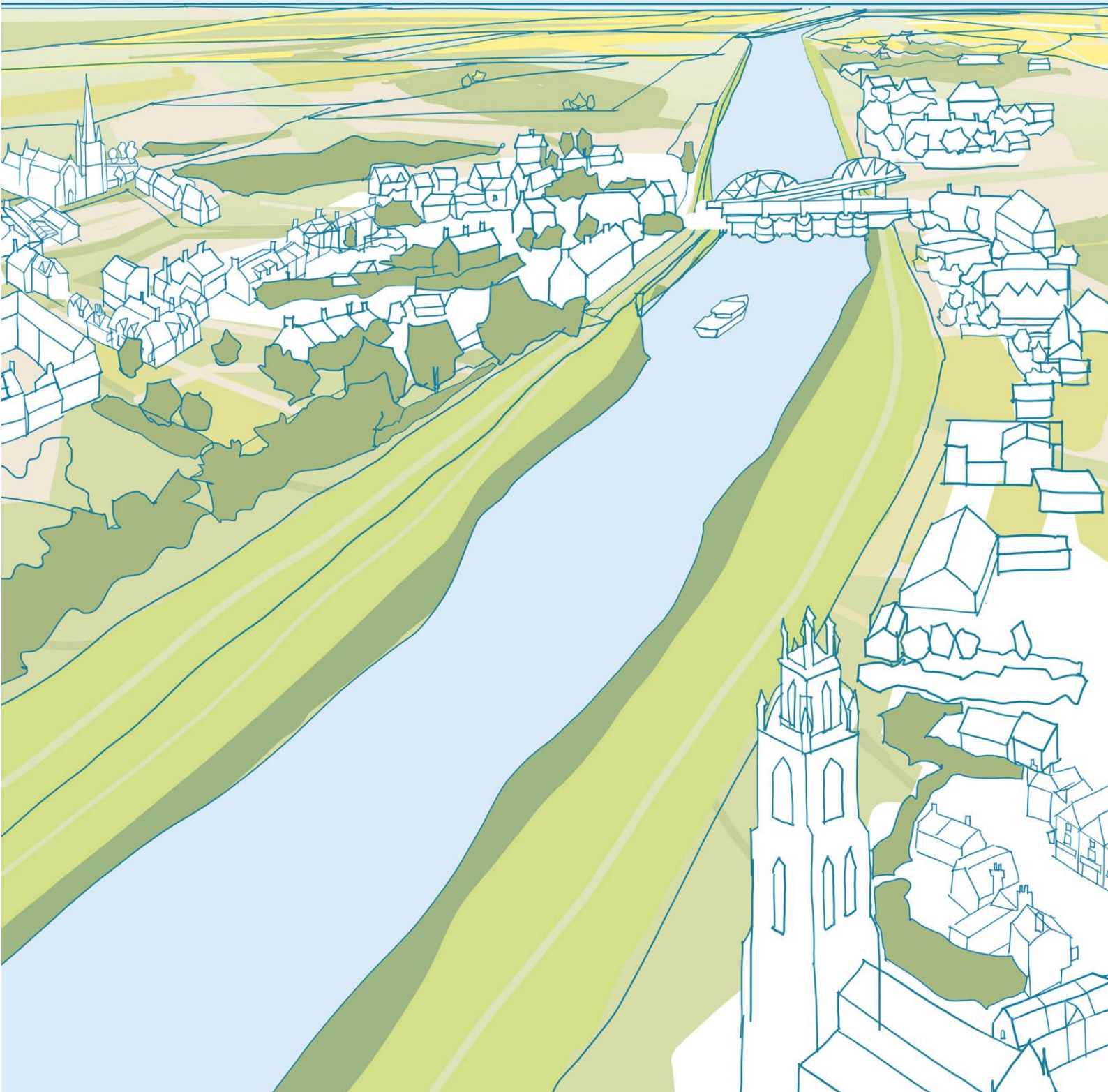




# Witham East and West Fens

## Baseline economic appraisal report

2025





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# 1. Executive Summary

As part of the Environment Agency collaborative delivery framework (CDF), Ove Arup and Partners Ltd (Arup) has been commissioned to present an economic baseline for the East and West Fens catchment, with reference to current and future flood risk management. This report presents an evaluation of key receptors at risk of flooding across the catchment and focuses on defining broad economic impacts. The project focuses on the extents of the East and West Fens catchment. It is a sub catchment of the River Witham. Located in south-eastern Lincolnshire, it extends from the Lincolnshire Wolds to The Wash and the tidal reach of the River Witham at Boston, known as The Haven. The catchment is protected by flood risk assets predominantly operated by the Environment Agency; Witham Fourth District Internal Drainage Board (IDB); and other risk management authorities.

This economic assessment has focused on quantitatively defining high-level impacts to a series of the key receptors at risk, including:

- Residential properties;
- Non-residential properties;
- Agriculture;
- Environment & recreational sites;
- Highways;
- Heritage;
- Rail;
- Gas;
- Electricity;
- Isolated properties; and,
- Local losses to the economy as Gross Value Added.

The Do-Nothing baseline scenario identifies present value damages of up to £7,411M across the catchment extents over a 100-year period. This is compared to the estimated damages associated with existing flood risk management arrangements of £427M. Based upon the analysis, the present FRM arrangements and activities across the catchment are estimated to afford a benefit of £6,984M to the East and West Fens catchment. Without these activities to reduce flood risk and manage water levels in the catchment, the study area is at risk of permanent inundation – impacting across the natural, social, economic, human, intellectual and manufacturing capitals. The analysis therefore suggests there is a case for maintaining the flood defence infrastructure in the long term, but whether this represents the optimum flood risk management regime remains to be investigated.

With a benefit cost ratio of 6.85, the East and West Fens catchment has a Partnership Funding score of 42% and is eligible for £430M in Grant in Aid, which leaves a funding gap of £589M.

## 1.1 Glossary

**Table 1-1: Glossary of economic terminology**

Terminology	Summary Definition
<b>Scenario</b>	A scenario is defined as a representation of what flood risk could be based on an explicit set of assumptions. This can include multiple flood mechanisms. For example, in a Do Nothing scenario all risk management authorities would walk away from operation and maintenance of their flood risk management assets leading to more extensive flooding of communities beyond the status quo. This could be made up of a combination of overtopping of defences, breach, or other flood mechanisms.
<b>Standard of Protection (SoP)</b>	At a given point in time, the Annual Exceedance Probability (AEP) of a flood event which an asset is able to withstand. SoP will vary over time.
<b>Standard of Service</b>	The physical attributes or output of an FCERM asset or service usually set out in a design specification. For example, the height of a wall or barrier, the pumping capacity of a pump, the scale, extent and frequency of a service. The standard of service does not change over time as a result of impacts such as climate change whereas the SoP does.
<b>Receptor</b>	A receptor is defined as something that is affected by a flood. For example, a residential property in the floodplain would be a receptor.
<b>Appraisal period</b>	The appraisal period is the length of time where damages, benefits, and costs are calculated for a particular intervention.
<b>Discounting</b>	Discounting is a method of converting future costs and benefits with different time spans to a common “present value” basis using a discount rate. HM Treasury discount rates are used, which adjust for social time preference, defined as the value society attaches to present, as opposed to future consumption. The rates are based on comparisons of utility across different points in time or different generations.
<b>Present Value</b>	Values expressed in today’s terms following relevant discounting.
<b>Cash</b>	Values expressed in today’s terms not discounted.
<b>Damages</b>	The value of negative social, economic and environmental impacts caused by flooding.
<b>Benefits</b>	The positive quantifiable and unquantifiable changes that a flood risk management scheme is expected to produce, i.e. damages avoided.
<b>Write off</b>	Write-off is losses to an asset deemed unrecoverable.

## 2. Introduction

### 2.1 Aim and purpose of this document

This document presents a catchment-scale economic baseline for the East and West Fens catchment as part of the Fens 2100+ Project 3 baselining, with reference to the current flood risk management regime. This report details the baseline scenarios assessed, the methodology utilised in the economic appraisal, costs associated with maintaining the status quo within the catchment, as well as a summary of the results.

The appraisal approach follows the principles developed as part of the previous work undertaken on the Great Ouse<sup>1</sup> but utilising latest available data and with changes to approach following subsequent reviews and work on the Lower Witham<sup>2</sup>. Details of methodologies have been consulted on and agreed with key stakeholders.

Along with the suite of Fens 2100+ documents, this report aims to build the evidence required to support investment certainty in the short term, clarity of actions in the medium term, and shared confidence for the long term. This will support RMAs and partners in securing the essential national and regional investment to ensure future flood resilience through delivery of the right projects, in the right places, at the right time.

This project has sought only to produce a baseline economic appraisal. At this stage, no Do Something options have been considered.

### 2.2 Catchment context

The East and West Fens catchment (hereafter referred to as “the catchment”) covers an area of approximately 353 km<sup>2</sup> of south east Lincolnshire, located at the north-east of the Fens 2100+ study area between Steeping and Lower Witham (see Figure 1). It extends from the Lincolnshire Wolds to The Wash and the tidal reach of the River Witham at Boston, known as The Haven. It is noted that this is not necessarily a hydrological catchment, but is defined as a catchment for the purposes of the Fens 2100+ work.

The majority of the East and West Fens catchment is set at a very low elevation (approximately 3m above sea level). The East Fen area is actually lower than sea level in some locations. The catchment contains some of the highest-grade agricultural land within the Fens, with half classified as Grade 1.

The catchment has a population of approximately 33,000. It is spread across numerous hamlets and villages. The larger populations centres are the eastern portion of Boston and the small market towns of Wrangle, Friskney and Sibsey. Major transportation routes, such as the A16 and A52, along with the Grantham-Skegness Railway Line, provide vital links between the catchment and the surrounding areas.

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<sup>1</sup> Environment Agency (May 2020). Future Fens Flood Risk Management Economic Appraisal Report

<sup>2</sup> Arup (September 2024). Lower Witham Flood Resilience Project Economic Appraisal Baseline Report



### **2.2.1 Drainage network**

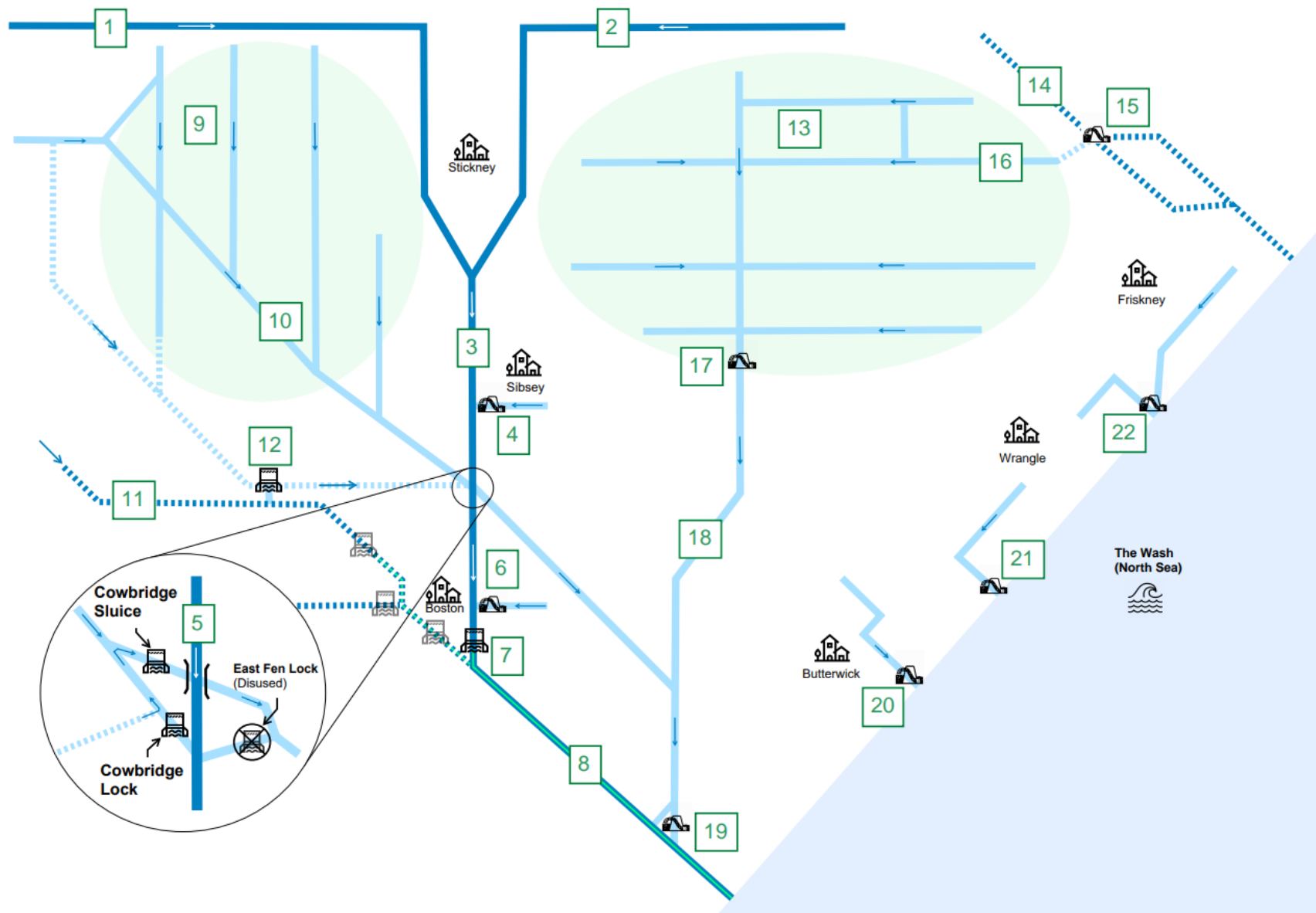
The catchment relies on a complex network of watercourses, pumping stations, and sluices to protect the land from flooding. It includes two drainage systems: Main Rivers managed by the Environment Agency and drains operated by Witham Fourth District IDB. The Main Rivers include the East Fen Catchwater Drain, Stonebridge Drain (Maud Foster Drain), and the River Witham. These rivers collect water from higher ground and convey it southwards, eventually discharging into the Witham (Boston Haven).

The drains managed by Witham Fourth District IDB include the Hobhole Drain, which is crucial for carrying water from the low-lying East Fen and West Fen to the Hobhole Pumping Station for discharge into The Haven. The Environment Agency and Witham Fourth District systems cross at Cowbridge, allowing water from the Environment Agency system to spill into the IDB system during flood events.

Effective water level management requires collaboration between the Environment Agency and the IDB. Other Risk Management Authorities (RMAs), such as water utility companies and local authorities, generally have fewer flood risk assets.

### **2.2.2 Asset schematisation**

A graphical schematisation of the catchment has been produced to provide additional context to this section. This is shown on Figure 2.



**Figure 2: Schematisation of the flood risk assets in the East and West Fens catchment**

- 1 West Fen Catchwater Drain**  
 Main River  
 Designed to minimise the amount of water entering the IDB district, it intercepts run-off from the Lincolnshire Wolds and carries it to Stonebridge Drain.
- 2 East Fen Catchwater Drain**  
 Main River  
 Like the West Fen Catchwater Drain, it intercepts run-off from the Lincolnshire Wolds, and carries it to Stonebridge Drain.
- 3 Stonebridge Drain**  
 Main River  
 Known as the Maud Foster Drain downstream of the Cowbridge Aqueduct, it carries water from the catchwater drains to Maud Foster Sluice.
- 4 Littlemore Lane Pumping Station**  
 Witham Fourth District IDB  
 Pumps water from a small area near Sibsey into the Stonebridge Drain.
- 5 Stonebridge Aqueduct**  
 Environment Agency  
 Carries the elevated Stonebridge Drain over the IDB's Cowbridge Drain.
- 6 Boston East Pumping Station**  
 Witham Fourth District IDB  
 Pumps water from eastern Boston into the Maud Foster Drain.
- 7 Maud Foster Sluice**  
 Environment Agency  
 The gravity outfall of the Maud Foster Drain. It can be closed during drier periods to maintain water levels in the drains upstream.
- 8 Boston Haven**  
 Main River  
 The tidal section of the River Witham.
- 9 West Fen**  
 A low-lying area which wasn't drained until the 19th Century.
- 10 West Fen Drain**  
 Witham Fourth District IDB  
 Carries water from the West Fen towards the Hobhole Drain.

- 11 River Witham**  
 Main River  
 Water from most of the catchment (except coastal areas) flows into the River Witham through the Maud Foster Sluice or Hobhole Pumping Station.
- 12 Anton's Gowt Lock**  
 Canal & River Trust  
 Enables access to the Witham Navigable Drains from the River Witham. W4DIDB have a license to bring in freshwater from the Witham here, to top-up water levels in their system during drier periods. During wetter periods, there is a risk of water entering the IDB drainage network here.
- 13 East Fen**  
 Contains the lowest lying land in the catchment. Water in the East Fen has to be pumped upwards twice to reach sea level: once at Lade Bank Pumping Station, and again at Hob Hole Pumping Station.
- 14 The Steeping River**  
 Main River  
 Neighbours the East and West Fens catchment.
- 15 Thorpe Culvert Pumping Station**  
 Lindsey Marsh Drainage Board  
 In the past, a culvert at this location acted as a route to transfer water from the Steeping catchment into the East and West Fens catchment. This transfer system is no longer operational.
- 16 Bellwater Drain**  
 Witham Fourth District IDB  
 In the past it acted as a spillover route for water from the neighbouring Steeping catchment through the connection at Thorpe Culvert. There is no longer a formal connection between the two catchments, but there is a risk that water from the steeping River spills over during high flows.
- 17 Lade Bank Pumping Station**  
 Witham Fourth District IDB  
 Pumps water upwards along the Hobhole Drain out of the low-lying area of East Fen.
- 18 Hobhole Drain**  
 Witham Fourth District IDB  
 The route for water from the East and West Fens to reach Hobhole Pumping Station.

- 19 Hobhole Pumping Station**  
 Witham Fourth District IDB  
 Separate electric and diesel pumping stations carry water upwards from the Hobhole Drain into the Boston Haven. During high spring tides, water must be lifted around 7m.
- 20 Benington Pumping Station**  
 Witham Fourth District IDB  
 Pumps water from coastal areas directly into The Wash.
- 21 Leverton Pumping Station**  
 Witham Fourth District IDB  
 Pumps water from coastal areas directly into The Wash.
- 22 Wrangle Pumping Station**  
 Witham Fourth District IDB  
 Replaced in Summer 2024, it pumps water from coastal areas directly into The Wash.

## 2.3 Study context

The catchment is heavily modified with engineered flood defence embankments and flood defence walls, in addition to the Witham Fourth District IDB assets including pumping stations, which are essential to the drainage of large areas of the catchment. Drainage works and embanked watercourses perched above the surrounding land have enabled highly productive arable land to be farmed and communities to be established in the area. The farmland is some of the highest-grade agricultural land in the country with half of land classified as Grade 1.



**Figure 3: East and West Fens at Stone Bridge Drain**

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## 2.4 Description of flood risks

The tributaries in the East and West Fens catchment are discharged and pumped through a network of hydraulic structures managed by both the Environment Agency and the Witham Fourth District IDB via gravity and pumped drainage networks. The low-lying catchment is protected by a series of raised flood defences and tidal sluices along the Main Rivers which prevent tidal inundation, as well as a complex series of water management systems operated by the Witham Fourth District IDB. Without these activities to protect and manage the water levels in the catchment, the study area would become uninhabitable with large parts reverted to marshland.

The East and West Fens catchment faces several key sources of flooding, including river flooding from Main Rivers like the West Fen Catchwater Drain and Maud Foster Drain, which can overflow during heavy rainfall. Surface water flooding is also a concern,

particularly in urban areas with impermeable surfaces that lead to rapid runoff. Coastal areas are susceptible to tidal flooding, especially during storm surges or high tides, and long-term sea level rise exacerbates this risk. Additionally, groundwater flooding can occur due to a high water table, and infrastructure failures, such as pumping station or sluice failures, can lead to significant flooding. Effective management of these risks requires continuous maintenance, monitoring, and collaboration between the Environment Agency, Witham Fourth District IDB, and other stakeholders.

### 2.4.1 Historic flooding

There is a history of significant flood events across the Fens 2100+ study extents. Prior to the 1600s, the wider Fens were formed of low-lying marshland with conurbations on islands of higher land. Historic flood events, within living memory, are outlined in Table 2-1. These events highlight the catchment’s vulnerability in the absence of effective performance and operation of assets.

**Table 2-1: Historic flood events**

Date	Source of flooding	Details
<b>November 1810</b>	Coastal/ Tidal	In November 1810, a North Sea storm surge overwhelmed the sea banks from Wainfleet to Fosdyke. The majority of the Borough of Boston was flooded <sup>3</sup> . This resulted in the raising of the existing sea banks by approximately 0.6m above the 1810 level (approximately 5.59m AOD at Newlyn) in and around Boston.
<b>1947</b>	Fluvial	<p>“The winter of 1946/47 was one of the coldest in living memory with long periods of freezing temperatures.</p> <p>This was accompanied by the worst snowfall for seventy years. Then in the second half of March came a rapid thaw and widespread flooding, which brought chaos to Lincolnshire due to overflowing rivers, dykes and ditches.</p> <p>Extensive flooding occurred in the catchment as a result<sup>4</sup>.</p>
<b>1953</b>	Coastal / tidal	<p>The flood of 1953 is the most devastating natural disaster recorded in the United Kingdom in the 20th Century. A severe north-westerly storm combined with a spring tide caused large parts of Britain’s east coast to flood. The tidal surge and waves overwhelmed sea defences and caused extensive flooding. In Lincolnshire, flooding occurred from Mablethorpe to Skegness, reaching as far as 3 km (2 miles) inland.</p> <p>There is no record of the East and West Fens catchment suffering flooding, although it is likely that the coastal areas were inundated.</p>

<sup>3</sup> Boston Story (2025) Floods and the Great Drainage Scheme. Available online at: <https://bostonstory.co.uk/chapters/21-30/28-great-drainage-schemes/floods-great-drainage-scheme.html> Accessed: March 2025

<sup>4</sup> Our History (2025) Available at: <https://www.w4idb.co.uk/about-us/our-history/> Accessed March 2025.

<b>1978</b>	Coastal / tidal	1978 North Sea storm surge causing extensive coastal flooding and considerable damage on the east coast of England. <sup>5</sup>  The tidal surge caused significant flooding in Witham Fourth district around Boston. The surge was around 1.2m and led to the collapse of a brick wall, flooding 180 houses and the church <sup>6</sup> . However, within the East and West Fens catchment, the Environment Agency recorded flood outline only shows a small area on the left bank of the Haven to have been inundated.
<b>April 1981</b>	Fluvial	The catchment experienced significant flooding due to heavy rainfall <sup>7</sup> in April 1981. It resulted in additional pumping capacity being installed at Lade Bank. The Environment Agency recorded flood outline shows large areas of agricultural land were inundated, with some property flooding around Hagnaby Lock.
<b>1993</b>	Fluvial	Flooding adjacent to the Catchwater drain in Stickford, Hagnaby, Stickney and Sibsey areas, due to heavy rainfall. <sup>8</sup> The Environment Agency recorded flood outline for this event shows two areas of flooding on the right bank of the Catchwater drain, with some property flooding at Horbling Lane. The recorded flood outline suggests that this was due to a breach in the embankment.
<b>2007</b>	Fluvial	At the time, the summer of 2007 was the wettest on record since 1766, with 55,000 homes being flooded and 13 people losing their lives across England. Across Lincolnshire, over 500 homes were flooded with 20 schools being forced to close. <sup>9</sup> There was significant flooding across the whole of the East and West Fens catchment.
<b>December 2013</b>	Tidal surge	The tidal surge which hit the east coast of Britain has been described as the "most serious" for 60 years. This event caused the River Haven to burst its banks, and 300 homes flooded in Boston. <sup>10</sup> It also breached the embanked sea defences at Wrangle, inundating a large area of agricultural land, parallel to the coast.
<b>June 2019</b>	Fluvial	When the banks of the Steeping River breached on 9 <sup>th</sup> June 2019, water was pumped into the Bellwater Drain at Thorpe Culvert to essentially re-create the facility of transferring water between the catchments through the historic culverts. This was done under strict requirements of Witham Fourth District IDB to ensure that their drainage network could cope with the extra water. Within the East and West Fens catchment, overtopping caused flooding of agricultural land from the East Fen Catchwater Drain.
<b>October 2023</b>	Fluvial	In October 2023 Storm Babet caused significant flooding throughout the catchment and put significant pressure on assets. Within the East & West Fens catchment large areas of agricultural land and many residentially properties were flooded internally <sup>11</sup> . Witham and Fourth District IDB incident log captured 70 incident reports. The worst impacted areas were in the north of the catchments, around Halton Fenside, Hagnaby; East Keel; and Stickney.

<sup>5</sup> Steers, J.A. et al. (1979). 'The storm surge of 11 January 1978 on the east coast of England'. The Geographical Journal, 145(2), pp.192–205.

<sup>6</sup> The Geographical Journal (1979) The Storm Surge of 11 January 1978 on the East Coast of England Available at: <https://www.jstor.org/stable/634386?origin=crossref&seq=3> Accessed: March 2025

<sup>7</sup> Our History (2025) Available at: <https://www.w4idb.co.uk/about-us/our-history/> Accessed March 2025.

<sup>8</sup> Our History (2025) Available at: <https://www.w4idb.co.uk/about-us/our-history/> Accessed March 2025.

<sup>9</sup> Lincolnshire Live (2017) It's 10 years since devastating 2007 flooding in Lincolnshire. Available at: [It's 10 years since devastating 2007 flooding in Lincolnshire - Lincolnshire Live](#). Accessed 27/03/2025.

<sup>10</sup> BBC (2013) Tidal surge hits east UK coastal towns after storm. Available at: [Tidal surge hits east UK coastal towns after storm - BBC News](#). Accessed 27/03/2025.

<sup>11</sup> Witham Fourth District Internal Drainage Board (2023). Storm Babet Technical Briefing Report

## 2.5 Existing flood risk assets, operation, and maintenance

The East and West Fens drainage system has been heavily engineered, with hydraulic structures designed to manage water levels and reduce flood risk, such as the Hobhole Pumping station and the Maud Foster Sluice.

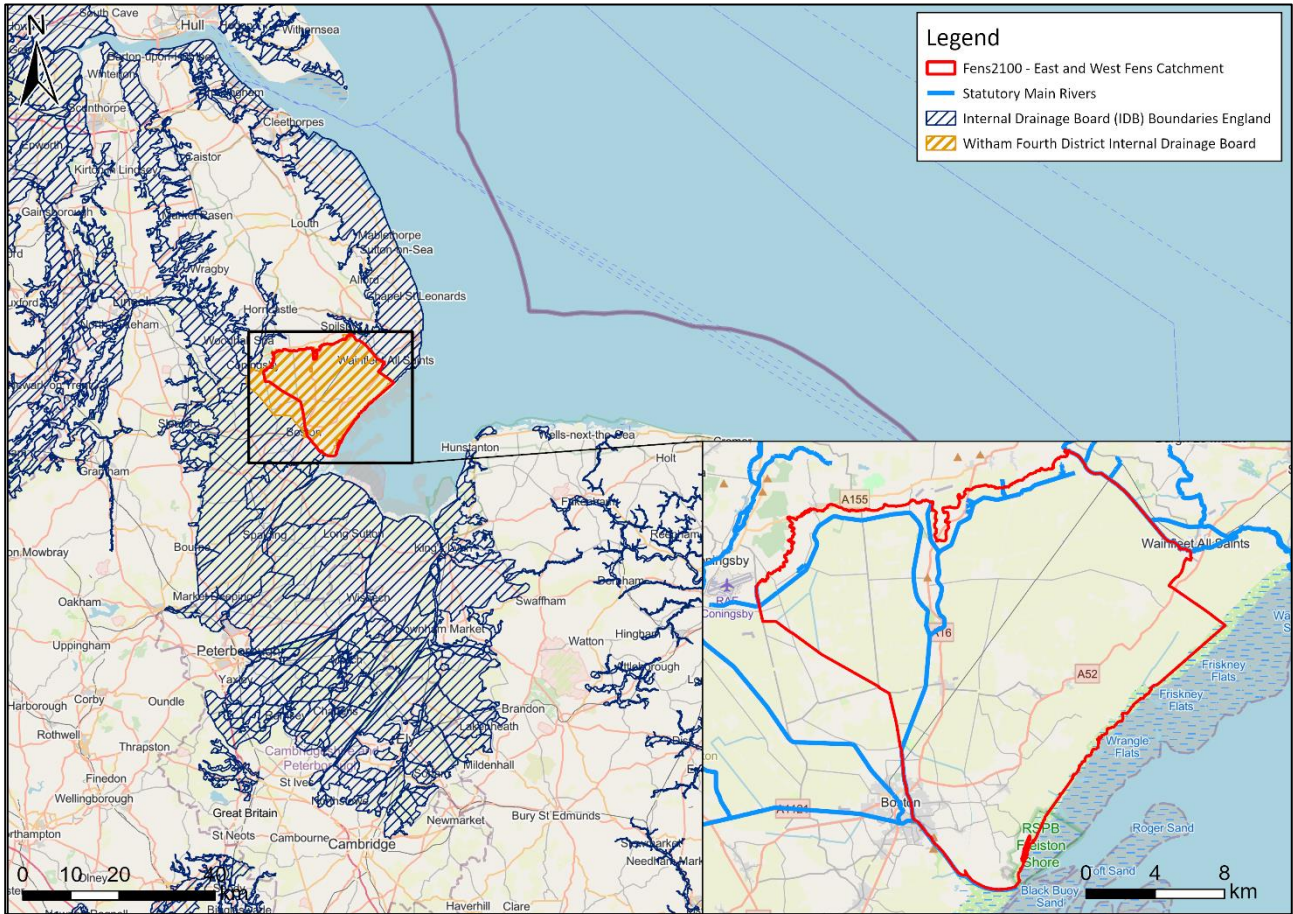
The study area is served by an extensive network of ditches and drains which have transformed the marshy ground of the original fen into high grade agricultural land. These ditches and drains are administered by the Witham Fourth District IDB which solely covers the study area as shown in Figure 4.

The Main Rivers in the catchment represent a high-level carrier system that accepts water from the more elevated land to the north and conveys this water by gravity to the Maud Foster Sluice, which is the key asset owned by the Environment Agency for allowing discharge of water from this system during high flows, as well as the retainment of water in this system during drier periods. The Environment Agency undertake a rolling programme of maintenance to protect and maintain the condition of the existing defences which contain these elevated Main Rivers, including grass cutting and other vegetation management, alongside maintenance of hydraulic structures.

The Witham Fourth District IDB provides water level management systems and regulate the water levels in their systems through a network of pumping stations. 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. The key assets owned, operated and maintained by Witham Fourth District IDB are pumping stations at: Hobhole, Lade Bank, Wrangle, Leverton, Benington, Littlemoor Lane and Boston East . The IDB also operates Cowbridge Sluice. The East Fen area is actually lower than sea level in some locations. Therefore, the only way to transmit water to the sea from the IDB catchment, without a natural gradient to convey water, is to use a series of pumps. Water is lifted first at Lade Bank Pumping Station, and then water is lifted a second time (by approximately 7m) at Hobhole Pumping Station into The Haven. The IDB systems are maintained to ensure the best possible drainage of the study area. Several on-going operation and maintenance activities are undertaken by the Witham Fourth District IDB, including pumping station operation/maintenance, channel dredging/clearance, and reinstatement of embankments.

The East and West Fens has several outfall systems. The Maud Foster Sluice serves as the outfall for the Environment Agency's high-level carrier drains. Whilst Witham Fourth District IDB operate the Hobhole Pumping Station which is the outfall for the majority of the water from their system. However, there are also three further IDB outfalls along the coast, at Leverton, Wrangle and Benington, where water from the coastal marshland is pumped directly out to The Wash.

The defences are essential, highly engineered assets which are of critical importance to the sustainability of the economy of the catchment and the people that reside within the catchment. Without these defences and the Witham Fourth District IDB assets (including pumping stations which drain large areas of land), much of the area would be marshland, regularly inundated by the sea.



**Figure 4: Internal Drainage Boards in the East and West Fens catchment**

## 3. Economic Appraisal Baseline Scenarios

The objective of this economic assessment is to provide a broad assessment of key receptors at risk for the East and West Fens catchment. The economic baseline is identified as the Do-Nothing scenario. Further analysis of the present flood risk management arrangements (the Maintain scenario) is undertaken to evaluate the existing protection and residual risk with the current flood mitigation measures in place, and the benefits of continuing to maintain the existing asset base. The scenarios to be utilised within this appraisal are described within the following sections.

### 3.1 Do-Nothing scenario

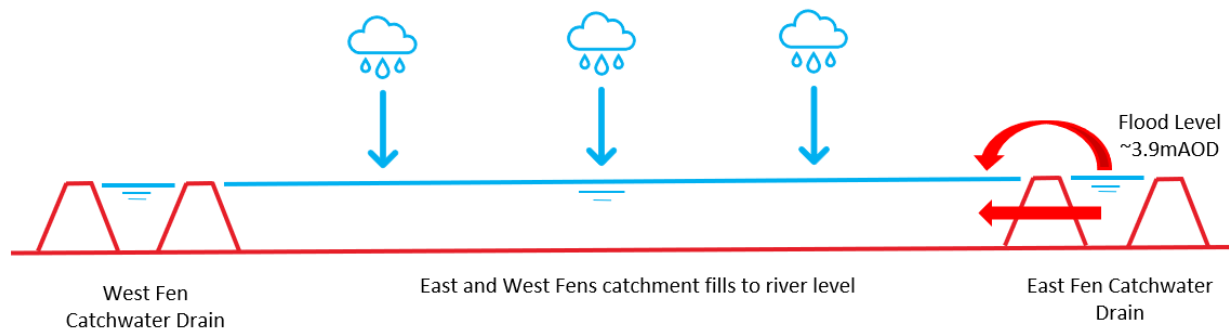
#### 3.1.1 Definition

Due to interdependent activities in managing flood risk across pumped catchments, the cessation of Flood Risk Management activities will lead to relatively rapid inundation of the catchment from water which is unable to drain to from the IDB watercourse network. The majority of the Witham Fourth district lies below the level of The Haven, so is almost entirely reliant on the pumping station to remove water from what is effectively a 'bowl'. The Main Rivers would also be affected by cessation of Flood Risk Management activities because they rely on operation of sluices to allow discharge into The Haven.

Under the Do Nothing scenario the pumping stations would cease operating resulting in water being unable to drain and the rainfall would start to fill the catchment. In addition, the sluices on the Main Rivers (including the key outfall at Maud Foster Sluice) would cease to operate and cause the rivers to back-up. Extreme flood events on the rivers will cause additional flooding that cannot drain away. There will be some loss of water over summer due to evaporation and transpiration, however the water levels would rise steadily over a few years. Sea defences are assumed to be robust and unlikely to fail in the short term. When the water levels in the catchment are high enough, they would spill over the sluices and embankments into neighbouring catchments or main rivers.

A rate of catchment fill of 0.5m per year is applied for the East and West Fens catchment. This has been taken from the Lower Witham study<sup>1</sup>. This rate was estimated based on the average rainfall minus an allowance for evapotranspiration and infiltration. It is assumed that water levels in the catchment will increase by the net rainfall per year, and will be unable to drain, therefore, resulting in permanent inundation of land, properties, and infrastructure.

The limiting level to which the East and West Fens catchment fills is defined at an individual catchment level, based on the level of Mean High-Water Springs (MHWS) because there is a tidal influence and high ground, and main river embankments are above this level. An illustration of the limiting level for the East and West Fens catchment is shown in Figure 5.



**Figure 5: Illustration of the Do-Nothing scenario limiting levels for the East and West Fens catchment**

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### 3.1.2 Key assumptions

For the purpose of the baseline economic appraisal, the East and West Fens is assumed to be frequently or permanently inundated to the water levels defined by the limiting level, with the rate at which this is achieved based on the rainfall estimates for the catchment. Before properties, land, and infrastructure fall below these water levels, they will be subject to risk from extreme events. This risk is represented using the best available data for the catchment.

No suitable local model was available to inform the economic analysis and, thus, a Weighted Annual Average Damages approach is applied for assessment of damages outside of the permanently flooded area. This approach is defined in the Multi-Coloured Manual<sup>2</sup>.

The median ground level across each sub-compartment is taken from LiDAR DTM data to determine a suitable starting point from which water can be assumed to fill the catchment. The starting points to be used are assessed for each sub-compartment individually. The rounded starting levels for each sub-compartment and subsequent fill over time to each of their limiting levels can be seen in Table 3-1.

The limiting levels will vary over time. Initially the limiting levels will be determined by the height of the barrier banks on the main rivers; this is the level which the flood water will need to reach before it can spill back into the main rivers and be carried away to The Wash. However, under the Do Nothing these barrier banks on the main rivers will not be maintained and therefore over time will breach, removing this initial limiting level. Once the main river barrier banks breach the limiting level will effectively revert to being the tidal level. Whilst the timing of the failure of the main river barrier banks under the Do Nothing approach with no further maintenance or repairs will vary between locations it is likely to occur in the short to medium term.

To simplify the assessment a limiting level based on MHS has been used which is much less than the height of the barrier banks and the 33.33% AEP event tidal level. The tidal

limiting level of 3.9m AOD has been applied throughout the appraisal period. This assumption is reasonable as the limiting level is likely to be reached within 5-10 years. This 3.9m AOD MHWS level was derived specifically for The Wash using tidal levels from Boston as part of 2020 updates to the Tidal River Nene model<sup>12</sup>.

Increases of flow and rainfall as a result of climate change have not been considered due a lack of modelling data to inform the assessment at this stage. Whilst it is acknowledged that sea level rise will lead to an increase in tide locking periods preventing fluvial discharge to the sea, no allowance has been made for sea level rise in this assessment. Due to the nature of the Do Nothing scenario, it is considered the impact on the damages assessment would be marginal if climate change were incorporated. Sensitivity analyses have been undertaken to test key assumptions around fill rates and maximum water levels to give confidence in this approach.

These assumptions follow the method statement<sup>13</sup> agreed with the Fens teams and were communicated to key stakeholders.

### 3.1.3 Flood extents

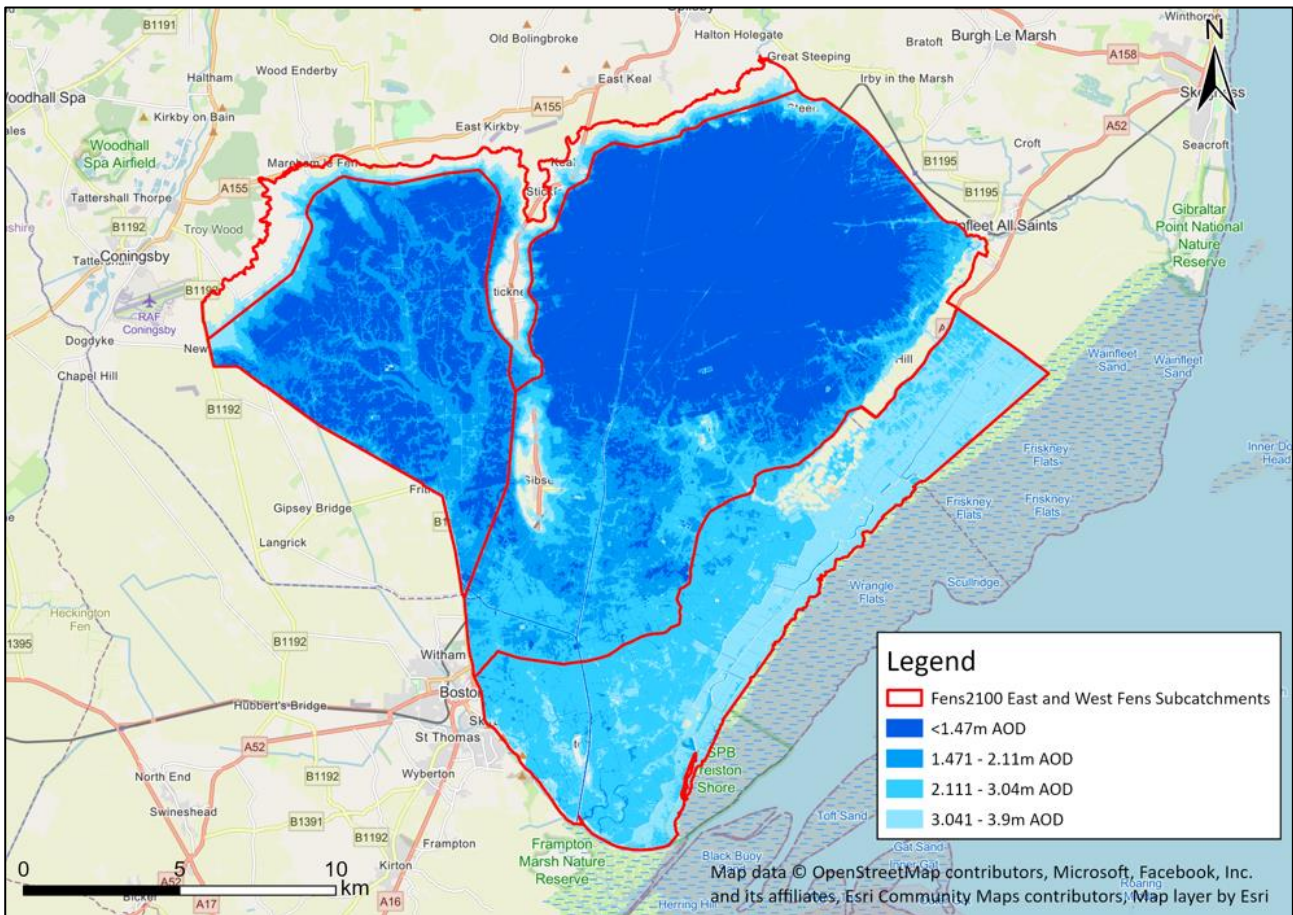
Based on the assumptions described above, indicative flood extents are generated for the East and West Fens catchment by GIS analysis. This involves the use of LiDAR data to define a series of flood extents for specific flooded water levels, i.e., elevation levels (m AOD). The flood extents represent the catchment gradually filling up over time. As an example, Figure 6 shows the permanent inundation levels based on this method for the East and West Fens catchment. The defined permanent inundation levels for each sub-compartment are present in Table 3-1.

**Table 3-1: Do Nothing Scenario assumptions regarding water level over time**

Appraisal Year [yr]	Water Level [m AOD]		
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C & D)
Year 0: Environment Agency and IDB cease maintenance of assets (incl. pumping); fluvial water begins to pond across the catchment.			
0	3.04	1.47	2.11
1	3.54	1.97	2.61
2	3.90	2.47	3.11
3	3.90	2.97	3.61
4	3.90	3.47	3.90
5	3.90	3.90	3.90
19	3.90	3.90	3.90
99	3.90	3.90	3.90

<sup>12</sup> Arup (April 2020). River Nene Modelling Update – Derivation of Updated Tide Curve

<sup>13</sup> Arup (February 2025). Fens 2100+ Proposed Economic Baseline Assumptions: East and West Fens



**Figure 6: Do Nothing permanent flood extents for the East and West Fens catchment**

### 3.1.4 Additional information

It is recognised that under a true Do Nothing scenario, it is likely that localised flood events would result from blockages in watercourses and flood risk management assets, and failure of coastal defences. However, this appraisal is focused on valuing broad economic damages using a simplified approach to the generation of the flood extents. For this reason, localised flood events from degrading assets, blockages of tidal defences are not included in this analysis. It is also anticipated that, due to the speed with which the catchment is assumed to fill, these events would have relatively minor impacts on the total damages in the Do Nothing scenario.

Before write-off of land, properties, and infrastructure occurs, these receptors are subject to risk from infrequent extreme storm and tidal events. This risk is represented using the ‘Risk of Flooding from Multiple Sources’ (RoFMS) dataset. To ensure no double counting of damages occurs, this residual risk associated with infrequent extreme events is recalculated for the assets at risk above each water level tabulated in Table 3-1, such that the damages associated with this risk reduce as the permanent water levels in the Do Nothing scenario rise.

### 3.1.5 Sensitivity test

Sensitivity testing of the Do Nothing scenario will focus on the rate of inundation of low-lying areas. The rate of inundation will be varied from 0.25m (lower estimate) to 0.75m (upper estimate) every year in order to better understand the potential impacts of inundation being less/more rapid than expected. In addition, an extreme scenario has

been tested for potential damages if the catchment were to fill to 6m AOD.

## **3.2 Maintain scenario**

### **3.2.1 Definition**

This baseline economic appraisal will also consider a Maintain scenario. This scenario represents the benefits of existing assets being maintained to continue to provide their existing Standard of Service. There is no allowance for adaptation to climate change. In a maintain scenario, the study area remains at risk from infrequent flooding in events exceeding the design standard of the existing Flood Risk Management assets.

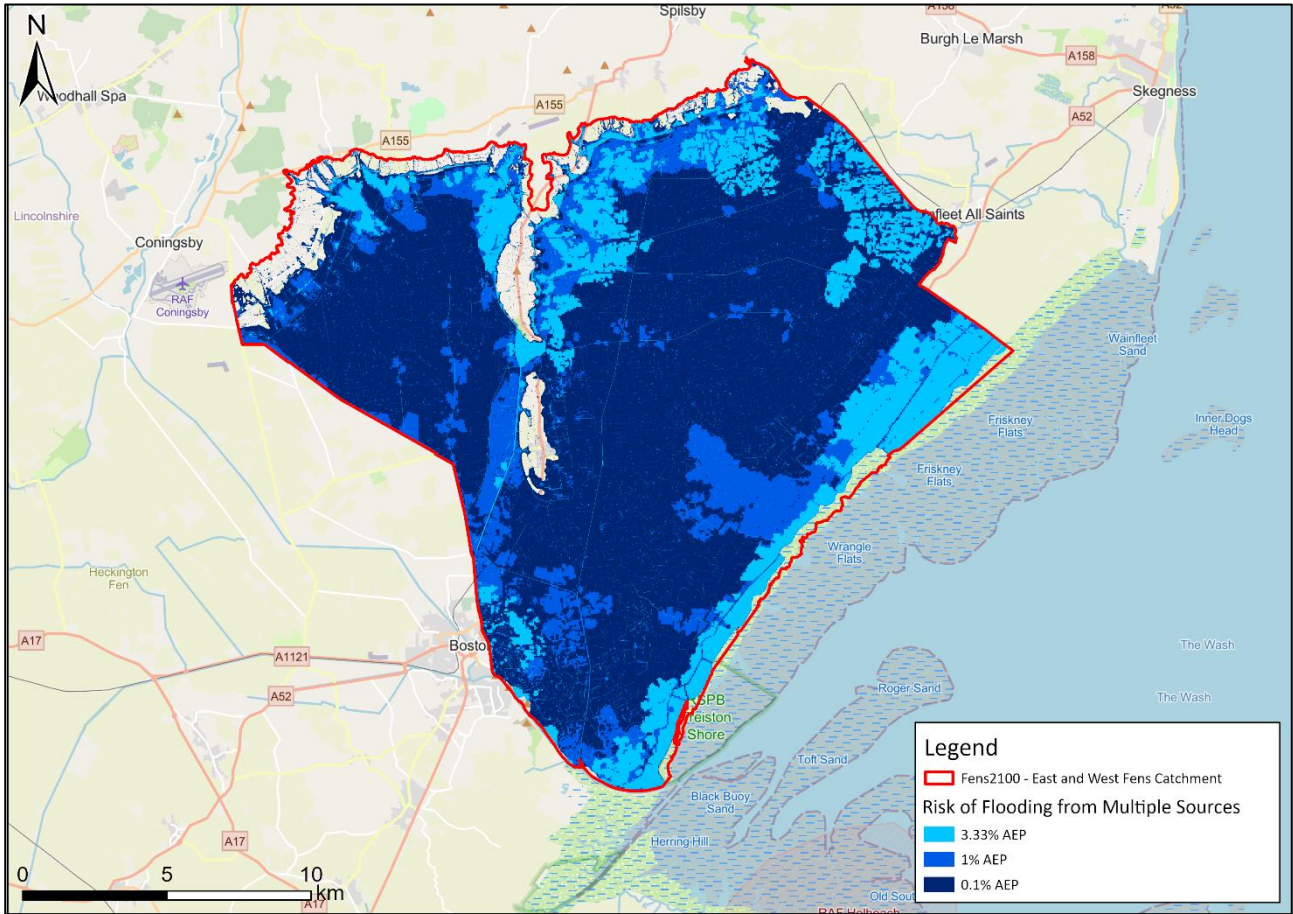
### **3.2.2 Description**

The Maintain scenario relates to the present business as usual (BAU) approach to fluvial and coastal flood mitigation for the East and West Fens catchment. This scenario is based on the best available flood risk data, which indicates the flood risk associated with exceedance of the existing flood risk management assets. In this scenario it is assumed that the existing flood risk management assets are maintained in serviceable condition and embankments will be maintained to their present crest level.

This scenario will be based on nationally available 'Risk of Flooding from Multiple Sources' (RoFMS) dataset which indicates the flood risk associated with exceedance of the existing flood risk management assets, including from tidal, fluvial and surface water sources.

### **3.2.3 Flood extents**

National RoFMS data will be used to inform a weighted annual average damage (WAAD) assessment as defined in the Multi-Coloured Manual. The RoFMS high risk category in the dataset is assumed to be representative of the 3.33% AEP event; the medium risk category in RoFMS is assumed to be equivalent to the 1% AEP event; and the low risk category is assumed to be equivalent to a 0.1% AEP event. Table 4.6 in the MCH will be used to determine the number of properties at risk in more frequent events than the 3.33% AEP event (10% AEP and 20% AEP).



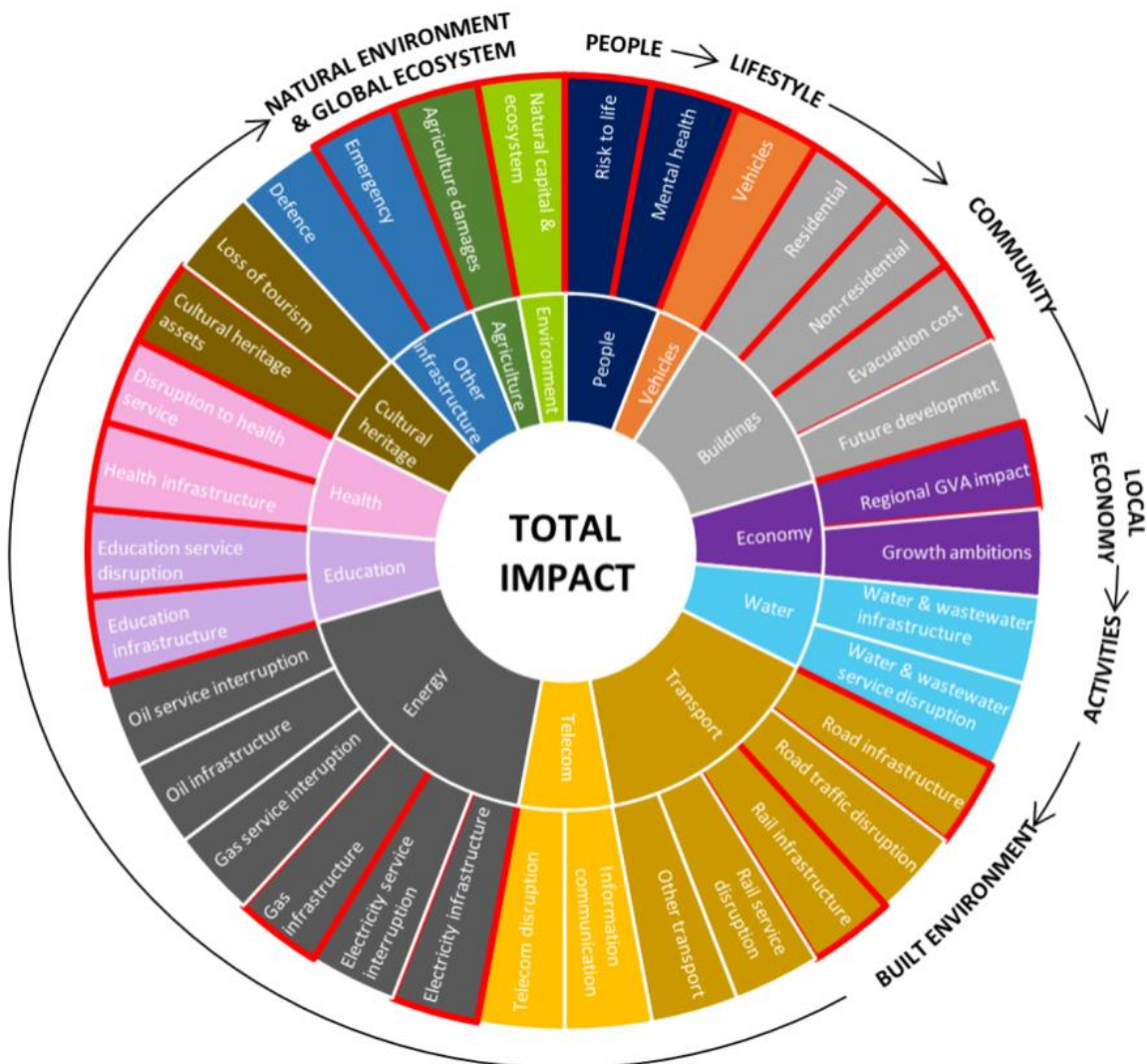
**Figure 7: Risk of Flooding from Multiple Sources for the East and West Fens model**

# 4. Appraisal Receptors

## 4.1 Economic appraisal receptors

The Total Impact Framework in Figure 8 identifies a series of common receptors across catchments loosely mapped across the wider determinants of health. The Framework demonstrates that the flood risk across the East and West Fens catchment has the potential to significantly impact the social, cultural, political, economic, commercial and environmental factors that shape the environment in which the local communities live, work and thrive.

Receptors bordered in red are those considered as part of this economic assessment.



**Figure 8: Total Impact Framework**

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## 5. Baseline Damages Appraisal

The baseline FCERM economic damages to the nation have been calculated in line with the standard guidance (FCERM Appraisal Guidance<sup>14</sup> (AG) (2022), and HM Treasury Green Book<sup>15</sup> (2022)) and using the Flood Hazard Research Centre's Multi Coloured Manual (MCM) (2013) methodology supplemented by the Multi Coloured Handbook (MCH) and data (2024). A 100-year appraisal period has been assessed, with results also presented for a 20-year appraisal period to inform any development of tactical plans and sustain projects ahead of more strategic long-term decisions being made.

Due to the nature of the project, the economic approach has focused towards defining 'broad-brush' economic damages for key receptors. Further detailed analysis could be undertaken in-line with the needs and requirements of any future stages of the project development and for individual investment business cases.

The following damage streams have been assessed and are described in detail in Sections as indicated:

Section 5.1	Residential and non-residential property damages
Section 5.2	Agricultural losses
Section 5.3	Environmental and recreational losses
Section 5.4	Heritage losses
Section 5.5 - 5.7	Infrastructure (transport & utilities) damages
Section 5.8	Isolated properties and land
Section 5.9	Mental health costs
Section 5.10	Intangible impacts
Section 5.11	Emergency service costs
Section 5.12	Risk to life
Section 5.13	Evacuation and temporary accommodation costs
Section 5.14	Vehicle damages
Section 5.15	Utilities disruption
Section 5.16	Educational losses
Section 5.17	Health service losses
Section 5.18	Losses to the local economy (as GVA)

All damages have been presented in a 2025 price base, using latest available GDP data from December 2024<sup>16</sup>. Where historic data has been used, this has been uplifted to a 2025 price base using GDP Deflator data.

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<sup>14</sup> [FCERM appraisal technical guidance - GOV.UK](#)

<sup>15</sup> [The Green Book: appraisal and evaluation in central government - GOV.UK](#)

<sup>16</sup> [GDP deflators at market prices, and money GDP December 2024 \(Quarterly National Accounts\) - GOV.UK](#)

## 5.1 Direct residential and non-residential property damages

Across the East and West Fens catchment, there are several small settlements benefitting from the existing FRM activities including but not limited to, Boston, Frithville and Eastville. Flooding to these rural communities can cause severe disruption to residents and damage to properties, with large financial costs in response and recovery activities and personal expenditure. This remains an area of significant concern for the government and the local communities at risk.



**Figure 9: Non-residential properties in Wrangle**

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Direct residential and non-residential property damages are the losses to property owners and residents because of the direct inundation of their property from a flood event and considers damage to building fabric and structure. Properties at risk have been identified using the National Receptor Dataset (NRD). Noting that the refreshed 2023 NRD data contains far fewer unknown '999' data points, a sensitivity analysis has been undertaken for these catchments to show the potential impact on benefits should these points be appropriate to include in the damages assessment, as described in Section 5.1.6.

### 5.1.1 Do-Nothing approach

Write off of property is assumed to occur at the point at which the water level in the catchment exceeds the level of the property such that it becomes permanently inundated or becomes un-inhabitable due to frequency of flooding; the property is written off in the year in which this is assumed to occur, as per specific assumptions made per catchment. The value of that property was taken as the loss and discounted to Present Value using HM Treasury discount rates. Residential properties have been valued based on the

regional property valuations for the East Midlands from the MCM Chapter 4 Table 5.9. Non-residential property has been valued based on MCM Chapter 5 Table 5.4 and Chapter 3 Table 3.4 taking rateable values for the East Midlands and using floor areas from NRD; where no floor area is available in NRD data, MasterMap building polygons have been used to determine an appropriate floor area.

Where properties have not been written off, they may be at risk of flooding due to extreme storm and tidal events, in exceedance of the Standard of Service of existing FRM assets. This risk has been assessed using the flood risk data set out in Figure 8.

A local model is not available and, thus, a Weighted Annual Average Damages approach is applied for assessment of damages outside of the permanently flooded area. This approach is defined in the Multi-Coloured Manual<sup>2</sup>.

Residential property damages are capped at average market value for the property type. Non-Residential properties are capped based on the rateable value for the property type multiplied by the rental yield factor, and the floor area for the property. Where properties have no floor area, they have been excluded from the analysis – this is recommended as an area for further development as part of any future more detailed appraisals. Damages due to extreme storm events cease to accrue following write-off of the property due to permanent or frequent inundation.

WAAD has been reassessed at each flood level as permanent flood levels within the catchment rise to ensure that damages are not double counted, i.e. properties which have been written off by permanent flooding are no longer assessed for WAAD. The WAAD value has then been forecast across the appraisal period and discounted to understand Present Value (PV) damages to properties.

### **5.1.2 Maintain approach**

For the Maintain scenario, properties are at risk from flooding due to extreme storm and tidal events in exceedance of the Standard of Service for existing FRM assets. Residential and non-residential property damages have been calculated based on the approach to calculating WAAD as detailed in Section 3.1.8 with no reduction in WAAD over time given that there is no permanent inundation assumed in the Maintain scenario. It has been assumed that there is a flood warning for this assessment. The WAAD value has been forecast across the appraisal period and discounted to understand PV damages to properties.

### 5.1.3 Key assumptions

**Table 5-1: Residential and non-residential property data and assumptions**

Key assumptions:			
Residential property values	<b>Property Type</b>		<b>Market Value (£)</b>
	Detached		361,975
	Semi-detached		231,449
	Terraced		189,400
	Flat		140,557
	Bungalow		140,557
	Source: MCM Handbook. (2024). Chapter 4, Table 4.9 Regional Residential House Prices (2024). East Midlands		
Non-residential property values	<b>Type</b>		<b>Market Value £/m<sup>2</sup></b>
	Retail		1,787
	Offices		1,171
	Distribution / logistics		598
	Leisure		1,093
	Playing fields		1,093
	Sports centre		1,093
	Marina		1,093
	Sports Stadium		1,093
	Public buildings		1,093
	Industry		683
	Car Park		1,093
	Electricity sub-station	Excluded to avoid double counting with electricity damages	
	Unknown (999 and 9)	Excluded	
Source: Based on MCM Table 5.4 for East Midlands; Savills Research			
<b>Key datasets:</b>			
<ul style="list-style-type: none"> <li>• East and West Fens model results</li> <li>• National receptor database</li> <li>• OS MasterMap</li> <li>• LIDAR DTM</li> <li>• MCH Chapter 3, 4, 5 data and tables.</li> </ul>			

### 5.1.4 Do-Nothing scenario outcomes

**Table 5-2: Do Nothing Write-off – number of residential properties impacted (cumulative) and PV residential losses (cumulative) (£k)**

Appraisal year (Year)	Number of residential properties				PV Property losses (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	198	86	2,245	275	45,846	19,960	519,815	64,896
1	356	468	4,594	3,620	81,184	105,380	1,045,164	813,245
2	538	809	5,853	7,213	120,505	179,033	1,317,246	1,589,469
3	538	896	6,442	8,248	120,519	197,187	1,440,239	1,805,503
4	538	935	6,646	8,453	120,532	205,050	1,481,403	1,846,844
5	538	953	6,646	8,453	120,544	208,556	1,481,438	1,846,856
99	538	953	6,646	8,453	120,910	208,556	1,482,444	1,847,197

**Table 5-3: Do Nothing – number of non-residential properties impacted (cumulative) and PV non-residential losses (cumulative) (£k)**

Appraisal year (Year)	Number of non-residential properties				PV Property losses (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	59	106	570	61	9,579	11,304	158,962	12,106
1	101	241	864	289	21,973	35,316	427,037	46,957
2	143	306	1,075	569	29,593	51,227	631,013	143,429
3	143	334	1,142	718	29,595	53,706	647,047	191,688
4	143	345	1,172	765	29,597	54,330	652,030	203,877
5	143	351	1,172	765	29,599	54,330	652,056	203,898
99	143	351	1,172	765	29,646	54,330	652,803	204,505

A total of 16,590 residential and 2,431 non-residential properties are written-off due to inundation in the Do Nothing. This amounts to a total of £3,659,107k and £941,284k of residential and non-residential property losses respectively over the 100-year appraisal period.

## 5.1.5 Maintain scenario outcomes

**Table 5-4: Maintain scenario – number of residential properties impacted and the associated cash property damages (£k)**

Annual Exceedance Probability	Residential properties impacted				Cash Property damages (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
20%	12	3	40	103	41	13	136	355
10%	24	8	80	207	21	7	70	181
3.33%	60	19	198	516	30	10	100	260
2%	99	60	554	1,013	14	15	126	176
1%	99	217	1,202	1,013	0	14	58	0
0.5%	106	233	1,293	1,089	0.3	1	4	3
0.1%	250	883	6,392	8,372	6	29	224	320

**Table 5-5: Maintain scenario – number of non-residential properties impacted (cumulative) and the associated cash property damages (£k) and cash indirect commercial losses (£k)**

Annual Exceedance Probability	Non-residential properties impacted				Cash property damages (£k)				Cash indirect commercial losses (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
20%	1,163	1,356	9,447	16,491	5	1	78	904	0.2	0	2	27
10%	2,328	2,711	18,891	32,984	4	1	59	649	0.1	0	2	19
3.33%	5,817	6,777	47,233	82,460	6	1	87	1,055	0.2	0	3	32
2%	10,147	19,203	114,952	107,492	0.3	2	24	35	0	0	1	1
1%	11,267	28,367	137,679	142,315	2	16	27	12	0.1	0.5	1	0.4
0.5%	11,992	30,246	148,042	151,555	0	1	4	5	0	0	0.1	0.2
0.1%	15,538	122,319	589,853	361,046	0.5	16	91	43	0	0.5	3	1

A total of £65,975k and £93,226k is accrued in residential and non-residential PV damages respectively when discounted over the full 100-year appraisal period. In addition, £2,797k of PV indirect commercial losses is accumulated over the same period of time.

### 5.1.6 Sensitivity testing

Sensitivity analysis has been undertaken to assess the impact of NRD 999 (classified as unknown receptors) on damages. These have been excluded from the baseline analysis, but for the sensitivity analysis have been included assuming damages equivalent to the non-residential sector average values. This provides an indication of the potential additional damages which could be included if these 999 points were reclassified based on local knowledge, aerial photography or similar, to a more appropriate classification.

**Table 5-6: Do Nothing – number of non-residential properties including NRD 999 impacted (cumulative) and PV non-residential losses (cumulative) (£k)**

Appraisal year (Year)	Number of non-residential properties				PV Property losses (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	101	190	1,789	76	13,055	25,236	445,723	16,064
1	204	530	2,617	418	36,284	88,626	863,001	84,939
2	295	784	3,053	1,016	52,409	154,646	1,106,501	285,926
3	295	858	3,183	1,511	52,526	163,098	1,132,882	385,891
4	295	884	3,249	1,612	52,638	165,821	1,142,131	408,501
5	295	897	3,249	1,612	52,747	167,022	1,142,171	408,553
99	295	897	3,249	1,612	55,888	167,022	1,143,327	410,069

**Table 5-7: Maintain scenario – number of non-residential properties including NRD 999 impacted (cumulative) and the associated cash property damages (£k) and cash indirect commercial losses (£k)**

Annual Exceedance Probability	Non-residential properties impacted				Cash property damages (£k)				Cash indirect commercial losses (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
20%	1,163	1,356	9,447	16,491	54	69	442	1,236	2	2	13	37
10%	2,328	2,711	18,891	32,984	40	51	326	893	1	2	10	27
3.33%	5,817	6,777	47,233	82,460	63	80	509	1,441	2	2	15	43
2%	10,147	19,203	114,952	107,492	40	111	606	193	1	3	18	6
1%	11,267	28,367	137,679	142,315	2	20	32	68	0	1	1	2
0.5%	11,992	30,246	148,042	151,555	2	4	22	18	0	0	1	1
0.1%	15,538	122,319	589,853	361,046	4	105	482	205	0	3	14	6

## 5.2 Agricultural losses

The East and West Fens and wider Fens 2100+ study area, which is a region of national agricultural importance due to its fertile soils. The Fens account for around half of the most productive (termed “grade 1”) agricultural land in England, which supports a nationally important agricultural industry. With a significant proportion of agricultural land across the catchment benefitting from the present FRM activities, frequent flooding or long-term inundation of the catchment would have a significant impact on regional and national food production.

“Although it covers less than 4% of England’s farmed area, the Fens produces more than 7% of England’s total agricultural production, worth a staggering £1.23 billion. The whole food chain, from farm to fork employs 80,000 people – equivalent to the population of Peterborough – and generates more than £3 billion a year for the Fens’ economy” (NFU, Farming Food in the Fens, 2020).



**Figure 10: East and West Fens agricultural land**

© Richard Humphrey

### 5.2.1 Do-Nothing approach

Flooding of farmland can lead to immediate, as well as long term, crop losses. The scale of impacts is likely to be a function of inundation depth, duration and seasonality. From a tidal perspective, even as flood waters recede, salt deposition from sea water establishes a legacy of soil salinity, negatively affecting the growth of many crops with long-term impacts on soil structure.

Due to the nature of the flooding in the Do-Nothing scenario, it is assumed agricultural land below Do-Nothing 'write off level' will be abandoned/written off. Where write off of agricultural land occurs, the valuation of this land has been based on survey data from Knight Frank. It has been conservatively assumed that the valuation of land can be equated to that of average arable and average pastureland from this survey, depending on the classification of the land use taken from CEH Land Cover Plus Crops data. A value of £600 has been removed from this valuation to account for farming subsidies; whilst the payment of subsidies to farmers from the EU have ceased, the UK government has replaced them with the Environmental Land Management Scheme (ELMS). ELMS is not yet considered mature enough to determine an appropriate alternative subsidy value to use and therefore £600 has been applied as a proxy for ELMS payments.

Where agricultural land is written off, it is recognised that the conversion of land use to an area which is frequently or permanently flooded may result in alternative ecosystem services benefits being provided to the food production benefits provided when in agricultural use. However, permanent inundation is also likely to create contamination issues within the area from increasing salinity, historical land use sources and other sources such as active and disused landfill sites. Over the longer-term, there is uncertainty over whether the area would become a "naturally functioning" system due to the absence of fresh sand supply and the presence of man-made structures within the flooded area. Therefore, these benefits have not been assessed for agricultural areas at this stage. Losses and benefits generated from ecosystem services at existing environmental sites are assessed as part of the Environmental Damages and Benefits assessment (Section 5.3).

Alongside write off, there is risk owing to extreme storm and tidal events in exceedance of the Standard of Service of the current FRM assets, as represented by the flood risk data noted in Table 5-9. Recognising the importance of agriculture within the Fens, a more detailed methodology to calculate agricultural flood damage due to these events has been used, as opposed to the standard agricultural losses detailed within the MCM (Table 9.20 in the MCM 2013; Tables 9.7 and 9.8 in MCH 2024). The approach is in-line with the detailed scheme appraisal level noted in Chapter 9 of the MCM and was developed as part of the Future Fens (Great Ouse) Economic Appraisal (2020). The approach considered land use and crop types across the catchment and the loss in crop/livestock output and associated loss of value-added (profits) due to flooding and a reduction in agricultural drainage conditions. This approach draws on techniques and analysis undertaken for the Future Fens (Great Ouse) appraisal.

The analysis utilised the CEH Land Cover plus Crops dataset which is a geographical agricultural land dataset to define land use. This dataset contains information on 11 crop types including a category for 'other' crops. The areas (ha) of agricultural land by crop type which are impacted by flooding in the Do-Nothing scenario were interrogated from this dataset and were averaged across three years of recent CEH data to reflect crop rotation activities.

Estimates of annual per hectare gross output, gross margin and net margin were produced for the main crop types following reviews of key datasets and engagement with key stakeholders and farmers across the Witham and Great Ouse catchments. The values derived for the Witham catchment have been used as proxies for the remaining catchments, except for the Great Ouse catchment which has its own estimates to account for the higher value of 'other' CEH category crops produced in this area. The annual Net Margins (per ha) were multiplied by the areas impacted by flooding in order to determine losses.

Damages due to extreme storm events cease to accrue following write off of agricultural land due to permanent or frequent inundation. Therefore, damages from extreme storm events have been recalculated for the area above each permanent flood level defined in the Do-Nothing scenario such that these decrease over time and there is no double counting of damages.

Appropriate soil saturation is required to successfully yield crops; for instance, if soil is too dry or wet it can result in poor conditions for crops to grow and a field's yield can be severely reduced. Recognising agricultural productivity is critically dependent on standards of land drainage and field water level control, the assessment considered the impact of poor drainage across the catchment due to the gradual filling up of the catchment under the Do-Nothing scenario. By applying a drainage freeboard above the permanent flood level, the area with sub optimal drainage conditions could be calculated. Three categories of freeboard were applied to agricultural land, as described in Table 5-8. Due to the suitability of each drainage class to different agricultural uses, the productivity of land within each drainage class is different (as highlighted in Table 5-8). The annual losses are defined by a move in land categorisation from good to bad or very bad drainage, or permanent inundation.

As the catchments are assumed to be gradually inundated in the Do-Nothing scenario, the freeboard was also assumed to rise over time relative to the assumed permanently inundated water level. This results in increasing levels of reduced productivity across the catchment.

Where land falls into the very bad drainage category, or where it is in the bad drainage category for more than five years, the land is assumed to be written off. As a result, there is a change in land use with associated potential for alternative ecosystem services to be provided. These potential benefits have been calculated as part of a sensitivity analysis due to uncertainty in the time and viability for naturally functioning habitats to develop (Section 5.2.4).

**Table 5-8: Agricultural land drainage assumptions**

Category	Freeboard	Assumptions
Permanent inundation	Water level	Agricultural activity ceases due to permanent inundation, as a result of the catchment being unable to appropriately drain.
Very bad drainage	0 – 0.5m above water level	Due to the severity of the very bad drainage conditions, it is assumed for land within this category conventional farming is not viable. Therefore, write off is also assumed for ground levels up to 0.5m above permanent water levels.
Bad drainage	0.5 – 1.5 m above water level	It is assumed that farming activities continue in bad drainage conditions – as in the short-term it is assumed farmers can cover the direct costs of production with the support of the current farm income support. Bad Drainage conditions result in negative margins (£/ha) due to the fact that low yields mean that farmers would fail to recover full costs on areas subject to Bad Drainage. Therefore, for most crops it is not considered a sustainable practice to continue farming in the longer term – as a result, farming activities are assumed to only continue for a period of five years beyond which activities cease and the land is written off.
Good drainage	+1.5m above water level	It is assumed agricultural land 1.5m above permanent water levels is not impacted.

## 5.2.2 Maintain scenario approach

The modelled data indicates the extents of the catchment impacted by extreme storm and tidal flood events. To define the impacts associated with these events, the losses from short term infrequent flood events for each crop type have been applied to the extents of the agricultural land impacted for each return period modelled. This has followed the same approach detailed for the Do-Nothing scenario based on Annual Net Margins for each crop type impacted. All agricultural land is assumed to have good drainage conditions in the Maintain scenario.

## 5.2.3 Key assumptions

**Table 5-9: Agricultural assumptions**

Key assumptions:				
Annual Net Margin per ha by Crop Type (£ / ha)	Estimates of net margins for main crops identified in Land cover plus, including high value 'other' (vegetable). These are 'economic' values to the economy rather than financial values to farmers, expressed in 2024 prices.			
	(£/ha)	Good Drainage	Bad Drainage	Very Bad Drainage
	Winter wheat	440	22	-396
	Spring wheat	305	145	-14
	Winter barley	279	-40	-359
	Spring barley	264	123	-17
	Field beans	272	147	22
	Oilseed Rape	464	280	97
	Maize	368	213	57
	Beet	571	22	-14
	Potatoes	3,167	22	-14
	Other Crops	2,601	22	-14
Grass	129	-111	-37	

Source: Analysis draws on the CEH Land Cover Plus data, Defra Farming Statistics 2010 and 2016, AgCensus 2010, and Eastern Regional Farm Business Surveys 2013/14 to 2017/18. Estimates of financial performance by crop and livestock type were expressed in 2024 values and adjusted to represent economic values.

Agricultural land valuations (£/ha)	Crop Type	Assumed Typology	Market Value (£/ha)
	Winter wheat	Arable	26,087
	Spring wheat	Arable	26,087
	Winter barley	Arable	26,087
	Spring barley	Arable	26,087
	Field beans	Arable	26,087
	Oilseed Rape	Arable	26,087
	Maize	Arable	26,087
	Beet	Arable	26,087

**Key assumptions:**

	Potatoes	Arable	26,087
	Other Crops	Arable	26,087
	Grass	Pasture	18,028

Source: Knights Frank, 2021 – Farmland Market Values for Lincolnshire

<https://www.fwi.co.uk/business/markets-and-trends/land-markets/find-out-average-farmland-prices-where-you-live>

Annual Agricultural Losses per Hectare for Short Term Infrequent Flooding (£)	Agricultural Losses per Hectare for Short Term Infrequent Flooding (£) – it is assumed good drainage is available throughout the catchment during the existing maintain scenario.	
	Crop Type	Floods over 2 weeks (£/ha) - Good Drainage conditions
	Winter wheat	440
	Spring wheat	305
	Winter barley	279
	Spring barley	264
	Field beans	272
	Oilseed Rape	464
	Maize	368
	Beet	571
	Potatoes	3,167
	Other Crops	2,601
Grass	129	

Source: Analysis draws on the CEH Land Cover Plus data, Defra Farming Statistics 2010 and 2016, AgCensus 2010, and Eastern Regional Farm Business Surveys 2013/14 to 2017/18. Estimates of financial performance by crop and livestock type were expressed in 2022 values (uplifted to 2024) and adjusted to represent economic values.

**Key datasets:**

- Flood risk data used
- CEH Land Cover plus Crops

## 5.2.4 Do-Nothing scenario outcomes

**Table 5-10: Do Nothing – Area of agricultural write off for the Do Nothing scenario (ha) (cumulative)**

Appraisal year (Year)	Area of agricultural write-off (ha)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	799	5,496	14,179	1,374
1	1,101	6,283	14,548	4,064
2	1,378	6,439	14,713	6,083
3	1,378	6,501	14,865	6,318
4	1,378	6,525	15,052	6,496
5	1,378	6,528	15,025	6,496
99	1,378	6,528	15,025	6,496

**Table 5-11: Do Nothing – Agricultural write off PV damages for the Do Nothing scenario with basin fill (£k) (cumulative)**

Appraisal year (Year)	Agricultural write-off damages (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	21,374	152,113	392,951	44,779
1	29,468	173,378	402,952	119,675
2	36,626	177,502	407,360	172,360
3	36,892	179,074	411,306	178,459
4	37,149	179,652	415,884	182,929
5	37,157	179,716	415,884	182,929
99	48,529	179,728	420,127	186,095

**5-12: Do Nothing – Residual agricultural PV damages (£k) (cumulative)**

Appraisal year (Year)	Agricultural write-off damages (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	8	1	3	24
1	13	1	5	31
2	16	1	5	35
3	18	1	6	38
4	20	1	6	40
5	22	1	6	42
99	70	1	6	79

**Table 5-13: Do Nothing – Total PV Damages (£k)**

Sub-compartment	Total agriculture PV damages (£k)
Witham Fourth (A)	48,599
Witham Fourth (B)	179,728
Witham Fourth (C)	420,134
Witham Fourth (D)	186,174
Total	834,635

**5.2.5 Maintain scenario outcomes****Table 5-14: Maintain scenario – Area of agricultural land flooded (cumulative) (ha)**

Annual Exceedance Probability	Area of agricultural flooding (ha)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
20%	103	126	558	650
10%	206	251	1,115	1,300
3.33%	516	629	2,789	2,350
2%	779	2,012	5,580	5,516
1%	779	2,362	5,580	5,516
0.5%	838	2,539	6,000	5,931
0.1%	1,218	8,502	20,170	9,419

**Table 5-15: Maintain scenario – Total agricultural cash damages (cumulative) (£k)**

Annual Exceedance Probability	Agricultural write-off damages (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
20%	55	64	282	737
10%	109	128	565	1,474
3.33%	273	319	1,412	3,686
2%	400	1,022	3,292	6,516
1%	400	1,146	3,292	6,516
0.5%	430	1,232	3,540	7,007
0.1%	613	4,028	13,266	11,627

**Table 5-16: Maintain scenario – Total PV Damages (£k)**

Sub-compartment	Total agriculture PV damages (£k)
Witham Fourth (A)	1,048
Witham Fourth (B)	2,020
Witham Fourth (C)	7,320
Witham Fourth (D)	15,362
Total	25,750

## 5.2.6 Sensitivity testing

### 5.2.6.1 Write off method

An alternative method for valuing agricultural write off was tested based on the approach used in the Great Ouse Fens project. Rather than writing off the land below the Do-Nothing 'write off level' based on land market valuations, agricultural land is valued based on lost productivity of the land at a field scale. The value of losses if the land is written off is assumed to be the lost productivity of the land for the remainder of the appraisal period rather than the land valuation from Knight Frank or similar. This approach was utilised in the Great Ouse following consultation with the NFU and farmers, where it was found that the process of write off was considered to undervalue the land and did not account for the significance of the agricultural sector in the Fens for national food security. The losses accrued beyond write off of land were based on net margins for good drainage conditions.

**Table 5-17: Do Nothing – Total PV damages for the Do Nothing scenario using a lost productivity approach (£k)**

Sub-compartment	Total agriculture PV damages (£k)
Witham Fourth (A)	31,307
Witham Fourth (B)	105,022
Witham Fourth (C)	334,901
Witham Fourth (D)	282,199
Total	753,429

### 5.2.6.2 Subsidy payments

Agricultural land valuations used in the assessment have been reduced by £600 to account for the ELMS payments (which have replaced EU subsidies) received from the UK Government. A sensitivity analysis has been undertaken to consider the removal of this subsidy from the assessment and thus taking the full land valuation. Further to this, an assessment of an increase in the subsidy to £1,200 has been undertaken, given the uncertainty in ELMS payment rates. This helps to assess the impact of any potential future changes in subsidies and provides a range of possible agricultural damages based on changing understanding of ELMS payment rates.

**Table 5-18: Do Nothing – Total PV damages for the Do Nothing scenario with no subsidy or increased subsidy (£1200) (£k) (cumulative)**

Sub-compartment	Subsidy of £0 (£k)	Subsidy of £1,200 (£k)
Witham Fourth (A)	49,661	47,524
Witham Fourth (B)	183,618	180,037
Witham Fourth (C)	429,221	411,602
Witham Fourth (D)	189,978	184,709
Total	852,477	823,872

### 5.2.6.3 Land subject to bad drainage conditions

The assessment has assumed that land subject to bad drainage conditions will be written off after five years of these conditions (see Table 5-8). This assumption aligns with those made for the Great Ouse and Witham economic baseline assessments undertaken previously. A sensitivity test has been undertaken to assess the impact on agricultural damages should this land be used as pasture rather than written off, and therefore the loss has been assessed based on the reduction in land market valuations from arable to pasture land (as per the values in Table 5-9).

**Table 5-19: Do Nothing – Total PV damages for the Do Nothing scenario with land subject to bad drainage converting to pasture land (£k)**

Sub-compartment	Total agriculture PV damages (£k)
Witham Fourth (A)	40,228
Witham Fourth (B)	179,720
Witham Fourth (C)	417,079
Witham Fourth (D)	183,955
Total	820,983

#### 5.2.6.4 Land use change – ecosystem service gains

Where permanent flooding occurs, there is the potential for the change in land use to result in alternative ecosystem services being generated. This is aligned to the assessment for environmental damages as described in Section 5.3. There is uncertainty in the viability and timescale for land to become a fully functioning natural habitat after land use change. A period of 50 years has been assumed for transition, after which, agricultural land is assumed to have converted to fully functioning Coastal habitat with ecosystem service benefits valued as per Table 5-22. The total area of agricultural land inundated is therefore multiplied by the value for coastal habitat to determine the annual benefits and is assumed to accrue for the remainder of the appraisal period from a point 50 years after the maximum water level is reached.

**Table 5-20: Do Nothing – Total PV benefits as a result of habitat created in the Do Nothing scenario (£k)**

Sub-compartment	Total agriculture PV benefits (£k)
Witham Fourth (A)	44,226
Witham Fourth (B)	247,374
Witham Fourth (C)	588,762
Witham Fourth (D)	263,902
Total	1,144,264

## 5.3 Environment and recreational losses

The East and West Fens is a distinct, historic and human influenced wetland landscape lying to the north-west of The Wash Estuary (which is a large intertidal bay of ecologically important estuarine mudflats, sandbanks, and saltmarshes). The catchment is notable for its large, flat and open topography with drainage ditches and dykes draining towards the Wainfleet Haven, which flows into The Wash Estuary close to a few distinct environmental designations including local nature reserves like Gibraltar Point, and SSSIs such as The Wash which cover a large proportion of the East and West Fens catchment coastline. Permanent inundation could lead to the loss of these habitats and the associated Natural Capital benefits they provide. In addition, these sites plus Public Rights of Way and other open spaces provide significant wellbeing value to local communities and visitors.

It should be noted that the damages and benefits calculated for environmentally designated sites in this section differ from the valuation of ecosystem service presented in the Natural Capital reporting in the baseline report. This is because the Natural Capital reporting provides a total value of ecosystem services currently estimated to be provided across the catchment, whilst this analysis focuses on estimating the impacts and losses of these services, and only for designated sites.



**Figure 11: Havenside Local Nature Reserve**

© Dave Hitchborne

### 5.3.1 Do-Nothing approach

Damages as a result of the loss of environmentally designated habitats, local nature reserves, Public Rights of Way (PRoW) and other open spaces have been calculated for

the Do-Nothing scenario. It is assumed damages associated with the majority of the remaining rural landscape have been captured as part of the agricultural analysis.

Environmental sites have been identified through the Natural Capital baselining work, with geospatial outputs from that work used to inform this assessment. This captured environmentally designated sites (including Natura 2000, SSSIs, RAMSAR, Local & National Nature Reserves, Special Protection Areas and WTT) for each catchment. In addition, PRowS and other open spaces have been captured based on data in the ORVal tool (University of Exeter)<sup>17</sup>.

Comparison with CEH Land Cover plus Crops data was undertaken to remove any areas included within the agricultural damages assessment and remove the possibility of double counting of damages. However, where agricultural land is written off, an assessment of potential benefits generated through provision of alternative ecosystem services has been undertaken as a sensitivity analysis under the agricultural damages assessment (see section 5.2.6).

Estimates of quantified ecosystem service benefits were calculated within the Natural Capital Baselining work using the NCRAT tool (with data informing this primarily from the DEFRA ENCA services data-book<sup>18</sup> and ORVal tool<sup>17</sup>). The areas identified as providing ecosystem benefits from this work were compared with the areas of permanent inundation to determine which sites would be lost, and as a result which ecosystem services would be lost. This builds on the work undertaken for the Great Ouse which valued only the most prominent ecosystem services afforded by the designated sites, which are considered to be:

- Carbon – i.e. the sequestration of carbon dioxide from the atmosphere. This varies between types of broad habitats.
- Flood regulation – i.e. some habitats can offer flood risk management benefits by regulating water flow through the retention and slowing of water.
- Recreation – i.e. environmental settings providing recreational use. The analysis is based on reported visitor numbers and Willingness to Pay (WTP) (£/visit) from the University of Exeter Outdoor Recreation Valuation Tool<sup>17</sup> (ORVal: Version 2.0) for specific site locations, aligned with other WTP for nature conservation sites.
- Biodiversity – i.e. providing habitats to support variability among living organisms, that supports the provision of environmental goods and services to people.
- Non-use value – i.e. the benefit of individuals knowing that an aspect of the environment exists and is being, or will be, maintained.

The percentage of the total area of each site lost in each Do-Nothing permanent flood level has been used to determine the loss of ecosystem services based on the total ecosystem services the sites are calculated to provide within the Natural Capital baseline.

The land use will change to coastal habitat, as per the broad definitions used in the Natural Capital baselining, though existing coastal habitats will change to marine habitats. However, no ecosystem service gains are included initially for the area permanently or

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<sup>17</sup> Day, B. H., and G. Smith (2018). Outdoor Recreation Valuation (ORVal) User Guide: Version 2.0, Land, Environment, Economics and Policy (LEEP) Institute, Business School, University of Exeter. Available online at: <https://www.leep.exeter.ac.uk/orval/>.

frequently flooded, as it is considered that this inundation is also likely to create contamination issues within the area, from increasing salinity, historical land use sources and other sources such as active and disused landfill sites. Over the longer-term, there is uncertainty over whether the area may become a “naturally functioning” system due to the absence of fresh sand supply and the presence of man-made structures within the flooded area, potentially limiting the quality of the habitat and the ecosystem services provided. However, it has been assumed that 50 years after the maximum water level is achieved, the change of land use will result in a naturally functioning habitat that will start to deliver ecosystem service benefits.

**Table 5-21: Habitat designation type and sites impacted**

Habitat Designation	Sites
Coastal	<ul style="list-style-type: none"> <li>• The Wash</li> <li>• Havenside LNR</li> </ul>

For recreational losses, wellbeing values associated with the PRowS and open spaces identified in ORVal<sup>17</sup> have been used to determine potential losses. A displacement factor, representing the number of visitors who would go to an alternative site, has been calculated for each site independently. However, for the Do Nothing scenario with write off across many sites and PRowS, an average value for displacement has been taken across the entire catchment, as it is considered some of the alternative sites to which it could be assumed visitors would go will also have been lost.

### 5.3.2 Maintain scenario approach

Losses of ecosystem services in a Maintain scenario are considered likely to occur where flooding is sufficiently frequent that it would impair the ability of the site to deliver these services. It can reasonably be assumed that a site would therefore need to be impacted in a 2-year return period (50% annual exceedance probability), or more frequently, for a habitat to be impacted in this way.

Of the catchments being considered as part of the Fens 2100+ work, only the Steeping catchment has data to inform risk in a 2-year return period event. The other catchments have insufficient evidence to determine areas which may be affected. Therefore, no losses as a result of environmentally designated site damages in the Maintain scenario are being considered as part of this appraisal.

For wellbeing, losses have been estimated for sites which are shown to be impacted by flood risk. It has been assumed that wellbeing value is lost for a period of disruption to the site, assumed to be one week. The losses have been converted into an Annual Average Damage based on probability of events occurring and total loss of wellbeing value as a result.

### 5.3.3 Key assumptions

**Table 5-22: Environmental assumptions**

Key assumptions:			
Environmental benefit valuations (DEFRA NCRAT, ENCA <sup>18</sup> , ORVal <sup>17</sup> )	Economic values drawn from research literature and the ENCA Services data book <sup>18</sup> created by DEFRA indicates economic values associated with a range of factors including carbon storage and residual flood storage. They include selected quantified benefits only and use cautious rates for estimating.  Values for recreational benefits are based on the Welfare values taken from the ORVal tool (University of Exeter) <sup>17</sup> .		
Environmental assumptions	It is recognised that whilst habitats may be lost, permanent inundation may result in the development of new habitats (e.g. wetlands) offering additional benefits. However, inundation is also likely to create contamination issues within the area from increasing salinity, historical land use sources and any other sources such as active and disused landfill sites. Over the longer-term, there is uncertainty over whether the area may become a “naturally functioning” system due to the absence of fresh sand supply and the presence of man-made structures within the flooded area. A conservative estimate of 50 years from maximum water level being reached has been used to determine when a new land use type may start to deliver ecosystem service benefits.		
Existing Habitat Type	Total Impact Value (2025) (£)	New Habitat	Change in Total Impact Value (2025) (£)
Wetlands / Freshwater	1,976	Coastal	+5,069
Woodland	2,036	Coastal	+5,010
Semi-natural grassland	462.31	Coastal	+6,583
Urban	-269	Coastal	+7,314
Enclosed farmland	576	Coastal	+6,470
Marine	874	Marine	-
Coastal	7,045	Marine	-6,171
Mountain, moor and heath	651	Coastal	+6,394
Recreational Asset	Displacement Factor (%)	Maintain Flood Duration (days)	
Parks and other recreational sites	35	7	
Public rights of way	30	7	
Key datasets:			
<ul style="list-style-type: none"> <li>Natural Capital Baseline assessment</li> <li>National Nature Reserves in England</li> <li>Local Nature Reserves in England</li> <li>Site of Special Scientific Interest (SSSI)</li> <li>ORVal Valuation Data (University of Exeter)<sup>17</sup></li> </ul>			

<sup>18</sup> Department for Environment, Food and Rural Affairs (2025) *Enabling a Natural Capital Approach*. Available online at: <https://www.data.gov.uk/dataset/3930b9ca-26c3-489f-900f-6b9eec2602c6/enabling-a-natural-capital-approach>.

**Key assumptions:**

- DEFRA ENCA<sup>18</sup>
- OS Greenspaces Sites<sup>19</sup>
- Rowmaps: Public Rights of Way<sup>20</sup>

**5.3.4 Do-Nothing scenario outcomes**

The total areas impacted in hectares for the environmental and recreational sites, as well as the lengths of public rights of way, can be seen in Table 5-23, Table 5-24, and Table 5-25 respectively.

**Table 5-23: Do Nothing - area of environmental sites impacted (cumulative) (ha) and PV losses from environmental sites (cumulative) (£k)**

Appraisal year (Year)	Environmental sites impacted (ha)				PV Environmental losses (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	0	0	0	5	0	0	0	42
1	0	0	0	11	0	0	0	144
2	0	0	0	32	0	0	0	426
3	0	0	0	335	0	0	0	2,887
4	0	0	0	428	0	0	0	5,903
5	0	0	0	428	0	0	0	8,817
99	0	0	0	428	0	0	0	92,905

**Table 5-24: Do Nothing – area of recreational sites impacted (cumulative) (ha) and PV damages to recreational sites (cumulative) (£k)**

Appraisal year (Year)	Recreational sites impacted (ha)				PV Recreation damages (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	0.16	0.39	38.49	1.18	0	1	100	3
1	0.85	1.97	63.53	11.21	3	6	263	32
2	1.41	4.41	68.52	17.81	6	17	436	77
3	1.41	5.06	71.67	21.61	10	30	614	131
4	1.41	5.48	72.72	23.26	13	43	793	188
5	1.41	5.60	72.72	23.26	16	57	968	244
99	1.41	5.60	72.72	23.26	194	764	10,160	3,184

<sup>19</sup> <https://www.ordnancesurvey.co.uk/products/os-mastermap-greenspace-layer>

<sup>20</sup> Cornelius, B. (no year). Rowmaps: Maps, KML and GPX showing rights of way. Retrieved from: <https://www.rowmaps.com/>

**Table 5-25: Do Nothing – length of public rights of way impacted (cumulative) (m) and PV damages to public rights of way (cumulative) (£k)**

Appraisal year (Year)	Public rights of way impacted (m)				PV Recreation damages (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	13,588	10,756	24,808	10,515	154	122	282	119
1	16,304	11,472	27,200	19,281	337	251	586	335
2	20,047	15,841	29,507	30,136	558	425	912	668
3	20,047	17,695	29,507	43,301	776	618	1,232	1,138
4	20,047	18,262	31,364	44,990	990	813	1,568	1,620
5	20,047	18,262	31,364	44,990	1,202	1,006	1,899	2,094
99	20,047	18,262	31,364	44,990	12,265	11,083	19,207	26,922

The losses associated with impacted environmental and recreational sites as well as public rights of way result in total damages of £188,704k by the end of the 100-year appraisal period. Discounted over 20-years in line with a tactical plan period, the total environmental and recreational damages amount to £104,473k.

### 5.3.5 Maintain scenario outcomes

**Table 5-26: Maintain scenario - area of recreational sites impacted (cumulative) (ha) and the associated cash damages (£)**

Annual Exceedance Probability	Recreational sites impacted (ha)				Cash damages (£)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
3.33%	0.06	0	14.68	3.54	3	0	721	160
1%	0.17	2.36	47.36	6.49	8	118	2,330	285
0.1%	0.60	5.54	71.71	25.44	30	276	3,573	1,228

**Table 5-27: Maintain scenario - length of public rights of way impacted (cumulative) (m) and the associated cash damages (£k)**

Annual Exceedance Probability	Public rights of way impacted (m)				Cash damages (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
3.33%	19,648	7,149	15,766	54,893	4	2	3	12
1%	21,974	13,991	26,654	75,510	5	3	6	16
0.1%	22,920	18,262	31,771	82,348	5	4	7	18

These cash damages produce AAD losses of just £1k. This gives PV losses of £55k when discounted across the 100-year appraisal period and £17k when discounted across the 20-year tactical plan period.

### 5.3.6 Sensitivity testing

#### 5.3.6.1 Reduction in valuations used in defining ecosystem services

A sensitivity test has been undertaken to test a reduction in the level of ecosystem service benefits provided by each habitat type. This test has been used to account for potential for:

- double counting of benefits across different ecosystem service types
- uncertainty in the level of ecosystem services a site can provide.

The test has assessed a 25% and 50% reduction in the value of ecosystem service benefits for all habitat types.

**Table 5-28: Do Nothing - area of environmental sites impacted (cumulative) (ha) and PV losses from environmental sites (cumulative) (£k) with a 25% reduction in ecosystem service benefits for all habitat types**

Appraisal year (Year)	Environmental sites impacted (ha)				PV Environmental losses (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	0	0	0	5	0	0	0	34
1	0	0	0	11	0	0	0	133
2	0	0	0	32	0	0	0	633
3	0	0	0	335	0	0	0	2,634
4	0	0	0	428	0	0	0	4,992
5	0	0	0	428	0	0	0	7,272
99	0	0	0	428	0	0	0	73,044

Note: negative losses are due to ecosystem service gains associated with long term land use change

**Table 5-29: Do Nothing - area of environmental sites impacted (cumulative) (ha) and PV losses from environmental sites (cumulative) (£k) with a 50% reduction in ecosystem service benefits for all habitat types**

Appraisal year (Year)	Environmental sites impacted (ha)				PV Environmental losses (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	0	0	0	5	0	0	0	25
1	0	0	0	11	0	0	0	106
2	0	0	0	32	0	0	0	553
3	0	0	0	335	0	0	0	2,020
4	0	0	0	428	0	0	0	3,722
5	0	0	0	428	0	0	0	5,367
99	0	0	0	428	0	0	0	52,822

Note: negative losses are due to ecosystem service gains associated with long term land use change

### 5.3.6.2 Changes in displacement of visitors making use of alternative sites

A sensitivity test has been undertaken to determine the impact of lower or higher displacement of visitors to environmental sites for both the Do Nothing and Maintain scenarios. This has tested a change in displacement by 10 and 20 percentage points, both as an increase and a decrease. The results of this sensitivity test are shown in Table 5-30 to Table 5-37.

**Table 5-30: Do Nothing – PV damages to welfare values of recreational sites when the displacement factor is changed by 20 percentage points**

Appraisal year (Year)	PV damages (£k): +20 percentage points				PV damages (£): -20 percentage points			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	0	1	71	2	1	1	130	4
1	2	4	186	22	3	8	340	41
2	4	12	308	54	8	22	564	99
3	7	21	434	92	12	39	795	169
4	9	31	560	132	17	56	1,026	243
5	12	40	684	172	21	73	1,253	315
99	137	539	7,172	2,248	252	989	13,148	4,121

**Table 5-31: Do Nothing – PV damages to welfare values of public rights of way when the displacement factor is changed by 20 percentage points**

Appraisal year (Year)	PV damages (£k): +20 percentage points				PV damages (£): -20 percentage points			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	110	87	201	85	198	157	362	154
1	241	179	419	239	433	322	754	431
2	399	304	651	477	717	547	1,172	858
3	554	441	880	813	997	794	1,584	1,463
4	707	581	1,120	1,157	1,273	1,045	2,016	2,082
5	858	718	1,356	1,496	1,545	1,293	2,441	2,692
99	8,760	7,917	1,3719	19,230	15,769	14,250	24,695	34,614

**Table 5-32: Do Nothing – PV damages to welfare values of recreational sites when the displacement factor is changed by 10 percentage points**

Appraisal year (Year)	PV damages (£k): +10 percentage points				PV damages (£k): -10 percentage points			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	0	1	85	3	0	1	115	4
1	2	5	224	27	3	7	302	36
2	5	15	372	65	7	20	500	88
3	8	25	524	111	11	34	705	150
4	11	37	676	160	15	50	909	215
5	14	48	826	208	19	65	1,111	280
99	166	652	8,666	2,716	223	876	11,654	3,652

**Table 5-33: Do Nothing – PV damages to welfare values of public rights of way when the displacement factor is changed by 10 percentage points**

Appraisal year (Year)	PV damages (£k): +10 percentage points				PV damages (£k): -10 percentage points			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	132	105	242	102	176	140	322	137
1	289	215	503	287	385	286	670	383
2	478	365	781	572	638	486	1,042	763
3	665	529	1,056	975	887	706	1,408	1,301
4	849	697	1,344	1,388	1,132	929	1,792	1,851
5	1,030	862	1,628	1,795	1,373	1,149	2,170	2,393
99	10,513	9,500	16,463	23,076	14,017	12,667	21,951	30,768

Changing the displacement factor by ten percentage points results in the Do Nothing PV recreational damages over the 100-year appraisal period to change by 14 percent, that is an increase to £95,807k and a decrease to £71,750k from £83,779k. Considering the sensitivity test, which adjusts the displacement factor by 20 percentage points, the PV recreational damages change by 29 percent, which results in an increase of damages to £107,836k and a decrease to £59,722k.

**Table 5-34: Maintain – Cash damages to welfare values of recreational sites when the displacement factor is changed by 20 percentage points**

Annual Exceedance Probability	Cash damages (£): +20 percentage points				Cash damages (£): -20 percentage points			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
3.33%	2	0	506	108	4	0	937	212
1%	6	83	1,634	190	11	152	3,025	381
0.1%	21	195	2,509	855	39	358	4,637	1,602

**Table 5-35: Maintain – Cash damages to welfare values of public rights of way when the displacement factor is changed by 20 percentage points**

Annual Exceedance Probability	Cash damages (£k): +20 percentage points				Cash damages (£k): -20 percentage points			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
3.33%	3	1	2	9	6	2	4	15
1%	3	2	4	12	6	4	7	21
0.1%	4	3	5	13	6	5	9	23

**Table 5-36: Maintain – Cash damages to welfare values of recreational sites when the displacement factor is changed by 10 percentage points**

Annual Exceedance Probability	Cash damages (£): +10 percentage points				Cash damages (£): -10 percentage points			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
3.33%	3	0	614	134	4	0	829	186
1%	7	100	1,982	238	10	135	2,677	333
0.1%	26	236	3,041	1,041	34	317	4,105	1,415

**Table 5-37: Maintain – Cash damages to welfare values of public rights of way when the displacement factor is changed by 10 percentage points**

Annual Exceedance Probability	Cash damages (£k): +10 percentage points				Cash damages (£k): -10 percentage points			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
3.33%	4	1	3	10	5	2	4	14
1%	4	3	5	14	5	3	7	19
0.1%	4	3	6	15	6	5	8	21

Changing the displacement factor by ten percentage points results in the Maintain PV recreational damages over the 100-year appraisal period to change by 14 percent, that is an increase to £62k and a decrease to £47k from £54k. Considering the sensitivity test, which adjusts the displacement factor by 20 percentage points, the PV recreational damages change by 29 percent, which results in an increase of damages to £70k and a decrease to £39k.

### 5.3.6.3 Land use change in the Do Nothing resulting in alternative habitat type

A sensitivity analysis has been undertaken to determine the impact of a change in the habitat type resulting from a change in land use in the Do Nothing. The baseline assessment assumes all areas will become coastal habitat, with existing coastal habitat becoming marine habitat. This sensitivity test assesses the impact on losses or benefits as a result of land use changing to wetlands/freshwater habitat instead, though coastal habitat will still change to marine habitat as previously.

**Table 5-38: Do Nothing - area of environmental sites impacted (cumulative) (ha) and PV losses from environmental sites (cumulative) (£k) where non-coastal/marine habitats shift to wetlands/freshwater habitat**

Appraisal year (Year)	Environmental sites impacted (ha)				PV Environmental losses (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	0	0	0	5	0	0	0	42
1	0	0	0	11	0	0	0	144
2	0	0	0	32	0	0	0	426
3	0	0	0	335	0	0	0	2,887
4	0	0	0	428	0	0	0	5,903
5	0	0	0	428	0	0	0	8,817
99	0	0	0	428	0	0	0	92,905

Note: negative losses are due to ecosystem service gains associated with long term land use change

For the East and West Fens catchment all of the habitat already falls into the coastal habitat type and therefore there are no long-term change in habitat benefits for either a change to coastal or freshwater.

## 5.4 Heritage losses

The East and West Fens catchment contains several heritage sites at risk of flooding. The catchment area has 179 listed buildings, 13 are grade 1, 166 are grade 2 and 9 are grade 2\*. These structures often include elements of timber construction that might be considered more susceptible to flood conditions. Within the East and West Fens catchment are also 13 scheduled monuments.



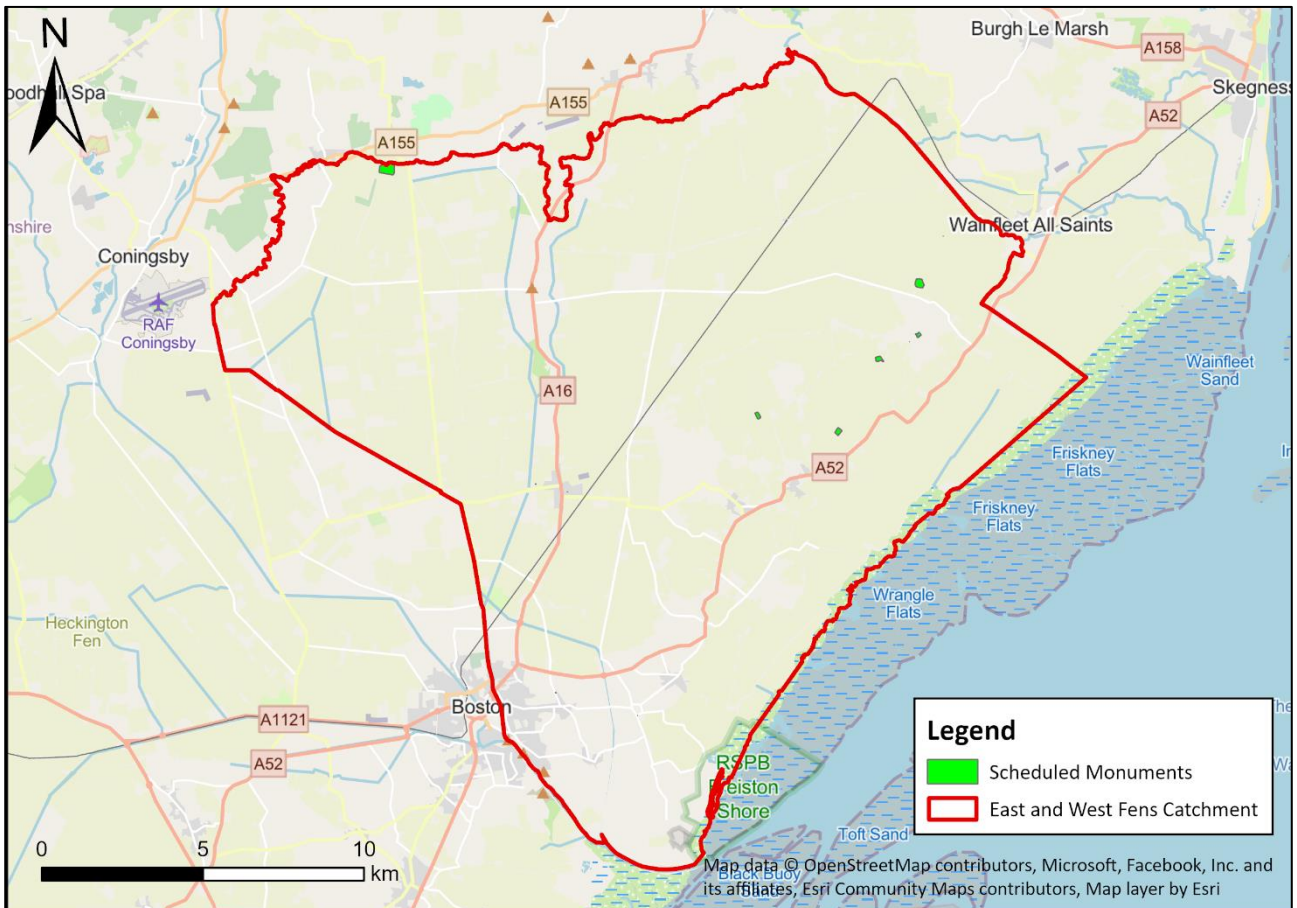
**Figure 12: King's Hill Motte and Bailey**

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Figure 13 shows that there are a total of 13 scheduled monuments in the East and West Fens catchment area. The 13 scheduled monuments are:

- Revesby Abbey;
- Churchyard cross, St James's churchyard;
- Churchyard cross, St Margaret's churchyard;
- Moated site 300m NE of All Saints Church;
- Churchyard cross, All Saints churchyard;
- Sibsey Trader Windmill;
- Churchyard cross, St Andrew's churchyard;

- Churchyard cross, St Mary's churchyard;
- Abbey Hills moated site;
- Rochford Tower;
- Medieval dyings and flood defence bank at Gold Fen Dike Bank, immediately south west of Ash Cottage;
- King's Hill motte and bailey castle; and,
- Decoy Wood decoy pond.



**Figure 13: Location of scheduled monuments in the East and West Fens catchment area**

#### 5.4.1 Do-Nothing scenario approach

Heritage assets at risk of flooding in the catchment area are identified using a range of data sources, which are outlined in Table 5-39. The value of these heritage assets will be calculated using the DCMS Culture and Heritage Capital Evidence Bank<sup>21</sup>. This valuation approach aligns with the Social Cost Benefit Analysis methods in the HM Treasury Green Book Guidance (2020).

Heritage assets are split into broad categories and Willingness-to-pay values are used to define the benefit. These benefits are split into user benefits, for those who visit and use

<sup>21</sup> [Rapid Evidence Assessment: Culture and Heritage Valuation Studies - GOV.UK \(www.gov.uk\)](https://www.gov.uk)

an asset, and non-user benefits which accounts for the value an asset provides to those in the local community who are aware of its existence, and value this, but do not necessarily visit it.

In the Do Nothing scenario write-off damages at each site will be calculated based on the total annual value of heritage capital lost for the area that is permanently inundated, forecast and discounted across the remainder of the appraisal period from the point at which it is lost. Residual AAD will not continue to be accrued for the assets that has been written off.

### 5.4.2 Maintain scenario approach

For the Maintain scenario the Willingness-to-pay valuations of assets are used along with estimated periods of disruption due to flood risk to determine a disruption cost for the asset being unavailable for a short period of time.

### 5.4.3 Key assumptions

**Table 5-39: Key assumptions for heritage losses**

Key assumptions			
DCMS Asset Types and Valuations	Cultural or Heritage Asset Type	Mean Low Willingness to Pay (£, 2025)	Mean High Willingness to Pay (£, 2025)
	Archaeological asset	8	17
	Built heritage	14	25
	Library	233	338
	Museum	36	73
Disruption time in the Maintain scenario	The valuation of heritage assets for this economic appraisal relies on a Willingness to Pay value which is assumed to be an annual value. This brings some limitations with it as some heritage assets may take a year to be fully dried and back in use, whilst others may only need months or weeks, and so when valuing disruption, there may be discrepancies in how much of the Willingness to Pay value is lost due to disruption. A single assumption of 1 year of value is used for simplicity in the assessment given the broad range of potential receptors covered.		
<b>Key datasets:</b>			
<ul style="list-style-type: none"> <li>• Department for Digital, Culture, Media and Sport. (2022). Culture and Heritage Capital Evidence Bank.</li> <li>• Historic England. (2023). Listed Buildings.</li> <li>• Historic England. (2023). Scheduled Monuments.</li> <li>• Office for National Statistics. (2024). Lower layer Super Output Area population estimates.</li> </ul>			

#### 5.4.4 Do-Nothing scenario outcomes

**Table 5-40: Do Nothing - number of heritage assets impacted (cumulative) and PV heritage losses (cumulative) (£k)**

Appraisal year (Year)	Heritage sites impacted				PV Heritage losses (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	3	6	25	2	40	81	289	25
1	3	9	34	7	78	188	664	87
2	3	17	56	22	115	378	1,254	252
3	3	18	73	40	151	574	1,992	566
4	3	18	77	50	185	763	2,735	953
5	3	18	77	50	219	946	3,452	1,327
99	3	18	77	50	1,183	6,224	24,164	12,123

The losses associated with impacted heritage assets in the Do Nothing are shown in Table 5-40. Approximately 148 heritage assets are impacted resulting in total damages of £43,694k by the end of the appraisal period. Discounted over the 20-year period in line with that of a tactical plan, heritage losses amount to £20,230k.

#### 5.4.5 Maintain scenario outcomes

**Table 5-41: Maintain scenario - number of heritage assets impacted (cumulative) and the associated cash damages (£k)**

Annual Exceedance Probability	Heritage sites impacted (ha)				Cash losses (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
3.33%	1	4	10	2	1	2	5	1
1%	1	7	21	10	1	4	9	4
0.1%	2	18	82	64	1	8	35	22

These cash damages produce AAD losses of £0.7k.

This gives a PV losses of £40k when discounted across the 100-year appraisal period and £13k when discounted across the 20-year period aligning with potential tactical plans, which is used as a sensitivity test.

#### 5.4.6 Sensitivity testing

##### 5.4.6.1 Change in willingness to pay valuations

A sensitivity test has been undertaken to test a change in the level of willingness to pay values for heritage assets. The test has assessed a 25% increase and decrease in the

willingness to pay rates for all heritage asset types. This test was applied to both Do Nothing and Maintain scenarios.

**Table 5-42: Do Nothing – PV heritage losses when the willingness to pay rates are changed by 25 percentage points**

Appraisal year (Year)	PV damages (£k): +25 percentage points				PV damages (£k): -25 percentage points			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	50	101	361	32	30	61	217	19
1	98	235	830	109	59	141	498	65
2	144	472	1,568	315	86	283	941	189
3	189	717	2,490	708	113	430	1,494	425
4	232	954	3,418	1,192	139	572	2,051	715
5	274	1,182	4,315	1,659	164	709	2,589	996
99	1,479	7,780	30,204	15,154	887	4,668	18,123	9,092

**Table 5-43: Maintain scenario - heritage losses when the willingness to pay rates are changed by 25 percentage points**

Annual Exceedance Probability	Cash damages (£k): +25 percentage points				Cash damages (£k): -25 percentage points			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
3.33%	1	3	6	1	0.4	2	4	1
1%	1	5	11	5	0.4	3	7	3
0.1%	1	10	44	28	1	6	26	17

## 5.5 Infrastructure damages

The catchment plays host to mostly minor country roads, with two primary routes (A16 and A52) crossing the catchment. The East Midlands Railway line, which provides the only rail connection between the major towns of Skegness and Sleaford, also crosses the catchment. Other major infrastructure, such as major electrical distribution networks, also cross the catchment.

Whilst infrastructure assets are generally protected to a fairly high standard for infrequent flood events, if the catchment were to become permanently or extensively impacted, vast swathes of infrastructure would be abandoned with alternative capacities or diversions required.

There are localised areas of existing risk, which whilst not primary roads or assets, are key connections between communities. Closures of these connections leads to disruption and local financial losses for businesses such as shops and pubs with customers having to take a longer route to access them or going elsewhere. These localised risks of disruption and financial losses are not captured as part of this assessment.



**Figure 14: Main road A16**

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Infrastructure assets are assumed to be largely protected to a high standard against short term flooding from infrequent events, and as such only damages associated with the Do-Nothing permanent flooding case have been calculated. The following two sections describe impacts to transport and utilities infrastructure.

## 5.6 Transport damages

### 5.6.1 Do-Nothing scenario approach

The Do-Nothing scenario assumes gradual inundation of the catchment resulting in highways infrastructure being written off as flood levels increase across the catchment. Damages from infrequent flood events, as per MCM guidance, are typically calculated based on disruption to traffic or damage repair costs (e.g. resurfacing). In this instance, highways are assumed to be permanently inundated resulting in a loss of the asset. The damage value has been defined from the length of highway impacted at each step-change in inundation of the catchment.

A sense check on highways being written off was undertaken to ensure these were only valued where they connect settlements outside of the catchment and are not valued where they just serve settlements within the catchment. This is because the highway would cease to have any value if the settlement it serves is lost to permanent inundation.

Further to the consideration of highways written off, the impact on rail infrastructure has also been considered. The same approach as highways is used for railways, with the length of infrastructure impacted used to define the damage value. No allowance has been made for loss of railway stations, as it is considered these would cease to have value when the communities they serve become permanently inundated.

### 5.6.2 Key assumptions

**Table 5-44: Do Nothing transport assumptions**

Key assumptions:					
Value of lost highway infrastructure	The value of lost roads has been based on the Future Fens (Great Ouse) economic analysis, which considered recent data from new build road schemes. No further publicly available information was considered to better the information utilised. Costs expressed in 2025 values.				
	<table border="1"> <thead> <tr> <th>Type of Road</th> <th>Cost per Metre (£)</th> </tr> </thead> <tbody> <tr> <td>A Road</td> <td>22,122</td> </tr> </tbody> </table>	Type of Road	Cost per Metre (£)	A Road	22,122
	Type of Road	Cost per Metre (£)			
A Road	22,122				
Roads impacted	A-Roads and primary roads (such as motorways) have been identified within the catchments using OS Open Roads dataset.				
Value of lost railway infrastructure	The value of lost railway has been based on the Future Fens (Great Ouse) economic analysis, which considered recent data from new build rail schemes. No further publicly available information was considered to better the information utilised. Costs expressed in 2025 values.				
	<table border="1"> <thead> <tr> <th></th> <th>Cost per Metre (£)</th> </tr> </thead> <tbody> <tr> <td>Railway cost</td> <td>6,301</td> </tr> </tbody> </table>		Cost per Metre (£)	Railway cost	6,301
		Cost per Metre (£)			
Railway cost	6,301				
Railway impacted	Railway identified within the catchments using OS Open dataset.				
Key datasets:					
<ul style="list-style-type: none"> <li>Length and type of highway impacted defined from OS Open Roads dataset (2023)</li> <li>Length of railway impacted defined from OS Open dataset (2024)</li> </ul>					

### 5.6.3 Do-Nothing scenario outcomes

**Table 5-45: Do-Nothing - length of road network impacted (cumulative) (m) and PV road network damages (cumulative) (£k)**

Appraisal year (Year)	Length of road impacted (m)				PV Highways damages (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	444	0	106	70	14,686	0	3,511	2,319
1	915	0	4,369	4,125	29,725	0	139,721	131,900
2	1,675	0	16,505	13,205	53,205	0	514,390	412,199
3	1,675	0	23,565	18,543	53,205	0	724,975	571,436
4	1,675	0	26,495	21,283	53,205	0	809,417	650,387
5	1,675	0	26,495	21,283	53,205	0	809,417	650,387
99	1,675	0	26,495	21,283	53,205	0	809,417	650,387

**Table 5-46: Do-Nothing - length of rail network impacted (cumulative) (m) and PV rail network damages (cumulative) (£k)**

Appraisal year (Year)	Length of rail impacted (m)				PV Railway damages (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	0	0	7,971	0	0	0	50,224	0
1	0	0	10,860	0	0	0	67,806	0
2	0	0	15,600	0	0	0	95,686	0
3	0	0	17,763	0	0	0	107,977	0
4	0	0	18,947	0	0	0	114,476	0
5	0	0	18,947	0	0	0	114,476	0
99	0	0	18,947	0	0	0	114,476	0

The damages associated with impacted road and rail networks for the Do-Nothing scenario are seen in Table 5-45 and Table 5-46. Approximately 49.5km of road network is impacted, resulting in total damages of £1,513,009k by the end of the appraisal period. Around 18.9km of rail network is impacted over the same period, leading to an observed £114,476k of damages. When combined, these damages give us a transport damage total of £1,627,485k.

### 5.6.4 Sensitivity testing

Sensitivity testing has been undertaken to assess:

- the valuations used for roads, with variance by 25%.
- the valuations used for railways, with variance by 25%.

The damages associated with decreasing and increasing the valuations of roads and railways by 25% each can be seen in Table 5-47 and Table 5-48.

**Table 5-47: Do-Nothing - PV road and rail network damages (cumulative) (£k) with a 25% decrease in valuations**

Appraisal year (Year)	PV Highways damages (£k)				PV Railway damages (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	11,014	-	2,633	1,739	-	-	37,668	-
1	22,293	-	104,790	98,925	-	-	50,854	-
2	39,904	-	385,793	309,149	-	-	71,764	-
3	39,904	-	543,732	428,577	-	-	80,982	-
4	39,904	-	607,063	487,790	-	-	85,857	-
5	39,904	-	607,063	487,790	-	-	85,857	-
99	39,904	-	607,063	487,790	-	-	85,857	-

**Table 5-48: Do-Nothing - PV road and rail network damages (cumulative) (£k) with a 25% increase in valuations**

Appraisal year (Year)	PV Highways damages (£k)				PV Railway damages (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	18,357	-	4,388	2,898	-	-	62,780	-
1	37,156	-	174,651	164,875	-	-	84,757	-
2	66,506	-	642,988	515,248	-	-	119,607	-
3	66,506	-	906,219	714,295	-	-	134,971	-
4	66,506	-	1,011,772	812,894	-	-	143,095	-
5	66,506	-	1,011,772	812,894	-	-	143,095	-
99	66,506	-	1,011,772	812,894	-	-	143,095	-

With a 25% decrease in road valuation, there is a total damage value of £1,134,757k by the end of the appraisal period. This means that there was a decrease in PV damages of £378,252k. Similarly, a 25% decrease in rail valuation resulted in a decrease in PV damages of £28,619k, resulting in a total of £85,857k. When combined, these damages give us a transport damage total of £1,220,614k.

With a 25% increase in road valuation, there is a total damage value of £1,891,262k by the end of the appraisal period. This means that there was an increase in PV damages of £378,252k. Similarly, a 25% increase in rail valuation resulted in an increase in PV damages of £28,619k, resulting in a total of £143,095k. When combined, these damages give us a transport damage total of £2,034,357k.

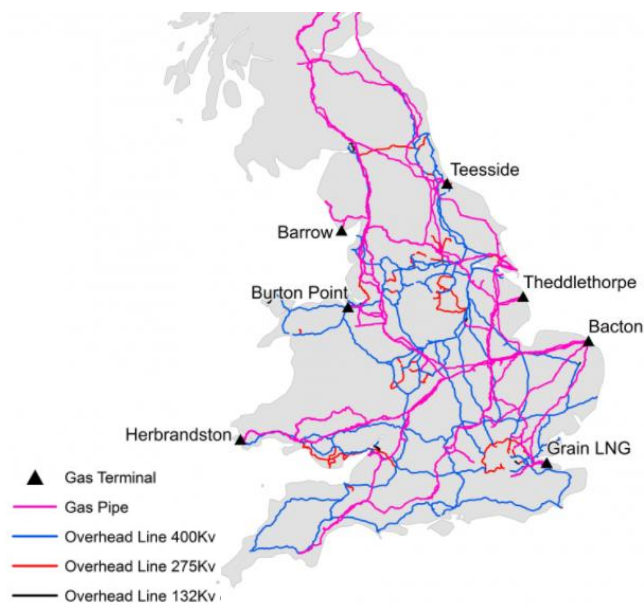
## 5.7 Utilities damages

For each of the utilities damage streams, damages are assumed (conservatively) to include only the assets directly impacted by permanent inundation within the Do-Nothing scenario. This does not account for the wider impacts and disruption likely to occur as parts of the network become flooded but was considered an appropriate approach at this stage where broad representation of damages is required and the data and effort to assess wider disruption would be disproportionate.

### 5.7.1 Power networks

Data pertaining to power generation assets within the catchments have been obtained from partners. The costs for the construction of infrastructure generating the equivalent power impacted by the Do-Nothing scenario has been calculated based on data from the UK Energy Generation Costs report<sup>22</sup> (Department for Energy Security and Net Zero) and used as a proxy for the value of infrastructure lost.

Electrical distribution assets across the catchments have been identified for Western Power Distribution (WPD), UK Power Networks and National Grid. The damages have been defined by the number of their assets within the permanently inundated extents, based upon publicly available GIS asset databases. This primarily relates to substations and pole tower assets. The value assigned to these assets is detailed in Table 5-49.



**Figure 15: National Grid electricity and gas distribution network**

Source: National Grid 2021

### 5.7.2 Water

Damages to above-ground water utility assets are assumed to have been captured through the NRD datasets, providing a proxy of the damages associated with these assets.

<sup>22</sup> <https://www.gov.uk/government/publications/electricity-generation-costs-2023>

No further data was available from Anglian Water to understand the asset-base at risk of inundation where these assets are not represented in NRD. The value of assets not included within the NRD data is therefore excluded from this assessment.

### 5.7.3 Gas

Damages would have been calculated for the loss of National Grid gas distribution assets based on the length (km) of gas main impacted at the permanently inundated water level, with geographically referenced data for the location of the pipeline being obtained from National Grid. However, there were no National Grid gas distribution assets found within the East and West Fens catchment. As such, no damages have been calculated.

### 5.7.4 Key assumptions

**Table 5-49: Do Nothing utilities assumptions**

Key assumptions:																							
Electrical asset replacement costs	<p>Electrical asset replacement costs for Poles and Substations are based on stakeholder engagement undertaken by the Future Fens (Great Ouse) economic analysis with UKPN. Overhead Conductors replacement costs have been derived from data by Electrical Engineering Portal, whilst Underground Cables replacement costs are derived from data by Roadnight Taylor. These costs have been applied across the National Grid and WPD assets as a proxy. All costs are expressed as 2025 values.</p> <table border="1"> <thead> <tr> <th>Asset (UKPN &amp; WPD)</th> <th>Replacement cost (2025)</th> </tr> </thead> <tbody> <tr> <td>Pole Tower (33kV)</td> <td>£3,752</td> </tr> <tr> <td>Pole Tower (11kV)</td> <td>£3,752</td> </tr> <tr> <td>Substation (132kV)</td> <td>£3,877,438</td> </tr> <tr> <td>Substation (33kV)</td> <td>£93,809</td> </tr> <tr> <td>Substation (11kV)</td> <td>£31,270</td> </tr> <tr> <td>Overhead Conductors (132kV)</td> <td>£144 per m</td> </tr> <tr> <td>Overhead Conductors (33kV)</td> <td>£58 per m</td> </tr> <tr> <td>Overhead Conductors (11kV)</td> <td>£23 per m</td> </tr> <tr> <td>Underground Cables (33kV)</td> <td>£339 per m</td> </tr> <tr> <td>Underground Cables (11kV)</td> <td>£169 per m</td> </tr> </tbody> </table>	Asset (UKPN & WPD)	Replacement cost (2025)	Pole Tower (33kV)	£3,752	Pole Tower (11kV)	£3,752	Substation (132kV)	£3,877,438	Substation (33kV)	£93,809	Substation (11kV)	£31,270	Overhead Conductors (132kV)	£144 per m	Overhead Conductors (33kV)	£58 per m	Overhead Conductors (11kV)	£23 per m	Underground Cables (33kV)	£339 per m	Underground Cables (11kV)	£169 per m
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Overhead Conductors (11kV)	£23 per m																						
Underground Cables (33kV)	£339 per m																						
Underground Cables (11kV)	£169 per m																						
Electricity assumptions	Costs relating to safe clearance of temporarily and permanently flooded assets have not been provided, nor have costs for a new submarine power network. Should the network become permanently inundated, the assets will be abandoned. Indirect damages from power outages outside the study area are not captured as part of this appraisal.																						
Key datasets:																							
<ul style="list-style-type: none"> <li>Electricity: Western Power Distribution and National Grid geographical datasets of their assets</li> <li>How close does an energy scheme need to be to an electricity network?   Roadnight Taylor</li> <li>Typical constructions of overhead lines (electrical-engineering-portal.com)</li> <li>Gas: National Grid Gas Distribution Network</li> </ul>																							

### 5.7.5 Do-Nothing scenario outcomes

**Table 5-50: Do-Nothing – number of pole towers and substations impacted (cumulative) and length of overhead conductors and underground cables impacted (cumulative) (m)**

Appraisal year (Year)	Number of pole towers impacted (all)				Number of substations impacted (all)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	113	237	1,615	72	11	29	307	9
1	177	467	1,994	307	25	68	411	53
2	220	608	2,113	667	33	101	461	152
3	220	655	2,166	775	33	116	473	193
4	220	673	2,190	791	33	121	480	198
5	220	678	2,190	791	33	122	480	198
99	220	678	2,190	791	33	122	480	198
Appraisal year (Year)	Length of overhead conductors impacted (all) (m)				Length of underground cables impacted (all) (m)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	10,193	23,574	183,184	5,212	-	-	-	-
1	15,571	43,420	222,037	30,010	-	-	-	-
2	19,266	55,179	232,332	68,600	-	-	-	-
3	19,266	58,824	239,755	78,109	-	-	-	-
4	19,266	60,074	243,393	80,404	-	-	-	-
5	19,266	60,481	243,393	80,404	-	-	-	-
99	19,266	60,481	243,393	80,404	-	-	-	-

**Table 5-51: Do-Nothing - PV electrical network damages (cumulative) (£k)**

Appraisal year (Year)	PV Electricity damages (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	1,009	2,341	25,046	725
1	1,787	4,796	31,287	3,995
2	2,252	6,507	33,523	9,266
3	2,252	7,165	34,328	11,078
4	2,252	7,385	34,728	11,330
5	2,252	7,435	34,728	11,330
99	2,252	7,435	34,728	11,330

The total lengths and counts of electrical utilities impacted for the Do-Nothing scenario can be found in Table 5-50, with damage totals for both located in Table 5-51. There is no gas pipeline located within the East and West Fens study area; therefore, no damages have

been accrued. By the end of the appraisal period, around 3,879 pole towers and 833 substations are impacted during the final inundation level, whilst approximately 404km of overhead conductor and underground cables are impacted, resulting in total electricity damages of £55,746k.

### 5.7.6 Sensitivity testing

A sensitivity analysis has been undertaken to assess the impact of varying the valuation for electricity distribution assets by 10%, both as an increase and a decrease. The damages associated with decreasing and increasing the valuations of these assets by 10% can be seen in Table 5-52.

**Table 5-52: Do-Nothing - PV electrical network damages with +/-10% valuations (cumulative) (£k)**

Appraisal year (Year)	PV damages (£k): +10 percentage points				PV damages (£k): -10 percentage points			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
0	1,110	2,575	27,551	798	908	2,107	22,541	653
1	1,965	5,275	34,416	4,395	1,608	4,316	28,159	3,596
2	2,478	7,157	36,875	10,193	2,027	5,856	30,171	8,340
3	2,478	7,881	37,760	12,185	2,027	6,448	30,895	9,970
4	2,478	8,123	38,201	12,463	2,027	6,646	31,255	10,197
5	2,478	8,178	38,201	12,463	2,027	6,691	31,255	10,197
99	2,478	8,178	38,201	12,463	2,027	6,691	31,255	10,197

With a 10% decrease in electrical distribution asset valuation, there is a total damage value of £50,171k by the end of the appraisal period. This means that there was a decrease in PV damages of £5,575k, a 10% decrease. With a 10% increase in electrical distribution asset valuation, there is a total damage value of £61,320k by the end of the appraisal period. This means that there was an increase in PV damages of £5,575k, a 10% increase.

## 5.8 Isolated land and properties

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. This aspect looks to account for the notion that areas of elevated land may not be directly flooded, but if surrounded by water are likely to be abandoned - with similar impacts to that of the damage streams described prior.

The term 'isolated properties' includes properties that are cut-off from existing road networks due to inundation, thus properties that are not flooded but are able to access an existing road network to either leave the study area and/or navigate around flooded extents through a longer, more indirect route are not classified as 'isolated'.

Similarly, properties that are scattered and/or are not part of a geographic cluster of isolated properties that share an existing road connection are not classified as being part of an 'isolated community'. In order to be classified as a community, a cluster of isolated properties that share a road network connection must be comprised of at least 10 residential receptors.

### 5.8.1 Do-Nothing approach

In accordance with HM Treasury Green Book<sup>23</sup> guidance, the analysis looks to define the "lowest cost to the nation". As such, the approach considered damages associated with isolated areas (at the point of permanent inundation) which are assumed to be abandoned; these costs were compared to cost of re-provision of services and to reconnect the isolated communities to the 'mainland'. This has conservatively been based on the cost of a new road to the isolated community utilising the same costs as described in Section 5.1.26. It is assumed new services could be provided along the route of any new raised road.

Whilst abandonment is considered to be the most likely scenario or outcome if a Do-Nothing event were to occur, recognising that the community would have no wider flood defence measures and be extremely vulnerable to coastal storm events, the approach taken provides a conservative estimate of potential losses where there is uncertainty.

The analysis has focused towards identifying isolated populated communities. Each settlement's residential and non-residential properties have been identified and values associated with their abandonment defined (as per the approach described in Section 5.1.25). Recognising the high-level nature of this assessment, it is assumed the majority of the losses associated with isolated agricultural land have been captured as part of the agricultural land assessment, and due to the small spatial extents, it is not considered to be proportionate to define isolated agricultural land losses. This logic also applies to the analysis of wider isolated infrastructure and environmental designations.

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<sup>23</sup> [The Green Book: appraisal and evaluation in central government - GOV.UK](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/432423/gb17-001-20170627.pdf)

## 5.8.2 Key assumptions

**Table 5-53: Key assumptions for isolated property damages**

Key assumptions		
Isolated community connection costs	Road connection costs are based on 'A Road' costs seen in Section 5.6. Costs are then multiplied by a factor of 2 to allow for uncertainty and complications of raising road above flood level. Electricity Distribution costs (per km) associated with raising roads has been provided by National Grid and Western Power Network. Likewise, water utilities costs have been provided by Anglian Water. All costs are assumed to be from 2021, with costs uplifted to 2025 values.	
	Element	Cost / m
	Road	£44,244
	Electricity Distribution	£1,399
	Water Utilities	£1,786
Defining isolated properties	Due to the rural nature of the catchments across the Fens, transport access through roads was used to determine isolation of properties due to the distances between rural settlements being deemed too great for pedestrian use. Whilst certain footpaths may not be inundated, we cannot assume all pedestrians have equal capability to carry out daily tasks on foot (elderly, physically disabled, etc.), even in more well-connected urban areas.	

## 5.8.3 Do-Nothing scenario outcomes

The total PV costs for isolated communities are shown in Table 5-54. Isolated communities and properties were determined whilst observing the maximum contour level flood extents for a given subcompartment, these being 3.90m.

**Table 5-54: Do-Nothing - summary of which communities were reconnected or abandoned as well as the discounted costs (£k) for the preferred option**

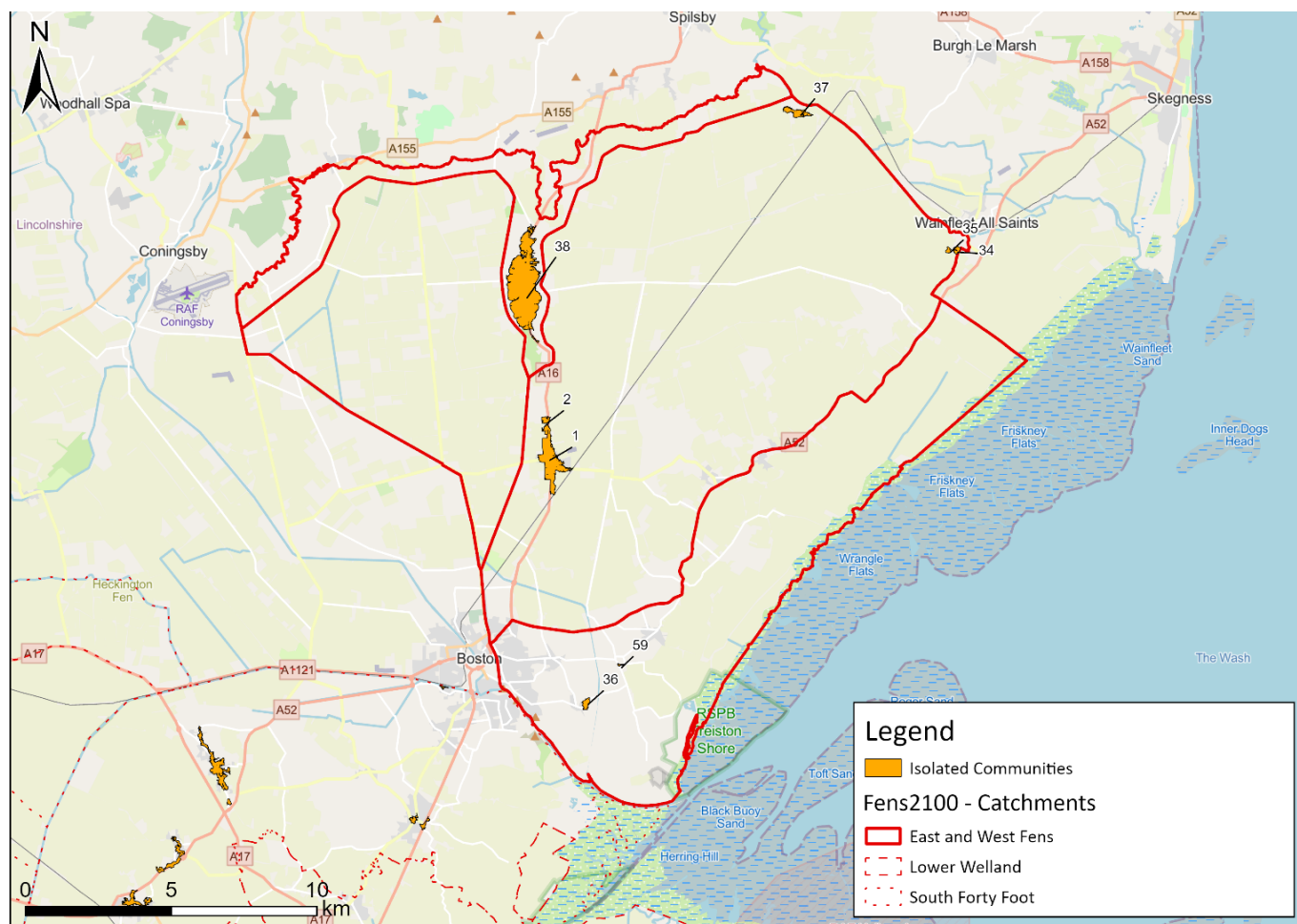
Community	Write-off costs (£k)	Distance for reconnection (m)	Reconnection costs (£k)	Reconnected	Abandoned	Total Discounted Costs (£k)
1	146,835	-	-	Yes	No	-
2	11,105	-	-	Yes	No	-
34	10,874	142	6,735	Yes	No	5,869
35	6,015	283	13,422	No	Yes	5,242
36	17,210	2,562	121,513	No	Yes	14,997
37	18,807	727	34,481	No	Yes	16,389
38	175,802	-	-	Yes	No	-
59	5,240	1,382	65,547	No	Yes	4,567

Note: Some communities do not have a reconnection cost as it is 'main road' that is already included in the transport damages, and therefore has been excluded here to avoid double counting

**Table 5-55: Do-Nothing - summary of residential and non-residential cumulative write-off costs for isolated properties as well as the discounted costs (£k) per year**

Appraisal year (Year)	Residential write-off costs (£k)	Non-residential write-off costs (£k)			Total discounted write-off costs (£k)
	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (C)	Witham Fourth (D)	
0	-	-	-	-	-
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	15,927	17,742	5,703	1,822	47,062
5	-	-	-	-	-

Across the catchment there were 8 isolated communities identified. The location of these isolated communities is shown in Figure 16. For four communities it was found to be more cost-effective to write-off the communities than to reconnect the communities to nearby road networks through building raised roads.



**Figure 16: Location of the isolated communities**

#### 5.8.4 Sensitivity testing

Sensitivity testing has been undertaken to assess the impact of including unknown '999' NRD receptors into the calculations using non-residential sector average values. This only impacts those settlements for which the cost of property write off is lower than the cost of reconnecting the land to the 'mainland'.

The total costs for isolated communities including unknown '999' NRD receptors are shown in Table 5-56.

**Table 5-56: Do-Nothing - summary of which communities were reconnected or abandoned whilst including unknown '999' NRD receptors, as well as the discounted costs (£k) for the preferred option**

Community	Write-off costs (£k)	Distance for reconnection (m)	Reconnection costs (£k)	Reconnected	Abandoned	Total Discounted Costs (£k)
1	148,780	-	-	Yes	No	-
2	11,105	-	-	Yes	No	-
34	10,874	142	6,735	Yes	No	5,869
35	6,015	283	13,422	No	Yes	5,242
36	17,210	2,562	121,513	No	Yes	14,997
37	21,143	727	34,481	No	Yes	18,424
38	185,876	-	-	Yes	No	-
59	5,383	1,382	65,547	No	Yes	4,690

Note: Some communities do not have a reconnection cost as it is 'main road' that is already included in the transport damages, and therefore has been excluded here to avoid double counting.

**Table 5-57: Do-Nothing - summary of residential and non-residential cumulative write-off costs for isolated properties whilst including unknown '999' NRD receptors, as well as the discounted costs (£k) per year**

Appraisal year (Year)	Residential write-off costs (£k)		Non-residential write-off costs (£k)		Total discounted write-off costs (£k)
	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (C)	Witham Fourth (D)	
0	-	-	-	-	-
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	15,927	17,742	7,738	1,946	49,222
5	-	-	-	-	-

## 5.9 Mental health costs

The impacts on mental health due to the higher rates of anxiety, depression and post-traumatic stress disorder after a flood event have been calculated using the latest guidance from the Environment Agency. The costs associated with these illnesses include treatment costs and the loss of employment. Co-morbidity and the proportion of those seeking treatment have also been considered.

As no local model data was available, and a depth damage approach was not able to be taken, this has been estimated at £2,399 per residential property affected by flooding.

This damage was calculated for the residual risk to properties which are not written off in a Do Nothing scenario, and for all properties impacted in the Maintain scenario.

### 5.9.1 Do Nothing scenario outcomes

**Table 5-58: Do Nothing - PV mental health costs (£k)**

Appraisal period (years)	PV Mental health costs (£k)				Total
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	
100	144	21	533	493	1,191

Total Do Nothing PV mental health costs over the 100-year appraisal period are £1,191k.

### 5.9.2 Maintain scenario outcomes

**Table 5-59: Maintain - PV mental health costs (£k)**

Appraisal period (years)	PV Mental health costs (£k)				Total
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	
100	1,060	994	7,429	12,054	21,536

Total Maintain PV mental health costs over the 100-year appraisal period are £21,536k.

## 5.10 Intangible impacts costs

Intangible health benefits reflect the longer-term personal impact of flooding on the health and wellbeing of those affected; a reduction in flood risk is correlated with an approximate equivalent financial benefit.

The MCM 2013 methodology was used to estimate intangible benefits with flood risk management improvements at a property level. The basis of the estimation is that flooding of residential properties causes stress, disruption, illness, and other losses that are not assigned a value in the main economic assessment. Generally, rather than increase the losses in each flood event to include this, the intangible impacts assessment provides a positive benefit that can be added to the 'damages avoided'. The magnitude of the benefit is dependent on the number of residential properties benefitting from flood risk management (i.e. with a reduced threshold of flooding), and the size of the change in threshold of flooding at each property. For the Fens 2100+ assessments, Intangible Benefits have been calculated based on an assumed loss at each flooded property, such that the benefits would be equal to these losses being avoided should Do Something options been appraised in future. As no local model data was available, and a depth damage approach was not able to be taken, this has been estimated at £332 per residential property affected by flooding.

This damage was calculated for the residual risk to properties which are not written off in a Do Nothing scenario, and for all properties impacted in the Maintain scenario.

### 5.10.1 Do Nothing scenario outcomes

**Table 5-60: Do Nothing - PV intangible impacts costs (£k)**

Appraisal period (years)	PV Intangible impacts costs (£k)				Total
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	
100	20	3	74	68	165

Total Do Nothing PV intangible impact costs over the 100-year appraisal period are £165k.

### 5.10.2 Maintain scenario outcomes

**Table 5-61: Maintain - PV intangible impacts costs (£k)**

Appraisal period (years)	PV Intangible impacts costs (£k)				Total
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	
100	147	138	1,029	1,669	2,982

Total Maintain PV intangible impact costs over the 100-year appraisal period are £2,982k.

## 5.11 Emergency service costs

Emergency service costs are calculated to account for the cost of police, fire, ambulance, local authority, and Environment Agency response to flood incidents. This has been estimated at 10.7% of the total cost of direct damages to properties as befits a rural area, in line with MCM guidance.

This damage was calculated for the residual risk to properties which are not written off in a Do Nothing scenario, and for all properties impacted in the Maintain scenario.

### 5.11.1 Do Nothing scenario outcomes

**Table 5-62: Do Nothing - PV emergency services costs (£k)**

Appraisal period (years)	PV Emergency services costs (£k)				Total
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	
100	60	16	350	1,182	1,608

Total Do Nothing PV emergency service costs over the 100-year appraisal period are £1,608k.

### 5.11.2 Maintain scenario outcomes

**Table 5-63: Maintain - PV emergency services costs (£k)**

Appraisal period (years)	PV Emergency services costs (£k)				Total
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	
100	416	397	3,467	12,754	17,035

Total Maintain PV emergency service costs over the 100-year appraisal period are £17,035k.

## 5.12 Risk to life

Risk to life assesses the potential for loss of life as a result of flooding. As no local model data was available, and a depth damage approach was not able to be taken, this has been estimated at 25% of the total cost of direct damages to properties.

This damage was calculated for the residual risk to properties which are not written off in a Do Nothing scenario, and for all properties impacted in the Maintain scenario.

### 5.12.1 Do Nothing scenario outcomes

**Table 5-64: Do Nothing - PV risk to life (£k)**

Appraisal period (years)	PV Risk to Life (£k)				
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Total
100	245	38	1,265	3,044	4,592

Total Do Nothing PV risk to life over the 100-year appraisal period is £4,592k.

### 5.12.2 Maintain scenario outcomes

**Table 5-65: Maintain - PV risk to life (£k)**

Appraisal period (years)	PV Risk to Life (£k)				
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Total
100	1,771	1,692	14,771	54,332	72,566

Total Maintain PV risk to life over the 100-year appraisal period is £72,566k.

## 5.13 Evacuation and temporary accommodation costs

The evacuation and relocation of people from flood affected residential properties is often undertaken as a short-term emergency response to flooding. In addition to where residential properties are affected by flooding, evacuation from the property may also be necessary to allow flood damage to be repaired. In such cases, evacuation requires temporary or alternative accommodation for households affected and this incurs costs.

As no local model data was available, and a depth damage approach was not able to be taken, this has been estimated at £5,813 per residential property affected by flooding.

This damage was calculated for the residual risk to properties which are not written off in a Do Nothing scenario, and for all properties impacted in the Maintain scenario.

### 5.13.1 Do Nothing scenario outcomes

**Table 5-66: Do Nothing - PV evacuation and temporary accommodation costs (£k)**

Appraisal period (years)	PV Evacuation and temporary accommodation costs (£k)				
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Total
100	197	51	860	1,041	2,149

Total Do Nothing PV evacuation and temporary accommodation costs over the 100-year appraisal period is £2,149k.

### 5.13.2 Maintain scenario outcomes

**Table 5-67: Maintain - PV evacuation and temporary accommodation costs (£k)**

Appraisal period (years)	PV Evacuation and temporary accommodation costs (£k)				
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Total
100	1,408	1,320	9,873	16,019	28,620

Total Maintain PV evacuation and temporary accommodation costs over the 100-year appraisal period is £28,620k.

## 5.14 Vehicle damages

Economic losses associated with damage to vehicles are estimated for all residential properties. As no local model data was available, and a depth damage approach was not able to be taken, this has been estimated at £6,668 per residential property affected by flooding.

This damage was calculated for the residual risk to properties which are not written off in a Do Nothing scenario, and for all properties impacted in the Maintain scenario.

### 5.14.1 Do Nothing scenario outcomes

**Table 5-68: Do Nothing - PV vehicle damages (£k)**

Appraisal period (years)	PV Vehicle damages (£k)				
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Total
100	226	58	987	1,194	2,465

Total Do Nothing PV vehicle damages over the 100-year appraisal period are £2,465k.

### 5.14.2 Maintain scenario outcomes

**Table 5-69: Maintain - PV vehicle damages (£k)**

Appraisal period (years)	PV Vehicle damages (£k)				
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Total
100	1,615	1,515	11,325	18,375	32,829

Total Maintain PV vehicle damages over the 100-year appraisal period are £32,829k.

## 5.15 Utilities disruption

Disruption to utilities at an individual property level have been calculated only for properties in the Maintain scenario and in the Do Nothing scenario where properties are not written off but are subject to residual risk. This is to avoid double counting with damages related to the distribution assets as described in Section 5.7. As a broad assessment of the potential scale of impacts, an indicative value of 5% of total residential and non-residential property AAD damages have been used to estimate utilities disruption costs in these events.

This damage was calculated for the residual risk to properties which are not written off in a Do Nothing scenario, and for all properties impacted in the Maintain scenario.

### 5.15.1 Do Nothing scenario outcomes

**Table 5-70: Do Nothing - PV Utilities disruption damages (£k)**

Appraisal period (years)	PV Property utilities damages (£k)				Total
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	
100	28	8	164	552	752

Total Do Nothing PV utilities disruption damages over the 100-year appraisal period are £752k.

### 5.15.2 Maintain scenario outcomes

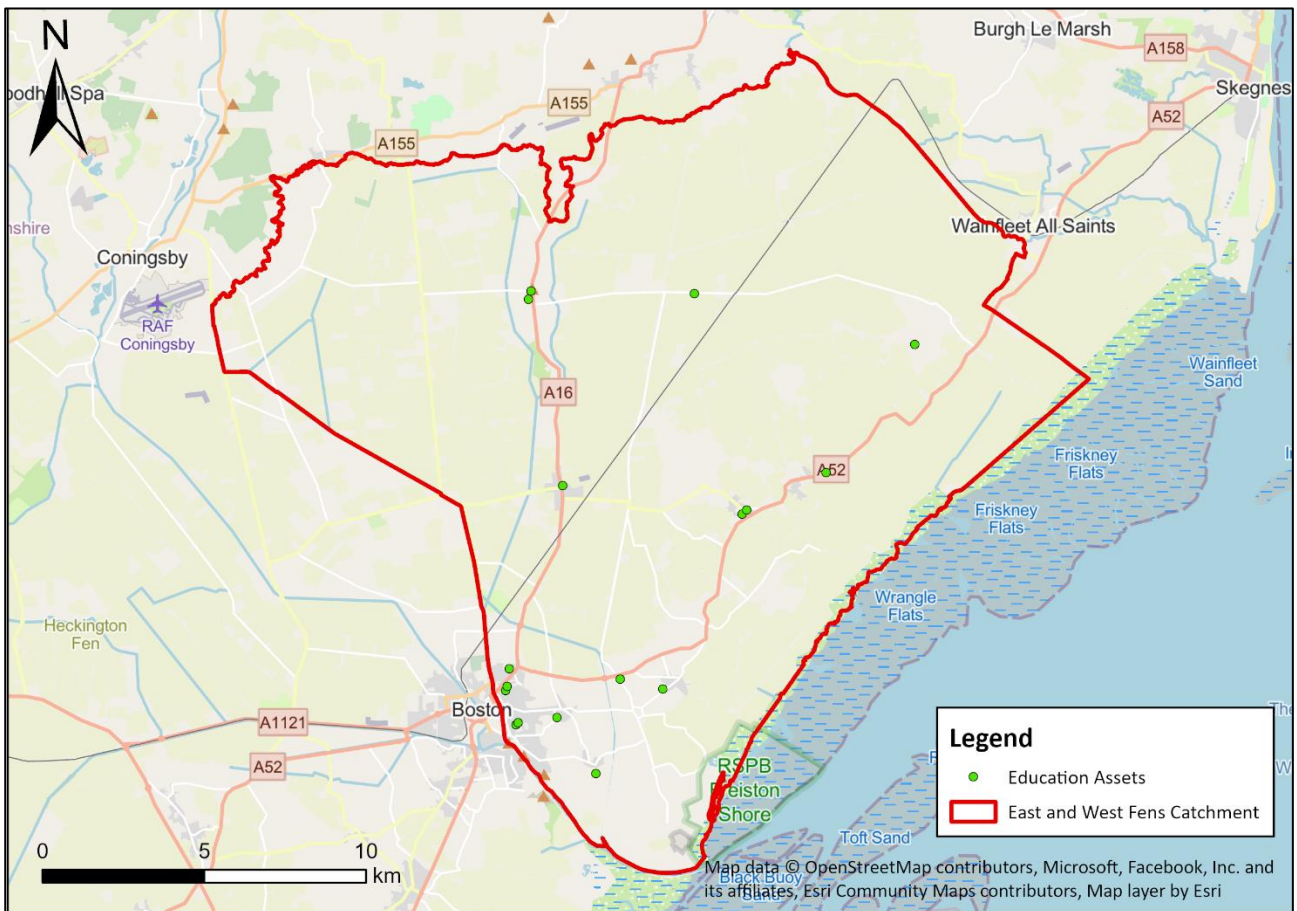
**Table 5-71: Maintain - PV Utilities disruption damages (£k)**

Appraisal period (years)	PV Property utilities damages (£k)				Total
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	
100	194	186	1,620	5,960	7,960

Total Maintain PV utilities disruption damages over the 100-year appraisal period are £7,960k.

## 5.16 Educational Losses

There are 17 educational assets located in the East and West Fens catchment area as highlighted in Figure 17 and Table 5-72 and comprise of primary and secondary schools. Losses to education can be assessed based on both the impacts to the buildings, and contents such as books and technology, and as a result of disruption to education of students and days of education lost.



**Figure 17: Location of educational assets in the East and West Fens catchment area**

Damages have been based on the cost of alternative classroom accommodation, taken as £15,000 per school based on evidence from the Pitt report in the 2007 floods<sup>24</sup>. This value was uplifted to a 2025 price base using GDP deflator values.

Disruption costs calculated in line with the MCM also include the cost of loss of education per day for pupils, impacts on parent productivity through missing employment to look after dependent children (assumed at one adult per three primary aged children), and the costs of counselling for children impacted by flooding. It was assumed that flooding leads to five days of disruption before alternative accommodation or ways of working can be enacted (as per MCM Chapter 6e Education and Health). Ofsted data was used to estimate the number of pupils attending each education facility<sup>25</sup>.

<sup>24</sup> Chatterton, J., Viavattene, C., Morris, J., Penning-Rowell, E.C. and Tapsell, S. (2010) The costs of the summer 2007 floods in England, Project: SC070039/R1, Environment Agency, Bristol

<sup>25</sup> <https://reports.ofsted.gov.uk/>

Losses relating to disruption of education has been calculated in the Maintain scenario only.

Permanent inundation in the Do Nothing scenario will lead to the complete loss of educational facilities and as a result a requirement to find alternative educational facilities for students. It is assumed that the loss of building is covered under the direct damage to properties calculations based on write-off of the buildings. The loss of educational services in the write-off assessment is also taking the total educational loss per event into account assuming that it will take five days to find alternative facilities to resume education elsewhere.

**Table 5-72: Educational assets and their education level/number of pupils in the East and West Fens catchment area**

Name	Education level	Number of pupils (2023)
Aspiration House School	Primary and Secondary	9
Boston Endeavour Academy	Primary and Secondary	151
Boston High School	Secondary	818
Fishtoft Academy	Primary	65
Friskney All Saints Church of England Primary School	Primary	79
Hawthorn Tree School	Primary	352
Old Leake Primary Academy	Primary	186
St Mary's RC Primary Academy Boston	Primary	193
St Nicholas CE Primary Academy	Primary	197
Stickney Church of England Primary School	Primary	130
The Butterwick Pinchbeck's Endowed CofE Primary School	Primary	315
The Giles Academy	Secondary	839
The New Leake Primary School	Primary	38
The Sibsey Free Primary School	Primary	176
Tower Road Academy	Primary	572
William Lovell Church of England Academy	Secondary	327
Wrangle Primary School	Primary	105

### 5.16.1 Maintain scenario outcomes

**Table 5-73: Maintain - PV educational losses (£k)**

Appraisal period (years)	PV Vehicle damages (£k)				Total
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	
100	0	0	801	584	1,385

Total PV educational losses over the 100-year appraisal period are £1,385k.

## 5.17 Health Service Losses

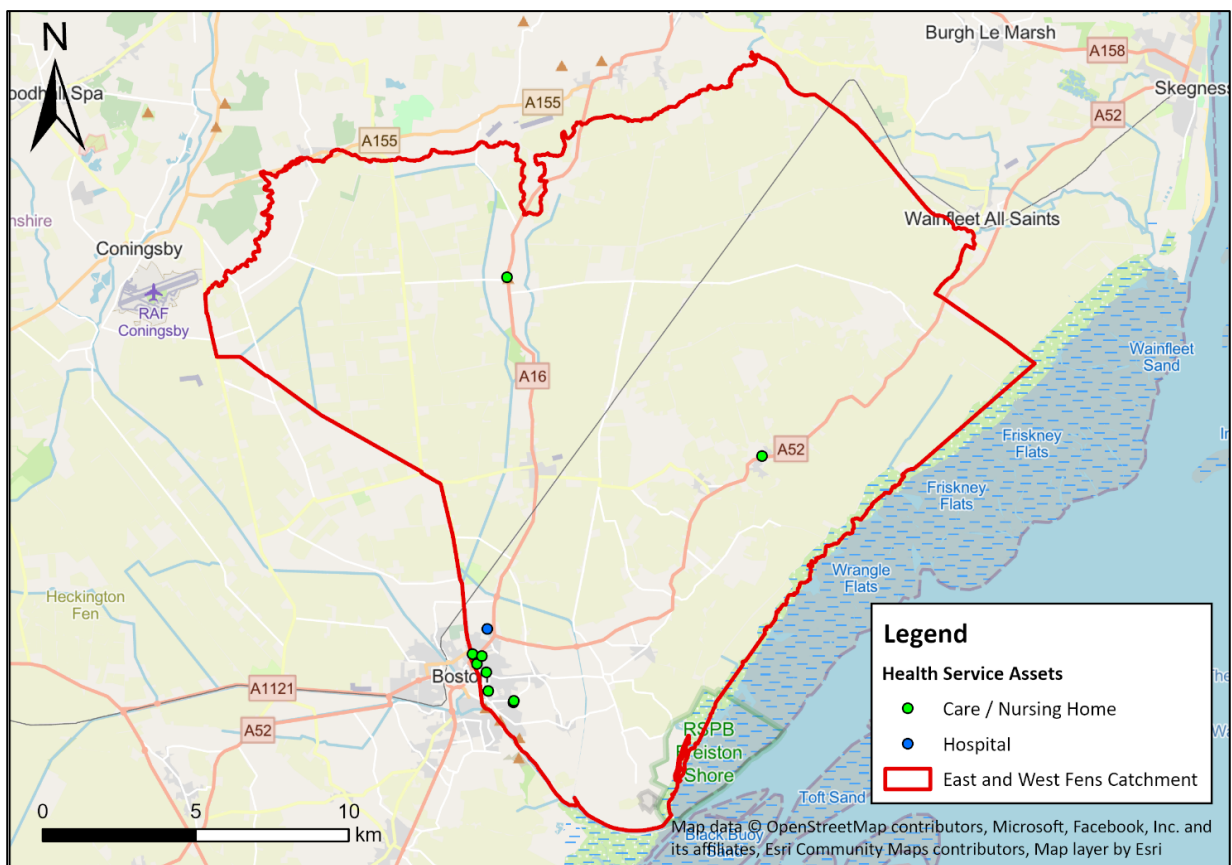
There are 10 health service assets located in the East and West Fens catchment area including Pilgrim Hospital in Boston. There are a total of 655 beds across these facilities where the day bed occupancy averages 86% as reported by NHS England. Health service assets located within the catchment are highlighted in Figure 18 and Table 5-74 and comprise of care/nursing home assets and hospital assets.

No assessment of disruption and losses because of flooding to General Practitioner surgeries or pharmacies has been included, though the direct damages associated with these facilities is included under the direct damages to properties.

The cost of health service losses has been based on the cost of transfer of a patient (£353.48) and bed redundancy (£453.15) taken from the MCM and uplifted to 2025 using GDP deflators.

Damages as a result of the loss of health service provision have been calculated for the Maintain scenario only. This has been calculated based on the total cost of patient transfer at the point of flooding in the defended mechanism, and the cost of the beds per day assuming these beds will need to be provided at alternative facilities. Damages due to write off are represented in the Do Nothing property write off calculations.

These disruption damages would only be assessed in the Maintain scenario as the health facilities will be written off in the Do Nothing scenario and the majority of the population they serve will have moved out of the area.



**Figure 18: Location of Health Service assets in the East and West Fens catchment area**

**Table 5-74: Health Service assets and their capacity in the East and West Fens catchment area**

Name	Capacity
Pilgrim Hospital, Sibsey Road, Boston, PE21 9QS	391
Willoughby Grange Care Home, Willoughby Road, Boston, PE21 9EG	39
Ashridge Care Home, 14 Tower Road, Boston, PE21 9AD	18
Skirbeck Court, 55A Spilsby Road, Boston, PE21 9NU	39
Vauxhall Court, Frieston Road, Boston, PE21 0JW	33
Haven Cottage, Kitwood Road, Boston, PE21 0PX	5
The Old Rectory, Main Road, Stickney, PE22 8AY	44
The Haven, Whitehouse Lane, Boston, PE21 0BE	38
Maple Lodge, Toot Lane, Fishtoft, PE21 0AX	15
The Minstrels, Main Road, Wrangle, PE22 9AJ	33

### 5.17.1 Maintain scenario outcomes

**Table 5-75: Maintain - PV health service damages (£k)**

Appraisal period (years)	PV Vehicle damages (£k)				Total
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	
100	0	0	48,934	4,910	53,844

Total PV health service damages over the 100-year appraisal period are £53,844k.

## 5.18 Losses to the local economy

The Fens has a diverse economy, to which agriculture contributes significantly, as previously highlighted within Section 5.2. In addition, there are a range of retail, industrial and manufacturing businesses across the catchments which would be impacted by flooding in the Do-Nothing scenario.

### 5.18.1 Do-Nothing approach

Losses to the local economy can be expressed in terms of Gross Value Added (GVA). GVA measures the contribution made to an economy by one individual producer, industry, sector or region. As per the HM Treasury Green Book<sup>26</sup> (2022), local or regional benefits cannot be included in applications for Grant in Aid funding (only those identified as losses to the nation are eligible). As such, only a high-level analysis of GVA has been undertaken to understand the regional impacts, particularly in terms of the number of jobs at risk under a Do-Nothing scenario (and thus benefiting from the existing FCERM arrangements). GVA has been calculated for the Do-Nothing scenario and Maintain scenario and is considered a broad high-level assessment.

The GVA has been defined based on DEFRA's Frontiers Toolkit<sup>27</sup> (2014). For each of the NRP's impacted by permanent inundation (at each write-off level), the associated floor areas have been captured. These were converted to Net Gross Floor areas, which were utilised to determine the number of jobs impacted based upon the application of the associated employment densities (as per the Employment Density Guidance, 3rd Edition (Homes and Communities Agency, 2015)) for the general business/industry type (refer to Table 5-76). The total number of jobs per non-residential property were multiplied by the gross annual average salary of the region to define the annual GVA losses. An uplift of 30% was applied (Table 4.14 Multiplier effects in HCA guidance (2000)) to account for the net indirect and induced jobs (i.e. the supply chain). As the methodology is centred around buildings and their floor area, it may not cover all agricultural jobs, some of which may be transient in nature. A 10% leakage reduction factor was applied to represent the level of benefits that are likely to go to residents who commute into the catchment. A 25% displacement reduction factor was also applied to represent the proportion of economic benefits that are displaced from elsewhere in the region.

The GVA annual losses are assumed to apply for a period of 10 years following inundation, to account for the notion that new businesses and employment opportunities will be displaced elsewhere across the nation to accommodate the loss in the provision of these services.

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<sup>26</sup> [The Green Book: appraisal and evaluation in central government - GOV.UK](#)

<sup>27</sup> [\\_FD2662\\_full\\_toolkit.pdf](#)

## 5.18.2 Key assumptions

**Table 5-76: Do Nothing GVA assumptions**

Key assumptions:					
Assumed employment density (m <sup>2</sup> ) and Gross annual wage per head (£)		SIC Code and Description	m2 per FTE	Mean gross annual wage (2025) (£)	
		A - Agriculture, forestry and fishing	36	29,723	
B - Mining and quarrying	-	56,864			
C - Manufacturing	37	42,282			
D - Electricity, gas, steam and air conditioning supply	36	60,114			
E - Water Supply; Sewerage, Waste Management and Remediation Activities	36	42,267			
F - Construction	-	44,749			
G - Wholesale and retail trade; repair of motor vehicles and motorcycles	26	31,649			
H - Transportation and storage	30	41,688			
I - Accommodation and Food Service Activities	19	20,679			
J - Information and communication	32	58,071			
K - Financial and Insurance Activities	16	80,397			
L - Real estate activities	-	36,403			
M - Professional, scientific and technical activities	45	51,632			
N - Administrative and support service activities	16	33,042			
O - Public administration and defence; compulsory social security	29	38,428			
P - Education	36	34,090			
Q - Human health and social work activities	33	33,182			
R - Arts, Entertainment and Recreation	58	31,193			
S - Other service activities	33	30,056			
T - Activities of households as employers; undifferentiated goods-	-	16,368			

Key assumptions:							
	<table border="1"> <tr> <td>and services-producing activities of households for own use</td> <td></td> <td></td> </tr> <tr> <td>U - Activities of extraterritorial organisations and bodies</td> <td>-</td> <td>-</td> </tr> </table> <p>Sources:  Homes &amp; Communities Agency (2010) <i>Employment Densities Guide (2<sup>nd</sup> ed.)</i>.  OBS (2025) <i>The economy forecast: Inflation</i>.  ONS (2024) Earnings and hours worked, industry by two-digit SIC: ASHE Table 4.7a Annual Pay - Gross 2024 (Provisional Data)</p>	and services-producing activities of households for own use			U - Activities of extraterritorial organisations and bodies	-	-
and services-producing activities of households for own use							
U - Activities of extraterritorial organisations and bodies	-	-					
Net indirect and induced jobs multiplier	30% - Ready reckoners for composite multiple (regional level) (HCA guidance (section 4.5 and 5))						
Displacement	25%						
Leakage	10%						
<b>Key datasets:</b>							
<ul style="list-style-type: none"> <li>National Receptor Database</li> </ul>							

### 5.18.3 Do-Nothing scenario outcomes

**Table 5-77: Do Nothing high-level estimates of number of jobs impacted (GVA - direct and indirect) (cumulative) and high-level PV GVA losses (direct and indirect) (cumulative) (£k)**

Appraisal period (years)	Number of jobs				Total PV GVA losses (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
10	398	808	20,754	12,967	133,884	213,213	6,294,158	2,966,787

Based on the number and area of non-residential properties impacted during the first 10 years of the appraisal period for the Do Nothing scenario, a high-level estimate of the number of jobs and associated GVA losses can be seen in Table 5-77. During this period an estimated 34,927 jobs are impacted whilst total GVA losses in excess of £9,608,042k are accrued.

#### 5.18.4 Maintain scenario outcomes

**Table 5-78: Maintain high-level estimates of number of jobs impacted (GVA - direct and indirect) (cumulative) and high-level PV GVA losses (direct and indirect) (cumulative) (£k)**

Appraisal period (years)	Number of jobs				Total PV GVA losses (£k)			
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)
10	1,770	717	11,985	13,155	38	94	1,610	633

Based on the number and area of non-residential properties impacted during the first 10 years of the appraisal period for the Maintain scenario, a high-level estimate of the number of jobs and associated GVA losses can be seen in Table 5-78. During this period an estimated 27,627 jobs are impacted whilst total GVA losses in excess of £2,375k are accrued.

## 6. Economic Damages and Benefits Summary

A summary of the Do-Nothing and Maintain scenario economic damages, and Maintain scenario benefits, are provided in the tables below.

### 6.1 Summary of Do Nothing Damages

**Table 6-1: Summary of PV Do Nothing damages (£k)**

Type	Do Nothing Damages (£k)				
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Total
Residential properties	120,910	208,556	1,482,444	1,847,197	3,659,107
Non-residential properties	29,646	54,330	652,803	204,505	941,284
Indirect commercial losses	3	2	38	256	299
Agricultural losses	48,599	179,728	420,134	186,174	834,635
Environment and recreational losses	12,459	11,847	29,367	135,031	188,704
Heritage losses	1,183	6,224	24,164	12,123	43,694
Transport damages	53,205	-	923,893	650,387	1,627,485
Utilities damages	2,252	7,435	34,728	11,330	55,746
Isolated land and properties	-	-	27,499	19,563	47,062
Mental health costs	144	21	533	493	1,191
Intangible impacts	20	3	74	68	165
Emergency service costs	60	16	350	1,182	1,608
Risk to life	245	38	1,265	3,044	4,592
Evacuation and temporary accommodation	197	51	860	1,041	2,149
Vehicle damages	226	58	987	1,194	2,465
Utilities disruption	28	8	164	552	752
<b>Total (excludes losses to the local economy)</b>	<b>269,177</b>	<b>468,318</b>	<b>3,599,302</b>	<b>3,074,141</b>	<b>7,410,938</b>
Losses to the local economy (GVA)	133,884	213,213	6,294,158	2,966,787	9,608,042

Total damages in the Do Nothing scenario is £7.4 billion across all four sub-compartments.

## 6.2 Summary of Maintain Damages

Table 6-2: Summary of PV Maintain damages (£k)

Type	Maintain Damages (£k)				
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Total
Residential properties	3,368	2,603	21,385	38,619	65,975
Non-residential properties	518	1,109	11,020	80,579	93,226
Indirect commercial losses	16	33	331	2,417	2,797
Agricultural losses	1,048	2,020	7,320	15,362	25,750
Environment and recreational losses	8	5	13	28	55
Heritage losses	1	7	21	11	40
Mental health costs	1,060	994	7,429	12,054	21,536
Intangible impacts	147	138	1,029	1,669	2,982
Emergency service costs	416	397	3,467	12,754	17,035
Risk to life	1,771	1,692	14,771	54,332	72,566
Evacuation and temporary accommodation	1,408	1,320	9,873	16,019	28,620
Vehicle damages	1,615	1,515	11,325	18,375	32,829
Utilities disruption	194	186	1,620	5,960	7,960
Health services	-	-	48,934	4,910	53,844
Educational losses	-	-	801	584	1,385
<b>Total (excludes losses to the local economy)</b>	<b>11,571</b>	<b>12,018</b>	<b>139,338</b>	<b>263,672</b>	<b>426,600</b>
Losses to the local economy (GVA)	38	94	1,610	633	2,375

Total damages in the PV Maintain scenario is £427 million across all sub-compartments.

## 6.3 Summary of Maintain Benefits

Table 6-3: Summary of PV benefits (£k)

Type	Benefits (£k)				
	Witham Fourth (A)	Witham Fourth (B)	Witham Fourth (C)	Witham Fourth (D)	Total
Residential properties	117,542	205,953	1,461,059	1,808,578	3,593,132
Non-residential properties	29,128	53,221	641,783	123,926	848,058
Indirect commercial losses* avoided	-13	-31	-293	-2,161	-2,498
Agricultural losses avoided	47,551	177,709	412,813	170,812	808,885
Environment and recreational losses** avoided	12,451	11,842	29,354	135,003	188,649
Heritage losses avoided	1,182	6,217	24,142	12,112	43,654
Transport damages avoided	53,205	-	923,893	650,387	1,627,485
Utilities damages avoided	2,252	7,435	34,728	11,330	55,746
Isolated land and properties	-	-	27,499	19,563	47,062
Mental health costs* avoided	-916	-973	-6,896	-11,561	-20,345
Intangible impacts*	-127	-135	-955	-1,601	-2,817
Emergency service costs* avoided	-356	-381	-3,117	-11,572	-15,427
Risk to life*	-1,526	-1,654	-13,506	-51,288	-67,974
Evacuation and temporary accommodation*	-1,211	-1,269	-9,013	-14,978	-26,471
Vehicle damages* avoided	-1,389	-1,457	-10,338	-17,181	-30,364
Utilities disruption* avoided	-166	-178	-1,456	-5,408	-7,208
Health services***	-	-	-48,934	-4,910	-53,844
Educational losses*** avoided	-	-	-801	-584	-1,385
<b>Total (excludes losses to the local economy)</b>	<b>257,606</b>	<b>456,300</b>	<b>3,459,964</b>	<b>2,810,468</b>	<b>6,984,338</b>
Benefits to the local economy (GVA)	133,846	213,119	6,292,548	2,966,154	9,605,667

\*These damage streams show negative benefits because they do not accumulate in the permanent inundation property write-off damages in the Do Nothing. They only accumulate in the residual flood risk above the permanent inundation which is over a smaller area than for the Maintain residual flooding.

\*\* These damages show negative benefits as they include the ecosystem service gains associated with long term land use change under the Do Nothing (i.e. agricultural land becoming coastal or freshwater habitats), that do not occur under the Maintain scenario.

\*\*\*These damage streams show negative benefits because they have only been assessed in the Maintain scenario and not in the Do Nothing scenario. The reason for exclusion from the Do Nothing assessment is that the health and education assets would be written off

due to permanent inundation. The direct asset impacts are included in the non-residential property benefits.

Total benefits in the PV Maintain scenario is £7 billion across all sub-compartments.

## 6.4 Sensitivity Testing

The impact of changes to assumptions have largely been reported under the individual damage sections in Section 5. The impact of three of the more uncertain elements with larger impacts on the overall damage figures are summarised below for context and comparison with the baseline values reported in Sections 6.1 to 6.3.

### 6.4.1 Variance of fill rate in the Do Nothing scenario

Two sensitivity tests have been undertaken across all damage streams to determine the impact of variance in the rate at which the catchment fills with water. The baseline assessment assumes a rate of 0.5m per year. For the sensitivity analyses, the rate has been varied to a slower rate of 0.25m a year, and a faster rate of 0.75m per year. The impact on benefits for the Maintain scenario as a result of this change in the Do Nothing baseline is shown in Table 6-4 and Table 6-5 for the decrease and increase in fill rates respectively.

**Table 6-4: Summary of PV benefits (£k) with a 0.25m per year fill rate**

Type	0.25m fill rate sensitivity		
	Do Nothing PV Damages (£k)	Maintain PV Damages (£k)	Maintain PV Benefits (£k)
Residential properties	3,541,076	65,975	3,475,101
Non-residential properties	917,460	93,226	824,234
Indirect commercial losses	451	2,797	-2,346
Agricultural losses	840,773	25,750	815,022
Environment and recreational losses	168,636	55	168,582
Heritage losses	41,819	40	41,778
Transport damages	1,533,725		1,533,725
Utilities damages	54,726		54,726
Isolated land and properties	41,014		41,014
Mental health costs	2,463	21,536	-19,073
Intangible impacts	341	2,982	-2,641
Emergency service costs	2,343	17,035	-14,692
Risk to life	6,420	72,566	-66,146
Evacuation and temporary accommodation	4,021	28,620	-24,600
Vehicle damages	4,612	32,829	-28,217
Utilities disruption	1,095	7,960	-6,865
Health services		53,844	-53,844
Educational losses		1,385	-1,385
<b>Total (excludes losses to the local economy)</b>	<b>7,160,973</b>	<b>426,600</b>	<b>6,734,374</b>
<b>% change compared to the baseline values</b>	<b>-3.4%</b>	<b>0.0%</b>	<b>-3.6%</b>
Losses to the local economy (GVA)	8,110,143	2,375	8,107,768
<b>% change compared to the baseline values</b>	<b>-15.6%</b>	<b>0.0%</b>	<b>-15.6%</b>

**Table 6-5: Summary of PV benefits (£k) with a 0.75m per year fill rate**

Type	0.75m fill rate sensitivity		
	Do Nothing PV Damages (£k)	Maintain PV Damages (£k)	Maintain PV Benefits (£k)
Residential properties	3,697,187	65,975	3,631,212
Non-residential properties	949,609	93,226	856,383
Indirect commercial losses	223	2,797	-2,574
Agricultural losses	827,297	25,750	801,547
Environment and recreational losses	180,024	55	179,969
Heritage losses	44,380	40	44,340
Transport damages	1,656,795		1,656,795
Utilities damages	56,092		56,092
Isolated land and properties	48,710		48,710
Mental health costs	1,077	21,536	-20,458
Intangible impacts	149	2,982	-2,833
Emergency service costs	1,272	17,035	-15,762
Risk to life	3,776	72,566	-68,791
Evacuation and temporary accommodation	1,882	28,620	-26,738
Vehicle damages	2,159	32,829	-30,670
Utilities disruption	594	7,960	-7,366
Health services		53,844	-53,844
Educational losses		1,385	-1,385
<b>Total (excludes losses to the local economy)</b>	<b>7,471,227</b>	<b>426,600</b>	<b>7,044,627</b>
<b>% change compared to the baseline values</b>	0.8%	0.0%	0.9%
Losses to the local economy (GVA)	10,083,739	2,375	10,081,364
<b>% change compared to the baseline values</b>	5.0%	0.0%	5.0%

The catchment benefits will reduce by 4% with the lower 0.25m/year fill rate and increase by 1% with the higher 0.75m/year fill rate. This demonstrates that the assessment is relatively insensitive to the rate at which it is assumed to fill at the 3.9m AOD limiting level.

#### 6.4.2 Extreme catchment fill scenario – 6m AOD

A further sensitivity test has been undertaken across all damage streams to determine the impact of an extreme event or scenario in which assets up to 6m AOD are written off. This test demonstrates the potential additional losses above the assumed limiting levels in the Do Nothing scenario, and how sensitive the assessment may be to changes in this level.

The impact on benefits for the Maintain scenario as a result of this extreme Do Nothing catchment fill scenario is shown in Table 6-6.

**Table 6-6: Summary of PV benefits (£k) with the 6m AOD extreme catchment fill scenario**

Type	6m AOD extreme level sensitivity		
	Do Nothing PV Damages (£k)	Maintain PV Damages (£k)	Maintain PV Benefits (£k)
Residential properties	3,980,439	65,975	3,914,464
Non-residential properties	1,042,007	93,226	948,781
Indirect commercial losses	259	2,797	-2,538
Agricultural losses	839,714	25,750	813,963
Environment and recreational losses	207,778	55	207,724
Heritage losses	53,875	40	53,835
Transport damages	1,899,540		1,899,540
Utilities damages	60,105		60,105
Isolated land and properties	-		-
Mental health costs	619	21,536	-20,917
Intangible impacts	86	2,982	-2,896
Emergency service costs	1,294	17,035	-15,741
Risk to life	3,088	72,566	-69,478
Evacuation and temporary accommodation	1,473	28,620	-27,147
Vehicle damages	1,689	32,829	-31,140
Utilities disruption	606	7,960	-7,354
Health services		53,844	-53,844
Educational losses		1,385	-1,385
<b>Total (excludes losses to the local economy)</b>	<b>8,092,572</b>	<b>426,600</b>	<b>7,665,972</b>
<b>% change compared to the baseline values</b>	9.2%	0.0%	9.8%
Losses to the local economy (GVA)	10,066,393	2,375	10,064,018
<b>% change compared to the baseline values</b>	4.8%	0.0%	4.8%

The catchment benefits will increase by 10% with the extreme 6m AOD fill level. This demonstrates that increasing the fill level from 3.9m AOD to 6m AOD does not significantly increase the Do Nothing damages.

## 7. Costing

This section sets out the approach to defining the estimated capital cost interventions required for all FRM assets in the East and West Fens catchment and the estimated point in time at which interventions are required, along with maintenance and operational expenditures.

This exercise has not considered any limitations on funding or the affordability of the investments needed, rather just examining the total investment requirements to sustain the existing asset base to continue to provide the existing Standard of Service, and to inform the cost benefit analysis for the Maintain scenario. An assessment of eligibility for funding at a catchment scale gives a better indication of the limitations on funding based on current Partnership Funding rules and is included in Section 9.

The exercise has been completed to gain a high-level understanding of the broad investment requirements for sustaining the existing asset base, and to understand the cost benefit ratio and available funding to do so. The results should be treated as indicative and used solely for planning of intervention works. For specific interventions, the costs should be reviewed considering existing knowledge, engineering assessment and site constraints in order to most effectively plan future intervention works, and ensure a robust cost is developed at business case development stage for individual investments.

A single “best estimate” cost has been produced based on best available data and standard approaches to estimation of uplifts for elements such as appraisal, design and risk. This has been used to determine the cost benefit analysis and eligibility for funding. However, noting the high-level nature of the data available at this stage, an additional range of costs has been estimated to demonstrate the uncertainty in the cost estimation at this stage.

Risk has been represented with the application of optimism bias; for the best estimate this has been included at 60% for all costs given the uncertainty in cost information at this stage. For the range estimation, optimism bias was included at 30% for the lower bound and 100% for the upper bound.

### 7.1 Capital costs

Cost information for assets have been collated based on comparable asset types from the Great Ouse and Witham Tactical Plans, along with data provided by the Middle Level Commissioners on their planned capital interventions. Where there is a lack of data, or the data is not representative, the cost estimation guidance has been used<sup>28</sup> to calculate an estimate of capital costs. Table 7-1 details these assumed costs.

Capital costs are assumed to be the cost of replacement of the asset at the end of its design life. The point in time at which these investments are required has been based on asset deterioration rates as defined in ‘Practical guidance on determining asset deterioration and the use of condition grade deterioration curves: Revision 1 (Report – SC060078/R1, Environment Agency, 2013). It has been assumed that all assets will deteriorate in line with maintenance regime standard 2 as defined this guidance, and that following investment assets will be returned to condition grade 3.

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<sup>28</sup><https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/long-term-costing-tool-for-flood-and-coastal-risk-management>

Conservatively, future investments are assumed required when the asset reaches condition grade 5, though it is noted that target condition grade is 3. Information on future investment needs is available from discussions with the North Level and South Holland Internal Drainage Boards, and so for those assets this information has been used instead of the average capital costs derived.

No adjustment is made to this approach for the lower and upper bound costs.

**Table 7-1: Estimate of capital costs per asset type**

Asset type	Asset Information	Assumed capital cost (£k)
Pumping station	0-1 m <sup>3</sup> /s capacity	1,097
	1-2 m <sup>3</sup> /s capacity	2,275
	2-5 m <sup>3</sup> /s capacity	3,708
	5-10 m <sup>3</sup> /s capacity	3,708
	10+ m <sup>3</sup> /s capacity	87,156
Embankments	Per m	2
Walls	Per m	4
Outfalls	Per unit	39
Sluices	Per unit	2,314
Control gates	Per unit	38
Open channels	Per m	-
Simple culvert	Per m	249
Weirs	Per unit	246
Debris screen	Per unit	19

## 7.2 Appraisal costs

Consultancy fees and Environment Agency staff costs have been estimated using Project Cost Tool (PCT) curves. At this stage, indicative costs have been included for environmental enhancement and survey exercises (including Ground Investigation (GI) and non-intrusive survey including topographic survey). It has been assumed that Environmental enhancement will equate to 3% of capital costs, that GI will be 5% and non-intrusive survey will be 3% of capital costs. These uplifts were derived based on outturn costs from similar packages of work.

For the lower bound cost estimate, the minimum percentage uplifts from the PCT curves for consultancy and Environment Agency staff costs have been used, regardless of

estimated construction value. Conversely, for the upper bound estimate the maximum percentage uplift has been used.

### **7.3 Future Costs**

Where costs have been provided for short term investments or capital interventions which are not a full asset replacement, these have been assumed as separate to the capital costs of asset replacement as described in Section 7.1. These costs are referred to as future costs, as they are planned interventions on a programme. However, it should be noted that in some cases these are expected to occur before asset replacement and capital costs.

No adjustment is made to this approach for the lower and upper bound costs.

### **7.4 Maintenance and Operational Costs**

Anticipated maintenance and operational costs have also been based on expenditure for similar assets in the Great Ouse and Lower Witham catchments. Where this information is not available the relevant cost estimation guidance has been used<sup>29</sup>. These costs were projected out over the whole appraisal period and a 60% risk applied to represent uncertainty in future maintenance and operational activities.

Maintenance and operational cost estimates were adjusted for the cost range estimation by reducing the 60% risk value to 30% for the lower bound estimate and increasing it to 100% for the upper bound estimate.

### **7.5 Whole life costs**

The cost information received from the Environment Agency and partner RMAs was forecast over the appraisal period to understand the profile of investment required over a 20 year and a 100-year period. These costs were discounted using HM Treasury discount rates to provide Present Value estimates of Whole Life Costs per asset, summed per sub catchment and totalled for the entire East and West Fens catchment.

The best estimate of cost to be used in cost benefit analysis, alongside the lower and upper bound costs accounting for uncertainty in investment needs at this stage, are presented in Table 7-3.

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<sup>29</sup><https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/long-term-costing-tool-for-flood-and-coastal-risk-management>

**Table 7-2: Estimate of whole life costs for the East and West Fens catchment and each subcompartment (£k)**

	<b>Witham Fourth (A)</b> <b>(£k)</b>	<b>Witham Fourth (B)</b> <b>(£k)</b>	<b>Witham Fourth (C)</b> <b>(£k)</b>	<b>Witham Fourth (D)</b> <b>(£k)</b>	<b>East and West Fens</b> <b>(£k)</b>
Capital costs	151,829	15,083	53,301	80,921	301,134
Appraisal costs	77,003	7,494	23,778	42,353	150,627
Risk contingency	137,299	13,546	46,247	73,964	271,057
Future costs	-	-	13,287	165,541	178,827
Maintenance and operational costs	27,093	11,539	30,229	48,724	117,586
<b>Whole life cost</b>	<b>393,225</b>	<b>47,663</b>	<b>166,842</b>	<b>411,502</b>	<b>1,019,232</b>

**Table 7-3: Range of whole life costs for the East and West Fens catchment and each subcompartment (£k)**

	<b>Witham Fourth (A)</b> <b>(£k)</b>	<b>Witham Fourth (B)</b> <b>(£k)</b>	<b>Witham Fourth (C)</b> <b>(£k)</b>	<b>Witham Fourth (D)</b> <b>(£k)</b>	<b>East and West Fens</b> <b>(£k)</b>
Lower bound cost	300,272	38,678	127,661	343,551	810,162
Best estimate cost	393,225	47,663	166,842	411,502	1,019,232
Upper bound cost	535,032	62,000	232,469	630,889	1,460,390

## 8. Cost Benefit Analysis

Capped PV damages, the net PV benefits of implementing the Maintain scenario, and the project costs are used to calculate the benefit cost ratios, shown in Table 8-1.

**Table 8-1: Cost Benefit Analysis**

Option	Damages (£k)	Benefits (£k)	Whole life costs (£k)	Benefit Cost Ratio
<b>Total – East and West Fens</b>				
Do Nothing	7,410,938	-	-	-
Maintain	426,600	6,984,338	1,019,232	6.85
<b>Witham Fourth (A)</b>				
Do Nothing	269,177	-	-	-
Maintain	11,571	257,606	393,225	0.66
<b>Witham Fourth (B)</b>				
Do Nothing	468,318	-	-	-
Maintain	12,018	456,300	47,663	9.57
<b>Witham Fourth (C)</b>				
Do Nothing	3,599,302	-	-	-
Maintain	139,338	3,459,964	166,842	20.74
<b>Witham Fourth (D)</b>				
Do Nothing	3,074,141	-	-	-
Maintain	263,672	2,810,468	411,502	6.83

## 9. Partnership Funding

The maximum level of Grant in Aid (GiA) available at a catchment (and sub compartment) level has been calculated using the benefits derived as damages avoided following the methodologies set out in Section 5, and compared with whole life costs for all assets within the catchment (or sub compartment) as derived under Section 7.

Outcome Measure 2 counts follow a simplified approach detailed in Section 9.3 of the Calculate GiA funding for FCERM projects guidance<sup>30</sup>. Outcome Measure 2 properties better protected from flood risk have been defined based on the number of properties at risk in the Maintain scenario, together with those written off in the Do Nothing scenario which are assumed to be at Low Risk in the “after” counts; for the “before” count of properties, these properties are shifted one risk band higher.

No Outcome Measure 4 have been included in the Partnership Funding calculators at this stage of assessment.

Table 9-1 to Table 9-10 detail the number of Outcome Measure 2a properties that are better protected against flood risk by sustaining the existing defences over the 100 years benefits period.

**Table 9-1: Outcome Measure 2 – East and West Fens catchment - at risk today**

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	1,852	71	-	91
21% to 40% most deprived	-	6,496	1,158	-	481
60% least deprived	-	5,579	509	-	221
All deprivation bands	-	13,927	1,738	-	793

**Table 9-2: Outcome Measure 2 – East and West Fens catchment - at risk after duration of benefits**

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	1,852	71	-	91	-
21% to 40% most deprived	6,496	1,158	-	481	-
60% least deprived	5,579	509	-	221	-
All deprivation bands	13,927	1,738	-	793	-

<sup>30</sup> [https://assets.publishing.service.gov.uk/media/66e15a1c44b517b5cc5e2688/LIT\\_58360\\_\\_Calculate\\_GiA\\_funding.pdf](https://assets.publishing.service.gov.uk/media/66e15a1c44b517b5cc5e2688/LIT_58360__Calculate_GiA_funding.pdf)

**Table 9-3: Outcome Measure 2 – Witham Fourth (A) - at risk today**

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	-	472	39	-	60
60% least deprived	-	6	-	-	-
All deprivation bands	-	478	39	-	60

**Table 9-4: Outcome Measure 2 – Witham Fourth (A) - at risk after duration of benefits**

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	472	39	-	60	-
60% least deprived	6	-	-	-	-
All deprivation bands	478	39	-	60	-

**Table 9-5: Outcome Measure 2 – Witham Fourth (B) - at risk today**

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	-	724	188	-	17
60% least deprived	-	2	10	-	2
All deprivation bands	-	726	198	-	19

**Table 9-6: Outcome Measure 2 – Witham Fourth (B) - at risk after duration of benefits**

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	724	188	-	17	-
60% least deprived	2	10	-	2	-
All deprivation bands	726	198	-	19	-

**Table 9-7: Outcome Measure 2 – Witham Fourth (C) - at risk today**

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	960	39	-	54
21% to 40% most deprived	-	2,950	614	-	129
60% least deprived	-	1,454	351	-	15
All deprivation bands	-	5,364	1,004	-	198

**Table 9-8: Outcome Measure 2 – Witham Fourth (C) - at risk after duration of benefits**

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	960	39	-	54	-
21% to 40% most deprived	2,950	614	-	129	-
60% least deprived	1,454	351	-	15	-
All deprivation bands	5,364	1,004	-	198	-

**Table 9-9: Outcome Measure 2 – Witham Fourth (D) - at risk today**

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	892	32	-	37
21% to 40% most deprived	-	2,350	317	-	275
60% least deprived	-	4,117	148	-	204
All deprivation bands	-	7,359	497	-	516

**Table 9-10: Outcome Measure 2 – Witham Fourth (D) - at risk after duration of benefits**

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	892	32	-	37	-
21% to 40% most deprived	2,350	317	-	275	-
60% least deprived	4,117	148	-	204	-
All deprivation bands	7,359	497	-	516	-

Table 9-11 details the maximum eligible GiA and the raw PF score for the whole of the East and West Fens catchment and each subcompartment.

**Table 9-11: Partnership funding calculator results**

	pv maximum eligible FCERM GiA (£k)	raw PF score (%)
East and West Fens	430,285	42
Witham Fourth (A)	-	-
Witham Fourth (B)	28,087	59
Witham Fourth (C)	212,296	127
Witham Fourth (D)	173,926	42

The subcompartment Witham Fourth (A) has a benefit cost ratio below 1, as shown in Table 8-1, and so is not eligible for FCERM GiA.

## 10. Limitations

There are a number of limitations for the work undertaken at this stage of assessment:

- National model data (Risk of Flooding from Multiple Sources) has been used to determine risk in the Maintain scenario and residual risk above permanent inundation levels in the Do Nothing scenario. This data allows for an indicative assessment of the risk and potential damages but caution is advised when using this data at a local level, and consideration given to the use of local model data for future business cases at individual assets.
- The benefits assessment undertaken is broad given the strategic nature of the project, and the damages assumed to accrue under Do Nothing and Maintain scenarios are based on a standardised set of assumptions. This does not allow for more discrete impacts of a Do Nothing scenario such as blockage or failure of structures which may exacerbate risk in discrete areas in the short term.
- The costs developed at this stage are considered indicative only and should be reviewed at more detailed stages of appraisal for individual investments.
- Costs and estimated years for interventions have not been provided by all RMAs for all assets and as such there may be assets for which no cost information is included. However, benefits have been allocated across all eligible FRM assets such that these assets do have available benefits. Further to this, standardised costing assumptions have been made for a number of assets which may not be appropriate across all assets. The overall impact of this is not considered likely to change the general outcome of the analysis, and the indication of affordability and value for money.

# 11. Conclusions

Over the next 100 years, the Do Nothing scenario is projected to result in PV damages exceeding £7.4 billion, compared to just £427k under the Maintain scenario. By continuing the current FRM approach, the Maintain scenario delivers estimated benefits of nearly £7 billion. The primary driver of these benefits is the high standard of existing flood protection, which does not lead to considerable flooding from overtopping of defences. In total, 16,590 residential properties as OM2a are protected by the FRM assets maintained under this scenario. Benefits include:

- £4.2 billion of property damages avoided<sup>31</sup>, including 16,590 residential and 2,431 non-residential properties avoiding write off
- £809m of agricultural losses avoided, and 29,427ha of land protected
- £189m of environmental and recreational losses avoided
- £44m of heritage losses avoided
- £1.6 billion of transport damages avoided
- £49m of utilities damages avoided
- £47m of land lost to isolation being avoided.

In addition to these economic benefits, there is an estimated £9.6 billion of financial losses to the local economy avoided in the first ten years.

To provide this level of protection, a total of 7 pumping stations, 41 outfalls, and significant reaches of open channel and linear flood defences will need to be sustained over the next 100 years, with total whole life costs estimated at £1,019 million to do so.

Based on the analysis, it is clear that the current FRM measures and activities provide substantial benefits across the East and West Fens catchment. However, these benefits are not evenly distributed. Witham Fourth (C) demonstrates the highest level of benefit, with a strong return on investment for the FRM interventions implemented with most subcompartments having a BCR above 1. However, Witham Fourth (A) shows a less good return on investment, with the lowest cost benefit ratio of 0.66. This is likely due to the limited number of benefits generated in the smallest subcompartment.

Given the high value of benefits and large numbers of residential properties protected, the catchment is eligible for £430 million of GiA funding with a PF score of 42%. Consequently, there is a funding gap of £589 million that needs to be closed when compared to the total whole life cost of sustaining the FRM assets.

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<sup>31</sup> Includes direct residential and non-residential damage as well as indirect commercial losses, mental health costs, emergency services costs, risk to life, evacuation and temporary accommodation costs and intangible impacts to human health

