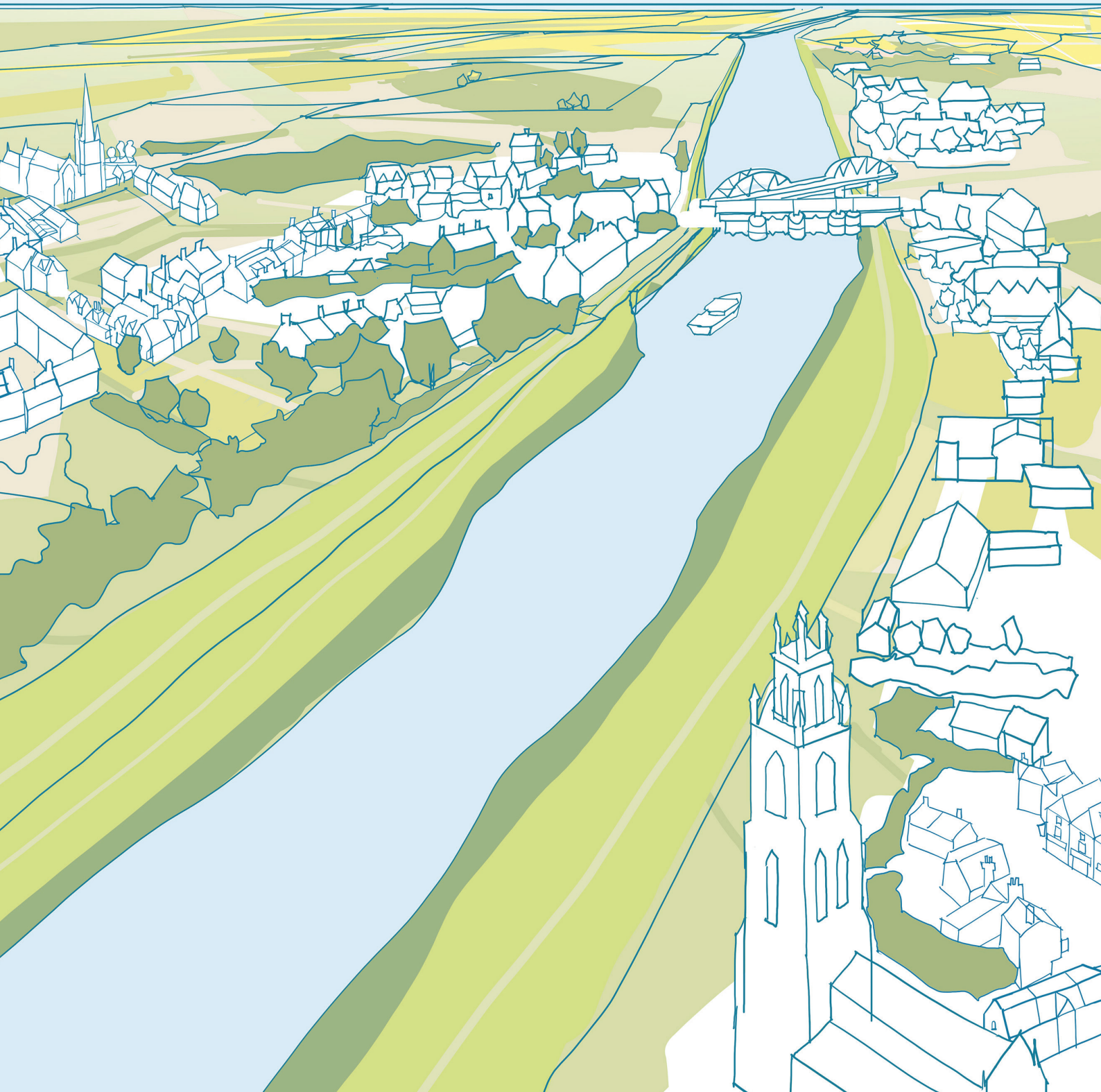
Fens 2100+

Witham East and West Fens

Baseline evidence report

2025



Find out more

Summary baseline evidence report

Discover key findings from across the Fens.



Catchment baseline evidence reports

View the full suite of reports, for more detail on each catchment.



Technical appendices

Explore the evidence, detailed in technical appendices for each catchment report:

- Flood risk baseline
- Baseline economic appraisal report
- Assets baseline report
- Environmental and agricultural baseline
- Natural capital register and account

For more information contact:

Fens2100@environment-agency.gov.uk

This document has been produced by Arup in collaboration with the Environment Agency, Rivelin Bridge and the Fens 2100+ Partners as part of a wider programme of work, drawing from engagement across the area and sector.

The report in context

A robust evidence base

This report provides, for the first time, a comprehensive picture of flood risk and asset performance across the East and West Fens catchment.

This report was compiled in collaboration with Internal Drainage Boards (IDBs) and local partners.

It forms part of a suite of catchment reports offering a robust evidence base to support the Fens 2100+ Partnership in transforming the approach to investing in flood and coastal resilience, including:

- Maintaining and managing critical assets, which are ageing and under increasing pressure from climate change.
- Addressing how the area will function in the future, balancing flood risk, water supply, sustainability and economic growth.

Each report brings together data and insights from key Risk Management Authorities (RMAs) on their experience of managing the catchment. Information includes the historical and environmental context, the function of flood risk assets and their economic impact, current and future flood risks and investment challenges and opportunities.

Securing the future of the Fens

Located in eastern England, the Fens is one of the UK's most distinctive landscapes. Significantly influenced by human activity, it has evolved over centuries from marshland into fertile farmland through drainage systems, embankments and pumping stations. Today, it is a vital region for food production and manufacturing and environmental value, contributing significantly to the UK economy.

Lying largely at or below sea level, this highly vulnerable region faces increasing risks from rising sea and river levels driven by climate change and land subsidence caused by drying peat soils.

Without constant water management, large areas of the Fens would become uninhabitable, with the lives and livelihoods of over 600,000 being impacted by flooding from the rivers and the sea.

Yet, many of the 17,000 flood risk management assets that sustain the region are being affected by reliability and performance issues caused by their age. Many were built in the post-war period, with some dating back to the 1600s.

If these critical assets fail, the consequences would be catastrophic, risking lives, land, businesses and infrastructure.

Witham East and West Fens

Total catchment area
353km²

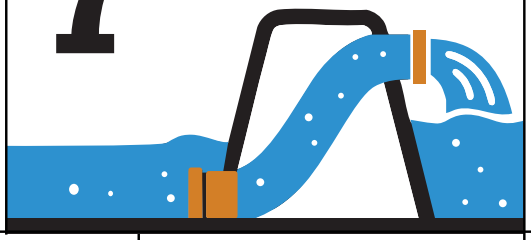


91%
of land classified as Grade 1 & 2 agricultural land



Estimated total population
32,999

7 pumping stations

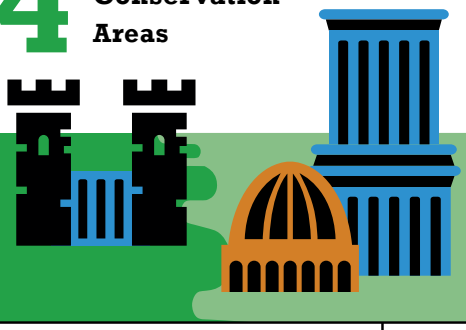


1 Internal Drainage Board

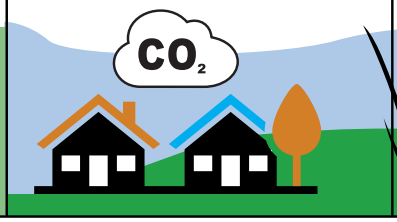


11 Scheduled Monuments

4 Conservation Areas



37,600
tonnes of CO_2 equivalent emitted by degraded peatland in the catchment each year



5 designated sites for nature conservation



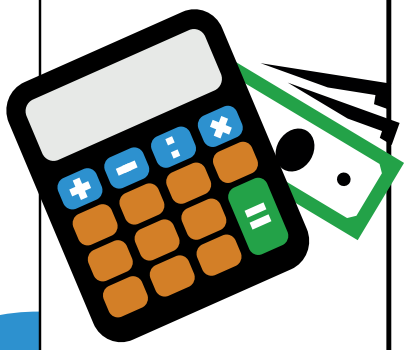
£46.8 million
total annual value from natural capital



71% Environment Agency maintenance expenditure spent on embankments

Total length of embankments managed by the Environment Agency **88km**





£7bn
economic benefits of current flood defences

Introduction

The evidence is clear: without urgent investment to maintain and upgrade flood risk assets across the East and West Fens catchment, £7.4 billion of damages could be sustained to land, homes and livelihoods.

A landscape worth protecting

Covering 353km^2 (35,300ha) of eastern Lincolnshire, the East and West Fens catchment is an area of national agricultural importance. Its healthy agricultural economy supports approximately 1,500 local jobs and contributes £125 million a year to the UK economy.

There are five designated nature conservation sites, including The Wash, an internationally important wetland for wading and migratory birds, shellfish and seals.

Natural capital delivers £46.8 million of benefits a year, including food production, flood risk management, carbon sequestration, clean water and recreation. Around 5% of land is underlain by rich peat deposits.

What's the challenge?

Continuous land drainage and flood defences are all that protect low-lying areas from permanent inundation. 294km^2 (29,400ha) of agricultural land and 16,590 homes are at risk. Yet, 87% of flood risk assets are being affected by reliability and performance issues caused by their age, and 26% have already expired.

Approximately 31% of assets are rated 'Poor', 'Very Poor' or 'Unknown', including critical structures such as outfalls. This complex system of assets requires significant resources and collaboration between RMAs.

Repeated flooding events highlight the catchment's vulnerability, including river flooding in 2007 and tidal flooding in 2013 and 2023. Climate change will intensify this risk, even if current defences are maintained.

What's needed?

£0.8-£1.5 billion

of investment

to sustain the current Standard of Service for 100 years

To maintain

£7.0 billion

of benefits

through reduction of damages to properties, agriculture, transport and the environment

Catchment overview map

The catchment in context

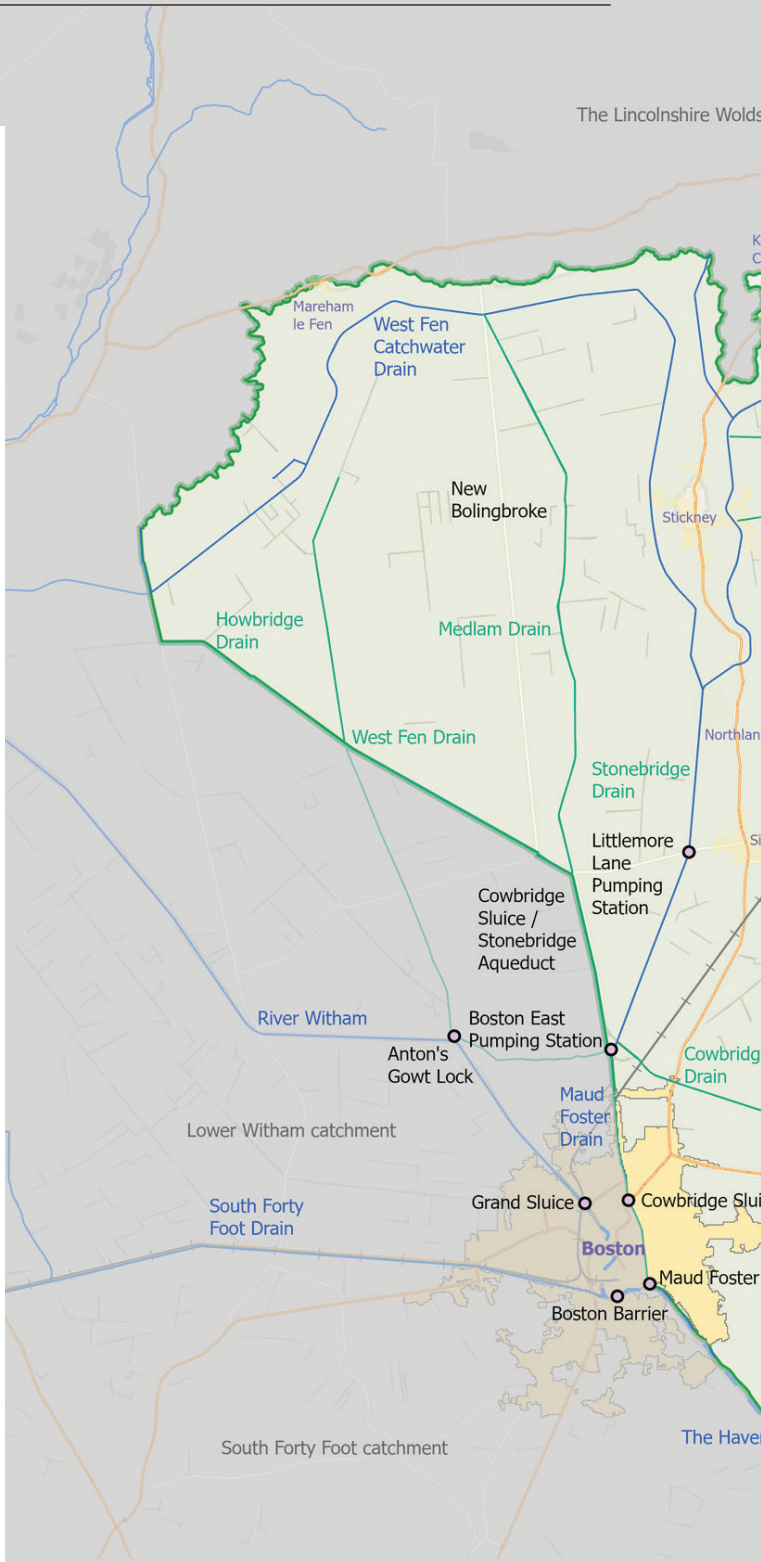
The East and West Fens catchment covers approximately 353km^2 (35,302ha) and is a subcatchment of the River Witham. Located in eastern Lincolnshire, it is bordered by the Lincolnshire Wolds to the north and The Wash to the east. To the south, the catchment boundary is formed by the tidal reach of the River Witham at Boston, known as The Haven. The catchment comprises two drainage systems: a network of Main Rivers managed by the Environment Agency, and a network of drains managed by Witham Fourth District IDB.

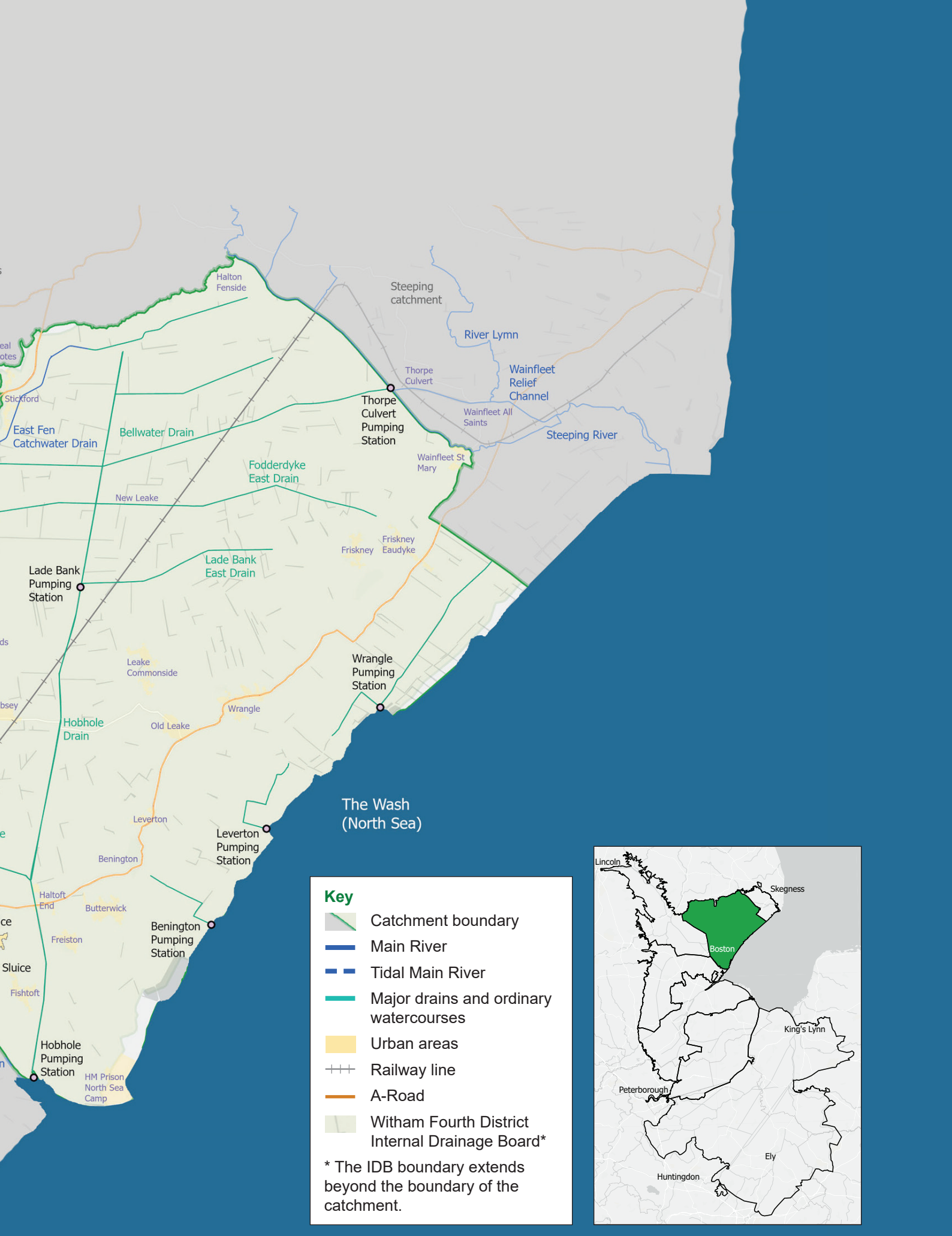
The Main River system includes the East Fen Catchwater Drain and the West Fen Catchwater Drain. These catchwater drains run along the foot of the Lincolnshire Wolds, collecting water from the higher ground and preventing it entering the pumped IDB district. At Northlands, the drains combine to become Stonebridge Drain, and downstream of Cowbridge Sluice it is known as Maud Foster Drain. The Maud Foster Drain outfalls at the Maud Foster Sluice into The Haven, downstream of the tidal Boston Barrier. This system operates by gravity, in contrast to the IDB system which is largely reliant on pumping to remove water.

The East and West Fens catchment covers approximately

353km^2

of eastern Lincolnshire.




Halton Fenside
Steeping catchment
River Lymn
Thorpe Culvert
Wainfleet Relief Channel
Stickford
Thorpe Culvert Pumping Station
Wainfleet All Saints
East Fen Catchwater Drain
Bellwater Drain
Steeping River
Wainfleet St Mary
Fodderdyke East Drain
New Leake
Friskney
Friskney Eaudyke
Lade Bank East Drain
Lade Bank Pumping Station
Wrangle Pumping Station
Leake Commonside
Wrangle
Hobhole Drain
Old Leake
The Wash (North Sea)
Leverton
Leverton Pumping Station
Benington
Haltoft End
Butterwick
Benington Pumping Station
Freiston
Sluice
Fishtoft
Hobhole Pumping Station
HM Prison North Sea Camp
Key
Catchment boundary
Main River
Tidal Main River
Major drains and ordinary watercourses
Urban areas
Railway line
A-Road
Witham Fourth District Internal Drainage Board*
* The IDB boundary extends beyond the boundary of the catchment.
Lincoln
Skegness
Boston
King's Lynn
Peterborough
Ely
Huntingdon

Catchment overview

The Main River and IDB systems operate independently, with Main Rivers discharging by gravity and IDB drainage requiring significant pumping.

The Witham Fourth District IDB system includes a complex network of drains and drainage assets. This system conveys water from the low lying areas of the catchment into The Haven and The Wash. Management of water levels in this system is achieved entirely by pumping.

The Witham Fourth District IDB system comprises five operating sub-catchments. The Wildmoor and West Fen and the East Fen sub-catchments drain into the Lower Hobhole sub-catchment, which is then discharged into The Haven at Hobhole Pumping Station. The Wrangle, Leverton and Benington sub-catchments outfall directly into The Wash at separate outfalls. Only two very small IDB sub-catchments at Sibsey and on the eastern edge of Boston outfall into the Main River system. Otherwise, the two drainage systems operate separately.

The key assets owned, operated and maintained by Witham Fourth District IDB are Cowbridge Sluice and the pumping stations at Hobhole, Lade Bank, Wrangle, Leverton and Benington.

The majority of the catchment lies just above sea level at approximately 2-3m Above Ordnance Datum (AOD) but some parts of East Fen in the north-east lie 0.6m below sea level. The only way to transmit water to the sea from the IDB catchment is to use a series of pumps. Water from East Fen is lifted first at Lade Bank Pumping Station, and again at Hobhole Pumping Station. Water is lifted upward by up to 7m into The Haven during a high tide.

The Main River and IDB systems cross each other at Cowbridge, where an aqueduct carries Stonebridge Drain over the Cowbridge Drain. Water from the Main River system can spill into the Witham Fourth District IDB system at Stonebridge aqueduct and Anton's Gowt, although this only occurs during extreme flood events.

The catchment has an estimated total population of 32,999, spread across numerous hamlets and villages. The larger population centres are the eastern portion of Boston and the settlements of Wrangle, Friskney, Stickney and Sibsey. Approximately 31% of the catchment is highly productive Grade 1 agricultural land.

Major transportation routes, such as the A16 and A52, provide vital links between the catchment and the surrounding areas.



View upstream on the Hobhole Drain from Hobhole Pumping Station
© Arup 2024

Flood management system

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 **Grand Sluice**
Environment Agency
Controls water levels on the River Witham, and prevents the tide coming further inland.

6 **Boston Barrier**
Environment Agency
Prevents extreme high tides or surges from flooding Boston and the surrounding land.

7 **Stonebridge Aqueduct**
Environment Agency
Carries the elevated Stonebridge Drain over the IDB's Cowbridge Drain.

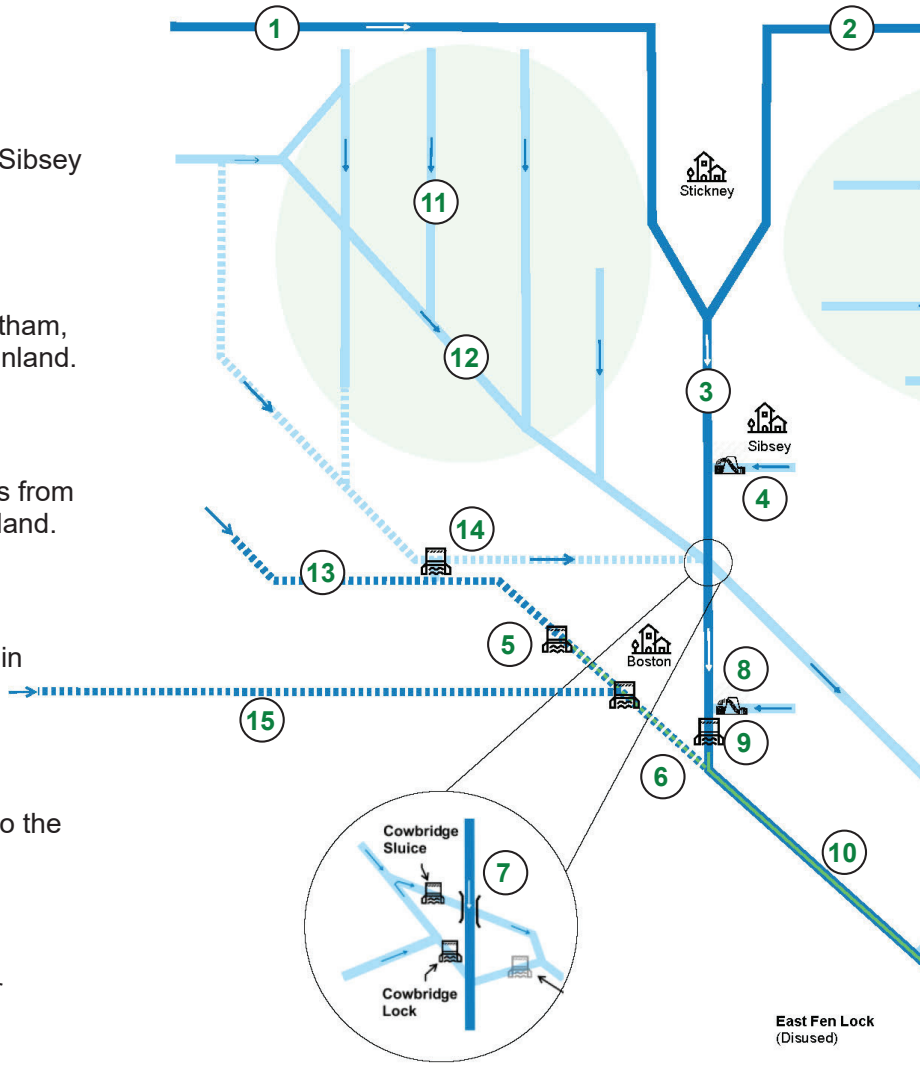
8 **Boston East Pumping Station**
Witham Fourth District IDB
Pumps water from eastern Boston into the Maud Foster Drain.

9 **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.

10 **The Haven**
Main River
The tidal section of the River Witham.

11 **West Fen**
A low-lying area to the west of Stonebridge Drain. Drainage began in the 1500s.

12 **West Fen Drain**
Witham Fourth District IDB
Carries water from the West Fen towards the Hobhole Drain.



13 River Witham

Main River

Water from most of the catchment (except coastal areas) flows directly into The Haven through the Maud Foster Sluice or Hobhole Pumping Station.

14 Anton's Gowt Lock

Canal & River Trust

Provides access between the River Witham and the Witham Navigable Drains managed by the Witham Fourth IDB.

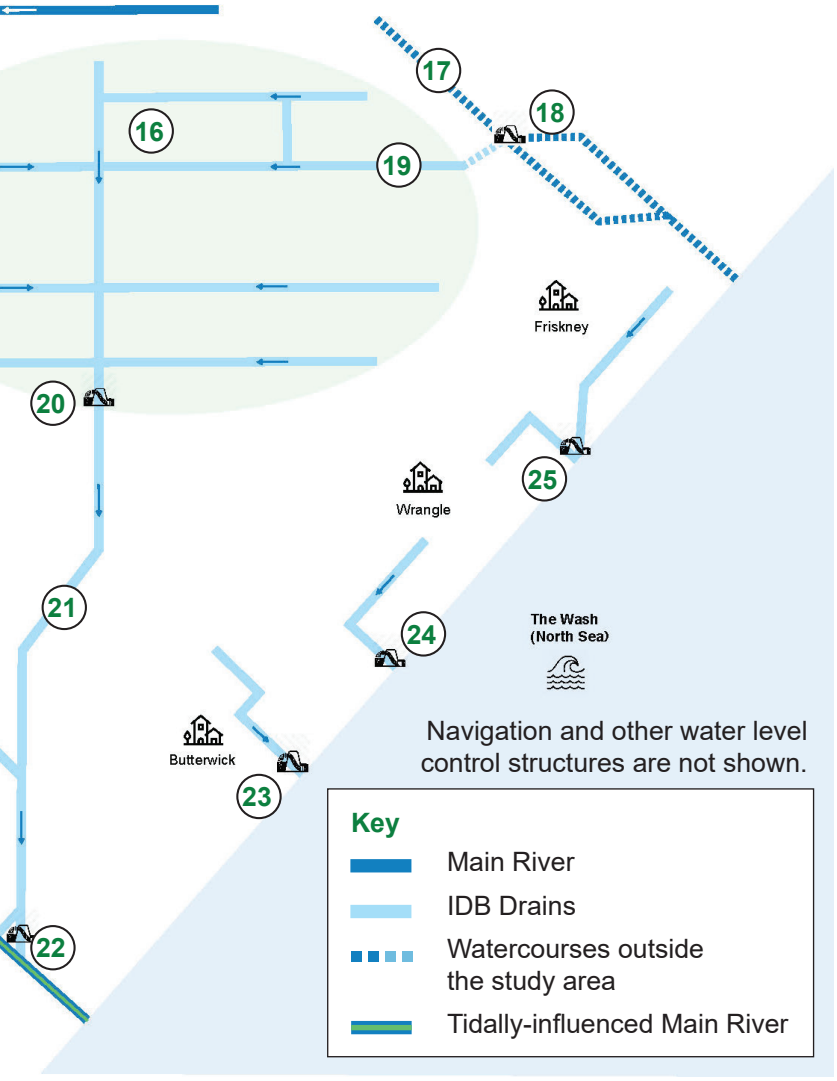
15 South Forty Foot Drain

Main River

Neighbours the East and West Fens catchment.

16 East Fen

Contains the lowest lying land in the catchment. Water has to be pumped upwards twice to reach sea level, at Lade Bank Pumping Station and Hobhole Pumping Station.



17 The Steeping River

Main River

Neighbours the East and West Fens catchment.

18 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.

19 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.

20 Lade Bank Pumping Station

Witham Fourth District IDB

Pumps water upwards along the Hobhole Drain out of the low-lying area of East Fen.

21 Hobhole Drain

Witham Fourth District IDB

The route for water from the East and West Fens to reach Hobhole Pumping Station.

22 Hobhole Pumping Station

Witham Fourth District IDB

Pumping station lifts water from the Hobhole Drain into The Haven by up to 7m during high spring tides.

23 Benington Pumping Station

Witham Fourth District IDB

Pumps water from coastal areas directly into The Wash.

24 Leverton Pumping Station

Witham Fourth District IDB

Pumps water from coastal areas directly into The Wash.

25 Wrangle Pumping Station

Witham Fourth District IDB

Replaced in summer 2024, it pumps water from the coastal areas directly into The Wash.

History of the catchment

In the 1500s, a group of wealthy investors known as ‘The Adventurers’ sought to drain the inland Fens in order to farm the land.

The first recorded flood management and drainage activities were made by local monks before 1100. Various works continued over the following centuries to protect land from flooding, from events such as the tidal flood of 1394. Navigation was also improved as neighbouring Wainfleet and Boston grew as important ports.

The cutting of the Maud Foster Drain in 1568 and the Hobhole Drain in 1569 started the drainage of the West Fen. Up until the late 1700s, the lower lying East Fen remained largely untouched and water drained eastwards towards Wainfleet Haven and the estuary at Gibraltar Point. Proposals to drain the East Fen were met with much opposition from local Fenmen who relied on its waters for fishing and fowling.

During the late 1700s, a report by engineer John Rennie was commissioned on the condition and drainage of the East and West Fens. Some of the recommendations were implemented in an Act of Parliament (1801), including extension of the Witham Fourth District to include the East Fen. As a result, Hobhole Sluice was constructed in 1806, followed by Maud Foster Sluice in 1807. These activities started to transform the East and West Fens from wetland to drained land fit for agriculture.

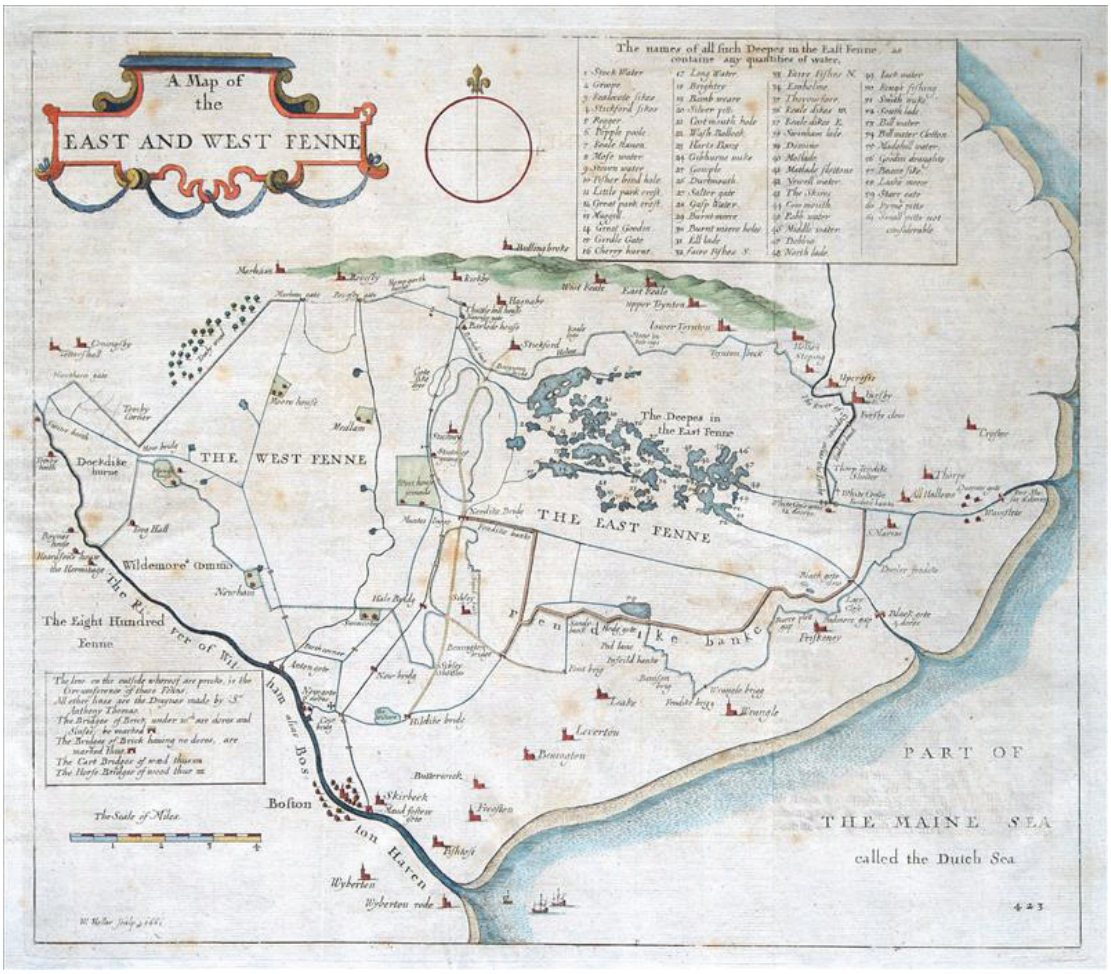
In 1810, an extreme tidal event prompted the raising of the existing sea banks by approximately 0.6m above the 1810 level (approximately 5.59m AOD in and around Boston).

Between 1818 and 1821, Thorpe Culvert was built which drained an area east of the Steeping River into East Fen. This arrangement ended in 1938 with the construction of Thorpe Culvert Pumping Station, which redirected water into the Steeping River and brought an end to the transfer of water between the Steeping and the East and West Fens catchments.

As land drainage progressed, the peat soils dried and eroded, reducing the level of the land. Therefore, Lade Bank Pumping Station was opened in 1867 to help transfer water upwards out of East Fen and towards Hobhole Sluice.

Over the next hundred years, land drainage continued and the establishment of modern agricultural practices created the landscape we see today. Works also helped improve existing tidal defences along The Haven.

The 1900s saw further developments to safeguard the agricultural land and local communities, with the Witham Fourth District IDB created in 1935. Other activities in the 1900s included the construction of a new diesel-powered pumping station at Hobhole, in response to the flooding of 1947. This enabled the IDB to remove water from the catchment regardless of tide levels. Additional capacity has since been added to Hobhole Pumping Station with the installation of four electric pumps.



A map of the East and West Fenne (1661) by Wenceslas Hollar, from William Dugdale's The History of Imbanking and Drayning of Divers Fenns and Marshes (1662) © copperplate.co.uk

Works were also undertaken in the 1930s, 1960s and 1980s at Lade Bank Pumping Station to increase capacity as a result of a series of flood events including an event in 1981. These works helped to ensure an efficient flow of water from the lowest areas of East Fen to Hobhole Pumping Station.

After the 2013 storm surge, the Boston Combined Strategy (2008) was given greater urgency. This resulted in the commencement of construction of the Boston Barrier and the improvement works to the embankments downstream along The Haven which were completed in 2020. In 2018, Witham Fourth District IDB completed the construction of 5.7km of raised flood defences at Wrangle.

Storm events in 2019, 2020 and 2023-2024 have put tremendous pressure on assets. When the banks of the Steeping River breached in June 2019, water was pumped into the Bellwater Drain at Thorpe Culvert to re-create the transfer of water between the catchments through the historic culverts. This was done with agreement of the Witham Fourth District IDB as they were confident that they had significant capacity in their system to help alleviate the flooding in the neighbouring IDB area. In January 2020, Hobhole Pumping Station worked at full capacity for three weeks.

History timeline





Pre-1800s

Pre-1100
Monks made attempts to drain the land. A sea defence known as the 'Roman Bank' was mentioned in records for the first time.

1200s
As Boston's port grew in importance, the River Witham was improved for navigation.

1394
A defective floodgate at Wainfleet was blamed for a major inundation of the East and West Fens which affected Leake, Wrangle, and Friskney.

1568-1569
The cutting of the Maud Foster Drain in 1568 and the Hobhole Drain in 1569 started the draining of West Fen.

1631
A tax was levied for drainage repairs in the catchment.

1766
The Haven was straightened and deepened for improved navigation.

1784
Partial drainage of East Fens was resisted by local Fenmen.

1799
Engineer John Rennie published a report on the benefits of draining the East and West Fens.

1800s

1801
An Act of Parliament was passed which extended Witham Fourth District to include East Fen.

1806-1807
Hobhole Sluice and Maud Foster Sluice were constructed.

1810
Extreme tidal event resulted in raising of the existing sea banks.

1818-1821
Thorpe Culvert was built to drain low lands east of the Steeping River into East Fen.

1867
Lade Bank Pumping Station constructed, to move water along Hobhole Drain.

1867
Steam pumps were installed at Lade Bank Pumping Station. Drains were constructed to transfer water from West Fen to Hobhole Drain instead of Maud Foster.

1880
The River Witham Outfall Improvement Act enabled more improvements along The Haven downstream of Hobhole Sluice.

1900s

1935
Witham Fourth IDB was formed following the Land Drainage Act (1930).

1938
Thorpe Culvert Pumping Station was commissioned to lift water into the Steeping River which had previously flowed towards East Fen.

1940
A new oil powered pumping station at Lade Bank was commissioned.

1947
Significant flooding across the catchment was caused by snowmelt. This event had a national impact.

1953
A tidal surge caused severe flooding in Boston. Despite the event having widespread impact it had little effect on the East and West Fens catchment outside Boston.

1953-1957
Construction of a new diesel-powered pumping station at Hobhole began in response to the 1947 flooding.



2000s

1959
Wrangle Pumping Station was commissioned.

1963
An electric pump was commissioned at Lade Bank following severe flooding.

1976
Pumping stations were commissioned at Leverton and Benington.

1977
Heavy rain and snow melt caused flooding across the catchment.

1978
A tidal surge caused significant flooding within the area of Boston managed by Witham Fourth District IDB.

1981
Significant flooding due to heavy rainfall resulted in additional pumping capacity being added at Lade Bank and Hobhole. Works were completed in 1989.

1993
Fluvial flooding affected Stickford, Stickney and Hagnaby.

2007
The highest recorded rainfall since 1766 led to widespread flooding in June and July. There was extensive flooding across the whole of the Fens including the East and West Fens catchment.

2008
Boston Combined Strategy aimed to determine a long-term approach to flood risk management and navigation improvements for the next 100 years.

2013
A storm surge breached the coastal embankments at Wrangle and Boston, causing significant damages. This event highlighted the urgent need for improved flood defences, including Boston Barrier, as outlined in the Combined Strategy.

2014
Inner and outer tidal seal doors of Hobhole Pumping Station were refurbished.

2018
Wrangle Sea Banks were raised to a height of 7.2m.

2019
An embankment breach along the Wainfleet Relief Channel led to water being pumped from the Steeping River into Bellwater Drain to help alleviate the flood risk in the neighbouring Steeping catchment.

2020
Construction of Boston Barrier was completed by the Environment Agency. Works were undertaken as part of the Boston Combined Strategy.

2023/2024
In 2023 work commenced on a new pumping station at Wrangle and a business case for a new pumping station at Hobhole.

In October 2023, Storm Babet caused significant flooding throughout the catchment and put significant pressure on assets. A series of named storms continued this pressure for the entire winter.

Managing flood risk

Across the East and West Fens, flood risk is managed by multiple organisations.

Roles and responsibilities

The Environment Agency have permissive powers to carry out flood and coastal erosion management activities on Main Rivers.

Witham Fourth District IDB are responsible for managing the complex network of drainage channels and pumping stations which drain the land within their district. They also regulate water levels on ordinary watercourses (non-Main Rivers).

Riparian Landowners have the main legal responsibility for maintaining all watercourses.

Lincolnshire County Council (LCC) acts as both the Lead Local Flood Authority (LLFA) and the local Highway Authority. The Highways department is responsible for maintaining highway drainage assets, while the LLFA has overall responsibility for local flood risk matters. Lincolnshire was one of the first areas in England to publish and implement a Local Flood Risk Management Strategy, and was forward-looking in the way all of the relevant risk management authorities were involved.

Boston Borough Council and East Lindsey District Council have a responsibility to promote sustainable development in their role as the Local Planning Authority. They also have responsibilities under the Land Drainage Act (1991) to undertake flood risk management works on ordinary watercourses outside IDB areas.

Anglian Water is the main water and sewerage company within the East and West Fens catchment and has a role in managing the risk of flooding posed by public drainage infrastructure.

Legislation

The roles and responsibilities of these RMAs are set out in the Flood and Water Management Act (FWMA) (2010). This national legislation was developed in response to the widespread flooding experienced across England in 2007. The Act re-established the roles and responsibilities of the RMAs related to flood risk. This Act is supported by local policies and plans that outline the management of local issues.

Local groups and partnerships

Under the FWMA (2010), Regional Flood and Coastal Committees (RFCCs) were established by the Environment Agency. RFCCs guide flood and coastal erosion risk management activities within their river catchments and along the coastline. The East and West Fens is within the Anglian (Northern) RFCC boundary.

The Lincolnshire Flood Risk and Water Management Partnership was set up to improve the management of flood risk and water resources in the region. This is comprised of the Environment Agency, LCC, the district and borough councils and IDBs across Lincolnshire, as well as Lincolnshire Resilience Forum and Natural England. This partnership provides co-ordinated management and delivery of flood risk and drainage functions across Lincolnshire.

Future Fens Integrated Adaptation (FFIA) is a strategic partnership initiative, with the aim of working together across sectors to determine the actions that partners involved in managing water across the landscape can jointly take to secure a vibrant future for the Fens.

National strategies

In 2020, the Environment Agency published the latest National Flood and Coastal Erosion Risk Management Strategy. It contains 'Measure 1.5.4', which requires development of a long-term plan for managing future flood risk in the Fens.

Local policies, strategies and plans

The key local policies, strategies and plans that directly influence how flood risk management is undertaken within the East and West Fens are outlined below.

Anglian River Basin District Flood Risk Management Plan 2021-2027

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

Joint Lincolnshire Flood Risk and Drainage Management Strategy 2019 - 2050

This provides a framework for flood risk management across Lincolnshire linking all the RMAs.

Witham Fourth District IDB Water Level & Flood Risk Management Policy Statement (2018)

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

Joint Lincolnshire Strategic Flood Risk Assessment (2017)

This outlines how development should consider flood risk at every stage of the development process including assessment and mitigation measures, based on Flood Zones and vulnerability to flood risk.

Gibraltar Point to Hunstanton Shoreline Management Plan 4 (2010)

Shoreline Management Plans (SMPs) outline a strategic approach to managing flood and coastal erosion risks through to 2105. The Policy Development Zone (PDZ) of particular relevance to the East and West Fens catchment is PDZ1 Gibraltar Point to Wolfreton Creek, where the intention is to hold 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.

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. Although this report has not been withdrawn, decision making is now largely based on the more recent River Basin District Flood Risk Management Plan.

The Boston Combined Strategy (2008)

This plan seeks to reduce the risk of tidal flooding to the town over the next 100 years. This strategy included recommendations for the construction of Boston Barrier which was completed in 2020, and the raising of flood banks along The Haven.

The role of critical infrastructure

Only the continuous operation of flood risk assets can protect the low-lying areas of the catchment from severe and long-term flooding. Parts of East Fen are below sea level.

Before human intervention, much of the East and West Fens catchment was a waterlogged landscape, covered by freshwater and intertidal marsh. Over centuries, huge effort and investment has enabled the transformation of the area into a habitable and productive landscape. If flood risk assets were abandoned, and constant management of water levels were to cease, then the landscape would soon be inundated, becoming an uninhabitable inland salt lake.

To demonstrate the existential risk of flooding to the catchment in the absence of defences, the map of tidal inundation from the Mean High Water Spring (MHWS) tide shows the tidal inundation that would occur on a regular basis in the absence of tidal flood defences. In this scenario, the tide would inundate the land to a level of 3.9m AOD. Whilst some areas of the catchment would drain as the tide recedes, the frequency of tidal inundation would mean the land was essentially uninhabitable.

A low-lying catchment

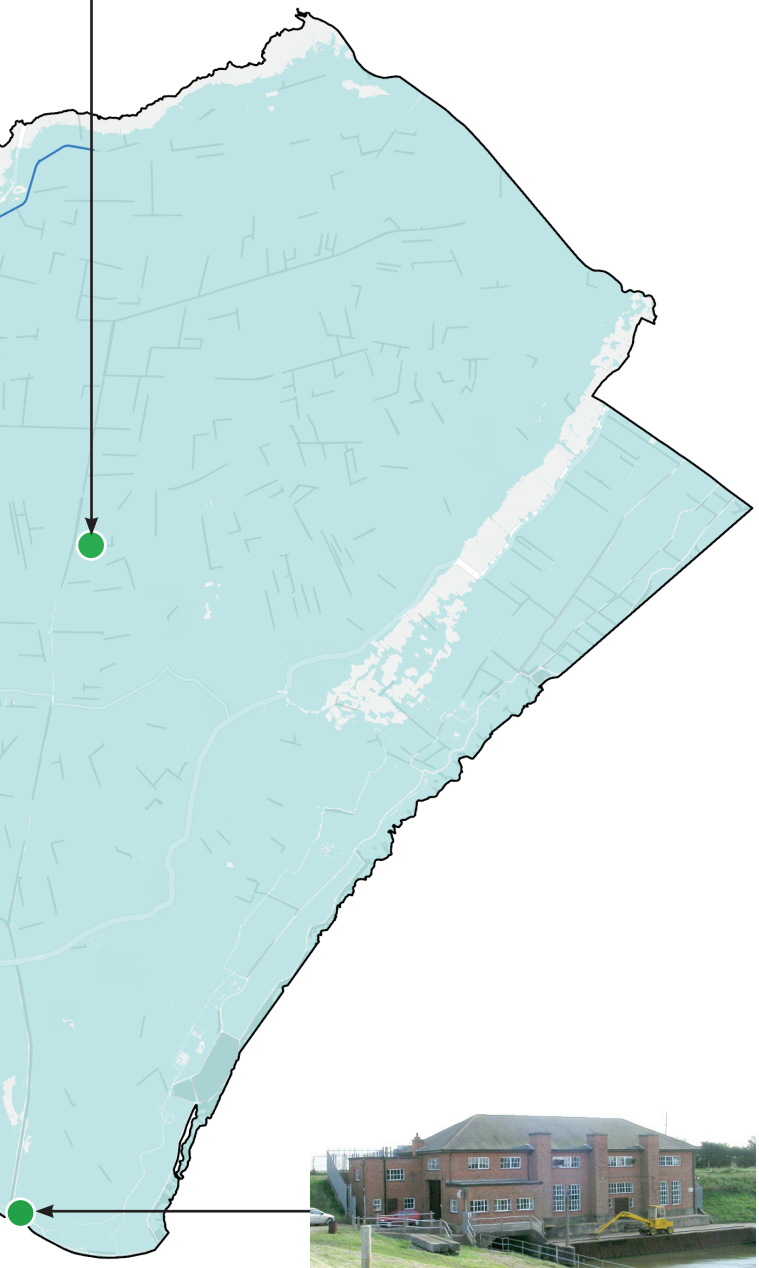
The catchment topography forms a bowl-shaped basin, with a slightly elevated coastal ridge running parallel to the coast, and lower-lying areas further inland. The lowest point of the East and West Fens catchment would be flooded to a depth of 4.5m in the MHWS tidal event. The topography makes it difficult for water to drain naturally from these lower-lying areas and if flooding occurs, the lack of gradient would allow floodwaters to spread over a large area.



Maud Foster Sluice
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Lade Bank Pumping Station
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Hobhole Pumping Station
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Reliance on flood risk assets

Defence of the land against tidal inundation relies on the presence of flood defences along the coast and the tidal reaches of The Haven.

The effective removal of water from the land drainage system into Main Rivers relies on the operation of pumping stations. In turn, the pumped system relies on other assets to prevent extra water entering the district which would have to be pumped out. Some of the most important are the embankments which contain the Main Rivers which carry water from higher ground across the catchment. Without effective containment, the Main River system could contribute additional water to the IDB network, and place greater pressure on pumping station capacity.

Sluices and other water management assets are monitored and adjusted all year round to maintain water levels in both the IDB and Main River systems. If these assets were not present, or if existing defences were allowed to deteriorate through age or lack of maintenance, extreme events would severely compromise drainage and could result in the inundation scenario depicted on the map, leading to uninhabitable conditions over a short timeframe.

Extreme events

Even with flood risk assets in place, tidal and fluvial flooding pose a significant risk to the catchment, as evidenced by flood events in 1947, 1953, 1977, 1978, 1981, 1993, 2007, 2013, and 2023. These flood events have arisen through a variety of mechanisms, such as the breach of sea defences, or insufficient capacity of the pumped system to deal with intense rainfall events.

Current flood risk

The risk of permanent inundation is mitigated by the operation of flood risk management assets.

Hydraulic modelling is used to understand the risk of flooding in an area. The hydraulic models used to assess flood risk are the 2010 Northern Area Tidal Model representing tidal events, and the 2017 Stonebridge model. The latter represents fluvial events on Main Rivers but not the IDB system. These models include existing flood defences at the time of model production, and assume that all assets are fully functional and maintained at their current Standard of Service. The models pre-date the Boston Barrier and The Haven bank raising completed in 2020. The flood map opposite is used to highlight areas of residual risk where flood events would exceed the protection offered by the defences. This might include the risk of overtopping. The models used herein do not include breaching (failure) of the embankments.

Tidal

Model results show that with existing defences (not including Boston Barrier and The Haven Bank raising of 2020), current tidal flood risk for a 0.5% AEP event, would impact approximately 12.3km^2 (1,233ha) of the total catchment area. This affected area includes approximately 7.3km^2 (726ha) of Grade 1 agricultural land. No properties are predicted to flood during this event. Floodwaters reach a maximum depth of approximately 1m around the mouth of The Haven.

Fluvial

Model results show that with existing river defences, 9.8km^2 (984ha) of the catchment is at risk of flooding from rivers during a 1% AEP event. This includes 7.2km^2 (717ha) of Grade 1 and 2 agricultural land. Under a more extreme 0.1% AEP event, flooding will cover 6.8% of the catchment area. In both scenarios, settlements including New Bolingbroke, Stickney and Keal Cotes are at risk.

Recent flood history shows that fluvial flood risk is higher in the present day than the modelling suggests. In October 2023, Storm Babet caused significant flooding in settlements such as Halton Fenside, Hagnaby, and Stickney.

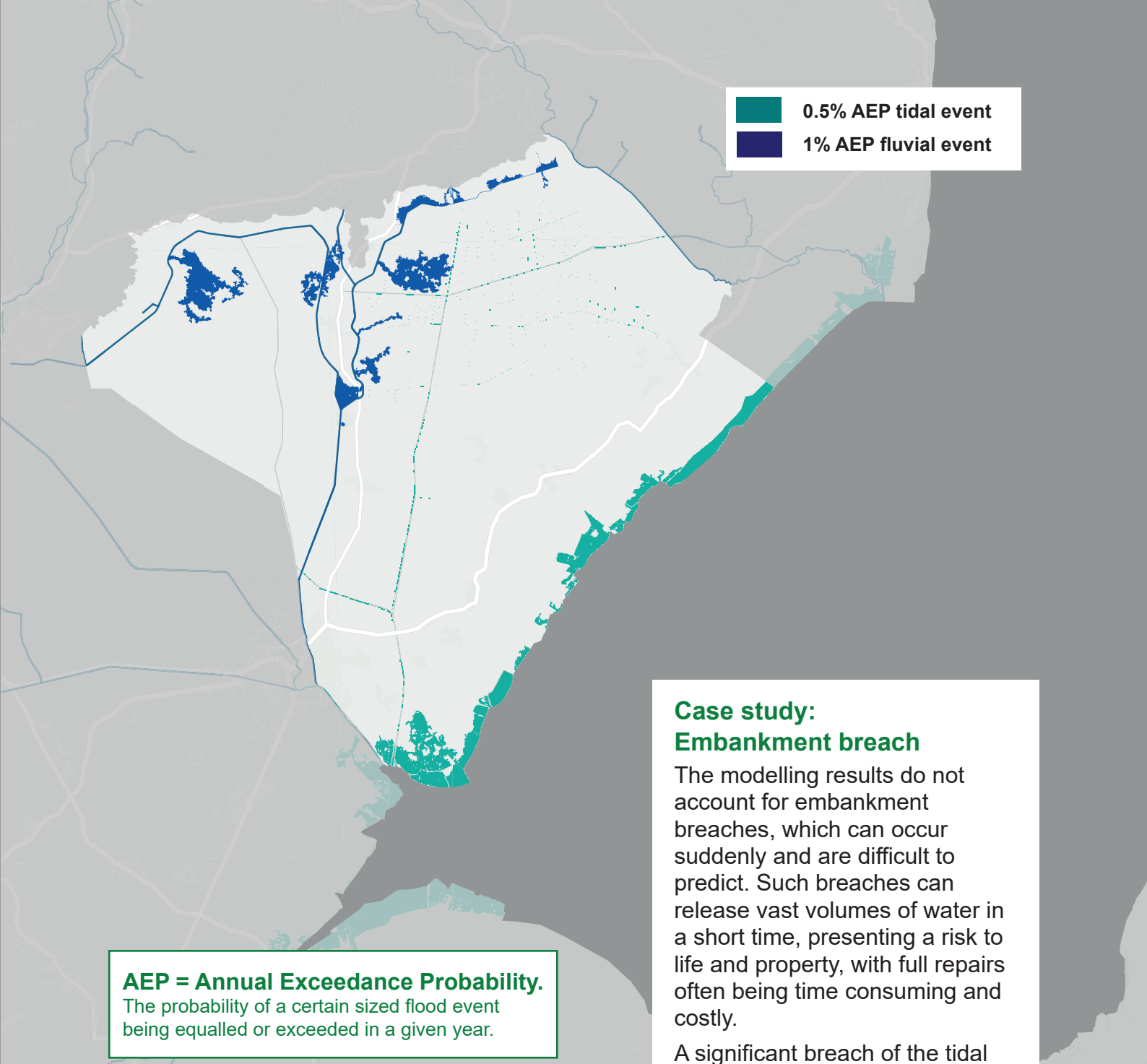
Other sources

Other sources of flood risk not included in the hydraulic models include:

Groundwater flooding. This occurs when the water table rises to meet the ground surface. It is not considered a significant source of local flood risk in the East Lindsey Strategic Flood Risk Assessment (SFRA), which identifies no recorded groundwater flooding incidents in the catchment.

Surface water flooding. This describes when the volume and intensity of rainfall overwhelms local drainage systems. The Environment Agency's' Risk of Flooding from Surface Water' dataset indicates that significant surface water flooding occurs along the northern boundary of the catchment and the Stonebridge Drain between Stickney and Sibsey.

Reservoir flooding. This is rare and happens when a reservoir's impounding structure fails. The East Lindsey SFRA considers the risk of reservoir flooding as low due to the provisions of the Reservoirs Act (1975).



AEP = Annual Exceedance Probability.
The probability of a certain sized flood event being equalled or exceeded in a given year.

Area calculated based on the model flooded area in comparison to the area represented within catchment boundary.

12.3km²

(1,233ha) of the catchment is at risk of flooding in a present-day 0.5% AEP tidal event including existing flood defences. This includes 7.3km² (726ha) of Grade 1 agricultural land.

9.8km²

(984ha) of the catchment is at risk of flooding in a present-day 1% AEP fluvial event including existing flood defences. This includes 7.2km² (717ha) of Grade 1 and 2 agricultural land.

Case study: Embankment breach

The modelling results do not account for embankment breaches, which can occur suddenly and are difficult to predict. Such breaches can release vast volumes of water in a short time, presenting a risk to life and property, with full repairs often being time consuming and costly.

A significant breach of the tidal embankments occurred in December 2013, when initial overtopping of an embankment near Wrangle weakened the structure and caused a breach. A strip of agricultural land near the coast was flooded as a result.



2013 breach of the tidal defences near Wrangle © Environment Agency

Future flood risk

Tidal and fluvial flood risk will increase over the next 100 years, even if defences are maintained to the current level of protection.

Future tidal and fluvial flood risk will rise due to the increasing tidal surges and higher river flows driven by climate change. These changes pose a growing threat to agricultural land and residential properties, with more frequent and severe overtopping events and failure of defences becoming more likely.

Tidal

Tidal flood risk is expected to increase significantly over the next 100 years due to rising sea levels from climate change. The 2010 Northern Area Tidal Model assumes that sea level will rise by 1.1m up to 2115. Under this scenario, approximately 230km^2 (23,002ha) of the catchment is at risk of inundation during the 0.5% AEP event, even with existing flood defences in place. This represents an approximate nineteen-fold increase, compared to existing conditions. This includes 109.6km^2 (10,960ha) of Grade 1 agricultural land and villages including Fishtoft, Butterwick, Benington, Old Leake and Wrangle. The railway line between Wainfleet All Saints and Boston could also be inundated, leaving communities isolated.

Since the modelling was undertaken in 2010, sea level rise estimates have been revised upwards and, under the UK government's upper end allowance, sea level could rise by between 1.2m and 1.6m by 2125. This means that potential flood risk could be even greater in the future.

There is a risk that higher sea levels will increase tide-locking at key outfalls such as the Maud Foster Sluice. Tide-lock means that water cannot be discharged from the river system during periods of high tide, causing it to back-up in the catchment and put increasing pressure on the river embankments.

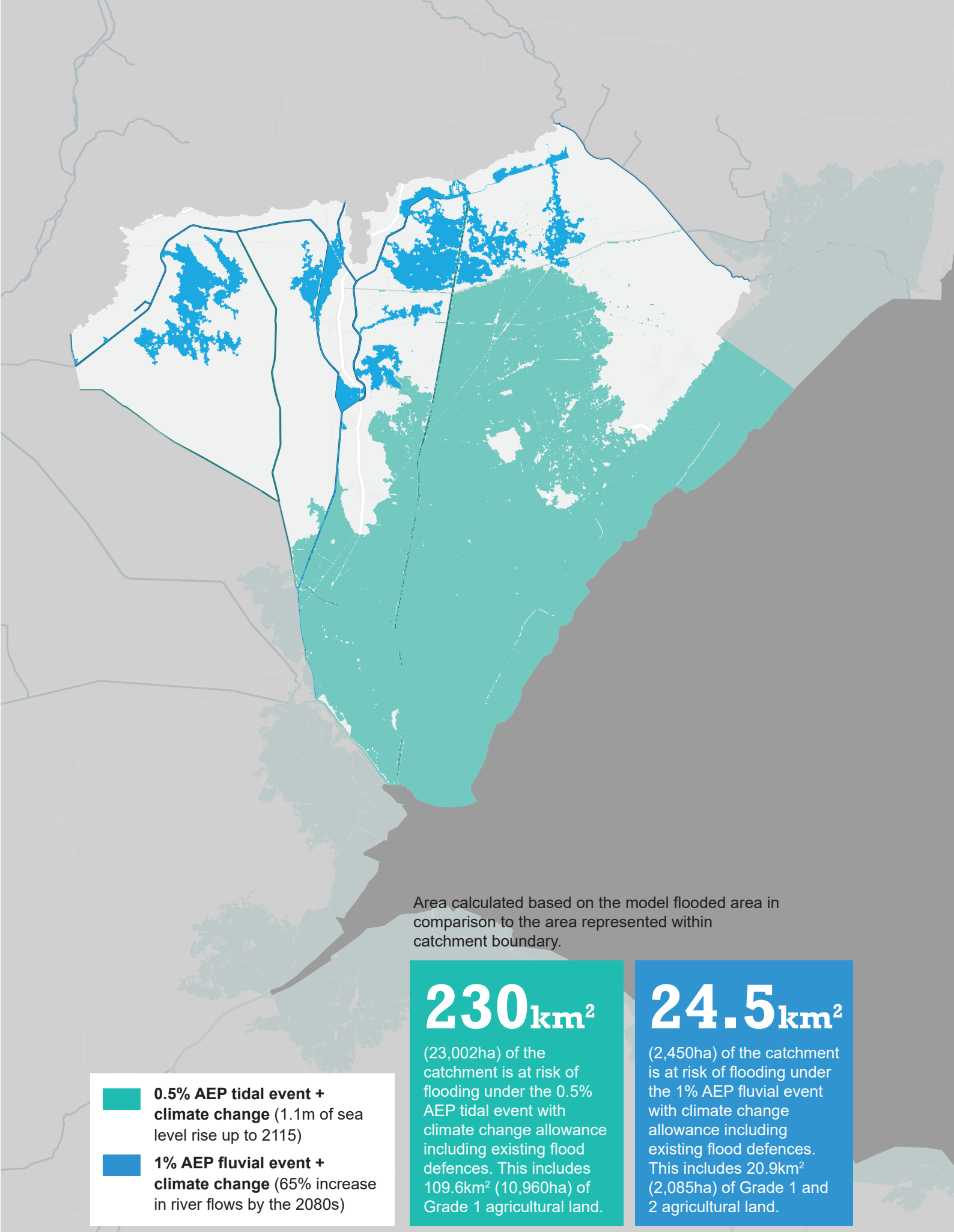
Fluvial

Modelling predicts an increase in fluvial flooding when climate change is applied to the 1% AEP event, with current flood defences still in place.

This scenario assumes a 65% increase in river flows leading to the inundation of 24.5km^2 (2,450ha) of the total catchment area, this includes 20.9km^2 (2,085ha) of Grade 1 and 2 agricultural land. This represents an approximate three-fold increase, compared to existing conditions. However, the risk to settlements from fluvial flooding is not significantly increased in this scenario.

Climate change

Assessment of climate change scenarios are based on government guidance and best available data at the time of writing, or model production. This guidance is revised as climate change projections are revised. Irrespective of the predicted magnitude of change, climate change will increase the frequency and severity of flood events over time. Longer term climate change scenarios have been considered within a Fens Climate Change Risk Assessment undertaken by FFIA.



Area calculated based on the model flooded area in comparison to the area represented within catchment boundary.

230km²

(23,002ha) of the catchment is at risk of flooding under the 0.5% AEP tidal event with climate change allowance including existing flood defences. This includes 109.6km² (10,960ha) of Grade 1 agricultural land.

24.5km²

(2,450ha) of the catchment is at risk of flooding under the 1% AEP fluvial event with climate change allowance including existing flood defences. This includes 20.9km² (2,085ha) of Grade 1 and 2 agricultural land.

0.5% AEP tidal event + climate change (1.1m of sea level rise up to 2115)

1% AEP fluvial event + climate change (65% increase in river flows by the 2080s)

Flood risk management assets

Site visits and workshops were undertaken with asset owners and operators, alongside data analysis, to understand key asset challenges.

Key catchment challenges

Assets are ageing

Many key assets in the catchment are ageing, with 26% affected by reliability and performance issues caused by their age. This can increase the amount of maintenance required for them to function.

Embankments, all built before 2000, are critical to flood protection but often lack modern construction standards and so require repair, refurbishment and in some cases replacement.

Pumping station challenges

Critical pumping stations at Hobhole and Lade Bank work at capacity during and after intense rainfall. These assets require 24-hour staff presence during these periods, which is expensive and takes resource from elsewhere.

Channel risk

Sedimentation and weed growth are persistent issues across the catchment, with around 80% of the area classed as unstable, contributing to high sediment loads that affect sluice operations. Weed growth, particularly severe in summer, is difficult to manage and drives largely reactive maintenance.

Investment needs

The pumps at Hobhole Pumping Station are operational but are of an age where reliability and performance is declining. This is a key asset to the catchment and so its continued operation is required. Consequently, a business case and design works are underway for a replacement pumping station with construction expected 2029-2031, representing approximately £100 million of investment.

This significant outlay does not take away the need for investment to maintain the operability of the other assets in the catchment.

Embankments are vulnerable

Many embankments, particularly older assets along The Haven, are poorly constructed and are generally constructed without clay cores. They are vulnerable to settlement and deformation, which can lead to slope instability, surface creep, and failures that obstruct watercourses. In addition, extensive work would likely be required to enable crest height raising. The unpredictability of embankment weakness can contribute to failures, such as the slips which took place during storm events in 2023 and 2024.

Data availability and quality

Data analysis is based on an export of the Environment Agency's Asset Information and Maintenance dataset (AIMS) from October 2024. This includes other RMA assets, but not all. The Environment Agency has advised that some data within AIMS may be outdated, potentially underestimating the number of assets currently under stress.

Additional data and insights have been collated through site visits and workshops with IDBs.

Asset ownership

Within AIMS, the Environment Agency own 35% of assets, for 42% the owner is recorded as 'Unknown' and the remainder is owned by other RMAs.

Asset age profile

As outlined above, key assets in the catchment are ageing, with 26% recorded as beyond their foreseeable design life. Around 58% of assets have a foreseeable design life of 16-30 years.

Asset condition profile

Approximately 31% of assets have a current condition score of 'Poor', 'Very Poor' or 'Unknown' in AIMS. Despite their age, 76% of the 282 embankment assets are recorded in AIMS as being in 'Fair' or 'Good' condition. The remainder are in 'Poor' condition. Of the other key asset types, outfalls have the highest proportion (17%) below the required condition grade.



Cowbridge Sluice © Arup 2024.



Hobhole Pumping Station © Betty Longbottom. Licensed for reuse under the Creative Commons Licence.



West Fen Catchwater Drain © Christine Johnstone. Licensed for reuse under the Creative Commons Licence.



View along the Stonebridge Aqueduct, where it crosses the Cowbridge Drain immediately below © Arup 2024



Lade Bank Pumping Station © Christine Johnstone. Licensed for reuse under the Creative Commons Licence.



Maud Foster Sluice © Dave Hitchborne. Licensed for reuse under the Creative Commons Licence.

Operating challenges

Stonebridge Drain suffers from issues with weed growth in summer.

The pumps at Hobhole Pumping Station are currently operational but affected by reliability and performance issues caused by their age. Pumping capacity falls sharply during high tides, often struggling to cope with incoming catchment flows during flood conditions. This will be exposed by climate change and rising sea levels.

Lade Bank Pumping Station worked at capacity during the October 2023 floods. During flood events, the station requires 24-hour staff presence. This results in a lack of available resources for any arising issues within the catchment during these periods.

Embankments in the catchment have historically suffered slips during storm and flood events, highlighting how defects of embankments are exposed by extreme weather.

Maud Foster Sluice and Maud Foster Drain are considered to be over-engineered, so the risk of flooding from this part of the system is low. However, there is a risk of flooding from overtopping of the sluice due to tidal inundation from The Haven. This occurred in 2013 due to a storm surge and high tide coinciding.

For the Environment Agency, the primary concern is managing embankments and weed growth in channels. For Witham Fourth District IDB, there are performance concerns at their key pumping station assets where the system is often operating at capacity. These challenges will be exacerbated further due to the impact of climate change.

Current asset maintenance

Environment Agency maintenance expenditure

Based on analysis of Environment Agency revenue programme dataset:

£448k was spent on embankment maintenance between 2022-2024, representing 71% of maintenance expenditure for the catchment.

£153k was spent on open channels between 2022-2024, 99% of which is spent on weed control by machine.

Witham Fourth District IDB maintenance expenditure

Maintenance expenditure has been generally consistent at around approximately £2 million between financial years 2018-2022, but there are known condition and performance challenges.

As a result, additional expenditure may be required until planned capital schemes can be completed. Witham Fourth District IDB spend a significant proportion of maintenance expenditure on their Water Level Control Structures, such as pumping stations.

Across all RMAs, substantial investment in capital and maintenance will be required. This will be to keep or improve the existing assets to a condition of 'Fair' or better, as well as new construction schemes to improve the area's resilience. The funding required will increase due to the vulnerability of flood risk assets to future climate hazards.



Hobhole Pumping Station, showing the two separate outfalls (electric on the left-hand channel, diesel on the right-hand channel) © Witham Fourth District Internal Drainage Board 2024.

Environment

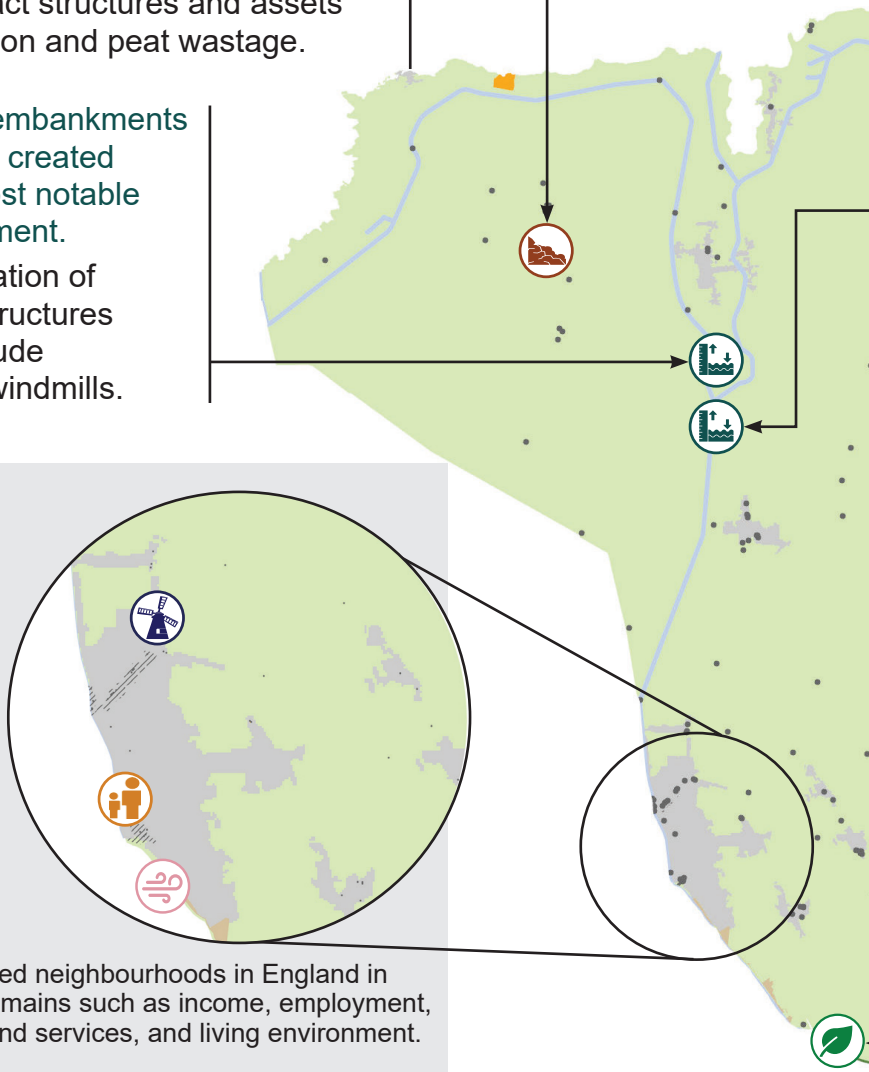
Mapping shows environmental features such as internationally significant coastal habitats. Along with Local Nature Reserves, they provide recreational opportunities for deprived communities in Boston.

Roddons (paleochannels) such as those documented in the vicinity of Medlam Drain, are an influential feature within the catchment.

Roddons are former river channels, typically filled with silt, which now sit proud of the land, potentially funnelling surface waters. Due to their composition, they may impact structures and assets through differential settlement, compaction and peat wastage.

The network of drainage channels and embankments such as the East and West Fens drains, created to drain the fenland, are some of the most notable historic landscape features in the catchment.

This represents the complete transformation of this area in the post-medieval period. Structures associated with this landscape also include bridges, sluices, pumping stations and windmills.



Boston, a historic market town and inland port, is located to the south-east of the catchment.

There are four Conservation Areas within the catchment, with three located within Boston.

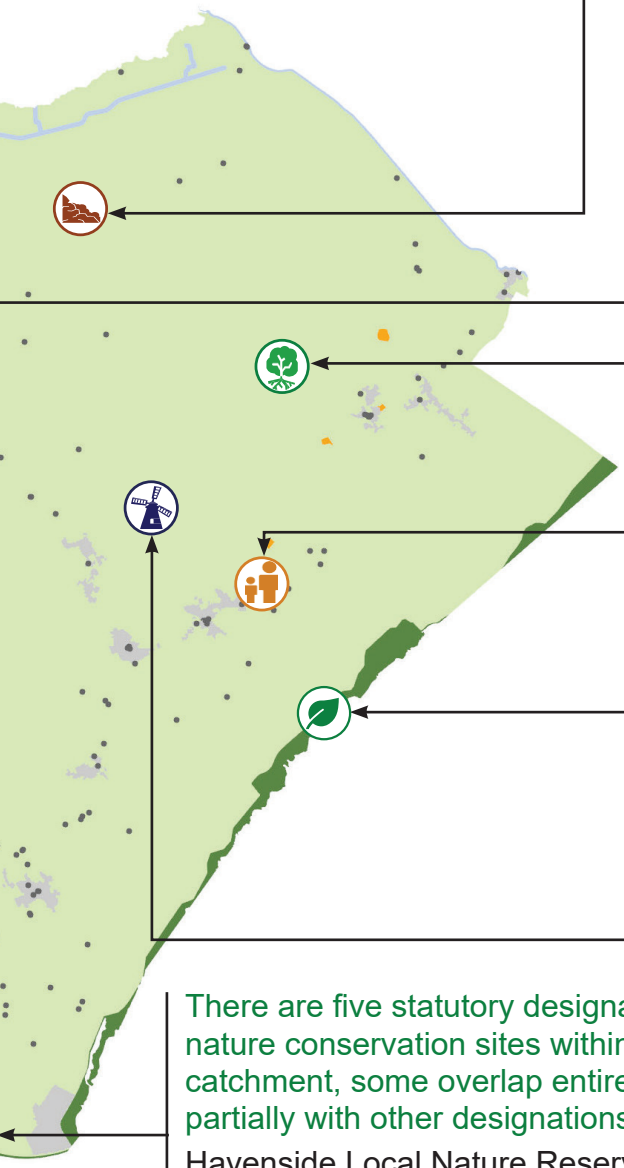
Conservation Areas possess special architectural or historic interest. The central core of the town is largely derived from its history as a thriving port between the 12th and 15th Century.

Some communities within Boston are amongst the most deprived areas in England.

The Lower layer Super Output Area (LSOA) Boston 004C is amongst the 20% most deprived neighbourhoods in England in terms of overall deprivation. This considers domains such as income, employment, education, health, crime, barriers to housing and services, and living environment.

There are no Air Quality Management Areas (AQMA) within the catchment.

The closest AQMA to the catchment boundary is the Haven Bridge AQMA, located approximately 200m south-west of the catchment. The AQMA was declared in 2001 by Boston Borough Council due to exceedances of annual mean nitrogen dioxide.



Peaty soils cover 5.0% of the catchment area.

They are deepest and most extensive east of Stickney, in the area known as East Fen.

The two water bodies in the catchment are classified as artificial water bodies under the Water Environment Regulations / Water Framework Directive.

These waterbodies, 'East and West Fens Drains' and 'Maud Foster and Fen Catchwater Drains' are currently impacted by rural and waste water pollution and invasive non-native species respectively. Both water bodies are also impacted by physical modifications largely related to agriculture.

The catchment is located almost wholly within The Fens National Character Area (NCA) – these are areas of distinct and recognisable character.

The Fens NCA is notable for its large-scale, flat, open topography with extensive vistas to level horizons. The Historic Landscape Character Areas include The Fens, The Wash, The Clay Vale and The Wolds which help explain the relationship between heritage features and how the landscape has evolved over time.

There are a number of settlements located along the A16 and A52.

These include Wrangle, Friskney, and Sibsey.

The Wash is designated as a Special Protection Area, Ramsar site and Site of Special Scientific Interest.

It is a wetland of international significance, particularly for migrating wildfowl and wading birds, it supports a shellfish fishery and is home to the largest breeding colony of the common seal in Europe.

There are five statutory designated nature conservation sites within the catchment, some overlap entirely or partially with other designations.

Havenside Local Nature Reserve is located on the outskirts of Boston and includes areas of grassland with scrubs and brambles, cattle grazed meadows, shallow seasonal ponds, estuary and mudflats.

There are eleven Scheduled Monuments within the catchment including King's Hill.

The King's Hill is a well-preserved motte and bailey castle from the medieval period, featuring extensive foundations within its moated area that indicate a house of significant importance.

Agriculture

The East and West Fens catchment is an area of national agricultural importance.

Soilscape

The majority of the catchment contains loamy and clayey soils of coastal flats with naturally high groundwater which can support different cropping. Towards the north of the catchment, soils are generally less productive due to 'impeded drainage'. A small area near New Leake contains peat, however it should be noted that any remaining peat is likely to be degraded due to agricultural land use and drainage activities.

Agricultural Land Classification (ALC)

Approximately 91% of land in the catchment is classified as Grade 1 and 2. Grade 1 land is predominately located along the south and south-east boundary of the catchment. This is high-yielding land with little or no limitations for agricultural use.

Water availability

The Witham Abstraction Licensing Strategy notes that water is only available for the majority of the catchment during higher flows. These are flows equalled or exceeded for at least 30% of the time. The catchment is characterised by a network of river channels embanked above the level of the surrounding land. Water is pumped into these from low lying areas during high flows and provide an irrigation source during low flows. There is a high demand for spray irrigation in the catchment, particularly in the summer months, where water is transferred from the Lower Witham into the Witham Fourth District IDB system.

Value of agriculture in the catchment

Arable agriculture dominates the catchment, including high value cropping such as brassicas. A proportion of the agricultural land is also used for livestock, across both pastureland and in rotation alongside cropping. Some farms have invested in controlled environment agriculture enterprises.

The whole agri-food chain employs people at different stages of food production, from agriculture to food processing and packing and retail. The estimated overall economic output of farm crop and livestock within the catchment is around £125 million annually (in 2023 values). Additional economic output is produced through farm diversification activities such as renewable energy generation and tourism.

	Area (km^2)	Area (ha)	Percentage of farmed land (%)	Estimated annual value* (£)
Cereals	136	13600	47.3%	£19.5 million
Arable crops (excluding cereals)	62.6	6260	21.8%	£14.6 million
Grassland	39.6	3960	13.8%	Grassland does not directly create economic value, but instead supports the grazing of sheep and cattle, or the production of livestock feed.
Fruit & vegetables	26.7	2670	9.3%	£51.1 million

*Key land use, crop areas and livestock populations on commercial agricultural holdings and estimated annual value (£) for the East and West Fens catchment. Data provided by Collison & Associates. Based on 2023 land and livestock data available from Defra.

Environmental stewardship

Government funded agreements, such as the Countryside Stewardship scheme or the historic Entry Level Stewardship scheme, are designed to financially support farmers and other land managers to enhance the natural environment. Approximately 38% of the catchment area has been managed under stewardship agreements, particularly in the north of the catchment.

Climate change

Climate change will increase the risks of fluvial and coastal flooding, as well as drought. Flood events can restrict the ability to establish new crops, reduce crop yields and quality, or destroy crops once ready for harvest. This leads to direct agricultural damages and wider economic consequences for landowners. The rural location of the catchment means disproportionate impacts may be felt with the local supply chain.

Examples of agricultural stakeholders and businesses

There is a large amount of land entered into various countryside stewardship agreements, including land in Carrington. Here, agri-tech and innovative farming methods are being trialled.



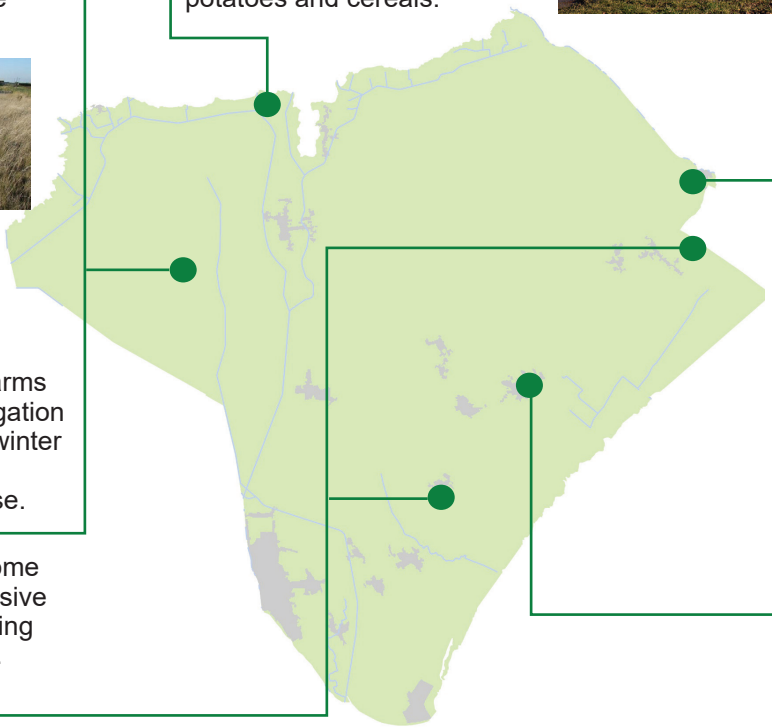
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A large number of farms have invested in irrigation reservoirs, to store winter abstracted water for summer irrigation use.

There are a number of large farming businesses based in the north of the catchment. Key produce in this area includes root vegetables, sugar beet, brassicas, peas, potatoes and cereals.



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There are several camping, caravan and holiday let sites operated by farming businesses in the catchment due to the close proximity to Skegness. They provide diversified income streams to landowners.

The catchment is home to a number of intensive poultry units, supplying eggs across the UK.

There are a number of leading food processing businesses in the catchment. For example, one company headquartered in Wrangle is a UK leading producer and processor of brassicas.

The catchment is home to a range of solar farms, including developments in Wainfleet and Leverton.



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Natural capital

Natural capital refers to elements of the natural environment that provide valuable goods and services to people, underpinning wellbeing and economic prosperity.

The benefits provided by natural capital assets such as freshwater, soils, air, and species of plants and animals are known as 'ecosystem services'.

These ecosystem services are vitally important for human wellbeing, and include provision of raw materials, food production, carbon sequestration, temperature regulation, crop pollination, as well as enabling recreation and cultural activities. Some of the services provided by nature do not directly benefit humans but support the provision of other ecosystem services, for example in the case of water and nutrient cycling, and soil formation. Together these services provide many benefits to society and the economy including improved physical and mental health through recreation; temperature regulation; flood protection; and provision of clean water.

The monetary value of benefits provided from ecosystem services can be estimated using information about the quantity, quality and location of natural capital assets, as well as societal use. Values may be underestimated due to lack of information, or complexity in assigning a monetary value.

Key ecosystem services that are difficult to quantify include biodiversity; pollination and seed dispersal; soil quality; and cultural benefits from education, volunteering, amenity, aesthetics and a sense of place. The financial value of these services is difficult to quantify but they are nevertheless vitally important for underpinning our economy, society and the natural world.

Natural capital in the East and West Fens catchment has an annual value of

£46.8 million

Climate regulation

In some cases, the degradation of natural habitats can compromise the benefits that they would otherwise provide. For example, peaty soils in healthy condition can continue to form peat and therefore sequester carbon, but when degraded through drainage, mineralisation and erosion under intensive agriculture they start to release carbon back to the atmosphere.

Enclosed farmland, woodland, saltmarsh and mudflats within the catchment sequester a total of 7,765 tonnes of CO_2 equivalent per year. However, this is far outweighed by the 45,350 tonnes of CO_2 emitted by the degraded peatland in the catchment, making the land a net source of carbon. The impact of climate change driven by this process gives a negative value (or cost) for climate regulation.*

Overall, the net release of CO_2 equivalent across the catchment has an annual **cost** of

£10.8 million

*This assessment only takes account of land-based emissions, and therefore excludes emissions from industry, transport or other sources.

£6.4 million
Recreation

The welfare value of approximately 1.5 million visits by adults each year to publicly accessible green space within the catchment. The welfare value of a further 388,000 visits made by children each year cannot be quantified but is likely to be significant.

£1.5 million
Physical health

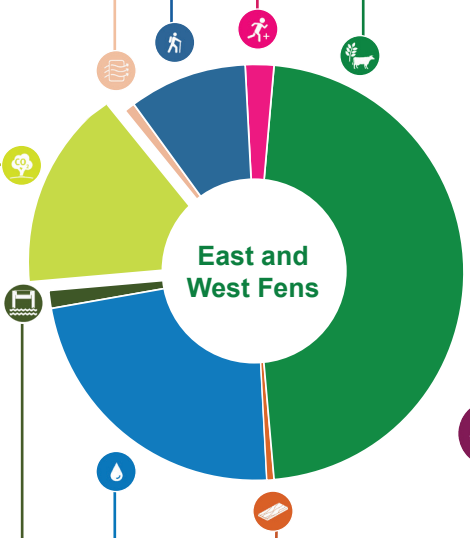
£1.48 million in healthcare treatment costs can be avoided every year due to improved physical health through approximately 1.92 million active visits to publicly accessible green spaces in the catchment. Active visits involve at least 30 minutes of exercise.

£32.5 million
Agriculture

The 336.1km^2 (33,610ha) of enclosed farmland in the catchment provide several ecosystem services, but the service with the largest annual value is food production. Arable and livestock yields from the catchment have a combined annual value of £32.47 million.

£0.4 million
Air Quality

The removal of 1,900 tonnes of air pollutants by vegetation in the catchment avoids the costs of damages to health. This has an annual value of £404,000 per year.



£0.0 million
Water quality

The annual value of 'Good' or high water quality is £9,451 per km^2 for transitional and coastal waterbodies, or £23,527 per km for river waterbodies. However, none of the waterbodies in the catchment meet these standards, giving a value of £0 for water quality.

£-10.8 million
Climate regulation

The value of climate change regulation in the catchment is negative because the habitats across the catchment release more carbon than they sequester overall. Each year, 37,600 tonnes of CO_2 equivalent are released, costing £10.8 million per year through the detrimental effects of climate change.

£0.0 million
Hazard regulation

The assessment does not provide a monetary value for this benefit. However, in the catchment an estimated 35,300m^3 of floodwater is temporarily stored in areas of woodland.

£0.9 million
Renewable energy

64,900MWh of renewable energy, predominantly from wind and solar, is generated per year within the catchment. This has a value of approximately £906,000 per year.

£15.9 million
Water supply

The annual value of approximately 3 million m^3 of water which is abstracted from the catchment each year, for public water supply and other uses such as irrigation.

£0.03 million
Timber

National data can be applied to the East and West Fens catchment to estimate a yearly timber production volume of 923m^3, which is valued at approximately £31,100 per year.

Flood economic damage scenarios

To understand the potential economic impact of flooding over the next 100 years, two scenarios have been explored which describe different approaches to managing flood risk assets. These are the 'Maintain' and 'Do Nothing' scenarios.

Maintain

The 'Maintain' scenario represents the continued maintenance of the existing flood defences. This assumes sufficient investment to maintain the existing flood defences for 100 years. All flood defences would continue to provide the same level of service that they currently offer. There is no allowance for increasing the Standard of Protection offered by existing assets or for climate change adaptation, such as increasing the height and resilience of flood defences, or increasing the capacity or performance of pumping stations.

In a 'Maintain' scenario, flooding would occur in events which exceed the height of existing flood defences or the capacity of pumping stations. The resulting damage to properties and infrastructure has been used to determine the scale of economic losses which might be expected over the next 100 years. Due to limitations of the 2017 Stonebridge model for use in the economic analysis, flood risk in this scenario is represented with the modelling results from the nationally available Risk of Flooding from Multiple Sources (RoFMS) dataset.

Do Nothing

The 'Do Nothing' scenario is a hypothetical scenario, used to understand the benefits of investment in flood defences by considering the consequences of investment being withdrawn. In this scenario, all flood risk management activities would stop, including maintenance of existing flood defences and pumping.

Sluices on Main Rivers would no longer operate, increasing the risk of flooding as river water backs up behind these sluices. Without pumped outfalls to the Main Rivers and The Wash, water would be unable to drain from the land.

The East and West Fens catchment is assumed to be frequently or permanently inundated to the water levels defined by the limiting level. The limiting level is the rate at which the inundation is achieved based on the rainfall estimates for the whole of the Fens catchment. In this scenario, the area would essentially act as a basin, filling with rainfall up to the limiting level.

Whilst there would be some loss of water over summer due to evaporation and transpiration, the water levels would be expected to rise steadily over a few years, filling the catchment. To represent this, it is assumed that each of the areas would fill by 0.5m per year up to the limiting level of 3.9m AOD. The limiting level is likely to be reached within 5-10 years. The resulting damages are used to determine the economic losses over the next 100 years, if all flood risk management activities ceased.

£7 billion

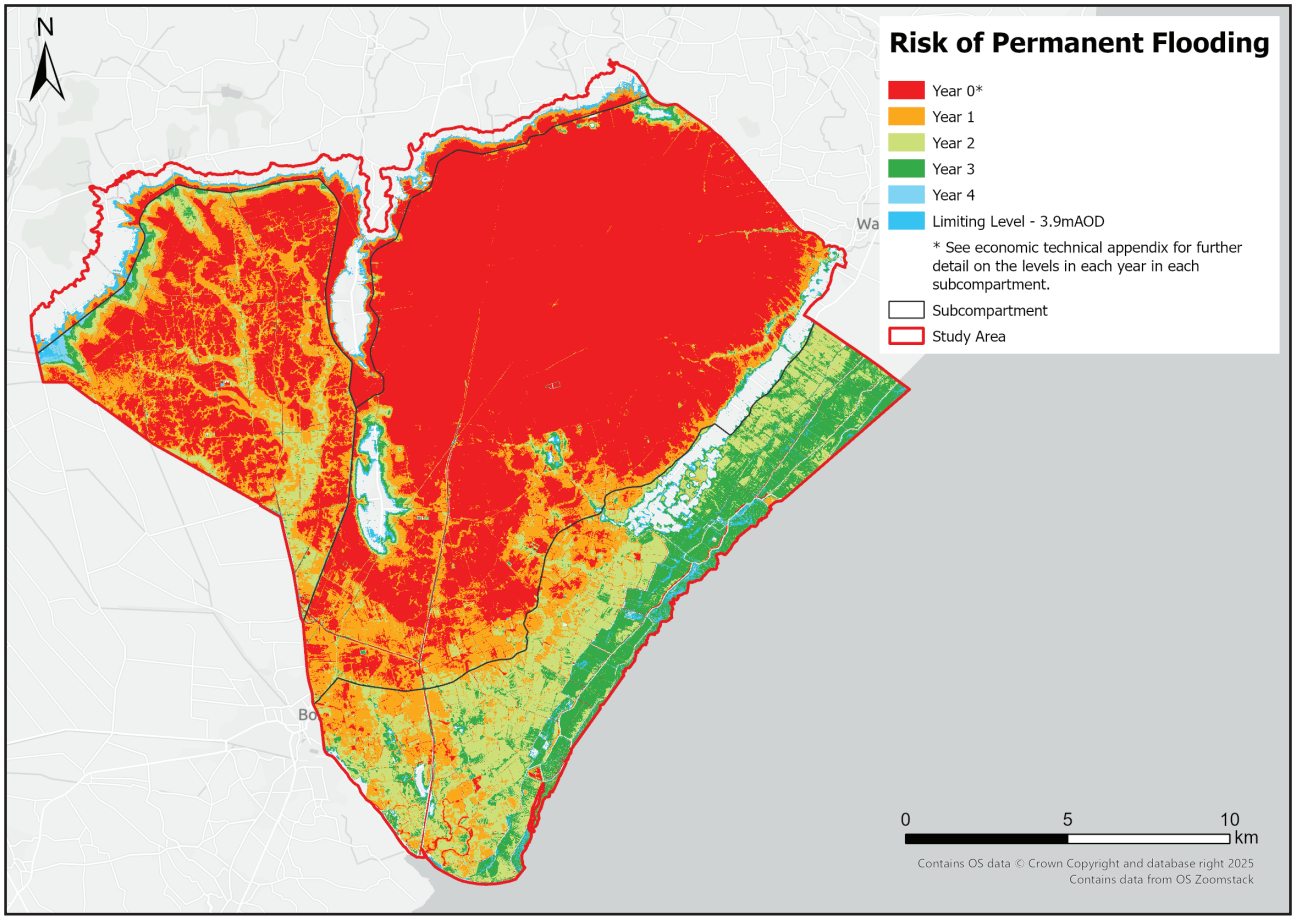
the economic benefits of current flood risk management activities



The economic analysis estimates the damages that would be expected to occur in each of the 'Do Nothing' and 'Maintain' scenarios. The economic benefit of maintaining the existing flood defences is the damages avoided in the 'Maintain' scenario compared to 'Do Nothing'.

The Total Impact framework to the left shows the range of damages considered.

The results of the assessment show that there is a total of £7.4 billion of economic damages in a 'Do Nothing' scenario, compared to only £426.6 million of economic damages in a 'Maintain' scenario. As such, the economic benefits of current flood risk management activities are valued at approximately £7 billion.



Risk of permanent flooding over time, in a 'Do Nothing' scenario

Economic damages and benefits of flood protection

If all flood risk management activities ceased ('Do Nothing'), total damages in the catchment over the next 100 years would exceed £7.4 billion, with £7.1 billion of this in the first ten years.

£835 million
Agriculture

Flooding to farmland will lead to immediate and long-term crop losses. Damages capture loss of crops and livestock and associated loss of profits.

294.3km² (29,427ha) of agricultural land written off in the 'Do Nothing' scenario, costing **£835 million**

£4.6 billion
Properties

Captures the impacts of flooding on residential and non-residential buildings, through damage to building fabric and structure.

16,590 residential properties written off in the 'Do Nothing' scenario, costing **£3.659 billion**

2,431 non-residential properties written off in the 'Do Nothing' scenario, costing **£941.3 million**

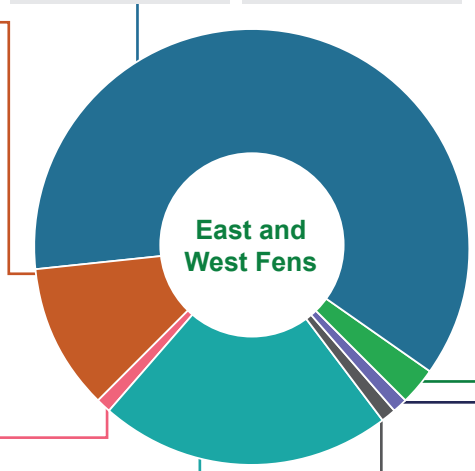
£189 million
Environment and recreation

Loss of 4.3km² (428ha) of designated environmental sites across the catchment will lead to losses of ecosystem services such as carbon sequestration, flood regulation, biodiversity, recreation and non-use values.

Recreational damage would arise through loss of 1km² (103ha) of recreational sites and 114.7km of Public Rights of Way.

£44 million
Heritage

Loss of heritage sites as a result of flooding. The catchment contains 179 Listed Buildings and 13 Scheduled Monuments, with a large proportion of these located within the eastern portion of the catchment.



£56 million
Utilities

Captures the impacts of flooding to power, water supply, and gas networks. This includes damage to 833 substations, 3,879 pole towers and 404km of power cables.

£9.6 billion
Losses to the local economy

Losses to the local economy have been considered in terms of Gross Value Added (GVA). This considers the cost to the local economy of 34,927 jobs being lost across the catchment under a 'Do Nothing' scenario. GVA is a local / regional benefit so cannot be included in application for Grant in Aid funding.

£1.6 billion
Transport

The cost of the loss of road infrastructure, and railway network as a result of permanent flooding.

Loss of **49.5km** of road infrastructure, costing **£1.513 billion**

Loss of **18.9km** of rail infrastructure, costing **£0.145 billion**

£47 million
Isolated land

The consideration of isolated land and properties is unique to the 'Do Nothing' scenario which considers permanent inundation of the catchment, rather than infrequent extreme flood events. It accounts for areas of land which may not be directly flooded, but are abandoned because flood waters cut-off the area from the existing road network.

East and West Fens	Do Nothing Damages	Maintain Damages	Maintain Benefits
Damages to properties and associated indirect damages	£4.6 billion	£393 million	£4.2 billion
Agricultural losses	£835 million	£26 million	£809 million
Environment and recreational losses	£189 million	£55,000	£189 million
Heritage losses	£44 million	£40,000	£44 million
Transport damages	£1.6 billion	-	£1.6 billion
Utilities damages	£56 million	£8 million	£49 million
Land lost due to isolation	£47 million	-	£47 million
TOTAL Excluding losses to the local economy	£7.4 billion	£426.6 million	£7 billion
Losses to the local economy	£9.6 billion	£2.4 million	£9.6 billion

£7 billion

total benefits of maintaining current flood defences for the next 100 years

Total investment needed:

£0.8-£1.5 billion

to sustain the current Standard of Service for 100 years (excluding the impact of climate change).

The investment needed to sustain the existing flood defences has been estimated with no allowance for improvements in protection or adaption to the impacts of climate change. These investment needs have been developed based on three types of assumed costs:

- Ongoing and routine maintenance and operational costs;
- Infrequent asset refurbishment costs; and
- End of life asset replacement costs.

The costs have been developed based on data for various assets across the wider Fens 2100+ study area, collated from the Environment Agency and IDBs.

All damages and benefits are shown for a 100-year period, except for GVA, which is for 10 years.

These have been used to determine the average costs for each type of asset, including for maintenance, operation and asset replacement. Asset refurbishment costs are only included where these have been provided for specific assets. The range of costs reflects the uncertainty in the assumptions made at this stage.

The flood risk, asset condition, economic and total investment analyses given within this baseline report demonstrate the critical importance of a strategic plan for the future of flood risk management within the East and West Fens catchment. Future stages of the Fens 2100+ Partnership will build on this evidence to set out an investment strategy for the region.

Details of the assessment of economic damages and benefits are provided in the technical appendix.

Glossary of terms and acronyms

Agricultural land Grades 1 and 2

Land classified as Grade 1, using the UK's Agricultural Land Classification (ALC), has little or no limitations and will consistently achieve high yields for most crops. Grade 2 has reduced flexibility compared to Grade 1 and yields are generally high but can be more variable compared to Grade 1.

Agri-environmental schemes

Agri-environment schemes provide funding to farmers and land managers to farm in a way that supports biodiversity, enhances the landscape, and improves the quality of water, air and soil.

Annual Exceedance Probability (AEP)

This is the probability of a certain sized flood event occurring in a single year.

Asset Information Management System (AIMS)

A database with information about flood defence assets currently owned, managed and inspected by the Environment Agency.

Benefits

The positive quantifiable and unquantifiable changes that a flood risk management scheme is expected to produce, i.e. damages avoided.

Capital funding

Funding secured for the creation of new assets or the major refurbishment of existing assets to maintain or increase current standards of protection.

Carbon sequestration

The process of capturing and storing greenhouse gases from the atmosphere. In the context of natural systems this is via plant vegetation and soil processes.

Catchment

For the purposes of the Fens programme, the catchment study area has been defined by land at or below the 6m AOD contour, which may differ slightly from the hydrological catchment.

Climate mitigation

Actions taken to limit the effects of climate changes by reducing carbon emissions or enhancing carbon sinks.

Damages

The value of negative social, economic and environmental impacts caused by flooding.

Ecosystem services

Services provided by the natural environment which benefit people. They provide outcomes that provide positive benefits to human wellbeing.

Flood risk management assets

In the context of this report this refers to a structure built and maintained specifically for flood risk management purposes, for example embankments, flood defence walls and pumps.

Main River

A statutory designation of watercourse, usually applied to larger streams and rivers. The Environment Agency have permissive powers to carry out maintenance, improvement and construction works on these watercourses, although usually the main responsibility for these lies with the riparian owner.

Maintenance funding

Funding secured for maintenance activities to existing assets to sustain the existing standard of protection. Sometimes this is referred to as revenue funding.

Maladaptation

Actions or strategies that, while intended to address a problem, ultimately increase vulnerability or harm, either in the short or long term.

Mean High Water Spring (MHWS)

The average height of high-water level during spring tides, placing this area at risk of permanent inundation.

Natural capital

Refers to elements of the natural environment that provide valuable goods and services to people, underpinning wellbeing and economic prosperity.

Ordinary watercourse

Any watercourse which is not designated as a Main River. Within the Fens the IDBs manage these watercourses on behalf of the riparian owners.

Ordnance Datum (OD)

The Ordnance Datum is the basis for all the land heights that appear on Ordnance Survey maps. It is essentially the mean sea level at Newlyn in Cornwall, and is sometimes called Ordnance Datum Newlyn (ODN).

Resilience

The capacity for people and places to plan for, protect, respond to and positively recover from flooding and coastal change.

Risk Management Authorities (RMAs)

Refers to the authorities which take a strategic lead on the management of flooding and have permissive powers to carry out the works. These authorities include the Environment Agency, LLFAs, district councils, IDBs, highway authorities and water companies.

Soilscape

A classification used to describe the broad regional differences in soil types and their distribution across a landscape.

Standard of Protection (SoP)

At a given point in time, the AEP of a flood event which an asset is able to withstand. SoP will vary over time.

Standard of Service (SoS)

Defined physical characteristics that a flood risk infrastructure asset is required to achieve. For example, the height of a protective barrier or throughput of a pump.

Fens 2100+

