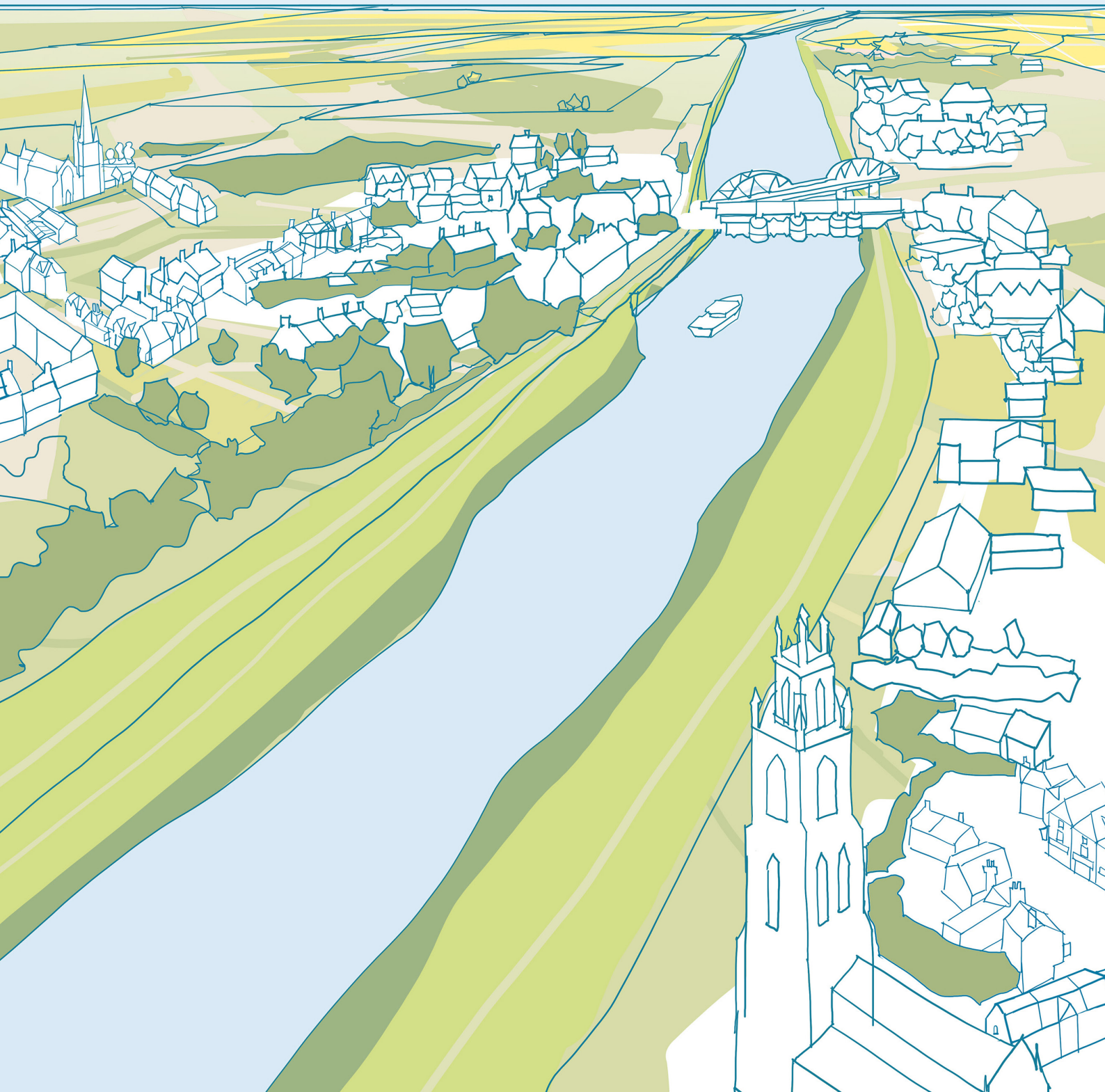


Witham East and West Fens

Flood risk baseline

2025



Contents

Glossary of Terms	1
1. Introduction	3
1.1 Aim and purpose of this document	3
1.2 Usage statement	3
1.3 The Fens 2100+ study area	3
1.4 East and West Fens catchment	4
1.5 Catchment context	5
1.6 Key assets	8
2. Notable flood history	17
2.1 November 1810	17
2.2 March 1947	17
2.3 January 1953	17
2.4 1977	17
2.5 November 1978	17
2.6 April 1981	18
2.7 1993	19
2.8 Summer 2007	20
2.9 December 2013	21
2.10 2019-2020	23
2.11 October 2023	24
2.12 Other events	27
2.13 Discussion	27
3. Methodology and data review	28
3.1 Methodology	28
3.2 Detailed hydraulic modelling	28
3.3 Other data sources	32
3.4 Other sources of information	34
3.5 Key receptors	35
4. Climate Change	39
4.1 Tidal climate change	39
4.1 H++ scenario	40
4.2 Fluvial climate change	40
4.3 Conclusion	41
5. Tidal Flood Risk	43
5.1 Current tidal flood risk	43
5.2 Future tidal flood risk	44
5.3 Key metrics	46

5.4	Discussion	47
6.	Fluvial Flood Risk	48
6.1	Current fluvial flood risk	48
6.2	Future fluvial flood risk	49
6.3	Key metrics	50
6.4	Discussion	51
7.	Other sources of flooding	53
7.1	Surface water and drainage	53
7.2	Groundwater	53
7.3	Reservoir	54
8.	Summary and recommendations	55
8.1	Tidal Flood Risk	55
8.2	Fluvial Flood Risk	55
8.3	Conclusions	55

Tables

Table 1: Overview of ALC classification within the catchment	36
Table 2: Sea level allowances for each epoch	39
Table 3: Witham Management Catchment peak river flow allowances	41
Table 4: Agricultural land grading at risk of tidal flooding	47
Table 5: Agricultural land grading at risk of fluvial flooding	51

Figures

Figure 1: Fens 2100+ study area	4
Figure 2: Maud Foster Drain in the East and West Fens catchment © Arup	6
Figure 3: Main Rivers in East and West Fens catchment	7
Figure 4: East and West Fens catchment overview	9
Figure 5: Cowbridge Sluice © Arup	11
Figure 6: Stone Bridge Drain Aqueduct © Arup	12
Figure 7: Maud Foster Sluice © Arup	13
Figure 8: Hobhole Pumping Station © Arup	14
Figure 9: Lade Bank Pumping Station © Arup	15
Figure 10: Environment Agency embankments in East and West Fens	16
Figure 11: 1978 Recorded flood outline	18
Figure 12: Recorded flood outline for 1981 event	19
Figure 13: Recorded flood outline for 1993 event	20
Figure 14: Image showing flooding due to breach at Wrangle © Environment Agency	22
Figure 15: Recorded flood outline at the Wrangle for the December 2019 event	22
Figure 16: Recorded flood extent for the June 2019 event	24

Figure 17: Storm Babet flooding © Witham and Fourth District Internal Drainage Board	26
Figure 18: Extent of Stonebridge 1D & 2D Hydraulic Modelling	29
Figure 19: Summary of Simulations Undertaken © Environment Agency	29
Figure 20: Northern Area Tidal Modelling study area, extracted from the Northern Area Tidal Modelling report © Environment Agency	30
Figure 21: Events modelled as part of the 2010 Northern Area Tidal Modelling extracted from the Northern Area Tidal Modelling report © Environment Agency	31
Figure 22: Risk of flooding from multiple sources © Environment Agency, 2025	33
Figure 23: Land classification across the catchment	37
Figure 24: Sea level rise used in 2010 Northern Area Tidal Modelling extracted from the Northern Area Tidal Modelling report © Environment Agency	39
Figure 25: Comparison of sea level rise estimates	40
Figure 26: 0.5% AEP event and 0.1% AEP event current tidal flood risk	44
Figure 27: Comparison between 0.5% present day and 0.5% with climate change applied up to 2115	46
Figure 28: The 1% AEP event and the 0.1% AEP event current fluvial flood risk in the catchment	49
Figure 29: The 1% AEP flood event compared to the 1% AEP flood event with 65% uplift for climate change	50

Glossary of Terms

- **AIMS** – Asset Information System - An Environment Agency hosted database of information on Environment Agency assets, as well as some other key RMA assets.
- **AOD** – Above Ordnance Datum - Referring to an altitude above a localised mean sea level.
- **BRC** - Below Required Condition.
- **Cumecs** – is the SI unit of volumetric flow rate and are equivalent to cubic meters per second (m^3/s).
- **FCERM** – Flood and Coastal Erosion Risk Management.
- **The Fens** – In the context of Fens 2100+, the combined catchments of the Witham, Lower Welland, Lower Nene, Great Ouse and Steeping, including land with an elevation at or below 6m AOD.
- **Flood risk** - A combination of the probability and the potential consequences of flooding. This includes risks from various sources such as rivers, the sea, direct rainfall, rising groundwater, overwhelmed sewers, and reservoirs
- **IDB** - Internal Drainage Board - A public body that manages water levels in an area, known as an internal drainage district.
- **LLFA** – Lead Local Flood Authority, bodies with a statutory responsibility for taking the lead operational role in managing the risk of flooding.
- **MEICA** - Mechanical, Electrical, Instrumentation, Control and Automation assets, in the context of this report relating to flood and coastal risk management (FCRM) assets.
- **NFM** – Natural Flood Management, the practice of using natural processes to reduce the risk of flooding.
- **Resilience**: The capacity of people and places to plan for, protect, respond to, and recover from flooding and coastal change. Resilience has been considered in the context of Fens 2100+ as follows:
 - Anticipate and adapt: Taking action to prepare for and adjust to both the current effects of climate change and the predicted impacts in the future, while responding to local place-based needs and ambitions.
 - Protect: Reducing the risk of flooding and coastal erosion to enhance the safety of communities and places (through investment in physical grey and green infrastructure).
 - Maintain: Co-ordinated activity to realise the whole life value from flood risk infrastructure through inspection, operational management, repair, replacement, renewal and decommissioning.
 - Respond: The ability of places and people to prepare for and react to flooding and coastal erosion in a way that results in minimal impacts to property, the natural environment and health and wellbeing.

- Recover: The ability of places and people to rebound from flooding and coastal erosion with minimal impacts to property, the natural environment, and health and wellbeing.
- Transform: To change and improve the way FCERM infrastructure is planned, delivered and operated to be more efficient, sustainable and resilient.
- **RMA** - Risk Management Authority - an organisation responsible by statute for flood and coastal erosion risk management.
- **RNAG** – Reasons for Not Achieving Good.
- **SoP** – Standard of Protection - The severity of flooding that something is designed to withstand, represented by the percentage chance of a certain level of flooding occurring in that year.
- **Telemetry** – is technology that enables an asset to operate without manual interaction.
- **WFD** – Water Framework Directive.
- **WLCS** – Water Level Control Structures.

1. Introduction

1.1 Aim and purpose of this document

This document presents a catchment-scale assessment of current and future flood risk for the Witham East and West Fens (also referred to as East and West Fens) catchment. Using the best available data, it presents an overview of current and future flood risk and is intended to support future choices, investments and actions for the Fens 2100+ programme (hereafter referred to as “Fens 2100+”).

1.2 Usage statement

The purpose of the document is to support strategic decision making for the Fens 2100+. This document should be read alongside the East and West Fens baseline evidence report and is intended to provide a strategic current and future flood risk baseline which will inform the development of a future asset management strategy for the Fens 2100+. This document provides a proportionate level of detail required for a strategic catchment-scale baseline. It is anticipated that specific interventions will need to be supported by a more detailed study.

1.3 The Fens 2100+ study area

Fens 2100+ comprises the seven catchments of the Steeping, Lower Welland, East and West Fens, Lower Witham Fens, South Forty Foot Drain, Lower Nene and Great Ouse (see Figure 1).

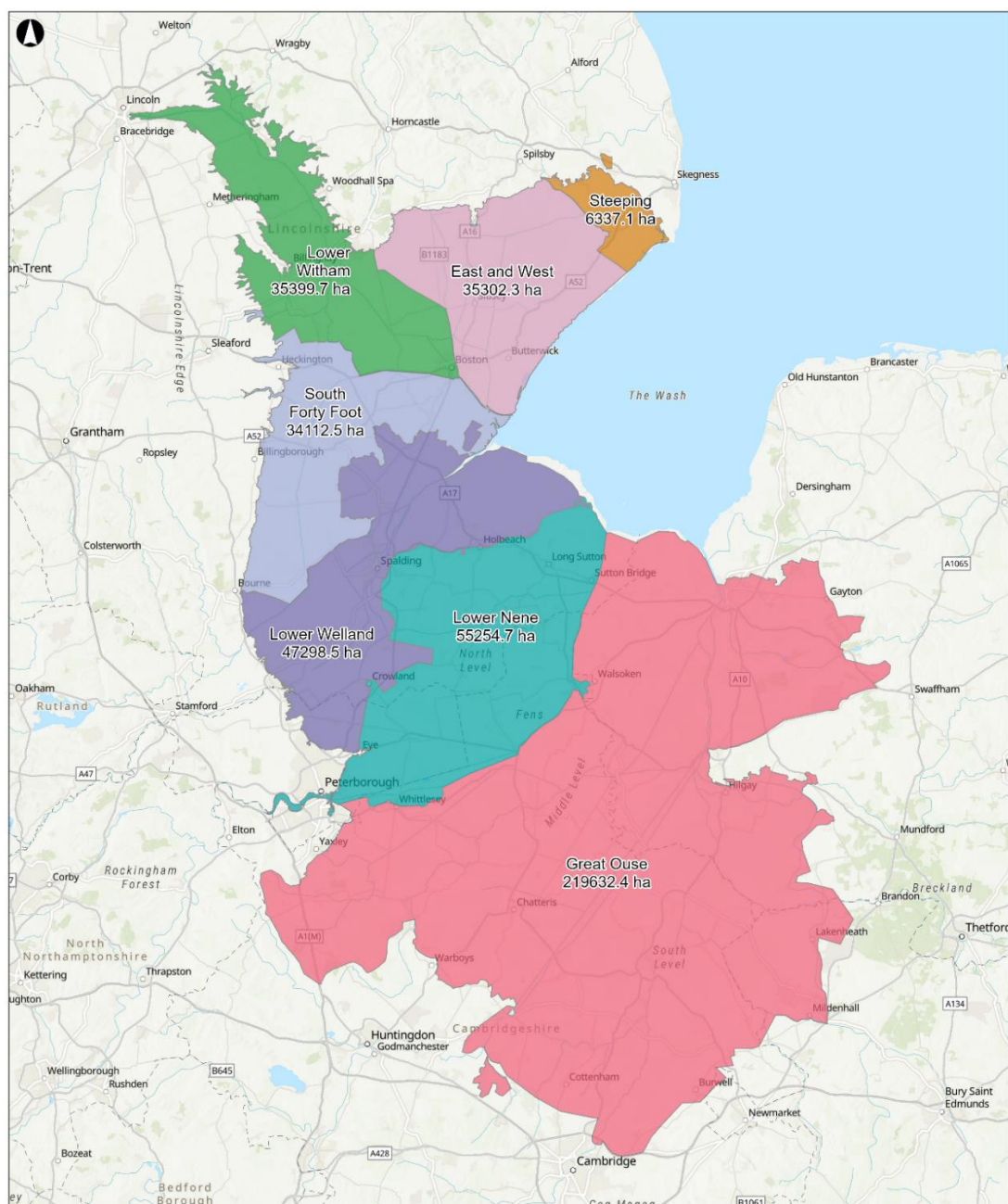


Figure 1: Fens 2100+ study area

1.4 East and West Fens catchment

The East and West Fens catchment (hereafter referred to as “the catchment”) covers an area of approximately 353km² (35,300ha), located in south-eastern Lincolnshire, in the middle of the Fens 2100+ study area. It is a sub-catchment of the River Witham and is bounded by the Lincolnshire Wolds to the north, The Wash and the tidal reach of the River Witham at Boston, known as The Haven to the south, the Steeping catchment to the east and the Lower Witham Fens catchment to the west.

The majority of the catchment lies only slightly above sea level (approximately 3m AOD) with the East Fen being lower than sea level in some areas. It is predominately artificially drained through a complex network of low-lying drains.

The catchment contains some of the highest-grade agricultural land within the Fens, with the majority of the land classed as Grade 1 and Grade 2.

It is acknowledged that the catchment is not strictly a hydrological catchment, as there are movements of water both into and out of the area defined, that are not being considered in this report. However, the term 'catchment' has been used throughout the dialogue with the Environment Agency during establishment of the study areas and these areas are being defined for water management purposes. Therefore, the term 'catchment' is used to describe the study area.

1.5 Catchment context

Within the catchment there is a network of Main Rivers. This network has two sources, the West Fen Catchwater Drain rises near Coningsby and flows east, and then south towards Stone Bridge Drain and the East Fen Catchwater Drain which rises south of Spilsby, flowing west and then south towards Stone Bridge Drain. These two converge at Northlands. This drain becomes known as the Maud Foster Drain downstream of Cowbridge Sluice. The Maud Foster Drain outfalls at the Maud Foster Sluice (see Figure 2) into The Haven at Boston. This system operates by gravity.



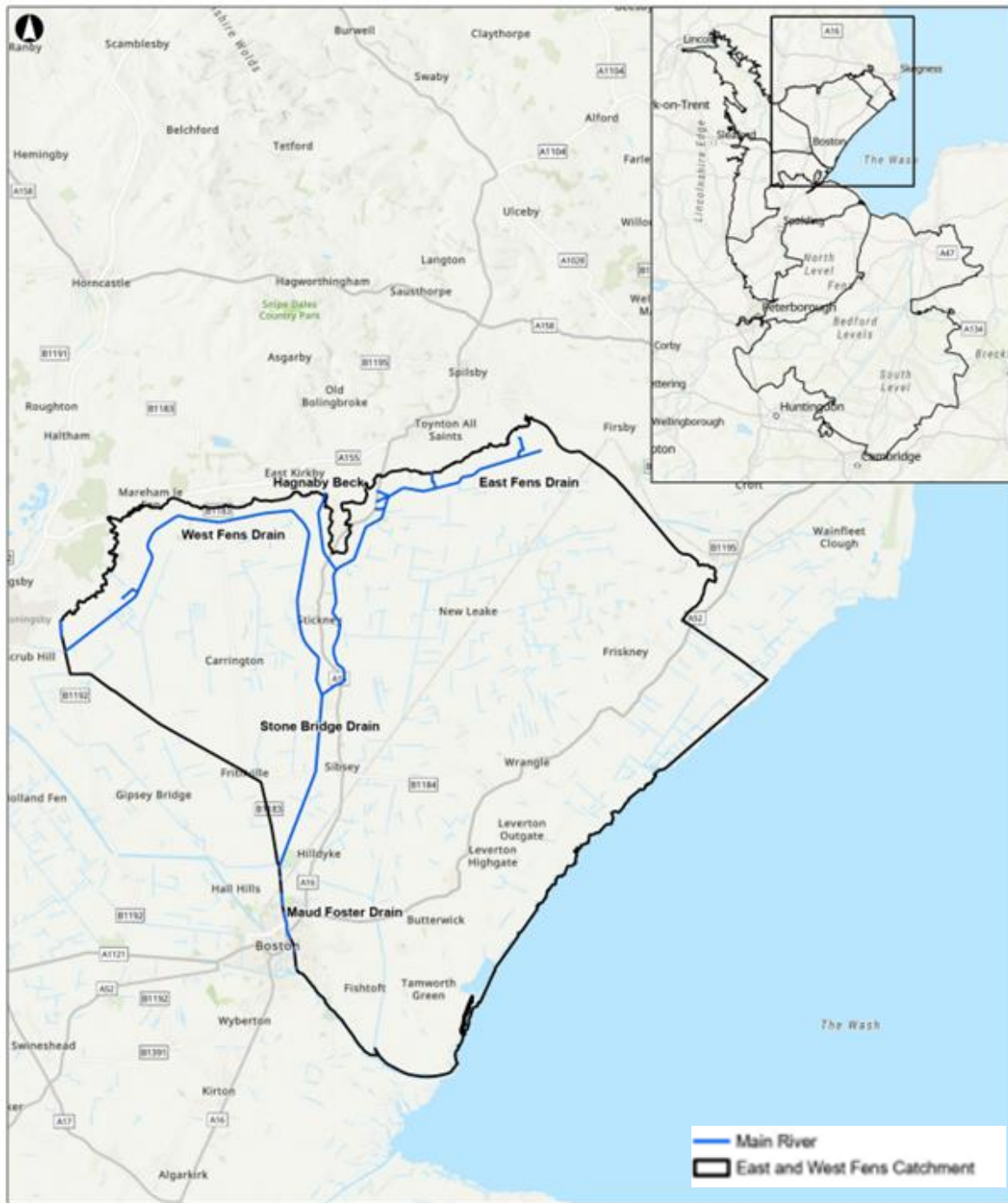
Figure 2: Maud Foster Drain in the East and West Fens catchment © Arup

There is also a network of drains managed by Witham Fourth District Internal Drainage Board (IDB). This includes; the West Fen Drain, Bellwater Drain, Hobhole Drain and Cowbridge Drain. The Hobhole Drain is the main channel used to drain the East and West Fens catchment. Witham Fourth District IDB also manages the following pumping stations within the catchment:

- Cowbridge Sluice;
- Lade Bank Pumping Station;
- Hobhole Pumping Station;
- Benington Pumping Station;
- Leverton Pumping Station; and,

- Wrangle Pumping Station.

The Main Rivers in the catchment are shown in Figure 3.



1.6 Key assets

The East and West Fens catchment contains a network of sluices, pumping stations, embankments and flood defences which work together to drain the catchment and prevent flooding.

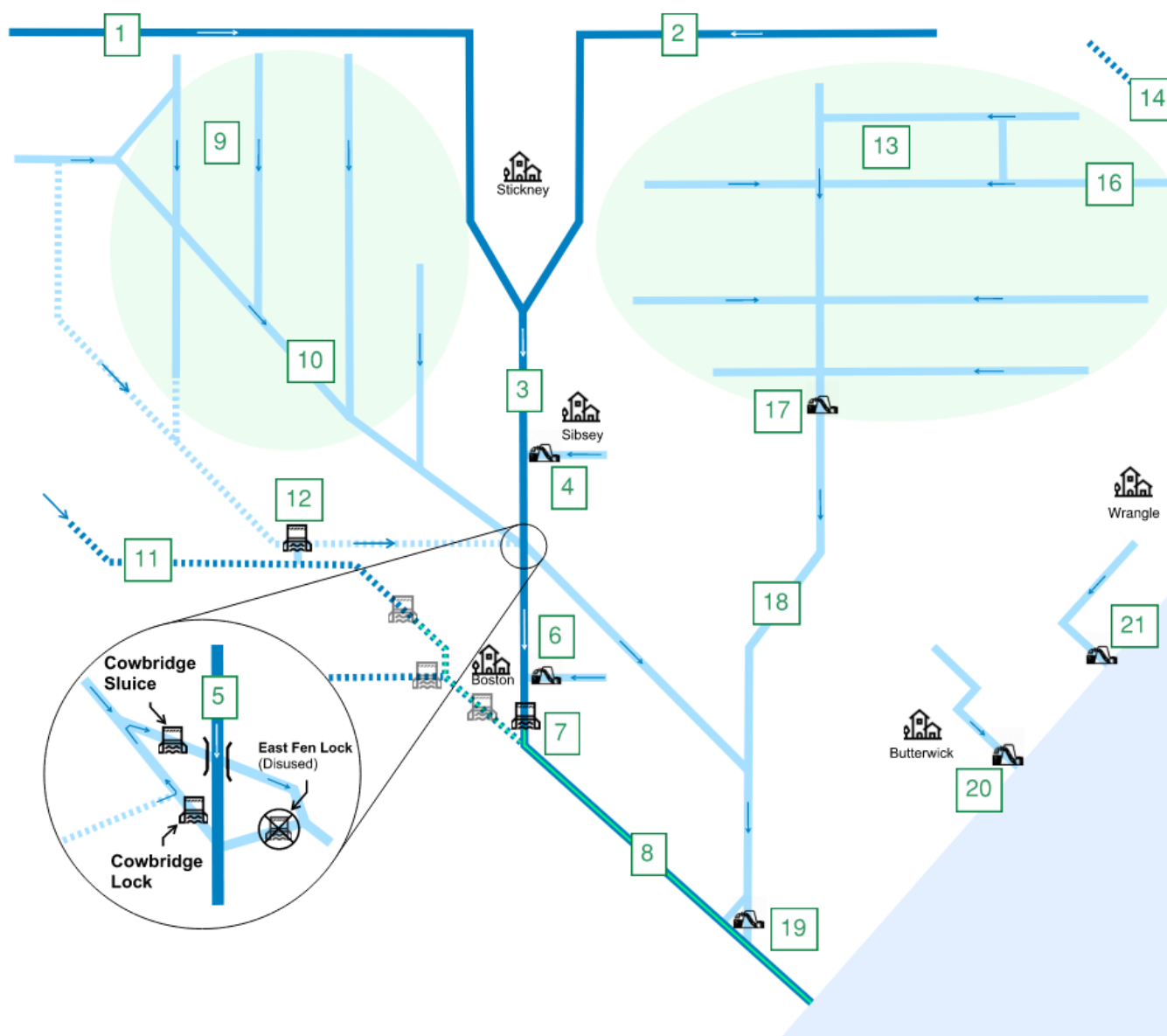


Figure 4: East and West Fens catchment overview

Figure 4 gives an overview of the locations of some of the key assets. For clarity, not all assets have been included.

The proceeding sections give further details of some of these key assets. Refer to the Assets Technical Baseline Report for further information.

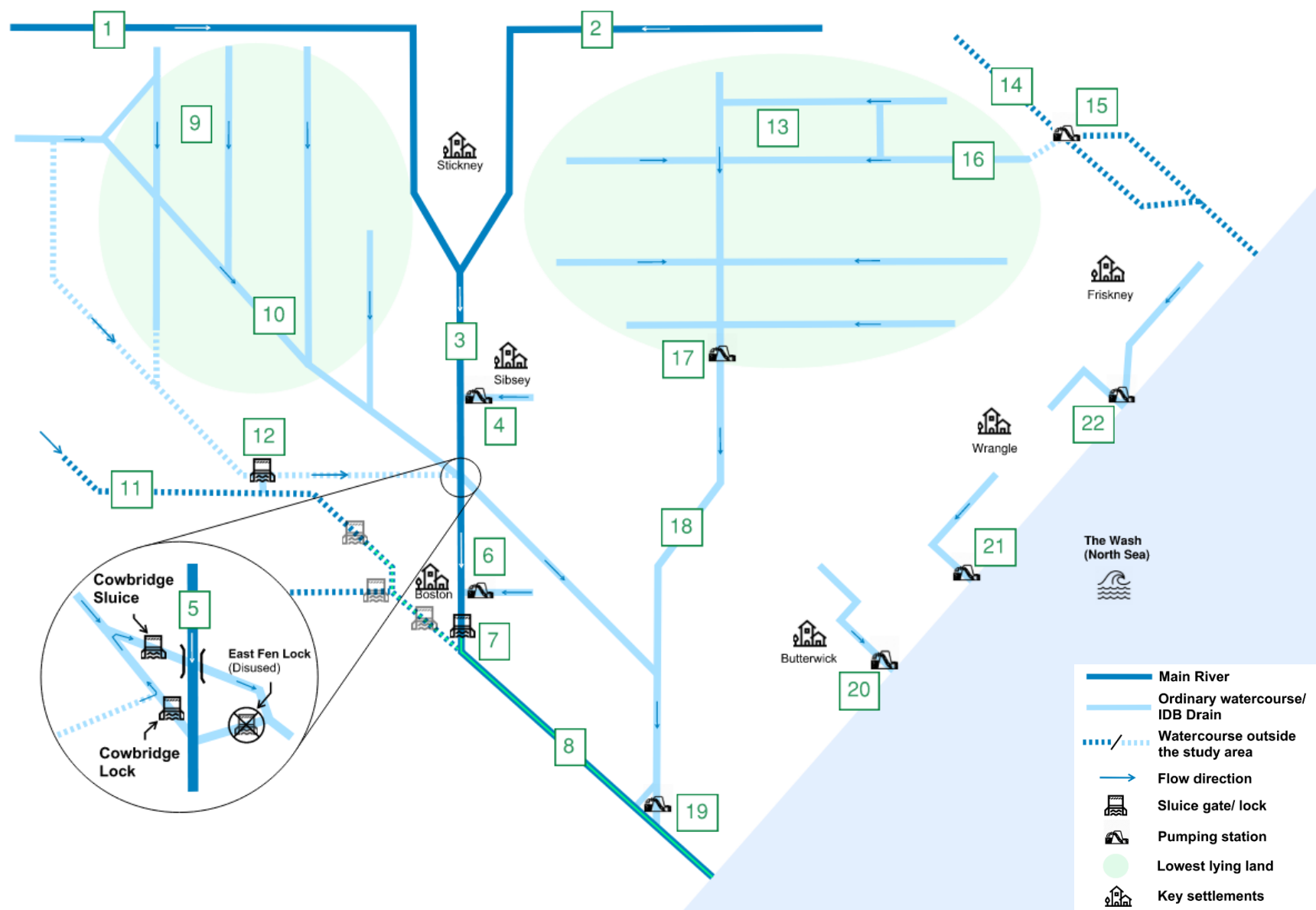


Figure 4: East and West Fens catchment overview

- 1

West Fen Catchwater Drain
[Main River](#)
 Designed to minimise the amount of water entering the IDB district, it intercepts run-off from the Lincolnshire Wolds and carries it to Stonebridge Drain.
- 2

East Fen Catchwater Drain
[Main River](#)
 Like the West Fen Catchwater Drain, it intercepts run-off from the Lincolnshire Wolds. and carries it to Stonebridge Drain.
- 3

Stonebridge Drain
[Main River](#)
 Known as the Maud Foster Drain downstream of the Cowbridge Aqueduct, it carries water from the catchwater drains to Maud Foster Sluice.
- 4

Littlemore Lane Pumping Station
[Witham Fourth District IDB](#)
 Pumps water from a small area near Sibsey into the Stonebridge Drain.
- 5

Stonebridge Aqueduct
[Environment Agency](#)
 Carries the elevated Stonebridge Drain over the IDB's Cowbridge Drain.
- 6

Boston East Pumping Station
[Witham Fourth District IDB](#)
 Pumps water from eastern Boston into the Maud Foster Drain.
- 7

Maud Foster Sluice
[Environment Agency](#)
 The gravity outfall of the Maud Foster Drain. It can be closed during drier periods to maintain water levels in the drains upstream.
- 8

Boston Haven
[Main River](#)
 The tidal section of the River Witham.
- 9

West Fen
 A low-lying area which wasn't drained until the 19th Century.
- 10

West Fen Drain
[Witham Fourth District IDB](#)
 Carries water from the West Fen towards the Hobhole Drain.
- 11

River Witham
[Main River](#)
 Water from most of the catchment (except coastal areas) flows into the River Witham through the Maud Foster Sluice or Hobhole Pumping Station.
- 12

Anton's Gowt Lock
[Canal & River Trust](#)
 Enables access to the Witham Navigable Drains from the River Witham. W4DIDB have a license to bring in freshwater from the Witham here, to top-up water levels in their system during drier periods. During wetter periods, there is a risk of water entering the IDB drainage network here.
- 13

East Fen
 Contains the lowest lying land in the catchment. Water in the East Fen has to be pumped upwards twice to reach sea level: once at Lade Bank Pumping Station, and again at Hob Hole Pumping Station.
- 14

The Steeping River
[Main River](#)
 Neighbours the East and West Fens catchment.
- 15

Thorpe Culvert Pumping Station
[Lindsey Marsh Drainage Board](#)
 In the past, a culvert at this location acted as a route to transfer water from the Steeping catchment into the East and West Fens catchment. This transfer system is no longer operational.
- 16

Bellwater Drain
[Witham Fourth District IDB](#)
 In the past it acted as a spillover route for water from the neighbouring Steeping catchment through the connection at Thorpe Culvert. There is no longer a formal connection between the two catchments, but there is a risk that water from the steeping River spills over during high flows.
- 17

Lade Bank Pumping Station
[Witham Fourth District IDB](#)
 Pumps water upwards along the Hobhole Drain out of the low-lying area of East Fen.
- 18

Hobhole Drain
[Witham Fourth District IDB](#)
 The route for water from the East and West Fens to reach Hobhole Pumping Station.
- 19

Hobhole Pumping Station
[Witham Fourth District IDB](#)
 Separate electric and diesel pumping stations carry water upwards from the Hobhole Drain into the Boston Haven. During high spring tides, water must be lifted around 7m.
- 20

Benington Pumping Station
[Witham Fourth District IDB](#)
 Pumps water from coastal areas directly into The Wash.
- 21

Leverton Pumping Station
[Witham Fourth District IDB](#)
 Pumps water from coastal areas directly into The Wash.
- 22

Wrangle Pumping Station
[Witham Fourth District IDB](#)
 Replaced in Summer 2024, it pumps water from coastal areas directly into The Wash.

1.6.1 Sluices

Cowbridge Sluice (Figure 5) is located along Cowbridge Drain and can be used to control the flow of water from West Fen Drain on its way towards Hobhole Drain. This can reduce the pressure on the Hobhole Pumping Station by holding water back. It's managed by the Witham Fourth District IDB.



Figure 5: Cowbridge Sluice © Arup

A short distance to the southwest of Cowbridge Sluice the **Stone Bridge Drain Aqueduct** (Figure 5), managed by the Environment Agency, carries the elevated Stone Bridge drain over the Witham's Fourth's Cowbridge Drain. There is no formal exchange of water between the Environment Agency drainage system and the IDB drainage system, although there is potential for flood waters from the Main River system to flow into the IDB network of drains. This should only occur during periods of intense or prolonged rainfall, when the Main River systems are overwhelmed.



Figure 6: Stone Bridge Drain Aqueduct © Arup

Maud Foster Sluice is managed by the Environment Agency and is located at the confluence of Maud Foster Drain and The Haven (Figure 7). It was first opened in 1807. When the sluice is open, it allows water from the highland catchwater drain system to flow into The Haven. It is normally closed to prevent tidal waters from The Haven flowing into the highland catchwater drain system.



Figure 7: Maud Foster Sluice © Arup

1.6.2 Pumping stations

The entire East and West Fens drainage network managed by Witham Fourth District IDB is wholly reliant on pumping stations to pull water from the low lying areas into The Haven.

Hobhole Pumping Station is an original steam powered pump built in 1810 (Figure 8). Replaced with diesel pumps in 1960's with additional electric pumps added in 1980's. On a high spring tide, the pumps at this location lift water from the Hobhole Drain approximately 7m into The Haven. In January 2020 it operated at full capacity for 3 weeks, because of a succession of winter storms. A business case and design are being developed on behalf of Witham Forth IDB for a new pumping station.



Figure 8: Hobhole Pumping Station © Arup

Lade Bank Pumping Station is an original steam powered pump built in 1867 to convey water from the low-lying East Fen (Figure 9). Since construction it has been upgraded multiple times in response to flooding throughout the 2000's. It is managed by the Witham Fourth District IDB and draws water along Hobhole Drain towards Hobhole Pumping Station.



Figure 9: Lade Bank Pumping Station © Arup

In addition to the pumping stations that help draw water through the catchment to Hobhole Pumping Station, Witham Fourth IDB manage three catchments that are pumped into The Wash by pumping stations at **Bennington, Leverton and Wrangle**. The pumping station at Wrangle was constructed in 1959, while those at Leverton and Bennington were constructed in 1976. In 2018 5.7km of raised defences were constructed to work in conjunction with Wrangle Pumping Station.

1.6.3 Embankments

Embankments are constructed features designed to contain water and are ideally constructed of a solid clay core surrounded by piled material, and finally a layer of grass/vegetation. The use of geotextiles is now often being implemented in embankments to better stabilise the slope and help improve the strength of utilised soils.

The tidal banks along The Haven have been identified as a failing asset and these were breached in 2013 during the tidal surge event. There have been some efforts within the catchment to raise tidal banks and in 2018, 5.8km of sea defences at Wrangle were raised to a height of 7.2m. This was completed by Witham Fourth District IDB, using Environment Agency funding. There are potential conflicts on the management of tidal banks, with Natural England promoting grazing which creates an uneven sward, which is not optimal for flood risk management.

The flood defence embankments maintained by the Environment Agency are shown in Figure 10.

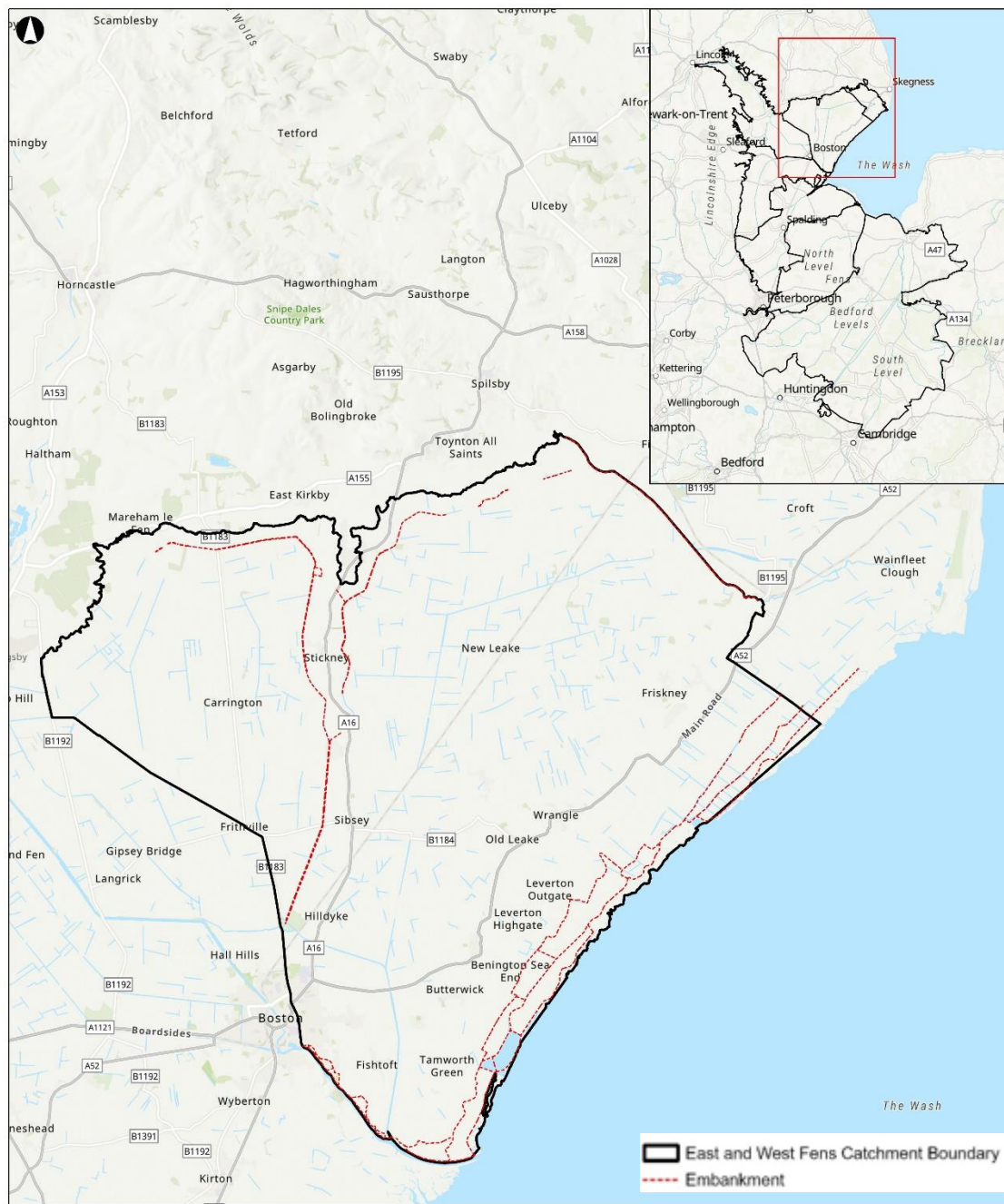


Figure 10: Environment Agency embankments in East and West Fens

2. Notable flood history

A number of flood events have impacted the East and West Fens catchment. These events have been summarised in the proceeding sections.

Information on flood history has come from a number of sources including:

- Environment Agency recorded flood outlines;
- Witham Fourth District IDB – Storm Babet Technical Briefing Report;
- Lincolnshire County Council – Section 19 Investigation Report – Overview of coastal surge flood event during 5th, 6th and 7th December 2013;
- Boston Story website; and,
- The Geographical Journal Archive.

2.1 November 1810

In November 1810, a North Sea storm surge overwhelmed the sea banks from Wainfleet to Fosdyke. The majority of the Borough of Boston was flooded¹. This resulted in the raising of the existing sea banks by approximately 0.6m above the 1810 level (approximately 5.59mAOD at Newlyn) in and around Boston.

2.2 March 1947

The winter of 1946/1947 saw extremely low temperatures and heavy snowfall. A rapid thaw led to significant flooding across the United Kingdom. Extensive flooding occurred in the catchment as a result².

2.3 January 1953

The greatest storm surge on record for the North Sea caused extensive tidal flooding along the coast. There is no record of the East and West Fens catchment suffering flooding.

2.4 1977

Flooding in East Fen due to rain and melting snow³. No further details known about this event.

2.5 November 1978

In November 1978, a tidal surge caused significant flooding in Witham Fourth IDB area of Boston (this encompasses the Fens 2100+ catchments of; East and West Fens, South Forty Foot and Lower Witham – see Figure 1). The surge was around 1.2m and led to the

¹ Boston Story (2025) Floods and the Great Drainage Scheme. Available online at: <https://bostonstory.co.uk/chapters/21-30/28-great-drainage-schemes/floods-great-drainage-scheme.html> Accessed: March 2025

² Our History (2025) Available at: <https://www.w4idb.co.uk/about-us/our-history/> Accessed March 2025.

³ Our History (2025) Available at: <https://www.w4idb.co.uk/about-us/our-history/> Accessed March 2025.

collapse of a brick wall, flooding 180 houses and the church⁴. However, within the East and West Fens catchment, the Environment Agency recorded flood outline only shows a small area on the left bank of the Haven to have been inundated, as shown in Figure 11.

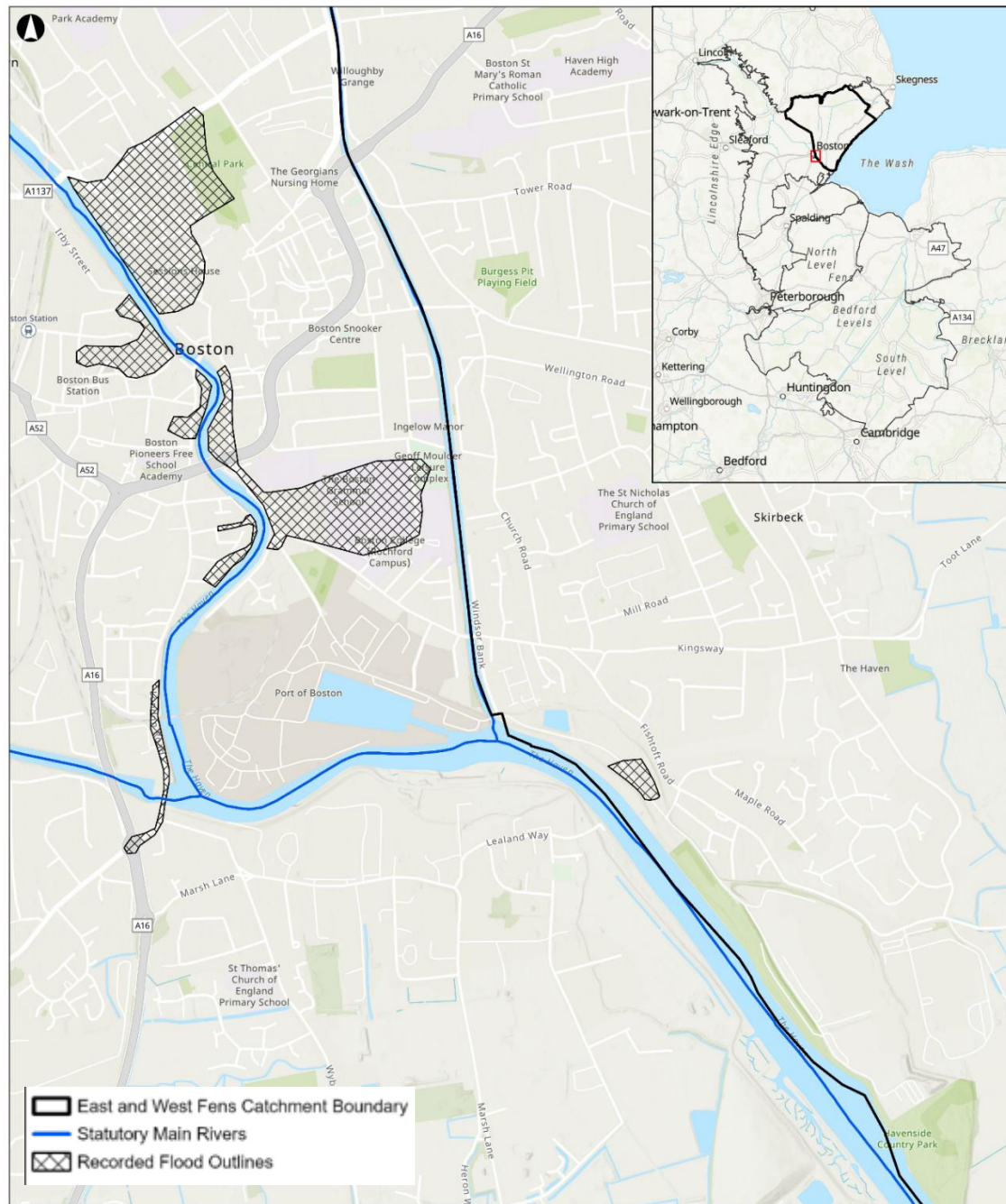


Figure 11: 1978 Recorded flood outline

2.6 April 1981

The catchment experienced significant flooding due to heavy rainfall⁵ in April 1981. It resulted in additional pumping capacity being installed at Lade Bank. The Environment

⁴ The Geographical Journal (1979) The Storm Surge of 11 January 1978 on the East Coast of England Available at: <https://www.jstor.org/stable/634386?origin=crossref&seq=3> Accessed: March 2025

⁵ Our History (2025) Available at: <https://www.w4idb.co.uk/about-us/our-history/> Accessed March 2025.

Agency recorded flood outline shows large areas of agricultural land were inundated, with some property flooding around Hagnaby Lock – as shown in Figure 12.

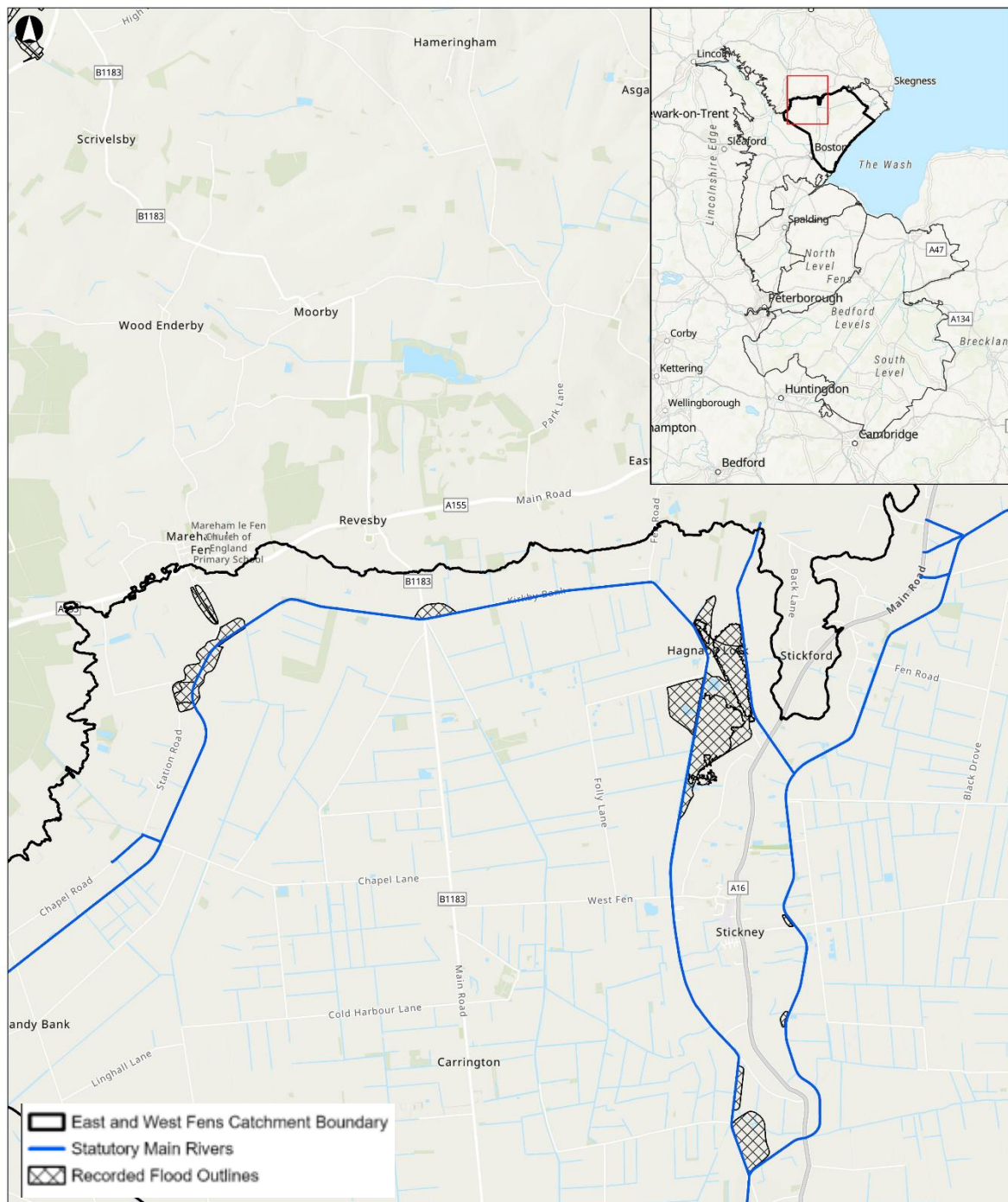


Figure 12: Recorded flood outline for 1981 event

2.7 1993

Flooding adjacent to the Catchwater drain in Stickford, Hagnaby, Stickney and Sibsey areas, due to heavy rainfall.⁶ The Environment Agency recorded flood outline for this event shows two areas of flooding on the right bank of the Catchwater drain, with some property

⁶ Our History (2025) Available at: <https://www.w4idb.co.uk/about-us/our-history/> Accessed March 2025.

flooding at Horbling Lane – as shown in Figure 13. The recorded flood outline suggests that this was due to a breach in the embankment.

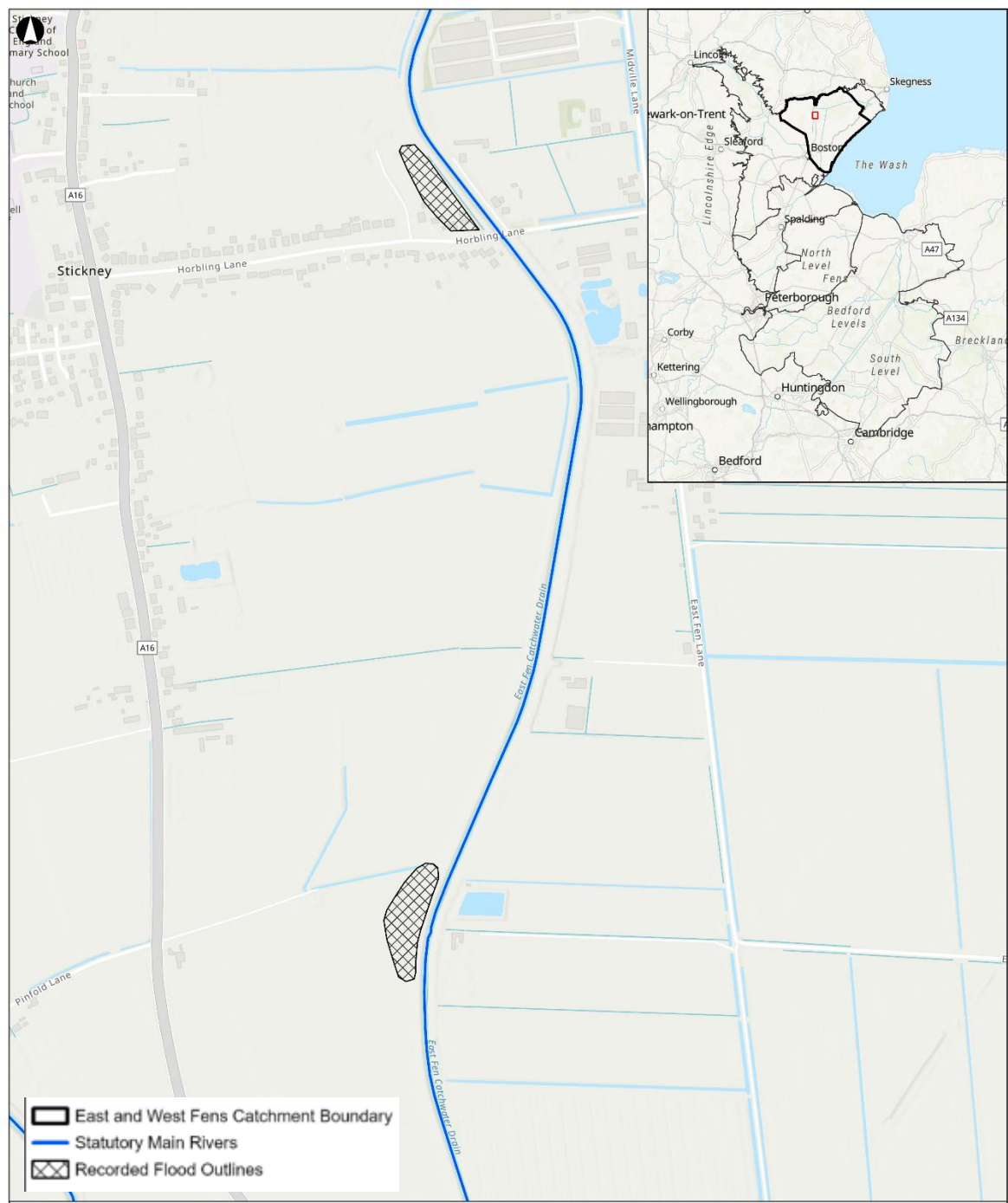


Figure 13: Recorded flood outline for 1993 event

2.8 Summer 2007

The flooding in June and July of 2007 was the result of the highest recorded rainfall since records began in 1766. The result was extensive flooding across the whole of the Fens including the East and West Fens catchment.

2.9 December 2013

A storm surge breached the embanked sea defences at Wrangle, inundating a large area of agricultural land, as shown in Figure 14. The full extent of the flooding is shown in Figure 15. The breach was caused by initial overtopping of the existing defences.



Figure 14: Image showing flooding due to breach at Wrangle © Environment Agency

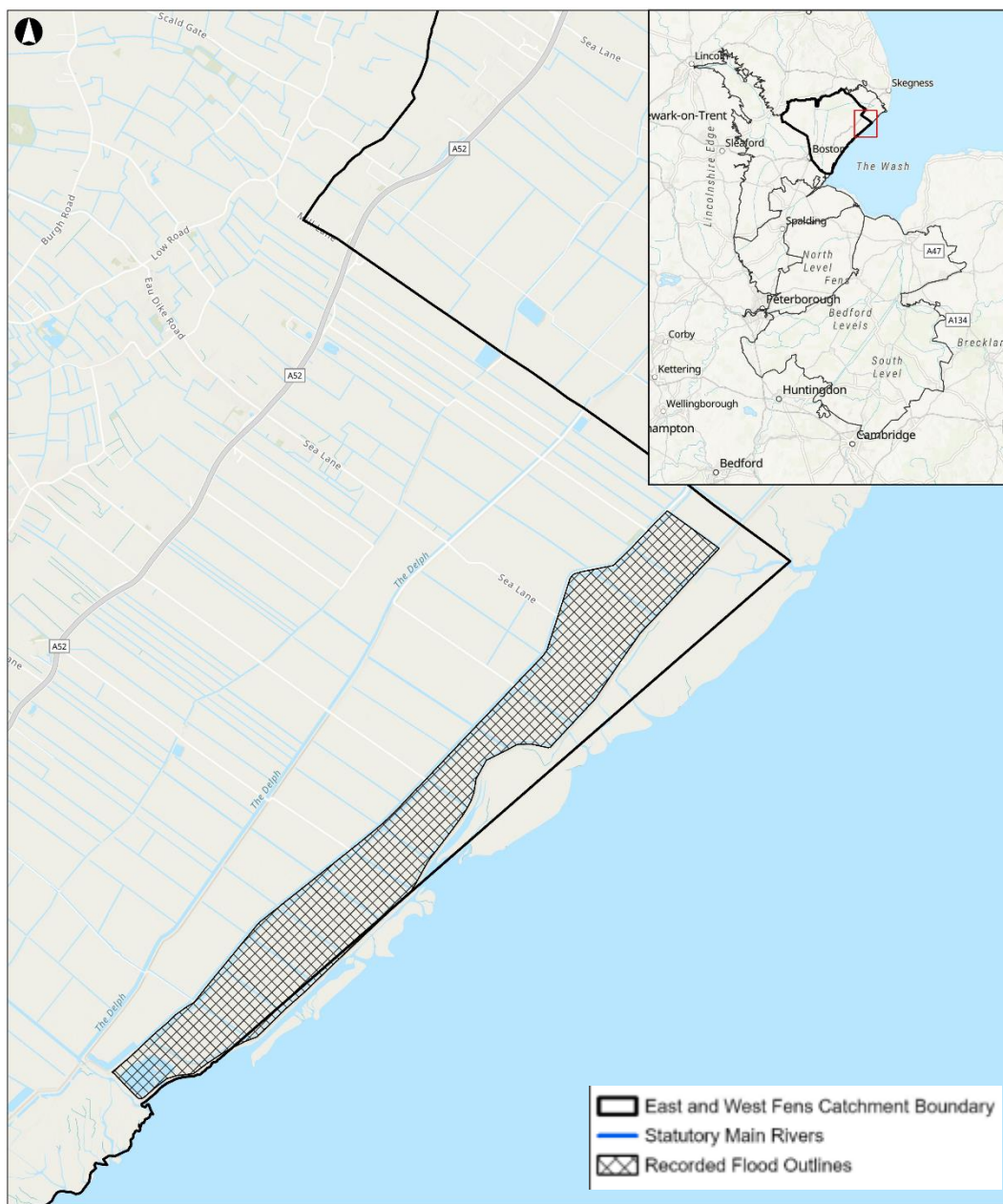


Figure 15: Recorded flood outline at the Wrangle for the December 2019 event

2.10 2019-2020

A succession of storm events in 2019 and 2020 put tremendous pressure on the assets located within the East and West Fens catchment.

When the banks of the Steeping River breached on 9th June 2019, water was pumped into the Bellwater Drain at Thorpe Culvert to essentially re-create the facility of transferring water between the catchments through the historic culverts. This was done under strict requirements of Witham Fourth District IDB to ensure that their drainage network could cope with the extra water. Within the East and West Fens catchment, overtopping caused flooding of agricultural land from the East Fen Catchwater Drain, as shown in Figure 16.

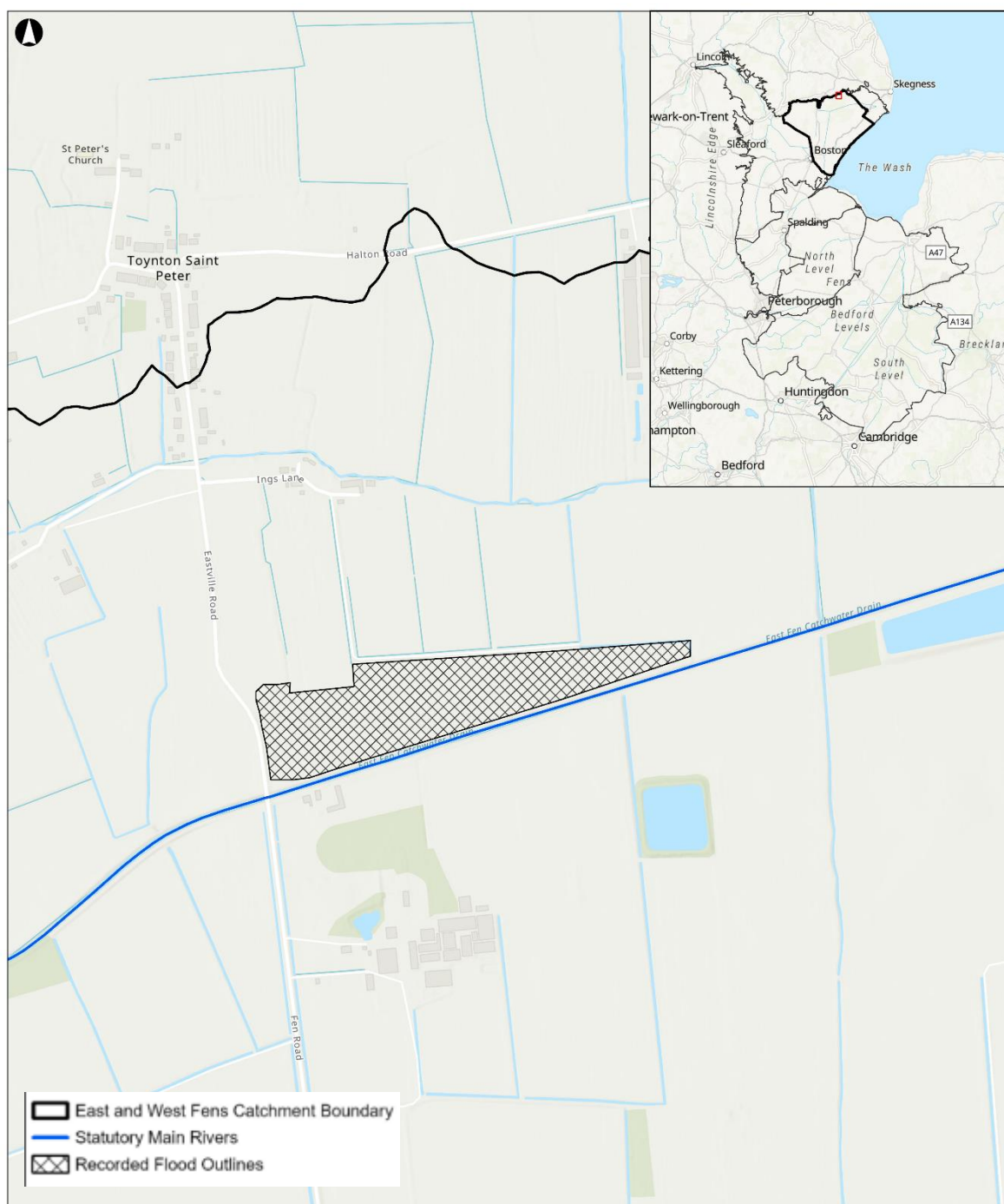


Figure 16: Recorded flood extent for the June 2019 event

2.11 October 2023

In October 2023 Storm Babet caused significant flooding throughout the catchment and put significant pressure on assets. Within the East and West Fens catchment large areas of agricultural land and many residential properties were flooded internally⁷. Witham and

⁷ Storm Babet Technical Briefing Report (2023) Witham Fourth District Internal Drainage Board

Fourth District IDB incident log captured 70 incident reports. The worst impacted areas were:

- Halton Fenside;
- Hagnaby;
- East Keel; and
- Stickney.

Figure 17 shows the extent of flooding across the catchment. The source of flooding at each location was difficult to assess, as throughout the event it came from a variety of sources, including surface water and Main River overtopping.

Halton Fenside, Fenland



River Steeping Overland Flows



Hagnaby Lock, Hagnaby



West Fen, Revesby



East Fen



Figure 17: Storm Babet flooding © Witham and Fourth District Internal Drainage Board

2.12 Other events

The flood events detailed in the preceding sections detail the flood history of the catchment where records have been found. Recorded flood history is likely to be biased towards flooding that impacts properties.

It is expected that there will be more instances of flooding of agricultural land that have not been recorded.

2.13 Discussion

There are two records of overtopping of defences in the East and West Fens, one in 1978 and one 2013. Both of these events resulted in a small area of flooding on the left bank of The Haven, where the defences at the Wrangle were overtopped and resulted in an embankment breach. There are more recorded instances of fluvial flooding than tidal in the East and West Fens catchment, however a number of these are due to breaching of embankments (1981 and 1993). Overtopping of existing embankments has caused flooding in 2019 and 2023 of agricultural land and property. Evidence from 2023 (Storm Babet) illustrates that during other flood events in the catchment, there is likely to be more flooding than recorded by the EA, due to ponding of surface water on already saturated land.

3. Methodology and data review

3.1 Methodology

The methodology used in this assessment is to use best available information (i.e. no new modelling work has been undertaken for this study) to document both current and future flood risk and has been agreed with the Environment Agency. This assessment has been informed by a review of the existing hydraulic modelling and engagement with the relevant Environment Agency teams.

The proceeding sections detail the existing datasets used to determine the baseline flood risk in the East and West Fens catchment.

3.2 Detailed hydraulic modelling

A review of all detailed models in the Fens 2100+ was undertaken. The review found that in the East and West Fens catchment, there were two models that could be used to describe flood risk and which several metrics could be extracted from:

- 2017 Stonebridge hydraulic model.
- 2010 Northern Area Tidal Modelling.

These models are described in more detail in the proceeding sections.

3.2.1 2017 Stonebridge hydraulic model

In 2017, CH2M were commissioned by the Environment Agency to carry out the review, and update of, a 2008 model of the Stonebridge catchment. The study area for the modelling is shown in Figure 18. The study focused on the Main Rivers in the catchment, including the:

- West Fen Catchwater;
- Hagnaby Beck;
- Stone Bridge Drain;
- East Fen Catchwater;
- Toynton Beck Diversion;
- Keal Coates South; and
- Halton Fenside.

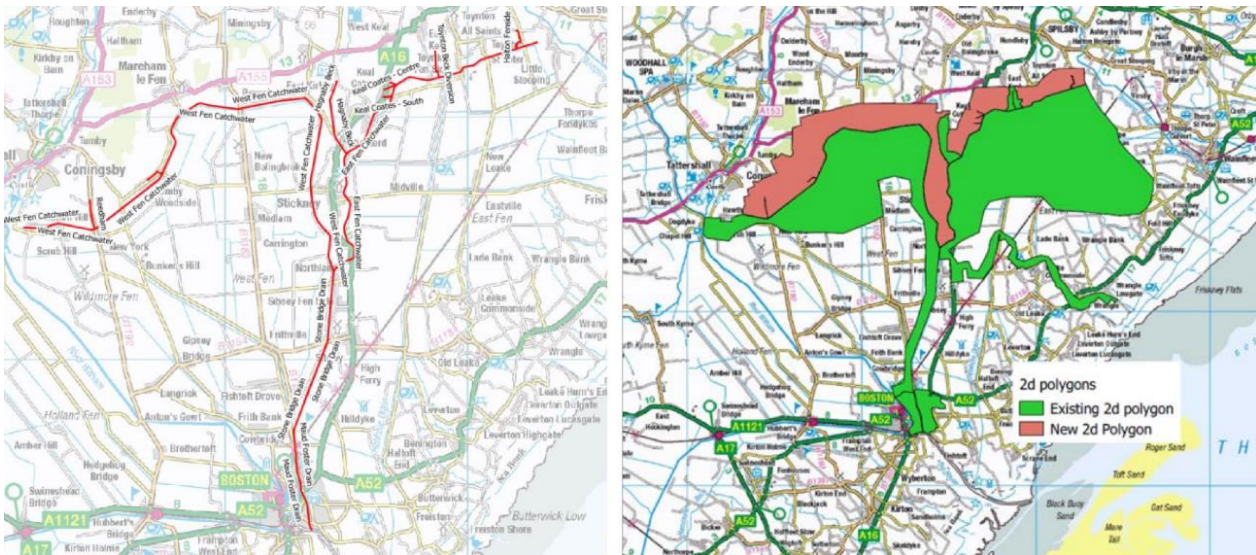


Figure 18: Extent of Stonebridge 1D & 2D Hydraulic Modelling⁸

A number of simulations have been carried out for baseline and climate change scenarios, as summarised in Figure 19.

Simulations	Runs (AEP event)	Total number of simulations	Notes
Baseline	50%, 20%, 10%, 5%, 4%, 3.3%, 2%, 1.3%, 1%, 0.5%, 0.1%	10	
Baseline with climate change	1% + 20% CC 1% + 25% CC 1% + 35% CC 1% + 65% CC 0.5% + 20% CC 0.5% + 25% CC 0.5% + 35% CC 0.5% + 65% CC 0.1% + 20% CC 0.1% + 25% CC	10	Tidal boundary uniformly raised by 1.24 m for climate change simulations (sea level rise).

Figure 19: Summary of Simulations Undertaken © Environment Agency

The modelling only assessed fluvial flood risk – no representation of tidal flooding was undertaken as part of this modelling study, except in the form of a downstream tidal boundary.

3.2.2 Northern Area Tidal Modelling

In 2010, Mott MacDonald, on behalf of the Environment Agency, undertook tide, surge and wave analysis of the coastline from the Humber to The Wash. The results from this analysis were input into a 2D TUFLOW model of the same area to understand the flood risk. The study area for the modelling is shown in Figure 20.

⁸ Environment Agency (2017) M+F Q2 Fluvial Package Modelling: Stonebridge Model Report

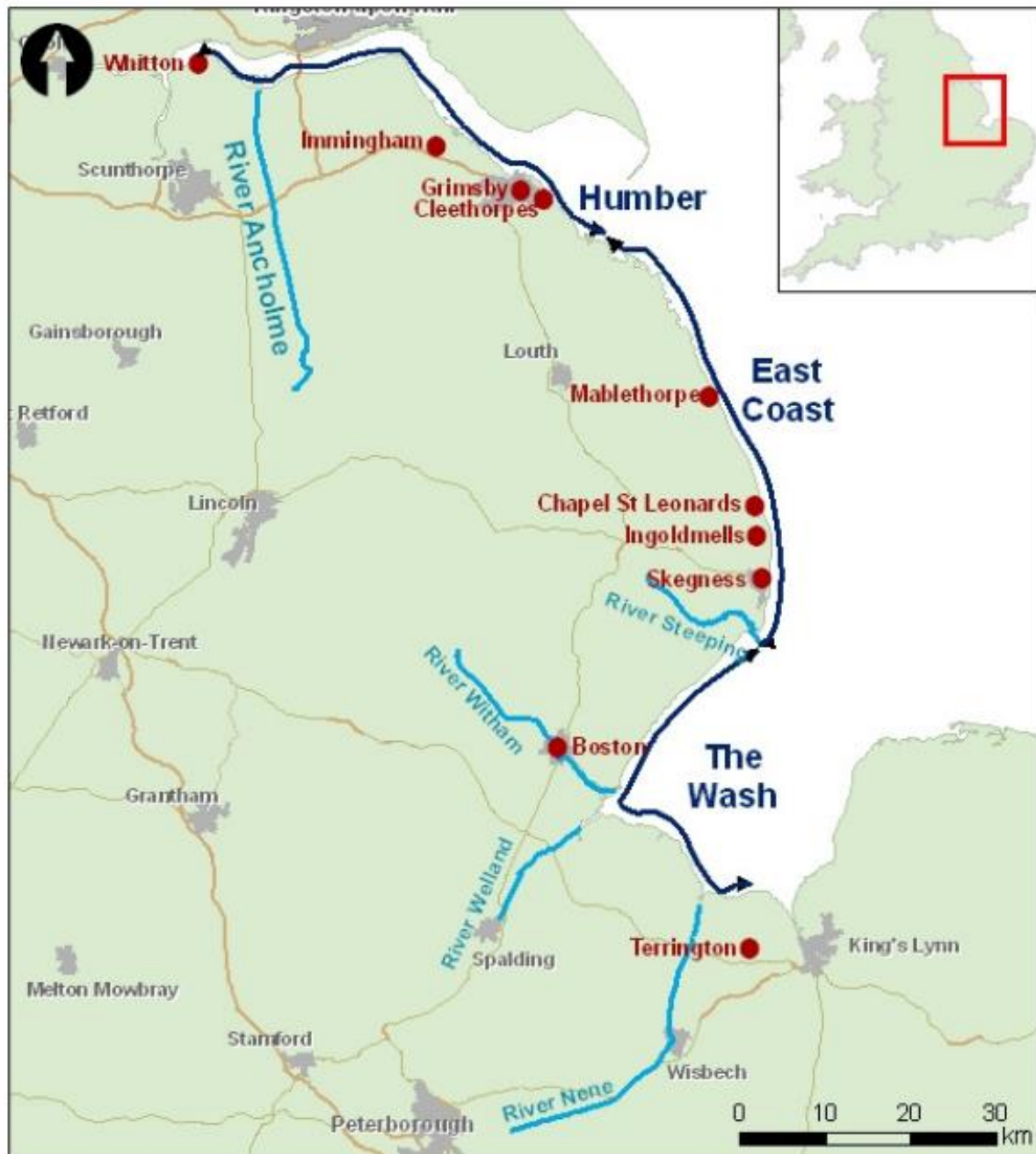


Figure 20: Northern Area Tidal Modelling study area, extracted from the Northern Area Tidal Modelling report © Environment Agency

As part of the inundation modelling, defended and undefended scenarios were undertaken.

The modelling only assessed tidal flood risk – no representation of fluvial flooding was undertaken as part of this modelling study.

A detailed analysis of the wind and wave conditions in the study area was undertaken. This established the 100% AEP (1 in 1 year) wave conditions and were used in the

TUFLOW inundation modelling. For the climate change scenarios, a 10% uplift was applied to wave inflows.

Figure 21 details the events modelled as part of the Northern Area Tidal Modelling study.

Water Level - Event Scenario	Water Level - Annual Exceedance Probability	Wave Condition	Present Day (2006)	Climate Change (2115)
1 in 10	10%	1 in 1 annual chance	Humber and East Coast models and for internal use only.	x
1 in 75	1.3%	1 in 1 annual chance	√	x
1 in 100	1%	1 in 1 annual chance	√	x
1 in 150	0.7%	1 in 1 annual chance	√	x
1 in 200	0.5%	1 in 1 annual chance	√	√
1 in 1000	0.1%	1 in 1 annual chance	√	√

Figure 21: Events modelled as part of the 2010 Northern Area Tidal Modelling extracted from the Northern Area Tidal Modelling report © Environment Agency

An update of the coastal modelling is currently in progress and is due to be delivered in March 2026.

3.2.3 Limitations

The following limitations are associated with the data:

- The 2010 and 2017 Environment Agency models are catchment scale and primarily focussed on Main River and tidal flooding, and as such the drainage ditches (geometry, capacity and conveyance) was not explicitly represented. In both the 2010 and 2017 models, the geometry, capacity and conveyance of drainage ditches have not been explicitly represented.

3.2.3.1 The 2017 Stonebridge model

The following are specific limitations to the 2017 Stonebridge model:

- There are no flow gauging stations in the headwaters of East and West Fen away from the influence of Maud Foster Sluice, this has mean that calibration of the model was not possible.
- Hydrological inflows derived as part of this study will have changed due to changes in methodologies and new data.
- The floodplain DTM is represented using LiDAR datasets from 2005.
- The majority of channel and structure information dates from 1999 and 2005, though as it is heavily engineered/canalised, it is therefore deemed acceptable for flood mapping as the geometry is unlikely to have changed significantly.
- As can be seen in Figure 18, the model extent only covers the Environment Agency Main Rivers that drain the upper catchment and does not include the low-lying East Fen and West Fen.
- The 2017 model does not include an assessment of joint probability for fluvial and tidal variables. The 2017 modelling assumed that fluvial was dominant mechanism – however there may be a tidal influence as well, albeit is considered small risk due to the presence of structures such as the Maud Foster Sluice keep the high tides out.

3.2.3.2 *The 2010 Northern Area Tidal model*

- The 2010 model did not include any fluvial elements.
- The 2010 model used tidal boundary data that is now 15 years old – these levels will certainly have changed.
- The 2010 model used LIDAR data has been superseded by finer resolution data.
- The 2010 model did not take into account the construction of the Boston Barrier (completed in 2020) and a series of embankments along The Haven downstream of Boston.

3.3 Other data sources

3.3.1 National Flood Risk Assessment

The National Flood Risk Assessment (NaFRA) consists of a number of different products, including:

Risk of Flooding from Rivers and Sea - A geospatial dataset which divides the floodplain into 50m x 50m cells and each allocated one of four flood risk likelihood categories.

Reduction in Risk of Flooding from Rivers and Sea Due to Defences - Produced using the defended scenario of flood risk in the Risk of Flooding from Rivers and Sea dataset and an undefended scenario of flood risk from rivers and sea.

Risk of Flooding from Surface Water (RoFSW) - A geospatial dataset the floodplain split into 2m x 2m cells and each allocated one of four flood risk likelihood categories.

Risk of Flooding from Multiple Sources (RoFMS) - A geospatial dataset combining data from RoFRS & RoFSW. The RoFMS inherits the appearance of the input datasets. When both RoFRS and RoFSW indicate a risk in the same area, the RoFSW (surface water flood risk) will be the more prominent feature, indicating the potential for flooding from surface water in that specific location (see Figure 22).

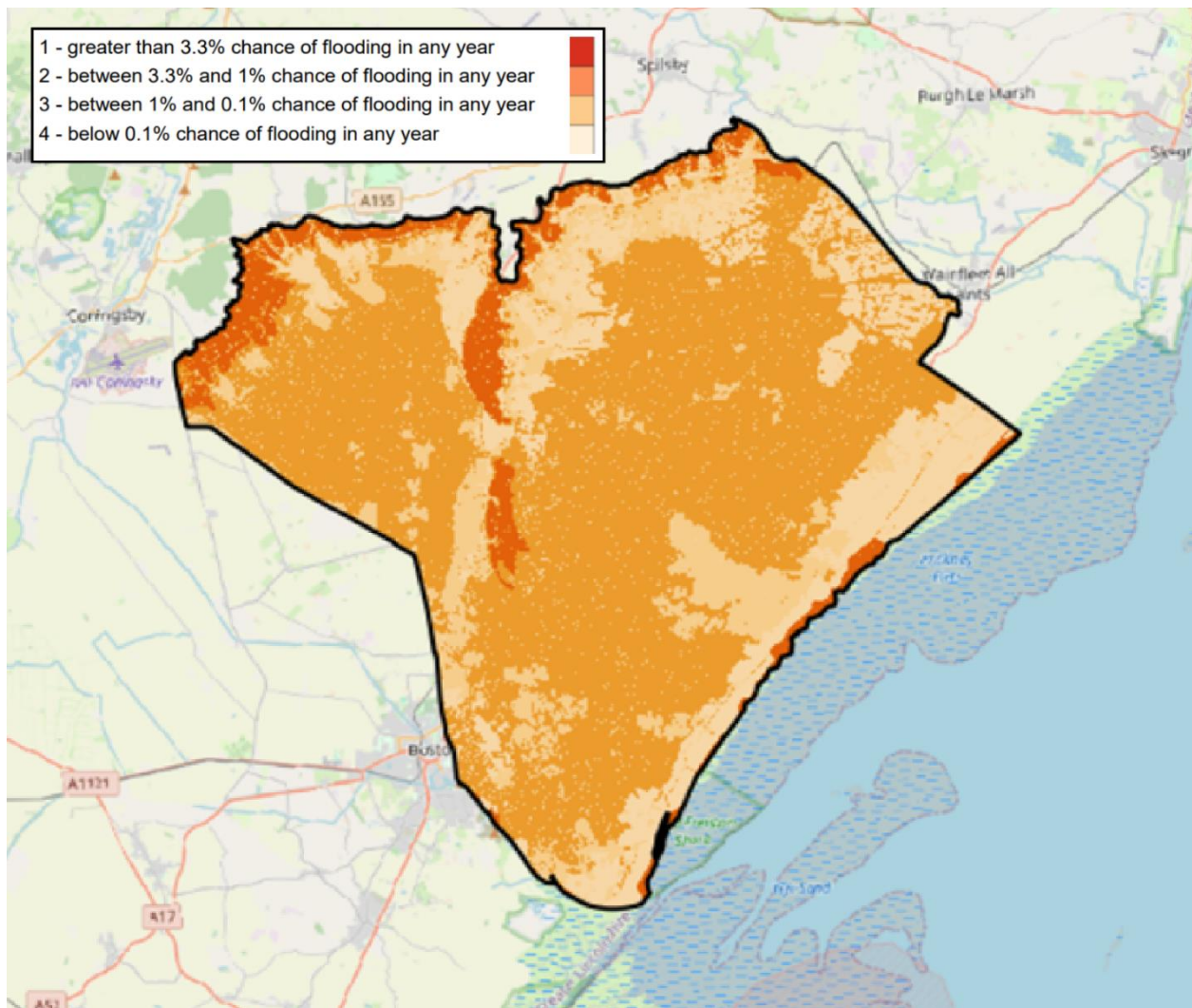


Figure 22: Risk of flooding from multiple sources © Environment Agency, 2025

Reduction in Risk of Flooding from Rivers and Sea Due to Defences - Produced using the defended scenario of flood risk in the Risk of Flooding from Rivers and Sea dataset and an undefended scenario of flood risk from rivers and sea.

Reduction in Risk of Flooding from Rivers and Sea Due to Defences - Produced using the defended scenario of flood risk in the Risk of Flooding from Rivers and Sea dataset and an undefended scenario of flood risk from rivers and sea.

Flood Zone 2 - It is the best estimate of the areas of land at risk of flooding, when the presence of flood defences is ignored and covers land between Zone 3 and the extent of the flooding from rivers or the sea with a 0.1% AEP chance of flooding each year.

Flood Zone 3 - It is the best estimate of the areas of land at risk of flooding, when the presence of flood defences is ignored and covers land with a 1% AEP or greater chance of flooding each year from Rivers; or with a 0.5% AEP or greater chance of flooding each year from the Sea.

The datasets listed above have been developed using an 'undefended' approach – i.e. the tidal and fluvial flood defences have been removed. Given the low-lying nature of the majority of the catchment, and the reliance on flood defence assets, this will inevitably result in an over-prediction of current flood risk. The dataset does not include any allowance for climate change. It will also not represent flood risk accurately in a heavily pumped catchment such as the East and West Fens catchment.

As the East and West Fens catchment has detailed models for both fluvial and tidal flood risk, NaFRA has not been used in this assessment.

3.3.2 National Flood Risk Assessment 2

National Flood Risk Assessment 2 (NaFRA2) includes:

- NaFRA2 software system: a web-based IT solution for Environment Agency staff; and
- New National Modelling (NNM): provides hazard outputs for rivers, sea, and surface water for various scenarios.

For NaFRA2, the focus is on using local modelling, though limited detailed local models are available within the catchment. The NNM will be used throughout most of the catchment and features:

- Outputs including maximum depth, level, etc.;
- A 2m model grid based on the Environment Agency's Integrated Height Model 2019 and Defra Marine DEM;
- Outputs including maximum depth, level, etc.; and
- Present day and climate change scenarios.

However, a specific Fens model developed for NaFRA2 is not available for this project, as it is not currently approved for use locally .

3.3.3 Internal drainage board models

It is our understanding that there is a model of the East and West Fens catchment developed by Witham Fourth District IDB – however at the time of writing we have not yet received this model.

Although the Environment Agency has catchment models for both fluvial and tidal flood risk as detailed in Section 3.2 these models would be of limited use when trying to understand the wider drainage network.

3.4 Other sources of information

3.4.1 Anglian River Basin District River Basin Management Plan

Updated in 2022, this policy tackles the challenges affecting the water environment in the Anglian River Basin District. Developed under the Water Framework Directive, it outlines actions to mitigate these pressures.

3.4.2 Anglian River Basin District Flood Risk Management Plan (2021-2027)

This plan encourages a partnership to explore the resilience measures that will help the basin district be more resilient and informs the delivery of existing flood programmes.

3.4.3 Joint Lincolnshire Flood Risk and Drainage Management Strategy (2019 - 2050)

The Strategy provides a framework for flood risk management across Lincolnshire, linking all the RMAs.

3.4.4 South East Lincolnshire Strategic Flood Risk Assessment (2017)

This outlines how development should consider flood risk at every stage of the development process. It includes a standard advice appendix which describes the assessment and mitigation measures required, based on Flood Zones and vulnerability to flood risk. No modelling was undertaken as part of the SFRA.

3.4.5 East Lindsey Strategic Flood Risk Assessment (2017)

East Lindsey Strategic Flood Risk Assessment (SFRA) was completed in 2017 and provides an assessment of flood risk to inform the Council's strategy for delivering sustainable development. No modelling was undertaken as part of the SFRA, therefore the outputs from this study have not been used in this assessment.

3.4.6 Boston Combined Strategy (2013)

The Strategy seeks to reduce the risk of tidal flooding to the town over the next 100 years. It includes the construction of the Boston Barrier, completed in 2020 and the raising of flood banks along The Haven.

3.4.7 The Wash Shoreline Management Plan 2 (2010) Section Gibraltar Point to Old Hunstanton

This plan outlines a strategic approach to managing flood and coastal erosion risks along the English coastline through to 2105. The Policy Development Zone (PDZ) of relevance to the East and West Fens is PDZ1 Gibraltar Point to Wolferton Creek, where the intention is to maintain the position and function of existing coastal flood defences. In the medium and longer term, managed realignment may be required depending on the potential loss of foreshore.

3.4.8 Witham Catchment Flood Management Plan (2009)

This plan guides the Environment Agency and its partners in planning and determining the most effective strategies for managing future flood risks. The key policy relevant to the catchment is Policy 4 which describes how further actions may be required to address the changes caused by climate change in areas that are prone to flood risk and are heavily managed, such as the Fens. Although this document has not been withdrawn, the publication of the River Basin Flood Risk Management Plan has diminished its weight in decision making.

3.4.9 Witham Fourth IDB Water level & Flood Risk Management Policy Statement

This policy statement makes public the Board's approach to water level and flood risk management within the district.

3.5 Key receptors

3.5.1 Settlements

Key settlements in the catchment include Boston (east), Butterwick, Friskney, Sibsey, Stickney, and Wrangle. Major transportation routes, such as the A16 and A52, along with the Grantham-Skegness Railway Line, provide vital links between the catchment and the surrounding areas.

3.5.2 Agriculture

The Fens is an area of national agricultural importance due to its rich peaty soils. Farms across the catchment are mainly focused on the production of arable and grassland crops. Smaller areas of more water-intensive, and higher value crops, such as potatoes and sugar beet are present, particularly in the south of the catchment fed by irrigation reservoirs.

Across the catchment, around 318km² (90%) of land is classified as ALC Grade 1 and 2 land, with the largest majority being classified as Grade 2. Table 1 and Figure 23 present an overview of ALC classification in the catchment.

Table 1: Overview of ALC classification within the catchment

	Grade 1	Grade 2	Grade 3	Grade 4	Non-agricultural
Area (km²)	109.66km ² (10,966ha)	208.45km ² (20,845ha)	21.00km ² (2,100ha)	7.60km ² (760ha)	0.10km ² (10ha)
Percentage of catchment (%)	31.08	59.08	5.95	2.15	0.03

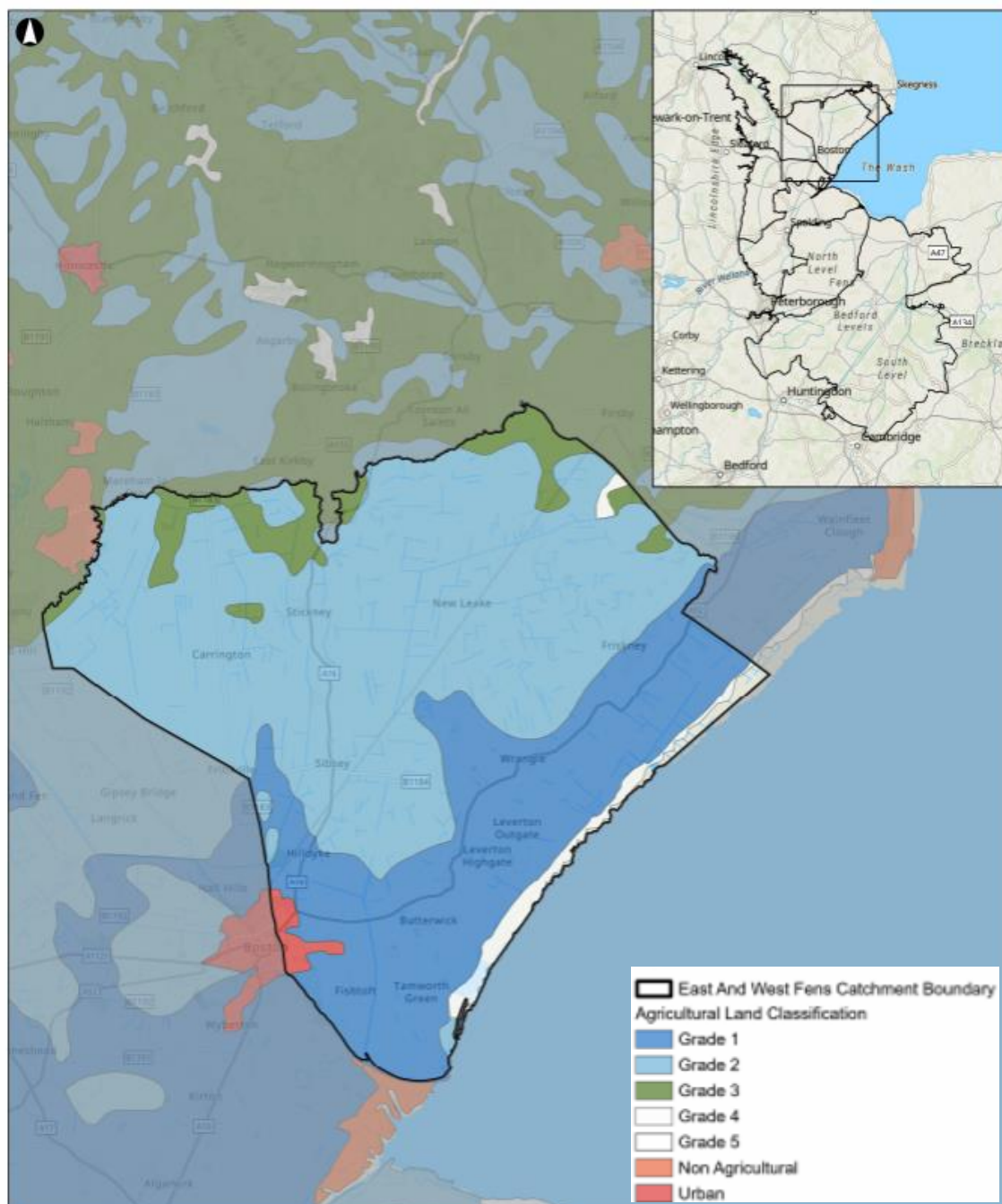


Figure 23: Land classification across the catchment

Approximately 287km² (82%) of land across the East and West Fens catchment is currently farmed.

It is estimated that the agricultural value of the crops grown on this land (based on 2021 data) is as follows:

- Cereal production – c.£19.5 million;
- Other arable – c.£14.6 million; and
- Fruit and vegetables – c.£51.1 million.

Grassland does not directly create economic value but instead supports the grazing of sheep and cattle, or the production of livestock feed. The estimated overall economic output of crops and livestock is in the region of £125 million, highlighting the importance of the agricultural sector.

4. Climate Change

The impact of climate change has been represented in both models used in this assessment to understand future tidal and fluvial. The approach to climate change in each of the models is described in the proceeding sections.

4.1 Tidal climate change

Climate change has been assessed as part of the Northern Area Tidal Modelling up to 2115 by an allowance for calculated rates of sea level rise over time. The increases used in this study are shown in Figure 24.

Years	Net Sea Level Rise (mm/yr)	Calculated Sea Level Rise (m)
2006 - 2025	4	0.08
2025 - 2055	8.5	0.26
2055 - 2085	12	0.36
2085 - 2115	15	0.45
Calculated Total Sea Level Rise (2006 – 2115)		1.14

Figure 24: Sea level rise used in 2010 Northern Area Tidal Modelling extracted from the Northern Area Tidal Modelling report © Environment Agency

The sea level rise applied to the design peak water levels generates a level of **6.02m AOD** at Maud Foster.

Since the study, which was completed in 2010, sea level rise estimates have been revised. Current Environment Agency guidance recommends assessing against two scenarios; Higher Central and Upper End⁹. The allowances for sea level rise are shown in Table 2.

Table 2: Sea level allowances for each epoch

Area of England	Allowance	2000 to 2035 (mm)	2036 to 2065 (mm)	2036 to 2065 (mm)	2066 to 2095 (mm)	Cumulative rise 2000 to 2125 (metres)
2025 Anglian	Higher Central	5.8	8.7	11.6	13	1.20
	Upper end	7	11.3	15.8	18.1	1.60

For flood risk assessments and strategic flood risk assessments, both the Higher Central and Upper End allowances will need to be assessed.

Flood and Coastal Erosion Risk Management (FCERM) schemes are typically assessed against the Higher Central. Given the long-term nature of the Fens 2100+ project, the 2080s epoch with the Higher Central allowance is most applicable to this study.

⁹ Environment Agency (2022) Flood and coastal risk projects, schemes and strategies: climate change allowances

These estimates have been compared to those applied in the 2010 modelling, shown in Figure 25. This shows that the estimates used in the 2010 study lie between the Higher Central and Upper End. Given that FCERM schemes typically assessed against the Higher Central it is considered that the climate change estimates used in the 2010 modelling are appropriate for use in this study.

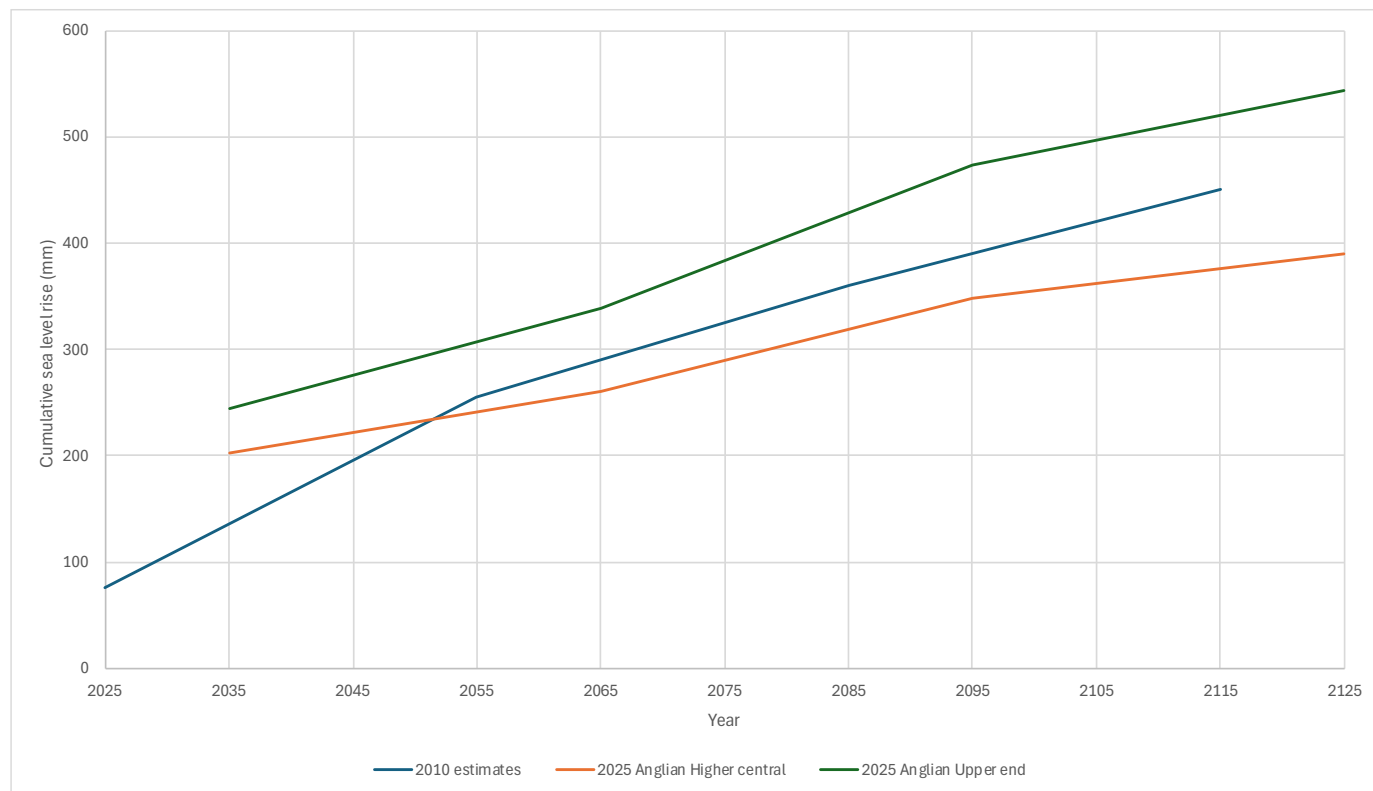


Figure 25: Comparison of sea level rise estimates

4.1 H++ scenario

The Fens 2100+ project is a long term adaptive plan for the landscape as such the H++ is a useful sensitivity test. Current Environment Agency guidance states that a value of 1.9m up to 2100 should be used (There is no H++ value for sea level rise beyond 2100).

None of the available modelling for the East and West Fens catchment includes an assessment of the H++ scenario. The most extreme value for climate change used within the 2010 modelling (as detailed in Figure 24) is 1.14m – this is considerably smaller than the value if 1.9m. We can therefore infer that the H++ scenario would show more flooding (depth and extent) than the results presented in the proceeding sections.

4.2 Fluvial climate change

The 2017 Stonebridge model assessed four climate change scenarios for the 1% and 0.5% AEP event:

- Uplift in fluvial flows of 20%
- Uplift in fluvial flows of 25%
- Uplift in fluvial flows of 35%
- Uplift in fluvial flows of 65%

These uplifts do not align with the latest DEFRA recommended values¹⁰ (see Table 3), however a number of modelled uplifts are close to those provided in the table below.

Table 3: Witham Management Catchment peak river flow allowances

	Central	Higher	Upper
2020s	9%	14%	27%
2050s	8%	15%	32%
2080s	21%	32%	57%

For flood risk assessments and strategic flood risk assessments the following are used:

- flood zones 2 or 3a:
 - essential infrastructure – Higher Central allowance
 - highly vulnerable – Central allowance (development should not be permitted in flood zone 3a)
 - more vulnerable – the Central allowance
 - less vulnerable – the Central allowance
 - water compatible – the Central allowance
- flood zone 3b:
 - essential infrastructure – use the Higher Central allowance
 - highly vulnerable – development should not be permitted
 - more vulnerable – development should not be permitted
 - less vulnerable – development should not be permitted
 - water compatible – use the Central allowance

For FCERM schemes, the following are used:

- Central allowance as the design allowance;
- Higher Central allowance to test the impacts of higher scenarios of climate change and any extra mitigation;
- Extreme allowance to test the option under more extreme climate change and exceedance events; and
- 2080s epoch allowances for changes beyond the 2080s epoch and up to 2115.

4.3 Conclusion

Both the 2010 Northern Area Tidal Model and the 2017 Stonebridge Model represent climate change. The 2017 Stonebridge Model uses slightly outdated climate change guidance; therefore, results may need to be interpolated between the various % uplift results. It is worth noting that the greatest percentage uplift used in the modelling a more

¹⁰ Environment Agency (2022) Flood and coastal risk projects, schemes and strategies: climate change allowances

than the current guidance recommendation (65% used in the 2017 modelling, 57% for the Extreme 2080s epoch).

The 2010 Northern Area Tidal Modelling study inevitably uses older sea level rise estimates. A review of the data suggests that these estimates will be between the Higher Central and Upper End scenarios in the current guidance. Whilst not exact, the sea level rise estimates in the 2010 model are broadly comparable to current estimates, as such are considered suitable for assessing future flood risk at a strategy scale.

5. Tidal Flood Risk

5.1 Current tidal flood risk

The East and West Fens catchment is protected by significant tidal embankments; these provide a high level of protection and are only overtopped during an extreme flood event.

The 2010 Northern Area Tidal Modelling showed that tidal current tidal flood risk in the 0.5% AEP would impact the agricultural areas close to the coastline. During the 0.5% AEP event no properties were predicted to flood, though there was flooding of high grade agricultural land. Around the mouth of The Haven, floodplain flood depths for this event reached a maximum of approximately 1m towards the boundary with the Steeping catchment and approximately 0.6m towards the boundary with the Steeping River catchment.

Inspection of model results showed that the defences are not overtopped during the 0.5% AEP event, rather the flooding is as a result of wave overtopping.

For the 0.1% AEP event, there was not a significant change in the modelled flood extents (see Figure 26), though the modelled flood extents do get close to properties in Boston. Flood depths are increased by approximately 1.5m around the mouth of The Haven in comparison to the 0.5% AEP event, with floodplain depths of up to approximately 1m towards the boundary with the Steeping catchment.

Closer inspection of the model results suggests that in addition to wave overtopping, defences are overtopped during the 0.1% AEP event.

Figure 26 shows there is currently limited tidal food risk in the catchment.

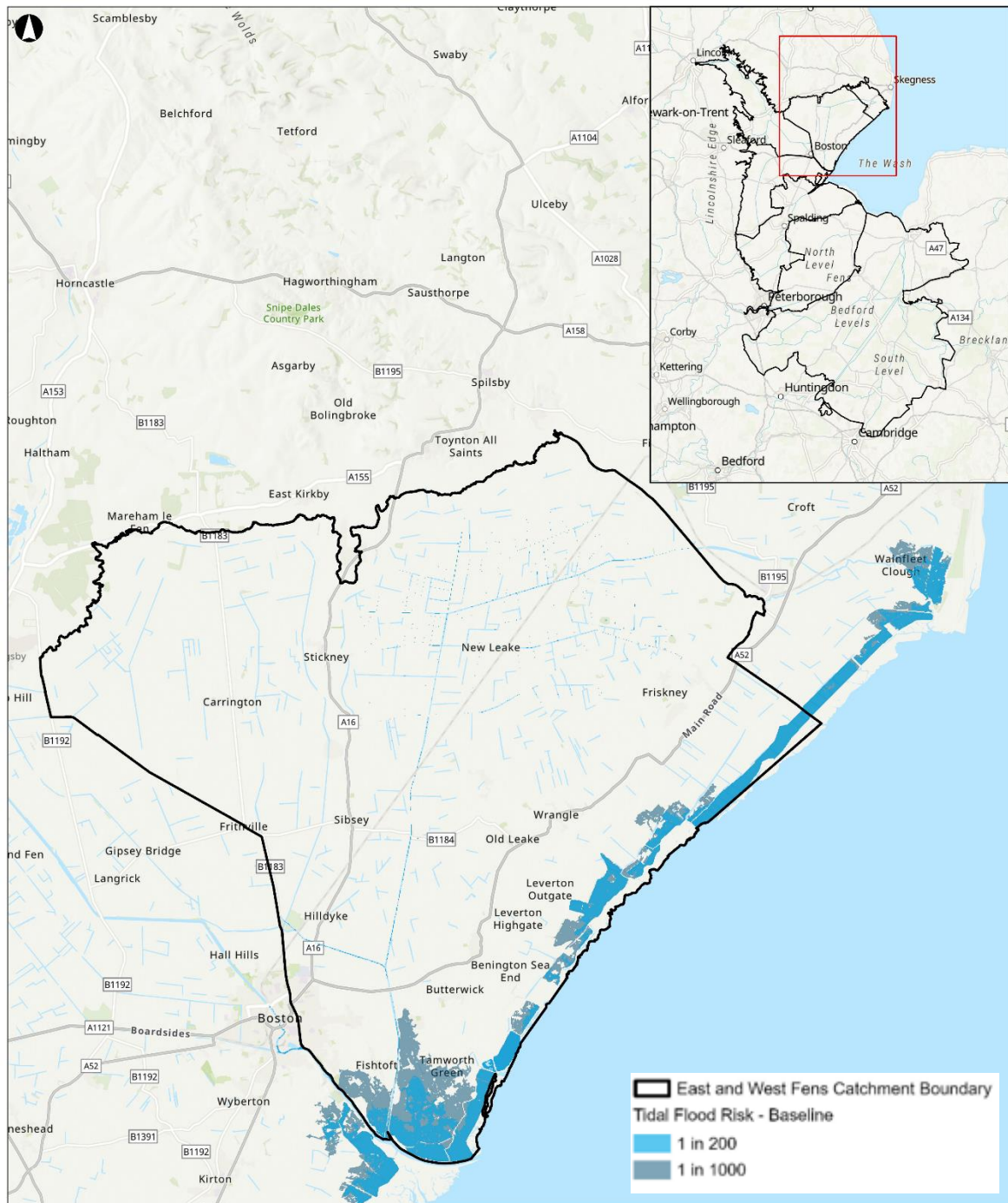


Figure 26: 0.5% AEP event and 0.1% AEP event current tidal flood risk

5.2 Future tidal flood risk

Tidal climate change has been assessed using the 2010 Northern Area Tidal modelling for the 0.5% AEP event up to 2115 (see Figure 27).

Results from the modelling showed a significant increase in flood risk in comparison to present day, with large areas of the East and West Fens catchment predicted to inundate, including large parts of Boston as well smaller villages including Fishtoft, Butterwick, Benington, Old Leake and Wrangle. It should be noted that model does not include the Boston Barrier (completed in 2020) and a series of embankments along The Haven, downstream of Boston. Whilst these defences would likely reduce the impact of flooding in

Boston to some degree, the widespread nature of the flooding suggests that floodwaters would find an alternative overland route into Boston.

The main mechanism is water overtopping of the existing flood embankments, as the sea level for the 0.1% AEP is higher than many of the existing embankments, and the future climate change flood extent is more extensive than the 0.1% AEP event. This results in significant flooding across the East and West Fens catchment.

In contrast to current flood risk, for the 0.5% AEP a number of settlements are at flood risk, these include:

- Fishtoft;
- Butterwick;
- Benington;
- Old Leake; and
- Wrangle.

It is also notable that the railway line between Boston and Wainfleet All Saints is predicted to inundate.

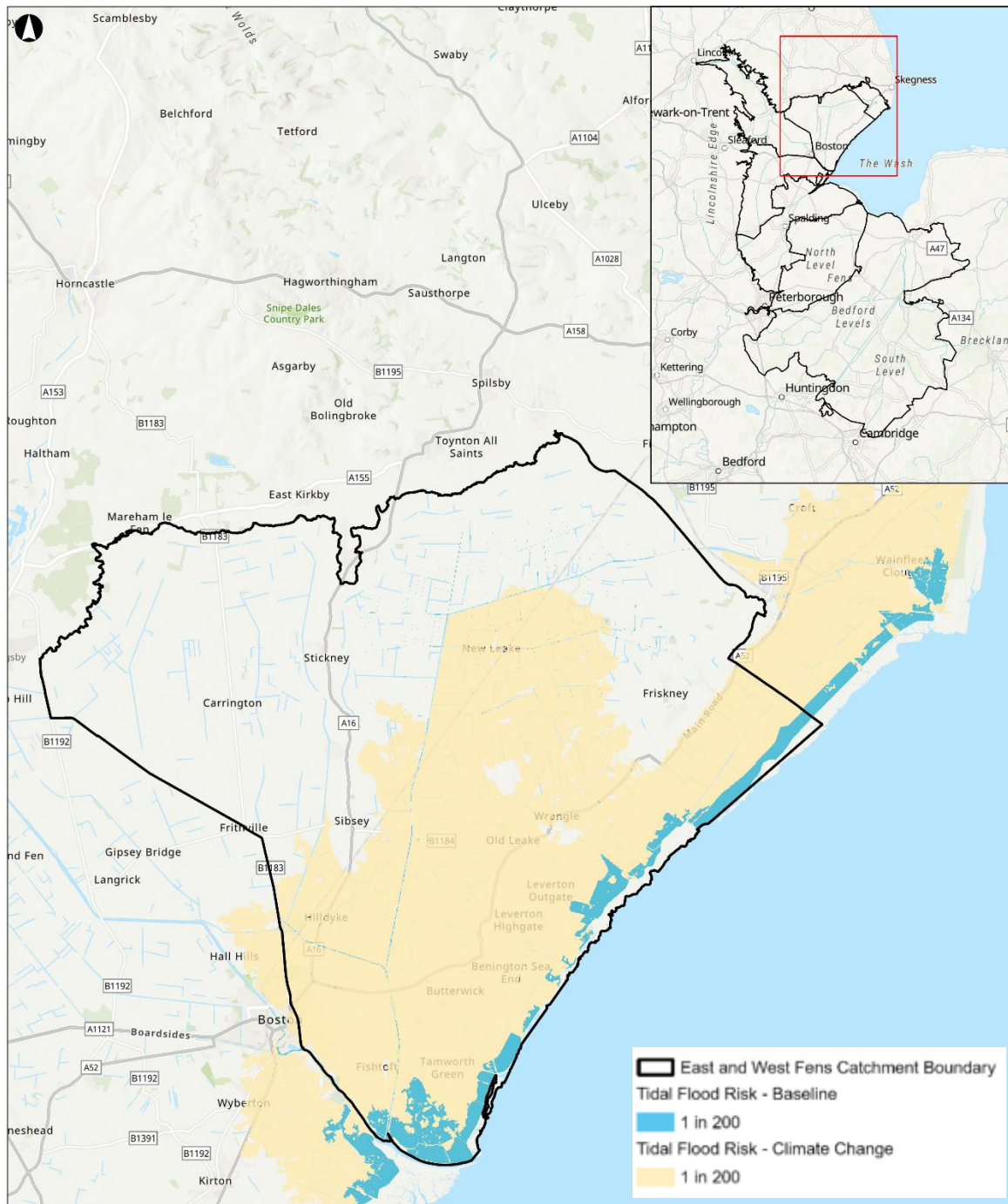


Figure 27: Comparison between 0.5% present day and 0.5% with climate change applied up to 2115

5.3 Key metrics

5.3.1 Total area

The total area found to be at risk of tidal flood risk, based on available model coverage within the East and West Fens catchment was:

- Current 0.5% AEP event – 12.33km² (1,233ha) – **3.5%** of total catchment area.
- Future 0.5% AEP with sea level rise up to 2115 – 230.02km² (23,002ha) – **65.2%** of the total catchment area.

- Current 0.1% AEP event – 21.2km² (2,120ha) – **6.01%** of total catchment area.

5.3.2 Grades of agricultural land

The agricultural land within the East and West Fens catchment area is assessed for tidal flood risk based on different grades, this has been summarised in Table 4.

Table 4: Agricultural land grading at risk of tidal flooding

Agricultural Grade	0.5% AEP (km ²)	0.5% with an allowance for climate change AEP (km ²)	0.1% AEP (km ²)
Grade 1	7.26km ² (726ha)	109.63km ² (10,963ha)	15.29km ² (1,529ha)
Grade 2	0.96km ² (96ha)	60.38km ² (6,038ha)	0.97km ² (97ha)
Grade 3	0.00km ²	0.01km ² (1ha)	0.00km ²
Grade 4	2.43km ² (243ha)	4.50km ² (450ha)	3.26km ² (326ha)
Total agricultural land flooded	10.65km² (1,065ha)	177.51km² (17,751ha)	19.53km² (1,953ha)

5.3.3 Percentage area over 30cm

The area that floods over 30cm for each event is:

- 0.5% AEP event – 6.4km² (640ha) – **1.81%** of total catchment area.
- 0.5% + CC AEP event – 151.42km² (15,142ha) – **42.92%** of total catchment area.
- 0.1% AEP event – 13.86km² (1,386ha) – **3.93%** of total catchment area.

5.4 Discussion

The significant increase in flood risk for the 0.5% AEP event when climate change is included shows how vulnerable the East and West Fens Catchment is to sea level rise. A present day 0.5% AEP event results in minimal flooding (and none to any settlements). When climate change is applied to the same event, the flood extent is considerably greater, with a number of settlements predicted to be at flood risk and significantly more high-grade agricultural land becoming inundated.

6. Fluvial Flood Risk

6.1 Current fluvial flood risk

Results from the 2017 Stonebridge Defended baseline model have been used to assess current fluvial flood risk. The results showed that there is some fluvial flooding during the 1% AEP event and the 0.1% AEP event in the north of the catchment, associated with the Main Rivers, namely Stone Bridge Drain, West Fen Catchment Drain and East Fen Catchment Drain (see Figure 28).

A number of small settlements are at risk of flooding in both scenarios, including New Bolingbroke, Stickney and Keal Cotes.

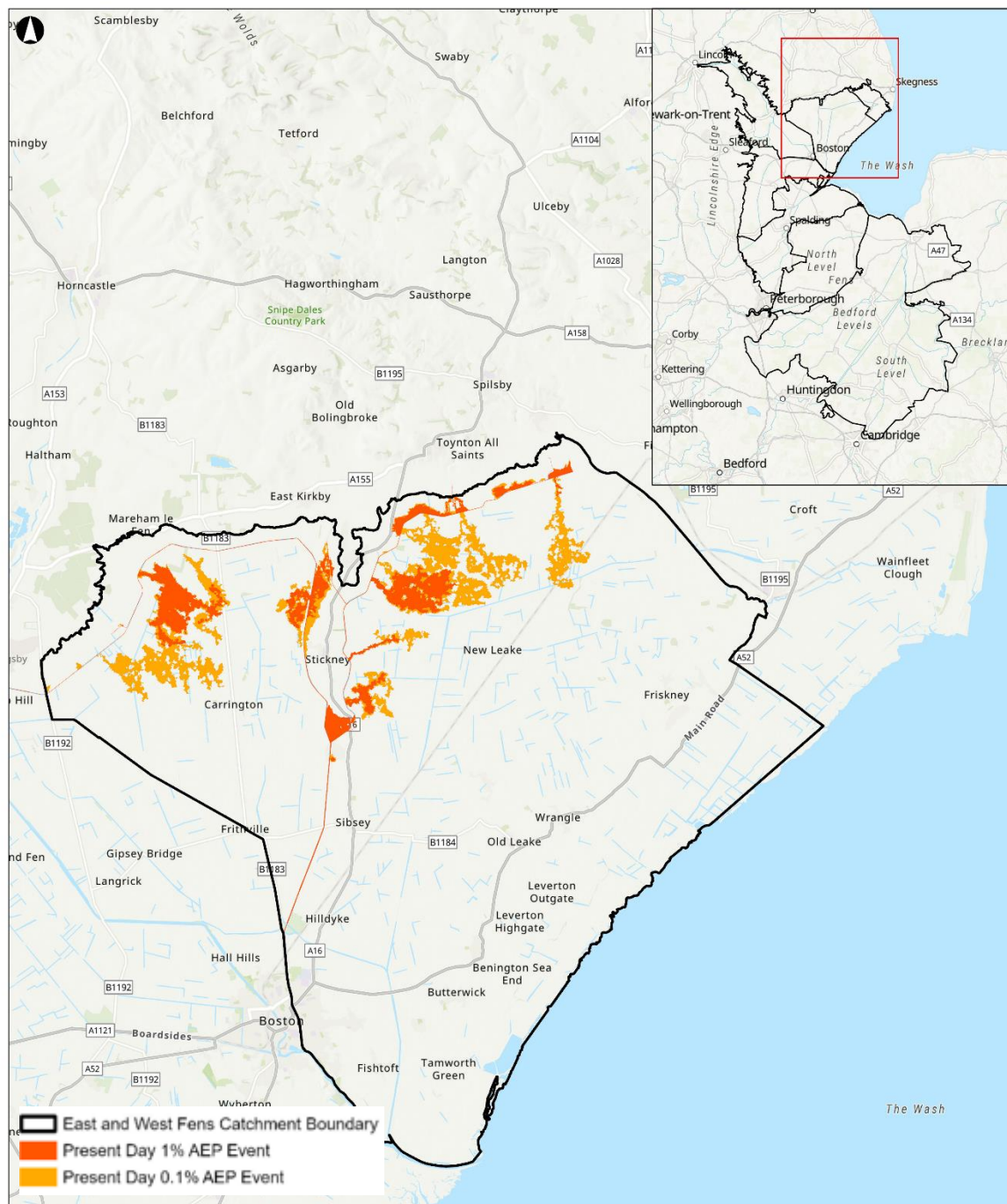


Figure 28: The 1% AEP event and the 0.1% AEP event current fluvial flood risk in the catchment

There is an increase in flood extent between the 1% AEP and the 0.1% AEP event, mainly affecting agricultural land.

6.2 Future fluvial flood risk

The 2017 fluvial model has assessed four climate change scenarios for the 1% AEP and 0.1% AEP event:

- Uplift in fluvial flows of 20%
- Uplift in fluvial flows of 25%
- Uplift in fluvial flows of 35%
- Uplift in fluvial flows of 65%

As expected, the uplift in fluvial inflows resulted in an increase in flood risk across the catchment. As discussed in Section 6, there was some flooding in the present day 1% event to the north of the catchment. For all climate change scenarios, there is an increase in flooding across the catchment, again mainly to agricultural land as shown in Figure 29.

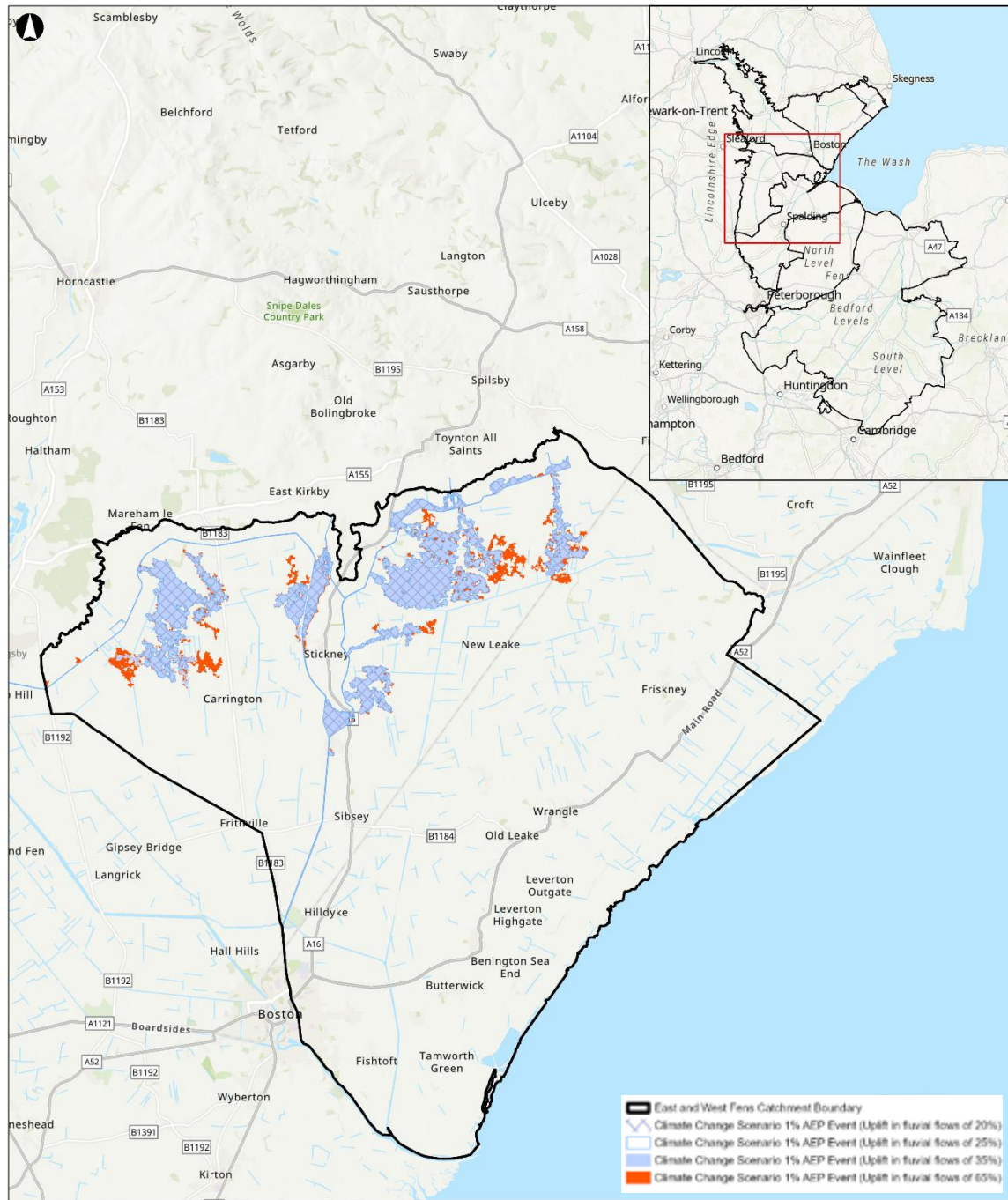


Figure 29: The 1% AEP flood event compared to the 1% AEP flood event with 65% uplift for climate change

6.3 Key metrics

6.3.1 Total area

The total area to be at fluvial flood risk within the East and West Fens catchment is as follows:

- 1% AEP event – 9.84km² (984ha) – **2.79%** of total catchment area.
- 1% AEP event with 20% fluvial uplift – 16.29km² (1,629ha) – **4.62%** of total catchment area.

- 1% AEP event with 25% fluvial uplift – 18.64km² (1,864ha) – **5.28%** of total catchment area.
- 1% AEP event with 35% fluvial uplift – 19.34km² (1,934ha) – **5.48%** of total catchment area.
- 1% AEP event with 65% fluvial uplift – 24.5km² (2,450ha) – **6.94%** of total catchment area.
- 0.1% AEP event – 23.82km² (2,382ha) – **6.75%** of total catchment area.

6.3.2 Grades of agricultural land

The agricultural land at flood risk within the East and West Fens catchment area has been assessed for flood risk based on different grades and has been summarised in Table 5

Table 5: Agricultural land grading at risk of fluvial flooding

Agricultural Grade	1% AEP (km ²)	1% AEP with a 20% allowance for climate change (km ²)	1% AEP with a 25% allowance for climate change (km ²)	1% AEP with a 35% allowance for climate change (km ²)	1% AEP with a 65% allowance for climate change (km ²)	0.1% AEP (km ²)
Grade 1	0.08km ² (8ha)	0.08km ² (8ha)	0.08km ² (8ha)	0.08km ² (8ha)	0.08km ² (8ha)	0.08km ² (8ha)
Grade 2	7.09km ² (709ha)	13.14km ² (1,314ha)	15.43km ² (1,543ha)	16.07km ² (1,607ha)	20.77km ² (2,077ha)	20.21km ² (2,021ha)
Grade 3	2.62km ² (262ha)	3.02km ² (302ha)	3.09km ² (309ha)	3.14km ² (314ha)	3.60km ² (360ha)	3.49km ² (349ha)
Grade 4	0.00	0.00	0.00	0.00	0.00	0.00
Grade 5	0.00	0.00	0.00	0.00	0.00	0.00
Total agricultural land	9.83km² (983ha)	16.29km² (1,629ha)	18.64km² (1,864ha)	19.34km² (1,934ha)	24.50km² (2,450ha)	23.81km² (2,381ha)

6.3.3 Percentage area flooded over 30cm

As it is a 1D only model, no 2D results (depth or level raster grids) were available for the 2017 Stonebridge model. Therefore, it is not possible to report the area that floods over 30cm for each event.

6.4 Discussion

Up to the 0.1% AEP event, fluvial flood risk across the catchment is low, within only small areas in the north of the catchment shown to be at fluvial flood risk consisting mainly of agricultural land. It's not possible to compare this flooding to historic records as no details were available of the specific location or extent of historic fluvial flooding. As previously

noted in Section 3.2.3, the model extent only covered the Main Rivers in the catchment and not the low lying drains in the East Fen and West Fen.

7. Other sources of flooding

Aside from fluvial and tidal, other sources of flooding include surface water, groundwater, and reservoirs. These sources can be the sole cause of flood events or compound the effects of flooding from fluvial or tidal sources. This section sets out these other sources of flood risk, and potential impacts from these sources. It will also consider historical events in the catchment which highlight these issues. This information is intended to provide a high-level summary of the risk of flooding from these wider sources.

7.1 Surface water and drainage

Surface water flooding occurs when intense rainfall results in an excess of overland flow before it can reach a watercourse or drainage network. This type of flooding can also happen when rainwater is unable to drain away through the usual drainage systems or soak into the ground. Contributing factors may include insufficient system capacity, saturated ground, or failures in the drainage network due to blockages or culvert collapses. Presence of sandy or gravel soils can mean increased susceptibility to movement of groundwater and flooding from this source.

While surface water flooding is typically caused by high-intensity rainfall, it can also occur during lower intensity rainfall if the land has low permeability. Permeability can be reduced by factors such as development, frozen ground, or already saturated soil. Additionally, flooding can occur if the drainage network is already at capacity, preventing water from draining efficiently to the intended watercourse or sewer.

The Environment Agency's long term flood risk service¹¹ provides mapping of surface water flood risk. It shows that flood risk from surface water is generally highly localised, with dense but small and isolated patches where surface water flooding is likely. However, there are larger areas of surface water flood risk concentrated along the course of the Main River Network, following the catchwater drains across the northern boundary of the catchment, and in the strip following the Stonebridge Drain between Stickney and Sibsey. In these areas there are larger continuous areas of high surface water flood risk, with more than a 3.3% chance of flooding each year. The SFRA for East Lindsey¹² identifies recorded incidents of internal flooding of properties from surface water in the village of Friskney following extreme rainfall events.

7.1.1 Surface water flood event Sibsey 20th October 2023

From the East Lindsey District Council Section 19 Reports, it is understood that flooding likely occurred as a result of surface water runoff, following substantial heavy rainfall, with surcharge and exceedance of the highway drainage system as a result. Surface water was reported to flow off of the highway, adjacent to the property and down the driveway.

7.2 Groundwater

Groundwater flooding occurs when the water table, the level of the water within the land, rises above the ground surface. This type of flooding typically follows extended periods of sustained rainfall. Groundwater flooding can persist for a prolonged duration, often lasting

¹¹ Environment Agency (2024) Check the long term flood risk for an area in England. Available at: [Information for planning - Check your long term flood risk - GOV.UK](#). Accessed 04/04/2025.

¹² East Lindsey District Council (2017). East Lindsey Strategic Flood Risk Assessment. Available at: [CHttpHandler.ashx](#). Accessed 08/04/2025.

longer than other types of flooding. Throughout the year, the water table naturally fluctuates in response to seasonal rainfall. Groundwater flooding is most common in spring, following prolonged rainfall during the preceding autumn. Presence of sandy or gravel soils can mean increased susceptibility to movement of groundwater and flooding from this source.

Across the East and West Fens catchment the land is low-lying, which can contribute to a higher risk of groundwater flooding through the water table being at a shallow depth. There is also a risk that flooding will not recede for long periods of time due to the flat nature of the catchment and the reliance on pumping for drainage. The SFRA for East Lindsey¹³ identified no recorded incidents of flooding from groundwater in Friskney, Sibsey or Stickney, although it is possible that high groundwater levels contributed to flooding in a number of historic flood events caused by other sources.

7.3 Reservoir

Reservoir flooding is very rare but occurs when there is a failure of reservoir impounding structures such as raised embankments. In the East and West Fens catchment, there are several on-farm reservoirs, but these are small and do not pose a significant flood risk. The SFRA for East Lindsey¹⁴ considers the risk of reservoirs as low across the district, as there is only one large reservoir listed as such under the Reservoirs Act of 1975, and this is located much further north in Covenham.

Mapping of reservoir flood risk across the UK¹⁵ shows reservoir flood risk is concentrated in the western half of the catchment. Reservoir flooding is predicted to occur when there is also flooding from rivers. When river levels are normal, no flooding from reservoirs is predicted.

¹³East Lindsey District Council (2017). East Lindsey Strategic Flood Risk Assessment. Available at: [CHttpHandler.ashx](#). Accessed 08/04/2025.

¹⁴East Lindsey District Council (2017). East Lindsey Strategic Flood Risk Assessment. Available at: [CHttpHandler.ashx](#). Accessed 08/04/2025.

¹⁵ Environment Agency (2024) Check your long-term flood risk. Available at: [Technical map - Check your long-term flood risk - GOV.UK](#). [Accessed 07/04/2025].

8. Summary and recommendations

8.1 Tidal Flood Risk

Current tidal flood risk is entirely to Grade 1 and Grade 4 agricultural land near the coast – the majority at risk being Grade 1. Overtopping of the existing embankments only occurs in the most extreme event modelled – the 0.1% AEP event. Flooding in the 0.5% AEP event is caused by wave overtopping, rather than the tide level being higher than the existing embankments. This indicates that current tidal flood risk in the East and West Fens catchment is low, assuming that there are no breaches in the embankments.

In the future, the flood risk increases significantly once sea level rise, up to the year 2115, has been used in the existing modelling. Modelling showed that for the 0.5% AEP event when sea level rise has been considered, the total area flooded covers approximately 65% of the East and West Fens catchment (in comparison to 3.5% in the present day). This results in the flooding of 110km² (11,000ha) of Grade 1 agricultural land – in comparison to 7.3km² (730ha) in the present day 0.5% AEP event. Future tidal flood risk results in flooding of a number of settlements within the East and West Fens catchment, including large parts of Boston.

Overall, current tidal flood risk to the East and West Fens catchment is low, however this increases when climate change is applied, resulting in flooding of more than half of the catchment during the 0.5% AEP event. Whilst it can be considered that current flood risk is low, this assumes the existing embankments do not fail during an event. A breach in the tidal defences is likely to result in significant flooding of the East and West Fens catchment – particularly to Grade 1 agricultural land.

8.2 Fluvial Flood Risk

The flood history of the East and West Fens catchment shows that there have been a number of fluvial flood events though details are not available regarding the location and extent, suggesting that the impact to properties was minimal. This is reflected in the existing model with the 1% AEP event showing limited flooding, predominantly of agricultural land – a total of 9.78km² (978ha). This figure increases to 23.76km² (2,376ha) for the current 0.1% AEP event.

There is an increase in flooding when climate change is applied to the 1% event, though in the upper allowance scenario, only 24.45km² (2,445ha) of agricultural land is inundated – a relatively small proportion of the overall catchment.

As previously noted in Section 3.2.3, the model extent only covers the Main Rivers in the catchment and not the low-lying drains in the East Fen and West Fen.

8.3 Conclusions

Modelled present day tidal and fluvial flood risk to the East and West Fens catchment is low. The presence of significant tidal and fluvial embankments, as well as assets such as the Boston Barrier provides a high degree of protection to the catchment from both fluvial and tidal sources. However, where current tidal and fluvial flood risk is predicted, it is usually to high grade agricultural land.

Modelling predicts that the East and West Fens catchment is vulnerable to sea level rise as a result of climate change – for the 0.5% AEP event, more than half the catchment is predicted to inundate, even allowing for the presence of the tidal embankments. As can be

seen during the 2013 tidal flood event, breaches to the existing tidal defences and result in significant flooding of Grade 1 agricultural land.

There is an increase in fluvial flood risk as a result of climate change, however its impact is dwarfed by the tidal flood risk.