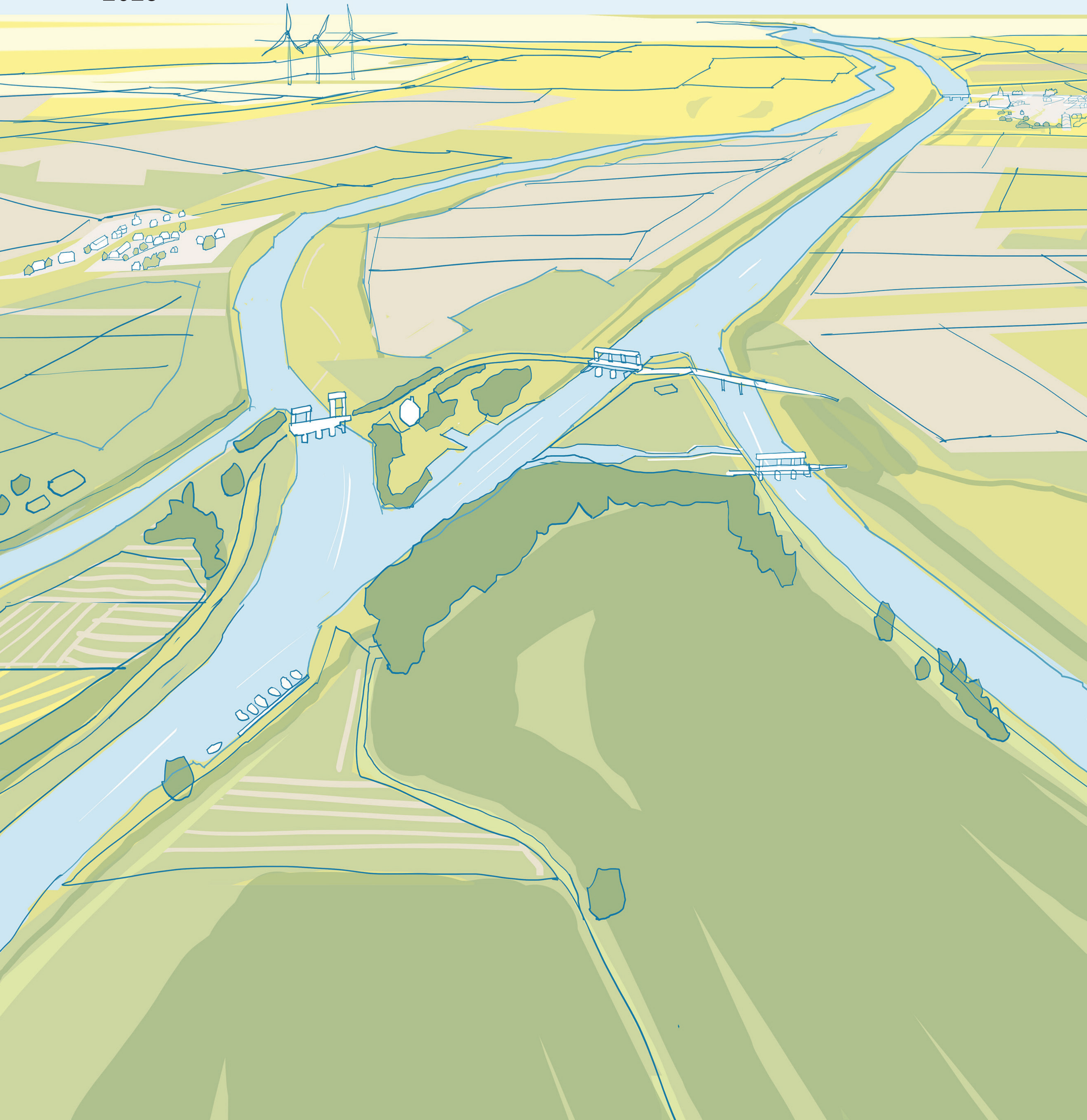
Fens 2100+

Great Ouse

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

Previous baseline reports

Future Fens Flood Risk Management Baseline Report (2020) established an evidence baseline for the Great Ouse.

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 a comprehensive picture of flood risk and asset performance across the Great Ouse catchment, supplementing earlier evidence published in the 2020 Future Fens Flood Risk Management Baseline Report.

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.

The Great Ouse

Total catchment area

2,196km²

72%

of land classified as Grade 1 & 2 agricultural land

16km

of coastline

48

Internal Drainage Boards

138

pumping stations

Estimated total population

325,828

1 million

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

CO_2

81

designated sites for nature conservation

130 Scheduled Monuments

60 Conservation Areas

£20.1bn

economic benefits of current flood defences

£268 million

total annual value from natural capital

Introduction

The evidence is clear: without urgent investment to maintain and upgrade flood risk assets across the Great Ouse catchment, £20.7 billion of damages could be sustained to land, homes and livelihoods.

A landscape worth protecting

The Great Ouse catchment is larger than the rest of the Fens 2100+ area combined, covering 2,196km^2 (219,600ha) of Cambridgeshire, Lincolnshire, Norfolk and Suffolk. Of national importance, the catchment's healthy agricultural economy contributes £520.8 million a year to the UK economy.

There are 81 designated nature conservation sites, including internationally important wetlands, The Wash, Woodwalton Fen and Wicken Fen, providing habitats for wading and migratory birds, shellfish and seals. 29% of land is underlain by rich peat deposits.

Natural capital delivers £268 million of benefits a year, including food production, flood risk management, carbon sequestration, clean water and recreation.

What's the challenge?

Continuous land drainage and flood defences are all that protect low-lying areas from permanent inundation. 17,149 homes and 19,746 businesses are at risk. Yet, 80% of flood risk assets will reach the end of their foreseeable design life within 50 years, and 20% within 15 years.

Approximately 31% of assets are rated 'Poor', 'Very Poor' or 'Unknown', including crucial embankments, outfalls and control gates. This complex system of assets requires significant resources and collaboration between RMAs.

Repeated flooding events highlight the catchment's vulnerability, including severe flooding across Cambridgeshire in 2023 and along the River Great Ouse, Lower River Cam and Ouse Washes in 2024. Climate change would intensify this risk, even if current defences are maintained.

What's needed?

£2.3-£3.6 billion

of investment

to sustain the current Standard of Service for 100 years

To maintain

£20.1 billion

of benefits

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

Catchment overview map

The river in context

The Great Ouse catchment covers 2,196km^2 (219,600ha) of highly productive agricultural land, with 32% of the study area lying below mean sea level. The catchment extends along the River Great Ouse from the Earith Sluice to the outlet of the Tidal River Ouse into The Wash at King's Lynn.

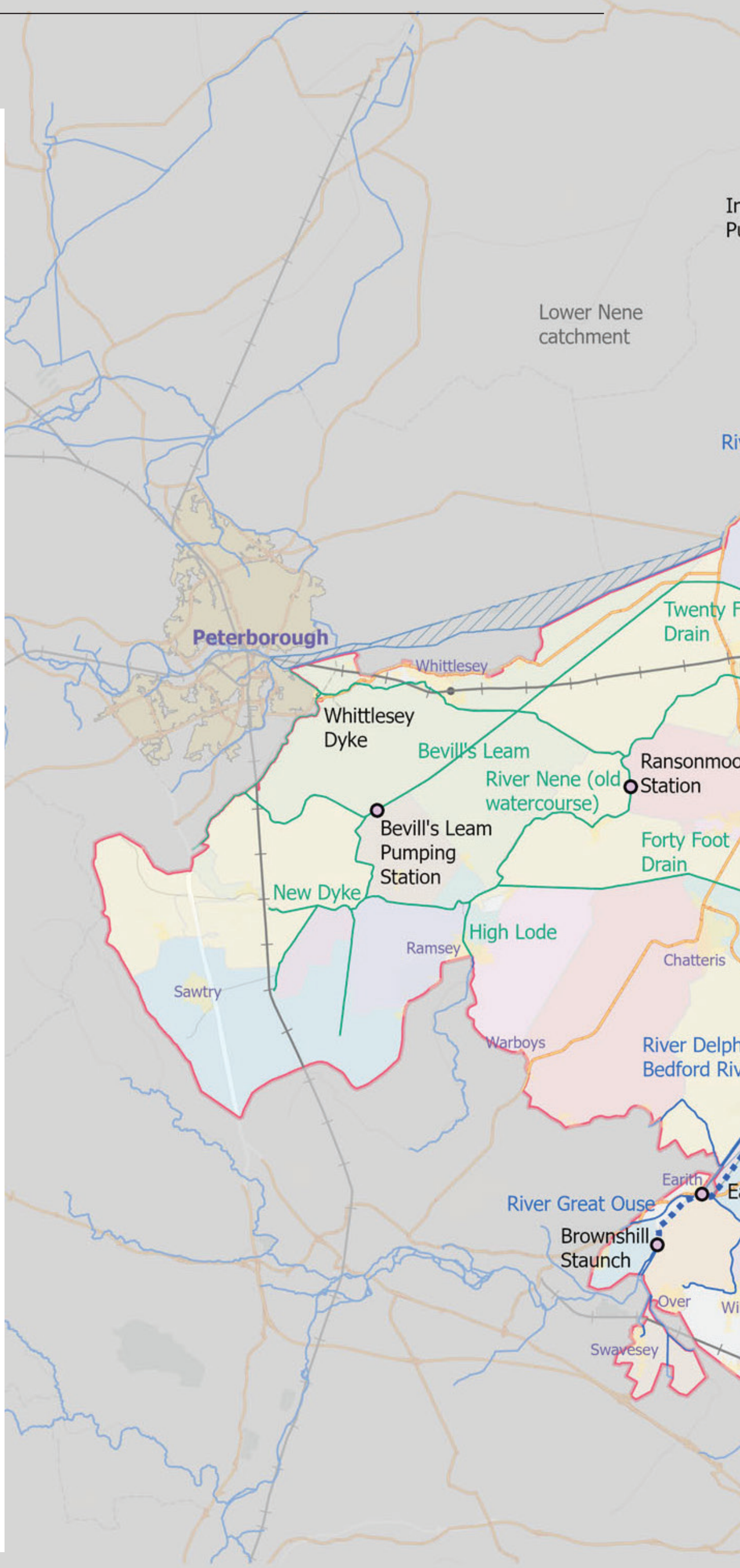
To the south-east the catchment is bordered by the low clay hills of the Huntingdonshire Uplands. In the north-west the natural catchment boundary sits along the edge of the Whittlesey (Nene) Washes and the River Nene.

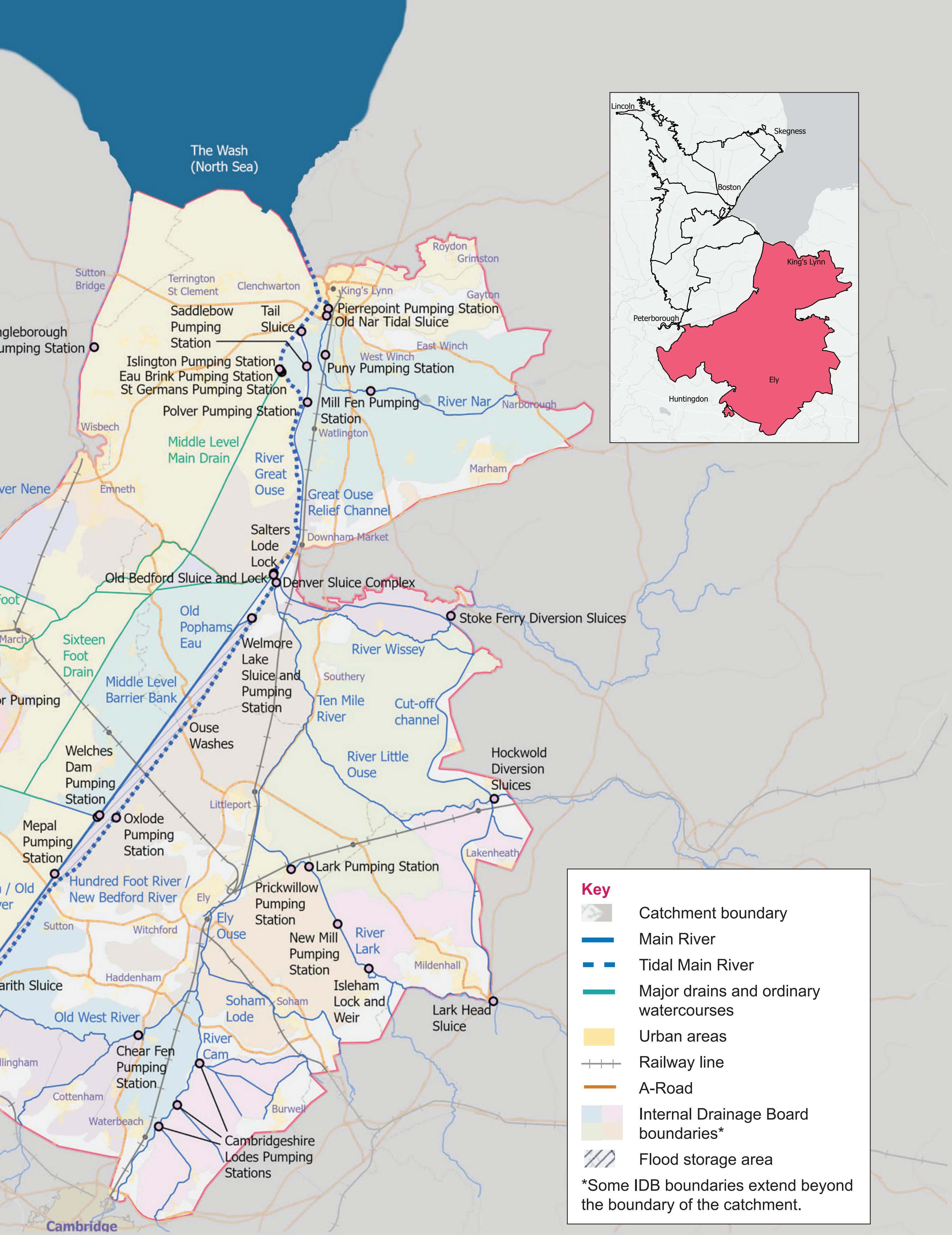
The study area includes 2.1% of England's farmed area and produces 4.4% of England's total agricultural output, worth an estimated £520.8 million per year. It contains 13,212 industrial and commercial properties and is home to approximately 326,000 people. The catchment is protected from flooding by a network of drains, embankments, pumping stations and sluice gates. One of the key assets is the Ouse Washes which provides 90 million m^3 of flood storage and is Britain's largest washland occupying around 25km^2 (2,500ha).

The Great Ouse catchment covers approximately

2,196km^2

of Cambridgeshire, Lincolnshire, Norfolk and Suffolk.





The Wash (North Sea)
Lincoln
Skegness
Boston
King's Lynn
Peterborough
Ely
Huntingdon
Sutton Bridge
Terrington St Clement
Clenchwarton
Roydon
Grimston
Gayton
Saddlebow Pumping Station
Tail Sluice
Pierrepoint Pumping Station
Old Nar Tidal Sluice
East Winch
West Winch
Islington Pumping Station
Eau Brink Pumping Station
St Germans Pumping Station
Puny Pumping Station
Polver Pumping Station
Mill Fen Pumping Station
River Nar
Narborough
Watlington
Wisbech
Middle Level Main Drain
River Great Ouse
Marham
Emneth
Great Ouse Relief Channel
Salters Lode Lock
Downham Market
Old Bedford Sluice and Lock
Denver Sluice Complex
Stoke Ferry Diversion Sluices
Old Pophams Eau
March
Sixteen Foot Drain
Welmore Lake Sluice and Pumping Station
River Wissey
Southery
Middle Level Barrier Bank
Ten Mile River
Cut-off channel
Ouse Washes
Welches Dam Pumping Station
River Little Ouse
Hockwold Diversion Sluices
Littleport
Mepal Pumping Station
Oxlode Pumping Station
Lakenheath
Lark Pumping Station
Hundred Foot River / New Bedford River
Ely
Prickwillow Pumping Station
Ely Ouse
Sutton
Witchford
New Mill Pumping Station
River Lark
Mildenhall
Haddenham
Isleham Lock and Weir
Lark Head Sluice
Soham Lode
Soham
Old West River
River Cam
Chear Fen Pumping Station
Cottenham
Burwell
Waterbeach
Cambridgeshire Lodes Pumping Stations
Cambridge
Key
Catchment boundary
Main River
Tidal Main River
Major drains and ordinary watercourses
Urban areas
Railway line
A-Road
Internal Drainage Board boundaries*
Flood storage area
*Some IDB boundaries extend beyond the boundary of the catchment.

Catchment overview

The primary watercourse within the catchment is the River Great Ouse, which is the fourth longest river in England.

The River Great Ouse has an overall length of 230km, with a catchment of 8,500km^2 (850,000ha) that is home to 1.7 million people.

As the River Great Ouse enters the Fens 2100+ study area at Earith it splits into the River Delph/Old Bedford River, Hundred Foot River/New Bedford River and the Old West River. The Hundred Foot River is the usual route for water entering the catchment from the upper course of the River Great Ouse, although during periods of high flow, Earith Sluice can be used to divert flows into the Old Bedford River, from which water can spill into the Ouse Washes flood storage area.

Registered under the Reservoir Act of 1975, the Ouse Washes is Britain's largest washland, capable of storing 90 million m^3 of water. Horseway Lock prevents water at Earith from flowing in a wide loop along the Old West River, but this watercourse collects water from many other tributaries, as well as pumped outfalls from IDB districts in the South Level.

The Old West River becomes the Ely Ouse after its confluence with the River Cam and further downstream is known as the Ten Mile River. At Denver, flows from the Hundred Foot River and the Ely Ouse System combine, and the parallel River Great Ouse and Great Ouse Relief Channel carry water northwards to King's Lynn and the outfall of the Great Ouse into The Wash.

The catchment's topography is flat and low lying with 32% of the study area lying below mean sea level, and 62% lying below 2.5m AOD (Above Ordnance Datum).

The lowest area sits 2.75m below sea level at Holme Fen. Therefore, all of the catchment is reliant on the constant management of water levels across the branched network of drainage channels and Main Rivers to remain habitable.

Flood risk management assets across the catchment include 138 pumping stations, 24 sets of sluice gates, 95km of coastal and tidal defences and 405km of fluvial embankments.

The pumping station at St. German's is the largest in the UK, with a capacity of 100m^3/s. It is the only drainage outlet for nearly a third or 700km^2 (70,000ha) of land within the catchment.

Recent storm events have highlighted the vulnerability of the catchment to flooding. In October 2023, Storm Babet caused flooding across Cambridgeshire, with three severe flood warnings issued in the county following the event. The whole catchment was affected, including March and Ely.

Storm Henk caused further flooding in the catchment in January 2024, prompting flood warnings on the River Great Ouse, Lower River Cam and the Ouse Washes.

Water scarcity has also become a focus in recent years, with eastern England facing a projected shortage of 800 million litres of water per day by 2050, the equivalent of a third of current water use in the region.

To create a more secure water supply for the Fens, a new reservoir will be built in the Great Ouse catchment just north of Chatteris and is planned to be operational by 2036. It will supply water to approximately 250,000 households.

The Ouse Washes near Welney

Flood management system: South Level

1 **River Great Ouse**
Main River
At 200km long, it is the fourth longest river in England.

2 **Brownshill Staunch**
Environment Agency
The tidal limit on the Great Ouse system, which is tidal on the Hundred Foot River.

3 **Swavesey Drain**
Main River
Drains the area between Swavesey, Over and Longstanton.

4 **Earith Sluice**
Environment Agency
Opens automatically when there are high flows in the Bedford Great Ouse to let some water into the River Delph/ Old Bedford River.

5 **Hundred Foot River/ New Bedford River**
Main River
The usual route for water from the River Great Ouse under normal conditions. It is tidal here and as far inland as Brownshill Staunch.

6 **River Delph/ Old Bedford River**
Main River

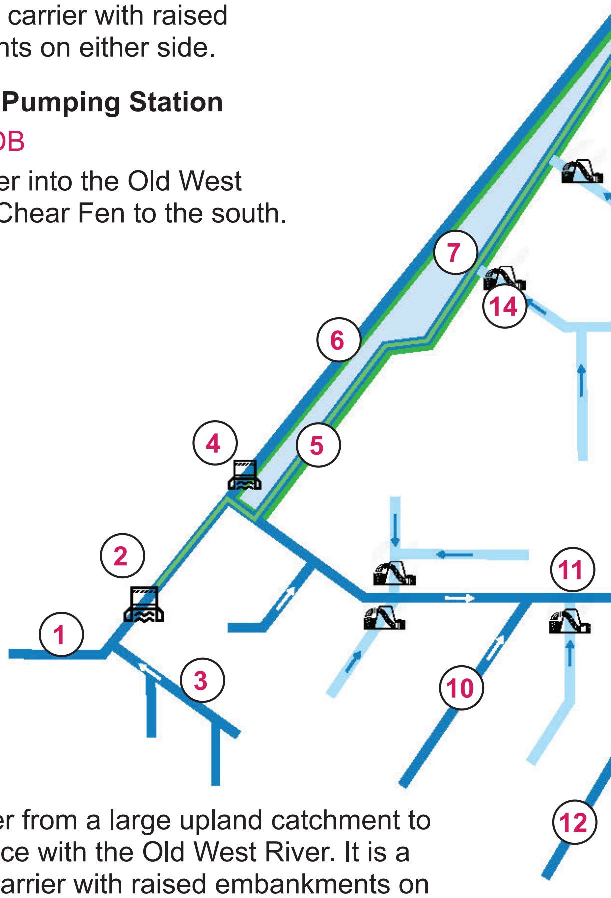
7 **Ouse Washes**
Environment Agency & Partners
When Earith Sluice opens, high flows are diverted into the Old Bedford River and once its capacity is exceeded, water spills into the Ouse Washes. Overtopping of the Cradge Bank from the Hundred Foot River may also occur. Water is stored in the Washes until flows subside and it can be discharged through Welmore Lake Sluice.

8 **Welmore Lake Sluice & Pumping Station**
Environment Agency
Used to release water from the Ouse Washes back into the Hundred Foot River.

9 **Old West River /Ely Ouse / Ten Mile River**
Main River
The Great Ouse River is known as the Old West River (between Hermitage Lock and the River Cam), the Ely Ouse (downstream of the River Cam), and the Ten Mile River (downstream of Littleport).

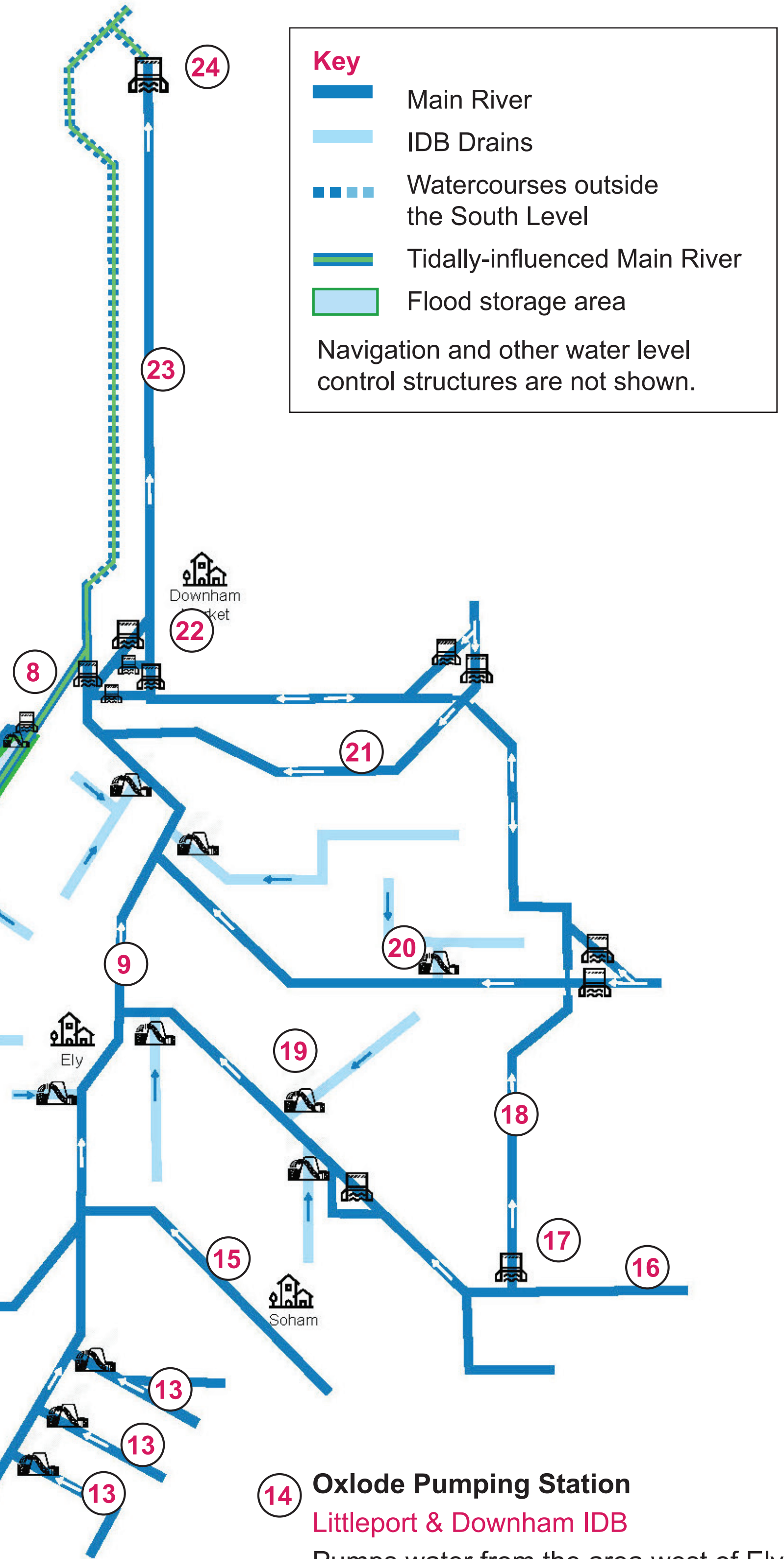
10 **Cottenham Lode**
Main River
A high level carrier with raised embankments on either side.

11 **Chear Fen Pumping Station**
Old West IDB
Pumps water into the Old West River from Chear Fen to the south.



12 **River Cam**
Main River
Brings water from a large upland catchment to its confluence with the Old West River. It is a high-level carrier with raised embankments on either side.

13 **Cambridgeshire Lodes**
Main Rivers
Bottisham Lode, Swaffham Lode, Reach Lode and Burwell Lode are all high-level carriers with raised embankments on either side. They mostly discharge into the River Cam by gravity but pumping stations can boost the flow of water during periods of high flow.



14 **Oxlode Pumping Station**

Littleport & Downham IDB

Pumps water from the area west of Ely into the Hundred Foot River.

15 **Soham Lode**

Main River

Beginning north of Newmarket, it carries water from Soham to the Ely Ouse.

16 **River Lark**

Main River

Rising south of Bury St Edmunds it is one of several tributaries of the Ely Ouse.

17 **Diversion Sluices**

Environment Agency

The Lark Head Sluice (on the River Lark), the Hockwold Diversion Sluices (on the Little Ouse River) and the Stoke Ferry Diversion Sluices (on the River Wissey) allow water to be diverted from these watercourses into the Cut-Off Channel. This relieves pressure on the Ten Mile River. Syphons allow the Cut-Off Channel to flow beneath the Wissey and Little Ouse.

18 **Cut-Off Channel**

Main River

Under flood conditions, water from the River Lark, Wissey and Little Ouse can be diverted into the Cut-Off Channel to relieve pressure on the rest of the South Level system. When required, the Cut-Off Channel’s flow can be reversed (via sluices at Denver) to transfer excess water to the Blackdyke Intake north of Hockwold, where it can be transferred to reservoirs in Essex.

19 **Lark Pumping Station**

Burnt Fen IDB

Pumps water from the area between the Little Ouse River and the River Lark.

20 **Little Ouse River**

Main River

Downstream of the Hockwold Sluices, the river is a high-level carrier with raised embankments on either side of the channel.

21 **River Wissey**

Main River

Joins the Ten Mile River just south of Denver.

22 **Denver Sluice Complex**

Environment Agency

The system of sluices here hold water levels throughout the South Level system and release flows into the River Great Ouse.

23 **Great Ouse Relief Channel**

Main River

Can be used to store more than 9.5 million cubic metres of water arriving from the South Level, to reduce flood risk to King’s Lynn.

24 **Tail Sluice**

Environment Agency

Opened in 1959, it sets the tidal limit of the Great Ouse Relief Channel. It is formed of seven sluices, each 9m wide.

Flood management system: Middle Level

1 **South Barrier Bank**

Environment Agency

As undertaker of the Whittlesey (Nene) Washes flood storage area, the Environment Agency are responsible for maintaining the South Barrier Bank which prevents water from spilling into the Middle Level.

2 **Triple pumping**

Middle Level Commissioners

The south-western area of the Middle Level contains the lowest land levels and the deepest peat, which will continue to shrink into the future. The area is vulnerable, being the first area to receive flood water from the higher ground to the south, whilst being located furthest from St. German's Pumping Station. Water in this area is pumped three times to reach the North Sea: at an IDB 'booster' pump, then at Bevills Leam, and finally at St. German's.

3 **Middle Level Catchwater Drain**

Middle Level Commissioners

Designed to minimise the amount of water entering the low-lying Middle Level district, it intercepts run-off from higher ground to the south and redirects it to Bevills Leam.

4 **Control Sluice & Woodwalton Fen Flood Storage Area**

Middle Level Commissioners

In times of high flows from the catchwater drain, the control sluice can be closed to divert water into Woodwalton Fen National Nature Reserve, as a back-up measure. Water can be stored here and discharged into the river system at a controlled rate.

5 **Ramsey High Lode**

Middle Level Commissioners

Ramsey High Lode receives and conveys water towards St. Germans Pumping Station from the Bury Brook sub-catchment. This sub-catchment is within the Middle Level Commissioners' highland area. Although this lies mostly beyond the Fens 2100+ study area boundary, accounts for 10% of the Commissioners' overall catchment.

6 **Bevills Leam Pumping Station**

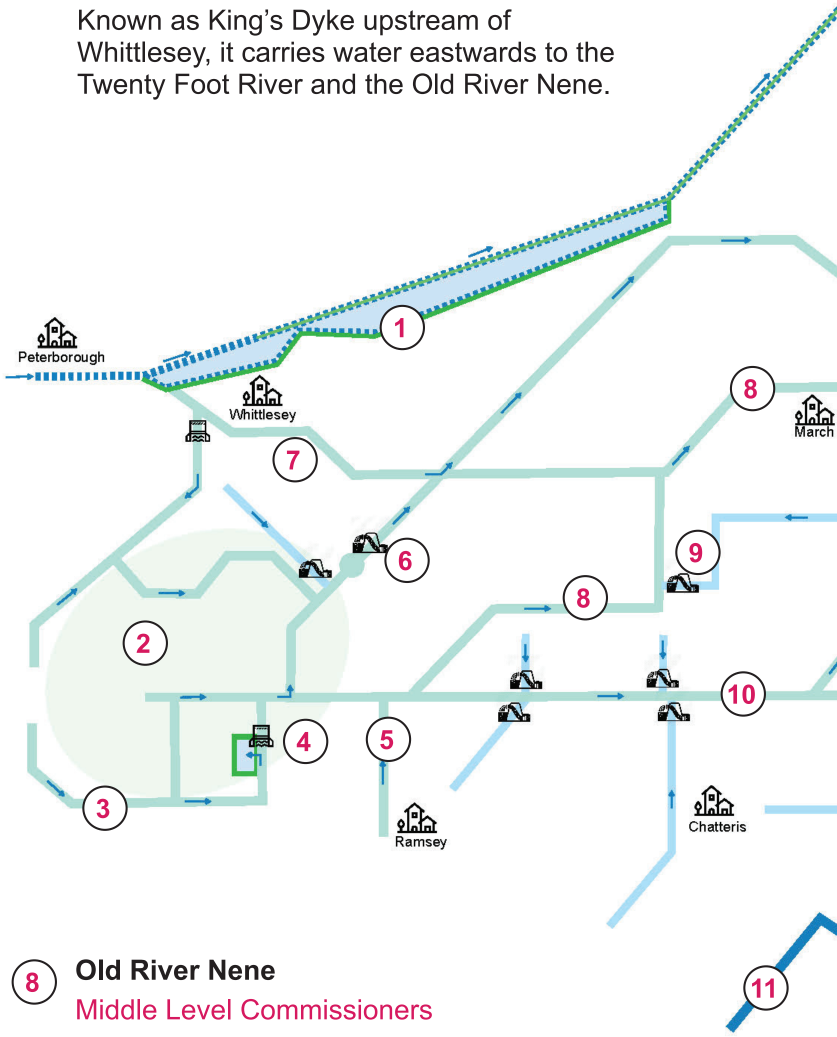
Middle Level Commissioners

Constructed to boost the flow from the lowest lying area of the Middle Level into Bevills Leam, to flow northwards to St. German's. Bevills Leam pond upstream of the pumping station provides temporary storage of flood water from the Catchwater Drain.

7 **Whittlesey Dyke**

Middle Level Commissioners

Known as King's Dyke upstream of Whittlesey, it carries water eastwards to the Twenty Foot River and the Old River Nene.



8 **Old River Nene**

Middle Level Commissioners

The previous meandering course of the River Nene before the new straightened channel was dug.

9 **Ransonmoor Pumping Station**

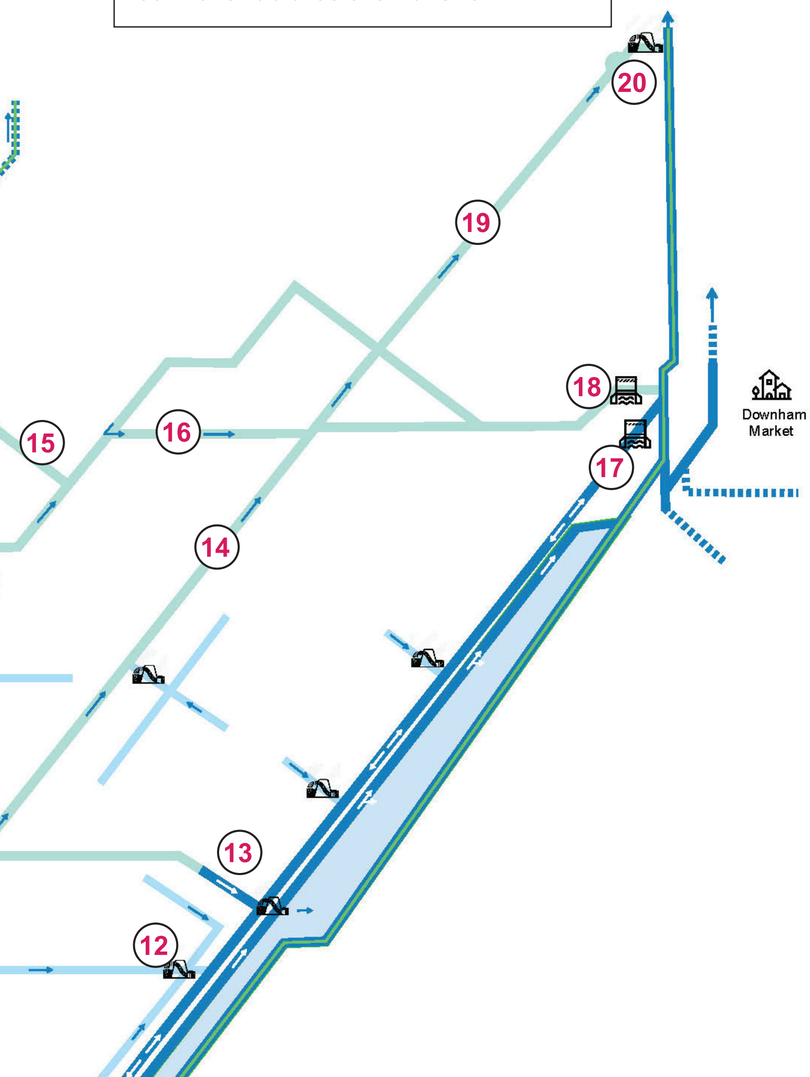
Ransonmoor District Drainage Commissioners

One of the 56 IDB pumping stations which outfall directly into the Middle Level Commissioners' watercourses.

Key

- Main River
- IDB Drains
- Watercourses outside the Middle Level
- Tidally-influenced Main River
- Lowest-lyng land
- Flood storage area
- Middle Level Commissioners watercourse

Navigation and other water level control structures are not shown.



10 Forty Foot Drain
Middle Level Commissioners
A straightened channel which links the Old River Nene with the Main River system via Horseway Lock.

11 Ouse Washes Counter Drain
Main River
Normally discharges water into the River Great Ouse through the Old Bedford Sluice, but also pumps backwards to maintain water resources in summer.

12 Mepal Pumping Station
Sutton & Mepal IDB
Originally built in 1840, it is typical of many fenland pumping stations which started out with coal fired steam operated pumps, then diesel and eventually electric. It discharges water into the Ouse Washes Counter Drain.

13 Welches Dam Pumping Station
Environment Agency
Moves water from the Ouse Washes Counter Drain into the Ouse Washes.

14 Sixteen Foot Drain
Middle Level Commissioners
IDB pumping stations pump water from surrounding land into the channel.

15 Twenty Foot River
Middle Level Commissioners
A continuation of Bevills Leam after its junction with Whittlesey Dyke, it connects to the Old River Nene north-east of March.

16 New Popham's Eau
Middle Level Commissioners
Water in this drain is pulled eastwards by St. German's Pumping Station.

17 Old Bedford Sluice & Lock
Environment Agency
Used to release water from the River Delph/ Old Bedford River into the River Great Ouse.

18 Salters Lode Lock
Middle Level Commissioners
The guillotine gate at Salters Lode form part of the Great Ouse Tidal Defences. The guillotine gate and the lock gate enables access for watercraft between the Great Ouse and the Middle Level system, which connects to the River Nene near Peterborough.

19 Middle Level Main Drain
Middle Level Commissioners
Brings water northwards from the Middle Level area and discharges it to the tidal reach of the River Great Ouse through St. German's Pumping Station.

20 St. German's Pumping Station
Middle Level Commissioners
The largest pumping station in Britain, it is the primary outlet for water from the Middle Level system, and pumps water from an area of 700km^2 (70,000ha) into the tidal stretch of the River Great Ouse. A 'pond' or widened section of the channel upstream can store additional water before it is pumped.

Flood management system: King's Lynn, East of Ouse and West of Ouse

1. **River Great Ouse**
   Main River
   Downstream of Denver Sluice it is tidal, and is a high-level carrier with raised embankments up to 6m above the surrounding land. Significant lengths of the embankments have erosion protection on the channel sides such as concrete block work.

2. **Great Ouse Relief Channel**
   Main River
   Part of the South Level system.

3. **Polver Drain/Sandy Drain/ Fourteeen Foot Drain**
   East of Ouse, Polver and Nar IDB
   Moves water from Marham Fen to the Great Ouse Relief Channel.

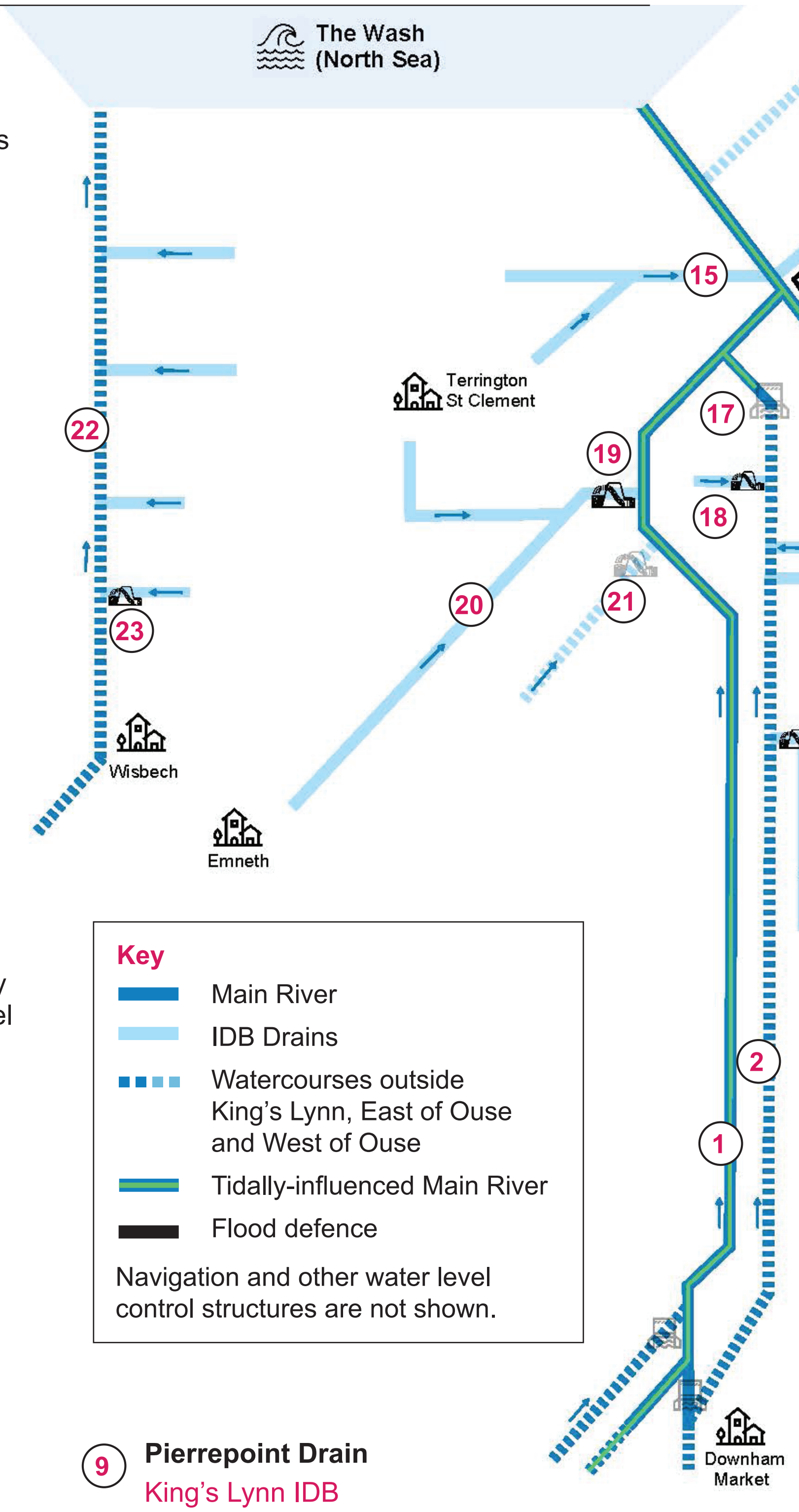
4. **Polver Pumping Station**
   East of Ouse, Polver and Nar IDB
   Pumps water from the Polver Drain into the Great Ouse Relief Channel.

5. **River Nar**
   Main River
   The river is a biological Site of Special Scientific Interest (SSSI). As Main River, the Nar is maintained by the Environment Agency and downstream of Narborough is a high-level carrier.

6. **Mill Fen Pumping Station**
   East of Ouse, Polver and Nar IDB
   Pumps water from the Mill Fen Drain into the River Nar.

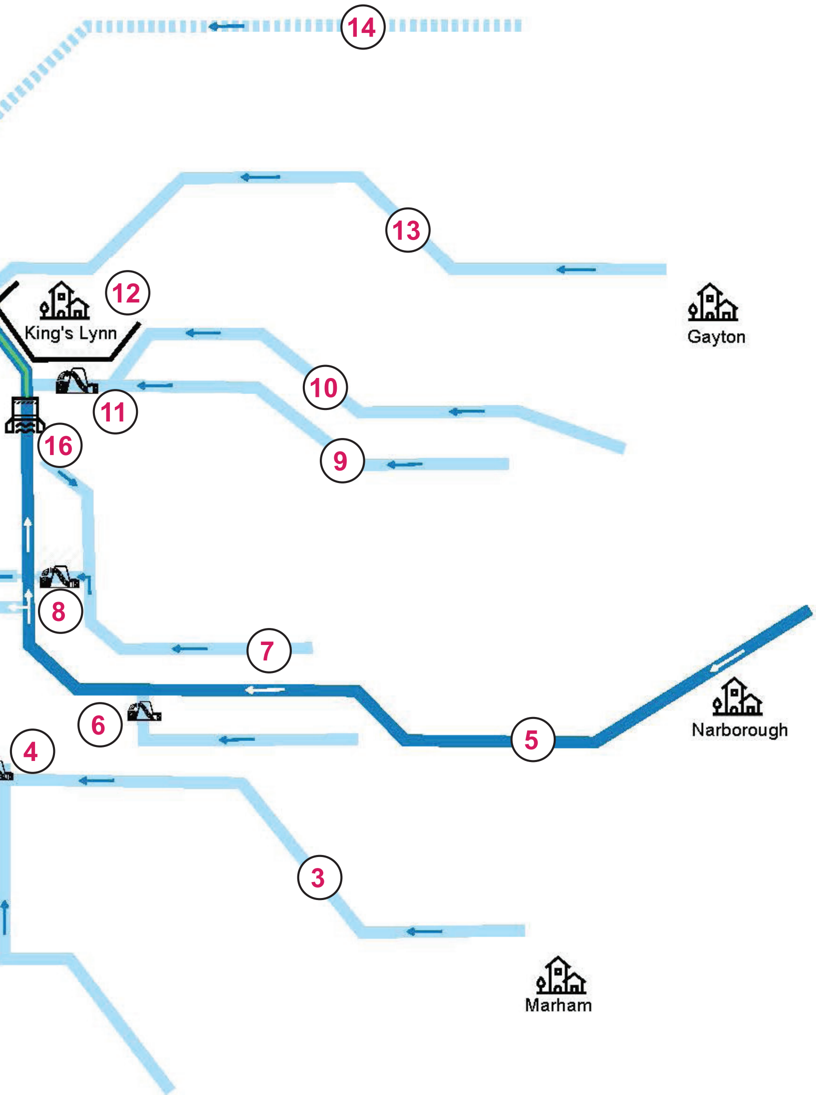
7. **Puny Drain**
   East of Ouse, Polver and Nar IDB
   Carries water in the Nar Valley towards Puny Pumping Station.

8. **Puny Pumping Station**
   East of Ouse, Polver and Nar IDB
   Located on a diversion channel, it can pump water out to the Great Ouse Relief Channel during high flows in the Puny Drain, to protect King's Lynn from additional water. There is a similar diversion channel between the River Nar and the Great Ouse Relief Channel for the same purpose.



9. **Pierrepoint Drain**
   King's Lynn IDB
   Carries water to Pierrepoint Pumping Station.

10. **Middleton Stop Drain**
    King's Lynn IDB
    Carries water to the Pierrepoint Drain.



River Babingley
King's Lynn IDB
Drains the coastal area north of the catchment boundary into the River Great Ouse by gravity.

West Lynn Drain
King's Lynn IDB
Drains the land west of King's Lynn into the River Great Ouse via gravity.

Old Nar Tidal Sluice
Environment Agency
Sets the tidal limit of the River Nar.

Tail Sluice
Environment Agency
Part of the South Level system.

Saddlebow Pumping Station
East of Ouse, Polver and Nar IDB
Pumps out the area between the River Great Ouse and the Great Ouse Relief Channel.

Islington Pumping Station
King's Lynn IDB
Replaced in 2022, this is the largest pumping station owned by King's Lynn IDB. It drains approximately 65km^2 of land south-west of King's Lynn.

Smeeth Lode
King's Lynn IDB
Collects water from a network of smaller channels between Emneth and Terrington St Clement.

St. German's Pumping Station
Middle Level Commissioners
Part of the Middle Level system.

River Nene
Main River
Forms the western boundary of the Great Ouse catchment. The western part of the King's Lynn IDB district discharges into the River Nene.

Ingleborough Pumping Station
King's Lynn IDB
Most of the King's Lynn IDB outfalls into the Nene drain by gravity, but the Ingleborough catchment is pumped. Ingleborough pumping station is King's Lynn IDB's oldest pumping station, commissioned in 1965.

Pierrepoint Pumping Station
King's Lynn IDB
Pumps water out of Pierpoint Drain into the River Nar.

King's Lynn defences
Environment Agency
The 'hard defences' comprise flood walls and 61 sets of flood gates which can be closed to protect King's Lynn from tidal flooding.

Gaywood River
King's Lynn IDB
Flows by gravity into the River Great Ouse.

History of the catchment

The low-lying fen landscape was first formed by the silt-laden rivers of the Quaternary Ice Age, which created ideal conditions for peat formation.

The Fens were settled during the Roman and medieval periods due to the rich resources offered by the extensive wetland. These resources supported the commercial success of local monasteries including Ely and Ramsey, which were located on naturally raised 'islands' above the fen. Landowners and monasteries were responsible for management of drainage, but these divided responsibilities inevitably led to neglect.

In the early Middle Ages, the Great Ouse and River Nene discharged into the sea together at Wisbech. These fenland rivers were choked with silt, causing water to back up and form large lakes or 'meres'. The largest of these was Whittlesey Mere in the south-west of the catchment, which was once the largest lake in England. By the end of the 1400s the Wisbech estuary had silted up and the course of the Great Ouse migrated eastward towards its current outfall at King's Lynn.

Following severe flooding in 1531 Henry VII granted power to the Commissioners of Sewers to enforce maintenance requirements. Despite some agricultural development, the landscape was still covered by extensive estuarine wetland and winding river channels, and further flooding in the late 1590s drove the idea of large-scale drainage projects to replace local efforts.

Francis Russell, the 4th Earl of Bedford agreed a contract with the Commissioners of Sewers in 1630 and, along with the entrepreneurs known as 'Adventurers', undertook the major project of cutting the Old Bedford River.

In 1653, the Dutch engineer Cornelius Vermuyden cut a second parallel channel, known as the New Bedford/Hundred Foot River. The space between the channels became the Ouse Washes, and a sluice was installed near Denver to prevent tidal ingress. Ancillary channels drained water from the land by gravity and for a while agriculture thrived. However, as silt built up in the Great Ouse estuary and the removal of water from the peaty soils further inland caused them to shrink and subside, reliance on gravity to drain the catchment became unfeasible. The system became very expensive to maintain and increasingly prone to flooding.

Vast sums of money had already been spent on drainage, and a tantalising period of highly profitable agriculture encouraged further investment in drainage works. The introduction of wind-powered pump engines in the 1700s was a critical factor in saving the Fens from permanent flooding. However, by the 1800s, they were becoming inadequate for draining the ever-shrinking peat, and they were replaced by more powerful steam-powered pumps.

Despite all these efforts, flooding persisted in the early 1900s, with large events in 1912, 1936, 1937, 1939, 1940 and 1947. There were also concerns about the shoals which were obstructing the tidal Great Ouse between Denver and King's Lynn.

The construction of the first St. German's Pumping Station in the 1930s aided drainage of the Middle Level, but the South Level was still largely waterlogged in the early decades of the 1900s, when demands on domestic food production were increased by World War 1.

A report published in 1940 recommended the construction of the Cut-Off Channel to collect water from the tributaries of the Great Ouse in the South Level, as well as construction of the Great Ouse Relief Channel between Denver and King's Lynn. The cost of the scheme was considered prohibitive, but pressure grew following devastating floods in March 1947. The Great Ouse Flood Protection Act of 1953 enabled the agreement of those with competing interests in drainage and navigation and works finally began in 1953.

Whilst modification of the Great Ouse drainage system had always been undertaken with the aim of mitigating flood risk, the 'Ely Ouse - Essex Water Act' of 1968 enabled the transfer of water from the catchment to existing reservoirs in Essex which were facing a potential water shortage. Additional sluices were built at Denver to enable the diversion of water.

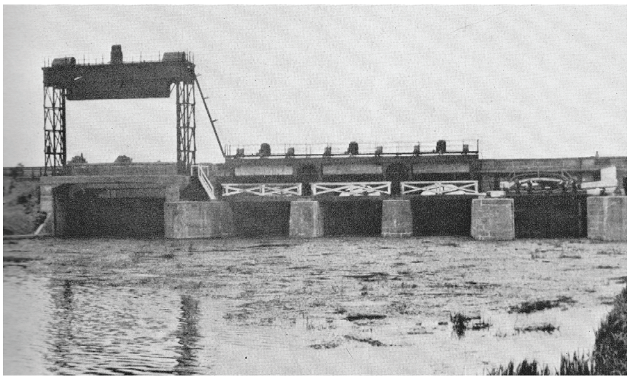
One of the most significant projects of the 2000s has been the construction of the new pumping station at St. German's, prompted by flooding in 1998. The new station has a capacity of 100 cubic metres of water per second and cost £40 million to build.

Today the Great Ouse Fens landscape remains a vast area of low lying highly rich agricultural land, topographically bound by slightly higher ground, forming a basin. The artificial network of drains and water resource channels continues to sustain agriculture. Parts of the land continue to subside due to peat loss, and sea levels continue their rising trend. There are now additional pressures from population growth, and global warming as a result of human activity, further increasing sea levels and intensifying rainfall.

Over the last 450 years, deliberate management decisions have been crucial in responding to landscape changes. Each generation has had to adapt the catchment's drainage system and wider landscape to address new challenges, such as loss of navigation, peat shrinkage, increasing agricultural demands, rising sea levels, and climate change. The installation of the new St. German's Pumping Station was the most recent major intervention, but it will not be the last. Proposals for a new Fens reservoir are in development and represent an opportunity for new system changes to be implemented.

4m

depth of peat loss at Holme Fen since 1851



Denver Sluice - viewed from downstream after 1924 improvement works © Summers "The Great Ouse".

New St. German's Pumping Station and remains of old © Richard Humphrey. Licensed for reuse under the Creative Commons Licence.

History timeline

Pre-1800s

Post-Quarternary Ice Age
Fenland was formed, and the first settlements were established.

Roman Period
Engineering works included canals and roads.

Middle Ages
The fenland was fully settled and commercially active.

1588
Dutch experts examined the fenland near Thorney.

1590s
Severe flooding occurred within the catchment.

1600
An Act for reclamation of the Fens was approved.

1630s
Under the 'Lynn Law', Cornelius Vermuyden was appointed to drain the southern part of the Great Ouse catchment. The Old Bedford River was constructed.

1650
Under the 'Pretended Act', Vermuyden was instructed to make the fenland dry all year round.

1653
The Hundred Foot River was constructed.

1800s

1800s
Pump engines were introduced to the Fens, gradually replacing the windmills which had been used to drain the land previously.

1844
The Middle Level Main Drain was excavated to connect the Middle Level to the River Great Ouse at St. German's.

1848
A timber gauging post was installed at Holme Fen to measure subsidence of the land surface, following the realisation that drainage of the area would cause the peat to shrink.

1862
Breakup of the Bedford Level Corporation.
The Middle Level Commissioners took responsibility for drainage within the Middle Level.

1900s

1934

Pumping station at St. German's was opened.

1936-1940

Continued flooding occurred within the catchment.

1940

Sir Murdoch MacDonald Report of Flood Protection published, which recommended the construction of the Cut-Off Channel and the Great Ouse Flood Relief Channel.

1947

Major flooding occurred within the catchment.

1953

15 people killed in King's Lynn due to breach of flood defences.

Agreement was reached on the Great Ouse Flood Protection Act, which balanced needs for navigation against flood risk reduction.

1954

Work began on the Murdoch MacDonald scheme, which had been put on hold during World War 2.

1968

The Ely Ouse-Essex Water Act was passed, resulting in three new sluices being constructed near Denver.

1970

The Murdoch MacDonald scheme works were finished.

2000s

2011

The new St. German's Pumping Station was completed.

2020

Phase 1 of the Future Fens Flood Risk Management Project completed.

2023

Storm Babet caused severe flooding across Cambridgeshire.

Water Resources East published their regional management plan, covering the period from 2025 to 2050.

2024

Storm Henk caused severe flooding along the Great Ouse, Lower River Cam and in the Ouse Washes flood storage area.

Managing flood risk

Across the Great Ouse catchment, flood risk is managed by multiple organisations.

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

A series of IDBs have permissive powers to manage the complex network of drainage channels and pumping stations which drain the land within their districts. They also regulate water levels on ordinary watercourses (non-Main Rivers). These IDBs are grouped within the catchment into the Middle Level Commissioners, Ely Group of IDBs, Downham Market Group of IDBs, the Whittlesey Consortium of IDBs and the King's Lynn IDB. Alongside their role as a drainage authority, the Middle Level Commissioners are the fourth largest navigation authority in the UK.

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

Different Local, County and District Councils each act as the Lead Local Flood Authority (LLFA) for different parts of the Great Ouse catchment. LLFAs have permissive responsibility for managing surface water and groundwater flood risks within a catchment. Additionally, they have a responsibility to promote sustainable development in their role as the Local Planning Authority.

LLFAs also have responsibilities under the Land Drainage Act (1991) to undertake flood risk management works on ordinary watercourses outside IDB areas.

Water Resource East, Cambridge Water and Anglian Water each share responsibility within the Great Ouse catchment for the management of flood risk posed by public drainage infrastructure.

Legislation

The roles and responsibilities of 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 flood 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 catchment sits across the Anglian Northern and Anglian Great Ouse RFCC boundaries.

The Cambridgeshire and Peterborough Flood and Water Partnership is made up of the Environment Agency, local, district and county councils, IDBs and water companies across Cambridgeshire and Peterborough. This group oversees flood risk management across Cambridgeshire and Peterborough.

The Lincolnshire Flood Risk and Water Management Partnership is comprised of the Environment Agency, Anglian Water, LCC, the district and borough councils and IDBs across Lincolnshire, as well as Lincolnshire Resilience Forum and Natural England.

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 and water management is undertaken within Great Ouse are outlined below.

Anglian Water draft Water Resources Management Plan (2024)

This plan sets out how water resources will be managed to ensure a sustainable and secure supply of clean drinking water for Anglian Water customers from 2025 to 2050.

Regional Water Resources Plan for Eastern England (December 2023)

This plan sets out details for the proposed management of water supplies while outlining the needs of different sectors for water in the region, now and in the future.

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.

Cambridgeshire Flood Risk Management Strategy 2021-2027

This management strategy (approved in 2022) is a revision of the existing Local Flood Risk Management Strategy created in 2015.

Joint Lincolnshire Flood Risk and Drainage Management Strategy 2019 - 2050

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

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)

This plan outlines a strategic approach to managing flood and coastal erosion risks through 2105. It provides guidance for coastal management investments, including the construction and maintenance of sea defences, the implementation of adaptation strategies, and the creation of coastal habitats. Under this plan the management of the coastal area of the River Great Ouse at Ongar Hill is covered under Policy Development Zone 1 (Gibraltar point to Wolferton Creek).

Policy Option 4 of the plan covers management of flood risk in this zone and focuses around sustaining the current level of flood risk protection into the future. It is proposed that in the medium-term this is done by holding defences in their current position. In the medium to longer term it is acknowledged that managed realignment of defences may be required.

The role of critical infrastructure

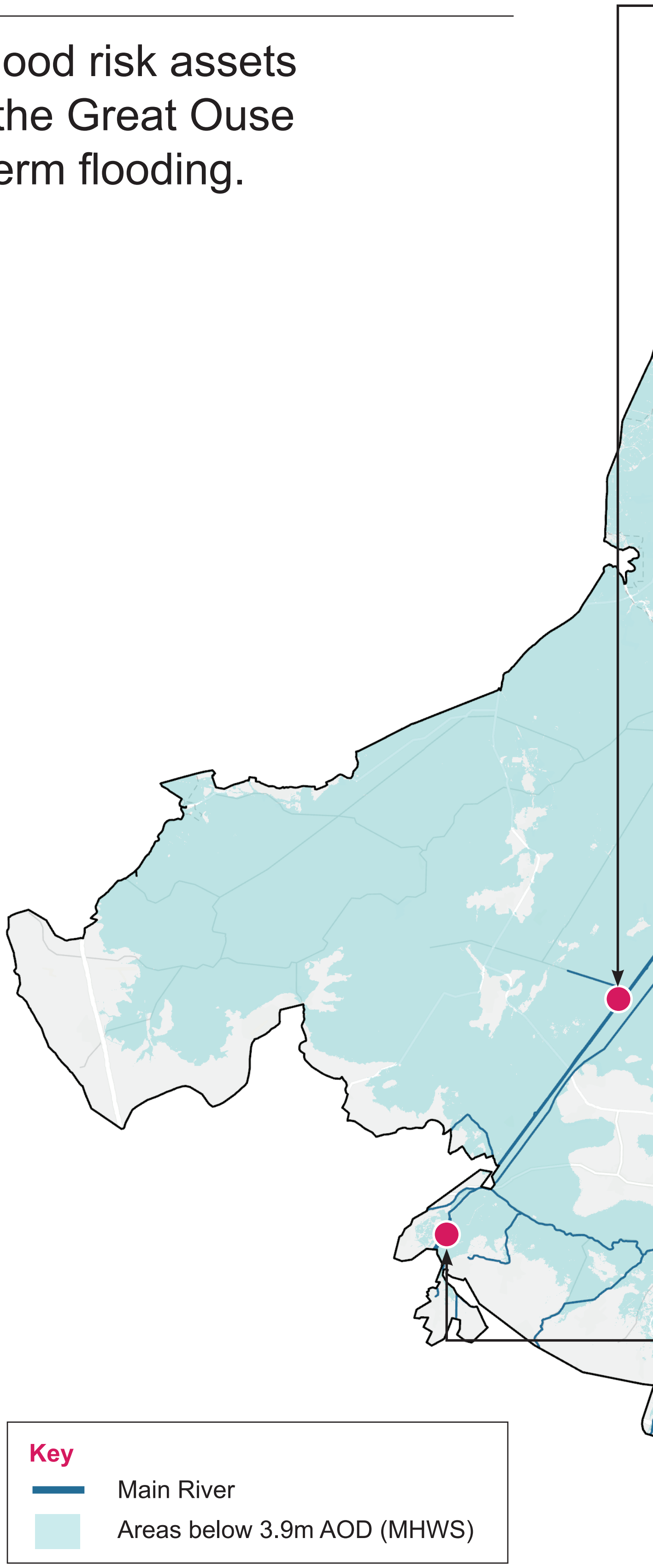
Only the continuous operation of flood risk assets can protect the low-lying areas of the Great Ouse catchment from severe and long-term flooding.

Before human intervention, much of the Great Ouse 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 functions as a bowl-shaped basin, with slightly elevated land located in the north-east and along the southern boundary of the catchment. The lowest point of the Great Ouse catchment would be flooded to a depth of 6.6m 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 allows floodwaters to spread over a large area.



Welches Dam Pumping Station
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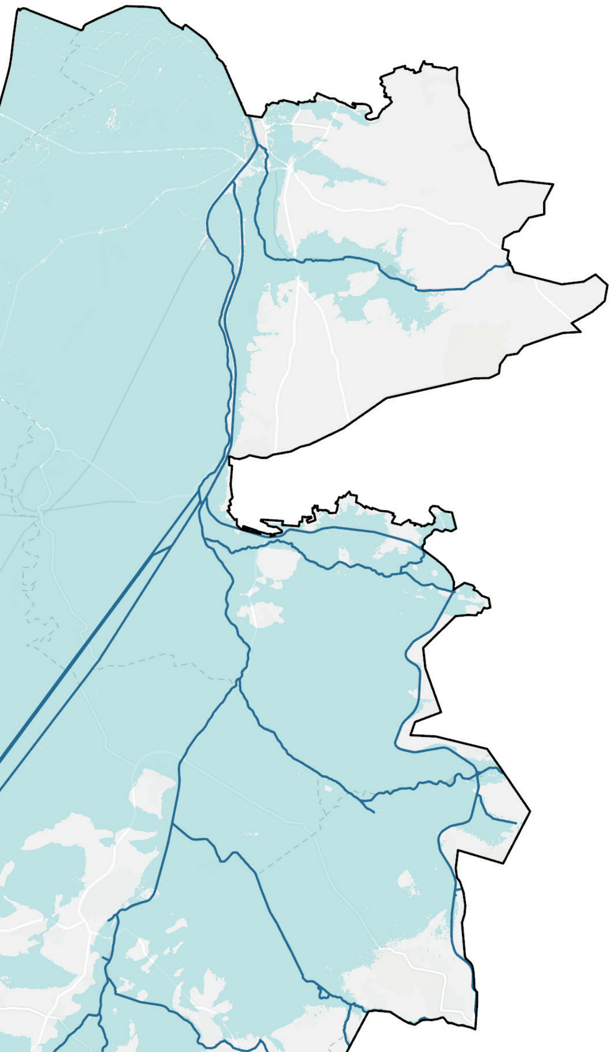

Brownshill Staunch
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Reliance on flood risk assets

The effective movement of water from the land into the Main River system across the catchment is reliant on the operation of pumping stations. Defence of the land against tidal flooding relies on the presence of tidal defences. Water management assets are monitored and adjusted all year round to maintain water levels and prevent permanent inundation. Without these assets, water levels would rise rapidly leading to widespread flooding. The catchment would become uninhabitable within weeks, with agricultural land and properties submerged.

Any deterioration or failure of management assets due to age, lack of maintenance and extreme events would severely compromise drainage and could result in the inundation scenario depicted on the map.

Extreme events

Even with flood management assets in place, tidal and fluvial flooding poses a significant risk to the Great Ouse catchment, as evidenced by historic flood events in 1912, 1936, 1937, 1939, 1940 and 1947. Even current modern flood management assets cannot completely combat extreme events as evidenced by flooding in both Storm Babet in 2023 and Storm Henk in 2024.

The primary sources of flooding have historically been associated with breaches in defence embankments along the Ouse and tidal flooding along the coast. Since the completion of improvement works within the catchment flooding has been more associated with surface water runoff and the swelling of rivers that overtop embankments.

Current flood risk

The impact 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 model used to assess flood risk are the 2018 Tidal Wash Model representing tidal events, and three combined fluvial models. The models include existing flood defences at the time of model production and assumes that all assets are fully functional and maintained at their current Standard of Service. 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

Currently, tidal flood risk with defences in place for a 0.5% AEP event would impact approximately 14.6km^2 (1460ha). Of this, 8.6km^2 (860ha) is projected to reach flood depths of 0.3m. The majority of the flooding is to Grade 4 agricultural land in the Ouse Washes. No properties are predicted to flood during this event.

Fluvial

Current fluvial flood risk is low, largely due to the network of flood defences throughout the catchment. With the existing river defences, only 41.1km^2 (4,106ha) of the catchment is at risk of fluvial (river) flooding during a 1% AEP event. This includes 11km^2 (1,100ha) of Grade 1 and 2 agricultural land. Under a more extreme 0.1% AEP event, flooding is expected to cover 4.1% of the catchment area.

The Ouse Washes (classified as Grade 4 agricultural land) make up the majority of land at risk from present-day fluvial flooding.

The Washes were designed to store this flood water periodically, and flooding outside the Washes tends to be localised and affect only small numbers of properties.

The flood history also suggests fluvial flood risk in the Great Ouse catchment is relatively low following the construction of the Relief Channel and Cut-Off Channel in the 1950s and 1960s. Flooding since has been on a much smaller scale, caused by surface water runoff and high river flows.

Other sources

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

Surface water flooding. This occurs when the volume and intensity of rainfall overwhelms local drainage systems. The Environment Agency's 'Risk of Flooding from Surface Water' dataset indicates that large areas of surface water flooding around March, Ely, Wisbech and King's Lynn.

Groundwater flood risk. This occurs when the water table rises to meet the ground surface. However, the Strategic Flood Risk Assessment (SFRA) for Borough Council of King's Lynn and West Norfolk records no incidents of groundwater flooding.

Reservoir flooding. This is rare and happens when a reservoir's impounding structure fails. The 'Risk of Flooding from Reservoirs' dataset shows that there is a risk of flooding from the Ouse Washes. However, these flood mitigation areas are designed to be empty until needed. Additionally, the provisions of the Reservoirs Act (1975) mean that the likelihood of a severe breach occurring is low.

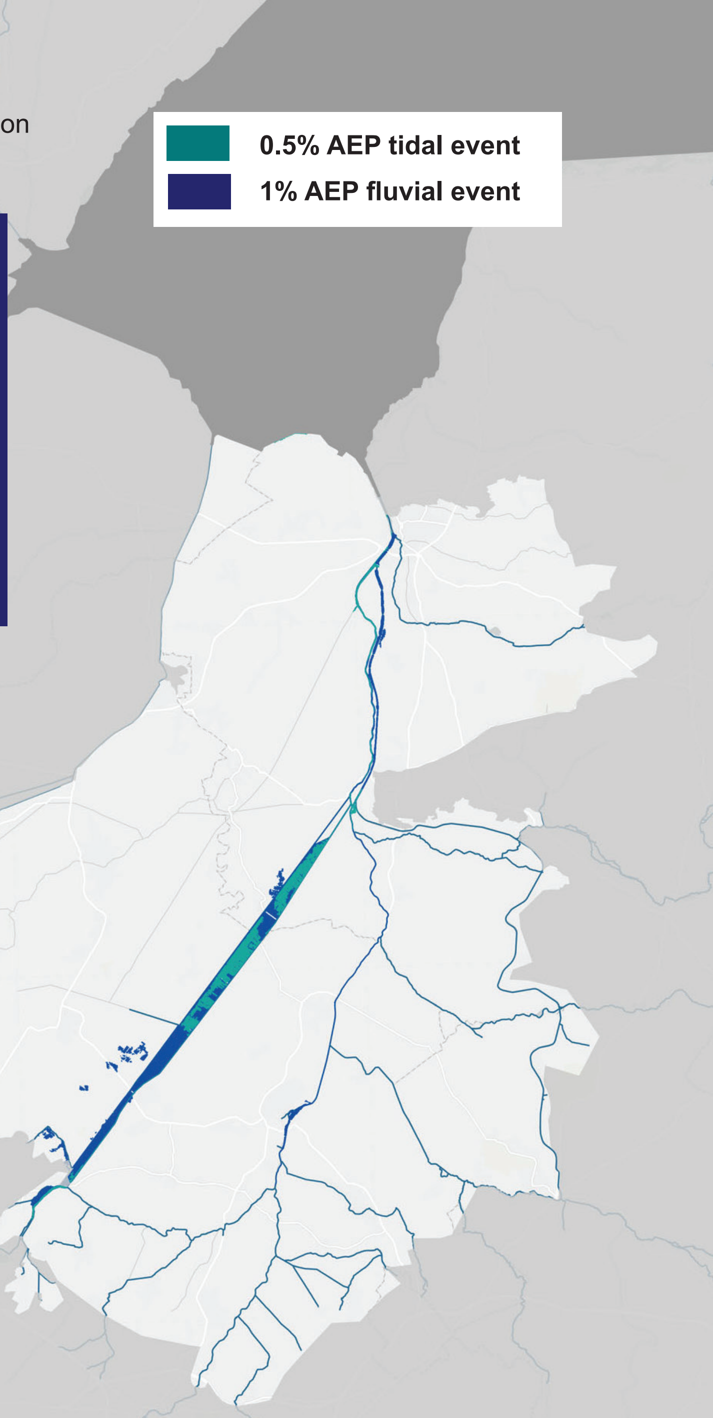
Area calculated based on the model flooded area in comparison to the area represented within catchment boundary.

14.6km²

(1,456ha) of the catchment is at risk of flooding in a present-day 0.5% AEP tidal event including existing flood defences. This includes 0.6km² (60ha) of Grade 1 agricultural land.

41.1km²

(4,106ha) of the catchment is at risk of flooding in a present-day 1% AEP fluvial event. This includes 11km² (1,100 ha) of Grade 1 and 2 agricultural land.



Case study: Embankment breach

The modelling results presented do not fully reflect the flood risk facing the catchment. In particular, they 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 and repairing them is often time consuming and costly.

A significant breach occurred in the Great Ouse catchment on 5th December 2013. A combination of high tide, a North-Westerly gale and low-pressure weather system led to a storm surge all along the Norfolk coast. The River Ouse burst its banks flooding South Quay and Purfleet Quay in King's Lynn.

Details of further flood events and flood risk within the catchment is detailed in the accompanying flood risk appendix.

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

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 to rise due to the increasing height and frequency of tidal surges and river flows driven by climate change. These changes pose a growing threat to agricultural land and residential properties, with the potential for more frequent and severe overtopping events and failure of defences.

Tidal

It is expected that tidal flood risk will increase significantly over the next 100 years as sea levels rise in response to climate change. The 2018 Tidal Wash Model assumes that sea level will rise by 1.1m up to 2115. Since the modelling was undertaken in 2018, sea level rise estimates have been revised upwards, and under the UK government's higher central and upper end allowance, sea level could rise by between 1.2m and 1.6m by 2125, meaning that potential residual flood risk could be even greater in the future than models currently predict.

Under this scenario, tidal flood risk increases compared to present-day conditions, even with existing defences in place. Approximately 31.3km^2 (3130ha) of the catchment is at risk of inundation. The majority of this flooding affects agricultural land within the Ouse Washes, including 25.2km^2 (2,520ha) that can be damaged by extended periods of saltwater inundation.

Residential areas in King's Lynn are also predicted to flood due to the overtopping of current flood defences within King's Lynn.

There is a risk that higher sea levels will increase tide-locking at key outfalls such as Tail Sluice and Denver 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, potentially exacerbating fluvial flooding.

Fluvial

Results from the three fluvial models combined predict an increase in fluvial flooding when climate change is applied to the 1% AEP event, even with current flood defences still in place. This scenario assumes a 20% increase in river flows leading to 14.2km^2 (1,420ha) of Grade 1 and 2 agricultural land in the catchment being inundated. A total area of 45.3km^2 (4,529ha) is expected to be inundated, accounting for 2.1% of the total catchment area.

Similar to the tidal model, climate change estimates for change in river flow have been updated since this modelling was undertaken. The higher and upper climate change allowances in areas of the Great Ouse predict increases in peak river flow, ranging from 33% to 57%. This means that the residual future flood risk could be much higher.

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.

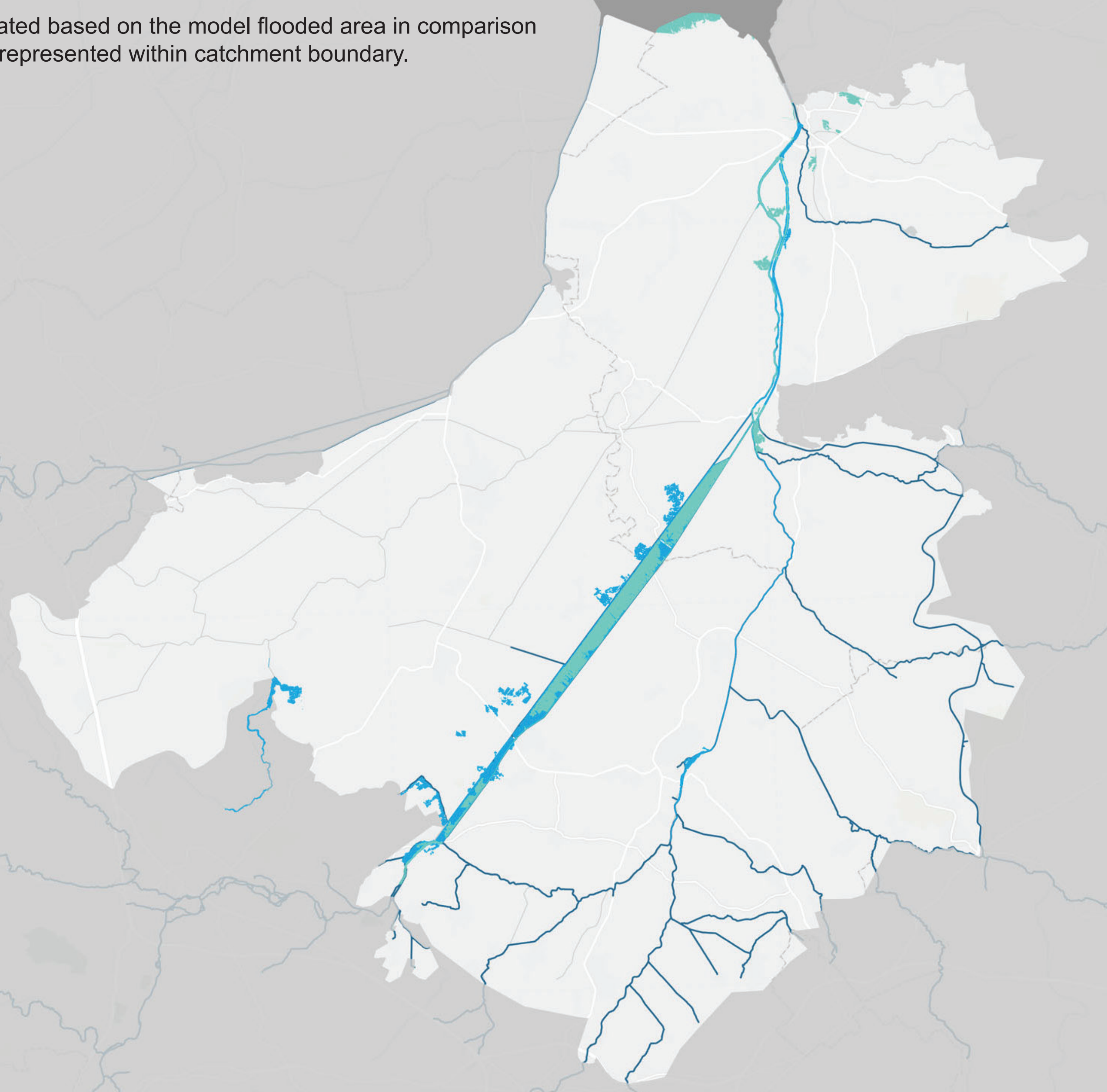
31.3km²

(3,130ha) 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 1.24km² (124ha) of Grade 1 agricultural land.

45.3km²

(4,529ha) of the catchment is at risk of flooding under the 1% AEP fluvial event with climate change allowance. This includes 14.2km² (1,420ha) of Grade 1 and 2 agricultural land.

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



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

1% AEP fluvial event + climate change (57% 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

Within the Great Ouse catchment, 67% of assets have a foreseeable design life of 16-30 years, and 20% have a foreseeable design life of less than 15 years. Therefore, waves of upcoming investment need can be expected.

Pumping station challenges

IDBs have concerns around the condition of the pump houses and supporting structures at several key pumping stations. Replacement parts for pumping station and pump repairs are often bespoke, making them time-consuming and costly to replace.

Flood storage challenges

Woodwalton Fen flood storage area is used to manage excess water in one of the UK's lowest-lying areas. As a designated SSSI and Ramsar site, its use is restricted, and the lease expires in 2052. Identifying an alternative site is challenging due to the surrounding low-lying peatland, which continues to subside. Increasing storage here would be an opportunity for better water management in the catchment.

Impact of changing land use

The impact of urbanisation and changing land use from agricultural land to urban has increased the runoff rate in the catchment. This alongside increased rainfall means that pumping station capacity can be stretched through too much water arriving simultaneously.

Investment needs

A significant number of control gates, 12%, have an 'Unknown' or 'Poor' condition score, representing a threat and immediate investment need. Additionally, a further 12% of embankments are in 'Poor' condition, which amounts to a large number of embankment assets requiring urgent investment.

Key asset vulnerability

Bevills Leam Pumping Station is responsible for removing water from the lowest lying areas of the country. It is ageing, frequently running at capacity, and has ongoing performance issues. As the land around it lowers further, greater pressure will be placed on the asset.

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, however this is not exhaustive.

Asset age profile

Approximately 70% of the assets within the catchment are of unknown age, and a large proportion of the remainder were constructed relatively recently, since 2000, with an age of less than 25 years.

The majority of assets in the catchment have a foreseeable design life of 16-30 years. This indicates that in the medium to long term, many assets in the catchment may reach end of life at the same time, requiring a burst of large investments in a short period.

Asset condition profile

Approximately 31% of active assets have a current condition score of 'Poor' or 'Very Poor' or 'Unknown' in AIMS. Despite their age, 76% of the 282 embankment assets recorded in AIMS are in 'Fair' or 'Good' condition. However, embankments still represent a vulnerability as 29 individual embankment assets are recorded as being 'Below Required Condition'. Embankments in the catchment have suffered slips during recent flood events. Of the other key asset types, outfalls have the highest proportion (17%) recorded as 'Below Required Condition'.

Operating challenges and key assets in the South Level

The Ely Group of IDBs are the consortium which cover many of the IDBs in the South Level. Many of the pumping stations across the South Level system were built around the same time, 50-60 years ago, and have now reached the end of their design life. Generally, pumping stations have enough capacity to manage normal conditions but run close to or at capacity during intense rainfall. Because many of the pumps in the South Level are relatively old and varied in their design, sourcing new parts can be a problem. If a pump fails, the manufacture of bespoke parts can extend pump downtime. This extends the period of vulnerability of the pumping station and the wider system.

Oxlode Pumping Station has experienced several problems with its pumps. It receives water from a large catchment, including urban areas of Ely, and can be inundated during intense rainfall events. Increased runoff due to further expansion of urban areas within its catchment is also a concern.

The Diversion Sluices at Hockwold are owned and operated by the Environment Agency. One of the sluices at the site is designed to block the Little Ouse River to prevent too much water reaching Denver during floods. This function has never been used, although the asset is maintained in an operable condition. There is some leakage of water through the sluice which can be a problem during drier periods.

Denver Sluice is a hugely influential asset, setting the water level across much of the catchment. A challenge for the Environment Agency at this site is balancing the water levels for flood risk against levels required for navigation and environmental quality.

Brownshill Staunch is owned and operated by the Environment Agency and lies downstream of St Ives Sluice. There are concerns about the condition of the three sluice gates which form the structure. There are also reliability issues with the mechanism used to open and close the gates, making managing water levels in this area difficult.

Bevills Leam Pumping Station © Richard Humphrey. Licensed for reuse under the Creative Commons Licence.

Woodwalton Fen flood storage area © Hugh Venables. Licensed for reuse under the Creative Commons Licence.

Welches Dam Pumping Station © Richard Humphrey. Licensed for reuse under the Creative Commons Licence.

St. German's Pumping Station © Fascinating Fens.

Operating challenges and key assets in the Middle Level

Pumping stations owned by the Middle Level Commissioners range in ages from the 1940s to the 2010s. In general, their pumping stations are considered to be in reasonable condition, able to deal with normal flows.

Bevills Leam Pumping Station drains the lowest area of the Middle Level. It has 6 pumps and runs at full capacity during storm events. During the winter storms of 2023-2025, all pumps ran continuously for a week to cope with the high volume of water. There are concerns that as the peat soils in the area contract and cause land levels to fall even lower, greater pressure will be placed on this asset to remove water from its catchment.

Woodwalton Fen flood storage area is a designated reservoir which is currently used to store water during extreme events. When flows exceed the capacity of Bevills Leam Pumping Station, the Control Sluice is used to direct water into the Fens. However, Woodwalton Fen is a Ramsar Site and SSSI, and therefore it is not desirable to store polluted storm water run-off within the Fens. Middle Level Commissionsers only deploy this function as a last resort.

Welches Dam Pumping Station is owned and operated by the Environment Agency. It has four pumps, but only three are currently used due to concerns about the reliability of the supply of electricity to the station.

St. German's Pumping Station is a relatively new station which came online in April 2010. It is in good condition but will be due its 20-year refurbishment in 2030. It is the largest pumping station in Britain, capable of pumping up to 100 cubic meters of water per second, able to drain an Olympic sized swimming pool in 25 seconds. It provides flood protection for 700km^2 (70,000ha) of high-grade agricultural land, 24,000 private properties and 1,100 commercial properties.

Operating challenges and key assets in the Tidal system (King's Lynn, West of Ouse and East of Ouse)

Puny Pumping Station, built in 2011, is owned by East of Ouse, Polver and Nar IDB. It is located on the diversion channel and protects King's Lynn by pumping water out to the Great Ouse Relief Channel during high flows in the Puny Drain.

Islington Pumping Station is the largest pumping station owned by King's Lynn IDB, with a capacity of 16 cubic meters of water per second. It drains an area of approximately 65km^2 (6,500ha) of land south-west of King's Lynn. It was constructed in 2022, to replace the previous pumping station built in 1959, and incorporates fish-friendly pumps to reduce the impact on aquatic life.

King's Lynn Tidal Defences include 61 flood gates, barriers and flood walls in the town. These are operated by the local Environment Agency teams on high tides to protect King's Lynn from tidal flooding.

Current asset maintenance

Based on analysis of Environment Agency revenue programme dataset:

£2.4M was spent on embankment maintenance between 2022 and 2024, making up 45% of total maintenance expenditure in the region.

£2.1M was spent on open channel maintenance within the catchment between 2022 and 2024, making up 41% of total maintenance expenditure.

IDB maintenance expenditure

Across the IDBs, maintenance expenditure on drains is generally greater than on Water Level Control Structures (WLCS). King's Lynn IDB had the greatest expenditure out of any individual IDB between 2017/18 and 2021/22. Anecdotally, the Ely Group of IDBs shared that their maintenance on pumping stations is usually 90% reactive, and 10% planned, and the opposite is true of open channel works.

Middle Level Commissioners carry out regular maintenance on pumping stations on a three-monthly basis. This has proved valuable in managing issues, making up most of the work they do. Bevills Leam is inspected once a week due to its vulnerability and importance.

Maintenance expenditure across the IDBs has been consistent between financial years 2017-2022, £1.92 million for the Ely Group of IDBs, £1.39 million for the Middle Level Commissioners, £1.12 million for the Downham Market Group, £0.72 million for the King's Lynn IDB, £0.25 million for the Whittlesey Consortium of IDBs and £0.63 million for the Ramsey IDB.

Overall, significant capital and maintenance investment in assets is needed across the catchment in the coming years. This will be to maintain the current protection offered, as well as ensuring future resilience to climate change.

Across all RMAs, substantial investment in capital and maintenance will be required to ensure all assets are in 'Fair' condition or better, as well as enabling new construction schemes to improve the area's resilience. Funding requirements will increase as climate hazards place greater strain on asset systems.

Further details of flood risk management assets are contained in the accompanying assets appendix.

Denver Sluice © Mike Todd. Licensed for reuse under the Creative Commons Licence.

Environment

Mapping shows environmental features. This includes designated conservation sites concentrated to the south of the catchment.

The area of the catchment with the lowest life expectancy for both males and females is North Lynn, where males are expected to live for just 72.2 years.

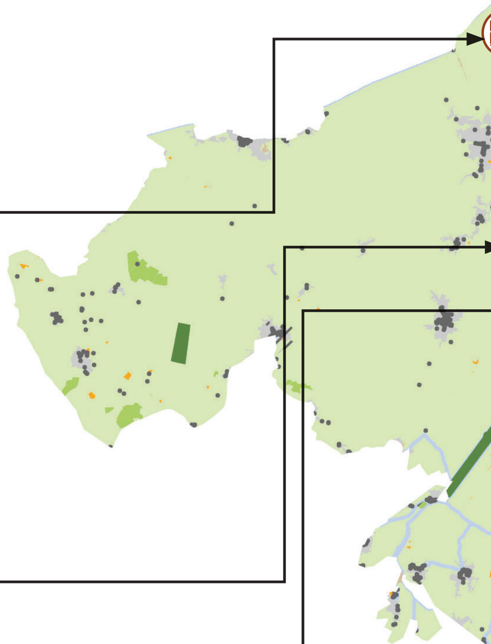
The life expectancy of females in North Lynn is almost 20 years lower than for their counterparts in the more affluent area of Warboys and Bury in the south-west of the catchment.

There is a large disparity in deprivation levels.

There are ten neighbourhoods in the north of the catchment which fall within the 10% most deprived in the country (considering domains such as income, employment, education, health, crime, barriers to housing and services, and living environment). Neighbourhoods towards Ely and South Cambridgeshire are in the least deprived 10% nationally.

There are six Air Quality Management Areas (AQMAs) in the catchment, located in King's Lynn, Wisbech, and Whittlesey.

These have been designated due to specific pollution concerns relating to industrial activity or road vehicles.



"Roddons" (raised paleochannels) have been well documented in the western catchment, but are likely to exist across a larger area.

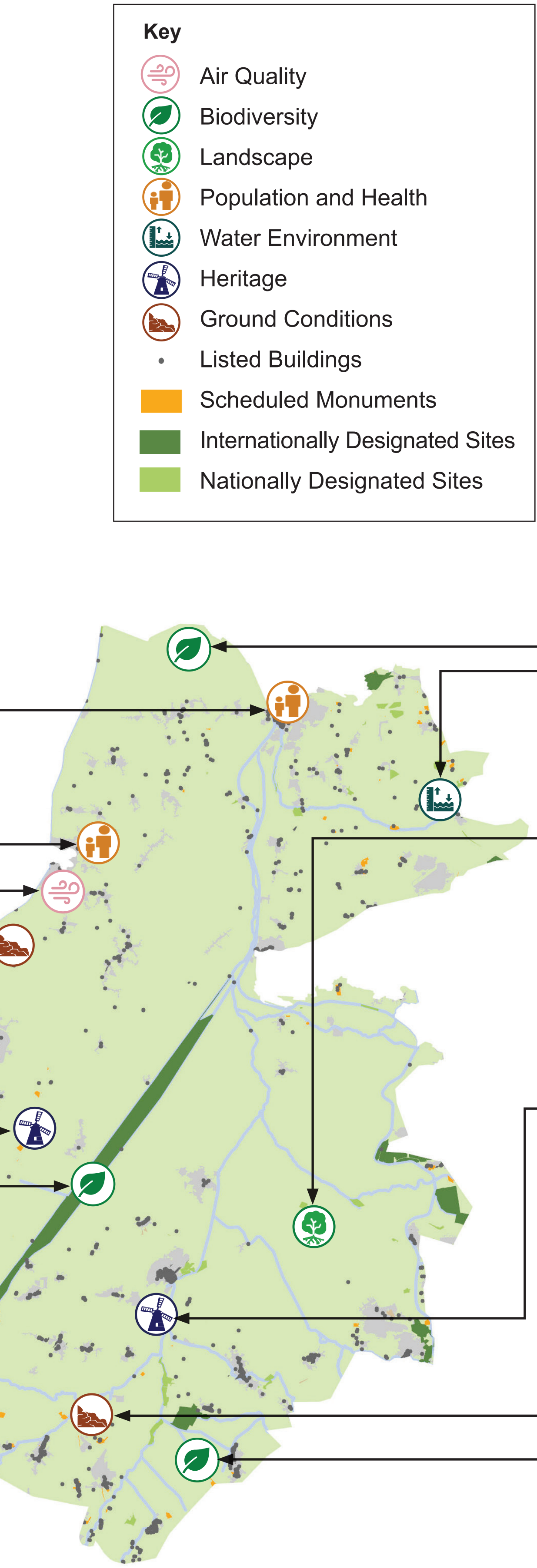
Palaeochannels are former river channels, typically filled with silt, which now sit proud of the land due to shrinkage of the surrounding peat soils. Due to their composition, they may impact structures and assets through differential settlement, compaction and peat wastage.

Iron Age and Roman evidence is found across the catchment.

There is evidence of Roman settlements and villas around areas of higher ground in the south and east. For example, the Fen Causeway, which covers 39km from March to Eldernell, and Stonea Camp, which is Britain's lowest-lying Iron Age 'hillfort'.

The Ouse Washes, the UK's largest washland, is designated as a Special Protection Area, Ramsar site and SSSI.

It contains internationally important water-dependent habitats and provides a flood storage area taking high flows from the River Great Ouse via the Hundred Foot Drain and Old Bedford River.



The Wash is designated as a Special Protection Area, Ramsar site, SSSI and a National Nature Reserve.

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

The catchment is fed on its western side by several East Anglian chalk streams including the River Nar and the Gaywood River.

These chalk streams are an internationally rare habitat and support a rich and diverse ecosystem. The Gaywood River is the only Water Environment Regulations / Water Framework Directive waterbody in the catchment that has achieved 'good' ecological status.

The majority of the catchment is located 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 level horizons and the huge scale of the landscape create a strong sense of isolation and tranquillity, and a distinctive sense of place.

There are over 2,300 designated heritage assets within the catchment, including 130 Scheduled Monuments and 60 Conservation Areas.

There are likely to be further non-designated archaeological remains across the catchment, particularly in peat soils which can preserve organic materials.

Peaty soils cover 29.3% of the catchment area.

They are deepest in the Ouse Washes, the south-west of Middle Level, and across much of the South Level.

There are 81 statutory designated nature conservation sites within the catchment, some overlap entirely or partially with other designations.

Wicken Fen is one of Europe's most important wetlands and one of the best examples of East Anglian peat fen. It supports over 9,000 species, including bitterns, Emperor dragonfly, and rare orchids.

Agriculture

The East Anglian Fens are known as the 'Breadbasket of Britain'. The agricultural sector is critical to the local economy.

Soilscape

The north-eastern catchment contains loamy and clayey soils with naturally high groundwater supporting different cropping regimes. It is estimated that the central and southern catchment contains almost a quarter of England's lowland peat. The condition of the peat is varied, with large swathes likely degraded.

Agricultural Land Classification

Approximately 72% of land in the Great Ouse catchment is classified as Grade 1 and 2. Grade 1 land is predominately located in the centre of the catchment. This is high-yielding land with little or no limitations for agricultural use.

Water availability

The catchment is included within several water abstraction licensing strategy catchments including 'the Cam and Ely Ouse', 'the Old Bedford including Middle Level', 'the North-West Norfolk' and 'the Nene' abstraction licensing strategy (ALS). Notably:

- The Cam and Ely Ouse suffers from over-abstraction of water.
- In North-West Norfolk, water is only available during higher flows. These are flows equalled or exceeded for at least 30% of the time.
- In Old Bedford and the Middle Level, abstraction is likely to only be licensed during winter.

Value of agriculture in the catchment.

The catchment contains a number of settlements such as March, Downham Market, Ely and King's Lynn in addition to large swathes of agricultural land. Farming businesses cover all sectors of agriculture and horticulture, including arable, livestock, poultry and dairy farming. Horticultural holdings cover a small area but are estimated to contribute the largest economic output.

The whole agri-food chain employs people at different stages of food production, from agriculture to food processing, packing and retail. The estimated overall economic output of farm crop and livestock within the catchment is in the region of £520.8 million annually (in 2023 values).

	Area (km^2)	Area (ha)	Percentage of farmed land (%)	Estimated annual value* (£)
Cereals	840.1	84010	49%	£120.8 million
Arable crops (excluding cereals)	417.1	41710	24.3%	£97.3 million
Grassland	224	22400	13%	Grassland does not directly create economic value but instead supports the grazing of sheep and cattle, or the production of livestock feed.
Fruit and vegetables	65.3	6530	3.8%	£124.8 million

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

Environmental stewardship

Much of the land in the Great Ouse catchment is managed under government funded agreements such as the recently introduced Countryside Stewardship scheme (part of Defra Environmental Land Management schemes), or the historic Entry Level Stewardship scheme. The north-western catchment has notably fewer land parcels covered by agreements, mainly due to the higher value cropping in this area.

Climate change

Climate change will increase the risks of fluvial and coastal flooding, as well as drought. Flooding and drought events can restrict the ability to establish new crops, reduce crop yields and quality, or destroy crops once ready for harvest leading to direct agricultural damages and wider economic consequences for landowners.

Examples of agricultural stakeholders and businesses

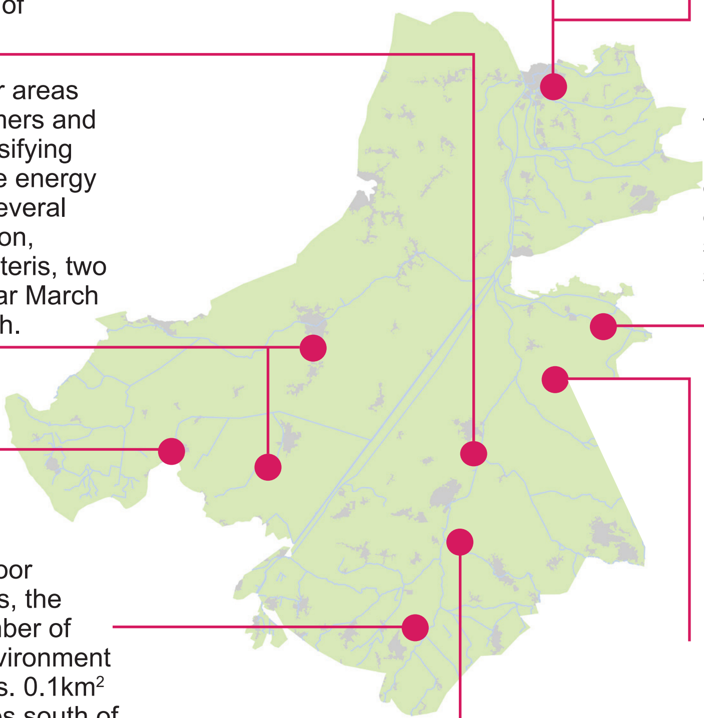
The second largest mushroom producer in the UK is located in Littleport, producing around 8,000 tonnes of mushrooms per year.

One of the world's largest food production corporations has a factory in King's Lynn which employs around 150 people.

Specialist agrichemicals for high value crops are manufactured and distributed by businesses in King's Lynn and Wisbech.

In common with other areas across the Fens, farmers and landowners are diversifying to invest in renewable energy projects. There are several solar parks in operation, including one at Chatteris, two at Whittlesey, two near March and two near Wisbech.

There are a number of large food and drink supply chain businesses within the catchment such as a large sugar processing plant which supplies food and beverage markets around the world.



Trials of wet farming methods to preserve peat, known as 'paludiculture', at Great Fen.

A farming business, based within the Great Ouse catchment and headquartered around Southery, farms 84km^2 (8,400ha) of potatoes, onions, sugar beet, wheat, spring barley, oilseed rape, peas and beans.

As well as large outdoor agricultural operations, the catchment has a number of leading controlled environment agriculture companies. 0.1km^2 (10ha) of greenhouses south of Ely produce around 10% of the UK's cucumber and tomato crops.

Nine of the seventeen producer-members of the largest fresh produce company in the UK are based within the Great Ouse catchment. In the UK, the group farms 175km^2 (17,500ha) of outdoor crops annually.

The 40MW Ely power station is the UK's first straw-fired power station, using around 200,000 tonnes of agricultural straw per annum.

There are a number of agricultural machinery manufacturing and supply businesses. The UK's largest potato equipment manufacturer is based in Ely.

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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 other ecosystem services. For example, in the case of water and nutrient cycling, and soil formation.

Together these services provide a wealth of benefits to society and the economy including improved physical and mental health through recreation, temperature regulation, flood protection, and provision of clean water. Ecosystems are fundamental to all economic activities.

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. These services cannot be given a financial value, but are nevertheless vitally important for underpinning our society and the natural world.

Natural capital in the Great Ouse catchment has an annual value of

£268.1 million

Climate regulation

In some cases, the poor condition of the environment can compromise the benefits that it would otherwise provide. For example, peaty soils in healthy condition can continue to form peat and therefore sequester carbon, but when degraded they start to release carbon back to the atmosphere.

Enclosed farmland, heaths, woodland and saltmarsh within the catchment sequesters a total of 64,573 tonnes of CO_2 equivalent per year. However, this is dwarfed by over 1 million tonnes of CO_2 emitted by the degraded peatland in the catchment, making the land a net source of carbon.

The negative effects of the 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

£292.5 million

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

£22.9 million
Recreation

The welfare value of approximately 14.8 million visits by adults each year to publicly accessible green spaces within the catchment. The welfare value of a further 3.8 million visits made by children each year cannot be quantified but is likely to be significant.

£14.3 million
Physical health

£14.3 million in healthcare treatment costs can be avoided every year due to improved physical health through approximately 7.6 million active visits to publicly accessible green spaces in the catchment. Active visits involve at least 30 minutes of exercise.

£188.7 million
Agriculture

The 1,915.1km^2 (191,512ha) 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 £188.7 million.

£3.3 million
Air quality

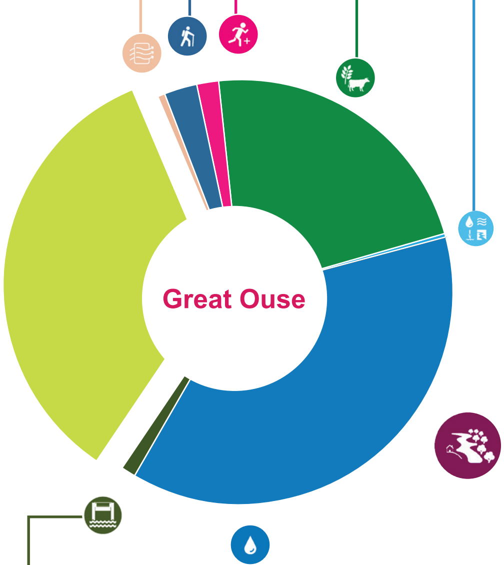
The removal of approximately 11,400 tonnes of air pollutants by vegetation in the catchment avoids the costs of damages to health. This has an annual value of £3.27 million per year.

£1.9 million
Water quality

Only 7 of the 76 river waterbodies within the catchment have ‘Good’ water quality. Based on a willingness-to-pay approach, the 8.2km of this watercourse within the catchment is worth approximately £1.9 million, as an alternative to having poorer water quality.

£-292.5 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, more than 1 million tonnes of CO_2 equivalent are released overall, costing around £292.5 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 1.08 million m^3 of floodwater is temporarily stored in areas of woodland.

£8.4 million
Renewable energy

An estimated 603,000MWh of renewable energy is generated each year within the catchment, predominantly from wind and solar. This has an annual value of approximately £8.4 million.

£321.1 million
Water supply

The annual value of approximately 75.5 million m^3 of water which is abstracted from the catchment each year, for public water supply and other uses such as irrigation.

£1.0 million
Timber

National data can be applied to the Great Ouse catchment to estimate a yearly timber production volume of 28,356m^3, which is valued at approximately £956,000 per year.

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. All flood defences would continue to provide the same level of service that they currently offer. In this scenario 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 pumping rates applied to 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. Flood risk in this scenario is represented with the modelling results from the nationally available Risk of Flooding from Rivers and Sea (RoFRS) dataset.

£20.1 billion

the economic benefits of current flood risk management activities

Do Nothing

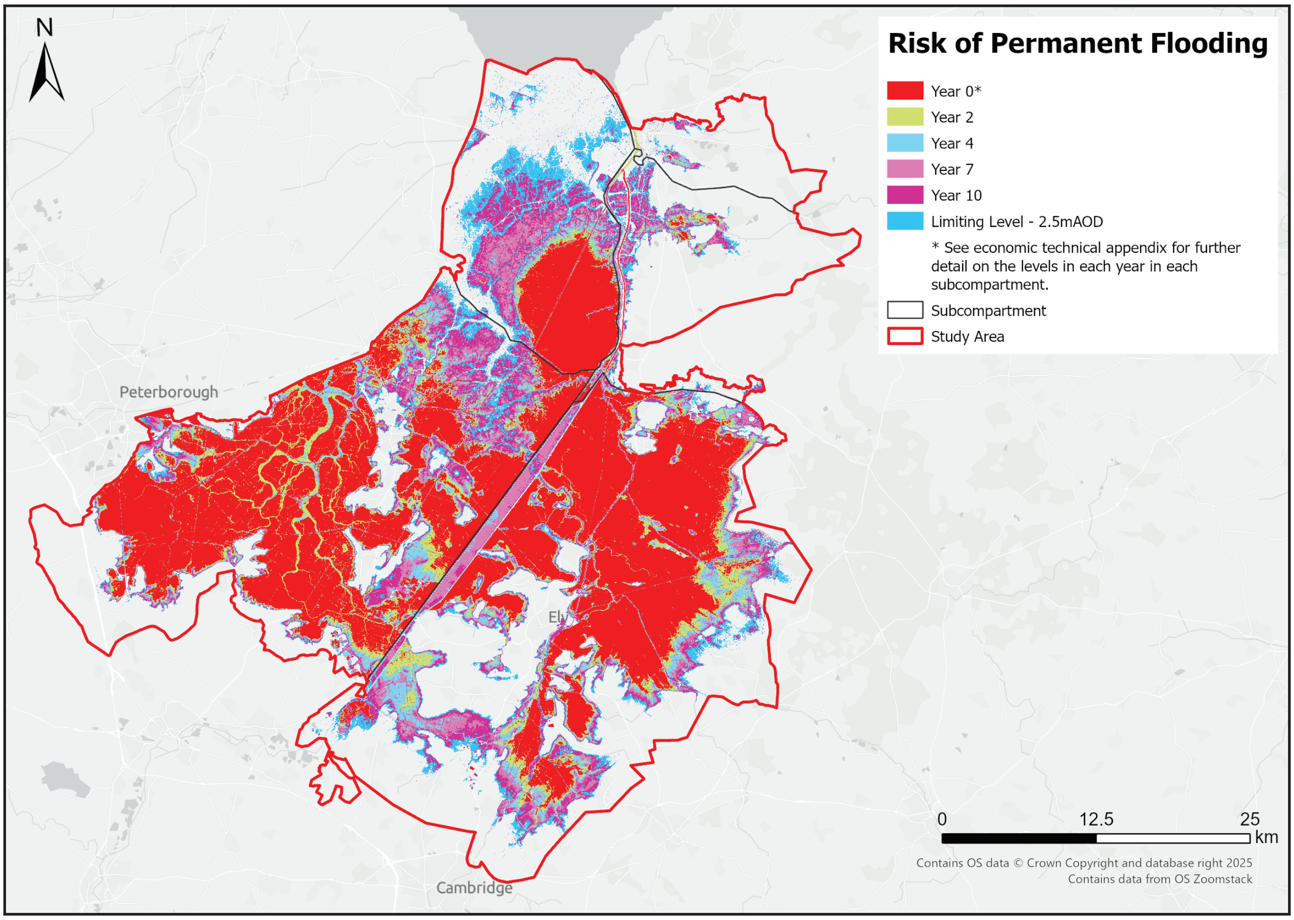
The 'Do Nothing' scenario is a hypothetical scenario, used to understand the benefits of investment in flood defences by considering the consequences of investment being withdrawn. In this scenario, all flood risk management activities would stop, including maintenance of existing flood defences and pumping. Sluices on the Main Rivers would no longer operate, increasing the risk as water levels are no longer managed upstream and downstream of the sluice. Without pumped outfalls to the Main Rivers and The Wash, water would be unable to drain from the land.

For the purposes of the economic scenario, the catchment is assumed to act as a basin, which fills water to the 'limiting level' (the maximum level that the catchment would be able to fill with water). Whilst there would be some loss of water over summer due to evaporation and transpiration, the water levels in the catchment would be expected to rise steadily over a few years, filling the catchment. To represent this, it is assumed that the basin would fill by 0.5m per year to a limiting level of 2.5m AOD. The resulting damages are used to determine the economic losses over the next 100 years, if all flood risk management activities ceased.

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 £20.7 billion of economic damages in a ‘Do Nothing’ scenario (excluding losses to the local economy), compared to only £558.8 million of economic damages in a ‘Maintain’ scenario. As such, the economic benefits of current flood risk management activities are valued at just over £20.1 billion.



Do Nothing permanent flood extents for the Great Ouse catchment (updated from the 2020 Great Ouse report).

Economics 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 £20 billion, with nearly £18 billion of this in the first ten years.

£9.6 billion

Properties

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

17,149 residential properties written off in the 'Do Nothing' scenario, costing **£5.9 billion**	**19,746** non-residential properties written off in the 'Do Nothing' scenario, costing **£3.7 billion**

£42.3 million

Environment and recreation

Loss 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.

The key nature reserve sites include the Great Fen, Wicken Fen, Lakenheath and Ouse Washes. Recreational damage would arise through loss of recreational sites and Public Rights of Way.

£4.1 billion

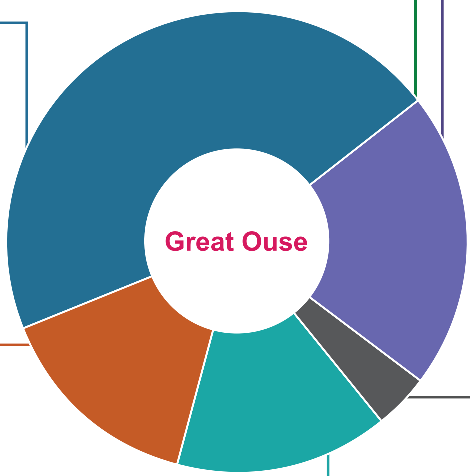
Utilities

Captures the impacts of flooding to power, water supply, and gas networks. This includes damage to 2,764 substations, 3,169 pole towers and 25 power stations.

£3.1 billion

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.



£750 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.

£6.6 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 69,975 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.

£3.1 billion

Transport

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

Loss of **87.6km** of road infrastructure, costing **£2.0 billion**	Loss of **85.9km** of rail infrastructure, costing **£1.1 billion**

Great Ouse	Do Nothing Damages	Maintain Damages	Maintain Benefits
Damages to properties and associated indirect damages	£9.58 billion	£479.14 million	£9.10 billion
Agricultural losses	£3.08 billion	£76.92 million	£3.01 billion
Environment and recreational losses	£42.26 million	£2.76 million	£39.50 million
Transport damages	£3.07 billion	-	£3.07 billion
Utilities damages	£4.13 billion	-	£4.13 billion
Land lost due to isolation	£750.20 million	-	£750.20 million
TOTAL Excluding losses to the local economy	£20.66 billion	£558.82 million	£20.10 billion
Losses to the local economy	£6.62 billion	-	£6.62 billion

£20.10 billion

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

Total investment needed:

£2.3-£3.6 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 Great Ouse catchment. Future stages of the Fens 2100+ Partnership will build on this evidence to set out an investment strategy for the region.

Further details of the economic assessment are contained in the economic 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+