innovyze advised that during the conversion process not all objects from the original model database were imported due to compatibility issues, therefore structures such as pumps, user defined controls, flap valves, screens, irregular weirs and siphons were not converted. Some culverts were also found to be missing. No hydrology is available for the Lower Witham model. Therefore, a full rebuild of this model was required to make it fit for purpose along with a new hydrological assessment to provide inflows.

2.7. The following actions were identified following the model review for the combined hydraulic model:

- Rebuild river reaches using the data contained within the Environment Agency models and new topographical surveys.
- Improve modelling around river reach junctions.
- Create new hydrology for both catchments of the study
- Update and add structures into the 1D network using topographical survey.
- Obtain operational rules for pumping stations and moveable structures.
- Review stability of the model following the combination of the models.

# 3. Hydrological Assessment

3.1. A new hydrology assessment was undertaken as part of the fluvial hydraulic modelling exercise in line with recommendations made from the existing model review.

3.2. A full flood estimation record has been completed as part of this assessment which is provided in Appendix B. A summary of which is provided below with the hydrology study area shown in Figure 3.

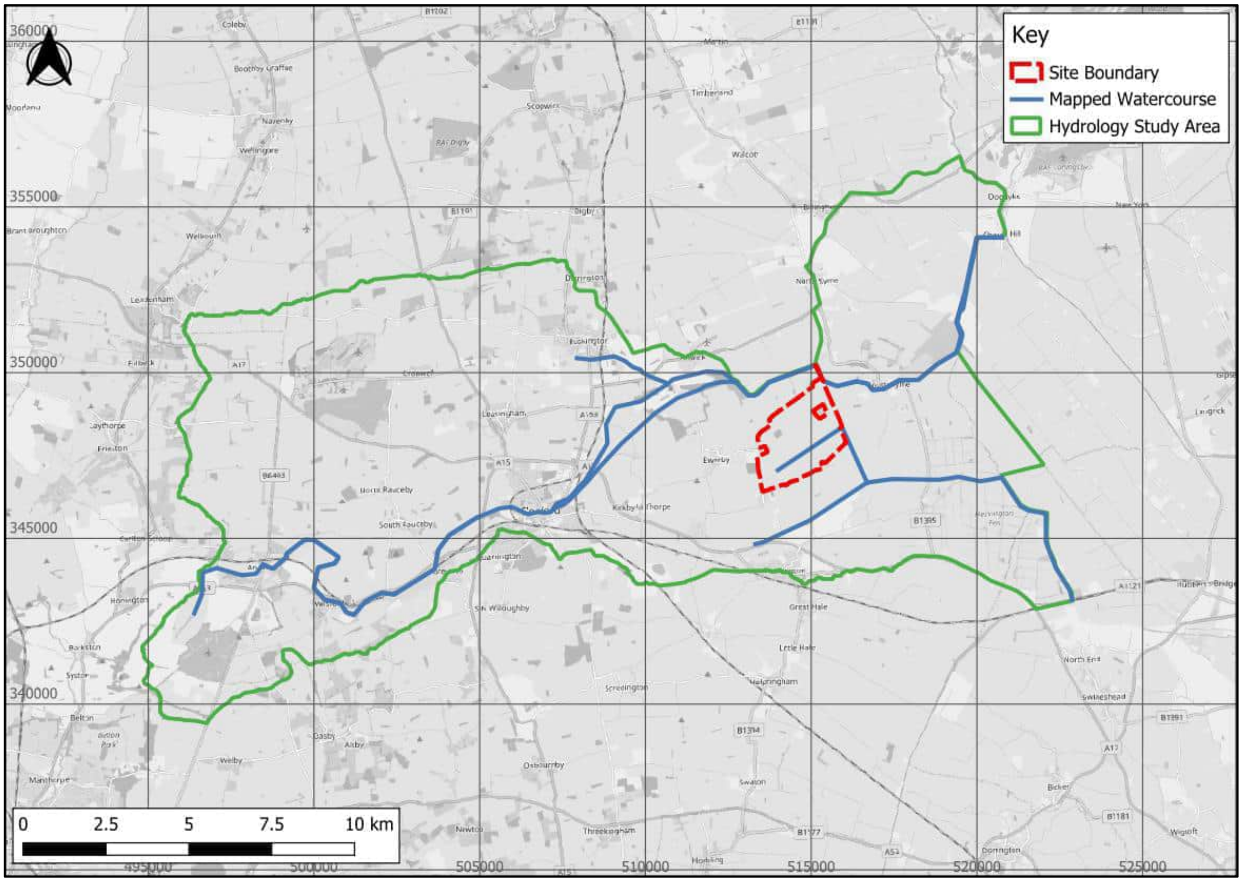


Figure 3: Hydrology Study Extent (Base map and data from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

# Catchment Summary

3.3. The study area covers 233 km$^2$ in Lincolnshire and comprises of statutory main rivers, River Slea (Lower Witham network) and Skerth Drain (Black Sluice network).

3.4. The catchment is characterised by a mixture of permeable limestone and impermeable clay bedrock with naturally high groundwater. Much of the catchment is low-lying, generally flat terrain with many artificial drains and dykes. This results in many pumped sub-catchments in the east and northeast of the study area. Watercourses within the study area are shown on Figure 4 while naturally drained and pumped catchments are shown on Figure 5.

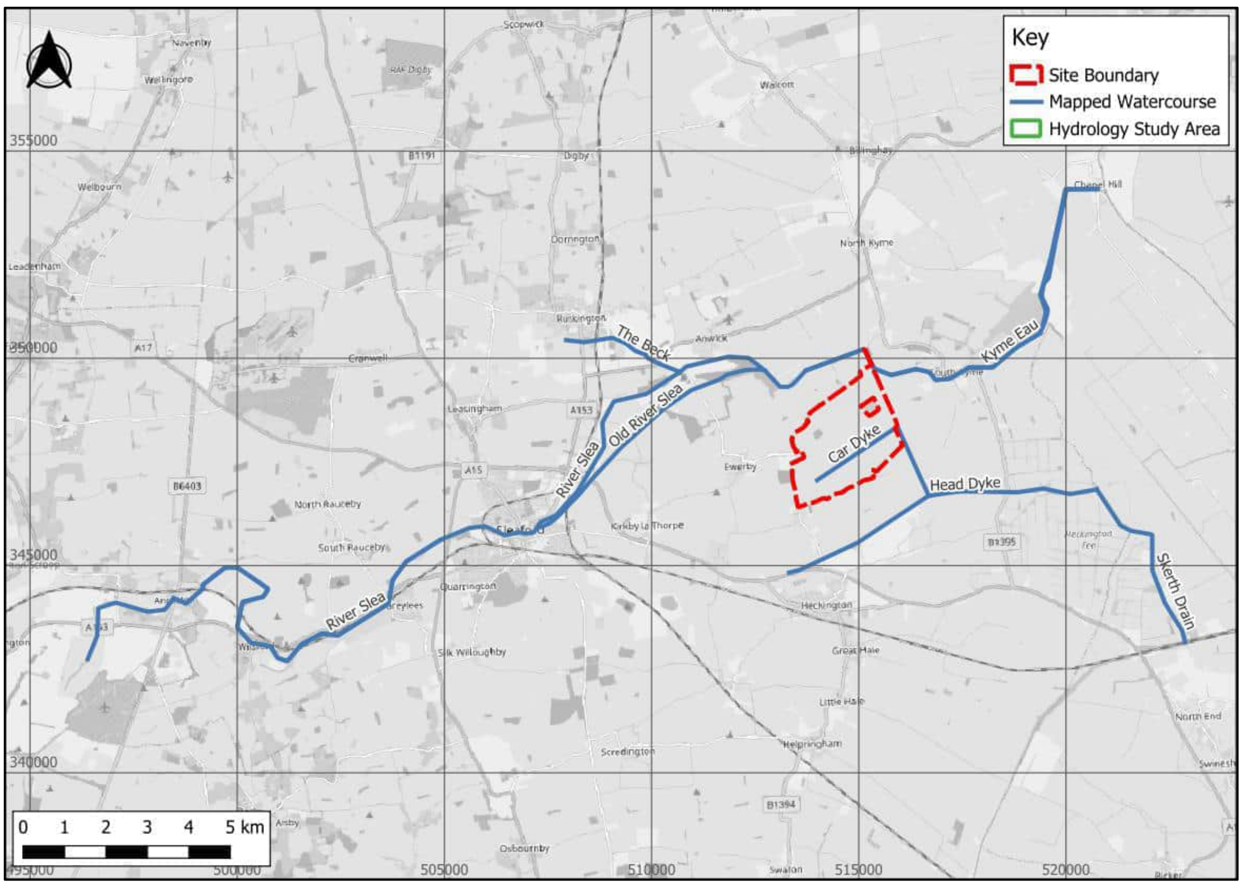


Figure 4: Watercourses within the study area (Base map and data from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

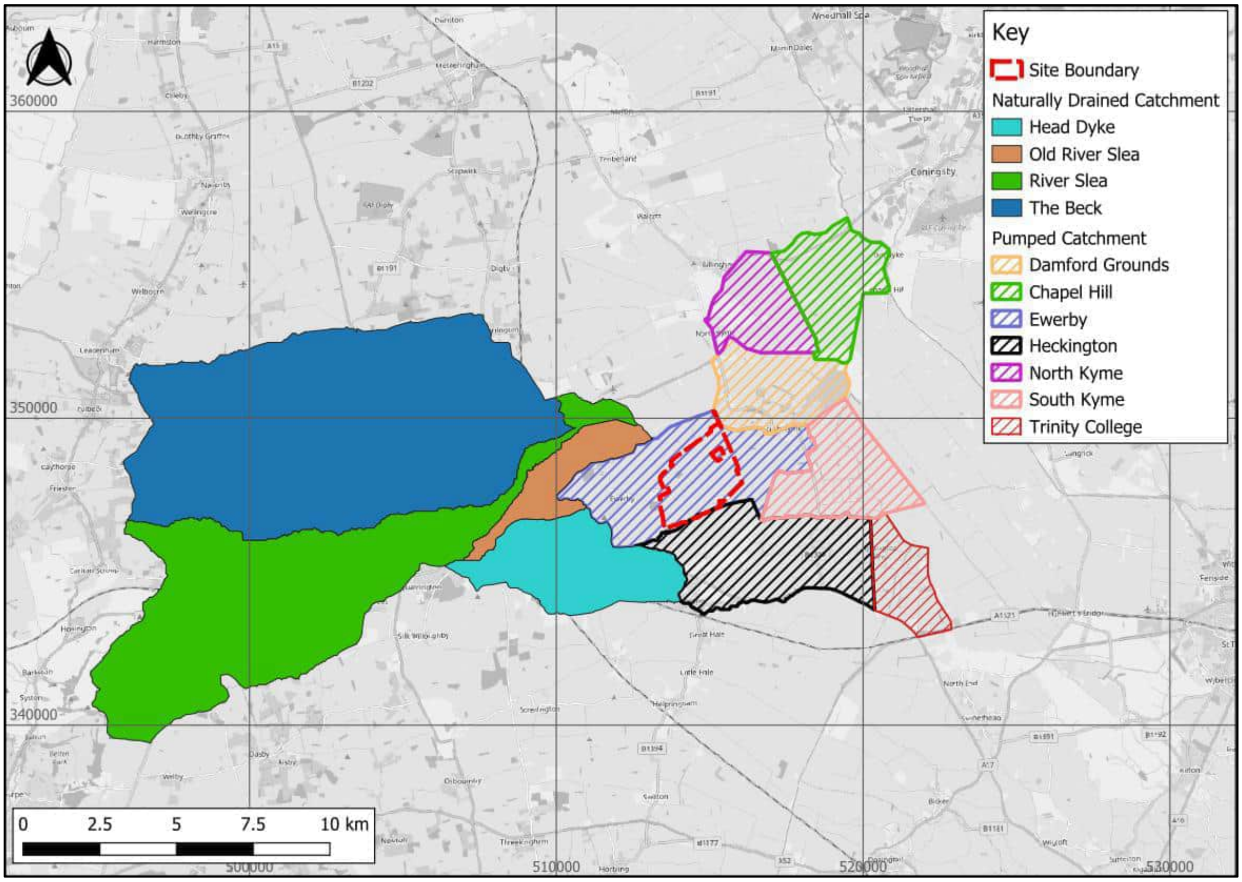


Figure 5: Natural (solid catchment) and pumped (hashed areas) catchments within the study area (Base map and data from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

3.5. Flooding within the study area is considered to be controlled by fluvial, pluvial and groundwater. This study is focused on fluvial flood risk therefore the hydrology study only assesses flows associated within watercourses.

3.6. There is a single flow gauge located within the study area, the River Slea at Leasingham Mill (NRFA gauging station 30006). This station has 40 years of data mostly rated as good. There are four further level gauges located within the study area, three are located on the River Slea and one on The Beck. A review of Leasingham Mill is provided in the full flood estimation record in Appendix B.

## Peak Flow Estimation

3.7. Two methods were used to generate flows for watercourses within the hydraulic model: FEH Statistical and Revitalised Flood Hydrograph (ReFH2). Flows were estimated for 6 hydrological estimation points (HEPs). These locations are shown on Figure 6 and were defined based on the hydraulic model extents. These methods are described in detail in the full flood estimation record in Appendix B along with comparison and checks between each method and available gauging stations. Electronic copies of hydrology models and input data are provided in the electronic appendix associated with this report.

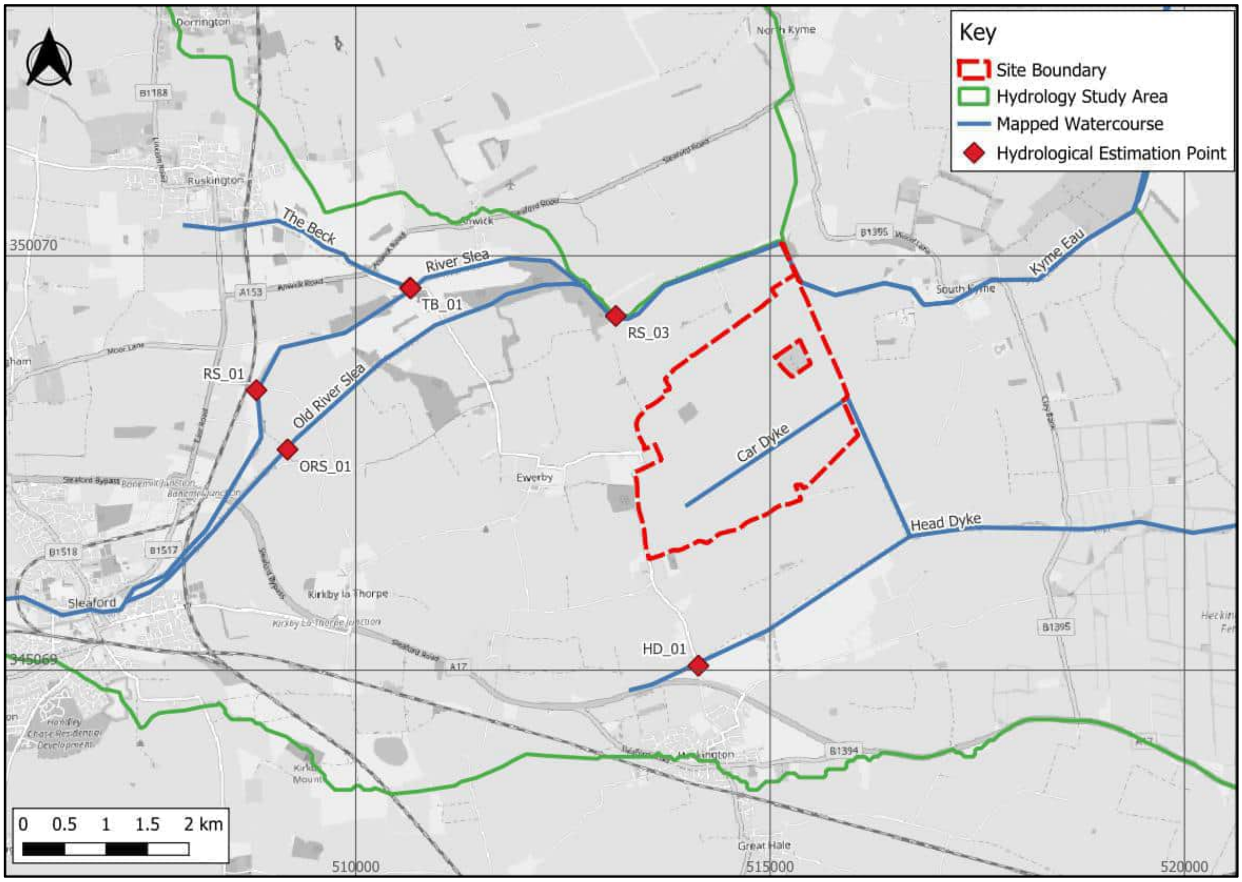


Figure 6: HEPs within the study area (Base map and data from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

3.8. FEH Statistical peaks fitted to ReFH2 hydrographs were selected as the final methods for ungauged catchments. The gauged catchment at HEP RS_01 was fitted to a standardised hydrograph for that gauge.

3.9. A single storm duration was assessed for each catchment individually. The final critical storm of 16.25 hours was estimated from the lag analysis and donor transfer method and was applied to the whole catchment.

3.10. Final flow estimations are provided in Table 1 for the key inflow locations and return periods. Intervening areas are not quoted within this report but are provided within the full flood estimation record in Appendix B.



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Table 1: Final peak flow estimates (in m3/s for return period in years or AEP (%) events)

| Event | | RS_01 | ORS_01 | TB_01 | RS_02 | RS_03 | HD_01 |
|---|---|---|---|---|---|---|---|
| 30 | 3.3% | 4.16 | 0.87 | 4.29 | 6.46 | 7.53 | 3.46 |
| 100 | 1.0% | 5.00 | 0.98 | 4.87 | 7.32 | 8.54 | 4.42 |
| 1000 | 0.1% | 9.28 | 1.70 | 9.13 | 13.79 | 16.00 | 7.82 |

## Pumped Catchments

3.11. Flows are estimated for naturally drained catchments only as part of the flood estimation report. Pumped catchments have been modelled using direct rainfall methodology with flow into watercourses limited by pumped rate and capacity at Internal Drainage Boards (IDB) pumping stations.

3.12. Pumped catchments within the study area are managed by IDBs. Two IDB's were identified as operating pumping stations within the study area. These are the Black Sluice and Witham First IDB's.

3.13. Operational catchments were identified for these IDB's using the administrative boundaries dataset released by the Environment Agency1. A data request was sent to each IDB to obtain pumping station information for inclusion within the model. In total 7 pumping stations were identified with varying pump rates and level controls. Detailed information on these pumping stations is provided in Appendix C. North Kyme was found to pump water outside the model extent and so was excluded from the model.

[1] **https://www.data.gov.uk/dataset/59af775e-efc7-458b-bdc3-593651d08aa8/association-of-drainage-authorities-administrative-boundaries-internal-drainage-districts-in-england** ***(accessed July 2024)***



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## Direct Rainfall Approach

3.14. Design rainfall calculated within the hydrological assessment using ReFH2.3 was applied for each pumped catchment within the model with pumping stations moving water into the different river systems.

3.15. The rainfall statistics used in the modelling were those for catchment RS_04 (NGR 520700, 345050) to ensure consistency across all model applications. The catchment descriptors were adjusted within the rxml file to represent only the pumped catchments (8.263 $km^2$). The reviewed catchment descriptors and FEH22 rainfall data were applied within ReFH2.3 to generate the total design rainfall.

3.16. Rainfall was applied within the hydraulic model as total rainfall, with rainfall losses simulated internally within the model rather than in the hydrological software. The approach adopted for applying rainfall and defining losses is described in 4.49.

3.17. Rainfall hyetographs have been generated for the 50% (1 in 2 year), 3.3% (1 in 30 year), 1% (1 in 100 year), and 0.1% (1 in 1000 year) annual exceedance probability events.

3.18. The summer storm profile was adopted for all design events, with a 16.25-hour storm duration to align with the critical fluvial event duration. Rainfall depth–duration–frequency (DDF) datasets were generated in accordance with the Environment Agency's user guidance 'Improving Surface Water Flooding Mapping'[2].

3.19. The total estimated design rainfall (mm) applied for each modelled return period are presented in Table 2.

[2] **https://assets.publishing.service.gov.uk/media/6036611ee90e0740b50cac5a/Improving_surface_water_flood_mapping_-_estimating_local_drainage_rates_-_user_guidance.pdf**

Table 2: Total design rainfall (15-min), summer profile, 16.25hr Storm Duration.

| | Storm Event (AEP%) | | | |
|---|---|---|---|---|
| | 50% (2-year) | 3.3% (30-year) | 1% (100-year) | 0.1% (1000-year) |
| Total Rainfall (mm) | 20.18 | 46.29 | 63.65 | 101.67 |

## Climate Change Allowances

3.20. Climate change allowances have been applied to flows and/or rainfall in accordance with current Environment Agency guidance[3]. The study area is located within the Witham Management Catchment, the climate change allowances associated with this management catchment are presented in Table 3 and Table 4.

Table 3: Witham Management Catchment peak river flow allowances

| Epoch | Central | Higher | Upper |
|---|---|---|---|
| 2020s | 9% | 14% | 27% |
| 2050s | 8% | 15% | 32% |
| 2080s | 21% | 32% | 57% |

[3] **https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances** ***(accessed July 2024)***



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Table 4: Witham Management Catchment peak rainfall allowances

| Epoch | Central | Upper |
|---|---|---|
| 3.3% AEP | | |
| 2050s | 20% | 35% |
| 2070s | 25% | 35% |
| 1% AEP | | |
| 2050s | 20% | 40% |
| 2070s | **25%** | 40% |

3.21. As the proposed development at the site is a solar farm with an operational end date of 2069, the 2080s river flow epoch and 2070s rainfall epoch have been selected to reflect the expected lifetime of the development.

3.22. The Higher (32%) allowance has been applied to river flows in accordance with Environment Agency guidance for essential infrastructure (electricity generation – solar panels) located within Flood Zone 3 extent[3].

3.23. For rainfall, the Central (25%) allowance has been applied to the 1% AEP event, as only fluvial flood risk is being assessed for a development with a design life extending beyond 2060[3].

3.24. For the purposes of reporting, the fluvial climate change scenario will be referred to throughout as the "1 in 100-year + CC" event, to avoid confusion arising from the use of two boundary conditions with different percentage uplifts (32% for river flow and 25% for rainfall).

## Assumptions and Limitations

3.25. Assumptions and limitations are described within Section 8.5 of the full flood estimation record (Appendix B). In summary it has been assumed that gauged data from the Leasingham Mill gauge is of suitable quality for use within this study. Gauged catchments are assumed to respond slower than ungauged catchments due to the size in contributing area. It has also been assumed that pumped catchments are best represented using the direct rainfall methodology.

3.26. Limitations of the study are the lack of gauged data across the catchment, a single gauge is present but the sub catchments within the model vary significantly. A site visit has not been undertaken to verify hydrological characteristics defined through the desk based assessment and no joint probability assessment has been undertaken. Finally, as with all permeable catchments there is a limitation in the methods used to calculated flows due to variability of inter-annual floods. Permeable catchments were used within the statistical analysis pooling groups as the best available method to reduce underestimation of flood events as per Environment Agency guidance[4].

3.27. Within the IDB-managed catchments, rainfall–runoff processes have been represented using a direct rainfall (rain-on-grid) approach, applied in conjunction with defined hydrological inflows and pumping station operations. While this approach is proportionate for large, low-lying and artificially drained systems, some limitations should be noted. The method assumes spatially uniform rainfall and generalised surface-loss parameters, which may not capture localised variations in rainfall intensity, infiltration potential or surface storage within agricultural drains and field depressions. Rainfall estimates were modelled using ReFH2 and adjusted for climate change per Environment Agency guidance. These methods may not fully account for local variations.

3.28. The resulting outputs therefore provide an indicative representation of broad hydrological response and relative flood behaviour within the IDB areas, rather than a detailed prediction of short-term drainage or pumping system performance.

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**[4] Environment Agency (2022). Flood Estimation Guidance (FEG): Estimation of flood flows following Environment Agency best practice. Version 09. https://www.gov.uk/government/publications/flood-estimation-guidelines**

# 4. Hydraulic Model Amendments

## Summary

4.1. This sections summarises the updates made to the Environment Agency's Lower Witham and Black Sluice model as part of this hydraulic modelling exercise.

4.2. To produce a single model suitable for assessing flood risk from fluvial sources the Lower Witham and Black Sluice models were combined allowing flooding from each watercourse network to interact.

4.3. A summary of actions undertaken as part of this hydraulic model update include:

- Update software versions to most recent at time of model construction.
- Rebuild river reaches using the data contained within the Environment Agency models and a new channel survey.
- Update and add structures into the 1D network using channel survey.
- Construction of a new 2D domain to represent the floodplain within the model.
- Apply quadtree grid along riverbanks to ensure spill points are well represented.
- Run a range of return events to define fluvial flood risk at the site.
- Undertake a sensitivity assessment for a range of parameters on the combined model.

## Software

4.4. The model was simulated using Flood Modeller version 7.3.0 and TUFLOW version 2025.1.0. TUFLOW Heavily Parallelised Compute (HPC) solver was used.

## 1D Domain

### 1D Domain Extent

4.5. The Lower Witham was converted from InfoWorks RS to Infoworks ICM format. This conversion was undertaken by Innovyze, the company that owns and develops the software, as the InfoWorks RS format is no longer supported and could not be opened within Infoworks ICM format. During the conversion Innovyze advised that there are compatibility issues between the InfoWorks RS and InfoWorks ICM as such, not all objects from the original model could be imported. Therefore some data relating to pumps, user defined controls, flap valves, screens, irregular weirs and siphons may be lost[5].

4.6. Data from the converted Lower Witham Infoworks ICM data was then converted into Flood Modeller network format to allow a single combined model to be constructed of both networks. The Flood Modeller network was then reviewed to identify potential missing data such as bridges, weirs and operational rules. Where possible additional channel survey was undertaken to provide additional data. The resulting combined network is shown on Figure 7.

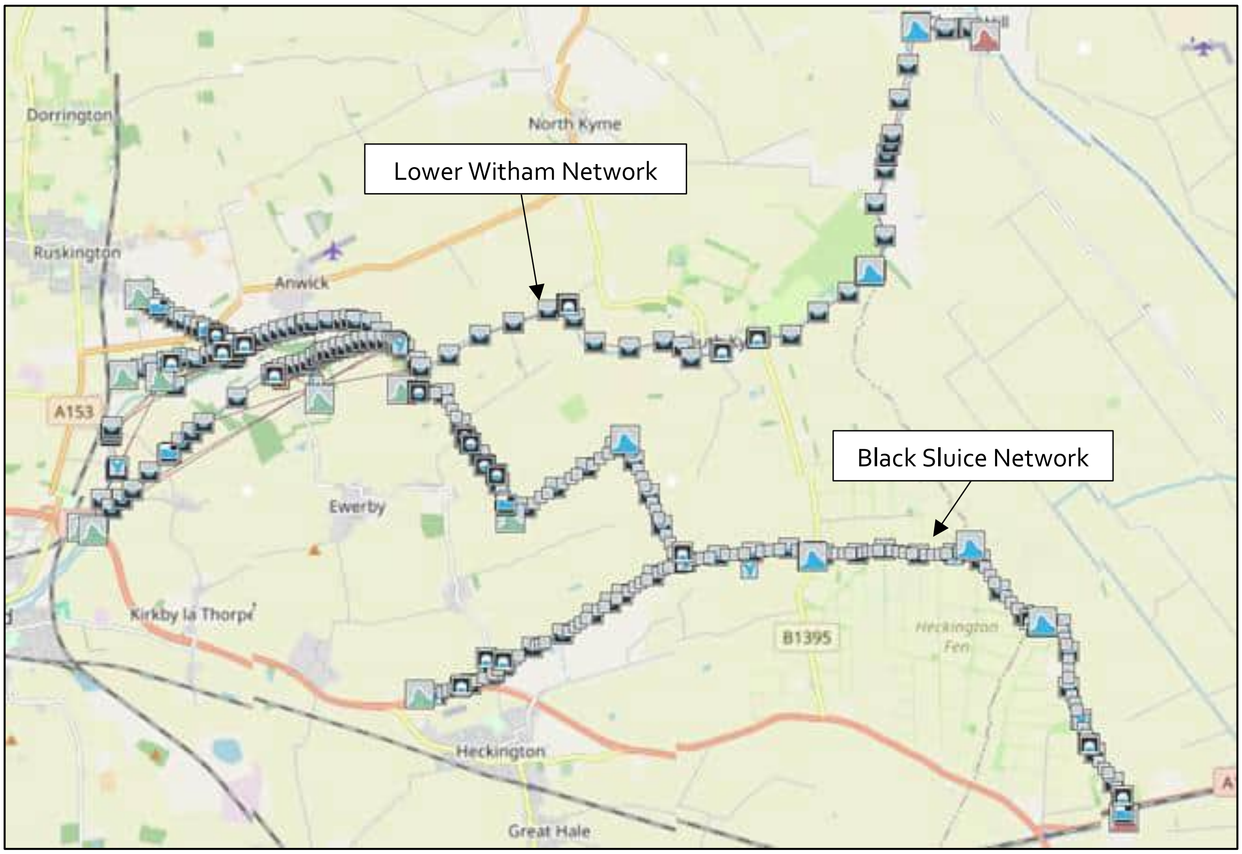


Figure 7: Flood modeller 1D network schematic (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

[5] **https://help2.innovyze.com/infoworksicm/Content/HTML/ICM_ILCM/Importing_InfoWorks_RS_Network_Data.htm**

## Channel Survey

4.7. A channel survey was undertaken in March 2024 by Storm Geomatics. The extent of the survey is provided in Appendix D. A total of 8 cross sections were surveyed within the extent, issues with access on private property prevented further locations from being surveyed.

4.8. The channel survey focused on obtaining information missing from structures within the model. Four cross sections were located at or near to points where data was already available within the model. The locations of the new channel survey are shown on Figure 8.

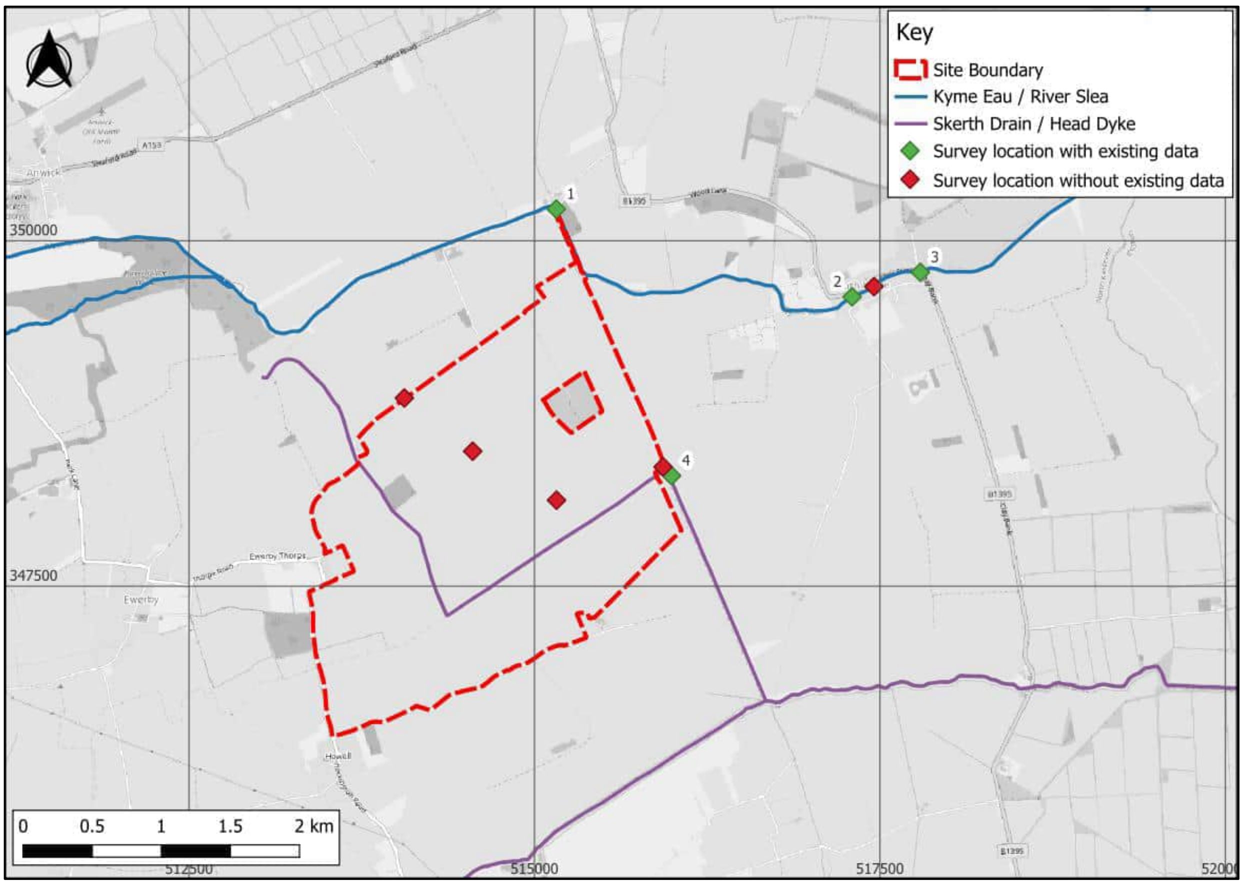


Figure 8: March 2024 survey locations (Base map and data from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

4.9. A comparison between the existing channel geometry and the new survey geometry was undertaken at the 4 locations marked in green on Figure 8. The result of the comparison is presented in Table 5. Location 4 has been included within the summary information despite the survey locations being approximately 150m apart as this is the only location on the Head Dike/Skerth Drain (Black Sluice network) which was surveyed. This location has been excluded from further comparisons as change in bed depth could be attributed to the difference in location rather than a change in bed levels over time.

Table 5: Comparison between existing model geometry and 2024 channel survey geometry levels.

| Location ID | Description of Location | Existing Bed Level (mAOD) | 2024 Surveyed Bed Level (mAOD) | Difference in bed level (m) |
|---|---|---|---|---|
| 1 | Kyme Eau at Ferry Road (bridge) downstream face. | 0.81 | 1.56 | +0.75 |
| 2 | Kyme Eau at Low Road (bridge) downstream face. Cross section profile observed to have changed significantly | 1.43 | 1.29 | -0.14 |
| 3 | Kyme Eau at High Street Road (bridge) upstream face. | 1.20 | 1.32 | +0.12 |
| 4 | Open channel at Eweby pumping station (survey locations ~150m apart) | -0.73 | -0.99 | -0.26 |

4.10. The bed level comparison shows a wide variation in bed levels between those within the existing model and those captured in the 2024 survey. This is possibly caused by changes to the watercourse morphology since the original survey used to inform the existing model was undertaken in 1999/2000. The average bed level change across locations 1 to 3 was found to be 0.25m. Location 4 was excluded as the difference in survey location may be the cause of the change in bed level.

4.11. Feedback from the surveying team included comments from a member of the public on the substantial change in the watercourse over the last 10 years with significant erosion of the banks of Kyme Eau just downstream of South Kyme. This may account for the difference in cross section profile and bed elevations since the original survey was undertaken.

4.12. To accurately predict existing fluvial flood risk to the site, the impact of the observed bed level differences was tested within the model. As there are limited data points to predict changes in bed levels across the full model reach (46.5 km) with the surveyed reach being 3 points over

3.3 km of the Lower Witham network only, it was agreed with the Environment Agency as part of the modelling methodology (Appendix A) to undertake a sensitivity test on a single uplift factor for the full model. The baseline model build was progressed without any uplift to the channel bed with the sensitivity assessment detailed in Section 6.

4.13. Roughness values applied across the Lower Witham network was reviewed against aerial imagery and new channel survey and updated where differences were noted.

4.14. All sections were reviewed for the suitable placement of panel markers to generate smooth conveyance curves with a minimum of two added to each section at the top of the left and right banks. Where roughness or geometry varied significantly across the section additional markers were applied.

## Structures

4.15. In total, there are 25 structures on the Lower Witham network and 29 structures on the Black Sluice network. All details were retained from the original model where possible. Where possible, a channel survey was undertaken to obtain information on structures which were found to be missing from the Environment Agency models or where data was lost in the conversion of unsupported software

4.16. Where structures have been retained from the original model report limited information other than that provided within the hydraulic models is known. It has, therefore, been assumed that these structures are correct within the model. Key structures were blocked as part of the sensitivity assessment in Section 6 and a bed level sensitivity test was also undertaken.

4.17. Operational rules for moveable structures within the model were reviewed and re-applied to the model where they were found to be missing. The 6 pumping stations identified in section 3.11 were included within the model. Rules for each pumping station were defined based on water levels within the individual IDB areas (on/off trigger levels were derived from representative water level conditions within the respective IDB catchments) and pump capacities provided by the IDB operator, as recorded in Appendix C. Other moveable structures were left in the open position during a fluvial flood risk simulation on the assumption that under all but tidal flood conditions these structures would be open.

4.18. In updating the model, pump abstraction rules were simplified compared with those used in the original 1D-only configuration. The previous model applied a network of linked floodplain sections to simulate pumping station operation, which introduced additional complexity to the control logic which was no longer needed due to the 1D-2D linked modelling approach. In the current linked 1D–2D (FM–TUFLOW) configuration, the same functional behaviour has been achieved using a simplified abstraction rule, as the floodplain is now represented within the 2D domain. This approach provides equivalent hydraulic performance, while enhancing model integrity as a result of the linked 1D–2D configuration.

4.19. The flood gate (Chapel Hill pointing doors) at the downstream end of the Lower Witham network is represented as open in the hydraulic model. This approach is supported by a review of historical evidence: five separate Google Street View images, captured over a 15-year period, consistently show the gates in the open position, an example of which is provided in Figure 9. This indicates that, under typical conditions, the pointing doors are normally open.

4.20. This representation is in line with Environment Agency Fluvial Modelling Standards (LIT 56326), which require that operational assumptions for hydraulic structures with uncertain operational records are explicitly stated and justified using available evidence. Should further operational data become available, the model can be updated to reflect more detailed site-specific conditions. By modelling the gates as open, the model reflects typical real-world operation and avoids introducing artificial downstream restrictions.

4.21. Additionally, higher water levels at the downstream boundary (located approximately 185 m downstream of the Chapel Hill pointing doors) were tested as part of the sensitivity testing (see Section 6). This sensitivity test involved applying elevated HT boundary conditions to simulate more extreme and restrictive downstream condition. The results showed that, while channel depths increased locally, there was no change in floodplain extents and flood depths only increased within channel at the development site. This confirms that the adopted downstream boundary configuration and operational assumption for the flood gates is robust for the purpose of this study.

Figure 9: Street view image of flood gate on Lower Witham Network (Kyme Eau) at Chapel Hill (Image taken from Google Street View © Google 2025)

# 2D Domain

## 2D Domain Extent

4.22. A new 2D domain was created to replace the lost data from the Lower Witham network and to create a single domain for both 1D networks. This domain connects both the Lower Witham and Black Sluice networks to their floodplain.

4.23. The extent of the 2D domain (as shown on Figure 10) was set based on the catchment review undertaken in the hydrology study. Topographical features such as the flood defences along the River Witham were used in addition to the catchment extents in defining the model domain area. The extents were reviewed through the model build process to ensure the predicted flooding did not interact with the model boundary outside of IDB areas.

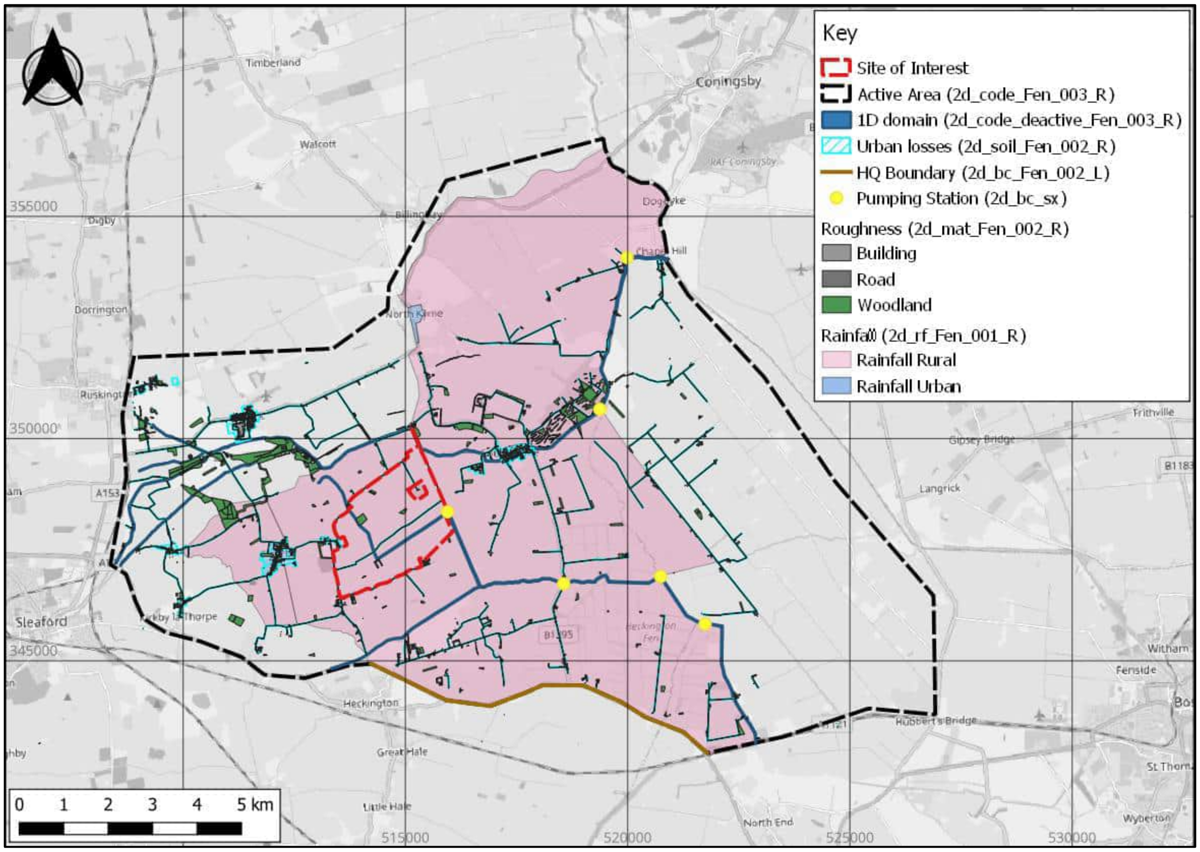


Figure 10: TUFLOW 2D network schematic (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

## Floodplain Construction

4.24. Environment Agency 1m resolution LiDAR DTM (2022 National LiDAR Programme) data was used as the basis for the 2D floodplain. This is considered to be a better representation of the floodplain elevations compared to the 2009-2012 LiDAR used within the original Environment Agency models. Generally, ground elevations at the site and within its vicinity are shown to be higher in the 2022 LiDAR data.

4.25. The 10m resolution grid was retained in the TUFLOW domain, as this is considered to be sufficient to provide a good representation of topography at the site, watercourses, and rural floodplain without compromising on model efficiency.

4.26. A quadtree grid was applied along the watercourse banks to capture topographical changes and low spots where out of bank flooding may occur. A nesting level of 2 was applied reducing the grid cell size around watercourses to 5m.

4.27. TUFLOW Sub-Grid Sampling (SGS) method was applied with a sample distance of 0.5m to capture topographical changes. This provides a higher level of accuracy in predicted model extents while maintaining the larger base grid size. The combination of SGS and quadtree is a standard approach for large models allowing areas of the model to have a higher resolution without creating excessive run times.

4.28. Topographical features within the model are enforced using max zsh lines to ensure no artificial leaks are present within the hydraulic model. Features enforced include the flood defences along the banks of the Lower Witham and Black Sluice networks.

4.29. A single gully feature was applied within the site boundary to represent a drainage channel. This feature represents a secondary channel which was not included within the 1D domain. The channel was surveyed with bed levels showing a constant drop across the length of the surveyed reach. It was decided to include this network as a 2D drain with embedded 1D culverts to maintain model stability due to the channel starting dry in each model. While gully features can overestimate capacity the fall across this feature required enforcing to ensure it matched surveyed levels.

4.30. Buildings in the catchment were modelled with a 300 mm threshold, following the 'stubby buildings' approach to align with EA national modelling standards. This enables overland flow to be routed around buildings until the threshold is exceeded.

4.31. A reduction of 125 mm has been applied to road levels in the 2D model to represent the typical kerb height. This ensures that ponding on carriageways and exceedance flows along road corridors are captured, reflecting how surface water is routed in flood conditions. This approach is consistent with the EA's Risk of Flooding from Surface Water (RoFSW) mapping methodology[6], which lowers all road surfaces in the national model DEM by 0.125 m to represent kerbs and improve hydraulic connectivity. Prior to application, the LiDAR-derived DTM was reviewed to confirm that kerbs were not already resolved in the terrain data, and Google Street View was used to verify the presence of kerbs across the study area. Together these checks support that the adjustment is appropriate and does not double-count kerb representation.

[6] **Environment Agency (2019) What is the Risk of Flooding from Surface Water Map?**

4.32. Banklines were reinforced in the 2D domain using 2d_zsh line and point layers to reflect surveyed 1D elevation data with additional LiDAR sampled points. This improved representation of channel margins and flow exchange between the 1D and 2D domains.

4.33. Roughness is assigned via a 2d_mat layer linked to the .tmf (TUFLOW Materials File). The 2D domain is assigned a general Manning's n value of 0.040 for rural floodplain areas, 0.090 for woodland, 0.035 for roads (reflecting typical rural road surfaces), and 0.300 for buildings. These values are typical for 2D floodplain modelling and were selected with reference to OS mapped land use and, satellite imagery and field evidence.

4.34. The Green-Ampt (GA) method in TUFLOW was used to represent the soil infiltration in rural and open areas of the IDB catchment where rainfall has been applied, including within the Site through the application of a 2d_soil layer and .tsoilf file linked to the TUFLOW control file. The Initial Loss / Continuing Loss (ILCL) approach was used to represent drainage system losses within the urban extent of the catchment. A standard 12mm/hr loss was applied to reflect the interception by surface water drains.

4.35. Depth-varying roughness (DVR) has not been applied to the modelled domain. This is consistent with the EA-agreed Hydraulic Modelling Methodology for this project, while uncertainty in modelled roughness has been addressed through sensitivity testing. Section 6 shows that a ±20% change in Manning's n produced negligible change in on-site flood depths and no change to flood extents or conclusions, indicating low sensitivity of the assessment to plausible variations in floodplain resistance.

4.36. The modelled floodplain is predominantly agricultural and hydraulically simple, with conveyance governed by the explicitly represented channels, IDB drains, and structures. Direct-rainfall zones are used to capture the numerous field ditches not represented in the 1D network. Land cover across these areas is relatively uniform, and there is no site evidence of pronounced depth-dependent resistance (e.g. dense emergent vegetation or complex urban form). Under these conditions, a uniform, land-use-based roughness method is appropriately robust for this site-specific study.

4.37. Introducing domain-wide DVR would require spatially resolved roughness-height data (e.g. vegetation height/density) for the entire catchment in order to undertake a meaningful assessment. Additionally, DVR also increases computational cost and can reduce numerical stability in large, low-slope domains. Most importantly, the ±20% Manning's n sensitivity (Section 6) brackets the scale of roughness change that DVR would represent for these rural land covers. That test produced no change to mapped flood extents at the Site and negligible trace-level depth differences that would not alter any design result or mitigation requirement. Any additional depth-based variation would fall within the tested uncertainty and be well below the vertical accuracy of the LiDAR DEM (±0.15 m). For this assessment, change is treated as "significant" if it (i) alters the mapped flood extent at the site, or (ii) changes on-site depths enough to affect the development layout or mitigation specified. Neither occurred under the ±20% test. On that evidence, omitting DVR is proportionate and robust for this site-specific study.

## Boundary Conditions

### 1D Network Boundaries

4.38. The updated hydrological inflows were applied to the hydraulic model at the upstream extents of the model. Hydrographs were generated as part of the hydrology assessment and were applied to the 5 inflow points as flow time boundaries (QT boundary). The location of the model inflows is illustrated within Figure 11.

4.39. In addition to the 5 model inflow locations, 2 QT boundaries were applied to the flood modeller network within IDB catchments. These boundaries are 'dummy nodes' applied to allow the model to run as they are located within IDB areas so only flows from the pumping stations or overland flow would enter these locations. A small inflow of 0.1 to 0.4$m^3$/s was applied at each dummy node to maintain model stability. The minimum flow applied was iteratively selected as the minimum flow to allow the model to run, while this double accounts for baseflow within the IDB area at the site this provides a conservative estimation of flooding as capacity has been removed from the model.

4.40. To capture intervening areas between the upstream inflow locations and IDB catchments, 2 lateral inflows (QT boundaries) have been applied to networks within the model.

4.41. Inflows from IDB pumped catchments are applied to the 1D domain via pump units connected to the 2D domain. The control for these units is described in Section 4.17.

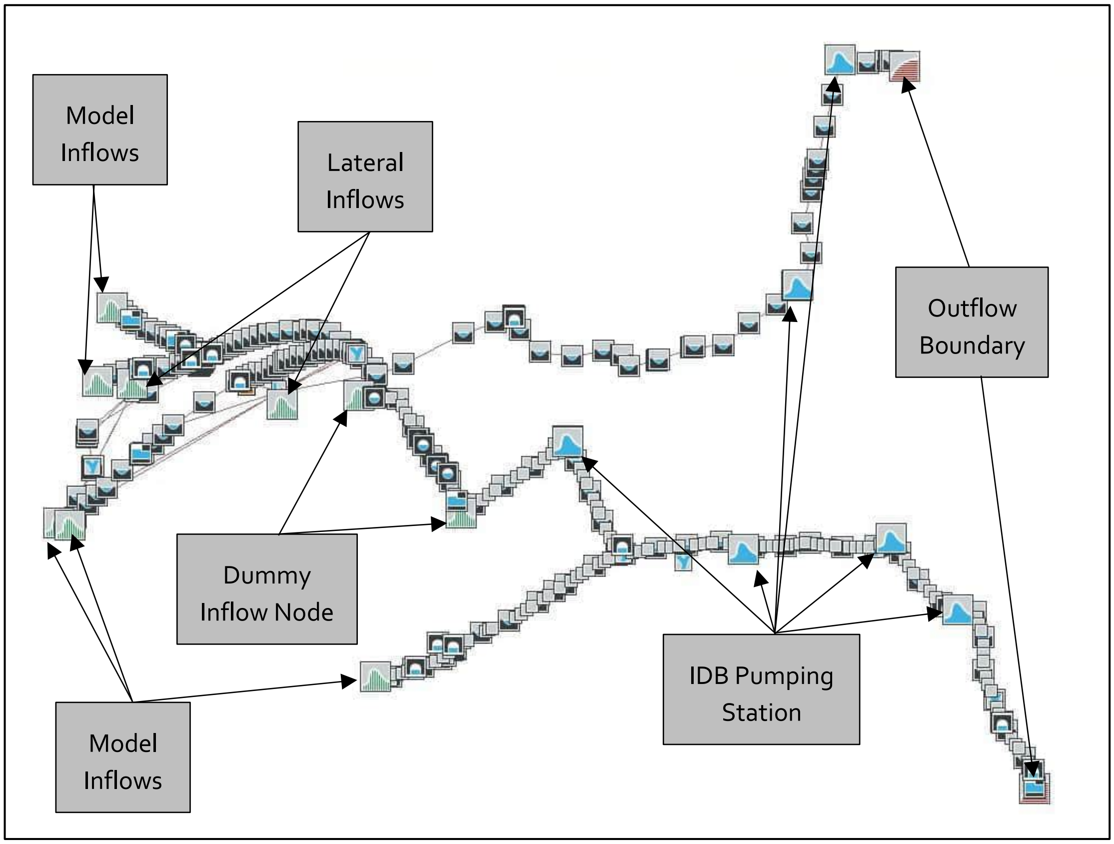

Figure 11: 1D Boundary Locations

4.42. Prior to undertaking the hydraulic modelling exercise a methodology was agreed with the Environment Agency (Appendix A), as part of this methodology the downstream boundary of the model was to be set to free discharge using a normal depth boundary. However, as the model was developed, it was determined that a restricted discharge representing tide locking of downstream watercourses would be more appropriate, providing a conservative estimate of flood extents.

4.43. A head time (HT) boundary was applied at the downstream end of each network to represent restricted discharge to the receiving watercourses under fluvial flood conditions. The downstream water level was set at 1.2 mAOD for each network, corresponding to typical near-bankfull channel conditions. The 1.2 mAOD threshold was therefore selected to represent a precautionary, near-bankfull scenario that is both hydraulically appropriate and supported by stable model performance.

4.44. Model results were reviewed for both networks to identify the extent of backwash in relation to the site. The site was found to be significantly upstream from the backwash effect on the Lower Witham. Backwash has been determined at the point where a flat water gradient changes from the downstream extent of the model. This is shown on the long section presented in Figure 12 with the downstream boundary backwash being limited to chainage KE_02640 and the site being located at KE_09500. This provides a 6km reach where backwash from the downstream boundary does not impact in channel results.

4.45. A longer backwash affect was observed from the downstream boundary on the Black Sluice network (Figure 13) with the site (NE101500) being located approximately 1.3km upstream from the observed backwash effect which has an upper limit of (NE100182)

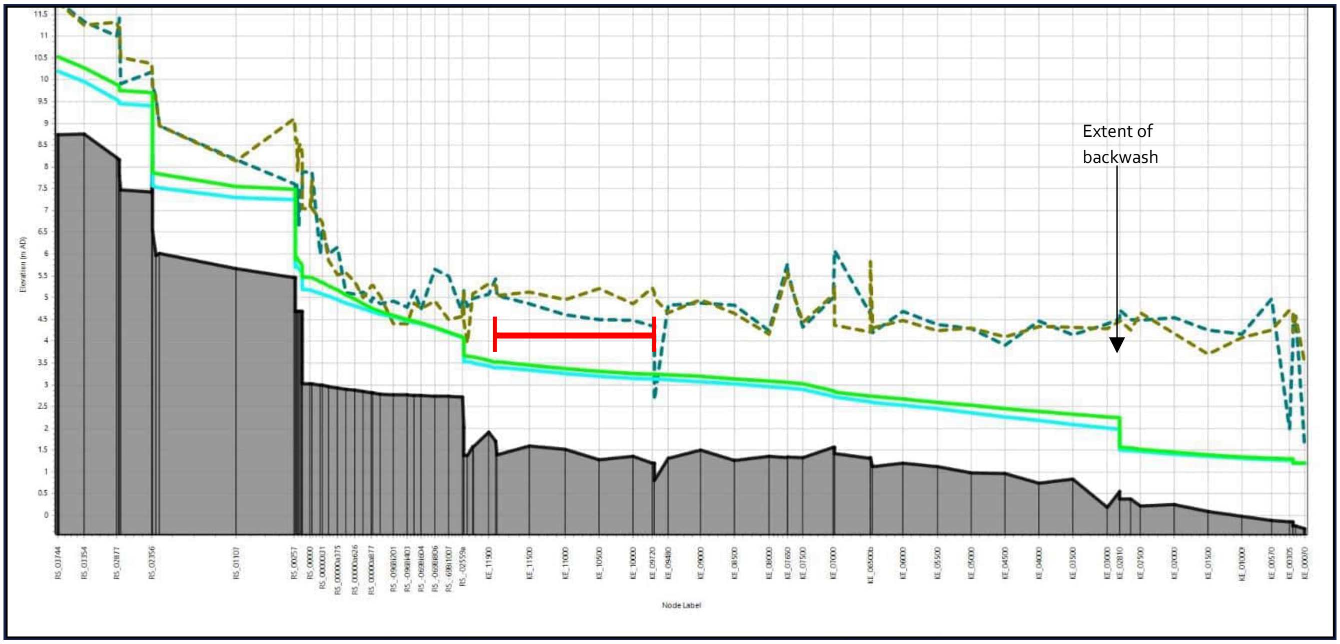


Figure 12: Lower Witham Downstream Boundary Backwash Impact (red area indicates site location, light blue is the maximum 30 year stage while light green is the maximum 100 year plus climate change stage.)

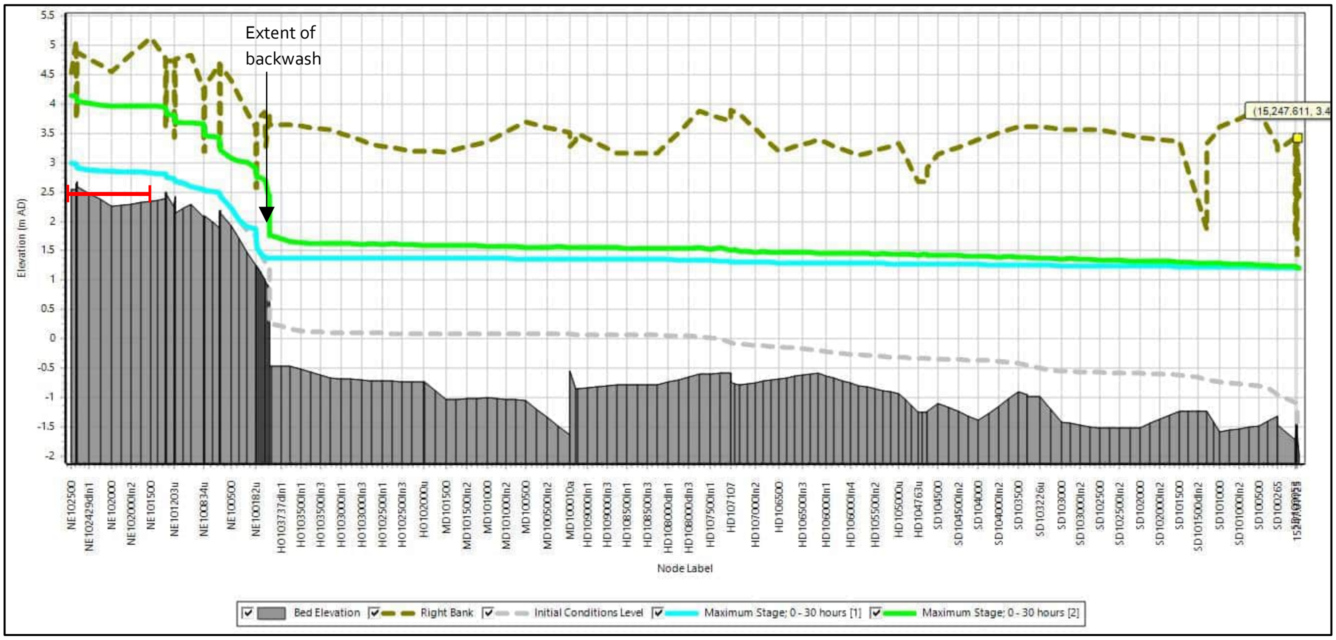


Figure 13: Black Sluice Downstream Boundary Backwash Impact (red area indicates site location, light blue is the maximum 30 year stage while light green is the maximum 100 year plus climate change stage.))

4.46. A warmup period of 2 hours was applied at the start of the model to ensure model stability. The downstream level was reached prior to the start of storm hydrographs. As the main control on flooding at the site is considered to be out of bank flooding from onsite watercourses/land drains and the Lower Witham network, a joint probability assessment with higher downstream levels was out of scope for this study.

4.47. The selection of a 1.2 mAOD head–time boundary at the downstream extent of each network was therefore reinforced by the following hydraulic considerations;

- The site is located 9.15 km (Lower Witham) and 11.2 km (Black Sluice) upstream of the model's downstream boundary so is considered to be sufficient due to the distance from the site on each river network.
- As demonstrated by long-section analysis (Figures 12 and 13), any backwash or backwater effects dissipate before reaching the site. This hydraulic separation ensures that downstream boundary changes exert minimal influence on flood behaviour at the site.

4.48. To further test the robustness of the downstream boundary assumption, sensitivity testing was undertaken (see Section 6). This involved applying elevated HT boundary levels corresponding to design-event water levels drawn from previous modelling studies; 3.69 mAOD for the River Witham (AECOM, 2009: node LWA_15880) and 2.16 mAOD for the South Forty Foot Drain (Mott MacDonald, 2016: node SD100028). The results showed that, while some localised increases in channel depth were observed downstream, there was no change to floodplain extents or flood depths at the development site, except in-channel. This confirms that the 1.2 mAOD boundary is suitably precautionary and does not affect the flood risk conclusions.

## 2D Floodplain Boundaries

4.49. Rain on grid areas have been defined within the 2D domain to represent rural and urban rainfall during storm events for catchments within IDB controlled areas (Figure 14). The gross design rainfall was applied directly to the 2D domain (2d_code) using 2d_rf polygons to spatially distribute rainfall across the catchment. While rainfall was assumed to be spatially uniform across each IDB catchment, the polygons were differentiated between urban and rural areas to apply appropriate surface loss parameters.

4.50. In accordance with Environment Agency's user guidance 'Improving Surface Water Flooding Mapping' a 70% runoff coefficient was applied to represent losses prior to interception in urban catchments.

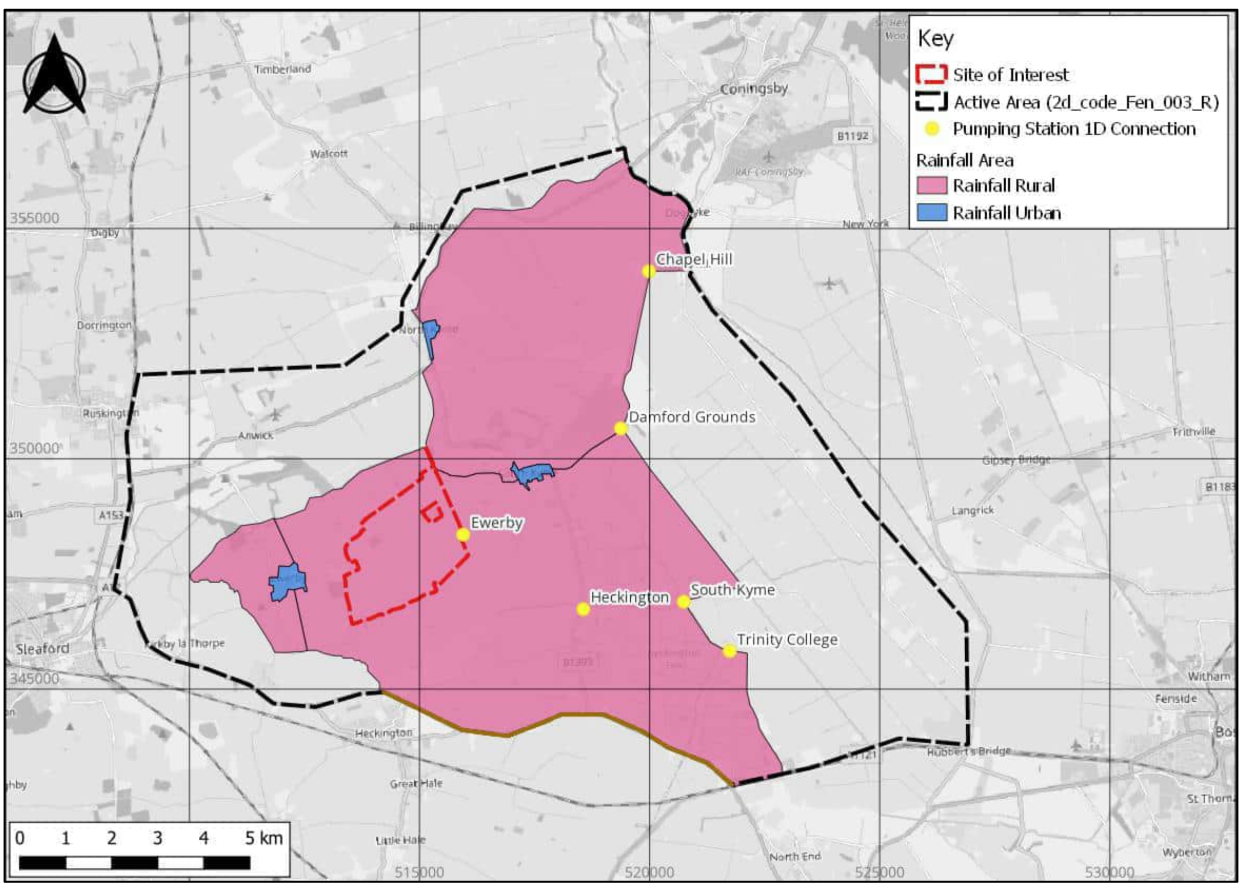


Figure 14: 2D Boundary Locations (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

4.51. Six IDB pumping stations connect the 2D floodplain to the 1D channels at locations where pumping occurs (Figure 14). Pump capacities have been provided by IDB managers either through direct communication or from information made available on their website (Appendix C). The pumping stations are represented as abstraction units in the 1D Flood Modeller domain connected to the 2D domain via a Source Area 'SA' region.

4.52. Abstraction units are controlled using variable logic rules based on levels within each IDB and provided pump rates. Pumps are off until the target level provided by the IDB is reached within channel, then they are switched on to full capacity as pump rating curves were not available at the time of modelling.

4.53. An automated (HQ) boundary was used as the downstream boundary for the TUFLOW domain to prevent glass walling artificially raising flood levels on the floodplain. The location of the downstream boundary is considered to be sufficient due to the distance from the site and location of IDB catchments within the model extent.

## Design Events

4.54. The model was simulated for the 1 in 2 year, 1 in 30 year, 1 in 100 year, 1 in 100 year + climate change and 1 in 1000 year design events. These events have been selected to represent the fluvial flood risk only to the site.

4.55. Flooding within the catchment is considered to be dominated by out of bank flows from the watercourses close to the site. Therefore, a joint probability assessment was not considered necessary. However, to ensure a conservative approach to assessing flood risk, bank-full stage was applied at the downstream end of each 1D network.

# 5. Model Results

5.1. Results from the hydraulic modelling exercise are presented in this section. Due to the hydrology methods applied in the complex catchment, filtering of results is required to remove pluvial flood risk (surface water runoff and ponding) from mapped results. Filtering was applied to areas within the model where rainfall was utilised (Figure 14).

5.2. Filtering was undertaken in line with previously agreed methods with the Environment Agency for fluvial flood risk models utilising rain on grid methodology. The methodology is summarised below and presented in detail in Appendix E. Maximum depth grids were cropped to the rainfall areas as defined on Figure 14. Standard Environment Agency RoFSW map filtering was then applied. This included removing depths less than 100mm and areas of flooding with a hazard rating of less than 0.757.

5.3. A manual second filter was then applied using the dynamic results. Flow velocities show flooding originating from a watercourse and were used to manually define the floodplain extent with results clipped to this extent. Flooding areas were only removed if flow vectors showed water entering the watercourse (i.e. flowing into the channel) and not leaving the banks.

5.4. The raw flood extents outside of the rain on grid area, the RoFSW and manual filtering grids were then combined to define a single fluvial flood risk extent for each return period.

5.5. The modelled floodplain extents are presented in Figure 15 for the site and close vicinity. The model results presented below are filtered to remove surface water flooding. Unfiltered model results for depth and velocity are presented in Appendix F and filtered results for the full model extent are presented in Appendix G.

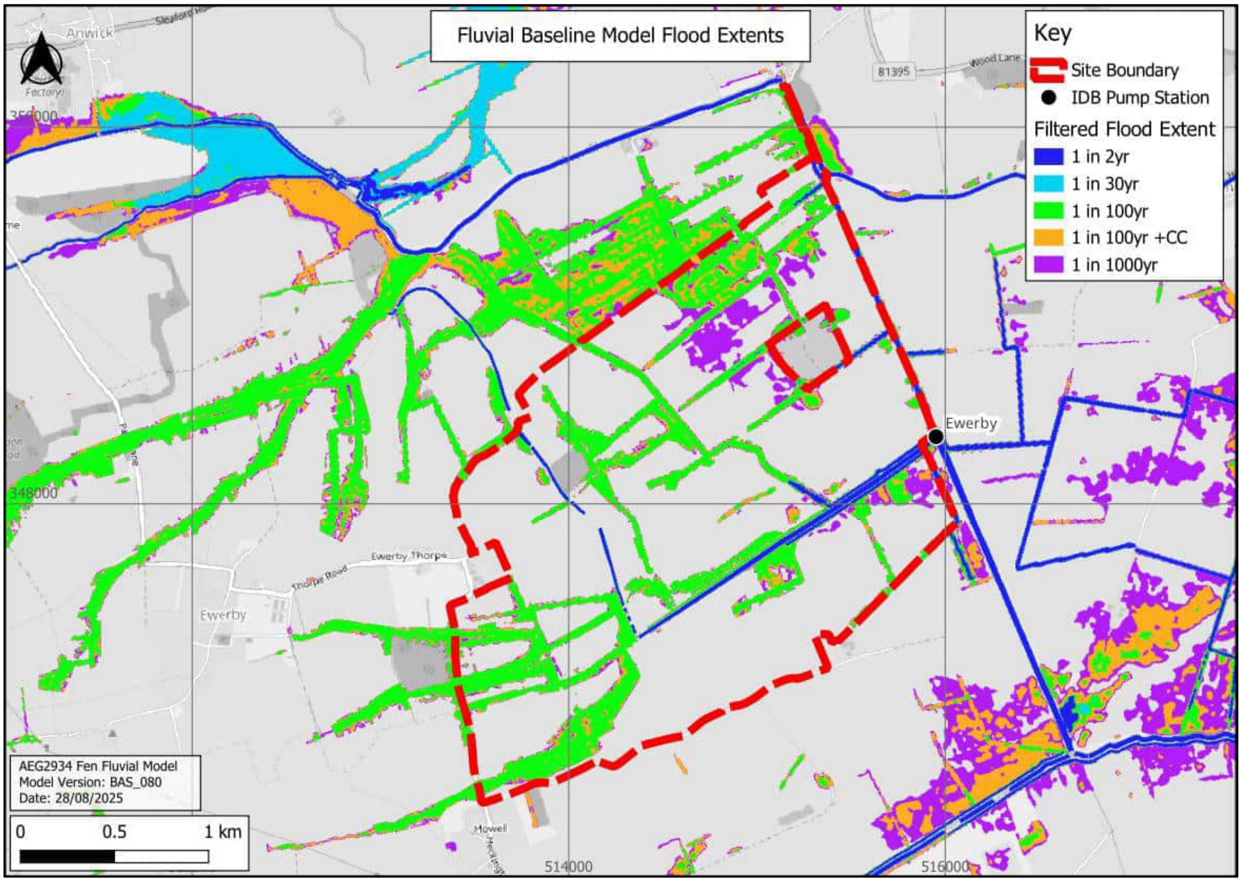


Figure 15: Filtered fluvial baseline flood extents (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

5.6. Flooding within the site boundary is shown to be contained within onsite watercourses for the 1 in 2 year and 1 in 30 year and mostly within the wider onsite ditches 1 in 100 year event. Larger storm events including the 1 in 100 year plus climate change and 1 in 1,000 year event show wider flooding across the site, mostly within the northeast and southwest areas of the site.

5.7. Flooding in the northeast of the site is caused by water exceeding the capacity of field drains to the northwest of the site and flood water flowing over land southeast towards Ewerby Pumping Station which is located on the east boundary of the site (Figure 15).

5.8. Flooding in the southwest of the site is caused by field ditch capacity being exceeded and water flowing overland to the watercourse in the centre of the site.

5.9. Peak flood depths from across the site are presented in Table 6 while corresponding flood elevations are presented in Table 7. The location of the flood depths across the site is presented on Figure 16. No depths or elevations are presented for the 1 in 2 year or 1 in 30 year event as no flooding is seen outside of onsite channels.



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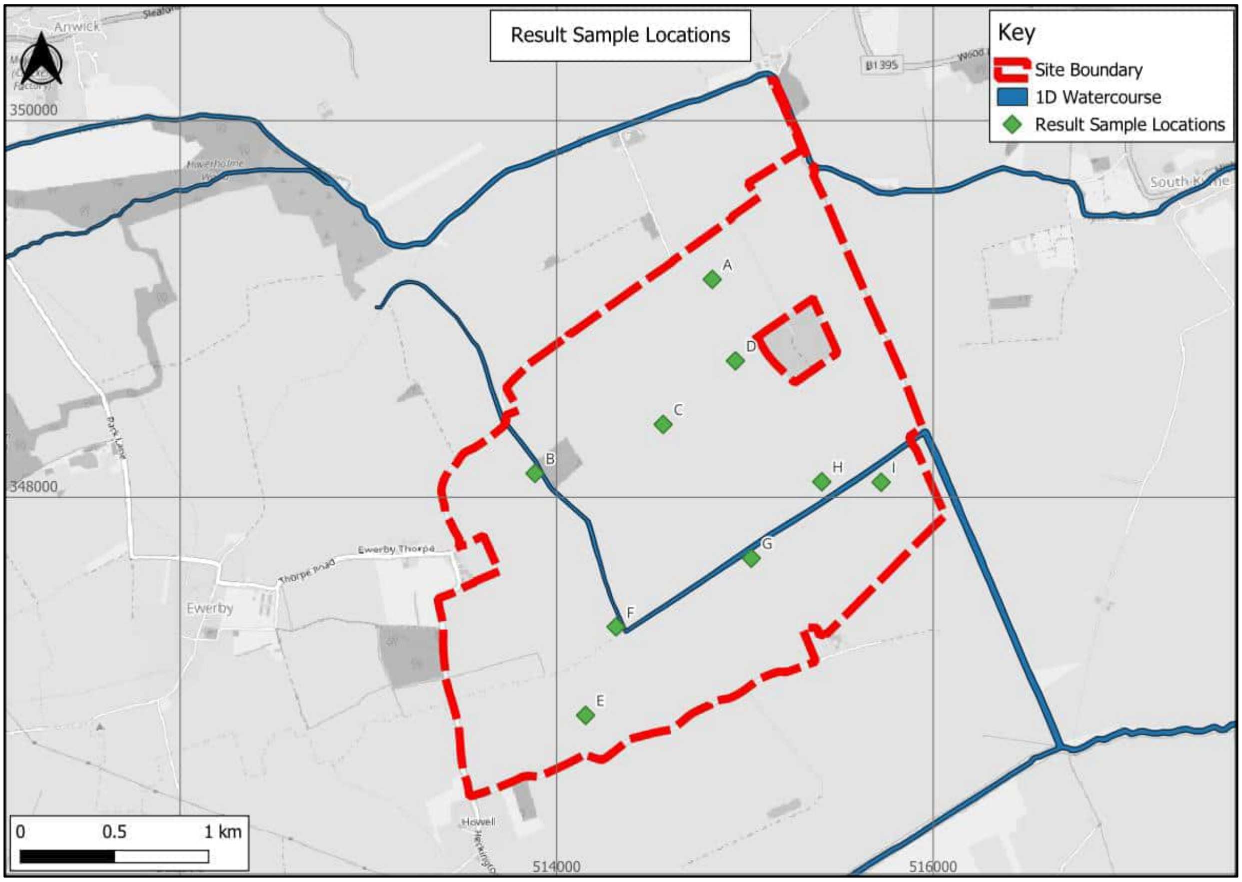


Figure 16: Modelled result sample locations (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

Table 6: Modelled Onsite Peak Flood Depths (m)

| Location ID | Maximum Modelled Flood Depth (m) | | |
|---|---|---|---|
| | 100-year | 100-year +CC32% | 1000-year |
| A | 0.16 | 0.23 | 0.35 |
| B | 0.22 | 0.26 | 0.28 |
| C | 0.10 | 0.14 | 0.17 |
| D | - | - | 0.21 |
| E | 0.04 | 0.07 | 0.09 |
| F | 0.23 | 0.32 | 0.39 |
| G | 0.10 | 0.14 | 0.17 |

| | | | |
|---|---|---|---|
| H | 0.26 | 0.37 | 0.41 |
| I | 0.18 | 0.35 | 0.51 |

Table 7: Modelled Onsite Peak Flood Elevations (mAOD)

| Location ID | Maximum Modelled Flood Elevation (mAOD) | | |
|---|---|---|---|
| | 100-year | 100-year +CC32% | 1000-year |
| A | 1.25 | 1.32 | 1.45 |
| B | 4.50 | 4.54 | 4.56 |
| C | 2.38 | 2.42 | 2.45 |
| D | - | - | 1.39 |
| E | 4.64 | 4.65 | 4.68 |
| F | 3.27 | 3.36 | 3.43 |
| G | 1.48 | 1.53 | 1.56 |
| H | 1.01 | 1.13 | 1.17 |
| I | 0.99 | 1.17 | 1.33 |

5.10. Flood depths from sample locations on the site (outside of watercourses and field ditches) range from 0.04m in the 100 year storm at Point E to 0.51m in the 1,000 year storm at Point I. The low flood depths observed across all storms at Point E suggest flood water is flowing through this location rather than ponding. All other locations show some level of flood water ponding with depths generally above 0.15m.

5.11. Flood elevations vary significantly across the site due to varying underlying ground levels. The highest flood elevation is seen at Point E despite flood water not ponding in this area. The next highest flood elevation recorded is Point B where water is found to leave the main channel within the site and pond in a topographical low area adjacent to the main channel.

5.12. Maximum modelled flood depths at the site for all modelled storm events are presented in Figure 17 to Figure 21.

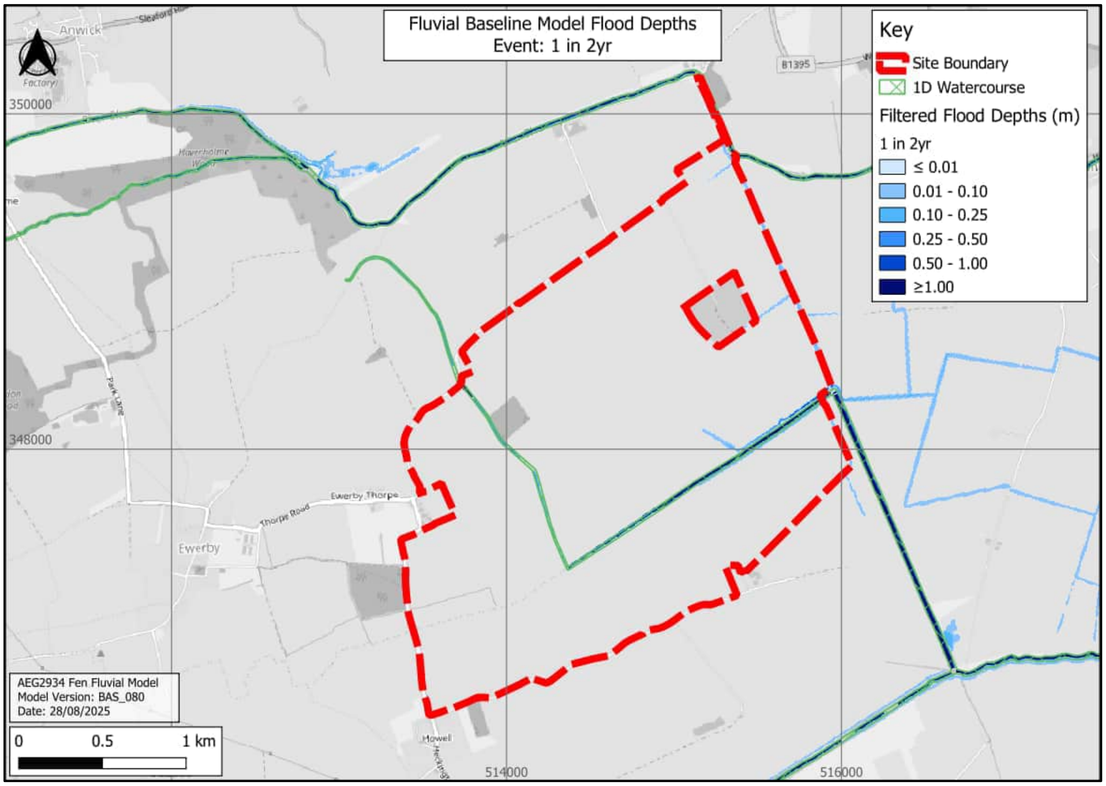


Figure 17: 1 in 2 year filtered modelled flood depths (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

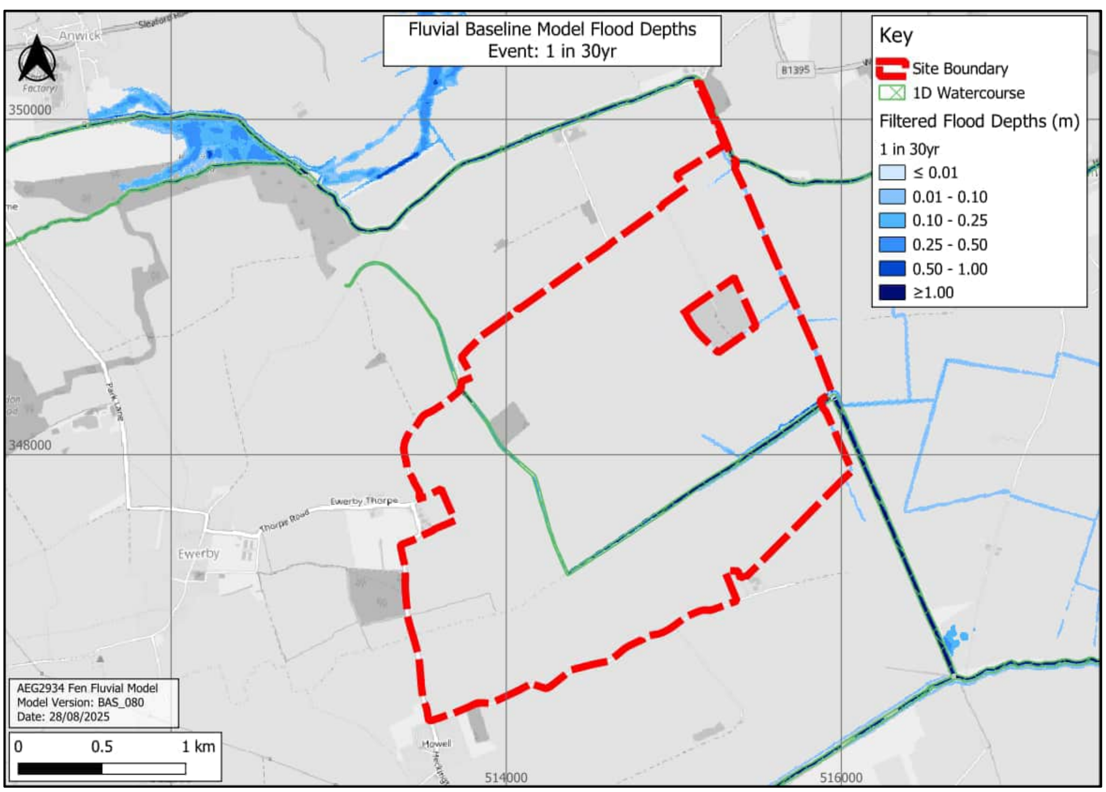


Figure 18: 1 in 30 year filtered modelled flood depths (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

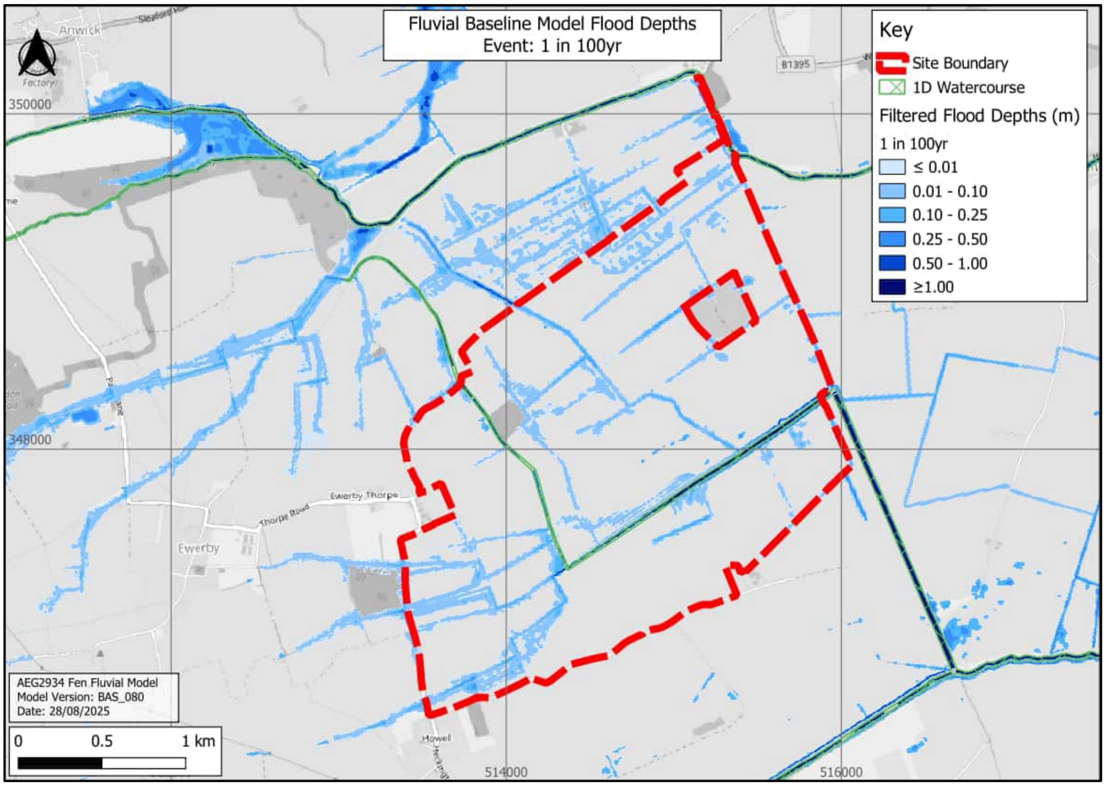


Figure 19: 1 in 100 year filtered modelled flood depths (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

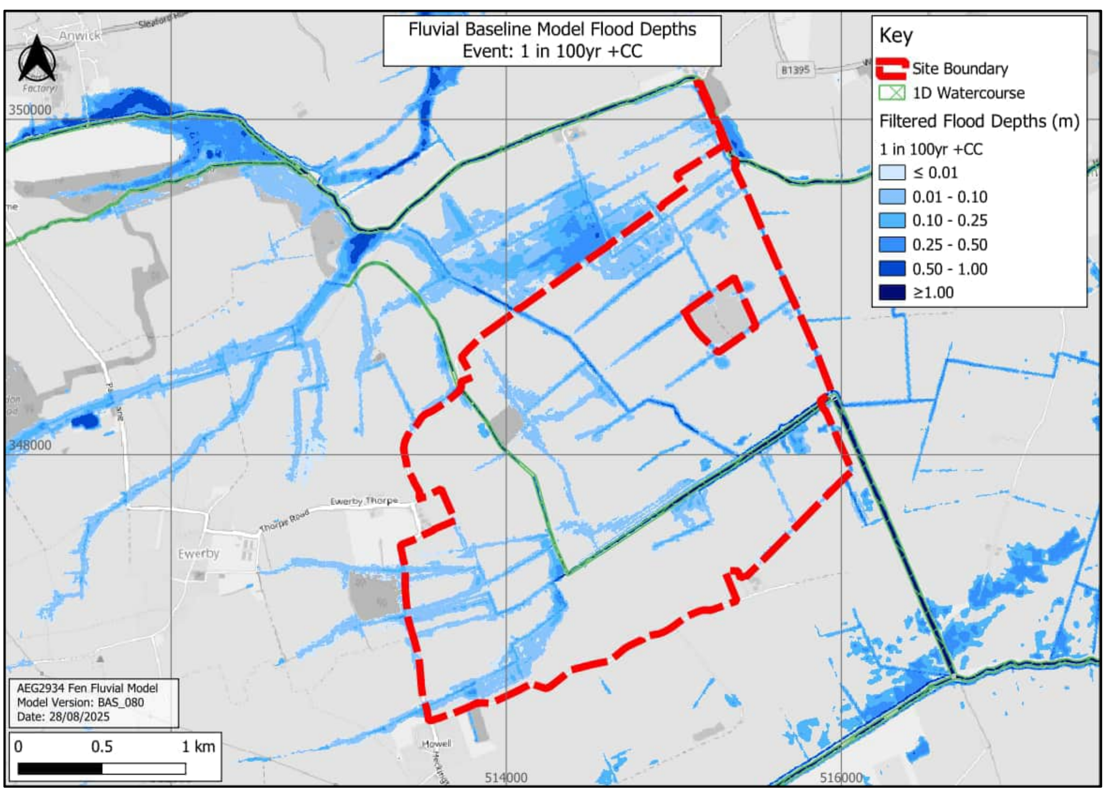


Figure 20: 1 in 100 year plus climate change filtered modelled flood depths (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

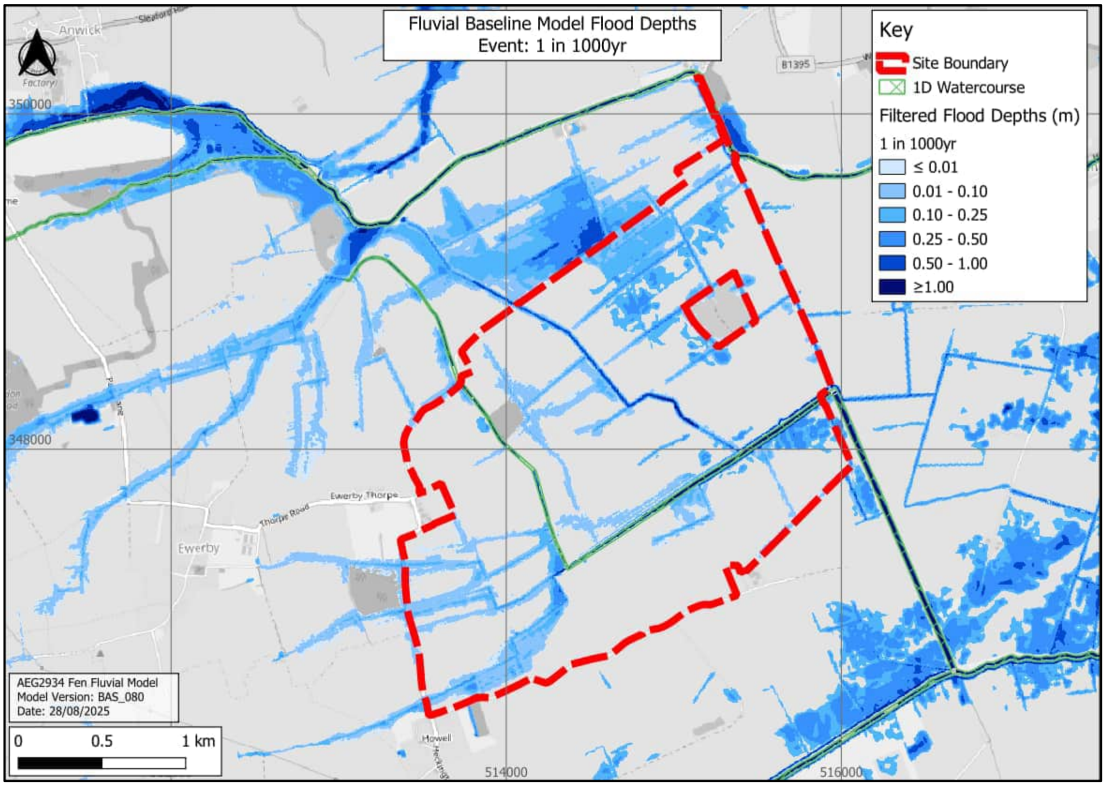


Figure 21: 1 in 1,000 year filtered modelled flood depths (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

## Recorded Flood Outline Comparison

5.13. The Environment Agency's Recorded Flood Outline (RFO) dataset (DEFRA Data Services Platform, accessed 28/08/2025) was obtained for the study area and compared with the modelled 1 in 100 year (1% AEP) and 1 in 1000 year (0.1% AEP) flood extents. The RFO dataset represents observed historic flood extents recorded during past events and does not carry return period attribution. The comparison has therefore been undertaken qualitatively, to provide confidence that the model reproduces the mechanisms and pathways associated with historic flooding.

5.14. Figure 22 presents the comparison between the RFO (hatched black polygon) and the modelled 1 in 100 year extent (green polygon) 1 in 1000 year extent (purple polygon). There are RFO's for extents around the River Slea and Old River Slea north-west of the site. The RFO date attributes align with Storm Babet (20/10/2023) and Lincolnshire floods affecting the River Witham and its tributaries, though not associated with a named Met Office storm (15/11/2019).

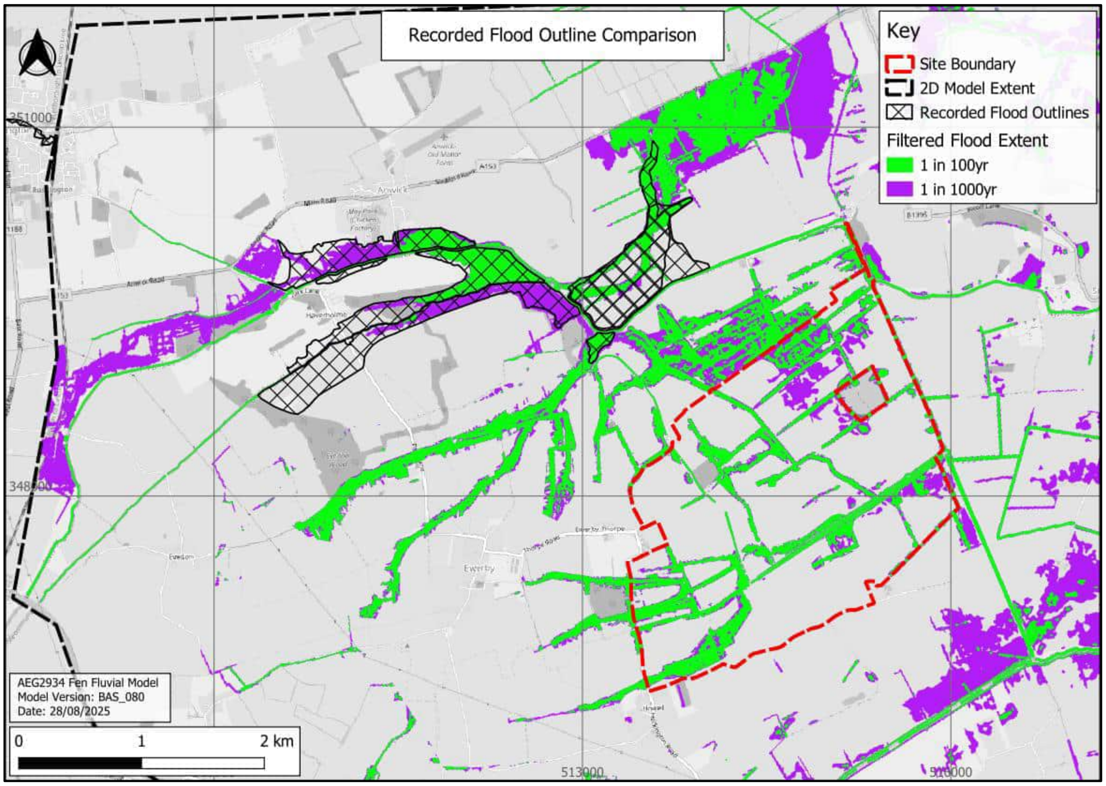


Figure 22: Recorded Flood Outline Comparison. Modelled Extent Events: 1 in 100 year and 1 in 1,000 year filtered (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

5.15. Overall, there is good spatial alignment between the modelled floodplain and the RFO, along the River Slea and Old River Slea. This provides confidence that the model is appropriately capturing the dominant flood pathways in this reach.

5.16. The RFO closest to the site (0.8 km north-east) is fully captured within the modelled outputs for all return periods greater than the 1 in 100 year event.

5.17. Some localised differences are noted:

- The modelled flood extent is slightly smaller than the RFO outline in places, most noticeably in the isolated area adjacent to the Old River Slea approximately 4.4 km upstream of the site, as well as the area to the north of the River Slea. However, the general alignment and representation of flooding in the model confirms that the model reproduces this known flood area.
- No RFOs intersect the site boundary. This does not preclude flooding within the site, only that no recorded outlines exist in this location.

5.18. These differences are likely to reflect the fact that the RFO dataset captures maximum observed extents from individual events, which may have been influenced by localised conditions (e.g.

temporary blockages, antecedent wetness, or defence performance at the time) not explicitly represented in the baseline model.

5.19. The comparison demonstrates that the model produces a reasonable representation of historic flood extents in the study area. All RFOs are captured within the modelled extents, and the minor differences observed are not considered significant given the limitations of the RFO dataset. On this basis, the model is deemed to be suitable for use in the subsequent flood risk assessment.

## High-Level Flow Verification

5.20. Observed flows at the 30006 Slea at Leasingham Mill gauge have been used to place recent recorded events in context with the modelled design hydrology. In particular, Storm Babet (20 October 2023) recorded a peak flow of 3.27 $m^3/s$, equivalent to approximately a 10% AEP (1 in 10 year) event, while Storm Henk (January 2024) recorded a peak flow of 5.74 $m^3/s$, equivalent to approximately a 0.5–0.2% AEP (1 in 200–1 in 500 year) event.

5.21. Figure 23 shows that the modelled flows for the 1% AEP event (extracted from model node RS_02343 – at Leasingham Mill) sits between the observed hydrographs for Babet and Henk, as expected. The modelled peak flow is within 1% of the estimated 1% AEP peak flow at the gauge, demonstrating that the model is consistent with the gauged record and provides confidence in the design hydrology adopted.

5.22. No additional gauges are available within the modelled reach for comparison; however, the alignment of modelled and observed flows at Leasingham Mill provides reassurance that the model is suitably representing flow conditions for use in this study.

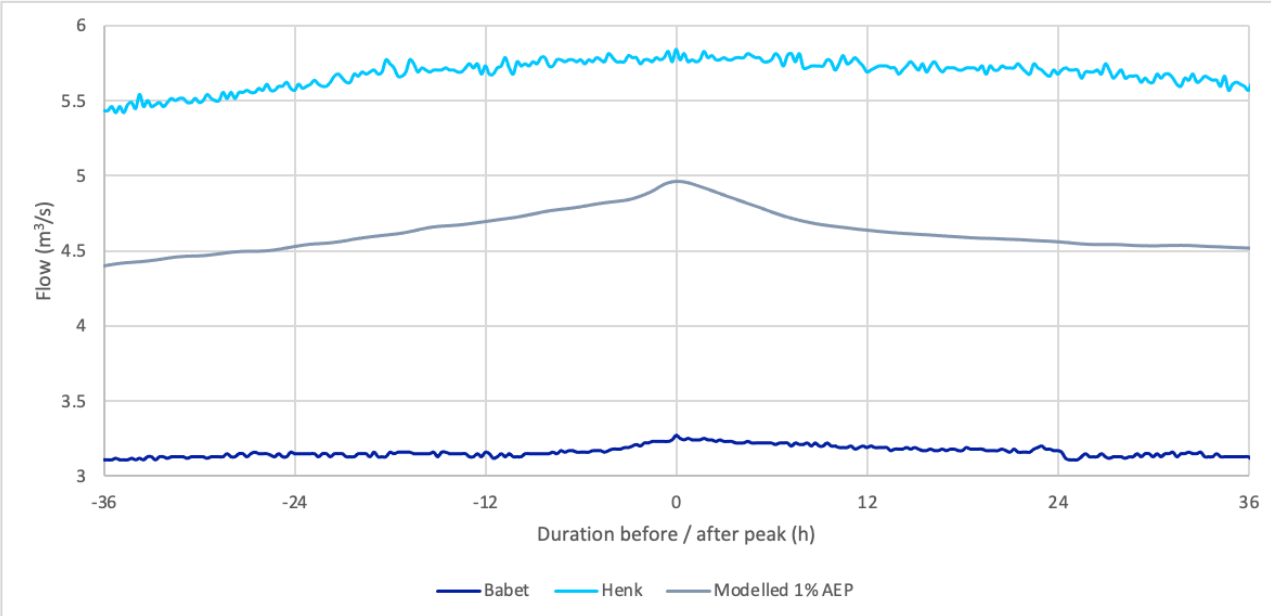


Figure 23: Comparison of gauged and modelled flood flows for 30006 Slea at Leasingham Mill (storms Babet and Henk vs. 1% AEP design storm).

5.23. When considered alongside the Recorded Flood Outline comparison, this high-level flow verification confirms that the model is consistent with both the spatial extent and the magnitude of historic flooding in the study area.

# 6. Model Sensitivity

6.1. This section summarises the sensitivity tests conducted using the 1 in 100-year plus climate change flows. The sensitivity tests were conducted against the baseline model to identify variations in key parameters' impact on results and robustness of the hydraulic model.

6.2. Six sensitivity assessments were undertaken on key parameters within the hydraulic model:

- Plus and minus 20% flows.
- Plus and minus 20% roughness in both the 1D and 2D domains.
- Bed elevation test.
- Blockage of 2 structures.
- Free discharge on (HQ) downstream boundary of each river network.
- Elevated discharge on (HT) downstream boundary of each river network.

## Flow

6.3. Flows within the model were increased and decreased by 20% to review the impact of uncertainty in the hydrological estimations. The resulting change in flood depths compared to the baseline model are presented on Figure 24 and Figure 25. A comparison of changes to predicted flood depth are presented in Table 8.

6.4. The model was found to be very sensitive to changes in flows with an increase in flood depths across the majority of the model. A similar response was observed for the decrease in flow with not only flood depths seeing a reduction but also flood extents. Overall, there was a negligible difference in the average flood depth change across the model.

6.5. As a new hydrological study was undertaken for this model which utilised local gauge data the flows applied to the baseline model are considered appropriate to assess the flood risk to the site.

Table 8: Inflow sensitivity results

| Sensitivity | Modelled Flood Depth Difference (m) | | |
|---|---|---|---|
| | Maximum Decrease | Maximum Increase | Average |
| Plus 20% flow | -0.16 | +0.63 | 0.02 |
| Minus 20% flow | -1.02 | 0.17 | -0.02 |

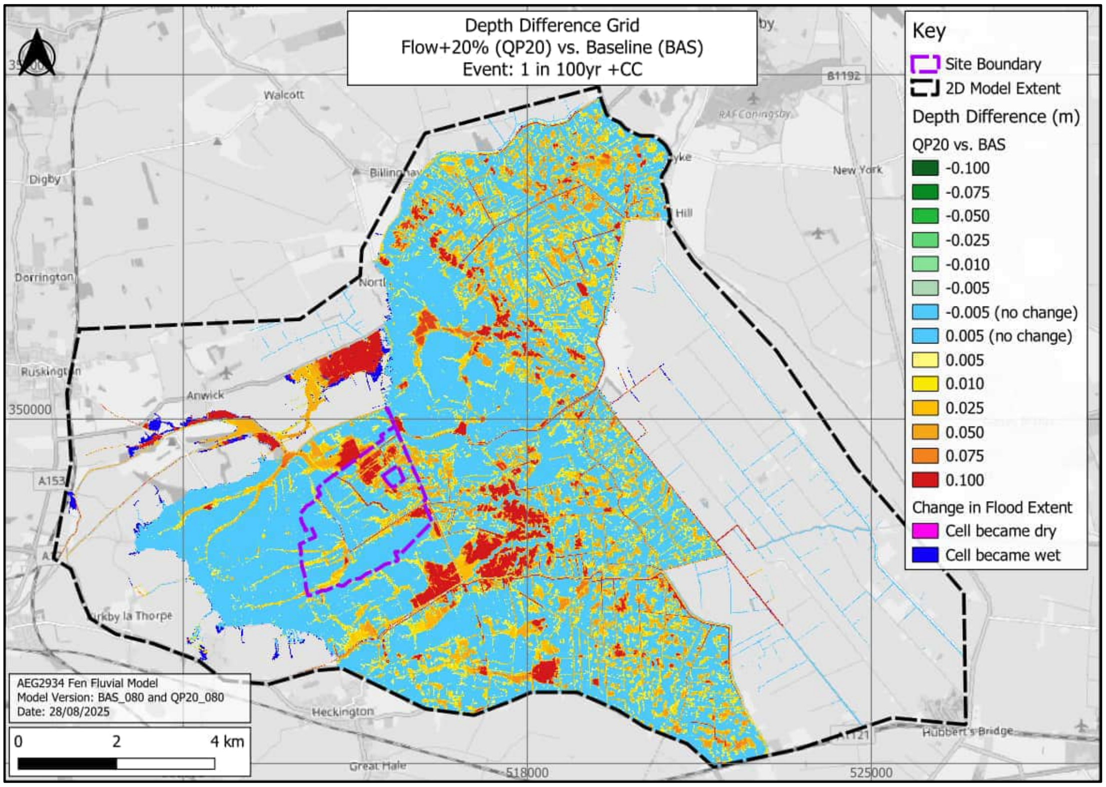


Figure 24: Depth Difference Grid - 20% increase flows vs Baseline (unfiltered). Event: 1 in 100-year + CC. (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

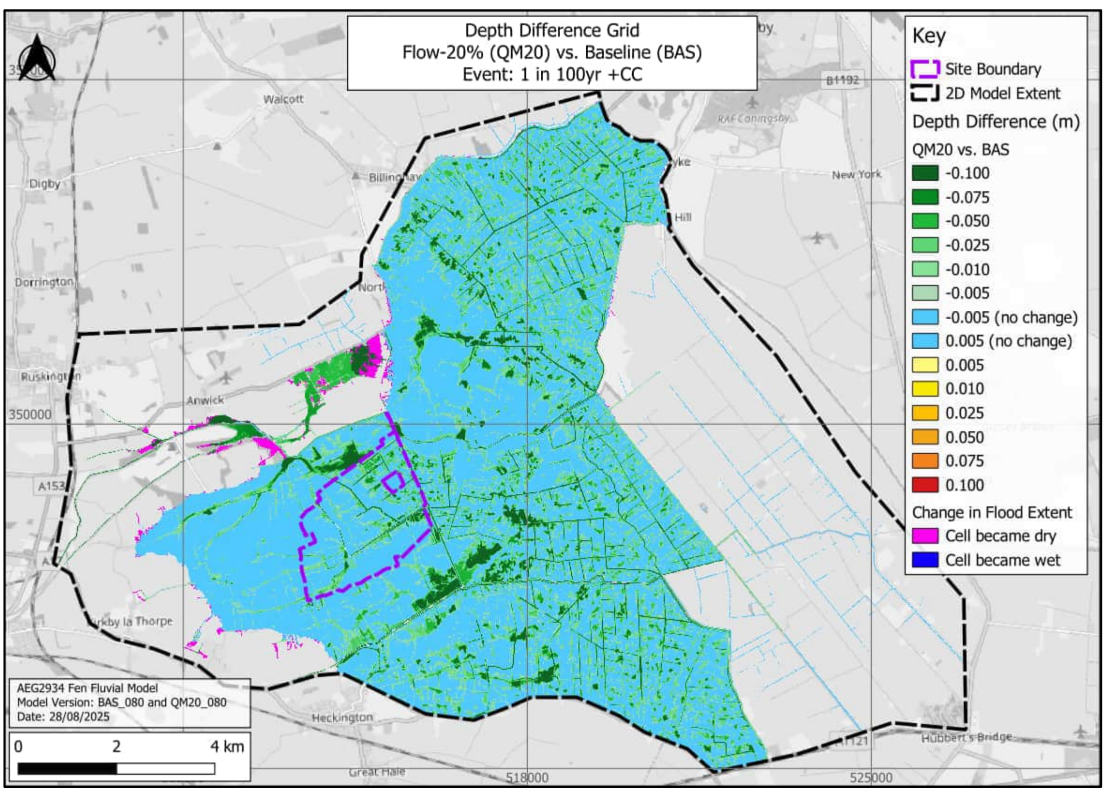


Figure 25: Depth Difference Grid - 20% decrease flows vs Baseline (unfiltered). Event: 1 in 100-year + CC. (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

## Roughness

6.6. Roughness within the model was increased and decreased by 20% to review the impact of seasonal variation in vegetation on flood risk. The resulting change in flood depths compared to the base model are presented on Figure 26 and Figure 27. A comparison of changes to predicted flood depth are presented in Table 9.

6.7. The model was found to be slightly sensitive to changes in roughness with an increase in flood depths observed in some areas within the model. A larger response was observed for a decrease in roughness with larger decreases in flood depths within the model. Changes in flood depths are mostly contained within field ditches within the 2D floodplain and flooding directly adjacent to the Lower Witham and Black Sluice networks. A negligible change in flood depths was observed within the site boundary.

Table 9: Roughness sensitivity results

| Sensitivity | Modelled Flood Depth Difference (m) | | |
|---|---|---|---|
| | Maximum Decrease | Maximum Increase | Average |
| Plus 20% roughness | -0.20 | +0.30 | 0.00 |
| Minus 20% roughness | -1.02 | +0.28 | 0.00 |

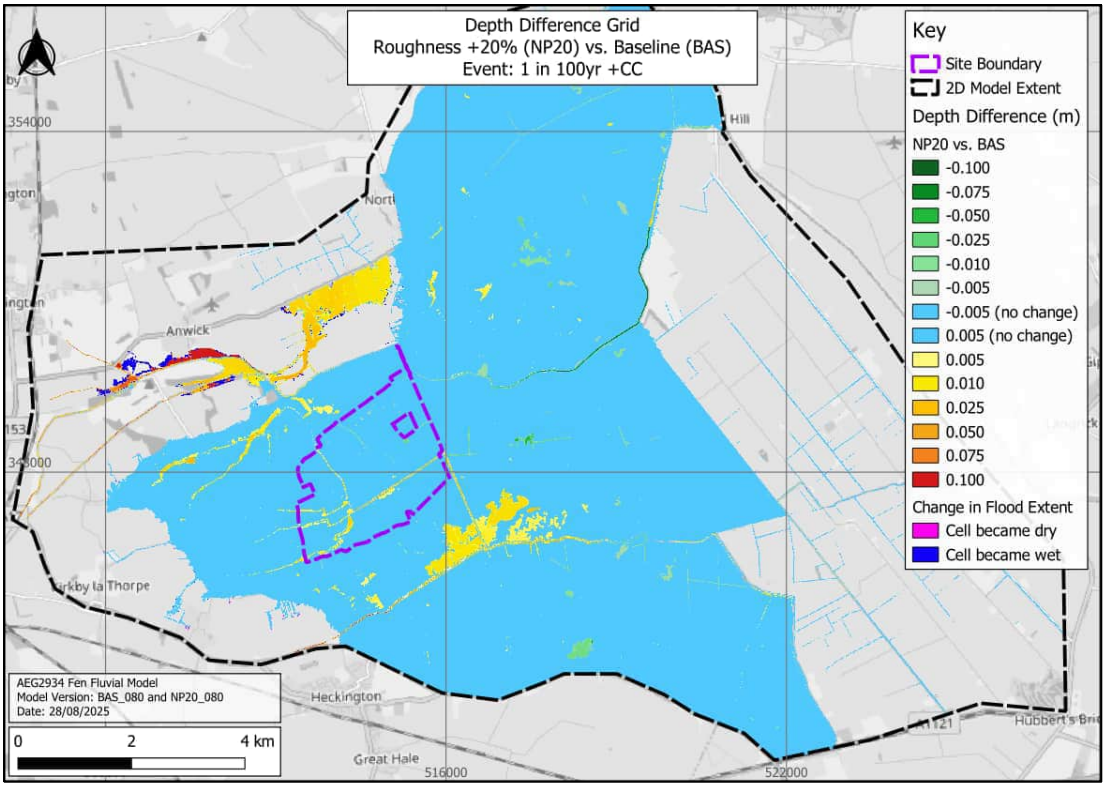


Figure 26: Depth Difference Grid - 20% Increase Manning's n (1D & 2D) vs Baseline (unfiltered). Event: 1 in 100-year + CC. (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

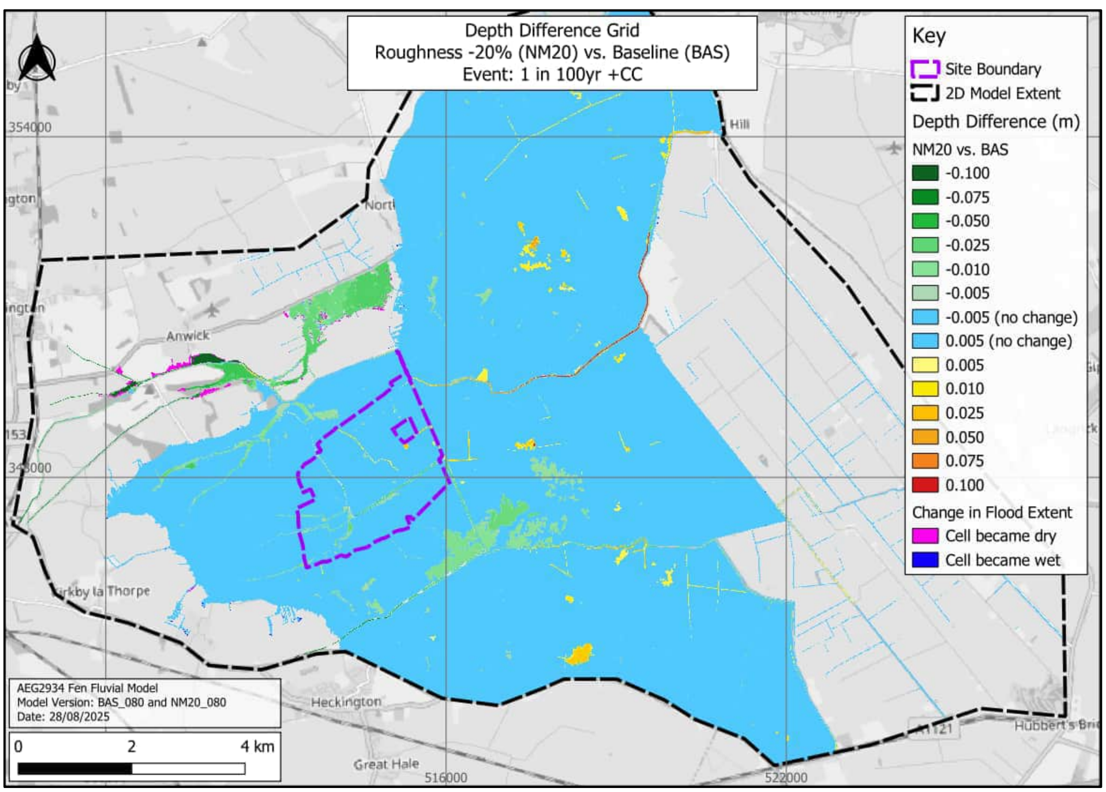


Figure 27: Depth Difference Grid - 20% Decrease Manning's n (1D & 2D) vs Baseline (unfiltered). Event: 1 in 100-year + CC. (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

## Bed Level Uplift

6.8. A sensitivity test on in-channel 1D bed levels was required to understand the impact of potential changes to bed levels within the model since the original survey was undertaken. This sensitivity was undertaken in agreement the Environment Agency following a review of new survey data collected in March 2024 as part of this study.

6.9. The uncertainty in the change in bed levels across the model could result in some areas overestimating the storage within the network and others underestimating the storage within the network. Due to the limited access for surveying the length of the hydraulic model it was agreed a single uplift would be applied across the hydraulic model (Paragraph 4.10). This is a conservative approach as no allowance for increase channel storage (bed level reduction) is considered.

6.10. The bed levels within the model were to be increased by 0.25m as this is the average change in level across locations 1 to 3 (Figure 8) which were surveyed in the same location as the original model. The average difference in bed level was applied as the largest increase in bed level of 0.75m would cause many of the in channel structures within the 1D network to be fully blocked, thereby not representing realistic conditions.

6.11. To run the sensitivity test all bed levels within the 1D network on both the Lower Witham and Black Sluice networks were manually increased between the bottom of bank points by 0.25m. This caused major instabilities within the model with numerous structures becoming unstable with a change in bed level and reduction in structure size.

6.12. Alternative methods to remove the capacity from the in-channel networks was applied to assess the impact on flood risk. Two methods were required as each removed different capacities from networks within the model. The first increased baseflow so the model has less capacity within the channel at the start of the storm hydrograph (Method A) and increasing channel roughness to increase water levels within the channel at the start of the storm event by 0.25m (Method B).

6.13. When checking each method to see if the channel capacity below 0.25m had been removed the model results at the start of the observed storm from the 100 year plus climate change storm in the baseline model was used. This ensured no model warm up influenced the capacity of the channel removed and the correct channel capacity was present at the start of the storm.

6.14. To identify the appropriate time to compare in channel levels the 1 in 100 year plus climate change stage hydrograph were reviewed (Figure 28) for each network.

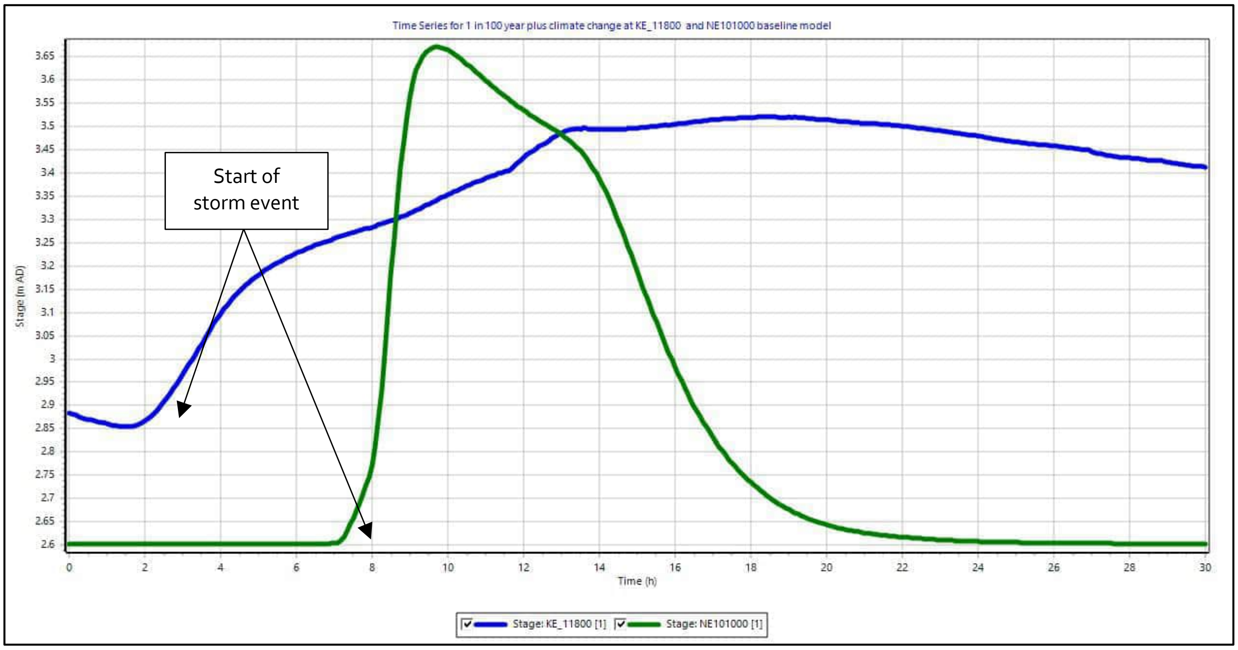


Figure 28: Time series plot for Lower Witham (KE_11800, blue) and Black Sluice (NE10100, green) networks identifying start of 1 in 100 year plus climate change on each network.

6.15. The Lower Witham was found to react faster to the storm event with an increase in stage observed at 2 hours while the Black Sluice does not show a response until approximately 7 hours. Therefore, a review of stage at the start of the 1 in 100 year plus climate change storm is taken as 2 hours on the Lower Witham network and 7 hours on the Black Sluice network. While the same storm was applied to the whole model the long lag time seen on the Black Sluice network is attributed to the influence of IDB pumped catchments providing significant storage slowing response of the catchment when compared to the Lower Witham network which has a much larger naturally drained catchment. Method A required the minimum flow across the 1D networks being increased to 75% of QMED for the associated catchment. This increase in baseflow was applied to each QT boundary as a minimum flow. A spot check of cross sections across Lower Witham and Black Sluice network found in channel levels were raised by approximately 0.25m across the network at the start of the model run. The change in level was not uniform across the whole network due to presence of structures however at the key cross sections on the Lower Witham (immediately north of the site) levels increased by 0.27m at KE_11800. Within the site itself levels were raised by 0.34m at NE10100.

6.16. To apply Method B to the model a global increase in roughness values of 1.5 times baseline roughness was applied. This uplift was applied to all 1D roughness values both in and out of bank. A spot check of cross sections across Lower Witham and Black Sluice network found in channel levels were raised by 0.20m across the network. The change in level was not uniform across the whole network. At the key cross sections on the Lower Witham (immediately north of the site) found levels only increased by 0.12m at KE_11800. Within the site itself levels were only raised by 0.06m at NE10100.

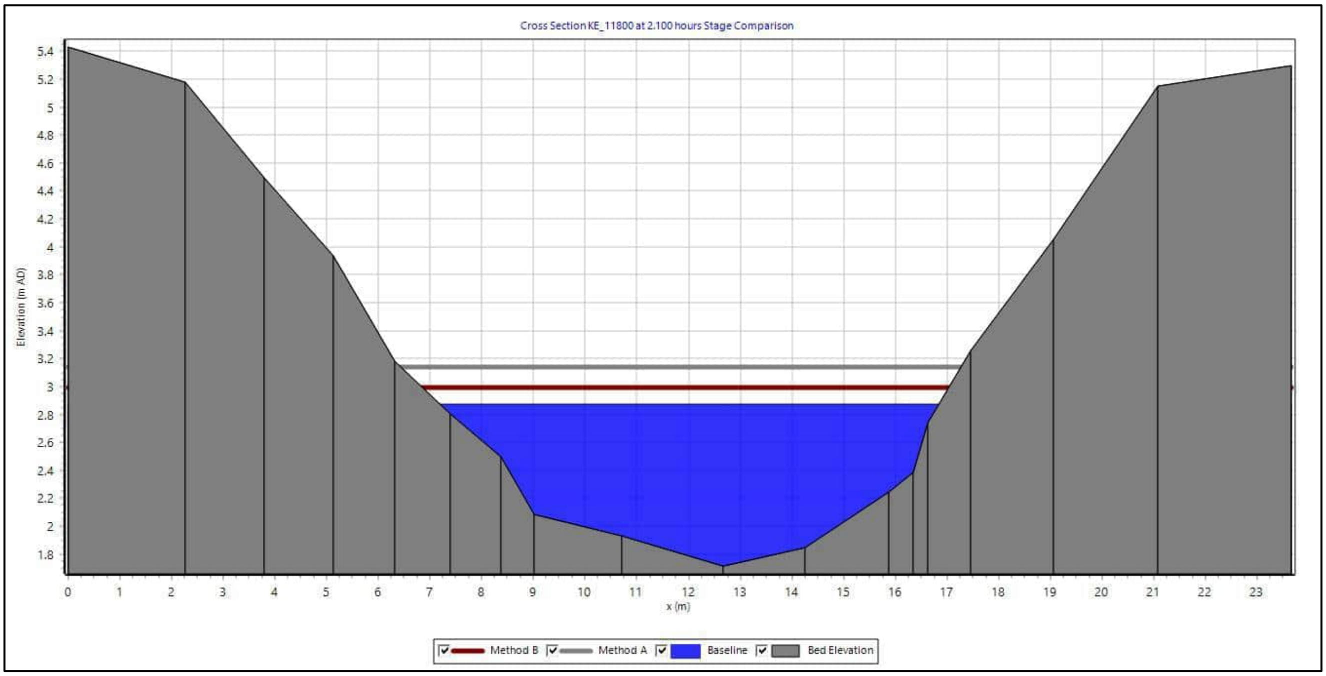


Figure 29: Cross section plot for Lower Witham Network bed level sensitivity assessment (Baseline – blue, Method A – grey, Method B - red)



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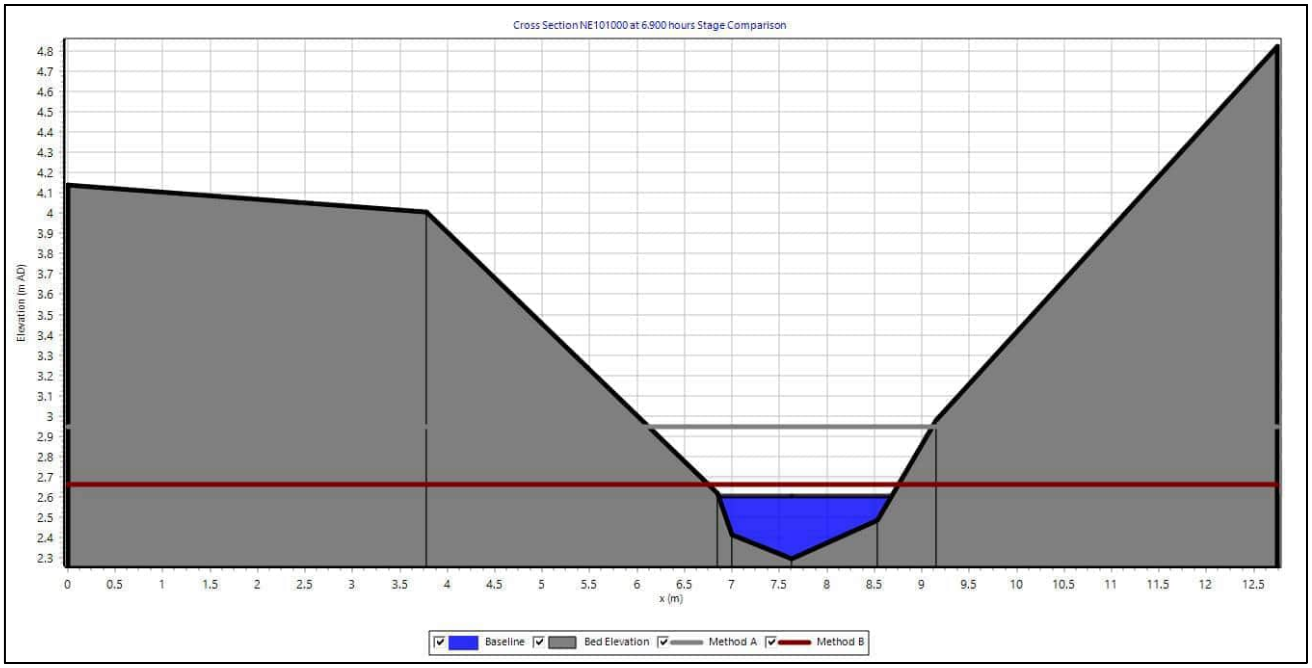

Figure 30: Cross section plot for Black Sluice Network bed level sensitivity assessment (Baseline – blue, Method A – grey, Method B - red)

6.17. Based on the in channel levels Method A provides a good representation of channel capacity removal. Method B was found not to remove enough channel capacity to assess the impact of a 0.25m bed lift. A higher roughness value uplift was applied to the network but this caused significant instabilities within the model. Therefore, Method A was taken forwards to assess the impact of a raised bed level on flood risk at the site.

6.18. Resulting changes to flood depths as a result of bed lift Method A are presented in Figure 31. A comparison of change to modelled flood depths are presented in Table 10 for the full model and for the site only. While a small increase of less than 0.15m was observed in flood levels across the whole domain, the greatest uplift within the site boundary was 0.05m. The larger increase in flood depths is observed on the left bank of the Lower Witham network away from the site boundary.

6.19. The average modelled flood depth difference is 0.0m. The maximum difference within the site is 0.05m, which is much less than the vertical resolution of the underlying LiDAR DTM; therefore, applying a raised bed across the model for the baseline model is not considered necessary.

Table 10: Bed lift sensitivity results

| Sensitivity | Modelled Flood Depth Difference (m) | | |
|---|---|---|---|
| | Maximum Decrease | Maximum Increase | Average |
| Whole model domain | -1.04 | 0.14 | 0.00 |
| Site Boundary | -0.17 | 0.05 | 0.00 |

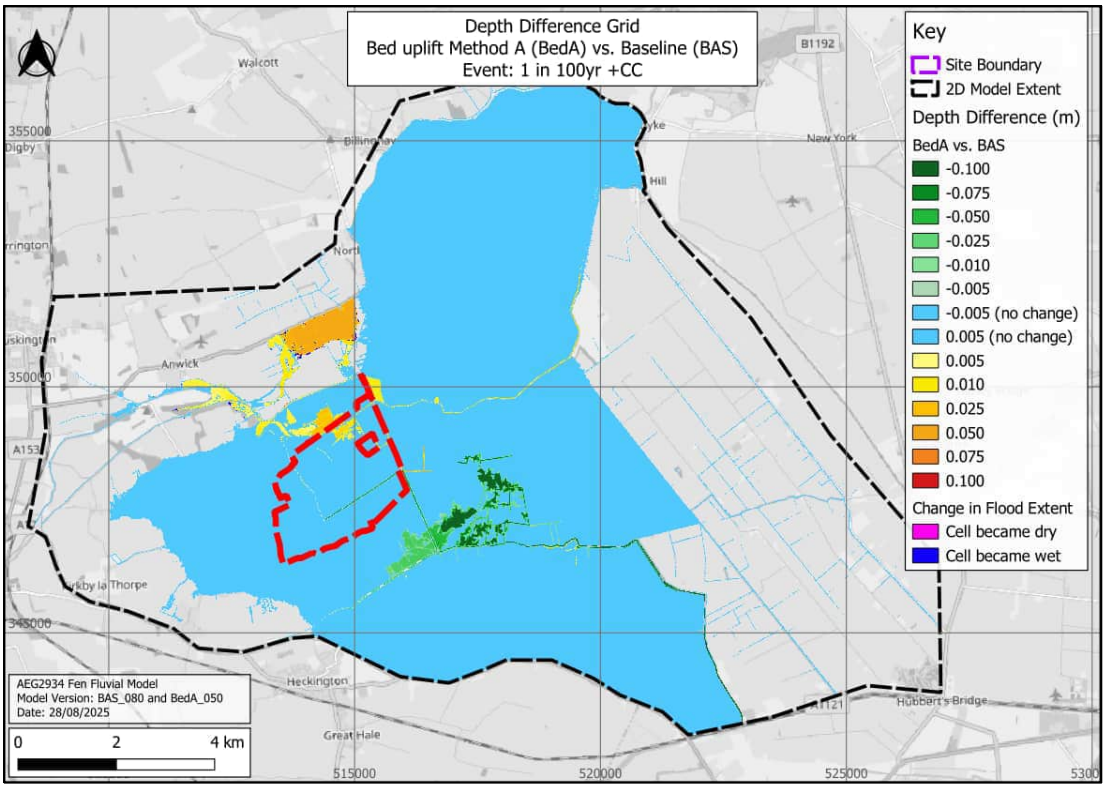


Figure 31: Depth Difference Grid - Bed uplift Method A vs. Baseline (unfiltered). Event: 1 in 100-year + CC. (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

## Blockage

6.20. To understand the impact of flood risk to the site from structures becoming blocked, 2 blockage scenarios were run. The structures were selected based on their potential to impact the site, and are shown on Figure 32. The first structure is located on the Lower Witham network, this was blocked to 50% using a blockage unit within Flood Modeller. A 50% blockage is considered a suitable assessment due to the large size of the structure (12m wide and 3.6m high). In addition, the network upstream of this location is bunded with minimal vegetation limiting the chance of debris entering the channel.

6.21. The second blockage is located on the Black Sluice network within the site boundary at the point where a large area of flood water was found to pool within the model results. The culvert at this location is 1.3m tall and 1m wide and located within an IDB area with no embankments along either side of the watercourse. A 100% blockage was applied to this structure to replicate potential silting up and debris blocking the structure.

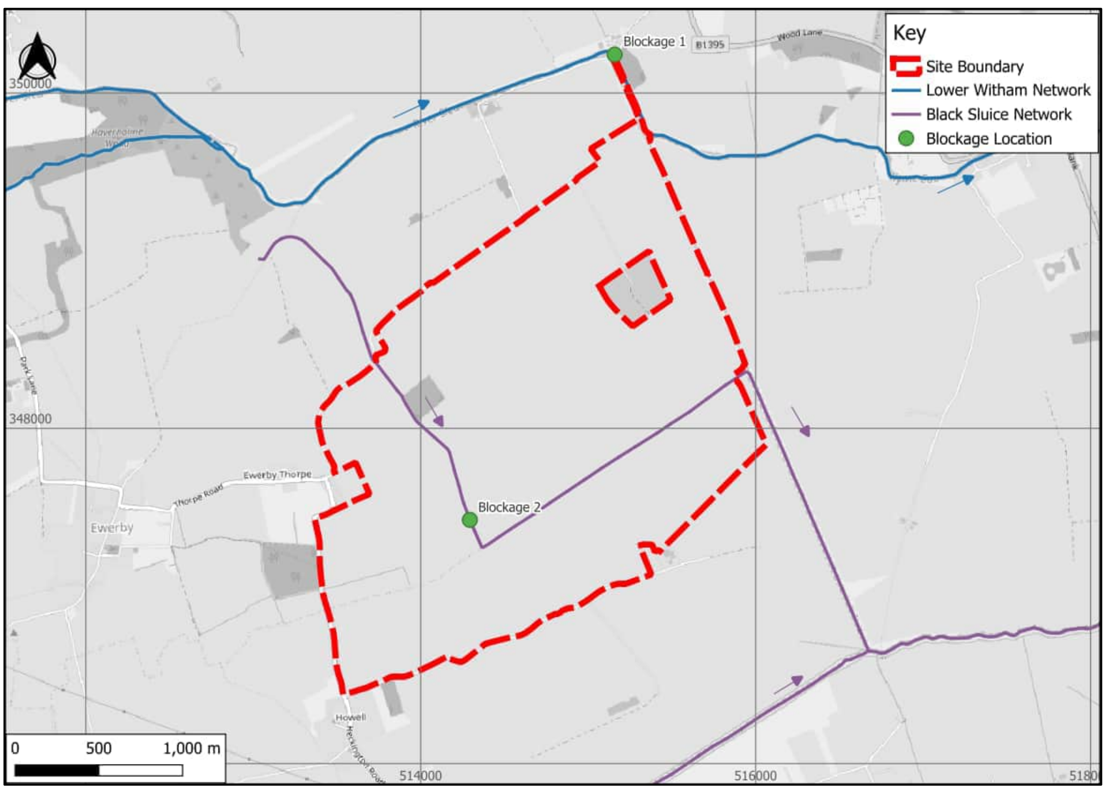


Figure 32: Sensitivity Structure Blockage Locations (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

6.22. The resulting change in flood depth compared to the base model are presented on Figure 33 and Figure 34. A comparison of changes to predicted flood depth are presented in Table 11.

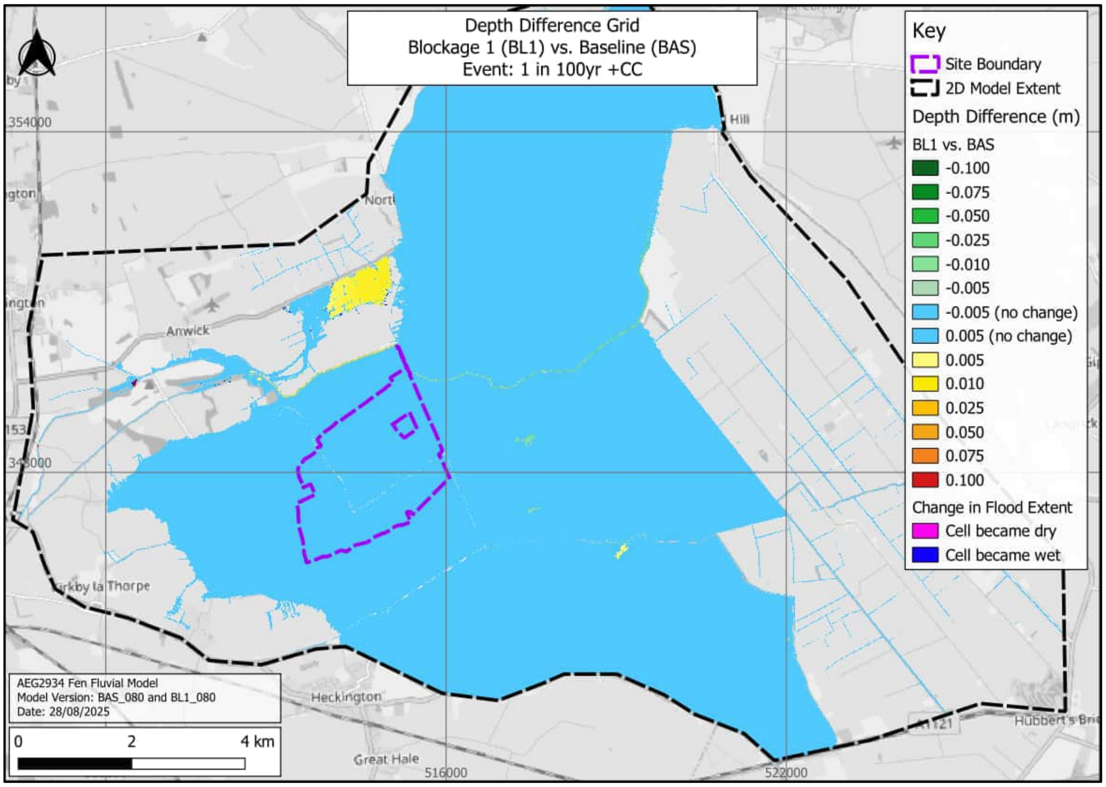


Figure 33: Depth Difference Grid - Blockage 1 (Lower Witham, 50%) vs Baseline (unfiltered). Event: 1 in 100-year + CC. (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

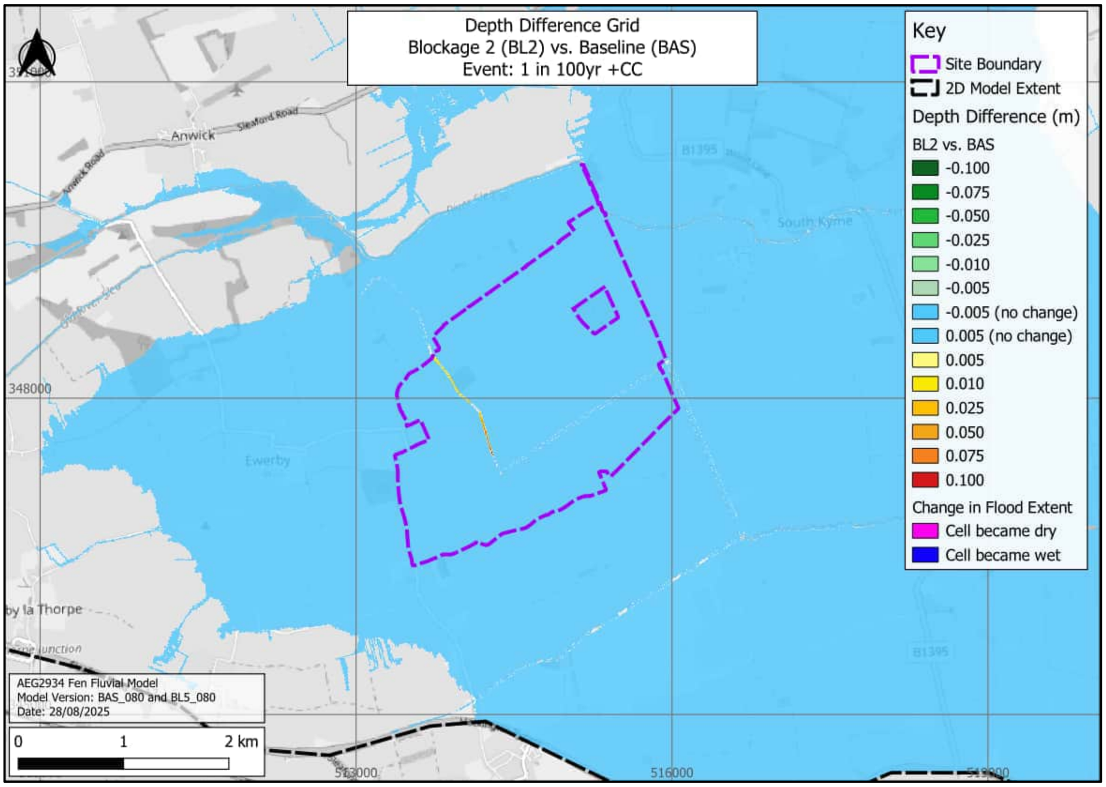

Figure 34: Depth Difference Grid - Blockage 2 (Black Sluice, 100%) vs Baseline (unfiltered). Event: 1 in 100-year + CC. (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

Table 11: Blockage sensitivity results

| Sensitivity | Modelled Flood Depth Difference (m) | | |
|---|---|---|---|
| | Maximum Decrease | Maximum Increase | Average |
| Blockage 1 | -0.12 | 1.16 | 0.00 |
| Blockage 2 | -0.03 | 0.12 | 0.00 |

6.23. Blockage 1 resulted in an increase in flood depths on the left bank of the Lower Witham network upstream of the structure and a decrease in flood depths downstream of the structure. No change in flood depths was observed onsite.

6.24. Blockage 2 resulted in an increase in flood depths within the Black Sluice network within the site. No change in flood depth was observed on the floodplain of the site.

## Downstream Boundary

6.25. To test the impact of a free discharge from the hydraulic model a normal depth boundary was applied at the downstream extent of each network. The resulting change in flood depth compared to the base model are presented on Figure 35. A comparison of changes to predicted flood depth are presented in Table 12.

6.26. Changes in predicted flood depths were found to be restricted to in channel depth changes on the Lower Witham network, this reflects the limited backwash effect observed at this boundary discussed in Paragraph 4.34. A reduction in flood depths was observed in the Black Sluice floodplain downstream of the site, this is potentially caused by a longer backwash effect being removed from the model as described in Paragraph 4.35. There were no observed changes to flood depths within the site boundary.

Table 12: Downstream boundary – normal depth sensitivity results

| Sensitivity | Modelled Flood Depth Difference (m) | | |
|---|---|---|---|
| | Maximum Decrease | Maximum Increase | Average |
| Normal Depth Boundary | -1.30 | 0.05 | 0.00 |

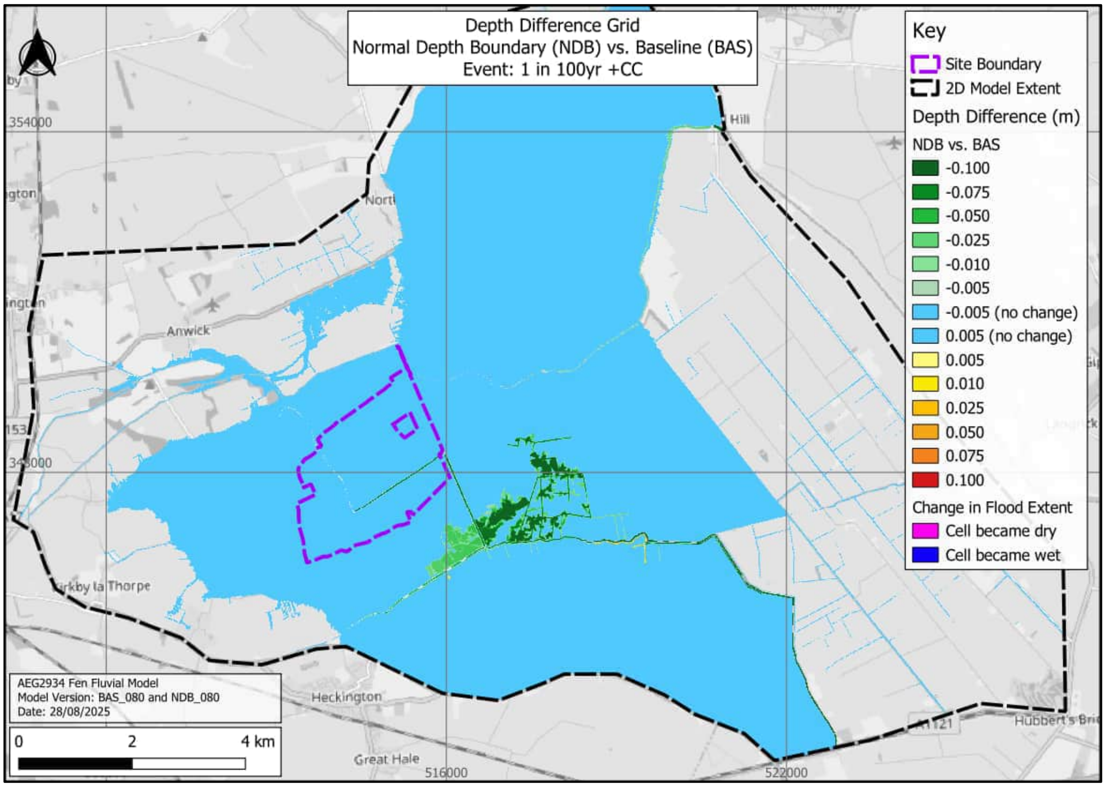


Figure 35: Depth Difference Grid - Free-discharge (HQ/normal depth) downstream boundary vs Baseline (unfiltered). Event: 1 in 100-year + CC. (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

6.27. To test the impact of elevated head–time (HT) levels on the River Witham and South Forty Foot Drain (reflective of previously modelled levels on these watercourses), elevated HT stage levels were applied at the two 1D downstream boundary nodes:

- KE_00070 (River Witham): peak 3.69 mAOD (AECOM, 2009; node LWA_15880).
- SD100020a (South Forty Foot Drain): peak 2.16 mAOD (Mott MacDonald, 2016; node SD100028).

6.28. These elevated boundary levels are representative of a 1 in 2-year (50% AEP) event on the respective watercourses, providing a robust sensitivity test of the model's response to higher downstream water levels.

6.29. All other boundary conditions and model settings (including the 2-hour warm-up) were unchanged. For reference, the baseline model adopts an HT level of 1.2 mAOD (see Sections 4.33–4.36); this test therefore assesses substantially higher downstream stages than baseline.

6.30. The resulting change in flood depth compared to the baseline model is presented in Figure 36. A summary of on-site differences is provided in Table 13.


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6.31. The sensitivity test applying higher HT levels at the downstream boundary resulted in an average depth change of 0.0008 m (0.8 mm) across the site of interest, which is negligible and within typical model tolerances. Localised increases were limited to channels, with up to 0.16 m within the site (Car Dyke near the north-eastern boundary) and 0.13 m in Hodge Dyke through the site. A larger in-channel increase of 0.22 m occurred in the Kyme Eau immediately beyond the north-eastern site boundary. There was no change to floodplain depths across the site (0.00 m) and no change to the mapped flood extent. These results indicate the site is robust to plausible variation in downstream tailwater.

6.32. As shown, the sensitivity test produced changes to flood extent and depth within the wider modelled catchment, particularly in low-lying areas beyond the site boundary toward the downstream boundary locations. These variations are an expected response to increased downstream water levels; however, they are confined to off-site areas and have no influence on the assessment of flood risk at the site.

6.33. The results demonstrate that the site is insensitive to plausible increases in downstream water levels, where impacts are restricted to in-channel and do not propagate onto the site floodplain. Consequently, the adopted 1.2 mAOD HT boundary for the design simulations remains a robust and proportionate representation of restricted discharge for the purpose of the site-specific assessment, and the conclusions of the flood risk appraisal are unchanged.

6.34. The application of elevated downstream boundary levels has also been carried forward into subsequent modelling phases to ensure consistency across all assessments. The same higher HT boundary conditions were applied within the fluvial extreme event (credible maximum) and breach modelling scenarios reported in AEG2934_LN4_Fen_Extreme Event_Model_Report_001 and AEG2934_LN4_Fen_Breach_Model_Report_003, respectively.

Table 13: Downstream boundary – elevated HT sensitivity results

| Sensitivity | Modelled Flood Depth Difference (m) | | |
|---|---|---|---|
| | Maximum Increase (on site - in channel) | Average Difference (on site including in-channel) | Maximum Increase (on site - floodplain only) |
| Elevated HT boundary | 0.1600 | 0.0008 | 0.0000 |

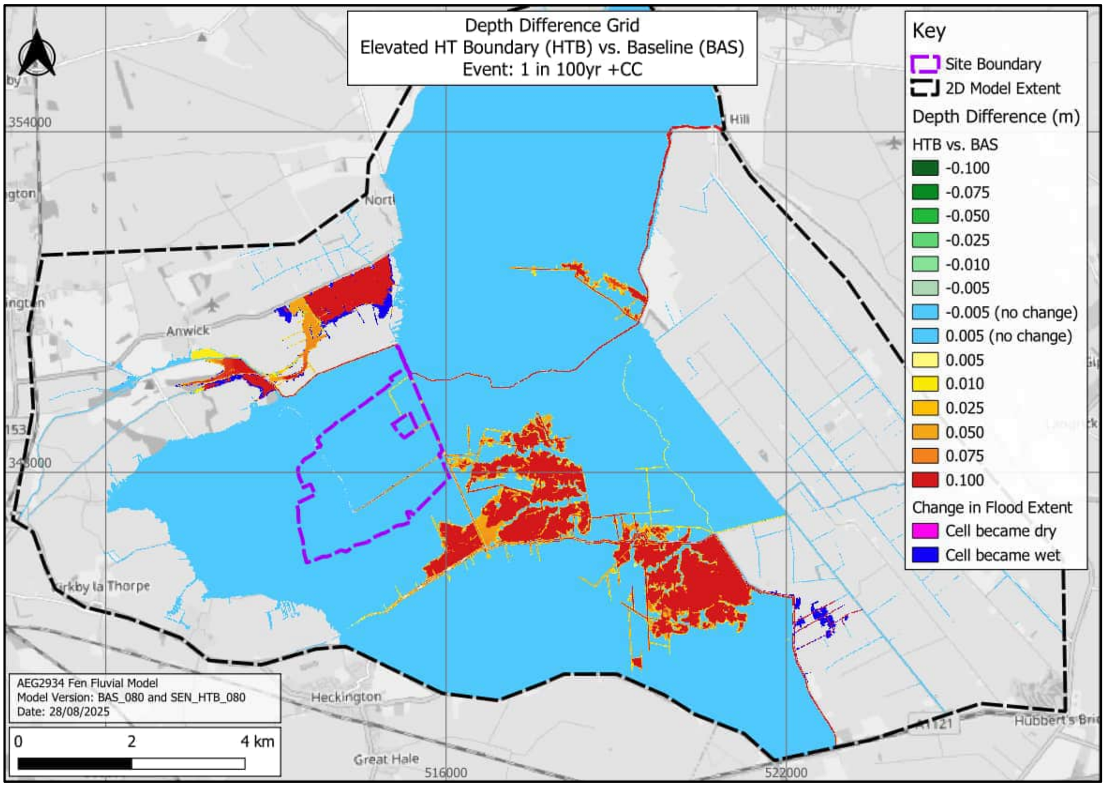


Figure 36: Depth Difference Grid - Elevated HT downstream boundary vs Baseline (unfiltered). Event: 1 in 100-year + CC. (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

# 7. Model Stability & Limitations

## Simulation Parameters

7.1. Flood Modeller Pro version 7.3.0 and TUFLOW version 2025.1.0-iSP-w64 Heavily Parallelised Compute (HPC) was used in all simulations.

7.2. All parameters were retained as default. A 1D timestep of 2.5 seconds and 2D initial timestep of 5 seconds was applied to the model. A 2D variable timestep is used as a standard approach for all HPC simulations i.e. based on stability criteria.

## Model Stability

7.3. No repeated timesteps were reported in the HPC (2D) domain.

7.4. TUFLOW reporting volume error and final cumulative error was reported at 0.00% for the 100 year plus climate change event.

7.5. Flood modeller 1D reported the model was fully converged with a mass balance error of -1.14% of the peak system volume and -0.39% of the boundary inflow for the 100 year plus climate change event. The slightly higher peak system volume mass balance error is expected as a large portion of flow enters the floodplain during the simulation and does not re-enter the channel before the simulation completes due to the presence of flood defences around IDB catchments.

7.6. For a HPC model to be considered stable, three parameters should be maintained: $N_u$ (Courant number relates to velocity relative to the cell size), $N_c$ (Celerity Control number relates to water depth relative to cell size) and $N_d$ (Diffusion control relates diffusion of momentum relating to the sub grid viscosity). Generally, for a stable model these values should be: $N_u<1$, $N_c<1$ and $N_d<0.3$. The model-specific stability outputs are shown in Table 14.

7.7. The $N_u$ and $N_d$ outputs indicate good model performance and stability. The $N_c$ number is at the upper limit for stability and warranted further investigation. $N_c$ is particularly sensitive to high water depths compared to grid cell size, as field drains within IDB areas are represented within the 2D domain some of these locations have large flood depths. As the 1D domain is very sensitive to any additional structures and connections it was decided not to convert any further field drains into the 1D domain. Despite the borderline $N_c$ value, the model remains within acceptable tolerance for stability.

Table 14: HPC solver stability outputs for the 100 year plus climate change

| | Maximum stability criteria value | Max Model outputs | Average Model outputs |
|---|---|---|---|
| $N_u$ (Courant control number) | 1.00 | 0.26 | 0.20 |
| $N_c$ (Celerity control number) | 1.00 | 1.00 | 1.00 |
| $N_d$ (Diffusion control number) | 0.30 | 0.04 | 0.03 |

## Limitations

7.8. The modelling exercise has made best use of the available data at the time of construction and simulation.

7.9. Limitations resulting from the hydrology study are outlined in Paragraph 3.25.

7.10. The baseline floodplain topography is derived from LiDAR which has limited accuracy (+/- 0.15m). This is considered to be sufficient for the purpose of this exercise.

7.11. Due to access restrictions a full channel survey was not possible for this study. Selected cross sections where access could be arranged were surveyed to compare existing model data to current channel geometry. Where differences were noted sensitivity testing was undertaken to ascertain the impact on modelled flood extents. While the sensitivity testing found no significant impact on modelled extents, future studies should consider extending the new survey locations to ensure the model is fit for purpose.

7.12. Where structures have been retained from the original model report limited information other than that provided within the hydraulic models is known. It has therefore been assumed these structures are correct within the model.

7.13. Depth-varying roughness (DVR) has not been applied in this model. This approach is consistent with the EA-agreed methodology and with current guidance, which does not require DVR for rural fluvial or breach studies. The floodplain in this catchment is predominantly agricultural with relatively uniform land cover, and conveyance is governed by explicitly modelled channels, drains and structures. Sensitivity testing of ±20% Manning's n (Section 6) showed negligible impact on on-site flood depths or extents, indicating that the assessment is not sensitive to plausible variations in floodplain resistance. On this basis, omission of DVR is considered proportionate and robust for the purposes of this site-specific study. The model should not be applied to other contexts (e.g. urban or heavily vegetated floodplains) without reconsidering roughness representation.

7.14. The downstream boundary is represented by a fixed HT level of 1.2 mAOD, adopted to provide a precautionary, near-bankfull condition consistent with the agreed methodology. Sensitivity testing of elevated downstream stages confirmed negligible impact on flood extents and depths at the Site, though some differences were observed further downstream of the modelled domain. As this study is site-specific, the downstream boundary representation is considered proportionate for the current assessment. The model should not be used to assess flood risk elsewhere within the wider catchment without further review and potential re-specification of downstream conditions.

7.15. The model has been constructed to assess fluvial flood risk, it does not assess flood risk from other sources such as tidal or surface water.

7.16. Unique Flood Modeller messages generated during the 100 year plus climate change baseline event are presented below.

Table 15: Flood modeller check and warning messages

| Note/ Warning | Flood Modeller ID | Description | Number of Occurrences | Comments |
|---|---|---|---|---|
| **Warning** | 2010 | Poor interpolation u/s of 'label' max u/s area of area1 -> area2 | 1 | This message can indicate additional survey data is required, a review of the location indicates it is an isolated location which already has interpolations assigned. Review of model results show no instability in this area so not considered to impact model results. |
| **Warning** | 2044 | Different values (+/- 20 %) for Mannings n encountered within one panel. | 33 | Message for modeller to check manning's within panel markers. As Manning's values were reviewed as part of this process it is not considered to impact results/ |

| | | | | |
|---|---|---|---|---|
| Warning | 2229 | Value of trash screen height is set to 0; areas will be calculated using piezometric head. | 17 | Message indicates no trash screens applied to structures, based on survey and past modelling this is true. |
| Warning | 2262 | Backflow encountered CULVERT OUTLET unit. | 46 | Message occurs during simulation; this can create instability but is an accurate representation of water backing up within areas of 1D network due to the very flat gradient and multiple lock and restrictive in-channel structures. A review of model stability found a good convergence and mass balance error so not considered to impact model results. |
| Warning | 2263 | Backflow encountered at CULVERT INLET unit; outlet control equations will be imposed | 24 | Message noting when control of flow through a unit switches from inlet to outlet controlled. As noted in warning 2262 backflow is expected in such a low gradient watercourse therefore outlet controlled units are realistic. |
| Warning | 2267 | No sub/supercritical depth could be found at node label1 | 42 | No bounds could be found for supercritical or subcritical depth at the section, therefore not being able to guarantee finding a solution for critical depth. Critical depth may be required for certain model processors. As mass balance and convergence are good within the model this is not considered to impact model results. |
| Warning | 2339 | input p1 value less than minimum: 0.100m; value reset to minimum. | 1 | Message stating elevation above bed on weir was input at 0, this is not possible to allow weir calculations to be run therefore a minimum elevation of 0.1m was applied. No impact on model results as weir drowned during warmup of the model. |

| | | | | |
|---|---|---|---|---|
| Warning | 2364 | Right springing point is lower than cross-section elevation. | 4 | It is noted that this may cause inaccuracies when calculating constricted bridge area however levels are take directly from survey or maintained from previous model input data therefore no evidence to change this. Mass balance and convergence both good so not considered to impact model results. |
| Note | 3006 | End of backflow at CULVERT INLET unit. | 42 | Message stating time when backflow through a culvert inlet stopped. No impact on model results |
| Note | 3007 | End of backflow at CULVERT OUTLET unit | 43 | Message stating time when backflow through a culvert outlet stopped. No impact on model results |
| Note | 3010 | Simplified method used to compute solution at one or more sections | 14 | Does not impact model results as unsteady model being run. Message shows where a hydraulic jump is being smoothed over a range of nodes. Out of 564 nodes within the 1D model only 14 nodes were assessed using the simplified method. |
| Note | 3025 | Minimum flow has been applied at boundary | 6 | Message stating when a minimum flow was applied to a hydrological boundary, all these messages occur at the start of the model run when the minimum flow has been set to prevent the channel drying out. No impact on model results |
| Note | 3028 | Data points omitted from deactivated section areas | 2 | Message noting deactivation markers are operating for 2 cross sections. No impact on model results as all sections reviewed with some having deactivated widths. |

7.17. Unique TUFLOW checks and warnings generated during the 100 year plus climate change baseline event are presented below.

Table 16: TUFLOW check and warning messages

| Check/ Warning | TUFLOW ID | Description | Number of Occurrences | Comments |
|---|---|---|---|---|
| Warning | 0646 | Input geometry maybe empty | 13 | No impact on model results full input geometry reviewed. |
| Check | 1099 | Object ignored. Only Points and Regions used. | 24 | No impact on model results full input geometry reviewed. |
| Check | 2099 | Ignored repeat application of boundary to 2D cell | 3 | Locations reviewed and located away from site and outside of any flood extents which interact with flooding upstream or downstream of the site. Not considered to impact results. |
| Check | 2370 | Ignoring coincident point found in Z Shape SGS layer | 24 | No impact on model, message recording locations where multiple vertices are in the same location. |
| Warning | 2583 | Material ID 15014 has a manning's n value (0.300) greater than Wu n limit (0.100) – n value will be limited to Wu formulation | 1 | No impact on model results, materials files reviewed. |
| Check | 3519 | Using MIN or GULLY option in SGS model | 8 | While not standard practice option applied to Zsh files to ensure observed channel fall applied within the model, without this option selected 2D representation of field ditch incorrect. |
| Warning | 3526 | SGS Sample distance command is ignored in SGS Approach == Method C | 2 | No impact on the model results as SGS method acceptable. |

| | | | | |
|---|---|---|---|---|
| **Check** | 3548 | Setting SGS sample distance target to minimum grid zpt resolution of 1 | 1 | No impact on model results, this has set SGS sample distance to same accuracy as base ground model. |

# 8. Conclusions

8.1. The fluvial hydraulic model build has been built inline with current best practice and provides a good representation of the existing fluvial flood mechanisms at the site.

8.2. The model shows flood water within the site for the 1 in 2 year and 1 in 30 year events are largely contained to watercourses and field ditches while out of bank flooding is seen in the 1 in 100 year and larger storms simulated.

8.3. The largest flood depth on site (outside of a watercourse or field ditch) is 0.51m in the 1 in 1,000 year event. The elevation of flooding varies across the site as some areas are flooded as a result of upstream channel capacity being exceeded and water flowing overland while other areas are flooded due to adjacent channels coming out of bank and water being stored in depressions in the floodplain.

8.4. Sensitivity testing demonstrated that the model outputs are robust to variations in key parameters, including floodplain roughness, downstream boundary conditions (elevated HT levels), surveyed bed levels, and structure blockages. Localised effects were observed within channels and in areas remote from the Site, but none resulted in changes to the mapped flood extent or to on-site flood depths of a magnitude that would influence the conclusions of the flood risk assessment or the development design requirements.

8.5. Sensitivity testing on flows shows the model is sensitive to inflows (+/-20%). As a new hydrological study was undertaken for this project using local gauged data, the modelled inflows are considered robust and representative of catchment behaviour.

8.6. Confidence in the model is further supported by the comparison against the Environment Agency's Recorded Flood Outline (RFO) dataset showed that there is good spatial alignment between the modelled flood extents and the RFO's, along the River Slea and Old River Slea. All recorded outlines within the study area were captured by the modelled extents for design events greater than the 1% AEP, despite minor localised differences upstream, all flow pathways are represented in the modelled extents.

8.7. High-level flow verification against gauged data at Leasingham Mill further confirmed that the modelled 1% AEP design hydrograph sits appropriately between the observed events of Storm Babet (10% AEP) and Storm Henk (0.5–0.2% AEP), with peak flows matching the gauged 1% AEP estimate to within 1%. These checks demonstrate that both the hydraulic behaviour and the adopted design hydrology are consistent with observed flood evidence, reinforcing confidence that the model provides a reliable basis for the flood risk assessment.

# Appendix A– Modelling Methodology and Environment Agency Communication

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# Appendix B– Flood Estimation Record

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# Appendix C– Pumping Station Details

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# Appendix D– Channel Survey

# Appendix E– Model Results Filtering Methodology

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# Appendix F– Model Results Unfiltered

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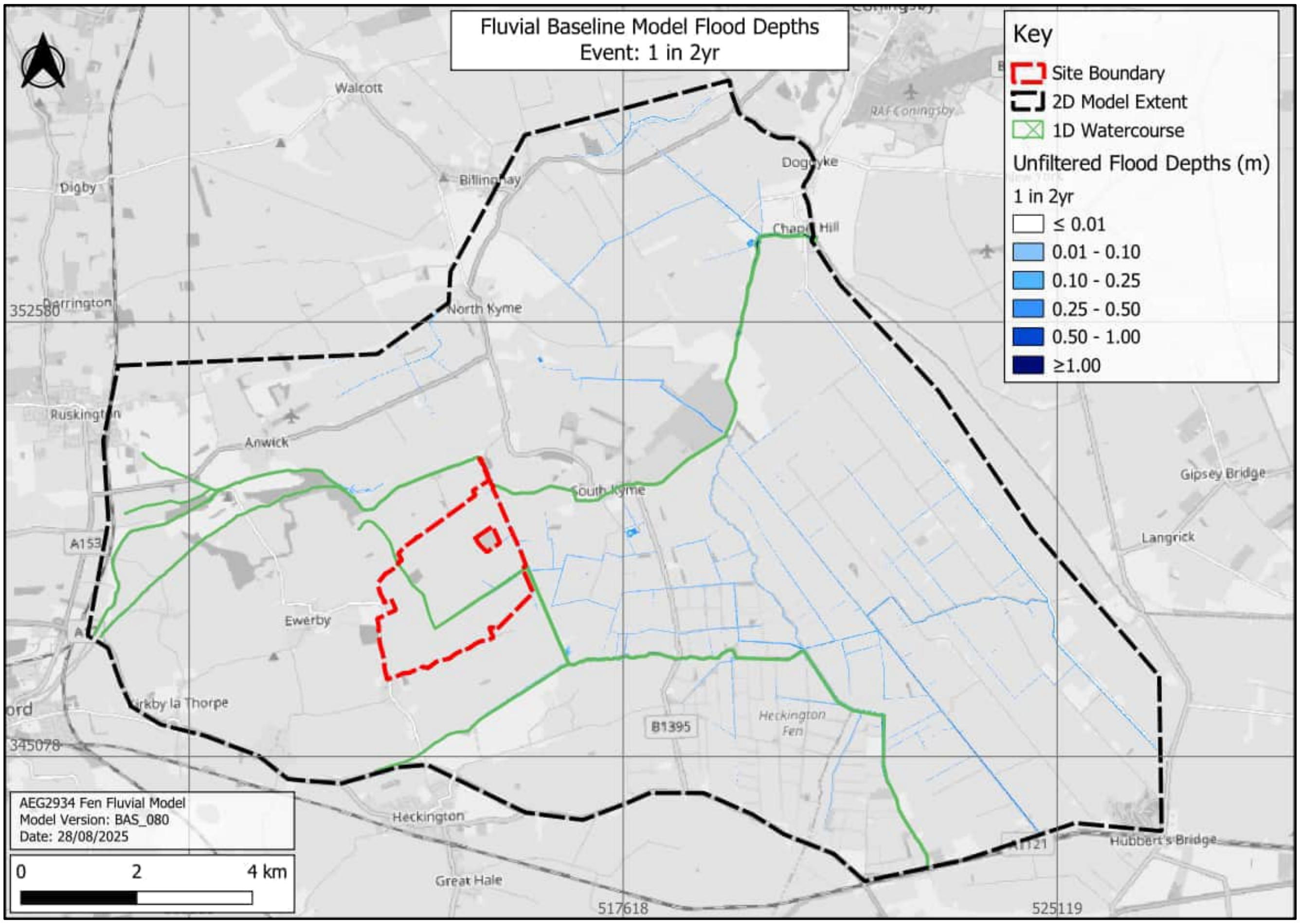
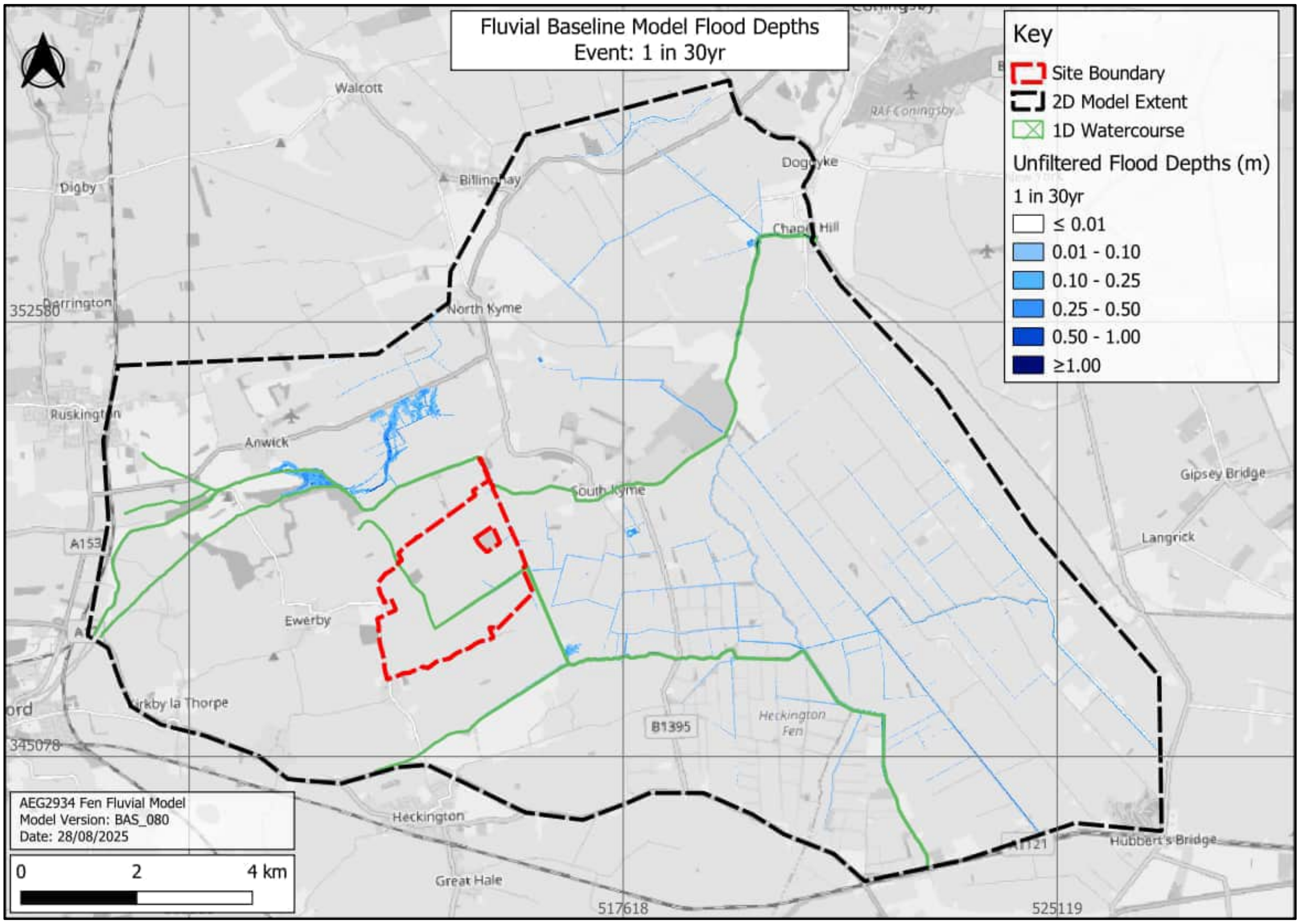
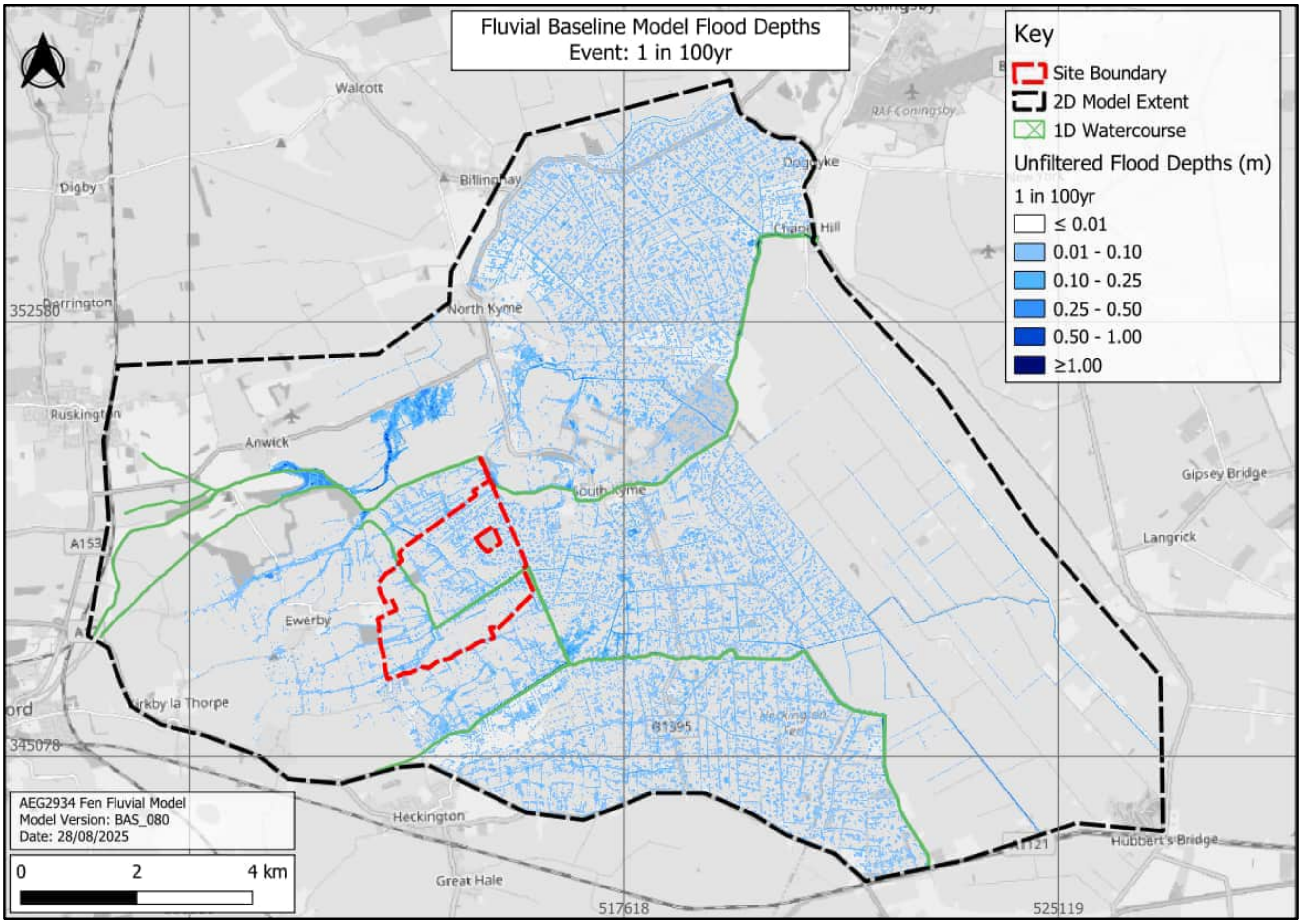


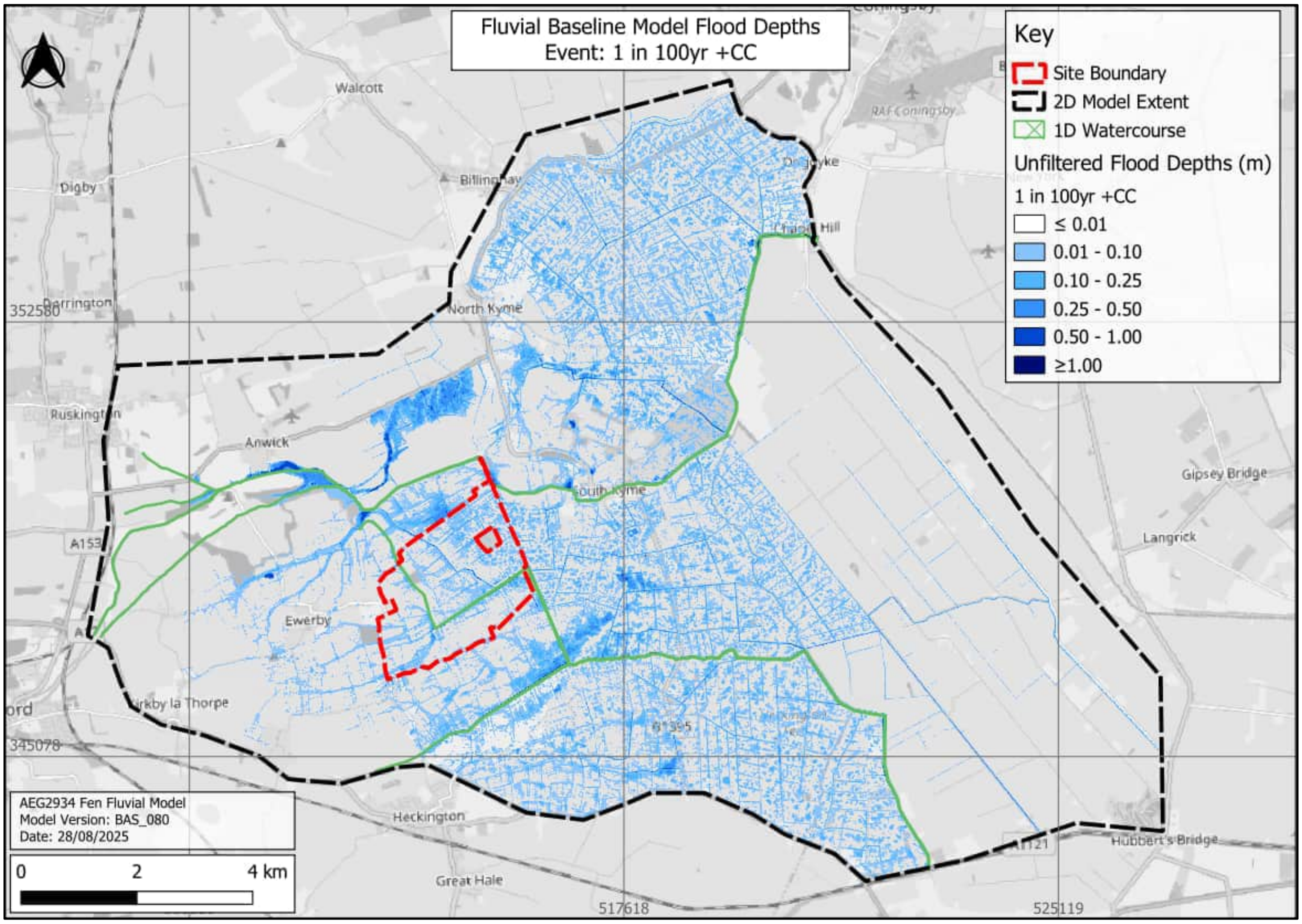

1 in 2 yr unfiltered modelled flood depths (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)



1 in 30 yr unfiltered modelled flood depths (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)



1 in 100 yr unfiltered modelled flood depths (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)



1 in 100 yr plus climate change unfiltered modelled flood depths (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

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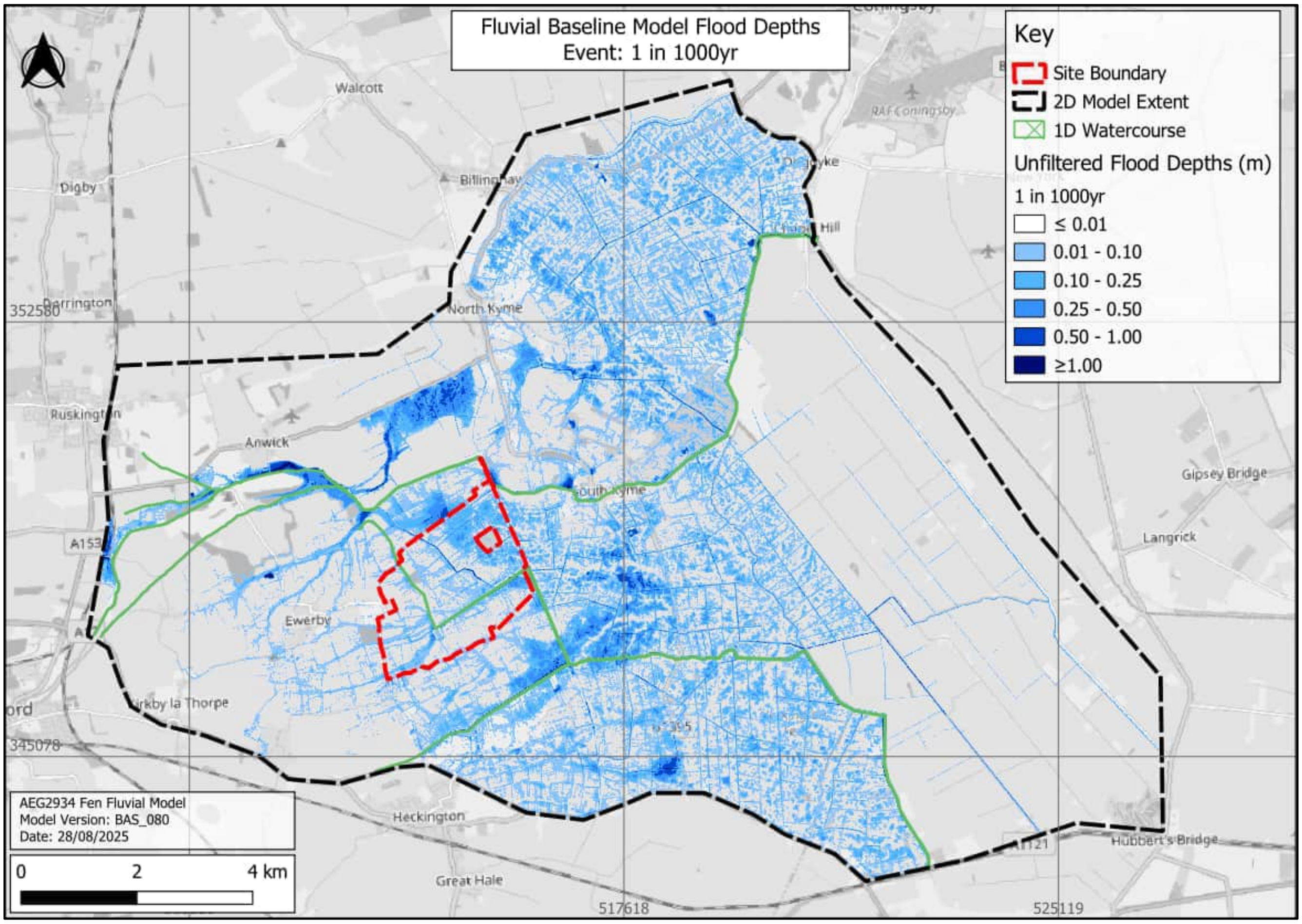


1 in 1,000 yr unfiltered modelled flood depths (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

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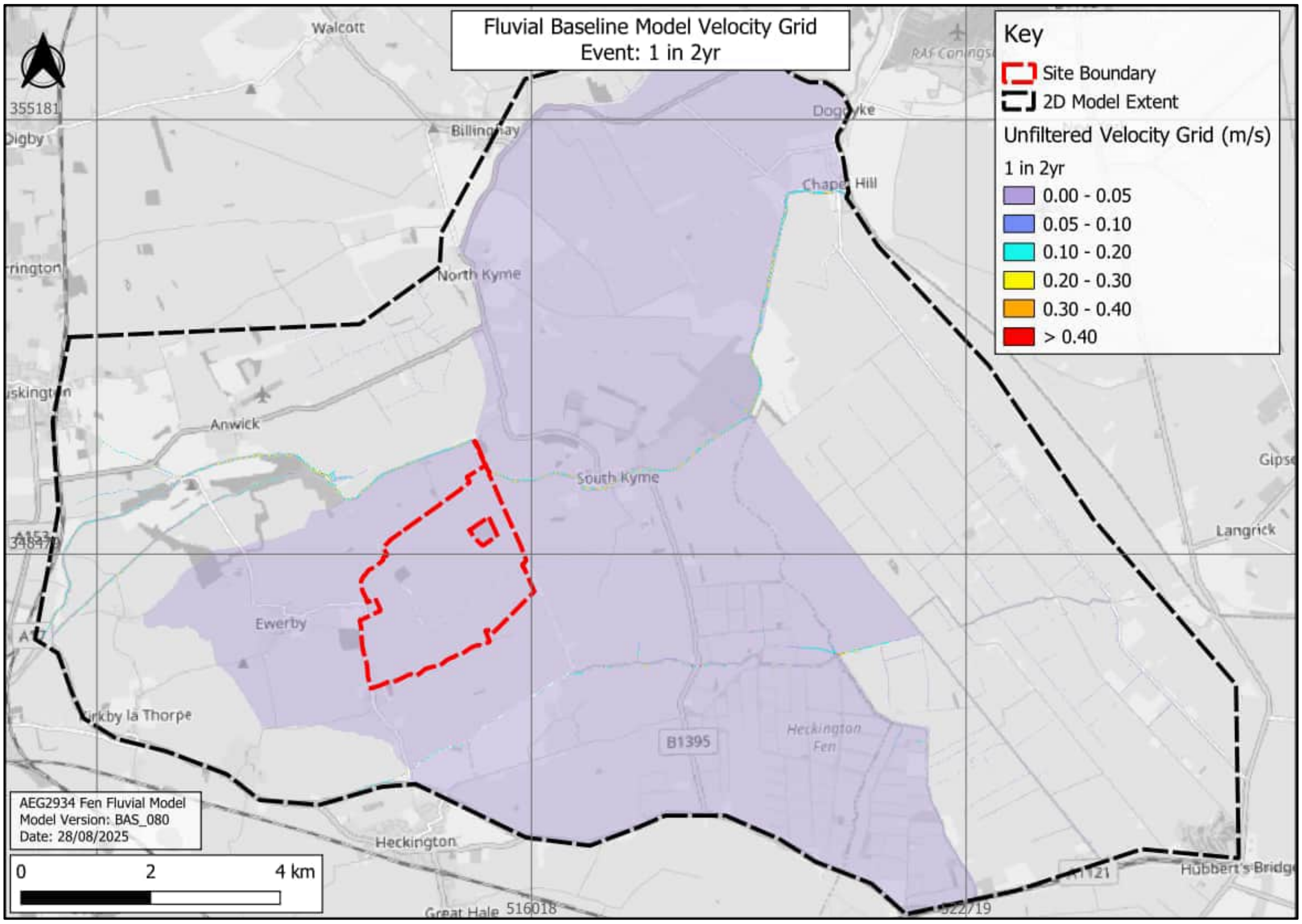
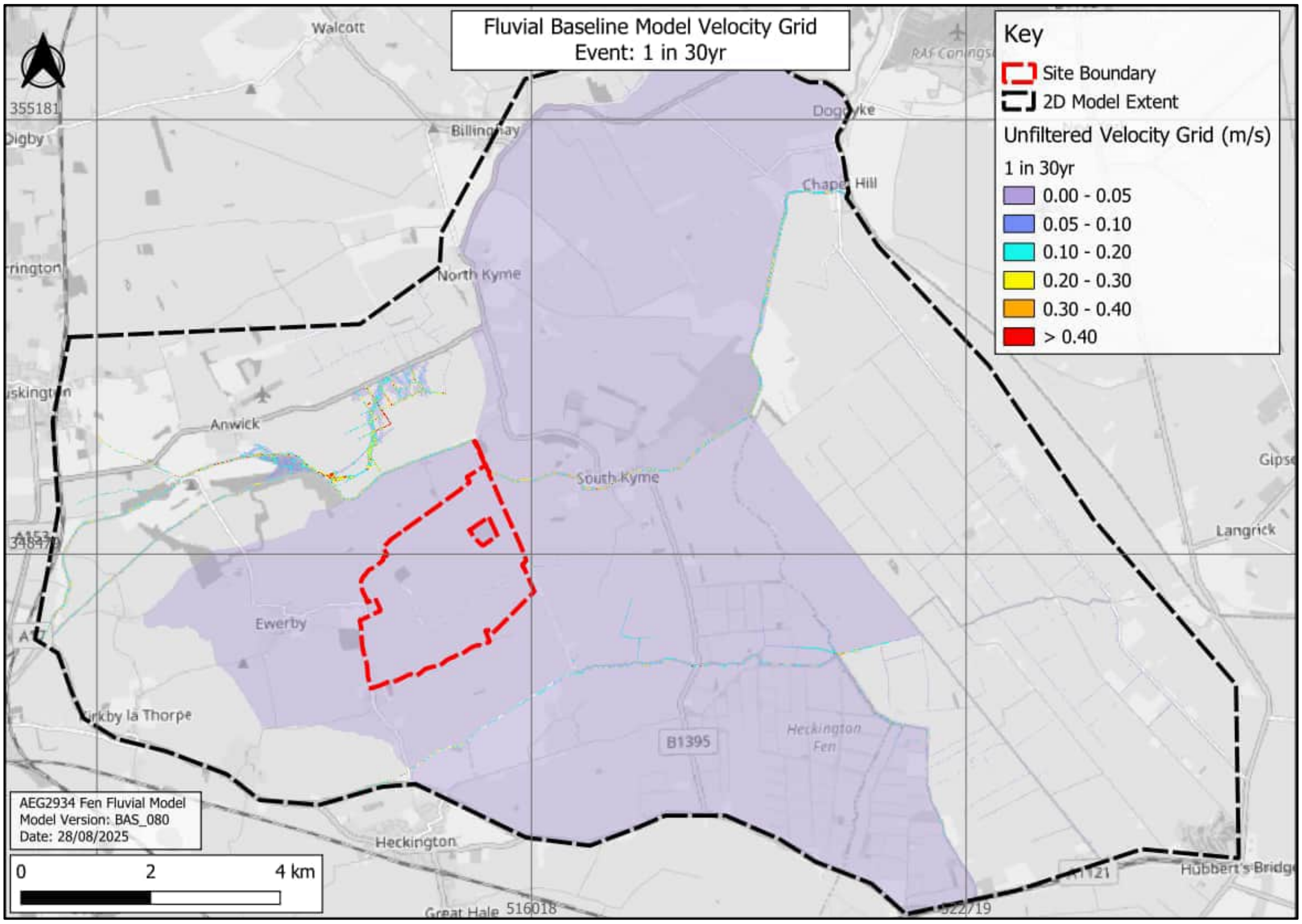
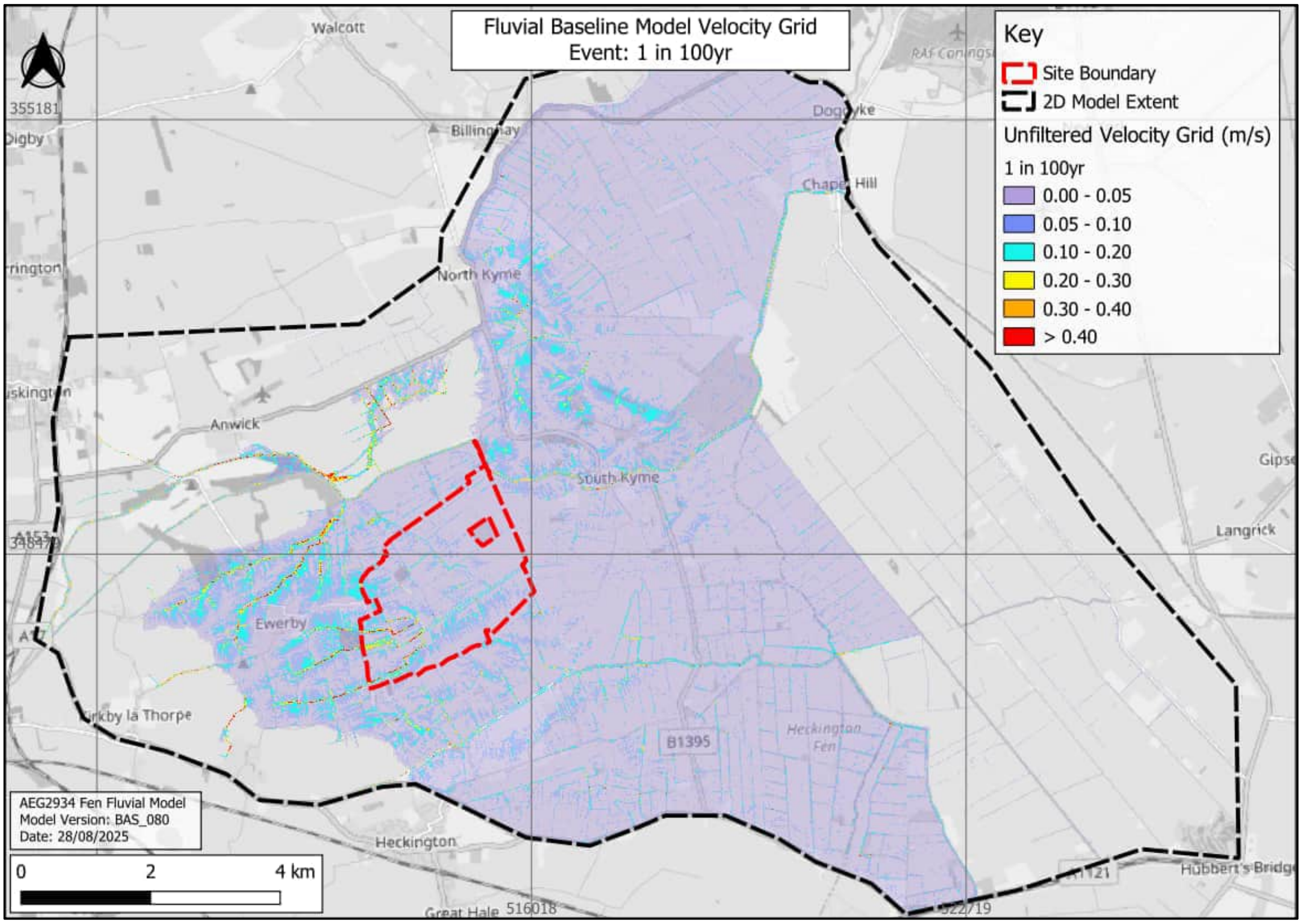



1 in 2 yr unfiltered modelled flood velocity (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)



1 in 30 yr unfiltered modelled flood velocities (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)



1 in 100 yr unfiltered modelled flood velocity (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

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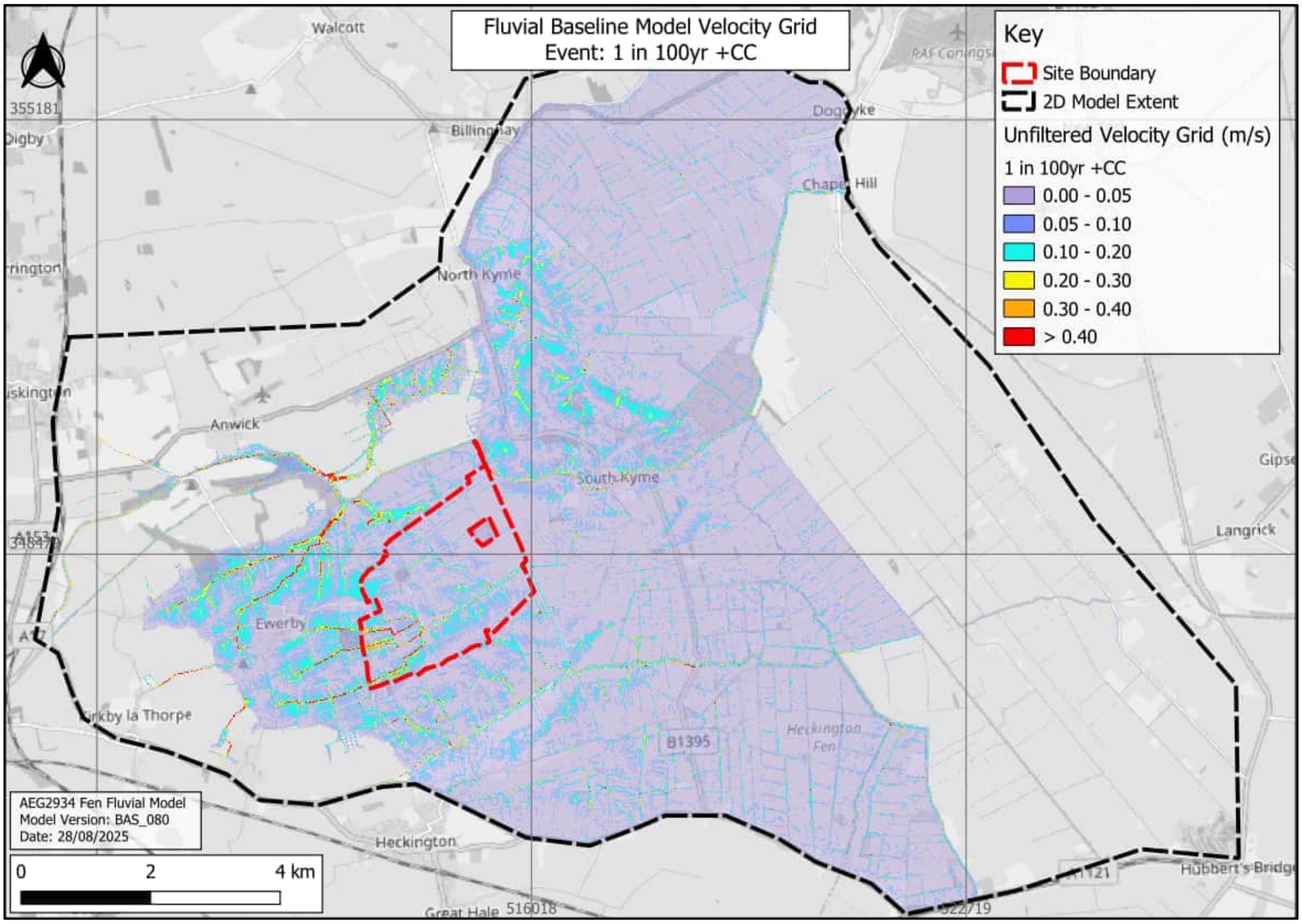
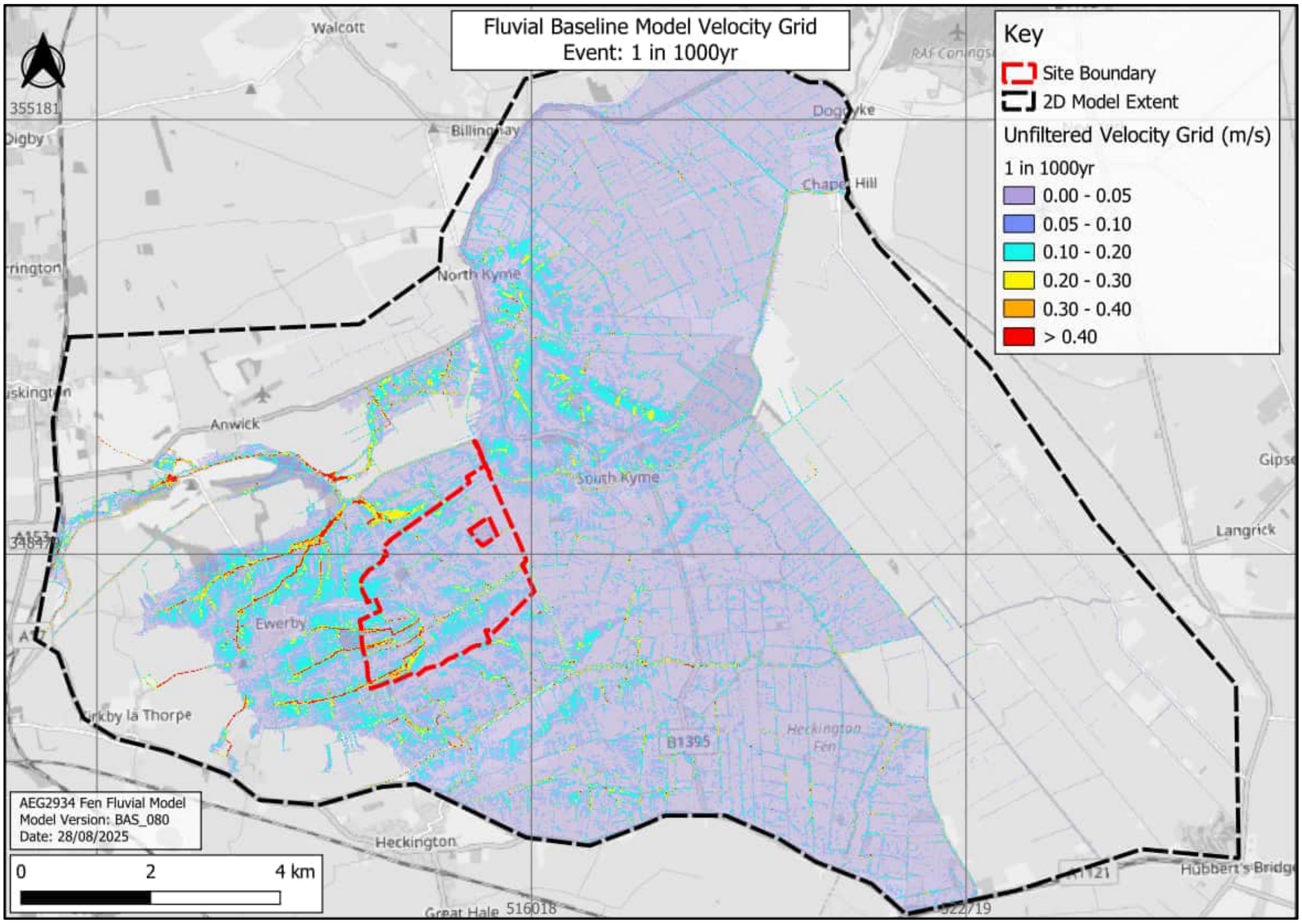



1 in 100 yr plus climate change unfiltered modelled flood velocity (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)




1 in 1,000 yr unfiltered modelled flood velocity (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

# Appendix G– Model Results Filtered

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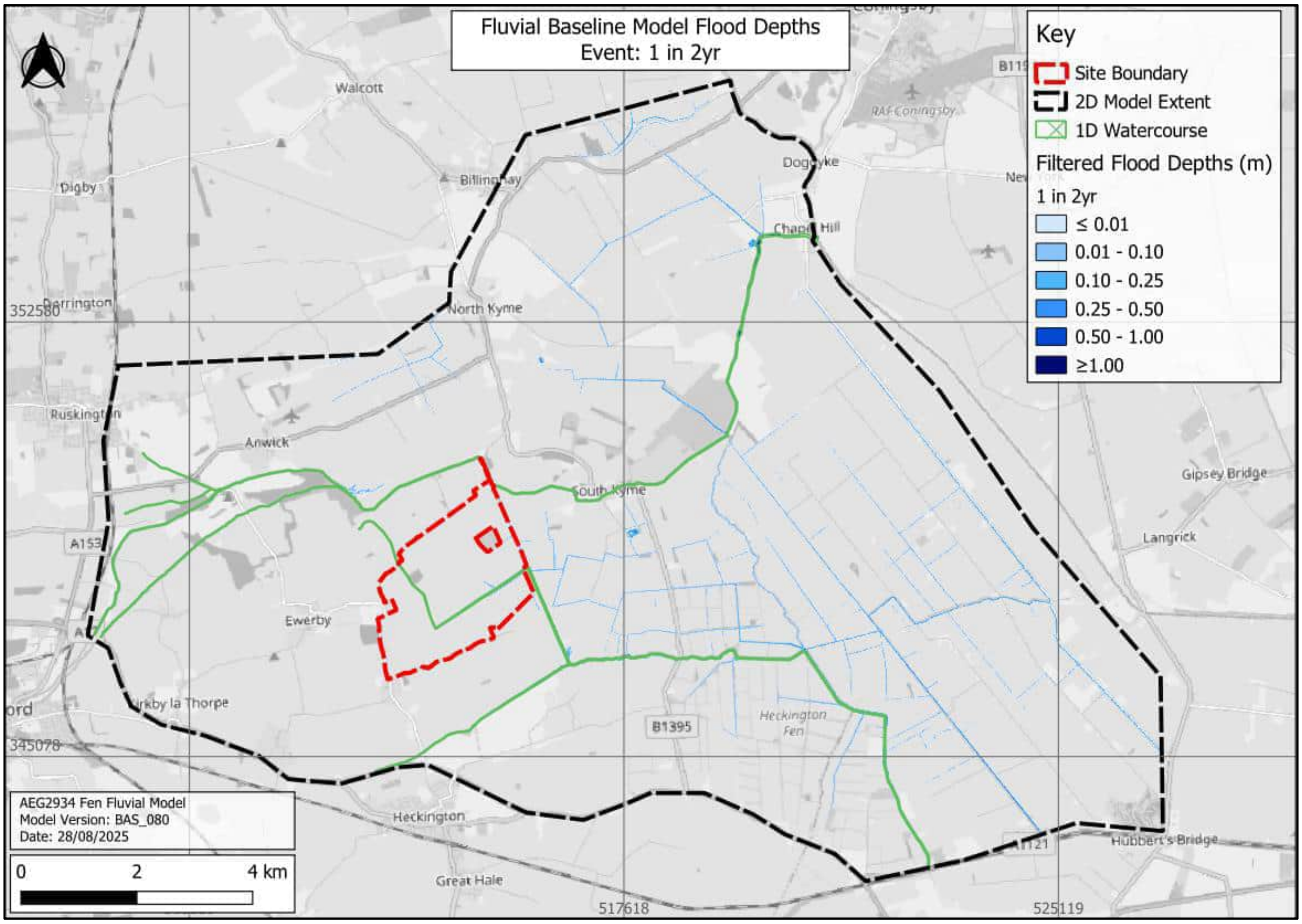

1 in 2 yr filtered modelled flood extents (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

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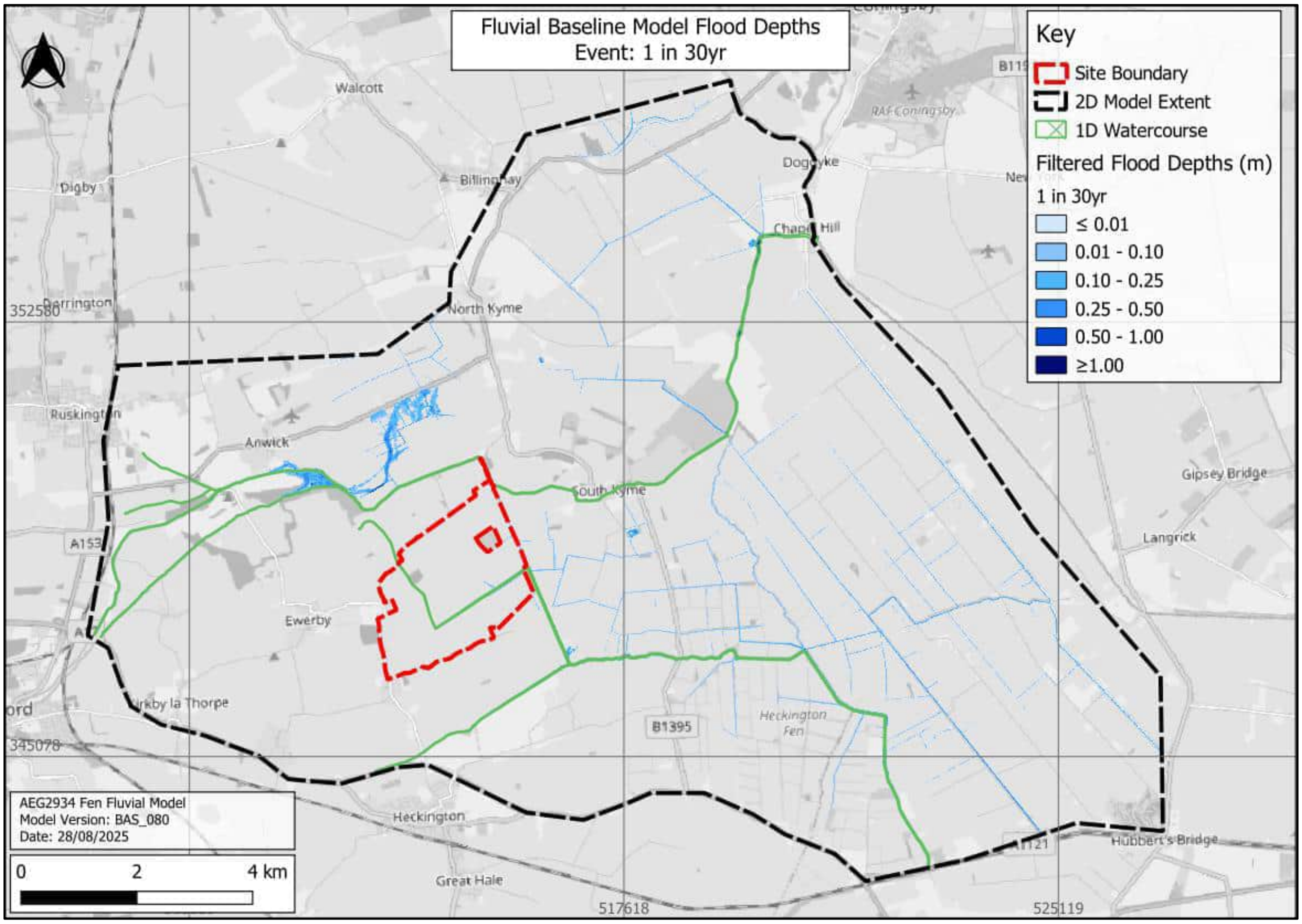
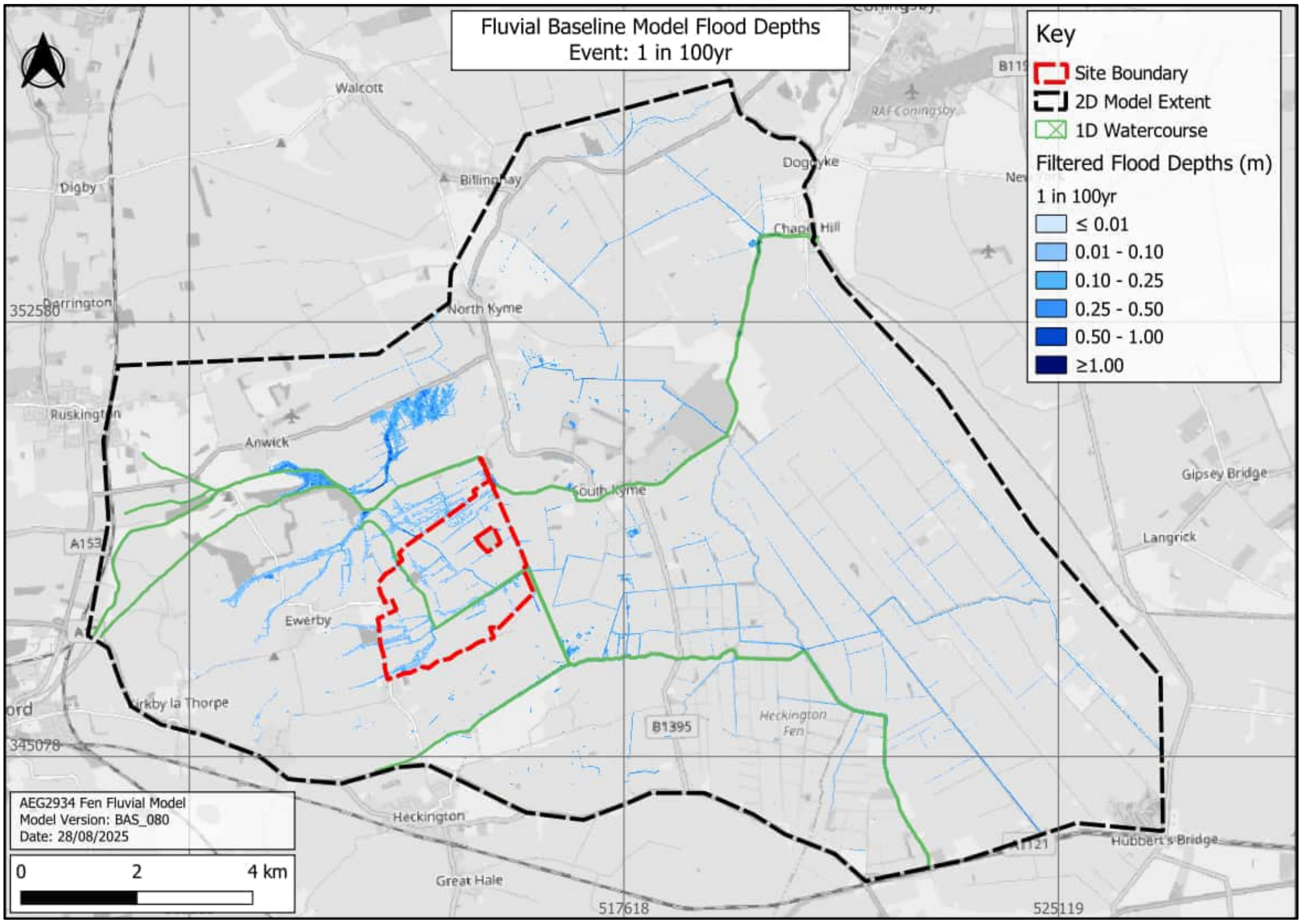



1 in 30 yr filtered modelled flood extents (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)




1 in 100 yr filtered modelled flood extents (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

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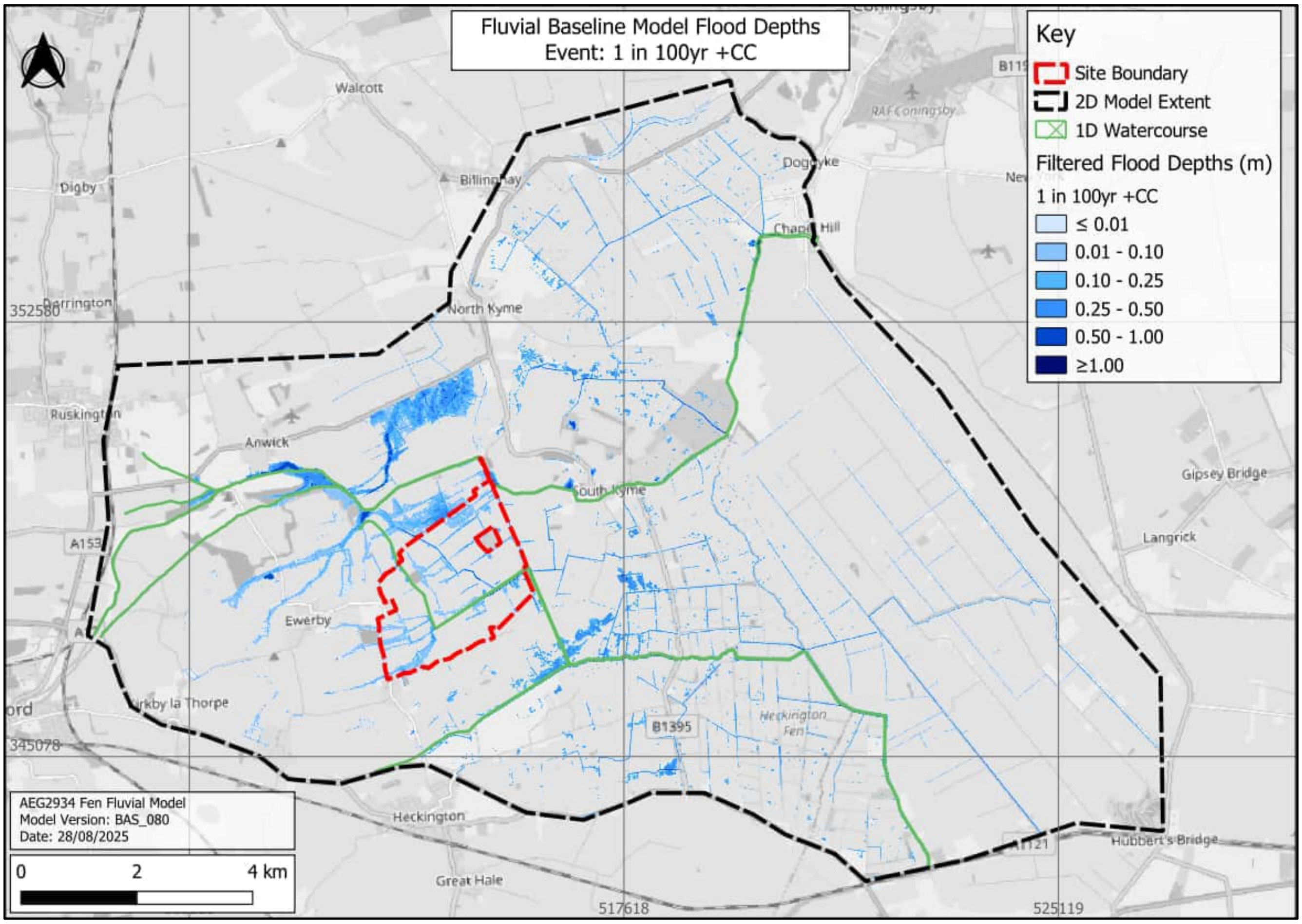
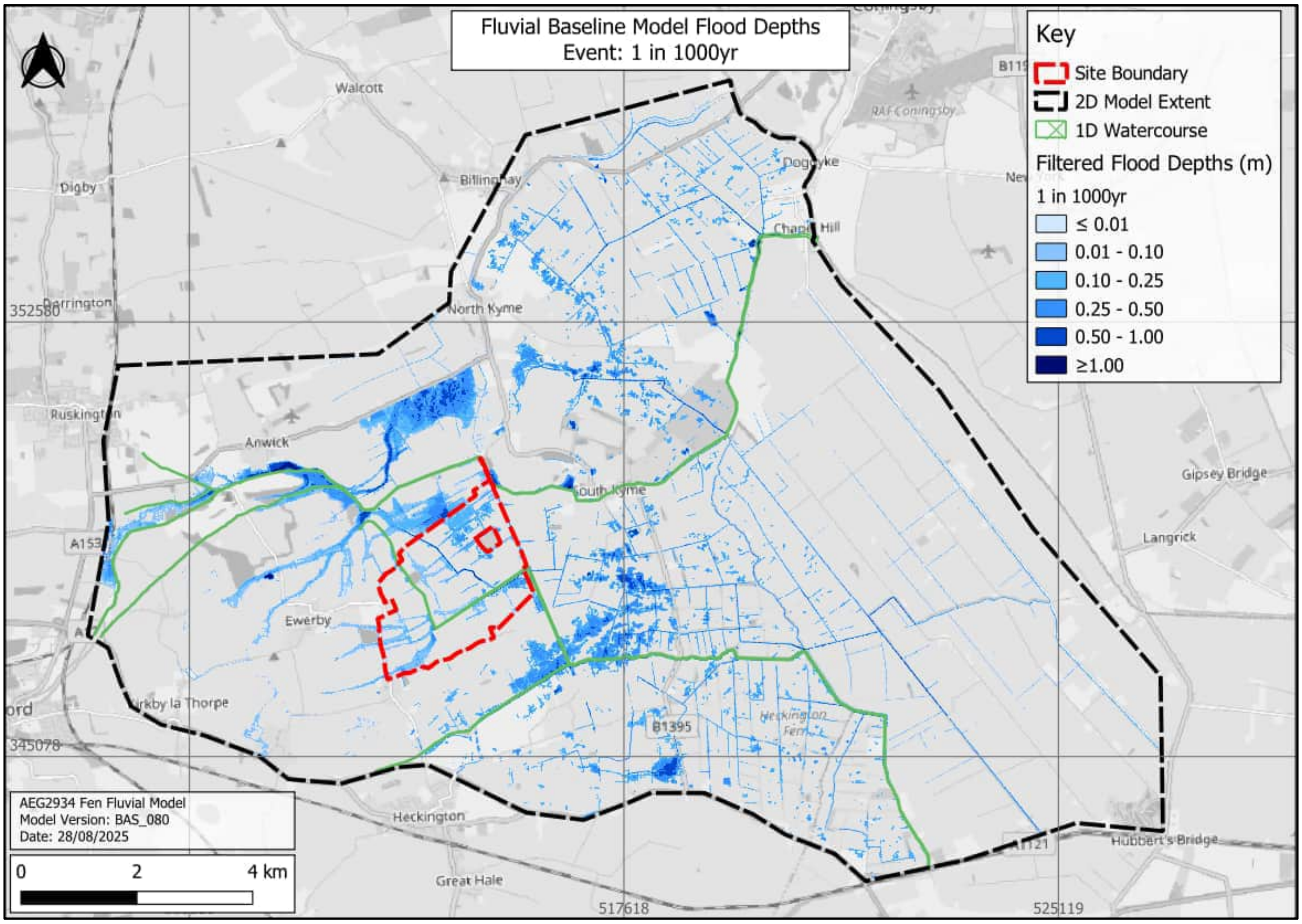



1 in 100 yr plus climate change filtered modelled flood extents (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)




1 in 1,000 yr filtered modelled flood extents (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

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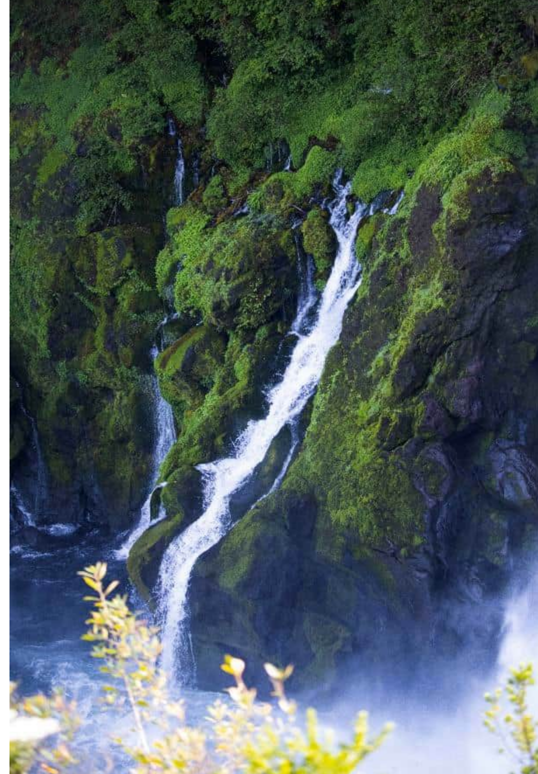

Extreme Event Model Report
AEG2934_LN4_Fen_03

Site Address:
Land at Westmoorland Farms
Howell
Fen
Lincolnshire
LN4 4AA

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## UK Experts in Flood Modelling, Flood Risk Assessments, and Surface Water Drainage Strategies

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# Document Issue Record

**Project:** AEG2934_LN4_Fen_03

**Prepared for:** Beacon Fen Energy Park Limited

**Reference:** AEG2934_LN4_Fen_Extreme_Event_Model_Report_001

**Site Location:** Land at Westmoorland Farms, Howell, Fen, Lincolnshire, LN4 4AA

**Revision:** 001

| Consultant | | Date |
|---|---|---|
| Author | Rebecca Thirkell | 09/05/2025 |
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| Revision 001 | | |
| Author | Paige Sanders | 04/11/2025 |
| Document Check | Calum Park | 05/11/2025 |
| Authorisation | Nick Darling-Drewett | 05/11/2025 |

## Please Note:



## Revision 001

Revision 001 incorporates updates made in response to the Environment Agency's model review comments. Specifically, fluvial extreme model outputs have been updated to reflect changes in the baseline model (Section 3), consistency of result sample locations has been ensured across all project reports, and a Downstream Boundary Sensitivity Test (Section 4) was undertaken to assess the model's sensitivity to elevated downstream water levels.

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# Table of Contents

# 1. Introduction

1.1. Aegaea have been commissioned to undertake a hydraulic modelling exercise (baseline model) of watercourses within the vicinity of the study site at Land at Westmoorland Farms, Fen, Lincolnshire, LN4 4AA. The objective of the baseline modelling was to identify the potential fluvial flood risk posed by local watercourses.

1.2. The extreme event assessment outlined in this modelling addendum forms a sensitivity assessment on the baseline model as part of Stage 3 of the project. This report should be read in conjunction with previous fluvial baseline modelling report:

AEG2934_LN4_Fen_Hydraulic_Model_Report_003.pdf

1.3. The work was undertaken in accordance with the agreed modelling methodology as approved by the Environment Agency. The modelling methodology and comments are provided in Appendix A. Where adjustments to the agreed methodology have been made these are flagged within this report with justifications for the adjustments.

1.4. It should be noted that while extreme climate change uplifts are applied as part of this modelling, the site has an end date of 2069, therefore the use of 2080s upper end epoch is not appropriate for site design.

## Aims and Objectives

1.5. The aim of this exercise is to establish an accurate hydraulic representation of the flood risk to site from a fluvial and tidal extreme climate change event.

1.6. To achieve this aim, the following objectives have been identified:

- Update the hydraulic model developed in Stage 2 to represent two extreme event scenarios.
- Simulate an extreme fluvial climate change and extreme tidal climate change storm event.

## Extreme Fluvial Climate Change

1.7. As part of the baseline modelling methodology discussions with the Environment Agency it was requested that an extreme fluvial climate change event is simulated as a sensitivity test for the baseline model due to the proposed development being a Nationally Significant Infrastructure Project. Comment ID 1.6 of the original methodology response (Appendix A – Land at Westmoorland Farm, Howell, Fen Methodology Review) requested the Upper End climate change allowance be applied to the hydraulic model in addition to the Central Allowance already applied.

1.8. A review of the climate change allowances for the Witham Management Catchment, within which the site is located, applies the 57% peak river flow uplift to the Upper End allowance for the 2080s epoch[1].

1.9. To ensure consistency across the hydraulic model the rainfall climate change was also uplifted to the 2070s Upper Allowance for the 100 year event, applying a 40% uplift to the direct rainfall within the model.

## Extreme Tidal Climate Change

1.10. In addition to the requested fluvial extreme climate change event, the Environment Agency also requested an extreme tidal event be tested within the hydraulic model. The H++ extreme event was requested to understand the impact from the extreme tidal event as requested during baseline modelling methodology discussions with the Environment Agency (Appendix A). It is noted in comment 1.6 that the extreme event should not be used to design the site.

1.11. The H++ to be used within the modelling was calculated from the Environment Agency Coastal Flood Boundary Extreme Sea Levels dataset[2]. The climate change uplift was calculated based on a development lifespan of 2069.

---

[1] https://environment.data.gov.uk/hydrology/climate-change-allowances/river-flow?mgmtcatid=3116

[2] https://www.data.gov.uk/dataset/73834283-7dc4-488a-9583-a920072d9a9d/coastal-design-sea-levels-coastal-flood-boundary-extreme-sea-levels-2018

# 2. Hydraulic Model Amendments

## Summary

2.1. This section summarises the updates made to the existing hydraulic model to assess both extreme climate change scenarios. The actions undertaken include:

- Uplift existing hydrology to simulate an upper end climate change fluvial flood event.
- Remove 1D domain and apply tidal boundary for tidal extreme flood event.

## Fluvial Extreme Event

### Software

2.2. The model was simulated using Flood Modeller version 7.3.0 and TUFLOW version 2025.1.0. TUFLOW Heavily Parallelised Compute (HPC) solver was utilised. This version of TUFLOW was used to maintain the same version as the existing 1D/2D model.

### Model Build

2.3. No changes were made to the 1D domain to run the 100 year plus Upper End climate change allowance.

2.4. No changes were made to the 2D domain to run the 100 year plus Upper End climate change allowance.

### Boundary Conditions

2.5. No changes were made to the inflow locations within the hydraulic model.

2.6. Inflows were uplifted within the hydraulic model by applying a higher uplift (57%) to the QT boundaries to represent the Upper End climate change allowance using the flow multiplier within the Flood Modeller event units.

2.7. Rainfall was increased within the bc_dbase by applying 40% directly to the 100 year rainfall hyetograph.

# Tidal Extreme Event

## Software

2.8. The model was simulated using TUFLOW version 2025.1.0 Heavily Parallelised Compute (HPC) solver. This version of TUFLOW was used to maintain the same version as the existing 1D/2D model.

## 1D Domain

2.9. The 1D domain was removed from the hydraulic model. This was done to maintain a stable model when significant volumes of water are expected across the model. This can create inherent instability within a 1D domain when channels are fully submerged.

## 2D Domain

2.10. An inflow boundary was applied around the east and southern edge of the 2D domain to represent tidal inflows to the model. Boundary conditions are detailed below. A tidal flood defence is located downstream of the model. This would offer some protection for the site however it is located outside of the model domain and so its influence has not been included. This provides a conservative estimation of risk to the site from an extreme tidal event.

2.11. No other changes were made to the 2D domain.

## Boundary Conditions

2.12. To assess the impact of an extreme tidal event ($H^{++}$) a single inflow boundary was located along the south and east boundary of the model extent. A single water level was applied to this boundary (HT type 2d_bc inflow) as a method of applying a high water level. It is recognised that in reality the tidal level would fluctuate with high and low tide conditions. The approach of applying a single level is considered conservative and represents a worst-case scenario. As this event is being run as a sensitivity assessment only and not for design this simplification of boundary approach is considered acceptable.

2.13. The level applied to the HT boundary was 6.68 mAOD. This level was calculated as the extreme tidal level rise from the base year of 2017 to the end of year for the proposed development in 2069 for a 1 in 200 year event. This resulted in 52 years of climate change increase in sea level.

2.14. In line with Environment Agency guidance a $H^{++}$ cumulative sea level risk to 2100 is 1.9 m[3]. The base sea level was taken from the Environment Agency Coastal Design Sea Levels dataset node 3992[4] T200 (1 in 200 year tidal water level) tide at 5.86 mAOD for the base year of 2017.

2.15. This tide level was then increased for the year the modelling was undertaken (2024). The uplift was calculated using Anglian Higher Central uplift allowance. Over the 7 years between 2024 and 2017 the sea level is expected to have increased by 40.6 mm (5.8 mm/year) resulting in a base level of 5.90 mAOD.

2.16. The $H^{++}$ climate change uplift was then applied to the 2024 base year tidal level. The cumulative uplift of 1.9m is calculated from a base year of 1990 to an end year of 2100. As the proposed development lifespan only extends to 2069 applying the full cumulative uplift is not considered representative of the risk the site will experience. Therefore the 1.9m was split into annual tide level increase of 0.0173 m/year (1.9 m divided by 110years). A total of 45 years uplift (0.7785 m) was then added to the 2024 tidal level base year to generate the H++ tidal level to be applied to the model of 6.68 mAOD.

2.17. Rainfall was removed from the hydraulic model as the source of flooding was tidal.

2.18. Pumps were removed from the model domain to represent the worst-case scenario of the tidal event occurring when pumping was not possible from the IDB areas into the watercourse due to bankfull levels.

2.19. The revised model schematic is shown on Figure 1.

---

[3] **https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#H-plus-plus**

[4] **https://www.data.gov.uk/dataset/73834283-7dc4-488a-9583-a920072d9a9d/coastal-design-sea-levels-coastal-flood-boundary-extreme-sea-levels-2018**

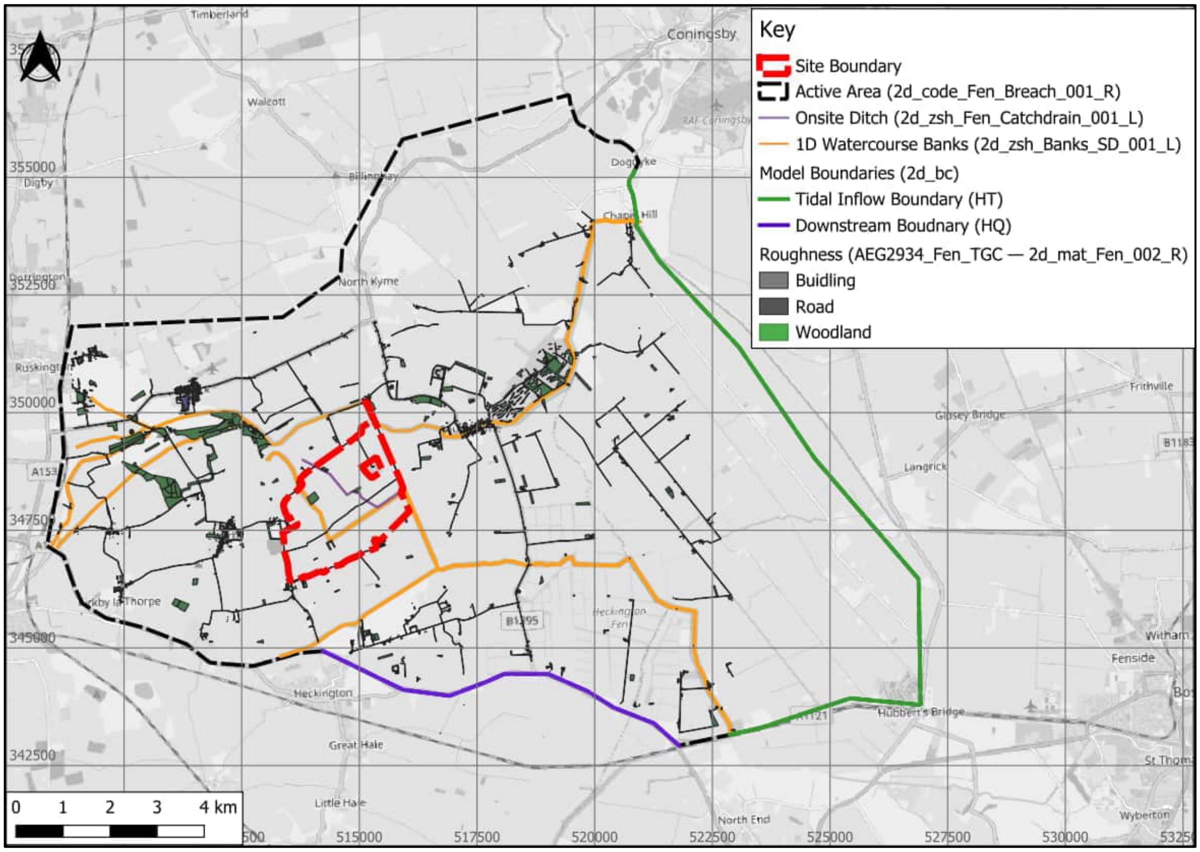


Figure 1: TUFLOW 2D model schematic for tidal extreme event (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

# 3. Model Results

3.1. Results from the hydraulic modelling exercise are presented in this section. Filtering of model outputs was applied to the fluvial extreme event, in line with the existing hydraulic model methodology, due to the application of direct rainfall within the model. No filtering is applied to the tidal extreme event as no direct rainfall is included within the tidal model.

## Fluvial Extreme Event

3.2. The flood extent for the fluvial extreme event is presented in Figure 2. The flooding is shown to be predominantly associated with onsite watercourses and drainage ditches. Out of bank flooding is seen entering the site along the northern boundary. This flood extent is similar to the 1 in 1,000 year flood extent presented in the baseline fluvial modelling report.

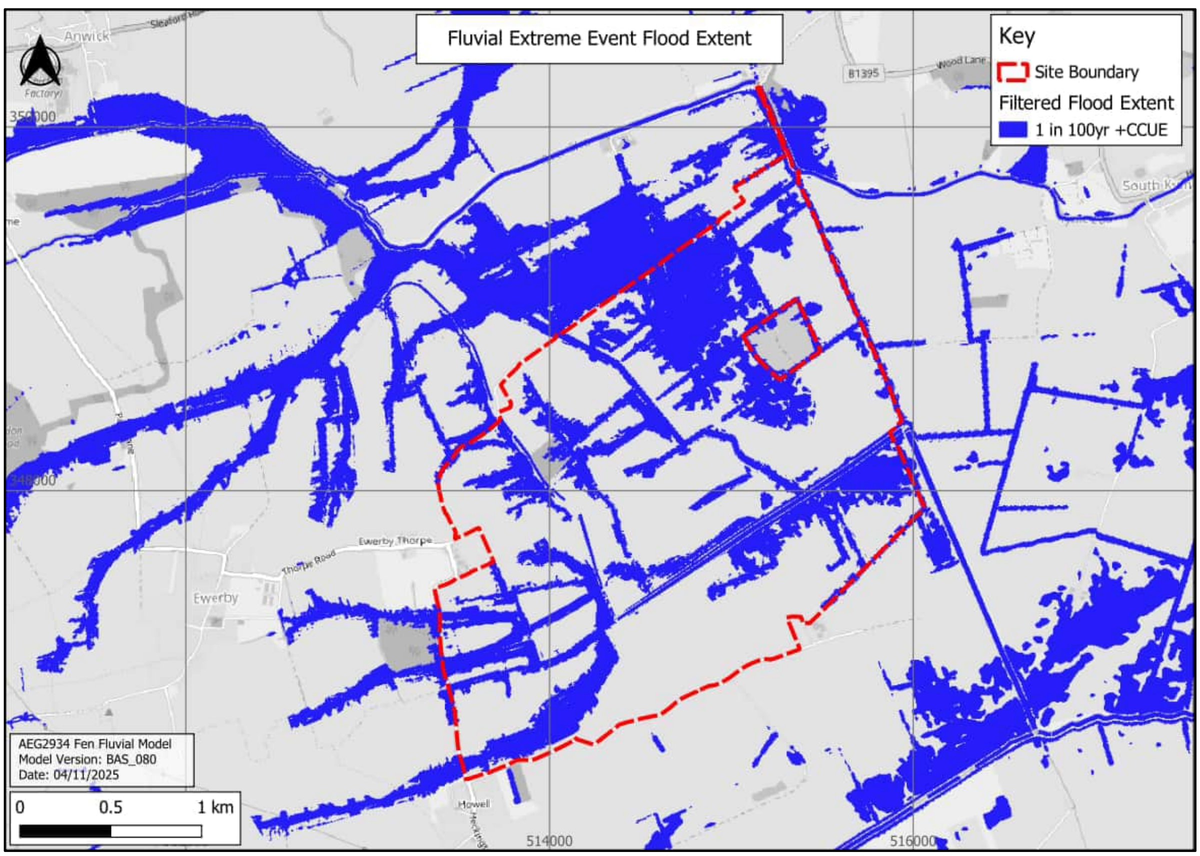


Figure 2: Modelled fluvial extreme flood extent (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

3.3. Reporting locations for both fluvial and tidal extreme events are shown in Figure 3. These points were used to extract modelled peak flood depths and elevations for the extreme event scenarios. The locations are consistent with those used in the fluvial hydraulic modelling report to enable direct comparison between results.

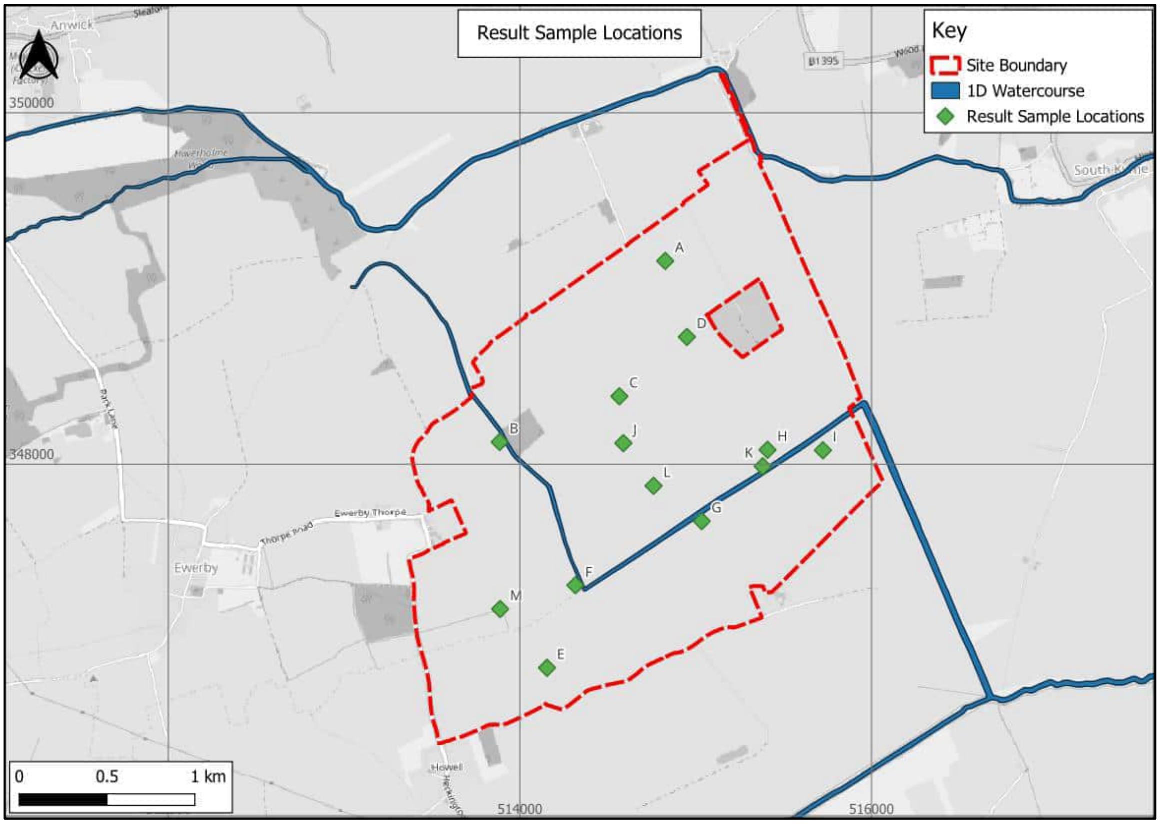


Figure 3: Modelled result reporting locations for fluvial extreme event (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

3.4. Maximum modelled flood depths at each sample location are presented in Table 1. Depths within the site range from 0.07m to 0.43m at the sample locations. Depths are shown to be greatest within the onsite watercourses and ditches with the majority of out of bank flooding being shallow in nature suggesting flooding at the site is dominated by overland land flow. Areas of the floodplain where depressions are present show greater depths suggest there is some flood storage within the site boundary. Maximum modelled flood depths for the tidal extreme event are presented in Table 1 below.



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Table 1: Modelled Onsite Peak Flood Depths (m)

| Location ID | Maximum Modelled Flood Depth (m) |
|---|---|
| A | 0.30 |
| B | 0.27 |
| C | 0.15 |
| D | 0.13 |
| E | 0.07 |
| F | 0.35 |
| G | 0.16 |
| H | 0.40 |
| I | 0.43 |
| J | - |
| K | 0.73 |
| L | - |
| M | 0.05 |

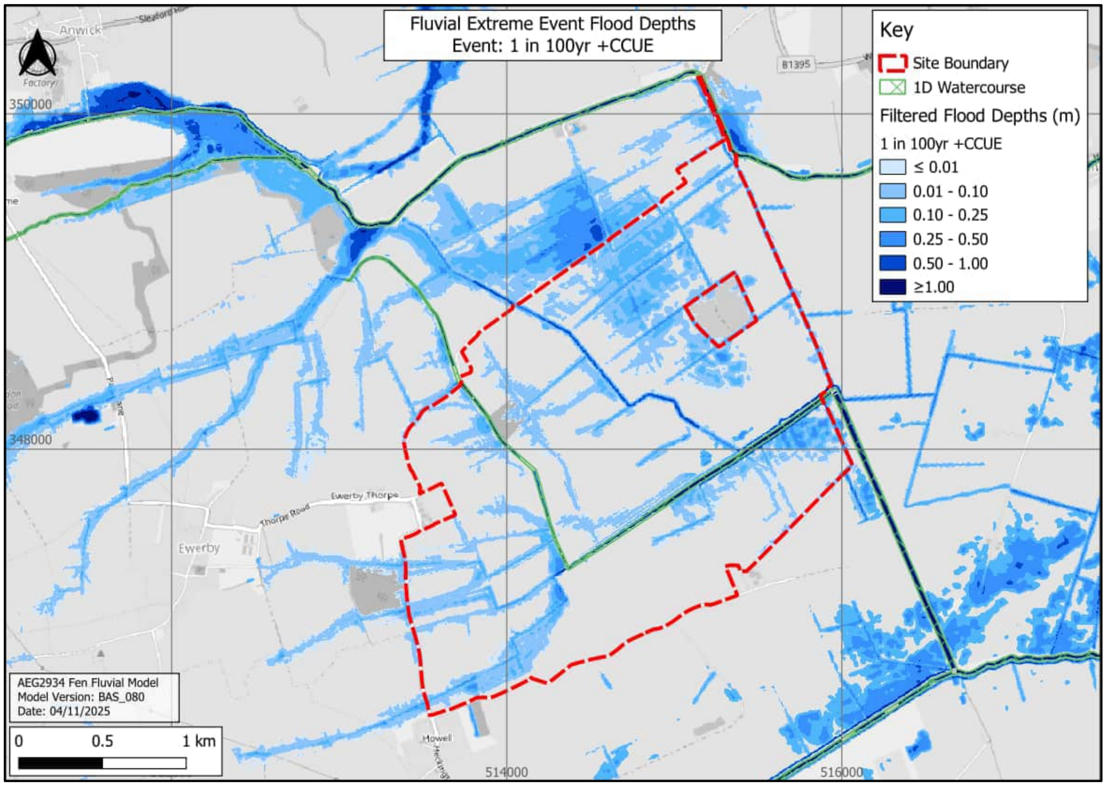


Figure 4: Maximum modelled flood depth for fluvial extreme event (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

3.5. Maximum modelled flood elevations for each sample location are presented in Table 2, while maximum modelled flood elevations are presented on Figure 5. Elevations are shown to increase from east to west across the site. This reflects the fall in ground levels as much of the flooding is associated with overland flow rather than ponding and storage.

Table 2: Modelled Onsite Peak Flood Elevations (mAOD)

| Location ID | Maximum Modelled Flood Elevation (mAOD) |
|---|---|
| A | 1.39 |
| B | 4.55 |
| C | 2.44 |
| D | 1.31 |
| E | 4.66 |
| F | 3.39 |

| | |
|---|---|
| G | 1.54 |
| H | 1.15 |
| I | 1.25 |
| J | - |
| K | 0.85 |
| L | - |
| M | 4.99 |

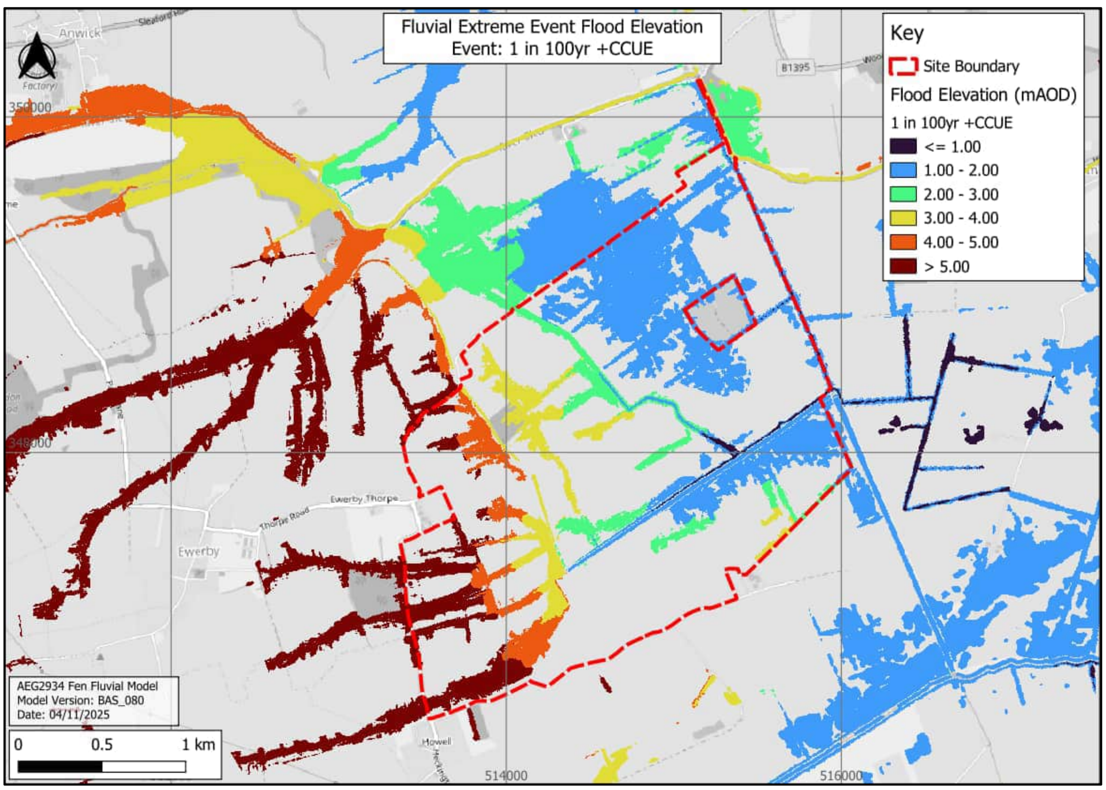


Figure 5: Maximum modelled flood elevation for fluvial extreme event (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

## Tidal Extreme Event

3.6. The flood extent for the tidal extreme event is presented in Figure 6. The flooding is shown to extend across the majority of the site with flow entering from the east (closest to the coast) and moving west.

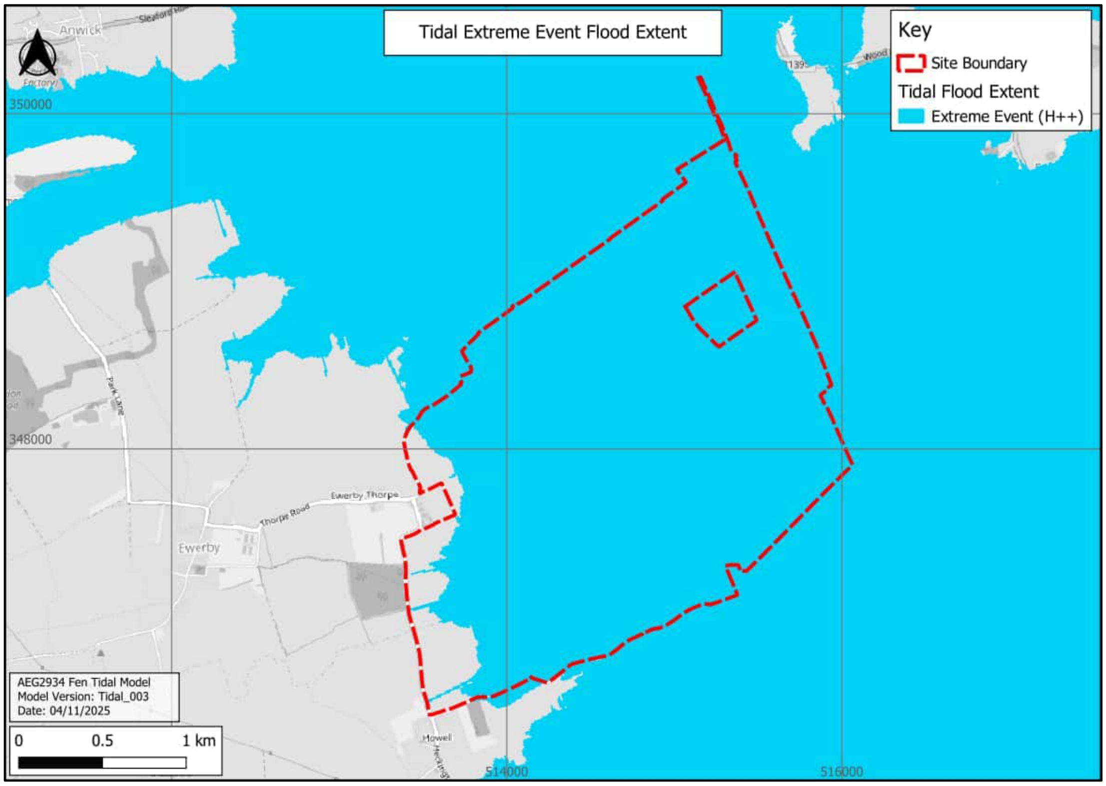


Figure 6: Modelled tidal extreme flood extent (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

3.7. Reporting locations for both fluvial and tidal extreme events are shown in Figure 3. These points were used to extract modelled peak flood depths and elevations for the tidal extreme event scenario.

3.8. Maximum modelled flood depths at each sample location are presented in Table 3. Depths within the site range from 1.43m to 6.33m at the sample locations. Depths fall from east to west as expected with flooding originating from the coast and reducing as the flood wave progresses inland.

Table 3: Modelled Onsite Peak Flood Depths (m)

| Location ID | Maximum Modelled Flood Depth (m) |
|---|---|
| A | 5.43 |
| B | 2.25 |
| C | 4.24 |
| D | 5.34 |
| E | 1.93 |
| F | 3.48 |
| G | 5.13 |
| H | 5.77 |
| I | 5.70 |
| J | 3.01 |
| K | 6.33 |
| L | 4.03 |
| M | 1.43 |

3.9. Maximum modelled flood elevations for each sample location are presented in Table 4. These results show that while depths vary across the site flood elevations are similar. This reflects the constant level applied to represent the tidal extreme event.

Table 4: Modelled Onsite Peak Flood Elevations (mAOD)

| Location ID | Maximum Modelled Flood Elevation (mAOD) |
|---|---|
| A | 6.53 |
| B | 6.53 |
| C | 6.53 |
| D | 6.53 |
| E | 6.52 |

| | |
|---|---|
| F | 6.52 |
| G | 6.52 |
| H | 6.53 |
| I | 6.51 |
| J | 6.52 |
| K | 6.54 |
| L | 6.52 |
| M | 6.52 |

3.10. Maximum modelled flood depths for the tidal extreme event are presented on Figure 7. Depths are shown to decrease from east to west as indicated by depths presented in Table 3.

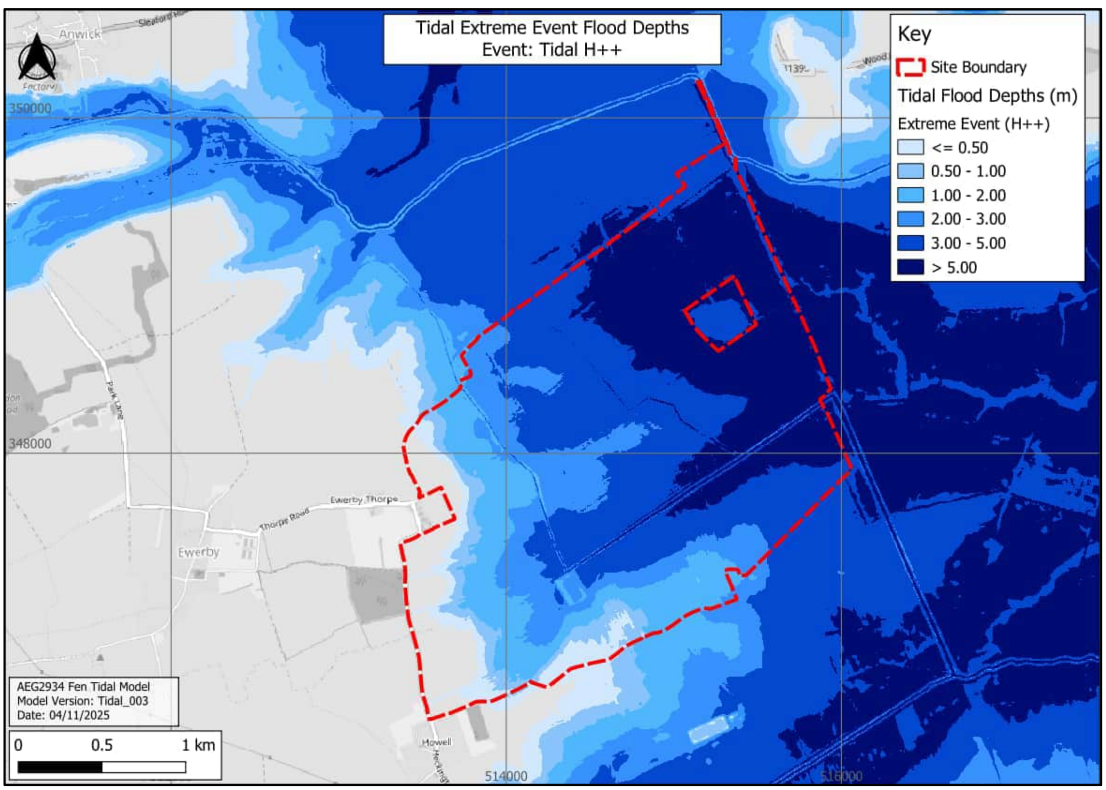


Figure 7: Maximum modelled flood depth for tidal extreme event (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

# 4. Model Sensitivity

4.1. The two extreme events discussed in Sections 2 and 3 were run as sensitivity tests on the baseline fluvial flood risk model. In addition, following a request from the Environment Agency, a further sensitivity test has been undertaken for the fluvial extreme event. This additional test applies elevated water levels at the downstream HT boundaries to assess the model's sensitivity to higher receiving-water conditions.

## Downstream Boundary

4.2. Elevated downstream HT boundary levels of 3.69 m AOD and 2.16 m AOD have been applied to the River Witham and South Forty Foot Drain boundaries respectively. These levels are representative of 50% AEP (1 in 2-year) water levels for the respective watercourses, as modelled in the Lower Witham Model (AECOM, 2009) and the South Forty Foot Drain Model (Mott MacDonald, 2016).

4.3. The resulting change in flood depth compared to the modelled baseline fluvial extreme event is presented in Figure 8. A summary of on-site differences is provided in Table 5.

4.4. The sensitivity test applying higher HT levels at the downstream boundary resulted in an average depth change of 0.0003 m (0.3 mm) across the site of interest, which is negligible and within typical model tolerances. Localised increases were limited to channels, with up to 0.20 m within the site in Car Dyke near the north-eastern boundary and 0.09 m in Hodge Dyke through the site. There was no change to floodplain depths across the site (0.00 m) and no change to the mapped flood extent. These results indicate the site is robust to plausible variation in downstream tailwater.

Table 5: Downstream boundary – elevated HT sensitivity results

| Sensitivity | Modelled Flood Depth Difference (m) | | |
|---|---|---|---|
| | Maximum Increase (on site - in channel) | Average Difference (on site including in-channel) | Maximum Increase (on site - floodplain only) |
| Elevated HT boundary | 0.20 | 0.0003 | 0.0000 |

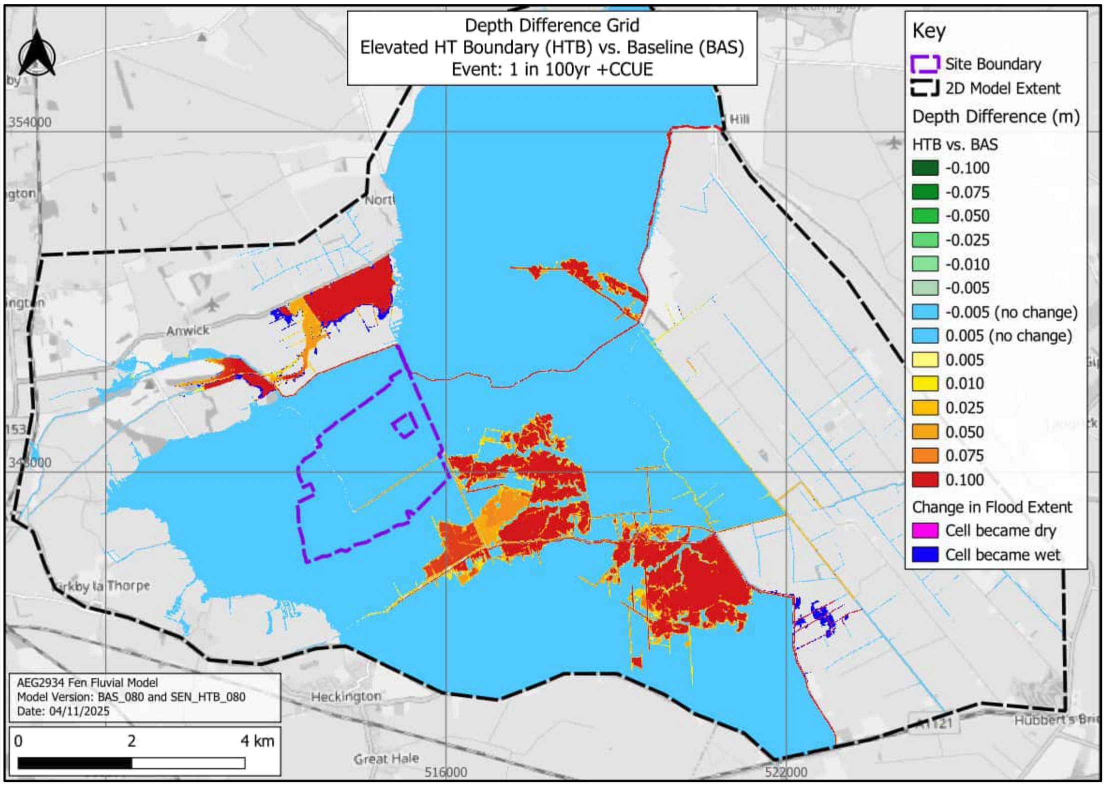


Figure 8: Depth Difference Grid - Elevated HT downstream boundary vs Baseline (unfiltered). Extreme Event: 1 in 100-year + CCUE. (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

4.5. As shown, the sensitivity test produced changes to flood extent and depth within the wider modelled catchment, particularly in low-lying areas beyond the site boundary toward the downstream boundary locations. These variations are an expected response to increased downstream water levels; however, they are confined to off-site areas and have no influence on the assessment of flood risk at the site.

4.6. The results demonstrate that the site is insensitive to plausible increases in downstream water levels, where impacts are restricted to in-channel and do not propagate onto the site floodplain. Consequently, the adopted 1.20 mAOD HT boundary for the baseline simulations remains a robust and proportionate representation of restricted discharge for the purpose of the site-specific assessment, and the conclusions of the flood risk appraisal are unchanged.

# 5. Limitations and Assumptions

## Simulation Parameters

5.1. All parameters were retained as default.

5.2. A 1D timestep of 2.5 seconds and 2D initial timestep of 5 seconds was applied to the model for the fluvial extreme event.

5.3. A 2D variable timestep was applied to the model with an initial timestep of 1 second for the tidal extreme event.

## Model Stability

5.4. No repeated timesteps were reported in the HPC (2D) domain for either model.

5.5. TUFLOW reporting volume error and final cumulative error was reported at 0.00% for both extreme events.

5.6. Flood Modeller mass balance reporting for the fluvial extreme event shows good model stability with mass balance of the peak of the system being reported as -1.51% while the mass balance of the boundary inflow is reported as 0.42%. While 1D models typically aim for boundary inflow mass balance within ±1%, the raised system mass balance is attributed to water entering the floodplain and remaining stored at the end of the simulation. This is expected behaviour in floodplain environments and does not indicate instability. The model is also reported to be 100% converged.

5.7. The tidal extreme event model shows good model stability with a final cumulative mass error of 0.00%.

5.8. For a HPC model to be considered stable, three parameters should be maintained: $N_u$ (Courant number relates to velocity relative to the cell size), $N_c$ (Celerity Control number relates to water depth relative to cell size) and $N_d$ (Diffusion control relates diffusion of momentum relating to the sub grid viscosity). Generally, for a stable model these values should be: $N_u<1$, $N_c<1$ and $N_d<0.3$.

5.9. The model-specific stability outputs are shown in Table 6 for both the fluvial and tidal extreme event simulations. The $N_u$ and $N_d$ outputs indicate good model performance and stability. The $N_c$ number is at the upper limit for stability and warranted further investigation.

Table 6: HPC solver stability outputs for fluvial and tidal extreme event simulation

| | | Fluvial | | Tidal | |
|---|---|---|---|---|---|
| | Maximum stability criteria value | Maximum Model outputs | Average Model outputs | Maximum Model outputs | Average Model outputs |
| $N_u$ (Courant control number) | 1.00 | 0.26 | 0.23 | 0.57 | 0.25 |
| $N_c$ (Celerity control number) | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 |
| $N_d$ (Diffusion control number) | 0.30 | 0.05 | 0.03 | 0.30 | 0.20 |

5.10. $N_c$ is particularly sensitive to high water depths compared to grid cell size, as field drains within IDB areas are represented within the 2D domain some of these locations have large flood depths. As the 1D domain is very sensitive to any additional structures and connections it was decided not to convert any further field drains into the 1D domain. Despite the borderline $N_c$ value, the model remains within acceptable tolerance for stability. This also maintained the same approach to the fluvial hydraulic model.

## Model Limitations

5.11. Model limitations and assumptions stated for the existing 1D/2D model continue to apply to this model. The following additional limitations and assumptions apply to this specific modelling exercise:

- The modelling exercise has made best use of the available data at the time of construction and simulation.
- A single tidal elevation has been applied resulting in a conservative flood extent for the extreme tidal scenario.

- No account of downstream tidal defences have been included within the hydraulic model resulting in a conservative flood extent for the extreme tidal scenario.
- It has been assumed that no pumping stations are active during the tidal event replicating a condition where watercourses are already full.

5.12. Unique TUFLOW checks and warnings generated during the fluvial extreme event are presented in Table 7 while Flood Modeller messages are presented in Table 8. Many of these messages are carried over from the existing fluvial model.

Table 7: TUFLOW check and warning messages for the fluvial extreme event

| Check/ Warning | TUFLOW ID | Description | Number of Occurrences | Comments |
| --- | --- | --- | --- | --- |
| Check | 3519 | Using MIN or GULLY option in SGS model | 8 | While not standard practice option applied to Zsh files to ensure observed channel fall applied within the model, without this option selected 2D representation of field ditch incorrect. |
| Check | 2099 | Ignored repeat application of boundary to 2D cell. | 3 | No impact on model results, 1D/2D boundary check files reviewed, and all connections represented. |
| Check | 2370 | Ignoring coincident point found in Z Shape SGS layer. | 24 | No impact on model results full input geometry reviewed. |
| Check | 3551 | SGS elevations have changes, reprocessing. | 2 | No impact on the model results as SGS method acceptable. |
| Check | 3548 | SGS elevations have changes, reprocessing. | 1 | No impact on model results, reporting standard sample distance. |
| Warning | 1099 | Object ignored. Only Points and Regions used. | 12 | No impact on model results full input geometry reviewed. |

| | | | | |
|---|---|---|---|---|
| Warning | 3526 | SGS Sample distance command is ignored in SGS Approach == Method C | 2 | No impact on the model results as SGS method acceptable. |

Table 8: Flood modeller check and warning messages for the fluvial extreme event

| Note/ Warning | Flood Modeller ID | Description | Number of Occurrences | Comments |
|---|---|---|---|---|
| Warning | 2010 | Poor interpolation u/s of 'label' max u/s area of area1 -> area2 | 1 | This message can indicate additional survey data is required, a review of the location indicates it is an isolated location which already has interpolations assigned. Review of model results show no instability in this area so not considered to impact model results. |
| Warning | 2044 | Different values (+/- 20 %) for Mannings n encountered within one panel. | 33 | Message for modeller to check manning's within panel markers. As Manning's values were reviewed as part of this process it is not considered to impact results/ |
| Warning | 2229 | Value of trash screen height is set to 0; areas will be calculated using piezometric head. | 17 | Message indicates no trash screens applied to structures, based on survey and past modelling this is true. |
| Warning | 2262 | Backflow encountered CULVERT OUTLET unit. | 44 | Message occurs during simulation; this can create instability but is an accurate representation of water backing up within areas of 1D network due to the very flat gradient and multiple lock and restrictive in-channel structures. A review of model stability found a good |

| | | | | |
|---|---|---|---|---|
| | | | | convergence and mass balance error so not considered to impact model results. |
| Warning | 2263 | Backflow encountered at CULVERT INLET unit; outlet control equations will be imposed | 24 | Message noting when control of flow through a unit switches from inlet to outlet controlled. As noted in warning 2262 backflow is expected in such a low gradient watercourse therefore outlet controlled units are realistic. |
| Warning | 2267 | No sub/supercritical depth could be found at node label1 | 23 | No bounds could be found for supercritical or subcritical depth at the section, therefore not being able to guarantee finding a solution for critical depth. Critical depth may be required for certain model processors. As mass balance and convergence are good within the model this is not considered to impact model results. |
| Warning | 2339 | input p1 value less than minimum: 0.100m; value reset to minimum. | 1 | Message stating elevation above bed on weir was input at 0, this is not possible to allow weir calculations to be run therefore a minimum elevation of 0.1m was applied. No impact on model results as weir drowned during warmup of the model. |
| Warning | 2364 | Right springing point is lower than cross-section elevation. | 4 | It is noted that this may cause inaccuracies when calculating constricted bridge area however levels are taken directly from survey or maintained from previous model input data therefore no evidence to change this. Mass balance and convergence both good so not considered to impact model results. |
| Note | 3006 | End of backflow at CULVERT INLET unit. | 44 | Message stating time when backflow through a culvert inlet stopped. No impact on model results |

| | | | | |
|---|---|---|---|---|
| Note | 3007 | End of backflow at CULVERT OUTLET unit | 43 | Message stating time when backflow through a culvert outlet stopped. No impact on model results |
| Note | 3010 | Simplified method used to compute solution at one or more sections | 2 | Does not impact model results as unsteady model being run. Message shows where a hydraulic jump is being smoothed over a range of nodes. Out of 564 nodes within the 1D model only 14 nodes were assessed using the simplified method. |
| Note | 3025 | Minimum flow has been applied at boundary | 6 | Message stating when a minimum flow was applied to a hydrological boundary, all these messages occur at the start of the model run when the minimum flow has been set to prevent the channel drying out. No impact on model results |
| Note | 3028 | Data points omitted from deactivated section areas | 2 | Message noting deactivation markers are operating for 2 cross sections. No impact on model results as all sections reviewed with some having deactivated widths. |

5.13. Unique TUFLOW checks and warnings generated during the tidal extreme event are presented in Table 9.

Table 9: TUFLOW check and warning messages for the tidal extreme event

| Check/ Warning | TUFLOW ID | Description | Number of Occurrences | Comments |
|---|---|---|---|---|
| Warning | 2370 | Ignoring coincident point found in Z Shape SGS layer. | 24 | No impact on model results full input geometry reviewed. |
| Check | 3519 | Using MIN or GULLY option in SGS model | 8 | While not standard practice option applied to Zsh files to ensure observed channel fall applied within the model, without this option selected 2D representation of field ditch incorrect. |
| Warning | 3526 | SGS Sample distance command is ignored in SGS Approach == Method C | 2 | No impact on the model results as SGS method acceptable. |
| Warning | 3548 | Setting SGS Sample Distance Target to minimum grid zpt resolution of 1. | 1 | No impact on model results, reporting standard sample distance |

# 6. Conclusions

6.1. The baseline hydraulic model (existing 1D/2D model) developed to predict fluvial flood risk to the proposed development site at Land at Westmoorland Farms, Howell, Fen, Lincolnshire, LN4 4AA has been updated to represent extreme fluvial and tidal events. These events were requested by the Environment Agency to test the extreme flood risk to the site and are not required for the site design.

6.2. The inflows for both the fluvial and tidal extreme events were updated to reflect the respective flood mechanism as detailed in the report.

6.3. The fluvial extreme event peak modelled extent was found to be similar to that predicted from the existing 1D/2D model 1 in 1,000 year event with flooding mostly contained within the onsite watercourse and ditches. Out of bank flooding is mostly overland flow with isolated areas of ponding/ flood storage.

6.4. The tidal extreme event showed flood risk extended across the majority of the site with deeper flooding seen in the east. This was expected due to tidal flooding emanating from the coast in the south east.

6.5. Sensitivity testing demonstrated that the model outputs are robust to variations in downstream boundary conditions (elevated HT levels). Localised increases in-channel were observed; however, there were no changes to the mapped flood extent or on-site flood depths of a magnitude that would influence the conclusions of the flood risk assessment.

6.6. Model stability was found to be good for both events, with a TUFLOW mass balance of 0.00% and all stability indicators within recommended limits. The Flood Modeller stability criteria were also found to be good with a mass balance error of 0.42% and a peak system mass balance of –1.51%.

6.7. The HPC solver stability parameters (Nu, Nc, Nd) were reviewed and found to remain within acceptable thresholds for both events. Although the Nc value reached the upper stability limit of 1.00, this was attributed to large flood depths within small 2D cells representing field drains in the Internal Drainage Board (IDB) areas. This approach is consistent with the baseline model configuration, and no timestep instability or numerical issues were observed. Model performance is therefore considered robust.

6.8. This model has been developed to assess flood risk specifically at the site and should not be used for applications beyond its defined extent without review and updates from a suitably qualified hydraulic modeller.

# Appendix A– Extreme Event Modelling Methodology and Environment Agency Communication

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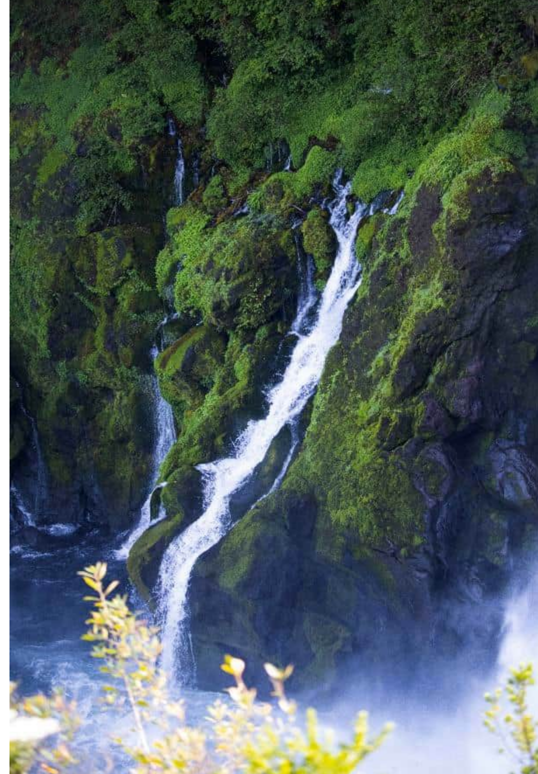

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# Breach Model Report

## AEG2934_LN4_Fen_03

Site Address:
Land at Westmoorland Farms
Howell
Fen
Lincolnshire
LN4 4AA

**UK Experts in Flood Modelling, Flood Risk Assessments, and Surface Water Drainage Strategies**

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## Revision 001

Revision 001 has been updated to account for a change in red line boundary around the proposed solar array at the request of Low Carbon. No other updates were made.

## Revision 002

Revision 002 incorporates updates made in response to the Environment Agency's model review comments. Specifically, all results and sensitivity testing outputs have been updated due to updated breach hydrograph.

## Revision 003

Revision 003 of this report incorporates updates made in response to the Environment Agency's model review comments. Specifically, the addition of the Downstream Boundary Sensitivity Test, undertaken to assess the model's sensitivity to elevated downstream water levels. The results of this test have been added to the report alongside updated figures and commentary to Section 4 of the report.

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Flood risk, water and environment

# Table of Contents

# 1. Introduction

1.1. Aegaea have been commissioned by Beacon Fen Energy Park Limited to undertake a fluvial hydraulic modelling exercise of watercourses within the vicinity of the study site at Land at Westmoorland Farms, Fen, Lincolnshire, LN4 4AA. This is to identify the potential fluvial flood risk posed by the watercourses.

1.2. The breach assessment outlined in this modelling addendum forms a sensitivity assessment on the baseline hydraulic model as part of Stage 3 of the project. This report should be read in conjunction with the fluvial baseline model report;

AEG2934_LN4_Fen_Hydraulic_Model_Report_003.pdf

1.3. The work was undertaken in accordance with the agreed modelling methodology as approved by the Environment Agency. The modelling methodology and comments are provided in Appendix A. Where adjustments to the agreed methodology have been made these are flagged within this report with justifications for the adjustments.

## Aims and Objectives

1.4. The aim of this exercise is to establish an accurate hydraulic representation of the residual risk from a breach in river flood defences.

1.5. To achieve this aim, the following objectives have been identified:

- Update the hydraulic model developed in Stage 2 to represent a breach in river embankments.
- Simulate a breach in the river embankment in three locations for the 100 year plus climate change storm.

## Breach Method

1.6. The site is protected by earth embankments located along the River Slea. Due to the site location only a breach to the defence on the right bank of the watercourse would pose a risk to the site.

1.7. While the breach methodology initially proposed a single breach location, further discussions with the Environment Agency (Appendix A) identified the requirement to test three breach locations. As such a total of three breach scenarios were run. The locations of the breaches are shown on Figure 1 with the centre of each breach presented in Table 1.

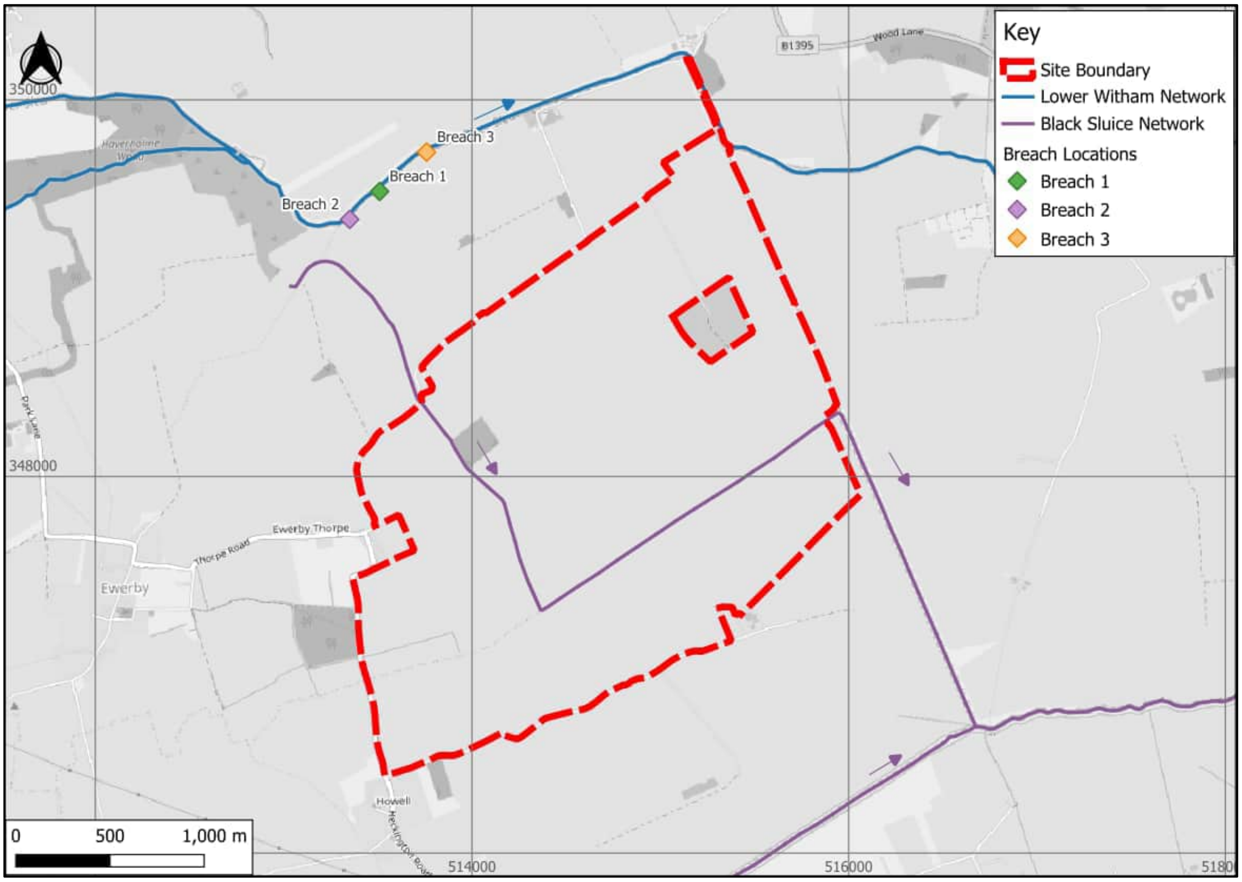


Figure 1: Breach Locations (Base map and data from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

Table 1: Breach Location

| Breach ID | Centroid Grid Reference |
|---|---|
| Breach 1 | TF 13506 49578 |
| Breach 2 | TF 13351 49366 |
| Breach 3 | TF 13759 49724 |

1.8. The breach locations were selected based on flood routes within the existing model. As part of initial discussions with the Environment Agency a potential breach location of TF 13669 49660 was suggested. This location was reviewed against the modelled flood routes and adjusted slightly to Breach 3 location to better align with flow pathways. Breach 1 was located on the main flow pathway through the site while Breach 2 was added to ensure a breach further west was also assessed.

1.9. The Environment Agency breach guidelines[1] have been followed to define the breach characteristics. The type of defence that could fail and impact the site at each location is earth embankments immediately adjacent to the River Slea. These embankments are unprotected other than short vegetation cover. The most likely failure method is considered to be slipping of the earth embankment as a result of water pressure from fluvial flooding within the River Slea.

1.10. As part of the agreed methodology, the modelled breach would occur during the 1 in 100 year plus climate change storm.

1.11. The flood defences located along the banks of the River Slea are represented within the Environment Agency LiDAR, a cross section is shown. The crest and toe of the embankment is shown in Figure 2. The cross section shows the River Slea channel bed is located below the adjacent ground level on the right bank. The River Slea channel bed is below the toe of the embankment meaning not all water would leave the channel during a breach.

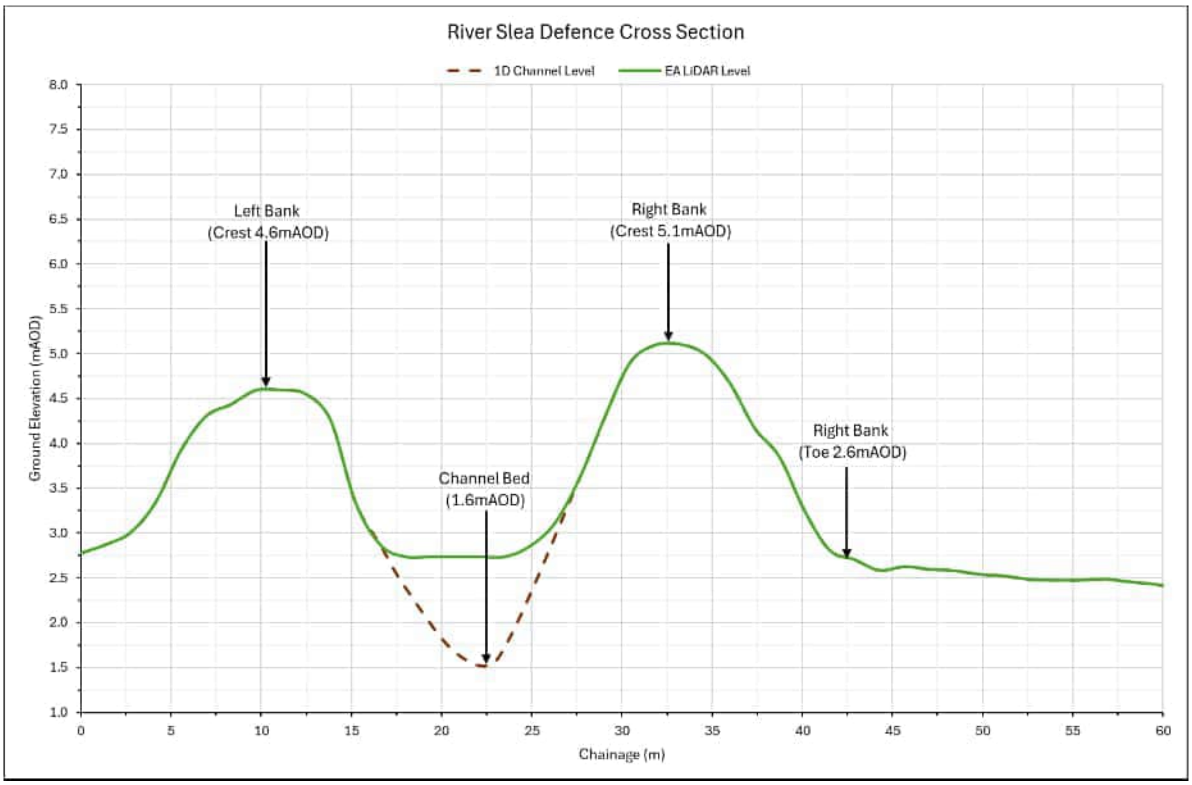


Figure 2: River Slea Cross Section

[1] **Environment Agency 2021, LIT56413 Breach of defences guidance**

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# 2. Hydraulic Model Amendments

## Summary

2.1. This section summarises the updates made to the existing hydraulic model to assess a breach to the earth embankments. The actions undertaken include:

- Updated existing 1D/2D model to represent a breach using a variable zsh file.
- Extracted breach hydrograph from linked 1D/2D hydraulic model.
- Updated model to extent to the floodplain within which the site is located and remove 1D domain to improve model stability and run times.
- Applied breach hydrograph to three locations along the River Slea bank upslope of the site.

## Software

2.2. The model was simulated using TUFLOW version 2025.1.0 TUFLOW Heavily Parallelised Compute (HPC) solver. This version of TUFLOW was used to maintain the same version as the existing 1D/2D model.

## 1D Domain

2.3. The 1D domain was removed from the hydraulic model. This was undertaken to remove instabilities within the 1D domain when the simulation time exceeded 30 hours. While efforts have been made to stabilise the model for longer run times, low flows within the watercourse resulted in errors being generated. As the purpose of the model is to assess the impact of flooding (high flows) instability at low flows was not considered critical. Removing the 1D domain also significantly improved model simulation time.

## 2D Domain

2.4. The 2D domain extent was reduced to remove floodplain on the left bank of the River Slea. This reduces the model grid size and simulation time in an area of the model which would not receive any water during the modelled breach events. The revised model extent is shown on Figure 3.

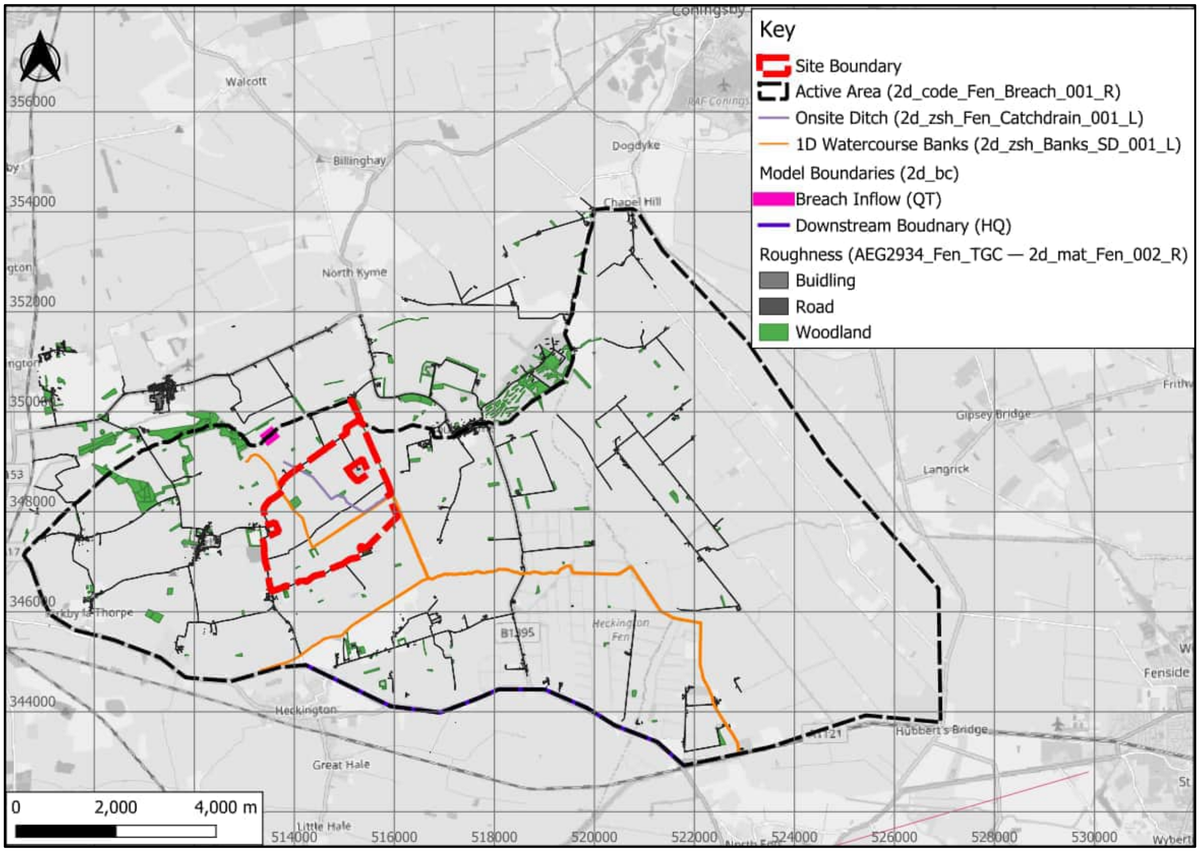


Figure 3: TUFLOW 2D model schematic (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

2.5. The deactive code area previously used to define the area within which the 1D Flood Modeller extent was maintained within the model to simulate bankfull conditions during a breach event. This is considered to be a conservative approach, as the existing 1D/2D hydraulic model found no out of bank flooding for the majority of the watercourses within the 1D domain

2.6. Soil infiltration was removed from the model as these losses are contained within the hydrology used to define flow within the River Slea channel. Inclusion of infiltration would double count for losses within the model.

2.7. No other changes were made to the 2D domain.

# Boundary Conditions

## Breach Hydrograph

2.8. The breach hydrograph was extracted from the linked 1D/2D hydraulic model using a variable zsh to represent the breach as described below.

2.9. The breach should be set to begin when the water level reached is at ¾ of the defence height[1]. This level would be 4.2mAOD based on the cross section provided in Figure 2. This suggests that as per guidance, a breach wouldn't occur along the River Slea at this reach. To generate a breach a lower level of was taken as 3.2m as the breach trigger point. This level represents water being approximately half the height of the defence height. A review of the existing 1D/2D model showed this level was reached at 6.5 hours in the 1 in 100-year + climate change (fluvial 32% higher uplift) event, consistent with the baseline fluvial modelling.

2.10. As the assessment is of extreme risk to the site, an instantaneous breach has been assumed for simplicity, it is acknowledged that a breach would not occur more slowly. By applying an instantaneous breach, the worst case impact on the site is being assessed. This follows the standard approach to fluvial breach assessments as laid out in the EA breach of defences guidance[1].

2.11. The time taken to close the breach has been set at 72 hours. While the standard EA closure time is 56 hours in a rural setting, discussion with the EA suggested the remoteness of site resulted in a longer than standard closure time (Appendix A) again following a conservative approach.

2.12. The width of the breach will be set to 40m with the breach location used as the centroid of the line.

2.13. To define the breach hydrograph the existing 1D-2D model was simulated for the 1 in 100-year + CC (fluvial 32%) storm event with a variable zsh file representing a 40m length of breach at Breach 1. The variable zsh file had a trigger time of 6.5 hours at which point ground levels are lowered to 2.6mAOD (downstream toe level). The restore time was set to 72 hours. However, due to model instabilities the maximum run time the existing 1D/2D model would complete to was 36 hours.

2.14. The breach hydrograph was extracted using PO lines from the 2D model domain. The remaining breach time (post 36-hrs) was then extended as shown by the black line on Figure 4. At 72 hours



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the flow is set to 0 $m^3/s$ to represent the breach being closed. The model was then run to 100 hours to allow flood water to travel across the site and adjacent floodplain.

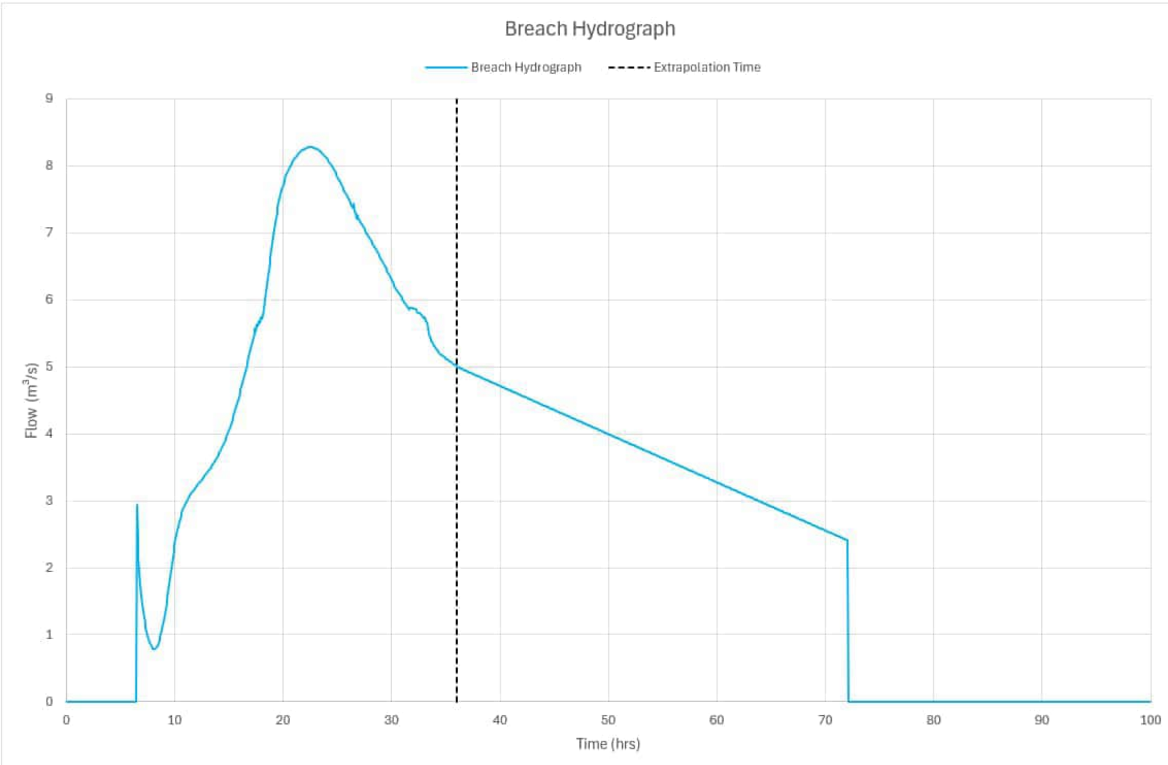


Figure 4: Breach Hydrograph

2.15. The breach hydrograph was applied using a 2d_bc line at the three defined breach locations shown in Figure 1.

## Other Boundaries

2.16. To assess the impact of a fluvial defence breach, all other inflows to the baseline hydraulic model were removed including direct rainfall and pumping stations connections.

2.17. Soil losses through infiltration were also removed from the hydraulic model. This prevents double accounting of losses both in the hydrology used to define the flow within the River Slea in the existing 1D/2D model and within the TUFLOW floodplain.

# 3. Model Results

3.1. Results from the hydraulic modelling exercise are presented in this section. As the only inflow to the model is the breach hydrograph, no filtering was applied to results.

3.2. The flood extents for each breach are presented on Figure 5. The flooding is shown to be contained mostly within the northeast of the site flowing in a northwest to southeast direction. Breach 2 is shown to create the most extensive flooding within the site boundary.

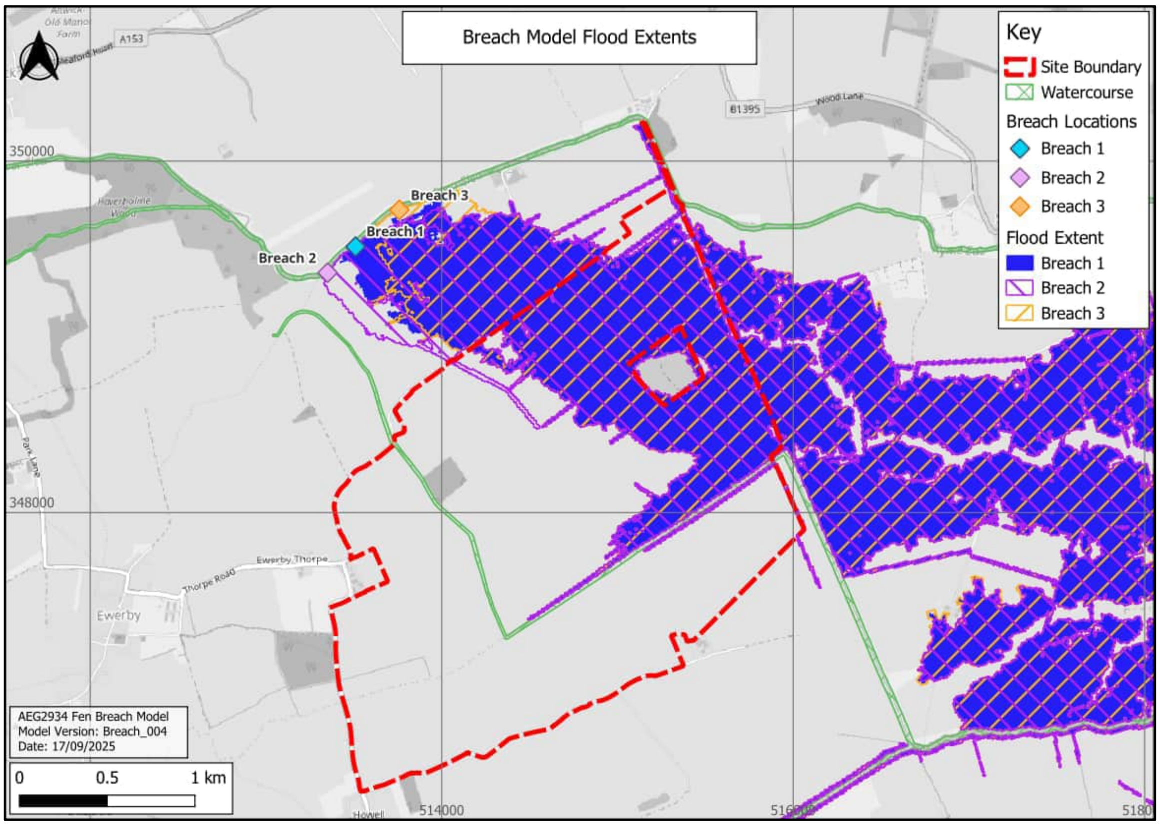


Figure 5: Modelled breach flood extents (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

3.3. Reporting locations are shown in Figure 6, these locations have been used to extract both flood depth and elevations for Breach 1, Breach 2 and Breach 3 scenarios. The flood depth levels at each location are presented in Table 2 while corresponding flood elevations are presented in Table 3. These reporting locations are consistent across all modelling reports for this project (Fluvial Baseline and Extreme Event) to enable direct comparison of results; hence, some points are located outside the modelled flood extents for certain scenarios.

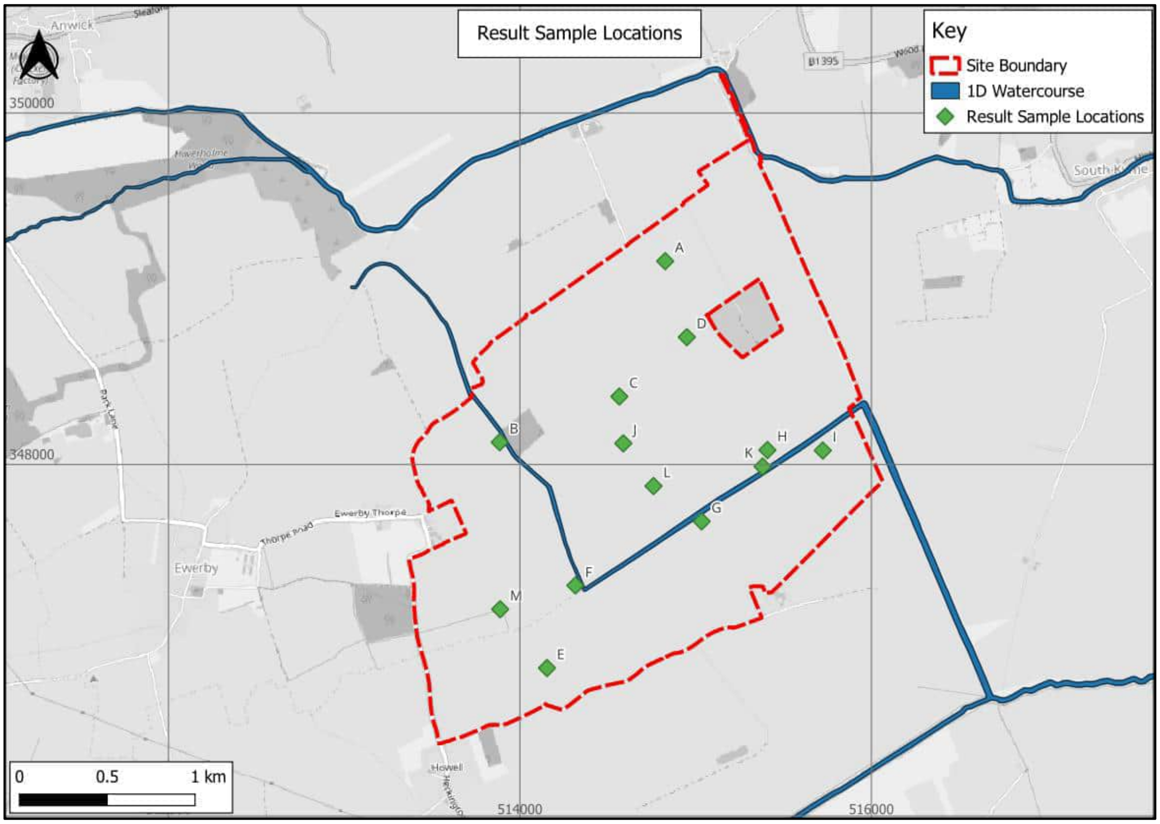


Figure 6: Modelled result sample locations (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

3.4. Flood depths from sample locations on the site (outside of watercourses and field ditches) range from 0.29m at Point D to 0.97m at Point K. Flow is shown to move across the site and pond in some of the lower areas of site (Point H and K) whereas Point A and D show lower depths as water flows across these locations. The shallowest recorded flood depth is 0.01m along the northern boundary of the site.

Table 2: Modelled Onsite Peak Flood Depths (m)

| Location ID | Maximum Modelled Flood Depth (m) | | |
|---|---|---|---|
| | Breach 1 | Breach 2 | Breach 3 |
| A | 0.40 | 0.40 | 0.40 |
| D | 0.29 | 0.29 | 0.29 |
| H | 0.69 | 0.69 | 0.69 |
| K | 0.97 | 0.97 | 0.97 |

Table 3: Modelled Onsite Peak Flood Elevations (mAOD)

| Location ID | Maximum Modelled Flood Elevation (mAOD) | | |
|---|---|---|---|
| | Breach 1 | Breach 2 | Breach 3 |
| A | 1.50 | 1.50 | 1.50 |
| D | 1.47 | 1.47 | 1.47 |
| H | 1.45 | 1.45 | 1.45 |
| K | 1.45 | 1.45 | 1.45 |

3.5. Flood elevations fall from the north boundary of the site where flood water first enters to the southeast boundary as water leaves. This shows the flood water is mostly flow through the site rather than ponding and being stored.

3.6. The maximum flood elevation recorded on the site is 1.79 mAOD at Point A due to the higher ground elevations as flood depths are lowest in this area of the site. As flood depths and elevations do not vary between each breach location the site is not considered to be sensitive to the location of the breach. The maximum modelled flood elevations for Breach 2 are shown on Figure 7, Breach 2 was selected as it had the largest flood extent.

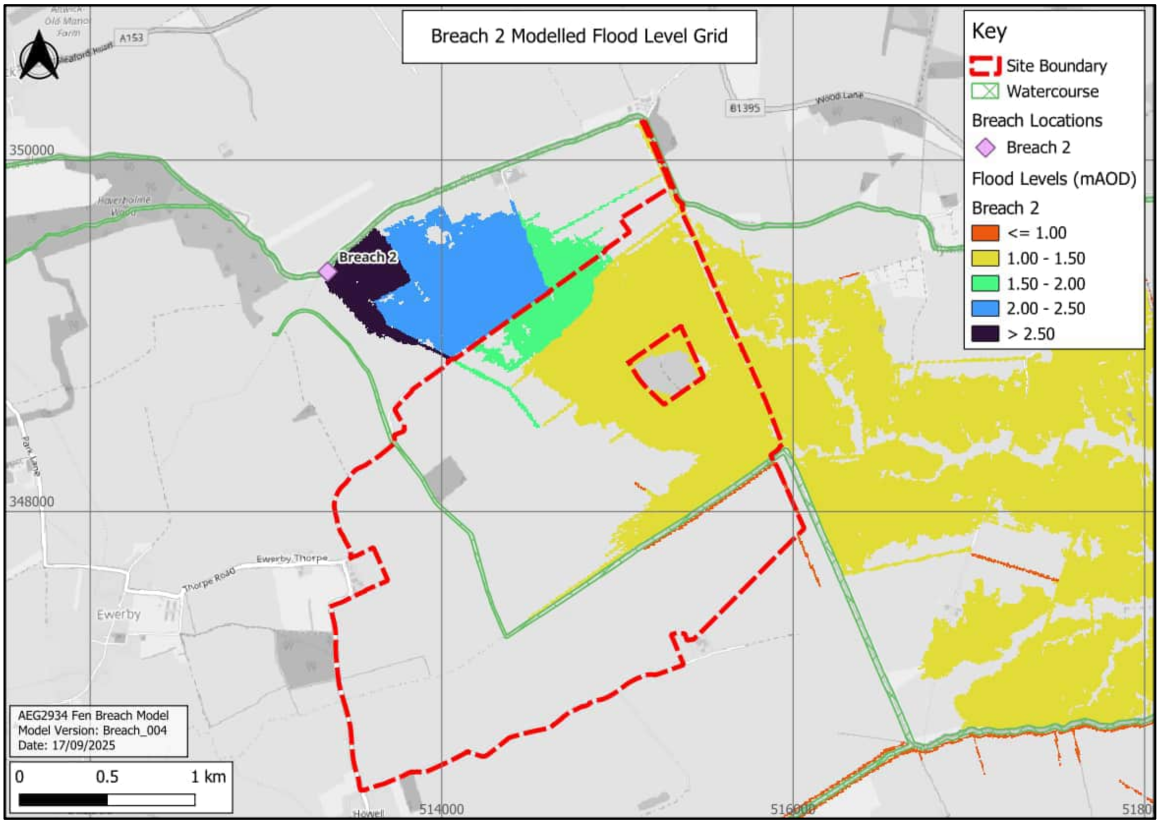


Figure 7: Breach 2 modelled flood elevations (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

3.7. Maximum modelled flood depths for the three breach locations are presented in Figure 8 to Figure 10. The depths across the site reporting locations are shown to be similar for all breach scenarios as shown previously in Table 2.



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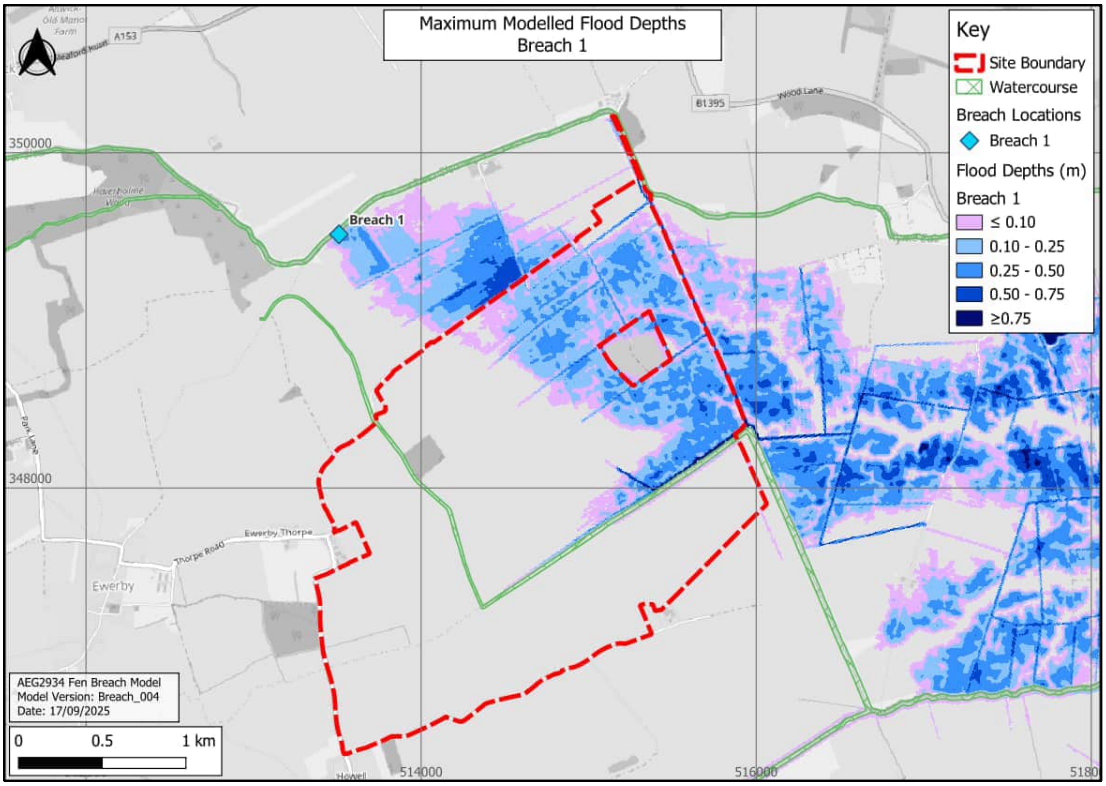


Figure 8: Breach 1 modelled flood depths (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

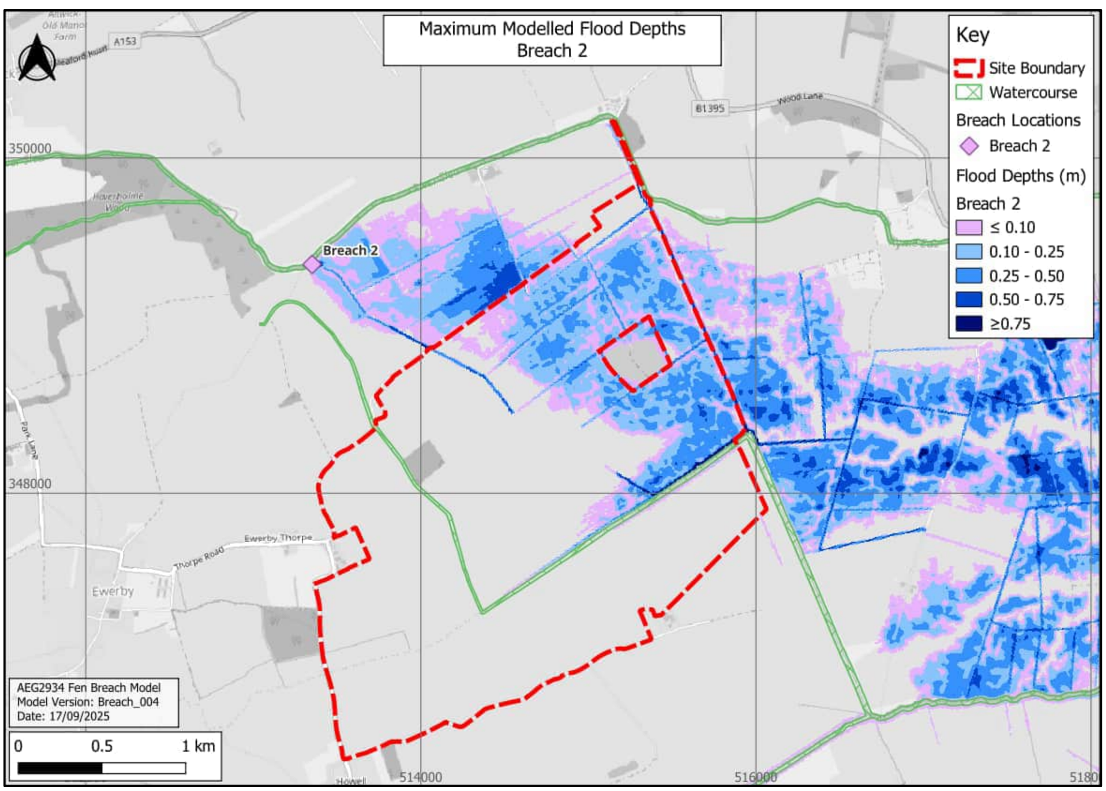


Figure 9: Breach 2 modelled flood depths (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

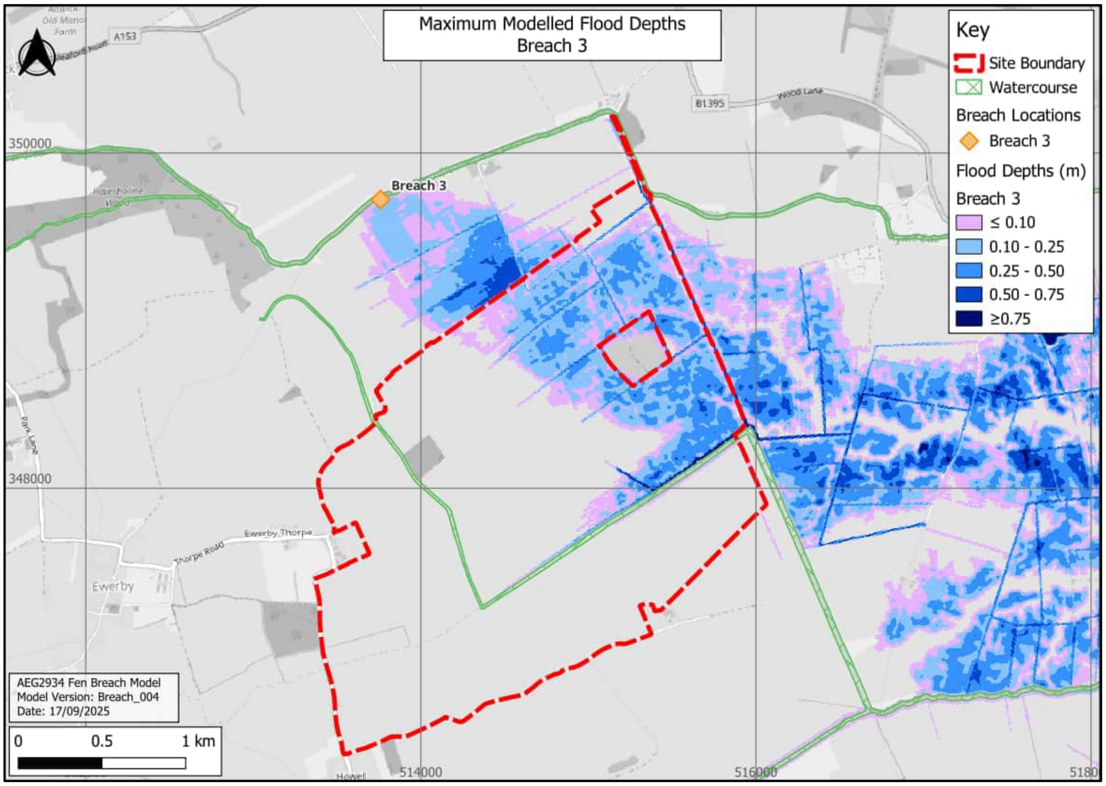


Figure 10: Breach 3 modelled flood depths (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

# 4. Model Sensitivity

4.1. Two sensitivity assessments have been undertaken on the existing 1D/2D fluvial model: one to assess the inclusion of direct rainfall and soil losses within the 2D domain, and another to test the effect of elevated water levels at the downstream HT boundaries and assess the model's sensitivity to higher receiving-water conditions.

## Direct Rainfall and Soil Losses

4.2. The 1D/2D fluvial baseline model included direct rainfall and soil losses within the model domain, however within the breach model these elements were removed. The rainfall and soil losses were applied for areas controlled by Internal Drainage Boards (IDB).

4.3. To check the sensitivity of the breach model results to the inclusion of direct rainfall and soil infiltration within the IDB area each breach scenario was run with rainfall and soil infiltration. The difference in modelled maximum depths for Breach 1, Breach 2 and Breach 3 are presented on Figure 11 to Figure 13. A comparison of changes to predicted flood depth within the site boundary are presented in Table 4.

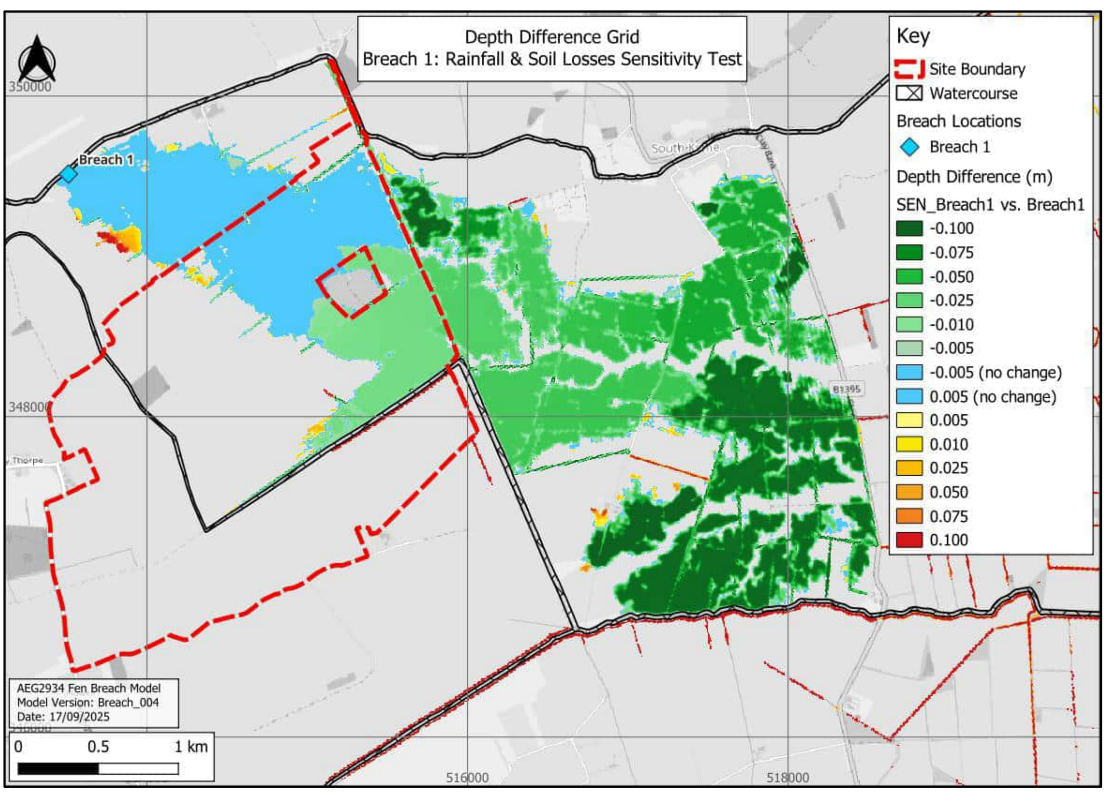


Figure 11: Breach 1 with direct rainfall and soil loss modelled flood depth difference to Breach 1 without direct rainfall and soil loss (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)



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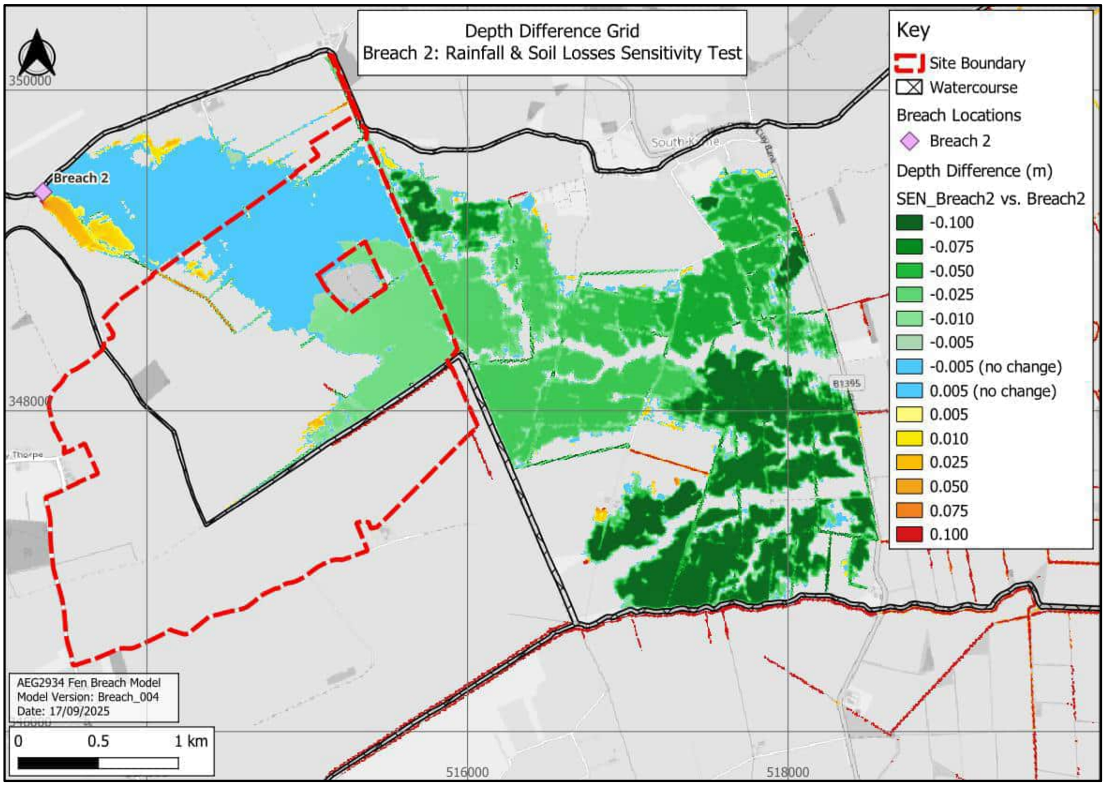


Figure 12: Breach 2 with direct rainfall and soil loss modelled flood depth difference to Breach 2 without direct rainfall and soil loss (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

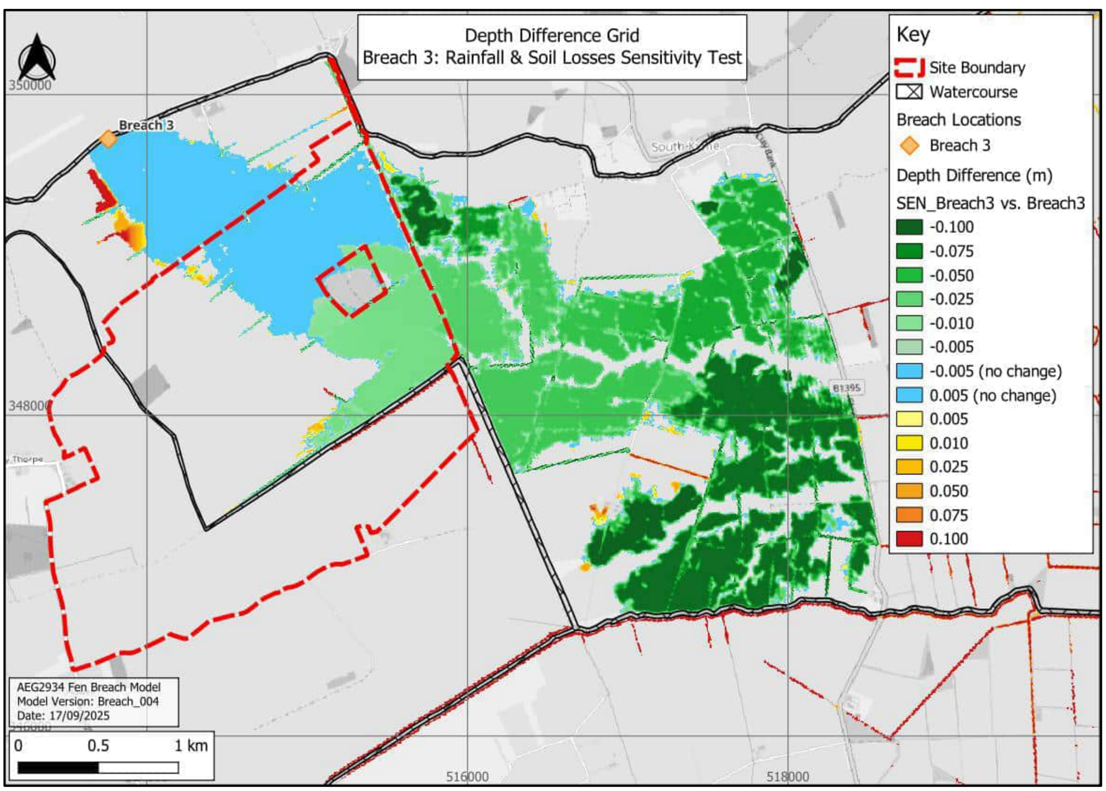


Figure 13: Breach 3 with direct rainfall and soil loss modelled flood depth difference to Breach 3 without direct rainfall and soil loss (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

Table 4: Direct rainfall and soil loss - sensitivity results on site

| Breach Scenario | Modelled Flood Depth Difference (m) | | |
|---|---|---|---|
| | Maximum Decrease | Maximum Increase | Average |
| Breach 1 | -0.65 | 0.87 | -0.01 |
| Breach 2 | -0.65 | 0.87 | -0.01 |
| Breach 3 | -0.65 | 0.87 | -0.01 |

4.4. As with the modelled flood depths and elevations there is no difference in results between the different breach locations.

4.5. The maximum increase in flood depths on site as a result of direct rainfall and soil losses being included with a breach is 0.87m (Table 4). Upon review of depth difference figures (Figure 11, 12 and 13) identifies this location to be located within a field ditch on the edge of the breach flood extent and is highly localised. The majority of the site and the developable area had no change with the average depth difference across the site recorded at -0.01m (Table 4).

4.6. The overall model conclusions are found not to be sensitive to the inclusion of direct rainfall and soil losses with the 2D domain as the average change across all three breach scenarios on site was less than -1cm.

4.7. As the breach modelling is to determine the flood risk to the site resulting from a failure in the River Slea flood defences the exclusion of direct rainfall and soil losses is appropriate.

## Downstream Boundary

4.8. The 1D/2D fluvial baseline modelling included a sensitivity test to assess the effect of elevated water levels at the downstream HT boundaries and the model's sensitivity to higher receiving-water conditions. This test showed no change in flood levels across the site and only minor increases within the channel. However, as the breach hydrograph was derived under baseline conditions, it was necessary to undertake an additional breach scenario in which the hydrograph was extracted from the linked 1D/2D model with elevated HT boundary levels applied.

4.9. Elevated downstream HT boundary levels of 3.69 m AOD and 2.16 m AOD have been applied to the River Witham and South Forty Foot Drain boundaries respectively. These levels are representative of 50% AEP (1 in 2-year) water levels for the respective watercourses, as modelled in the Lower Witham Model (AECOM, 2009) and the South Forty Foot Drain Model (Mott MacDonald, 2016).

4.10. The higher downstream boundary levels result in water within the channel sitting at a greater elevation, thereby increasing peak in-channel levels and allowing a larger volume of flow to spill through the breach.

4.11. The breach hydrograph applied for the downstream boundary sensitivity test is shown in Figure 14, alongside the baseline breach hydrograph for comparison. The elevated downstream boundary levels result in an increase in peak flow (14.37 $m^3/s$ compared to 8.28 $m^3/s$), while the overall timing and duration of the breach event remain consistent. This reflects the higher in-channel water levels generated under the raised HT boundary condition, confirming the expected hydraulic response to increased tailwater.

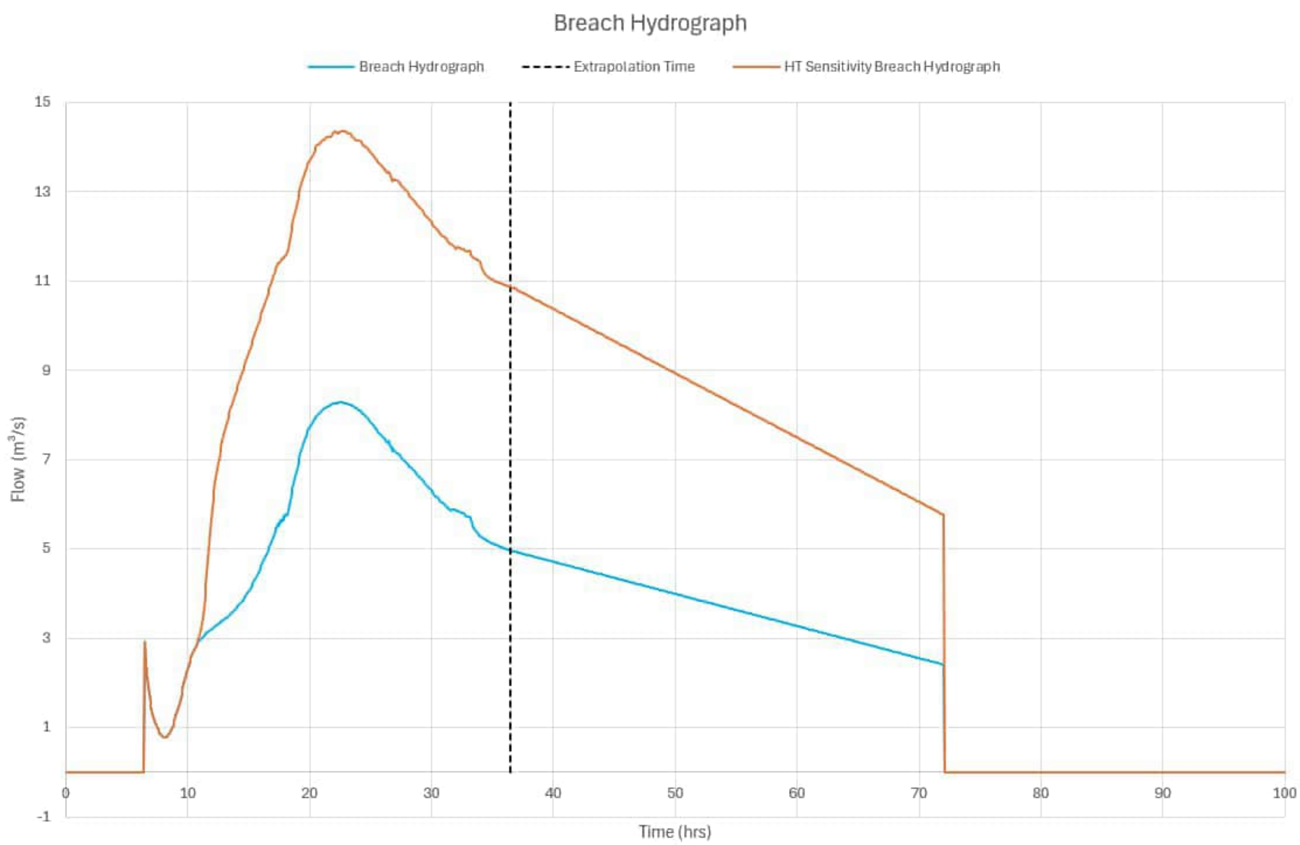


Figure 14: Comparison of baseline breach and elevated downstream boundary (HT) sensitivity breach hydrographs

4.12. As with the original breach hydrograph, the sensitivity-test hydrograph was extrapolated beyond 36 hours, applying a drawdown rate of –0.012 $m^3/s$ per timestep, based on the average drawdown over the final two hours of modelled output (34–36 hours).



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4.13. This test was completed for Breach 2 only, as this scenario produced the largest flood extent across the site and therefore represents the most conservative case.

4.14. A summary of depth differences is provided in Table 5 below.

Table 5: Downstream boundary – elevated HT sensitivity results

| Sensitivity | Modelled Flood Depth Difference (m) | | |
|---|---|---|---|
| | Maximum Increase (on-site) | Average Difference (on-site) | Maximum Increase (off-site) |
| Elevated HT boundary | 0.16 | 0.10 | 0.77 |

4.15. The resulting change in flood depth compared to the modelled baseline fluvial extreme event is presented in Figure 15. The results show a similar overall flood extent, with a slightly larger area surrounding the Breach 2 extent, indicated in blue on the depth-difference grid. Flood depths show a general trend of increase across the flooded area, with localised depth increases of up to 0.16 m and an average increase of 0.10 m. Off-site there is a maximum increase in flood depths of 0.77 m due to breach water pooling in low lying areas of the floodplain.

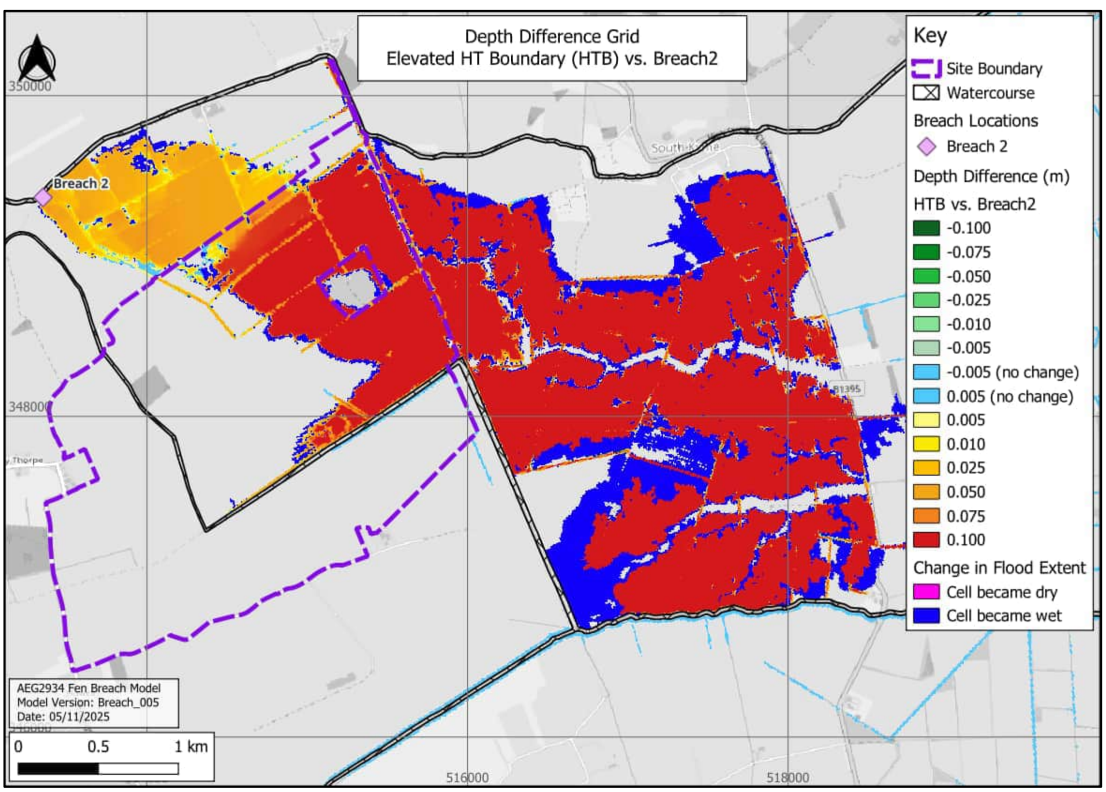


Figure 15: Depth Difference Grid – Breach 2 Elevated HT downstream boundary vs Breach 2. Storm Event: 1 in 100-year + CC32%. (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

4.16. This sensitivity test indicates a moderate response to elevated downstream water levels (Elevated HT), resulting in on-site flood-depth increases of up to 0.16 m and an average increase of 0.10 m. A marginal expansion of the flood extent is observed, primarily buffering around the Breach 2 footprint; these changes are confined to low-lying areas adjacent to existing flood pathways and do not materially affect the developable area.

4.17. Given the observed localised increases in flood depth and minor expansion of the flood extent within the site, additional mapping has been produced to illustrate the spatial distribution of flood levels and depths for the downstream boundary sensitivity test. The maximum flood depth and maximum flood level results are presented in Figure 16 and Figure 17, respectively.

4.18. These figures represent a robust worst-case breach scenario, supporting the interpretation of the results within the Flood Risk Assessment. The maximum flood depth recorded on site is 2.09 m, located within the Hodge Dyke channel that runs through the site, with an average on-site flood depth of 0.29 m. The maximum modelled flood level on site is 2.54 mAOD, occurring along the northern boundary, where ground elevations are higher. The average flood level across the site is 1.57 mAOD, which is representative of typical water levels across the main developable area.

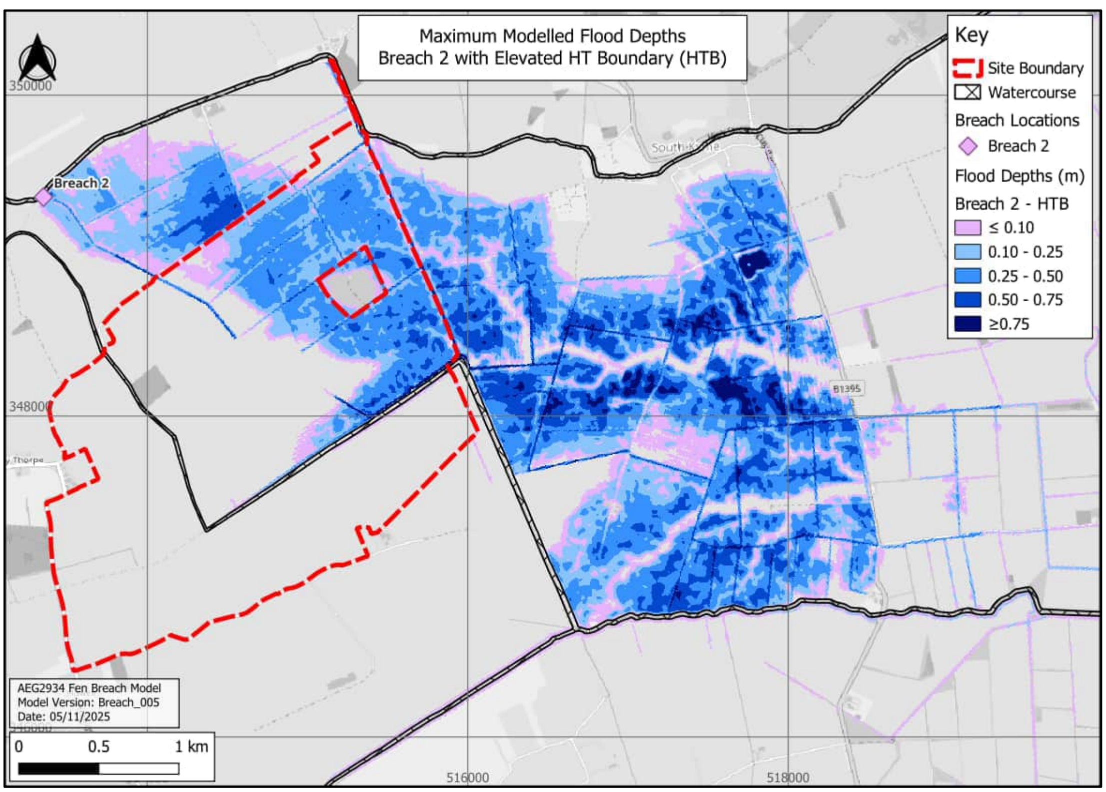


Figure 16: Breach 2 Elevated HT downstream boundary sensitivity test, modelled flood depths (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

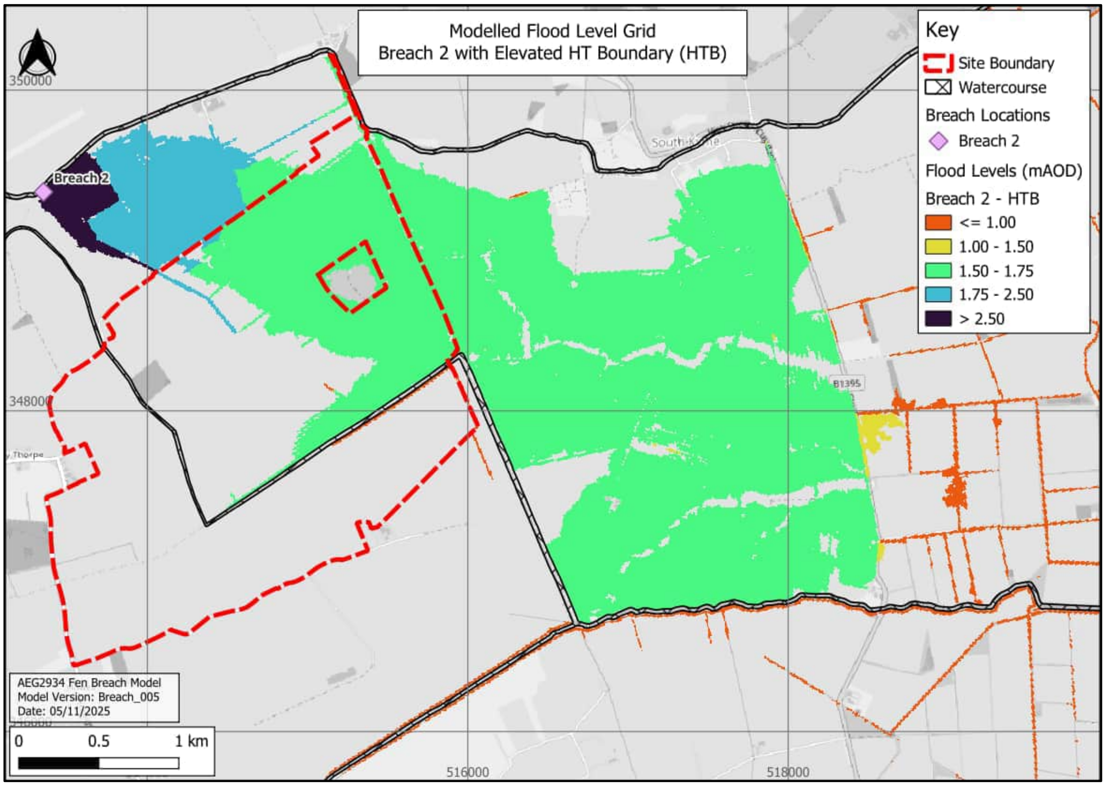


Figure 17: Breach 2 Elevated HT downstream boundary sensitivity test modelled flood elevations (Base map from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors)

4.19. A comparison of modelled peak flood depths and flood elevations between the Breach 2 baseline and Elevated HT downstream boundary sensitivity test is presented in Table 6 and Table 7, respectively.

Table 6: Modelled Onsite Peak Flood Depths (m) comparison

| Location ID | Maximum Modelled Flood Depth (m) | |
|---|---|---|
| | Breach 2 | Elevated HT Sensitivity Test |
| A | 0.40 | 0.50 |
| D | 0.29 | 0.41 |
| H | 0.69 | 0.82 |
| K | 0.97 | 1.07 |

Table 7: Modelled Onsite Peak Flood Elevations (mAOD) comparison

| Location ID | Maximum Modelled Flood Elevation (mAOD) | |
|---|---|---|
| | Breach 2 | Elevated HT Sensitivity Test |
| A | 1.50 | 1.60 |
| D | 1.47 | 1.59 |
| H | 1.45 | 1.57 |
| K | 1.45 | 1.57 |

4.20. No additional sensitivity tests were required for this modelling as no changes were made to the input hydrology, 2D build or boundary conditions.

# 5. Limitations and Assumptions

## Simulation Parameters

5.1. Flood Modeller Pro version 7.3.0 and TUFLOW version 2025.1.0-iSP-w64 Heavily Parallelised Compute (HPC) was used in the 1D-2D linked model used to derive the breach hydrograph. The final 2D Breach model uses TUFLOW 2025.1.0-iSP-w64 Heavily Parallelised Compute (HPC) in all simulations.

5.2. All parameters were retained as default. A 2D variable timestep was applied to the model with an initial timestep of 2 seconds and maximum timestep of 4 seconds.

## Model Stability

5.3. No repeated timesteps were reported in the HPC (2D) domain.

5.4. TUFLOW reporting volume error and final cumulative error was reported at 0.00% for all three breach scenarios.

5.5. For a HPC model to be considered stable, three parameters should be maintained: $N_u$ (Courant number relates to velocity relative to the cell size), $N_c$ (Celerity Control number relates to water depth relative to cell size) and $N_d$ (Diffusion control relates diffusion of momentum relating to the sub grid viscosity). Generally, for a stable model these values should be: $N_u<1$, $N_c<1$ and $N_d<0.3$. The model-specific stability outputs are shown in Table 8 for Breach 2.

Table 8: HPC solver stability outputs for Breach 2

| | Maximum stability criteria value | Max Model outputs | Average Model outputs |
|---|---|---|---|
| $N_u$ (Courant control number) | 1.00 | 0.33 | 0.16 |
| $N_c$ (Celerity control number) | 1.00 | 1.00 | 1.00 |
| $N_d$ (Diffusion control number) | 0.30 | 0.03 | 0.01 |

5.6. The $N_u$ and $N_d$ outputs indicate good model performance and stability. The $N_c$ number is at the upper limit for stability and warranted further investigation. $N_c$ is particularly sensitive to high water depths compared to grid cell size, as field drains within IDB areas are represented within the 2D domain some of these locations have large flood depths. As the 1D domain is very sensitive to any additional structures and connections it was decided not to convert any further field drains into the 1D domain. Despite the borderline $N_c$ value, the model remains within acceptable tolerance for stability.

## Model Limitations

5.7. Model limitations and assumptions stated for the existing 1D/2D model continue to apply to this model. The following additional limitations and assumptions apply to this specific modelling exercise:

5.8. The modelling exercise has made best use of the available data at the time of construction and simulation.

5.9. If further updates are made to the baseline fluvial model, the breach model would also need to be updated with a new breach hydrograph. In that case, the results presented in this report would no longer be valid.

5.10. The breach hydrograph has been extrapolated beyond the stable runtime of the 1D–2D model in order to simulate a 72-hour breach closure. While this is 14 hours after the peak flows and follows Environment Agency guidance, results after the extrapolation time should be considered indicative.

5.11. It has been assumed that no pumping stations are active during the time of a breach event.

5.12. Watercourses within the hydraulic model previously included within the 1D model domain are represented as inactive areas. This assumes the channels are full and flood water from a breach cannot enter them, this may overestimate the flood risk from the breach.

5.13. Unique TUFLOW checks and warnings generated during the Breach 2 scenario model run are presented below in Table 9.

Table 9: TUFLOW check and warning messages

| Check/ Warning | TUFLOW ID | Description | Number of Occurrences | Comments |
|---|---|---|---|---|
| Check | 3519 | Using MIN or GULLY option in SGS model | 4 | While not standard practice option applied to z-shape files to ensure observed channel fall applied within the model, without this option selected 2D representation of field ditch incorrect. |
| Check | 3551 | SGS elevations have changes, reprocessing. | 1 | Triggered when SGS (Sub-Grid Sampling) reprocessed elevations after z-shape edits were applied. Occurs automatically when geometry is updated; no impact on model stability or results. |
| Warning | 1099 | Object ignored. Only Points and Regions used. | 12 | No impact on model results full input geometry reviewed. |

# 6. Conclusions

6.1. The baseline hydraulic model (existing 1D/2D model) developed to predict fluvial flood risk to the proposed development site at Land at Westmoorland Farms, Howell, Fen, Lincolnshire, LN4 4AA has been updated to represent a breach in flood defences along the River Slea.

6.2. A breach hydrograph was developed using the existing linked 1D/2D model and a variable zsh layer to represent the breach. The hydrograph was then extended to simulate the breach remaining open for 72 hours. Following this, the breach is closed with the model run time extending to 100 hours.

6.3. The breach hydrograph has been applied at three locations within a 2D only model as the only inflow to ascertain the flood risk to the site from a breach.

6.4. The breach scenarios assume defences fail instantaneously and pumping stations are inactive. These are conservative assumptions adopted to provide a worst-case assessment of residual risk.

6.5. Model results show no difference in modelled flood depths or elevations between the three simulated breach locations suggesting the risk to site is not sensitive to location of the breach.

6.6. The deepest recorded flood depth was 0.97m at Point K adjacent to the Hodge Dyke, while the shallowest recorded flood depth is 0.01m along the northern boundary of the site. In contrast the highest flood elevation is observed along the northern boundary of the site while the lowest elevation is in the centre of the site. This is due to the undulating natural ground levels within the site.

6.7. The breach model was not found to be sensitive to the inclusion of direct rainfall and soil losses.

6.8. However, the downstream boundary sensitivity test demonstrated a moderate response to elevated downstream water levels, with higher tailwater conditions producing greater breach outflows, localised increases in flood depth (up to 0.16 m on site), and a marginal expansion in flood extent. The deepest recorded flood depth was 1.07m at Point K adjacent to the Hodge Dyke.

6.9. The model stability was found to be good with a 0.00% mass balance reported for all breach scenarios run and stability indicators all within recommended limits. In total 3 check messages and 1 warning was reported prior to the start of the model run. These messages were reviewed and found not to impact model outputs.

6.10. This is a site-specific modelling study prepared using the best available data at the time of construction. If the baseline fluvial model is updated in future, the breach model would need to be updated accordingly. In that case, the results presented here would no longer be valid.

# Appendix A– Breach Modelling Methodology and Environment Agency Communication

aegaea
water, civils and environment

# Appendix 3. Environment Agency S42 Response

[redacted]

[redacted]

**Our ref:** XA/2024/100054/01-L01
**Your ref:** 16449

**Date:** 01 March 2024

Dear Sir/Madam

**SECTION 42 PRELIMINARY ENVIRONMENTAL INFORMATION REPORT CONSULTATION - BEACON FEN ENERGY PARK.**

Thank you for consulting us on the Preliminary Environmental Information Report (PEIR) for the Beacon Fen Energy Park project.

Our views are in response to the materials that have been provided as part of this consultation. This response does not represent our final view in relation to any future Development Consent Order (DCO) application or any permit applications made to us under the Environmental Permitting Regulations (EPR) 2016. Our final views will be based on all relevant information, including applications and guidance available at the time of submission.

The key issues we have identified are:

- Impacts on fish have not been included within the ecological assessment
- The dewatering / abstraction strategies are unclear and the permitting requirements therefore not fully understood
- The assessment of potential construction impacts is incomplete and it is unclear how mitigation measures will be secured
- The assessment of flood risk is incomplete and appropriate mitigation measures have not been provided.

We have addressed each of these topics in more detail within Appendix A. Please also note the informatives provided within Appendix B.

You should give consideration to whether you will seek to disapply the Environmental Permitting (England and Wales) Regulations 2016 through the DCO process. Should you decide to pursue this, you should provide a request to us in writing, clearly setting out the permits/consents that you would require for the project. This should be done as soon as possible to allow us sufficient time to consider the request (minimum 6 months) and depending on the outcome this will have implications on the content of the DCO.

Environment Agency
Lateral 8 City Walk, LEEDS, LS11 9AT.
Customer services line: 03708 506 506
www.gov.uk/environment-agency
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We look forward to continuing to work with you as the detailed proposals continue to develop, and to reviewing and providing advice on relevant supporting documents as these are generated. If you have any questions regarding any of our comments, please do not hesitate to contact me.

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## Appendix A: Detailed Comments

### Ecology - Legislation

National Policy Statement (NPS) EN-1 states that “the design of Energy NSIP proposals will need to consider the movement of mobile / migratory species such as birds, fish and marine and terrestrial mammals and their potential to interact with infrastructure.”

**Issue:** The legislative framework (paragraph 7.2.2 and Appendix 7.1) does not include fish species of conservation concern within the development boundary.

**Impact:** Increased risk to fish species if the correct legislation is not taken into account.

**Solution:** Add Eel (England and Wales) Regulations 2009, and Salmon and Freshwater Fisheries Act 1975 to the legislative framework sections.

### Ecology - Species of Concern

NPS EN-1 states that “the design of Energy NSIP proposals will need to consider the movement of mobile / migratory species such as birds, fish and marine and terrestrial mammals and their potential to interact with infrastructure.” In addition, EN-1 states that “the applicant should demonstrate that:…the timing of construction has been planned to avoid or limit disturbance.”

**Issue:** The desk study used to establish baseline conditions has not incorporated fisheries data (see Table 7.3), including for eels. Eels are a critically endangered species and are protected by The Eels (England and Wales) Regulations 2009.

**Impact:** The predicted impacts of the proposed development on fish, and specifically eels, cannot therefore be verified at this time.

**Solution:** Fisheries data should be included and potential impacts to the species identified, including an assessment of potential impacts to eels, and mitigation proposed for any identified impacts.

Additional Comment: Ewerby Catchwater is a salmonid sealed main river, so timing restrictions will apply (no works between 1st October – 15th June).

### Ecology - Ecological Features

NPS EN-1 states that “the design of Energy NSIP proposals will need to consider the movement of mobile / migratory species such as birds, fish and marine and terrestrial mammals and their potential to interact with infrastructure.”

**Issue:** Table 7.6 summarises sensitive ecological features but does not include Eels. Eels are a critically endangered species and are protected by The Eels (England and Wales) Regulations 2009.

**Impact:** The predicted impacts of the proposed development on fish, and specifically eels, cannot therefore be verified at this time.

**Solution:** Eels should be added to the list of ecological features in Table 7.6.

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**Ecology - Watercourse Buffers**

**Issue:** The buffer zone within Figure 1.5 – the Embedded Mitigation Plan - is not sufficient.

**Impact:** Not having an appropriate buffer for the riparian zone will result in increased risk to protected species.

**Solution:** Increase the watercourse buffer on the Embedded Mitigation Plan to 10 metres.

Additional Comment: This will also align with Biodiversity Net Gain guidance, in which the riparian zone is considered to be 10 metres from top of bank.

**Ecology - Decommissioning**

Issue: The current strategy to remediate the site is not appropriate - the proposal to remediate the site back to arable land does not take into account biodiversity enhancements created by the development.

Impact: Risks to biodiversity and protected species.

Solution: Ensure mechanisms in place to have a remediation strategy which takes into biodiversity enhancements (thus reflecting the new ecological baseline in the area).

**Water Resources - Dewatering**

Paragraph 7.11 of the Desk Study report indicates that "dewatering measures should be incorporated into the construction phase should they be required." There is no further mention of dewatering in the desk study or in Chapter 11: Water Resources & Flood Risk.

**Issue:** The dewatering strategy has not been confirmed.

**Impact:** There is a risk that the impacts of, and permitting requirements for, dewatering are not understood and therefore adequate mitigation not provided. Dewatering without a permit may cause derogation of supply to other users of water and there is a potential increased risk to protected species.

**Solution:** The dewatering strategy should be clearly defined and any appropriate mitigation secured.

Additional Comment: Please see the informative in Appendix B relating to permit requirements for dewatering. You should engage with the Environment Agency regarding the need for an environmental permit and sure that the consenting process is reflected in project timelines.

**Water Resources - Abstraction**

NPS EN-1 states that the Environmental Statement (ES) should describe "existing water resources affected by the proposed project and the impacts of the proposed project on water resources, noting any relevant existing abstraction rates, proposed new abstraction rates and proposed changes to abstraction rates (including any impact on or use of mains supplies and reference to [Abstraction Licensing Strategies]) and also

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demonstrate how proposals minimise the use of water resources and water consumption in the first instance".

**Issue:** The current strategy for water supply is unknown.

**Impact:** The environmental impacts for each of the options listed in section 11.6.14 have not been fully considered.

**Solution:** Consider the environmental consequences of each option and provide details of a sustainable water supply strategy.

Additional Comment: It is not clear whether the option for an onsite reservoir is for a new reservoir or use of an existing one. In either case, there are potential permitting implications. A new or varied permit, if granted, may include certain restrictions that will need to be taken into account when selecting the appropriate strategy, so we recommend that you engage with us early on this matter.

The development is within the South Forty Foot assessment area and within the Black Sluice Internal Drainage Board (IDB). The licensing strategy for this catchment states that there is water available during periods of high flows/levels and a new licence is likely to have conditions relating to both local watercourses and relating to levels in the South Forty Foot drain which restrict abstraction to these periods (typically experienced over the winter). More information can be found in the abstraction licensing strategy for the Witham catchment.

**<u>Water Resources – Magnitude of Change</u>**

**Issue:** Temporary impacts during construction may have been underestimated.

**Impact:** The current approach risks potentially significant effects during construction being underestimated and inappropriate mitigation being proposed, which increased the risk to the environment and protected species from pollution.

**Solution:** The activities associated with temporary works should be reassessed to ensure they reflect the appropriate level of risk to the environment.

Additional Comment: The criteria for determining "Medium" and "High" magnitude of change will only consider post-development characteristics, so temporary effects which only occur during construction will be considered to have a "Low" or "Negligible" magnitude of change.

**<u>Water Resources – Impacts of Climate Change</u>**

NPS EN-1 is clear that impacts of the proposed project on water quality, water resources and physical characteristics of the water environment must be assessed, as well as how these might change due to the impact of climate change on rainfall patterns and consequently water availability across the water environment.

**Issue:** The impacts of climate change have not been considered sufficiently.

**Impact:** Wider impacts of climate change on water quality and resources are not fully understood so appropriate mitigation may not have been secured.

**Solution:** Consider which other aspects of climate change are relevant to the future

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baseline conditions of the study area.

Additional Comments: For instance, there is likely to be an increase in average summer temperatures and increased frequency of extreme heat events. Hotter weather will result in higher water temperatures and therefore a more sensitive water environment. Including these conditions will ensure a more accurate description of future baseline conditions.

**Water Resources – Mitigation Measures**

**Issue:** It is not clear how mitigation measures, such as a sediment management plan and emergency response plan will be secured within the DCO application.

**Impact:** If mitigation measures are not secured under an appropriate mechanism within the DCO then there is a risk that they will not be implemented. There is therefore an increased risk to water quality and protected species via pollution.

**Solution:** You need to provide clarity on how each mitigation measure will be secured within the DCO application.

**Water Resources – Potential Construction Impacts**

**Issue:** The list of the potential impacts during construction phase is incomplete.

**Impact:** There is a risk that the potential impacts during construction have not been fully assessed, and appropriate mitigation measures may not be developed as a result. This poses an increased risk to the water environment and protected species.

**Solution:** The assessment of risks should be revisited, and relevant mitigation measures identified.

Additional Comments: Impacts that have not been identified in Table 11.9 include, but are not limited to:

- Increased risk of sediment laden runoff due to vegetation removal.
- Water ingress into underground cable excavations and subsequent need to dewater.
- Run-off generated from stockpiled materials.

**Water Resources - CEMP**

**Issue:** The CEMP is proposed as a mitigation measure for many activities, but the CEMP's objectives are not clear.

**Impact:** If the objectives are not made clear in the DCO application, we will not be able to support its use as an appropriate mitigation measure to prevent significant impacts on the water environment.

**Solution:** There should be a clear link between the CEMP and the potential impacts it seeks to mitigate against within the DCO application. Should it not be possible to provide the CEMP with the DCO submission, an Outline CEMP should be produced in which the principles of the CEMP can be agreed.

Additional Comments: We welcome the proposal to produce a Construction Environment Management Plan (CEMP) to manage potential effects on the water environment during construction. Large construction sites often cause pollution due to the production of an insufficient CEMP or the failure of contractors to follow the CEMP. To reduce this risk, the CEMP must include pollution prevention measures that can withstand significant heavy rainfall events. Additionally, we recommend the inclusion of monitoring, reporting, and reviewing procedures to ensure the project team and principal contractor have sufficient oversight of the contractors that they employ.

We will review the CEMP in due course and will want to see that it is clear regarding 'corrective actions'. We expect this to mean remediation of any pollution that poses a risk to the water environment.

It is currently unclear how the CEMP will prevent impacts from the use of cement bound sand. Will the CEMP ensure that highly alkaline water will not be produced at all, or will it lower the risk of production and detail appropriate disposal measures?

**Water Resources – Water Discharge Activity**

**Issue:** The need for an environmental permit to carry out a water discharge activity has not been recognised. This is a requirement of the Environmental Permitting (England and Wales) Regulations 2016.

**Impact:** The obligation to apply for and comply with a water discharge activity permit could be used as appropriate mitigation for several impacts that could occur during construction.

**Solution:** You should engage with the Environment Agency regarding the need for an environmental permit and sure that the consenting process is reflected in project timelines.

Additional Comments: please see the informative relating to water discharge activities in Appendix B.

**Water Resources – Potential Operational Impacts**

**Issue:** The list of the potential impacts during construction phase is incomplete.

**Impact:** There is a risk that the possible effects during operation have not been fully assessed and appropriate mitigation measures may not be developed as a result. This poses an increased risk to the water environment and protected species.

**Solution:** The assessment of risks should be revisited and relevant mitigation measures identified.

Additional Comment: Impacts that have not been identified in Table 11.10 include, but are not limited to:

- Impacts of watercourse crossings on water quality, for example a possible reduction in dissolved oxygen due to slower flows.
- Impacts from the use of the fire suppression system during operation.

**Water Resources - Foul Sewage Disposal**

**Issue:** The method of foul water disposal has not been confirmed.

**Impact:** Increased risks to water quality and protected species.

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**Solution:** Foul water disposal strategy should be provided.

Additional Comment: If sewage will be discharged to public sewer, you should consult with the local water company to ensure that adequate sewer capacity is available, and no adverse effects will occur because of the connection. If treatment and discharge at the site is required, you should consider any potential impacts of this discharge and confirm that a water discharge activity permit will be sought. If road transport to an offsite disposal facility is required, then there should be regard for this within the waste management procedures.

**Flood Risk - Fluvial Flood Risk**

**Issue:** The draft flood risk assessment (FRA) does not adequately assess fluvial flood risks posed to/by the development, both now and in the future.

**Impact:** An FRA is vital to making informed planning decisions. In the absence of reliable modelled flood data, the risks posed by/to the development are unknown, and the relevant mitigation measures have not been identified.

**Solution:** You must use appropriate and reliable fluvial flood modelling data to inform the assessment of flood risk, utilising the correct allowances for climate change.

Additional Comments: It is important to note that even our most recent flood models available for this area need to be updated based on current climate change estimates, in accordance with 'Flood Risk Assessments: climate change allowances'.

It was suggested within our response to the EIA Scoping consultation that you obtain modelled fluvial flood risk data from the local Customers and Engagement Team. Although Appendix 11.1 refers to data obtained through a Product 4 request, the data referenced does not include the best data that we currently have available.
We advise the applicant to submit an additional request to LNenquiries@environment-agency.gov.uk for the following Environment Agency flood models:

- 2017 flood model for the South Forty Foot Drain
- Lower Witham model updated in 2015
- Breach / overtopping model available for the Wash

Please note that our models are not designed to assess third party developments. Even though they are the best available data currently held by us, it cannot be assumed they are suitable for assessing the flood risk associated with a particular development. Our models are created for our own purposes and are usually at a catchment-scale. Although they are made available for third parties to use, it is up to the applicant to review the modelling and determine whether it appropriately represents flood risk on a site-specific basis, or whether any updates or modifications need to be made to improve its usefulness in informing the assessment of flood risk.

We note that the PEIR submission refers to your intention to produce site specific fluvial flood modelling, which we strongly support. For this, we would recommend you use the Higher Central climate change allowance, for the 2080s epoch, for the Witham management catchment in order to assess future fluvial flood risk, in accordance with 'Flood Risk Assessments: climate change allowances'.

You will be required to provide evidence of any modelling checks and subsequent updates carried out, and document these in the FRA model reporting. You will also need to provide the model and any model files so that we can conduct a detailed model review. We recommend you refer to the guidance here: Using modelling for flood risk assessments - GOV.UK (www.gov.uk).

Please also note that for a thorough understanding of the flood risks associated with the proposed development it is important that flood risk is considered in terms of depth, rate of onset, and flow rate.

**Flood Risk - Residual Flood Risk**

One of the minimum requirements for an FRA, according to NPS EN-1, is to "include the assessment of the remaining (known as 'residual') risk."

**Issue:** The FRA does not assess the residual flood risk, should fluvial flood defences be breached / overtopped.

**Impact:** The development may be at an unacceptable risk of flooding should defences be overtopped or fail.

**Solution:** You must consider the residual risks over the lifetime of the development, factoring in the condition of existing flood defences and their standard of protection, to inform how such risks will be mitigated.

Additional Comment: It is acknowledged within Appendix 11.1 that the data previously provided by us only considers the defended fluvial flood scenario. The breach/overtopping model for the Wash previously mentioned should aid in your assessment of any residual flood risk.

**Flood Risk - Reservoir Flood Risk**

In line with paragraph 5.8.6 of NPS EN-1, it should be ensured that flood risk from all sources of flooding is taken into account. The FRA should assess all sources of flood risk to be able to inform planning decisions.

**Issue:** The draft FRA fails to consider the risks associated to the proposed development from reservoir flooding.

**Impact:** In the absence of any assessment of reservoir flood risk, the risks posed to the development are unknown.

**Solution:** The applicant should assess the risk of reservoir failure to the proposed development and determine whether any mitigation measures will be necessary.

Additional Comment: Reservoir flood maps are available to the public to view on Gov.uk.

**Flood Risk - The Exception Test & Flood Storage Compensation**

NPS EN-1 states that "where new energy infrastructure is, exceptionally, necessary in flood risk areas (for example where there are no reasonably available sites in areas at lower risk), policy aims to make it safe for its lifetime without increasing flood risk elsewhere and, where possible, by reducing flood risk overall."

**Issue:** The draft FRA does not demonstrate that the proposed development will be safe, without increasing flood risk elsewhere, and does not consider possibilities for reducing flood risk overall.

**Impact:** The proposed development would not pass the second part of the Exception Test and based on the information provided, the proposed development is expected to impede flood flow and reduce flood storage capacity, thereby increasing the risk of flooding elsewhere in the catchment.

**Solution:** You should revise your FRA to demonstrate that adequate flood storage compensation arrangements will be made to ensure that there will be no loss in flood storage capacity, regardless of whether it is deemed negligible or not.

Additional Comments: Aspects of the proposed development are expected to fall within Flood Zone 3a, which is land defined by the Planning Practice Guidance (PPG) as having a high probability of flooding. As shown in Table 2 of the PPG for flood risk and coastal change, development classified as Essential Infrastructure under Annex 3 of the National Planning Policy Framework is only appropriate in Flood Zone 3 if the Exception Test is passed alongside the Sequential Test.

Specifically, the submitted PEIR states that ‘potential loss of floodplain storage as a result of the proposed development will be minimal’ and ‘any impact on fluvial flooding as a result of the proposed development within the Solar Array Area will, therefore, be negligible’. In accordance with paragraph 5.8.12 of NPS EN-1, ‘there should be no net loss of floodplain storage and any deflection or construction of flood flow routes should be safely managed within the site’. A ‘minimal’ loss of floodplain storage is still a loss and will not be acceptable.

The second part of the Exception Test requires the applicant to demonstrate, via a site-specific flood risk assessment, that the development will be safe, without increasing flood risk elsewhere. Where possible, the development should reduce flood risk overall. The development must be designed to ensure there is no increase in flood risk elsewhere, accounting for the predicted impacts of climate change throughout the lifetime of the development. There should be no net loss of floodplain storage and any deflection or construction of flood flow route should be safely managed within the site. Mitigation measures should make as much use as possible of natural flood management techniques.

The best way to compensate for flood storage loss is to recreate an area of floodplain that mimics the area, shape and volume of the section of floodplain that has been lost by the development.

Please be aware that any increase in built footprint or raising of ground levels within the floodplain (1% annual probability, plus an allowance for climate change, flood extent) will only be considered acceptable if it can be demonstrated the proposed development will not result in a loss of flood storage. Level-for-level and volume-for-volume compensation is the preferred method of mitigation. However, for this to be achievable, it requires land on the edge of the floodplain and above the 1% annual probability flood level, with an appropriate allowance for climate change, to be available.

**<u>Flood Risk - Design and Operation</u>**

NPS EN-1 states that "where new energy infrastructure is, exceptionally, necessary in flood risk areas (for example where there are no reasonably available sites in areas at lower risk), policy aims to make it safe for its lifetime without increasing flood risk elsewhere and, where possible, by reducing flood risk overall. It should also be designed and constructed to remain operational in times of flood."

**Issue:** It has not been demonstrated that the proposal will be appropriately resilient to flood risk and remain operational during the lifetime of the development.

**Impact:** If the development cannot remain operational during a flood, there are increased risk of flood damages to the infrastructure and disruptive impacts of flooding on those homes and businesses that rely on that infrastructure.

**Solution:** Any operational elements of the proposal must be located 600mm above the 1% annual probability (plus climate change) flood level.

Additional Comment: As essential infrastructure, it is necessary that the development remains operational for its lifetime, but this will not be possible without appropriate flood resilience measures. Appendix 11.1 of the PEIR states that solar panels within Flood Zone 3 will be secured on metal piles and that it may also be necessary to situate transformers located within Flood Zone 3 on raised ground to elevate these above the 1% annual probability (plus climate change) flood level, but operational elements of the proposal must also be above this level. The 600mm freeboard will provide additional resilience to the solar panel structures against damage from debris potentially caught up in flood water, as well as account for possible model uncertainty.

**Flood Risk – CEMP & DEMP**

**Issue:** There is insufficient assessment of flood risk throughout the construction and decommissioning stages of the proposal.

**Impact:** Without a detailed assessment of the flood risks associated with the construction and decommissioning stages of the development, we cannot make an informed decision on the proposal's appropriateness with regards to flood risk and relevant mitigation measures cannot be identified.

**Solution:** You should provide a detailed assessment of flood risk in relation to the construction and decommissioning activities and confirm how such risks could be mitigated.

Additional Comment: We note that you intend to produce a CEMP and a Decommissioning Environment Management Plan (DEMP). However, the FRA should ensure that future flood risk, accounting for climate change, be considered for the lifetime of the scheme, including decommissioning. We will also request sight of the Decomissioning Environment Management Strategy when it becomes available.

We will also expect to be consulted on the Construction Environment Management Strategy and for it to include information on the following:

- A flood emergency response plan.
- Plans for the storage of construction materials (outside of the flood zone).
- Flood defence vibration monitoring.
- Surveys for any works close to a flood defence to better understand the defences' geometry, condition, composition and structure.
- Details of construction phasing to ensure there is no loss in flood storage at any point during construction.

# Appendix B: Informatives

### Nature Conservation Sites

According to Table 7.6, the impact on The Wash Ramsar and The Wash Special Protection Area is estimated to be negligible. We recommend that you consult Natural England in regard to this. The designated sites that have been scoped in will also require Habitats Regulations Assessment and Site of Special Scientific Interest assent from Natural England.

### Biodiversity Net Gain

Paragraph 7.7.2 sets out habitat enhancements that will be made in support of BNG. In addition to the habitats listed, we would like to see habitat enhancements specifically for species such as Great-Crested Newts, water vole, otter, and eel through Biodiversity Net Gain. We advise that you consider opportunities to link with Local Nature Recovery Strategies when available, River Basin Management Plan objectives, and any mitigation measures listed for the affected waterbodies under the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017.

We will expect to see a River Condition Assessment for any watercourse (including 10m either side of the bank top) within the redline boundary. Ditches are included in the watercourse metric.

The local nature partnership is working with Lincolnshire Wildlife Trust to look strategically at solar farm proposals across the county. We recommend you link in with them in regard to this.

### Ground Conditions

We note that ground conditions were scoped out of requiring further assessment, but a preliminary risk assessment (Ground Conditions Desk Study) was completed to complement the PEIR. The desk study conceptual site model risk classification for controlled waters has been determined as very low to low (Table 6.1). Based on the information presented in the report we are satisfied with this conclusion.

The report goes on to state (in paragraph 8.7) that, for completeness, contamination testing will be carried out during geotechnical design investigations. Please note, we are likely to request that a Requirement regarding how unsuspected contamination is managed should be included in the DCO.

### Dewatering

If dewatering is required, it may require an environmental permit if it doesn't meet the exemption in The Water Abstraction and Impounding (Exemptions) Regulations 2017 Section 5: Small scale dewatering in the course of building or engineering works. You should refer to our regulatory position statement here: Temporary dewatering from excavations to surface water: RPS 261 - GOV.UK

If you don't meet the exemption and require a full abstraction licence you should be aware that some aquifer units may be closed for new consumptive abstractions in this area. More details can be found in the Abstraction Licensing Strategy for the catchment. If the dewatering activity can be demonstrated to be discharged to the same source of

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supply without intervening use (i.e. non-consumptive), this will increase the likelihood of a licence being granted. Examples of (consumptive) intervening uses include: dust suppression, mineral washing, washing down machinery and potable supply.

**Water Resources - Existing Abstraction Points**

Appendix 11.3 of the PEIR identifies abstraction licences 4/30/12/*S/0250, 4/30/12/*S/0272, AN/030/0012/050, and AN/030/0012/009 as having abstraction points located within the site boundary, and therefore possibly being affected by the proposals.

Changes in land use or access rights to abstraction points may require the licence to be changed. It is the responsibility of the licence holder to apply to make changes to the licence, which are reflective of continued justification of need and practical operational use.

We recommend that the IDB are informed on any aspects of abstraction, storage and subsequent use of water which may impact upon levels in the IDB drains or pumping regimes undertaken by the IDB. It is worth noting that they would also be consulted by our national permitting service as part of the determination of a new licence of variation to an existing licence.

**Waterbody Ecological Status**

The "Black Sluice IDB draining to the South Forty Foot Drain Water Body" Water Framework Directive catchment has been described as classified in 2019 with an ecological status of "Poor". This is not quite correct; it was designated as "Moderate" in 2019 and "Poor" in 2022.

Ultimately the baseline conditions remain as described. However, the applicant may want to update this section to ensure the accuracy of the report. Update this section as appropriate.

**Water Discharge Activities**

A water discharge activity permit is required to carry out discharges of sewage and trade effluent. An exemption exists under the Regulatory Position Statement on Temporary dewatering from excavations to surface water. However, it is unlikely that all the conditions of this RPS can be met due to the duration of the project. Therefore, a permit will likely be required to discharge dewatering effluent or surface water run-off generated from areas of exposed soil during construction. Given the timeframe to determine environmental permits we encourage applicants to engage with us on permit requirements at the earliest possible stage.

**Maintenance**

We would expect the FRA to be supported by a maintenance plan, particularly relating to flood risk areas where mounted solar panels are proposed. It is important that the space beneath the solar panels remain clear of debris so water can flow freely, without loss of flood storage.

**LLFA and IDB consultation**

If you have not done so already, we would strongly recommend that you consult the Lead Local Flood Authority (LLFA) and IDB for their advice on surface water flood risk and any other local drainage matters.

**Cumulative Effects**

The proposal involves several watercourse cable crossings. There is also another DCO being progressed for Heckington Solar Energy Park, which is also proposing to connect into the existing Bicker Fen substation. We are concerned about the number of potential watercourse crossings, particularly in terms of recording where these are located, how much space is required and the possible disturbance to the watercourse and their associated flood defence assets. We're keen to have further discussions into the possibility of combining cable crossings with other energy infrastructure to keep the number of crossings to a minimum.

**Flood Risk Activities**

The Environmental Permitting (England and Wales) Regulations 2016 require a permit to be obtained for any activities which will take place:

- on or within 8 metres of a main river (16 metres if tidal)
- on or within 8 metres of a flood defence structure or culverted main river (16 metres if tidal)
- on or within 16 metres of a sea defence
- involving quarrying or excavation within 16 metres of any main river, flood defence (including a remote defence) or culvert
- in the floodplain of a main river if the activity could affect flood flow or storage and potential impacts are not controlled by a planning permission

We are pleased to see your intention to incorporate a minimum 9 metre setback distance between built development and any watercourse. Please engage with us early on if there are any instances where this 9 metre setback is not going to be possible.

**Waste**

We support your intention to produce a DEMP and a Waste & Recycling Strategy alongside the ES. NPS EN-1 requires that information be included on how re-use and recycling will be maximised in addition to the proposed water recovery and disposal for all waste generated by the development. This should include assessment of the impact of waste arising from development on the capacity of waste management facilities to deal with other waste arising in the area.

<u>Panels</u>

It is important that consideration is given to the design and manufacture of the panels in the first place, as poor design makes them very hard to recycle, especially as currently there are very few companies who can do this effectively.

<u>Batteries</u>

A key factor that can be overlooked by parties involved in new battery storage projects is that battery storage falls within the scope of the UK's producer responsibility regime for batteries and other waste legislation. This creates additional lifecycle liabilities which must be understood and factored into project costs, but on the positive side, the regime also creates opportunities for battery recyclers and related businesses.

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Operators of battery storage facilities should be aware of the Producer Responsibility Regulations. Under the Regulations, industrial battery producers are obliged to:

- take back waste industrial batteries from end users or waste disposal authorities free of charge and provide certain information for end users
- ensure all batteries taken back are delivered and accepted by an approved treatment and recycling operator
- keep a record of the amount of tonnes of batteries placed on the market and taken back
- register as a producer with the Secretary of State
- report to the Secretary of State on the weight of batteries placed on the market and collected in each compliance period (each 12 months starting from 1 January)

Putting aside the take back obligations under the producer responsibility regime, batteries have the potential to cause harm to the environment if the chemical contents escape from the casing. When a battery within a battery storage unit ceases to operate, it will need to be removed from site and dealt with in compliance with waste legislation. The party discarding the battery will have a waste duty of care under the Environmental Protection Act 1990 to ensure that this takes place.

The Waste Batteries and Accumulators Regulations 2009 also introduced a prohibition on the disposal of batteries to landfill and incineration. Batteries must be recycled or recovered by approved battery treatment operators or exported for treatment by approved battery exporters only.

Many types of batteries are classed as hazardous waste which creates additional requirements for storage and transport.

**Battery Safety Management Plan**

Battery Energy Storage Systems have the potential to pollute the environment, so we welcome the proposal to produce a Battery Safety Management Plan. You should consider the impact to all environmental receptors during each phase of development. Particular attention should be applied in advance to the impacts on groundwater and surface water from the escape of firewater/foam and any contaminants that it may contain. Suitable environmental protection measures should be provided including systems for containing and managing water run-off. You should ensure that there are multiple 'layers of protection' to prevent the source-pathway-receptor pollution route occurring.

Further Government guidance on considering potential risks of BESS in planning applications is available online: Renewable and low carbon energy - GOV.UK (www.gov.uk)

End

# Appendix 4. Greenfield Runoff Estimation UK SuDS Tool

[redacted]

# Greenfield runoff rate estimation for sites

[redacted]

| | |
|---|---|
| **Calculated by:** | [redacted] |
| **Site name:** | Beacon Fen |
| **Site location:** | Ewerby, Sleaford |

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

## Site Details

| | |
|---|---|
| **Latitude:** | 53.01379° N |
| **Longitude:** | 0.28964° W |
| **Reference:** | 2597143849 |
| **Date:** | Dec 19 2024 11:30 |

## Runoff estimation approach

IH124

## Site characteristics

**Total site area (ha):** 1

## Methodology

| | |
|---|---|
| **$Q_{BAR}$ estimation method:** | Calculate from SPR and SAAR |
| **SPR estimation method:** | Calculate from SOIL type |

## Soil characteristics

| | Default | Edited |
|---|---|---|
| **SOIL type:** | 2 | 2 |
| **HOST class:** | N/A | N/A |
| **SPR/SPRHOST:** | 0.3 | 0.3 |

## Hydrological characteristics

| | Default | Edited |
|---|---|---|
| **SAAR (mm):** | 574 | 574 |
| **Hydrological region:** | 5 | 5 |
| **Growth curve factor 1 year:** | 0.87 | 0.87 |
| **Growth curve factor 30 years:** | 2.45 | 2.45 |
| **Growth curve factor 100 years:** | 3.56 | 3.56 |
| **Growth curve factor 200 years:** | 4.21 | 4.21 |

## Notes

### (1) Is $Q_{BAR}$ < 2.0 l/s/ha?

When $Q_{BAR}$ is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

### (2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

### (3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

## Greenfield runoff rates

| | Default | Edited |
|---|---|---|

| | | |
|---|---|---|
| $Q_{BAR}$ (l/s): | 1.44 | 1.44 |
| 1 in 1 year (l/s): | 1.26 | 1.26 |
| 1 in 30 years (l/s): | 3.54 | 3.54 |
| 1 in 100 year (l/s): | 5.14 | 5.14 |
| 1 in 200 years (l/s): | 6.08 | 6.08 |

# Appendix 5. Attenuation Calculations (BESS & Onsite Substation and Bicker Fen Substation)

# Calculation Sheet

wardell armstrong

| CLIENT: | PROJECT: Beacon Fen Energy Park | JOB NO.: ST19595 | CALC. REF. NO.: |
|---|---|---|---|
| | | | PAGE: 1 OF 1 |

**CALCULATION: Causeway Flow Required Attenuation (BESS and Onsite Substation)**

## Design Settings

| | |
|---|---|
| Rainfall Methodology | FSR |
| FSR Region | England & Wales |
| M5-60 (mm) | 20.000 |
| Ratio-R | 0.400 |
| Summer CV | ☑ 0.750 |
| Winter CV | ☑ 0.840 |
| Analysis Speed | Normal |
| Skip Steady State | ☐ |
| Drain Down Time (mins) | 240 |
| Additional Storage (m³/ha) | 20.0 |

| Return Period (years) | Climate Change (CC %) | Additional Area (A %) | Additional Flow (Q %) |
|---|---|---|---|
| 1 | 0 | 0 | 0 |
| 30 | 35 | 0 | 0 |
| 100 | 40 | 0 | 0 |

Discharge Rate based on greenfield runoff rate of 2.44l/s/ha or 15.12l/s of the total impermeable area (10.5ha)

No infiltration is assumed.

### Catchment 1; Bess Area (North)

| Storage Estimate | | |
|---|---|---|
| Return Period (years) | 30 | 100 |
| Climate Change (%) | 35 | 40 |
| Impermeable Area (ha) | 5.650 | 5.650 |
| Peak Discharge (l/s) | 11.120 | 11.120 |
| Infiltration Coefficient (m/hr) (leave blank if no infiltration) | | |
| Required Storage (m³) | Calc | Calc |
| from | 3252 | 4571 |
| to | 3899 | 5223 |

1in30+35%CC = 3576m3

1in100+40%CC = 4897m3

### Catchment 2; Bess Area (South)

| Storage Estimate | | |
|---|---|---|
| Return Period (years) | 30 | 100 |
| Climate Change (%) | 35 | 40 |
| Impermeable Area (ha) | 2.150 | 2.150 |
| Peak Discharge (l/s) | 2.000 | 2.000 |
| Infiltration Coefficient (m/hr) (leave blank if no infiltration) | | |
| Required Storage (m³) | Calc | Calc |
| from | 1422 | 1925 |
| to | 1542 | 2046 |

1in30+35%CC = 1482m3

1in100+40%CC = 1985m3

### Catchment 3; Onsite Substation

| Storage Estimate | | |
|---|---|---|
| Return Period (years) | 30 | 100 |
| Climate Change (%) | 35 | 40 |
| Impermeable Area (ha) | 2.700 | 2.700 |
| Peak Discharge (l/s) | 2.000 | 2.000 |
| Infiltration Coefficient (m/hr) (leave blank if no infiltration) | | |
| Required Storage (m³) | Calc | Calc |
| from | 1828 | 2461 |
| to | 1949 | 2582 |

1in30+35%CC = 1889m3

1in100+40%CC = 2522m3

# Calculation Sheet

REF:

| CLIENT: | PROJECT: Beacon Fen Energy Park | JOB NO.: ST19595 | CALC. REF. NO.: PAGE: OF |
|---|---|---|---|

Calculation: Required Attenuation - Construction Phase Work No.'s 4A, 5A to 5D

## Causeway 'Flow' Attenuation Volume Estimate

| | |
|---|---|
| Rainfall Methodology | FSR |
| Rainfall Events | Singular |
| FSR Region | England & Wales |
| M5-60 (mm) | 20.000 |
| Ratio-R | 0.400 |
| Summer CV ☑ | 0.750 |
| Winter CV ☑ | 0.840 |

Calculations assume no infiltration as a worst case' scenario

Discharge rates based on 1.44 l/s/ha QBAR rate

### Work No. 4A, 5A, 5B and 5C

**Storage Estimate**

| | |
|---|---|
| Return Period (years) | 30 |
| Climate Change (%) | 35 |
| Impermeable Area (ha) | 5.410 |
| Peak Discharge (l/s) | 7.790 |
| Infiltration Coefficient (m/hr) (leave blank if no infiltration) | |
| Required Storage (m³) | Calc |
| from | 3350 |
| to | 3808 |

**Average: 3,579m3**

**Storage Estimate**

| | |
|---|---|
| Return Period (years) | 100 |
| Climate Change (%) | 45 |
| Impermeable Area (ha) | 5.410 |
| Peak Discharge (l/s) | 7.790 |
| Infiltration Coefficient (m/hr) (leave blank if no infiltration) | |
| Required Storage (m³) | Calc |
| from | 4802 |
| to | 5264 |

**Average: 5,033m3**

### Work No. 5D

**Storage Estimate**

| | |
|---|---|
| Return Period (years) | 30 |
| Climate Change (%) | 35 |
| Impermeable Area (ha) | 2.160 |
| Peak Discharge (l/s) | 3.110 |
| Infiltration Coefficient (m/hr) (leave blank if no infiltration) | |
| Required Storage (m³) | Calc |
| from | 1338 |
| to | 1520 |

**Average: 1,429m3**

**Storage Estimate**

| | |
|---|---|
| Return Period (years) | 100 |
| Climate Change (%) | 40 |
| Impermeable Area (ha) | 2.160 |
| Peak Discharge (l/s) | 3.110 |
| Infiltration Coefficient (m/hr) (leave blank if no infiltration) | |
| Required Storage (m³) | Calc |
| from | 1842 |
| to | 2027 |

**Average: 1,935m3**

# Calculation Sheet

REF:

| CLIENT: | PROJECT: Beacon Fen Energy Park | JOB NO.: ST19595 | CALC. REF. NO.: PAGE: OF |
|---|---|---|---|

Calculation: Required Attenuation - Construction Phase Existing Bicker Fen Substation

## Causeway 'Flow' Attenuation Volume Estimate

| | |
|---|---|
| Rainfall Methodology | FSR |
| Rainfall Events | Singular |
| FSR Region | England & Wales |
| M5-60 (mm) | 20.000 |
| Ratio-R | 0.400 |
| Summer CV ☑ | 0.750 |
| Winter CV ☑ | 0.840 |

Calculations assume no infiltration as a 'worst case' scenario
Discharge rates based on 1.44 l/s/ha QBAR rate

### Existing Substation

**Storage Estimate**

| | |
|---|---|
| Return Period (years) | 30 |
| Climate Change (%) | 35 |
| Impermeable Area (ha) | 7.140 |
| Peak Discharge (l/s) | 10.280 |
| Infiltration Coefficient (m/hr) (leave blank if no infiltration) | |
| Required Storage ($m^3$) | Calc |
| from | 4422 |
| to | 5025 |

**Average: 4,724m3**

**Storage Estimate**

| | |
|---|---|
| Return Period (years) | 100 |
| Climate Change (%) | 40 |
| Impermeable Area (ha) | 7.140 |
| Peak Discharge (l/s) | 10.280 |
| Infiltration Coefficient (m/hr) (leave blank if no infiltration) | |
| Required Storage ($m^3$) | Calc |
| from | 6089 |
| to | 6699 |

**Average: 6,394m3**

# Calculation Sheet

REF:

| CLIENT: | PROJECT: | JOB NO.: | CALC. REF. NO.: | |
|---|---|---|---|---|
| | Beacon Fen Energy Park | ST19595 | PAGE: | OF |

Calculation: Required Attenuation - Operational Phase Work No.'s 4A, 5A to 5D

## Causeway 'Flow' Attenuation Volume Estimate

| | |
|---|---|
| Rainfall Methodology | FSR |
| Rainfall Events | Singular |
| FSR Region | England & Wales |
| M5-60 (mm) | 20.000 |
| Ratio-R | 0.400 |
| Summer CV ☑ | 0.750 |
| Winter CV ☑ | 0.840 |

Calculations assume no infiltration as a 'worst case' scenario

Discharge rates based on 1.44 l/s/ha QBAR rate

Existing Bicker Fen Substation is not modified

### Work No. 5B (all other areas within 4A, 5A and 5C revegetated)

| Storage Estimate | | Storage Estimate | |
|---|---|---|---|
| Return Period (years) | 30 | Return Period (years) | 100 |
| Climate Change (%) | 35 | Climate Change (%) | 40 |
| Impermeable Area (ha) | 2.200 | Impermeable Area (ha) | 2.200 |
| Peak Discharge (l/s) | 3.170 | Peak Discharge (l/s) | 3.170 |
| Infiltration Coefficient (m/hr) (leave blank if no infiltration) | | Infiltration Coefficient (m/hr) (leave blank if no infiltration) | |
| Required Storage (m³) | Calc | Required Storage (m³) | Calc |
| from | 1362 | from | 1876 |
| to | 1548 | to | 2064 |

**Average: 1,455m3** **Average: 1,970m3**

### Work No. 5D (existing aggregate compound retained - other areas of 5D revegetated)

| Storage Estimate | | Storage Estimate | |
|---|---|---|---|
| Return Period (years) | 30 | Return Period (years) | 100 |
| Climate Change (%) | 35 | Climate Change (%) | 40 |
| Impermeable Area (ha) | 0.770 | Impermeable Area (ha) | 0.770 |
| Peak Discharge (l/s) | 1.110 | Peak Discharge (l/s) | 1.110 |
| Infiltration Coefficient (m/hr) (leave blank if no infiltration) | | Infiltration Coefficient (m/hr) (leave blank if no infiltration) | |
| Required Storage (m³) | Calc | Required Storage (m³) | Calc |
| from | 477 | from | 657 |
| to | 542 | to | 722 |

**Average: 510m3** **Average: 690m3**

# Calculation Sheet

REF:

| CLIENT: | PROJECT: Beacon Fen Energy Park | JOB NO.: ST19595 | CALC. REF. NO.: PAGE: OF |
|---|---|---|---|

Calculation: Required Attenuation - Operational Phase Existing Bicker Fen Substation

## Causeway 'Flow' Attenuation Volume Estimate

| | |
|---|---|
| Rainfall Methodology | FSR |
| Rainfall Events | Singular |
| FSR Region | England & Wales |
| M5-60 (mm) | 20.000 |
| Ratio-R | 0.400 |
| Summer CV ☑ | 0.750 |
| Winter CV ☑ | 0.840 |

Calculations assume no infiltration as a 'worst case' scenario
Discharge rates based on 1.44 l/s/ha QBAR rate

### Substation

**Storage Estimate**

| | |
|---|---|
| Return Period (years) | 30 |
| Climate Change (%) | 35 |
| Impermeable Area (ha) | 7.140 |
| Peak Discharge (l/s) | 10.280 |
| Infiltration Coefficient (m/hr) (leave blank if no infiltration) | |
| Required Storage (m³) | Calc |
| from | 4422 |
| to | 5025 |

**Average: 4,723m3**

**Storage Estimate**

| | |
|---|---|
| Return Period (years) | 100 |
| Climate Change (%) | 40 |
| Impermeable Area (ha) | 7.140 |
| Peak Discharge (l/s) | 10.280 |
| Infiltration Coefficient (m/hr) (leave blank if no infiltration) | |
| Required Storage (m³) | Calc |
| from | 6089 |
| to | 6699 |

**Average: 6,394m3**

# Calculation Sheet

REF:

| CLIENT: | PROJECT: Beacon Fen Energy Park | JOB NO.: ST19595 | CALC. REF. NO.: PAGE: 1 OF 1 |
|---|---|---|---|

Calculation: Required Attenuation - Worst Case Fire Event

**Causeway 'Flow' Attenuation Volume Estimate**

| | | |
|---|---|---|
| Rainfall Methodology | | FSR |
| Rainfall Events | | Singular |
| FSR Region | | England & Wales |
| M5-60 (mm) | | 20.000 |
| Ratio-R | | 0.400 |
| Summer CV | ☑ | 0.750 |
| Winter CV | ☑ | 0.840 |

Development will be lined and no infiltration is applied to calculations

All shut off valves closed and no discharge off site

1 in 10 year event is considered a reasonable worst-case scenario

**Impermeable Area (individual BESS area)**

Storage Estimate

| | |
|---|---|
| Return Period (years) | 10 |
| Climate Change (%) | 35 |
| Impermeable Area (ha) | 0.310 |
| Peak Discharge (l/s) | 0.000 |
| Infiltration Coefficient (m/hr) (leave blank if no infiltration) | |
| Required Storage (m³) | Calc |
| from | 185 |
| to | 185 |

**Total: 185m3**

**Attenuation provided within aggregate void space (0.3 void ration @ 0.5m depth = 465m3**

**Including 360m3 firewater required for 4 hour fire event = 545m3 required attenuation**

**Sufficient capacity for rainfall**
**Additional capacity is required within lagoon for firewater + rainfall**

# Appendix 6. Access Track Runoff Volume Calculation; 1 in 100 year, 6hr pre dev

# Pre-Development Runoff Volume
## 1 in 100 Year Storm Event

**Runoff Volume for Specified Storm:** **13.1 $m^3$**

| FACTOR | VALUE | SOURCE |
|---|---|---|
| Design Return Period (yrs): | 100 | |
| Design Storm Duration (mins) | 360 | |
| Contributing Area (ha): | 0.05 | Site plans **(100m X 5m)** |
| Impervious, PIMP (%): | 0 | Site plans |
| M5-60min (mm): | 20 | Volume 3 maps and site location |
| SAAR (mm/yr): | 568 | Volume 3 maps and site location |
| Ratio, r: | 0.4 | Volume 3 maps and site location |
| SOIL: | 2 | Soil Type and Volume 1, Section 7.4 |
| UCWI: | 41 | SAAR and Volume 1, Figure 9.7 |
| Calculated PR | 32.49 | |
| Percentage Runoff = | 30.00 | |

| FACTOR | VALUE |
|---|---|
| Additional Inflow (l/s): | 0 |
| Climate Change Allowance | 40 |
| Calculate/Specify PR | Specify |
| Specify PR: | |

| Duration, D (min) | M5-60 (mm) | Z1 for r=0.40 | M5-D (mm) | Z2 for M100 | M100-D (mm) | incl climate change | Area C (ha) | PR (%) | Runoff (m3) | Add. Runoff (m3) | Total Runoff (m3) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 20 | 0.38 | 7.6 | 1.86 | 14.2 | 19.8 | 0.05 | 30 | 3.0 | 0.0 | 3.0 |
| 10 | 20 | 0.54 | 10.8 | 1.93 | 20.8 | 29.1 | 0.05 | 30 | 4.4 | 0.0 | 4.4 |
| 15 | 20 | 0.63 | 12.6 | 1.96 | 24.7 | 34.5 | 0.05 | 30 | 5.2 | 0.0 | 5.2 |
| 30 | 20 | 0.80 | 16.0 | 2.00 | 32.0 | 44.8 | 0.05 | 30 | 6.7 | 0.0 | 6.7 |
| 60 | 20 | 1.00 | 20.0 | 2.03 | 40.6 | 56.8 | 0.05 | 30 | 8.5 | 0.0 | 8.5 |
| 120 | 20 | 1.20 | 24.0 | 2.01 | 48.3 | 67.7 | 0.05 | 30 | 10.2 | 0.0 | 10.2 |
| 240 | 20 | 1.46 | 29.2 | 1.98 | 57.8 | 80.9 | 0.05 | 30 | 12.1 | 0.0 | 12.1 |
| ***360*** | ***20*** | ***1.60*** | ***32.0*** | ***1.95*** | ***62.5*** | ***87.5*** | ***0.05*** | ***30*** | ***13.1*** | ***0.0*** | ***13.1*** |
| 480 | 20 | 1.70 | 34.0 | 1.94 | 65.9 | 92.2 | 0.05 | 30 | 13.8 | 0.0 | 13.8 |
| 600 | 20 | 1.83 | 36.6 | 1.91 | 70.1 | 98.1 | 0.05 | 30 | 14.7 | 0.0 | 14.7 |
| 720 | 20 | 1.85 | 37.0 | 1.91 | 70.8 | 99.1 | 0.05 | 30 | 14.9 | 0.0 | 14.9 |
| 840 | 20 | 1.90 | 38.0 | 1.91 | 72.4 | 101.4 | 0.05 | 30 | 15.2 | 0.0 | 15.2 |
| 1440 | 20 | 2.28 | 45.6 | 1.84 | 84.0 | 117.6 | 0.05 | 30 | 17.6 | 0.0 | 17.6 |
| 2880 | 20 | 2.70 | 54.0 | 1.78 | 96.3 | 134.8 | 0.05 | 30 | 20.2 | 0.0 | 20.2 |

# Appendix 7. Access Track Runoff Volume Calculation; 1 in 100 year, 6hr post dev

**Runoff Volume for Specified Storm:** **43.8 $m^3$**

| FACTOR | VALUE | SOURCE |
| --- | --- | --- |
| Design Return Period (yrs): | 100 | |
| Design Storm Duration (mins) | 360 | |
| Contributing Area (ha): | 0.05 | Site plans (100m X 5m) |
| Impervious, PIMP (%): | 100 | Site plans |
| M5-60min (mm): | 20 | Volume 3 maps and site location |
| SAAR (mm/yr): | 568 | Volume 3 maps and site location |
| Ratio, r: | 0.4 | Volume 3 maps and site location |
| SOIL: | 2 | Soil Type and Volume 1, Section 7.4 |
| UCWI: | 41 | SAAR and Volume 1, Figure 9.7 |
| Calculated PR | 115.39 | |
| Percentage Runoff = | 100.00 | |

| FACTOR | VALUE |
| --- | --- |
| Additional Inflow (l/s): | 0 |
| Climate Change Allowance | 40 |
| Calculate/Specify PR | Specify |
| Specify PR: | |

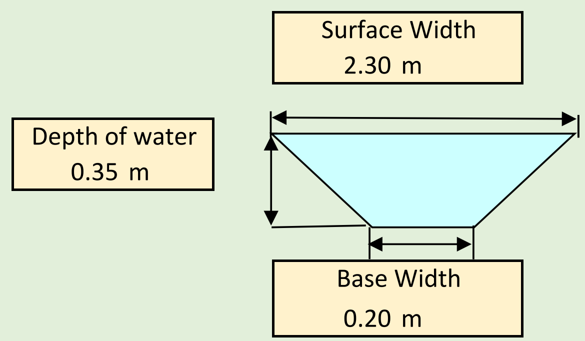
| Duration, D (min) | M5-60 (mm) | Z1 for r=0.40 | M5-D (mm) | Z2 for M100 | M100-D (mm) | incl climate change | Area C (ha) | PR (%) | Runoff (m3) | Add. Runoff (m3) | Total Runoff (m3) |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 5 | 20 | 0.38 | 7.6 | 1.86 | 14.2 | 19.8 | 0.05 | 100 | 9.9 | 0.0 | 9.9 |
| 10 | 20 | 0.54 | 10.8 | 1.93 | 20.8 | 29.1 | 0.05 | 100 | 14.6 | 0.0 | 14.6 |
| 15 | 20 | 0.63 | 12.6 | 1.96 | 24.7 | 34.5 | 0.05 | 100 | 17.3 | 0.0 | 17.3 |
| 30 | 20 | 0.80 | 16.0 | 2.00 | 32.0 | 44.8 | 0.05 | 100 | 22.4 | 0.0 | 22.4 |
| 60 | 20 | 1.00 | 20.0 | 2.03 | 40.6 | 56.8 | 0.05 | 100 | 28.4 | 0.0 | 28.4 |
| 120 | 20 | 1.20 | 24.0 | 2.01 | 48.3 | 67.7 | 0.05 | 100 | 33.8 | 0.0 | 33.8 |
| 240 | 20 | 1.46 | 29.2 | 1.98 | 57.8 | 80.9 | 0.05 | 100 | 40.4 | 0.0 | 40.4 |
| ***360*** | ***20*** | ***1.60*** | ***32.0*** | ***1.95*** | ***62.5*** | ***87.5*** | ***0.05*** | ***100*** | ***43.8*** | ***0.0*** | ***43.8*** |
| 480 | 20 | 1.70 | 34.0 | 1.94 | 65.9 | 92.2 | 0.05 | 100 | 46.1 | 0.0 | 46.1 |
| 600 | 20 | 1.83 | 36.6 | 1.91 | 70.1 | 98.1 | 0.05 | 100 | 49.0 | 0.0 | 49.0 |
| 720 | 20 | 1.85 | 37.0 | 1.91 | 70.8 | 99.1 | 0.05 | 100 | 49.6 | 0.0 | 49.6 |
| 840 | 20 | 1.90 | 38.0 | 1.91 | 72.4 | 101.4 | 0.05 | 100 | 50.7 | 0.0 | 50.7 |
| 1440 | 20 | 2.28 | 45.6 | 1.84 | 84.0 | 117.6 | 0.05 | 100 | 58.8 | 0.0 | 58.8 |
| 2880 | 20 | 2.70 | 54.0 | 1.78 | 96.3 | 134.8 | 0.05 | 100 | 67.4 | 0.0 | 67.4 |

# Appendix 8. Access Track; Swale Volume Calculation

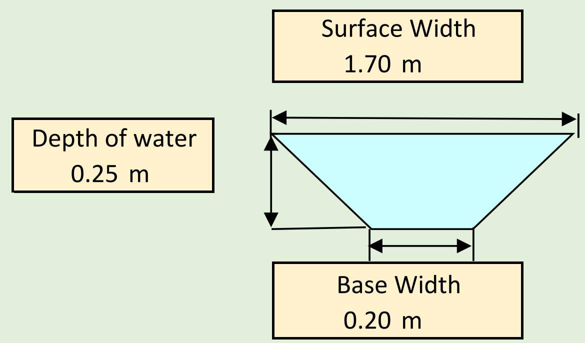
## Swale Volume Calculation - Access Tracks (requiring 30.7m3 per 100m of track (0.05ha))

| | | |
|---|---|---|
| Length of Swale | 100.00 | m |
| Gradient (1:x) | 1000 | |
| Side Slope (1:X) | 3 | |
| **Downstream** | | |
| Surface Width (at water level) | 2.30 | m |
| Base Width | 0.20 | m |
| Depth of water | 0.35 | m |
| Cross-sectional area | 0.44 | $m^2$ |
| **Upstream** | | |
| Base Width | 0.20 | m |
| Surface Width (at water level) | 1.7 | m54.14 |
| Avg Width | 0.95 | m |
| Depth of Water | 0.2500 | m |
| Cross-sectional area | 0.24 | $m^2$ |
| Length of swale with water | 350.00 | m |
| Volume of water | **33.24** | **$m^3$** |

**Downstream Cross-Section**




**Upstream Cross-Section**



# Appendix 9. Transformer Runoff Volume Calculation; 1 in 100 year, 6hr pre dev

**Runoff Volume for Specified Storm:** **0.6 $m^3$**

| FACTOR | VALUE | SOURCE |
|---|---|---|
| Design Return Period (yrs): | 100 | |
| Design Storm Duration (mins) | 360 | |
| Contributing Area (ha): | 0.0021 | Site plans |
| Impervious, PIMP (%): | 0 | Site plans |
| M5-60min (mm): | 20 | Volume 3 maps and site location |
| SAAR (mm/yr): | 568 | Volume 3 maps and site location |
| Ratio, r: | 0.4 | Volume 3 maps and site location |
| SOIL: | 2 | Soil Type and Volume 1, Section 7.4 |
| UCWI: | 41 | SAAR and Volume 1, Figure 9.7 |
| Calculated PR | 32.49 | |
| Percentage Runoff = | 30.00 | |

| FACTOR | VALUE |
|---|---|
| Additional Inflow (l/s): | 0 |
| Climate Change Allowance | 40 |
| Calculate/Specify PR | Specify |
| Specify PR: | |

| Duration, D (min) | M5-60 (mm) | Z1 for r=0.40 | M5-D (mm) | Z2 for M100 | M100-D (mm) | incl climate change | Area C (ha) | PR (%) | Runoff (m3) | Add. Runoff (m3) | Total Runoff (m3) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 20 | 0.38 | 7.6 | 1.86 | 14.2 | 19.8 | 0.00 | 30 | 0.1 | 0.0 | 0.1 |
| 10 | 20 | 0.54 | 10.8 | 1.93 | 20.8 | 29.1 | 0.00 | 30 | 0.2 | 0.0 | 0.2 |
| 15 | 20 | 0.63 | 12.6 | 1.96 | 24.7 | 34.5 | 0.00 | 30 | 0.2 | 0.0 | 0.2 |
| 30 | 20 | 0.80 | 16.0 | 2.00 | 32.0 | 44.8 | 0.00 | 30 | 0.3 | 0.0 | 0.3 |
| 60 | 20 | 1.00 | 20.0 | 2.03 | 40.6 | 56.8 | 0.00 | 30 | 0.4 | 0.0 | 0.4 |
| 120 | 20 | 1.20 | 24.0 | 2.01 | 48.3 | 67.7 | 0.00 | 30 | 0.4 | 0.0 | 0.4 |
| 240 | 20 | 1.46 | 29.2 | 1.98 | 57.8 | 80.9 | 0.00 | 30 | 0.5 | 0.0 | 0.5 |
| ***360*** | ***20*** | ***1.60*** | ***32.0*** | ***1.95*** | ***62.5*** | ***87.5*** | ***0.00*** | ***30*** | ***0.6*** | ***0.0*** | ***0.6*** |
| 480 | 20 | 1.70 | 34.0 | 1.94 | 65.9 | 92.2 | 0.00 | 30 | 0.6 | 0.0 | 0.6 |
| 600 | 20 | 1.83 | 36.6 | 1.91 | 70.1 | 98.1 | 0.00 | 30 | 0.6 | 0.0 | 0.6 |
| 720 | 20 | 1.85 | 37.0 | 1.91 | 70.8 | 99.1 | 0.00 | 30 | 0.6 | 0.0 | 0.6 |
| 840 | 20 | 1.90 | 38.0 | 1.91 | 72.4 | 101.4 | 0.00 | 30 | 0.6 | 0.0 | 0.6 |
| 1440 | 20 | 2.28 | 45.6 | 1.84 | 84.0 | 117.6 | 0.00 | 30 | 0.7 | 0.0 | 0.7 |
| 2880 | 20 | 2.70 | 54.0 | 1.78 | 96.3 | 134.8 | 0.00 | 30 | 0.8 | 0.0 | 0.8 |

# Appendix 10. Transformer Runoff Volume Calculation; 1 in 100 year, 6hr post dev

# Post-Development Runoff Volume
# 1 in 100 Year Storm Event



**Runoff Volume for Specified Storm:** **1.8 $m^3$**

| FACTOR | VALUE | SOURCE |
|---|---|---|
| Design Return Period (yrs): | 100 | |
| Design Storm Duration (mins) | 360 | |
| Contributing Area (ha): | 0.0021 | Site plans (100m X 5m) |
| Impervious, PIMP (%): | 100 | Site plans |
| M5-60min (mm): | 20 | Volume 3 maps and site location |
| SAAR (mm/yr): | 568 | Volume 3 maps and site location |
| Ratio, r: | 0.4 | Volume 3 maps and site location |
| SOIL: | 2 | Soil Type and Volume 1, Section 7.4 |
| UCWI: | 41 | SAAR and Volume 1, Figure 9.7 |
| Calculated PR | 115.39 | |
| Percentage Runoff = | 100.00 | |

| FACTOR | VALUE |
|---|---|
| Additional Inflow (l/s): | 0 |
| Climate Change Allowance | 40 |
| Calculate/Specify PR | Specify |
| Specify PR: | |

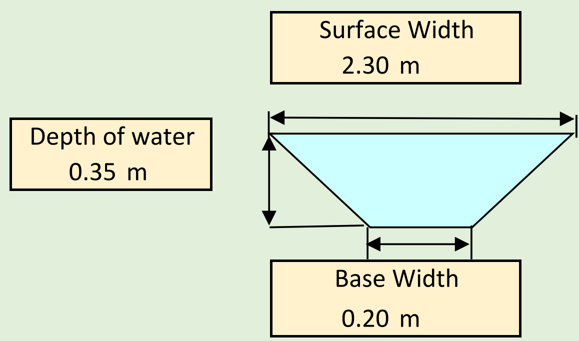
| Duration, D (min) | M5-60 (mm) | Z1 for r=0.40 | M5-D (mm) | Z2 for M100 | M100-D (mm) | incl climate change | Area C (ha) | PR (%) | Runoff (m3) | Add. Runoff (m3) | Total Runoff (m3) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 20 | 0.38 | 7.6 | 1.86 | 14.2 | 19.8 | 0.00 | 100 | 0.4 | 0.0 | 0.4 |
| 10 | 20 | 0.54 | 10.8 | 1.93 | 20.8 | 29.1 | 0.00 | 100 | 0.6 | 0.0 | 0.6 |
| 15 | 20 | 0.63 | 12.6 | 1.96 | 24.7 | 34.5 | 0.00 | 100 | 0.7 | 0.0 | 0.7 |
| 30 | 20 | 0.80 | 16.0 | 2.00 | 32.0 | 44.8 | 0.00 | 100 | 0.9 | 0.0 | 0.9 |
| 60 | 20 | 1.00 | 20.0 | 2.03 | 40.6 | 56.8 | 0.00 | 100 | 1.2 | 0.0 | 1.2 |
| 120 | 20 | 1.20 | 24.0 | 2.01 | 48.3 | 67.7 | 0.00 | 100 | 1.4 | 0.0 | 1.4 |
| 240 | 20 | 1.46 | 29.2 | 1.98 | 57.8 | 80.9 | 0.00 | 100 | 1.7 | 0.0 | 1.7 |
| ***360*** | ***20*** | ***1.60*** | ***32.0*** | ***1.95*** | ***62.5*** | ***87.5*** | ***0.00*** | ***100*** | ***1.8*** | ***0.0*** | ***1.8*** |
| 480 | 20 | 1.70 | 34.0 | 1.94 | 65.9 | 92.2 | 0.00 | 100 | 1.9 | 0.0 | 1.9 |
| 600 | 20 | 1.83 | 36.6 | 1.91 | 70.1 | 98.1 | 0.00 | 100 | 2.1 | 0.0 | 2.1 |
| 720 | 20 | 1.85 | 37.0 | 1.91 | 70.8 | 99.1 | 0.00 | 100 | 2.1 | 0.0 | 2.1 |
| 840 | 20 | 1.90 | 38.0 | 1.91 | 72.4 | 101.4 | 0.00 | 100 | 2.1 | 0.0 | 2.1 |
| 1440 | 20 | 2.28 | 45.6 | 1.84 | 84.0 | 117.6 | 0.00 | 100 | 2.5 | 0.0 | 2.5 |
| 2880 | 20 | 2.70 | 54.0 | 1.78 | 96.3 | 134.8 | 0.00 | 100 | 2.8 | 0.0 | 2.8 |

# Appendix 11. Transformer; Swale Volume Calculation

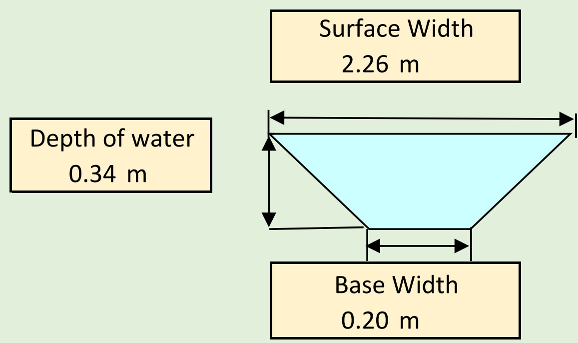
## Swale Volume Calculation - Transformer (requiring 1.2m3 within 6m length of swale)

| | | |
|---|---|---|
| Length of Swale | 6.00 | m |
| Gradient (1:x) | 1000 | |
| Side Slope (1:X) | 3 | |
| **Downstream** | | |
| Surface Width (at water level) | 2.30 | m |
| Base Width | 0.20 | m |
| Depth of water | 0.35 | m |
| Cross-sectional area | 0.44 | $m^2$ |
| **Upstream** | | |
| Base Width | 0.20 | m |
| Surface Width (at water level) | 2.26 | m54.14 |
| Avg Width | 1.23 | m |
| Depth of Water | 0.3440 | m |
| Cross-sectional area | 0.42 | $m^2$ |
| Length of swale with water | 350.00 | m |
| Volume of water | **2.58** | **$m^3$** |

**Downstream Cross-Section**




**Upstream Cross-Section**



# Appendix 12. Bespoke Access Road Runoff Volume Calculation; 1 in 100 year, 6hr pre dev

## Pre-Development Runoff Volume
## 1 in 100 Year Storm Event



**Runoff Volume for Specified Storm:** **15.8 $m^3$**

| FACTOR | VALUE | SOURCE |
|---|---|---|
| Design Return Period (yrs): | 100 | |
| Design Storm Duration (mins) | 360 | |
| Contributing Area (ha): | 0.06 | Site plans **(100m X 6m)** |
| Impervious, PIMP (%): | 0 | Site plans |
| M5-60min (mm): | 20 | Volume 3 maps and site location |
| SAAR (mm/yr): | 568 | Volume 3 maps and site location |
| Ratio, r: | 0.4 | Volume 3 maps and site location |
| SOIL: | 2 | Soil Type and Volume 1, Section 7.4 |
| UCWI: | 41 | SAAR and Volume 1, Figure 9.7 |
| Calculated PR | 32.49 | |
| Percentage Runoff = | 30.00 | |

| FACTOR | VALUE |
|---|---|
| Additional Inflow (l/s): | 0 |
| Climate Change Allowance | 40 |
| Calculate/Specify PR | Specify |
| Specify PR: | |

| Duration, D (min) | M5-60 (mm) | Z1 for r=0.40 | M5-D (mm) | Z2 for M100 | M100-D (mm) | incl climate change | Area C (ha) | PR (%) | Runoff (m3) | Add. Runoff (m3) | Total Runoff (m3) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 20 | 0.38 | 7.6 | 1.86 | 14.2 | 19.8 | 0.06 | 30 | 3.6 | 0.0 | 3.6 |
| 10 | 20 | 0.54 | 10.8 | 1.93 | 20.8 | 29.1 | 0.06 | 30 | 5.2 | 0.0 | 5.2 |
| 15 | 20 | 0.63 | 12.6 | 1.96 | 24.7 | 34.5 | 0.06 | 30 | 6.2 | 0.0 | 6.2 |
| 30 | 20 | 0.80 | 16.0 | 2.00 | 32.0 | 44.8 | 0.06 | 30 | 8.1 | 0.0 | 8.1 |
| 60 | 20 | 1.00 | 20.0 | 2.03 | 40.6 | 56.8 | 0.06 | 30 | 10.2 | 0.0 | 10.2 |
| 120 | 20 | 1.20 | 24.0 | 2.01 | 48.3 | 67.7 | 0.06 | 30 | 12.2 | 0.0 | 12.2 |
| 240 | 20 | 1.46 | 29.2 | 1.98 | 57.8 | 80.9 | 0.06 | 30 | 14.6 | 0.0 | 14.6 |
| ***360*** | ***20*** | ***1.60*** | ***32.0*** | ***1.95*** | ***62.5*** | ***87.5*** | ***0.06*** | ***30*** | ***15.8*** | ***0.0*** | ***15.8*** |
| 480 | 20 | 1.70 | 34.0 | 1.94 | 65.9 | 92.2 | 0.06 | 30 | 16.6 | 0.0 | 16.6 |
| 600 | 20 | 1.83 | 36.6 | 1.91 | 70.1 | 98.1 | 0.06 | 30 | 17.7 | 0.0 | 17.7 |
| 720 | 20 | 1.85 | 37.0 | 1.91 | 70.8 | 99.1 | 0.06 | 30 | 17.8 | 0.0 | 17.8 |
| 840 | 20 | 1.90 | 38.0 | 1.91 | 72.4 | 101.4 | 0.06 | 30 | 18.3 | 0.0 | 18.3 |
| 1440 | 20 | 2.28 | 45.6 | 1.84 | 84.0 | 117.6 | 0.06 | 30 | 21.2 | 0.0 | 21.2 |
| 2880 | 20 | 2.70 | 54.0 | 1.78 | 96.3 | 134.8 | 0.06 | 30 | 24.3 | 0.0 | 24.3 |

# Appendix 13. Bespoke Access Road Runoff Volume Calculation; 1 in 100 year, 6hr post dev

**Runoff Volume for Specified Storm:** **52.5 $m^3$**

| FACTOR | VALUE | SOURCE |
|---|---|---|
| Design Return Period (yrs): | 100 | |
| Design Storm Duration (mins) | 360 | |
| Contributing Area (ha): | 0.06 | Site plans (100m X 6m) |
| Impervious, PIMP (%): | 100 | Site plans |
| M5-60min (mm): | 20 | Volume 3 maps and site location |
| SAAR (mm/yr): | 568 | Volume 3 maps and site location |
| Ratio, r: | 0.4 | Volume 3 maps and site location |
| SOIL: | 2 | Soil Type and Volume 1, Section 7.4 |
| UCWI: | 41 | SAAR and Volume 1, Figure 9.7 |
| Calculated PR | 115.39 | |
| Percentage Runoff = | 100.00 | |

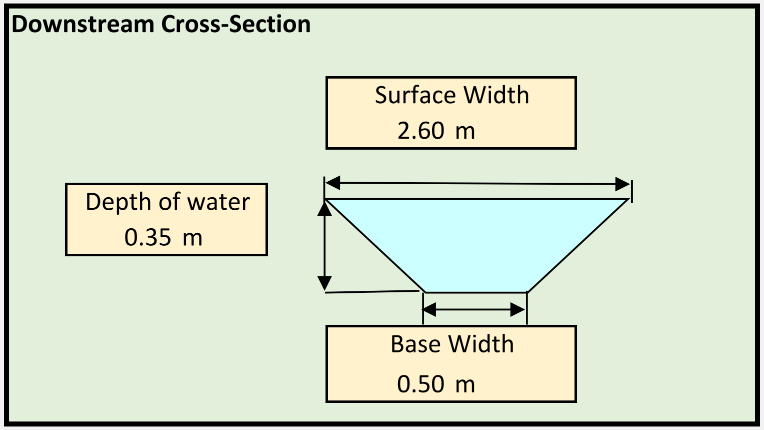
| FACTOR | VALUE |
|---|---|
| Additional Inflow (l/s): | 0 |
| Climate Change Allowance | 40 |
| Calculate/Specify PR | Specify |
| Specify PR: | |

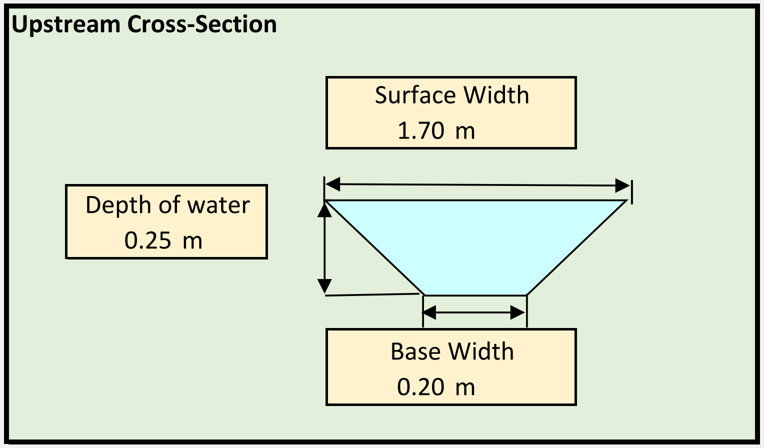
| Duration, D (min) | M5-60 (mm) | Z1 for r=0.40 | M5-D (mm) | Z2 for M100 | M100-D (mm) | incl climate change | Area C (ha) | PR (%) | Runoff (m3) | Add. Runoff (m3) | Total Runoff (m3) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 20 | 0.38 | 7.6 | 1.86 | 14.2 | 19.8 | 0.06 | 100 | 11.9 | 0.0 | 11.9 |
| 10 | 20 | 0.54 | 10.8 | 1.93 | 20.8 | 29.1 | 0.06 | 100 | 17.5 | 0.0 | 17.5 |
| 15 | 20 | 0.63 | 12.6 | 1.96 | 24.7 | 34.5 | 0.06 | 100 | 20.7 | 0.0 | 20.7 |
| 30 | 20 | 0.80 | 16.0 | 2.00 | 32.0 | 44.8 | 0.06 | 100 | 26.9 | 0.0 | 26.9 |
| 60 | 20 | 1.00 | 20.0 | 2.03 | 40.6 | 56.8 | 0.06 | 100 | 34.1 | 0.0 | 34.1 |
| 120 | 20 | 1.20 | 24.0 | 2.01 | 48.3 | 67.7 | 0.06 | 100 | 40.6 | 0.0 | 40.6 |
| 240 | 20 | 1.46 | 29.2 | 1.98 | 57.8 | 80.9 | 0.06 | 100 | 48.5 | 0.0 | 48.5 |
| ***360*** | ***20*** | ***1.60*** | ***32.0*** | ***1.95*** | ***62.5*** | ***87.5*** | ***0.06*** | ***100*** | ***52.5*** | ***0.0*** | ***52.5*** |
| 480 | 20 | 1.70 | 34.0 | 1.94 | 65.9 | 92.2 | 0.06 | 100 | 55.3 | 0.0 | 55.3 |
| 600 | 20 | 1.83 | 36.6 | 1.91 | 70.1 | 98.1 | 0.06 | 100 | 58.8 | 0.0 | 58.8 |
| 720 | 20 | 1.85 | 37.0 | 1.91 | 70.8 | 99.1 | 0.06 | 100 | 59.5 | 0.0 | 59.5 |
| 840 | 20 | 1.90 | 38.0 | 1.91 | 72.4 | 101.4 | 0.06 | 100 | 60.8 | 0.0 | 60.8 |
| 1440 | 20 | 2.28 | 45.6 | 1.84 | 84.0 | 117.6 | 0.06 | 100 | 70.6 | 0.0 | 70.6 |
| 2880 | 20 | 2.70 | 54.0 | 1.78 | 96.3 | 134.8 | 0.06 | 100 | 80.9 | 0.0 | 80.9 |

# Appendix 14. Bespoke Access Road; Swale Volume Calculation- single slope

**Swale Volume Calculation - Access Road (single slope) (requiring 36.7m3 per 100m of track (0.06ha))**

| | | |
|---|---|---|
| Length of Swale | 100.00 | m |
| Gradient (1:x) | 1000 | |
| Side Slope (1:X) | 3 | |
| **Downstream** | | |
| Surface Width (at water level) | 2.60 | m |
| Base Width | 0.50 | m |
| Depth of water | 0.35 | m |
| Cross-sectional area | 0.54 | $m^2$ |
| **Upstream** | | |
| Base Width | 0.20 | m |
| Surface Width (at water level) | 1.7 | m54.14 |
| Avg Width | 0.95 | m |
| Depth of Water | 0.2500 | m |
| Cross-sectional area | 0.24 | $m^2$ |
| Length of swale with water | 350.00 | m |
| Volume of water | **37.96** | **$m^3$** |



# Appendix 15. Bespoke Access Road; Swale Volume Calculation - dual slope

## Swale Volume Calculation - Access Road (dual slope (X2 swales requiring 18.4m3 each per 100m of track (0.06ha))

| | | |
|---|---|---|
| Length of Swale | 100.00 | m |
| Gradient (1:x) | 1000 | |
| Side Slope (1:X) | 3 | |
| **Downstream** | | |
| Surface Width (at water level) | 1.90 | m |
| Base Width | 0.40 | m |
| Depth of water | 0.25 | m |
| Cross-sectional area | 0.29 | $m^2$ |
| **Upstream** | | |
| Base Width | 0.20 | m |
| Surface Width (at water level) | 1.1 | m54.14 |
| Avg Width | 0.65 | m |
| Depth of Water | 0.1500 | m |
| Cross-sectional area | 0.10 | $m^2$ |
| Length of swale with water | 250.00 | m |
| Volume of water | **18.41** | **$m^3$** |