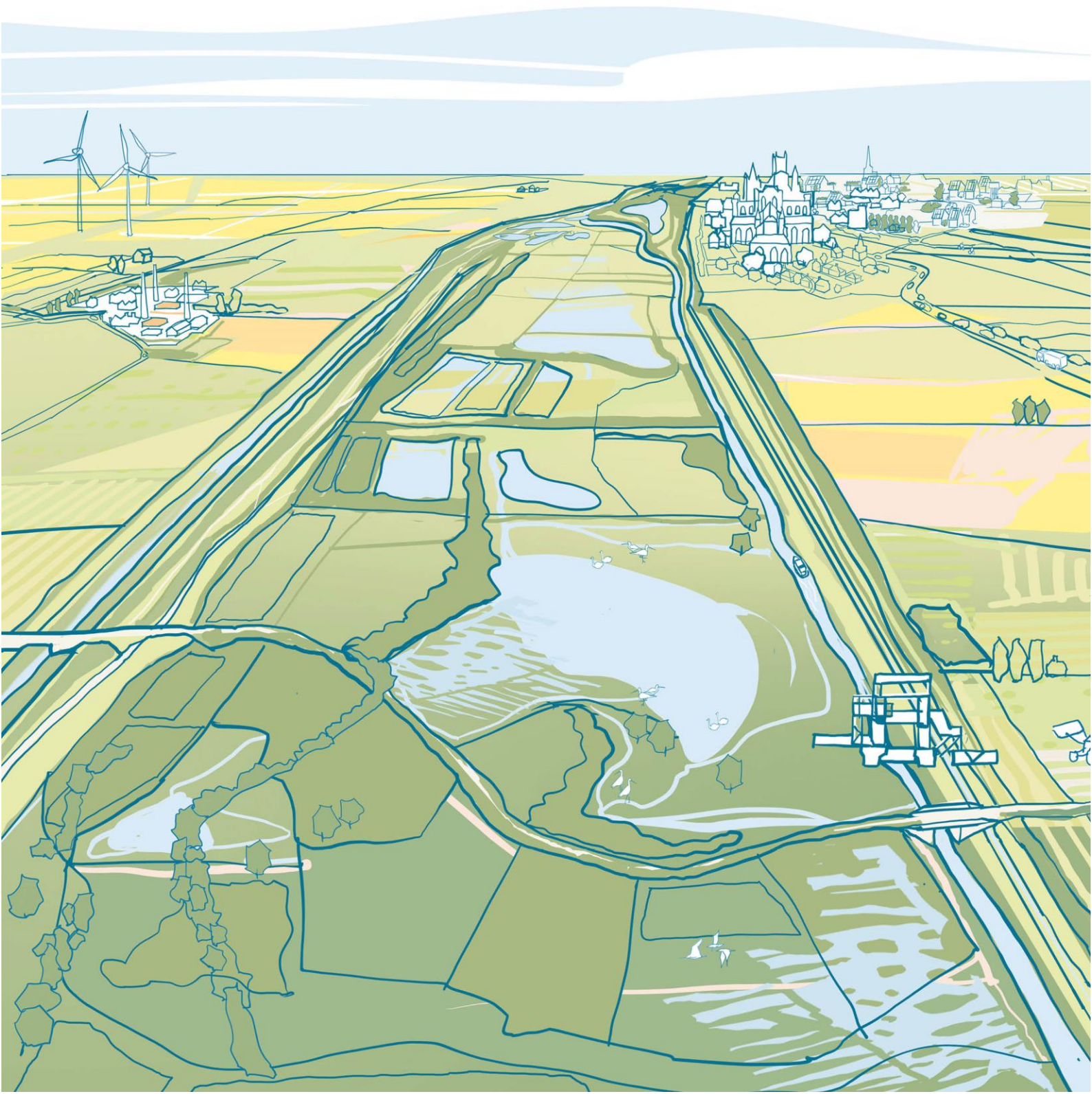


# Lower Nene

## 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 Lower Nene catchment, with reference to current and future flood risk management (FRM). 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 Lower Nene catchment stretching from Peterborough in the West to the coast at Guy's Head. This catchment is protected using a series of raised flood defences and a complex set of water management systems operated by three Internal Drainage Boards (IDBs), this being the Feldale IDB, South Holland IDB, and North Level District IDB.

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;
- Heritage;
- Highways;
- Rail;
- Gas;
- Electricity;
- Isolated Properties;
- Mental Health;
- Emergency Service costs;
- Risk to life;
- Evacuation and temporary accommodation costs;
- Vehicle damages;
- Intangible impacts to human health;
- Utilities disruption; and,
- Local losses to the economy as Gross Value Added.

The Do-Nothing baseline scenario identifies present value damages of up to £13,013 million across the catchment extents over a 100-year period. This is compared to the estimated damages associated with FRM arrangements of £13k. Based upon the analysis, the present FRM arrangements and activities are estimated to afford a benefit of £13,013 million to the Lower Nene 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 capital. The analysis therefore suggests there is a case for maintaining the flood defence infrastructure in the long term, but whether this represents the optimum FRM regime remains to be investigated. With a benefit cost ratio of 15.48, the Lower Nene catchment has a Partnership Funding score of 94% and is eligible for £270 million in Grant in Aid, which leaves a funding gap of £50 million.

## 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 FRM 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 FRM 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 Lower Nene catchment as part of the Fens 2100+ Project 3 baseline reports, with reference to the current FRM 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 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 Risk Management Authorities (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 Lower Nene catchment (hereafter referred to as “the catchment”) covers 553 km<sup>2</sup> of primarily rural, highly productive agricultural land. The catchment is situated at the centre of the wider Fens 2100+ catchment bordering the Lower Welland and Great Ouse catchments (see Figure 1). The catchment stretches from Peterborough in the south-west to the Luton Leam Sluice where it discharges to the North Sea. The section of the River Nene within the catchment extends from approximately 8km upstream of Peterborough and is approximately 55km long. Outside the catchment boundary to the west, the River Nene and its tributaries the Kislingbury Branch, the Brampton Branch and Wootton Brook, rise in the Northamptonshire Uplands. These headwaters meet in Northampton and from here the River Nene flows across gently undulating rural country to the flat plains around Peterborough, where it enters the Lower Nene catchment study area and its embanked tidal reach across the Fens. 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.

Although largely rural, the catchment includes several key urban areas, such as Peterborough, Holbeach, Long Sutton and Wisbech. The River Nene allows for water navigation from Peterborough to the discharge of the river to the North Sea. Railway networks further connect Peterborough with March and Spalding, with major roads across the catchment supporting both local and regional connectivity.

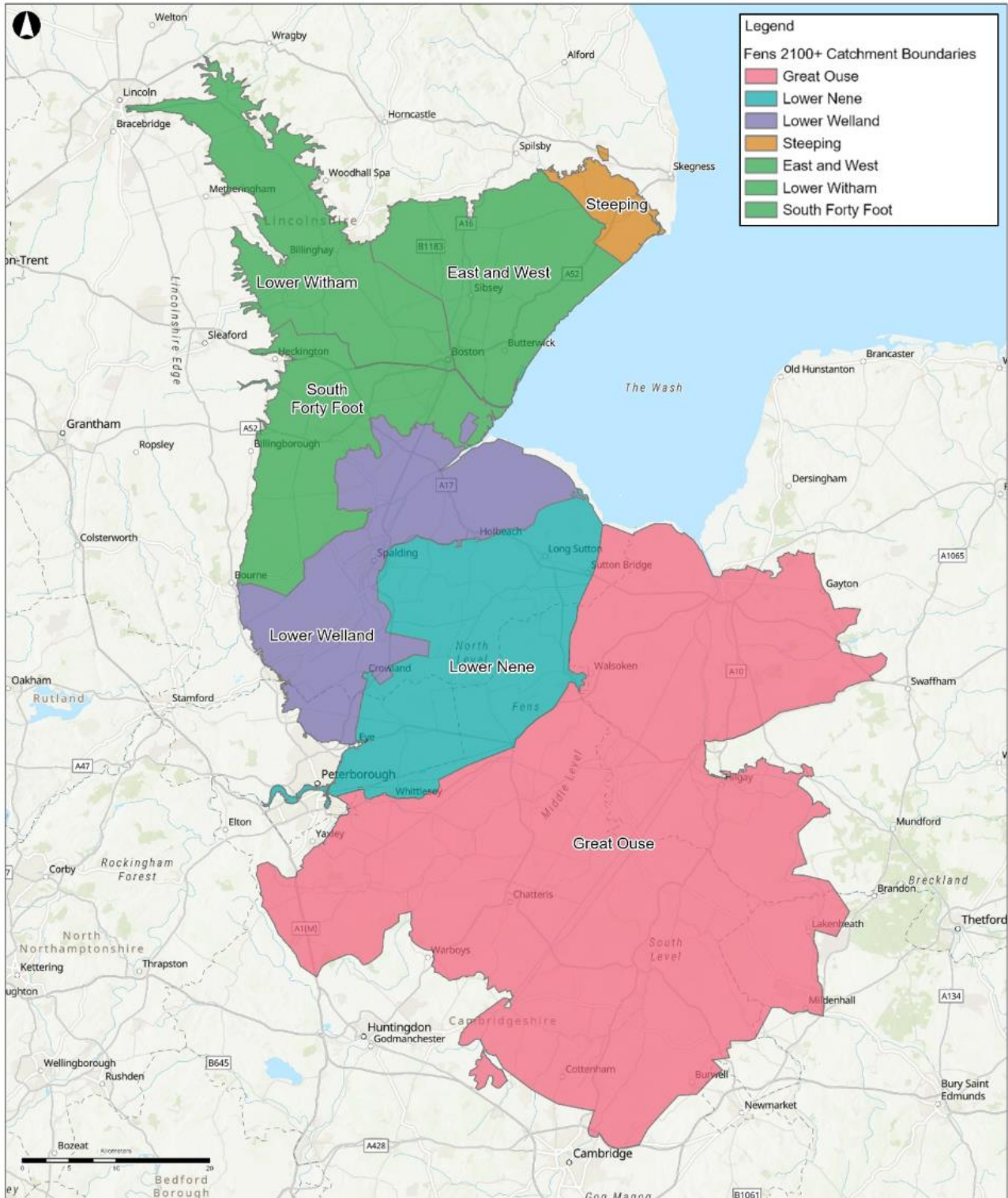
The lowest lying areas in the catchment sit at approximately 3m below sea level in the vicinity of the Lowland Drain south-west of Tydd Saint Giles and the A47 between Thorney

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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

and Guyhirn. Being below sea level puts these areas at significant risk of tidal and fluvial flooding.



**Figure 1: Catchments covered within the Fens 2100+ economic appraisal**

### **2.2.1 Drainage network**

The Lower Nene catchment relies heavily on its pumped drainage system to maintain its highly productive agricultural land. The loss of these pumped systems would render the land uninhabitable.

The catchment is comprised of several interlinked drainage systems; there is a network of Main Rivers for which the Environment Agency have permissive powers to manage and maintain, and there are three IDB drainage networks which discharge water into the Main Rivers.

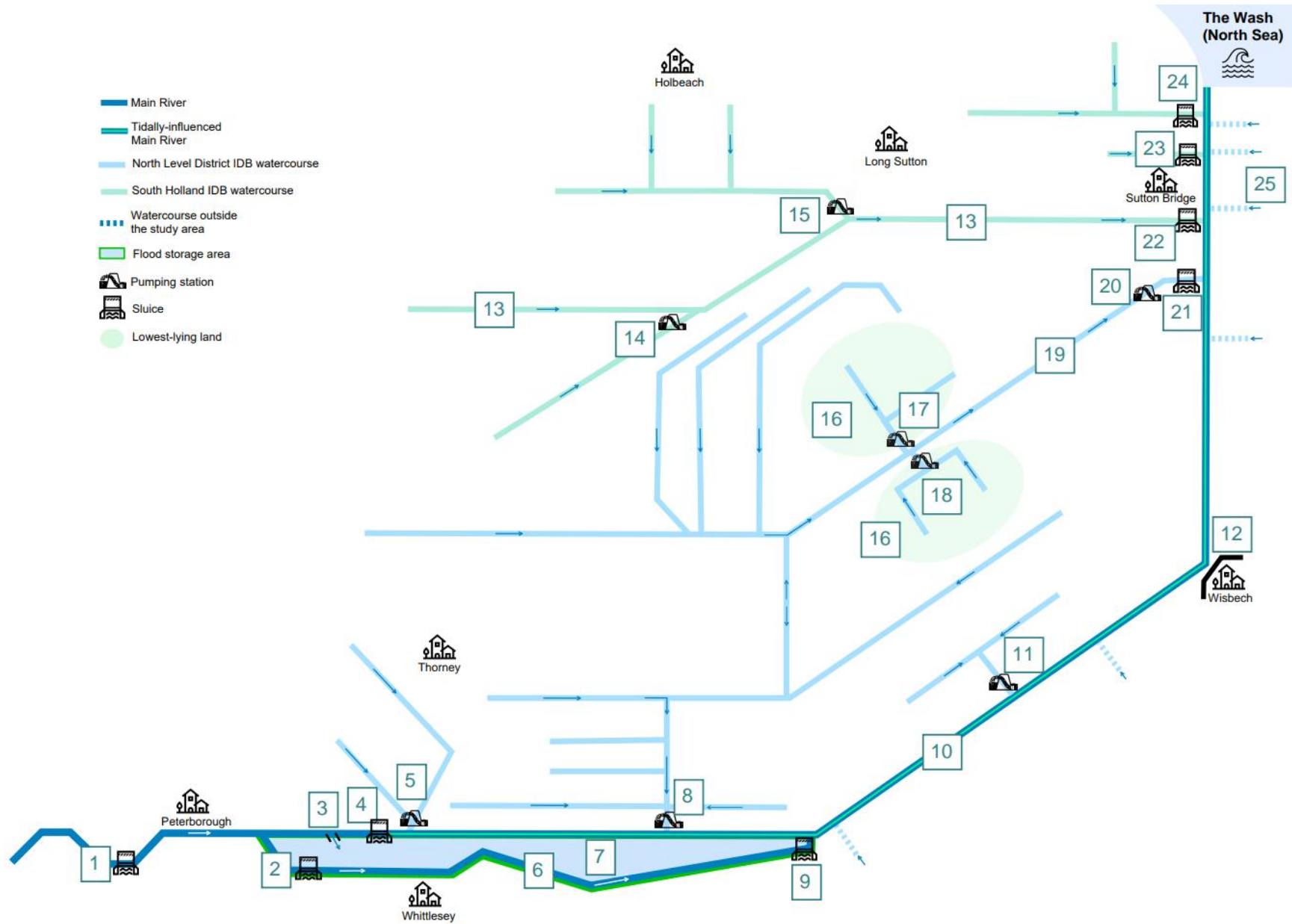
The Main Rivers include the River Nene itself, and Morton's Leam which runs around the southern edge of the Whittlesey Washes.

There are three Internal Drainage Boards whose districts overlap with the Lower Nene catchment. North Level District IDB and South Holland IDB account for the majority of the catchment, but a small area near Whittlesey is drained by Feldale IDB. IDBs are responsible for all pumping activities within the catchment, moving water from the land into the River Nene. Each IDB maintains a drainage network of channels, control sluices and pumping stations which control the discharge of water into the Main River or keep water on the land during drier periods. Some of the key IDB watercourses include the North Level Main Drain, South Holland Main Drain, New South Eau and the Little Holland Drain.

Effective water level management in the catchment 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 Lower Nene catchment**

- 1 Orton Mere Sluice**  
 Environment Agency  
 Helps to control water levels on the River Nene and includes a navigation lock.
- 2 Stanground Sluice**  
 Environment Agency  
 In flood conditions, water is diverted out of the River Nene and into Morton's Leam through Stanground Sluice so that the Washes can start to fill. Water can also enter the washes by spilling over the Cradge Bank via Northey Gravel Weir on the southern bank of the River Nene.
- 3 Northey Gravel Weir**  
 Environment Agency  
 The original inlet structure for the Whittlesey (Nene) Washes. Water flows over the weir during winter flood conditions.
- 4 Dog in a Doublet Sluice**  
 North Level District IDB Environment Agency  
 Marks the tidal limit of the River Nene. It controls water levels from the fluvial to the tidal section and includes a navigation lock. In flood conditions it can become tide-locked, resulting in the operation of the Whittlesey (Nene) Washes.
- 5 Dog in a Doublet Pumping Station**  
 North Level District IDB  
 Pumps water from the area of land between Peterborough and Thorney into the River Nene.
- 6 Morton's Leam**  
 Main River  
 Flows through the Washes along its southern edge. During periods of high flow in the River Nene, Morton's Leam becomes a route for water onto the Washes, and then to Ring's End Sluice for discharge.
- 7 Whittlesey (Nene) Washes**  
 Environment Agency & Partners  
 Registered under the Reservoirs Act 1975 and operated by the Environment Agency. The Washes function as a flood storage area for the equivalent of 14,000 olympic-sized swimming pools of water. The storage area is contained by the Cradge Bank and the South Barrier Bank.
- 8 Cross Guns Pumping Station**  
 North Level District IDB  
 Pumps water into the Nene from land to the north. The network of drains across the North Level District are connected so that water can be pulled south towards Cross Guns to take pressure off Tydd Pumping Station.
- 9 Ring's End Sluice**  
 Environment Agency  
 Water is released from the Washes back into the River Nene through Ring's End Sluice when river flows and tidal conditions allow.
- 10 River Nene**  
 Main River  
 The study area encompasses around 60km of the Nene's lower course, which is tidal downstream of Dog-in-a-Doublet Sluice.
- 11 Mouth Lane Pumping Station**  
 North Level District IDB  
 Pumps water from a small sub-catchment into the River Nene.
- 12 Wisbech flood defences**  
 Environment Agency  
 Flood walls protect properties in Wisbech from high flows in the River Nene.
- 13 South Holland Main Drain**  
 South Holland IDB  
 Carries water from smaller drains to the outfall at Sutton Bridge Sluice.
- 14 Fleet Fen Pumping Station**  
 South Holland IDB  
 Pumps water out of the Fleet Drain into the South Holland Main Drain.
- 15 Little Holland Pumping Station**  
 South Holland IDB  
 Pumps water out of the Little Holland Drain into the South Holland Main Drain.
- 16 Poplars and Willow Holt sub-catchments**  
 North Level District IDB  
 These are especially low-lying.
- 17 Poplars Pumping Station**  
 North Level District IDB  
 Pumps water out of a small low-lying sub-catchment into the North Level Main Drain. This water is pumped upwards again into the River Nene at Tydd Pumping Station.
- 18 Willow Holt Pumping Station**  
 North Level District IDB  
 Pumps water out of a small low-lying sub-catchment into the North Level Main Drain.
- 19 North Level Main Drain**  
 North Level District IDB  
 The main carrier of water from the southern portion of the Lower Nene catchment to Tydd Pumping Station.
- 20 Tydd Pumping Station**  
 North Level District IDB  
 The largest pumping station in the Lower Nene catchment. It removes the majority of water from the North Level IDB system into the River Nene. Pumped water can be held in the water-storage pound upstream if Foul Anchor Sluice is tide-locked.
- 21 Foul Anchor Sluice**  
 North Level District IDB  
 A Grade II listed structure which acts as a tidal defence.
- 22 Sutton Bridge Sluice**  
 South Holland IDB  
 Controls discharge of the South Holland Main Drain into the Tidal River Nene. Although a network of pumps move water into the South Holland Main Drain upstream, there are no pumps here, so water can only be discharged through the sluice at low tide.
- 23 Westmere Sluice**  
 South Holland IDB  
 Outfall for Westmere Creek into the Tidal Nene.
- 24 Lutton Leam Sluice**  
 South Holland IDB  
 Outfall of Lutton Leam into the Tidal Nene.
- 25 Other inflows to the Nene**  
 King's Lynn IDB  
 King's Lynn IDB discharge water from the west of their district into the River Nene. Further south, Waldersey IDB and Hundred of Wisbech IDB also discharge to the Nene, but are part of the Middle Level system of the Great Ouse catchment.

## 2.3 Study context

The Lower Nene catchment consists primarily of low-lying agricultural land with the lowest lying areas sitting approximately 3m below sea level. The primary watercourse within the catchment is the River Nene. From Peterborough the River Nene flows north-east through the catchment, eventually discharging into the North Sea via The Wash.

Much of the economy of the region is agricultural with highly productive farmland making the catchment a vital contributor to national food security. The low-lying terrain of the catchment is typical of the wider Fens, with over a third of the catchment lying below sea-level. The lowest lying areas are in the vicinity of the Lowland Drain south-west of Tydd Saint Giles and the A47 between Thorney and Guyhirn. Being below sea level puts these areas at significant risk of tidal and fluvial flooding.



**Figure 3: North Level Main Drain**

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## 2.4 Description of flood risks

There are limited records of tidal flooding in the Lower Nene catchment following the construction of the Dog-in-a-Doublet sluice and the defence improvements at Wisbech following the flooding occurred in 1978. As such the Current tidal flood risk in the Lower Nene catchment is low.

The Tidal River Nene model results, which indicate the flood risk associated with overtopping of the existing defences in the Lower Nene catchment, has been used to assess current and future flood risk. It shows limited overtopping for all present day

scenarios evaluated, i.e., the 0.5% Annual Exceedance Probability (AEP), the 0.33% AEP, and the 0.1% AEP.

Current fluvial flood risk to the Lower Nene catchment is concentrated upstream of Dog-in-a-Doublet sluice, within Peterborough. At this location, commercial and residential properties appear to be most at risk during flood events.

Present day tidal and fluvial flood risk is low downstream of Dog-in-a-Doublet sluice, with the flood embankments and defences, as well as the Whittlesey (Nene) Washes providing a degree of protection against both sources of flooding. Upstream of the sluice, there is evidence of risk to properties from fluvial flooding.

## 2.5 Historic flooding

There is a history of significant flood events across the Fens 2100+ study area. 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>1868</b>	Fluvial	On 11th July 1868, 4.15 inches of rain fell in 12 hours causing much damage to crops in the North Level District. Approximately 30.14 inches of rain fell in that year, leading to the Clark Scheme of major improvement.
<b>November 1903</b>	Unknown	Early photographs dated to 1903 capture flooding in the Lower Nene catchment, before the Dog-in-a-Doublet Sluice was constructed to protect the city of Peterborough from flooding.
<b>1912</b>	Fluvial	Heavy rainfall between the 20th and 26th August brought 4 inches of rainwater and flooded the Whittlesey (Nene) Washes. Most of the North Level District was flooded, and the potato crop failed as a result. This flood event occurred prior to the construction of the Dog-in-a-Doublet sluice gates.
<b>Winter 1946/47</b>	Fluvial	The winter of 1946/1947 saw extremely low temperatures and heavy snowfall. A rapid thaw led to significant flooding across the United Kingdom. Failure of the southern barrier of the Crowland High Wash leads to severe flooding of the North Level District IDB’s district, causing widespread damage.  There was also flooding from the River Nene during this event around Peterborough.
<b>1953</b>	Coastal / tidal	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 flood and waves overwhelmed sea defences and caused extensive flooding. The surge travelled inland from The Wash along the Rivers Great Ouse and Nene, causing both rivers to overflow and break their banks. Across the region, flooding seriously damaged 24,000 properties, of which 500 were totally destroyed. Around 32,000 people were safely evacuated.

<b>January 1978</b>	Coastal / tidal	1978 North Sea storm surge causing extensive coastal flooding and considerable damage on the east coast of England. About 1,000 people were evacuated in Wisbech when the Nene overflowed its banks, with flood water reaching 5 ft. [1.5 m] deep. One person lost their life.
<b>April 1998</b>	Fluvial	In April 1998 the River Nene burst its banks after Northamptonshire received a month's worth of rain in just 24 hours. 4,200 properties were flooded as towns, villages and agricultural land were deluged with flood water. Northampton, Weedon, Kislingbury and Thrapston were worst affected – all upstream of the Tidal Nene extents.
<b>December 2013 – Near Miss</b>	Tidal surge	The tidal surge which hit the east coast of Britain has been described as the "most serious" for 60 years. The event caused the River Nene to come within a few inches of breaching Wisbech's flood defences.
<b>December 2020</b>	Fluvial & surface water	Incidents of flooding reported across the catchment. Heavy rain was reported to have caused the Nene to burst its banks and leave many low-lying areas surrounding Peterborough flooded. The Middle Levels and North Bank in Whittlesey flooded due to the Nene being too high (resulting in tide lock conditions) following heavy rainfall and surface water being unable to discharge.
<b>November 2012</b>	Fluvial	On 27th November 2012 heavy rain caused flooding from the River Nene at a number of locations, including upstream of the city at Orton Mere <sup>3</sup> .
<b>2023</b>	Fluvial	Heavy rainfall in Storm Babet leads to flooding along the River Nene in the vicinity of Peterborough and throughout the catchment.

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

The Lower Nene has been heavily engineered along its course, with hydraulic structures, including Whittlesey Washes (with Stanground Sluice and Rings End Sluice on Morton's Leam controlling inflow and outflow) and the Dog in a Doublet Sluice, and hydraulic restrictions (e.g. bridges) through Wisbech. Much of the River Nene flows through raised earth embankments, supported by hard defences (e.g. retaining wall structures and sheet piling) through the centre of Wisbech. The tidal limit of the river is at the Dog-in-a-Doublet sluice. Downstream of this point, the River Nene is a highly engineered channel which includes tidal embankments along its 55km length.

The Environment Agency undertakes a rolling programme of maintenance to protect and maintain the condition of the existing defences on Main Rivers, including grass cutting and other vegetation management, and maintenance of hydraulic structures.

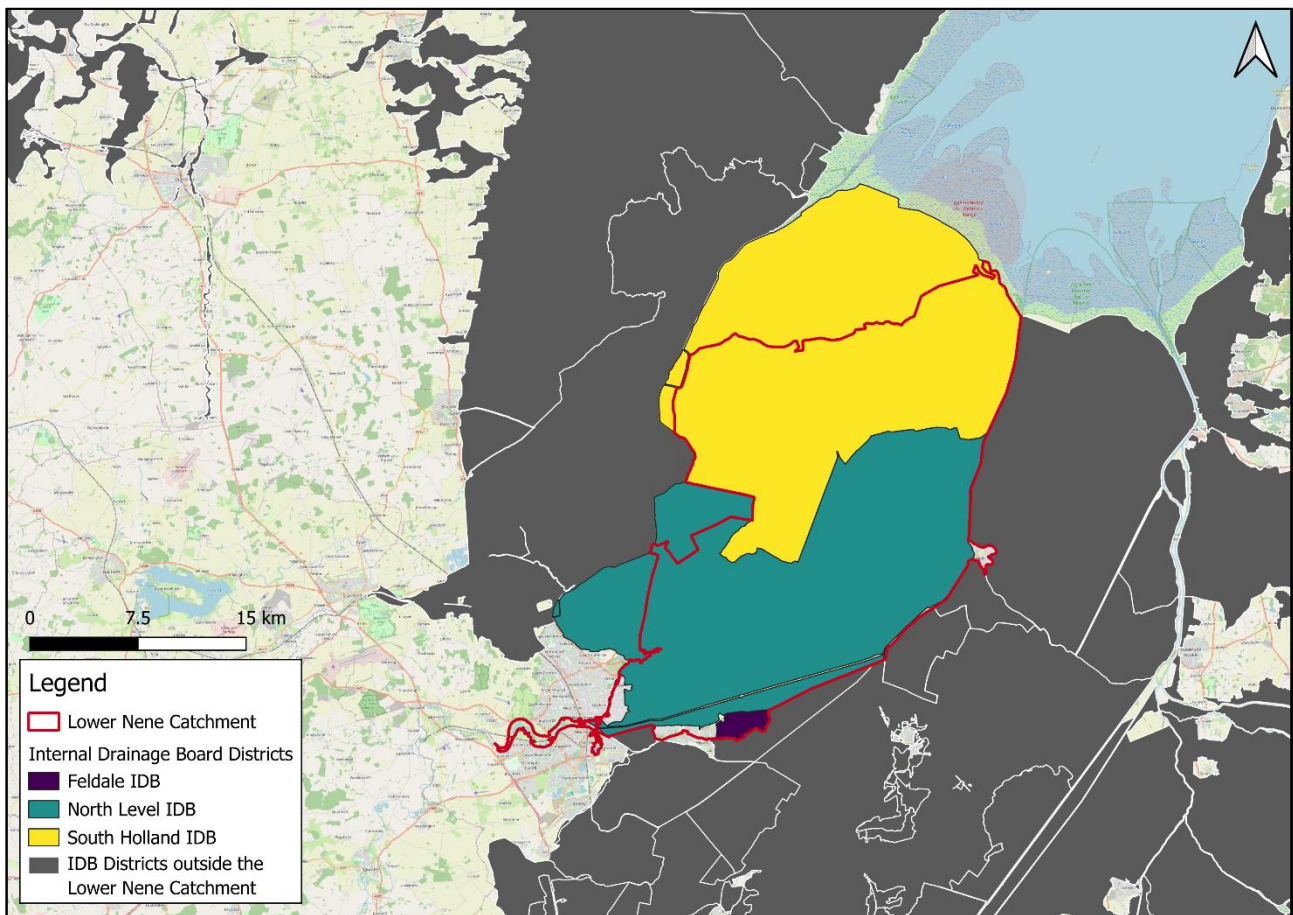
The wider network of IDB drains, sluiced and pumping stations are administered by the Feldale, North Level District, and South Holland Internal Drainage Boards which together cover the study area as shown in Figure 4. These IDBs pump water to the Nene to manage drainage in their catchments.

IDBs provide water level management systems and regulate the water levels in their systems through a network of pumping stations. Water management in the catchment is supported by a system of pumping stations, the largest of which is Tydd Pumping Station, owned by North Level District IDB.

<sup>3</sup> <https://www.peterboroughimages.co.uk/peterborough-in-flood-november-2012/>

These systems are maintained to ensure a high standard of drainage is afforded to the study area. Several on-going operation and maintenance activities are undertaken by the IDBs, including pumping station operation/maintenance, channel dredging/clearance, and reinstatement of embankments.

One of the most critical flood management assets in the catchment is the Whittlesey (Nene) Washes, a flood storage area covering 15km<sup>2</sup> and extending 20km along the southern side of the River Nene. This provides flood storage capacity of 35 million m<sup>3</sup> (equivalent to 14,000 Olympic swimming pools) which provides tidal flood protection to Peterborough, as well as fluvial flood protection to agricultural land to the south. If flows in the River Nene are exceptionally high and the river becomes tide locked, water is designed to overtop the Cradge Bank and spill into The Washes, which are contained on the outer edge by the South Barrier Bank. In flood conditions water is diverted through Stanground Sluice so The Washes can fill, Ring's End Sluice is located at the end of The Washes and releases water back into the River Nene. During periods of high river flow, the washes act as a vital flood storage area, and during dry periods form an important nature reserve.



**Figure 4: Internal Drainage Boards in the Lower Nene catchment**

As the outfall to the system near Luton Leam Sluice is tidal, there are periods when high tide levels prevent discharge of fluvial waters. This restricted period can be extended if surges occur in the tidal waters. During these periods of 'tide lock', river flows are diverted into Morton's Leam via Stanground Sluice, eventually overflowing and flooding the Nene Washes. The water remains in The Washes until tidal levels permit its discharge at Ring's End Sluice at the downstream end of Morton's Leam.



**Figure 5: The North Level Main Drain joins the River Nene at Foul Anchor Sluice**

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**Figure 6: Dog-in-a-Doublet Sluice**

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## 3. Economic Appraisal Baseline Scenarios

The objective of this economic assessment is to provide a broad assessment of key receptors at risk for the Lower Nene catchment. The economic baseline is identified as the Do-Nothing scenario. Further analysis of the present FRM 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 FRM activities will lead to relatively rapid inundation of the catchment from water which is unable to drain to Main Watercourses such as the River Nene.

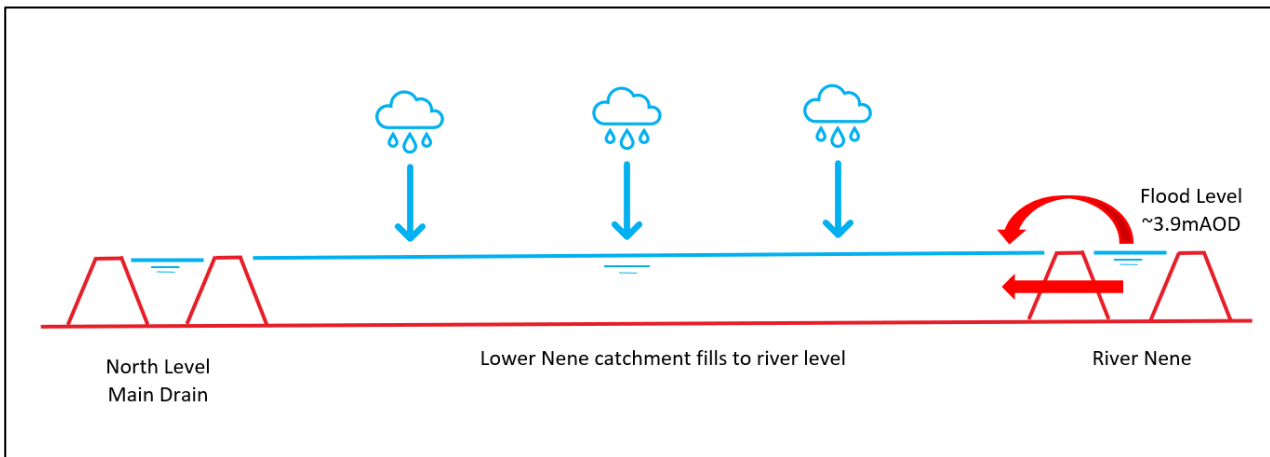
Under the Do-Nothing scenario the pumping stations would cease operating resulting in water being unable to drain and the rainfall would start to fill the catchment. In addition, the sluices on the main rivers would cease to operate and cause the rivers to back-up. Extreme flood events on the rivers 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. Wash banks 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. Water is not assumed to spill over coastal defences.

A rate of catchment fill of 0.5m per year is applied for the Lower Nene catchment. This has been based on the Lower Witham strategy<sup>4</sup>. This rate was assumed 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 Fenlands catchments fill will be defined at an individual catchment level. Where subcompartments are used within a catchment, the limiting level may differ within each subcompartment. An illustration of this limiting level for the Lower Nene catchment is shown in Figure 7.

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<sup>4</sup> Lower Witham Flood Resilience Project – Economic Appraisal Report – September 2024



**Figure 7: Illustration of the Do-Nothing scenario limiting levels for the Lower Nene catchment**

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### 3.1.2 Key assumptions

For the purpose of the baseline economic appraisal, the Lower Nene catchment 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.

The Tidal River Nene model results were considered appropriate for use in a depth damage approach and were applied to assess residual damages from temporary flooding in areas that are not permanently inundated. This approach is defined in the Multi-Coloured Manual<sup>5</sup>. The impacts of climate change are not incorporated into the appraisal.

Assumptions in the Lower Nene regarding the rate and level to which it is permanently inundated have been reviewed and agreed with partners. The median ground level below 3.9m AOD between the River Nene and Welland embankments (2.19m AOD) as well as for Feldale IDB (0.79m AOD) is taken from LiDAR DTM data to determine a suitable starting point from which water can be assumed to fill the catchment. Where subcompartments are used, the starting points to be used are assessed for each subcompartment individually. The rounded starting levels for each subcompartment 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 (i.e. no further maintenance or repairs) will vary between locations it is likely to occur in the short to medium term.

<sup>5</sup> Flood Hazard Research Centre & Environment Agency. (2013). *Flood and Coastal Erosion Risk Management: A Manual for Economic Appraisal*. Milton Park: Routledge.

To simplify the assessment, a limiting level based on MHWS 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.

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.

A sensitivity on the limiting level will be carried out to test a level higher (present day 33.33% AEP tidal level is approximately 5m AOD, tidal defences are greater than 6m AOD) than the Mean High Water Springs level of 3.9m AOD and to test the limiting level being reached in a shorter period of time (i.e. within 1 year). It is not anticipated that a significant additional area will be flooded under a higher limiting level because the ground levels rise relatively quickly at the edges of the Fens floodplain.

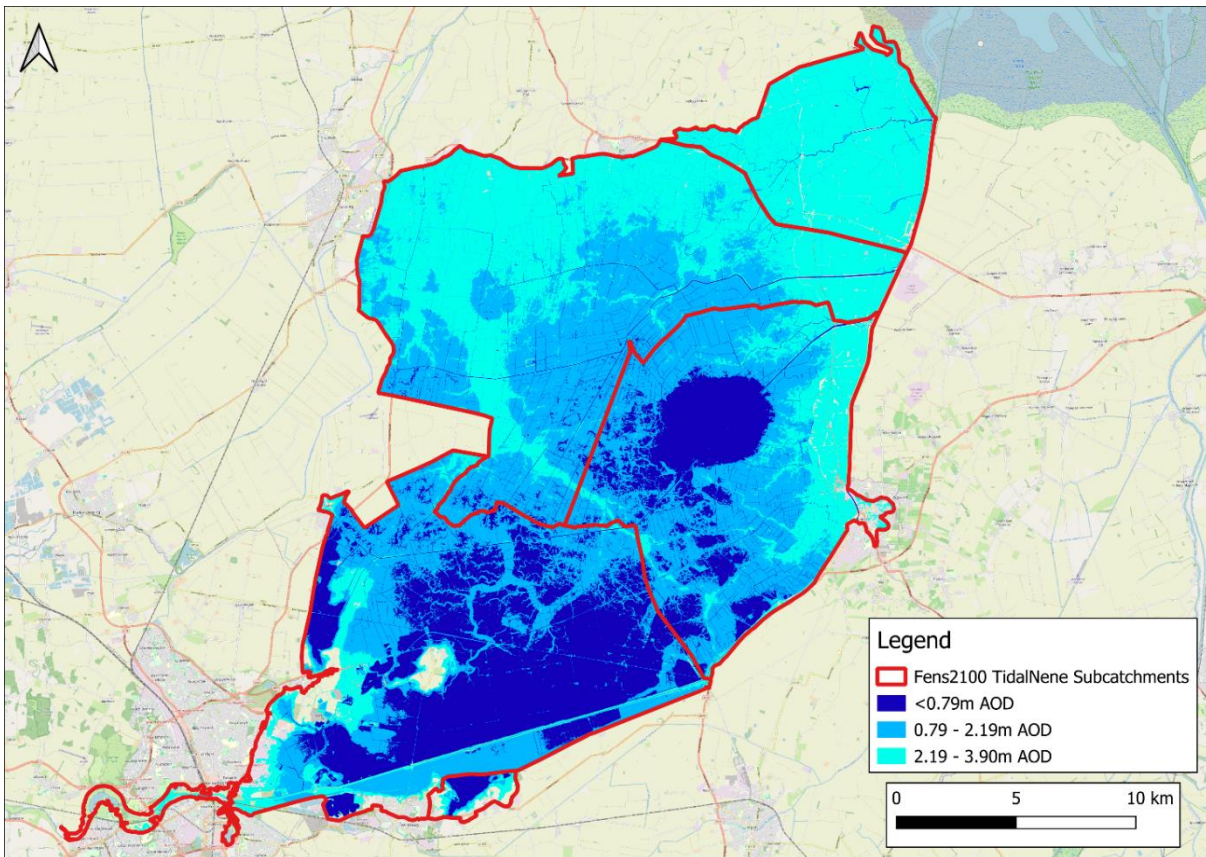
### 3.1.3 Flood extents

Based on the assumptions described above, indicative flood extents will be generated for the Lower Nene 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. Figure 8 shows the permanent inundation levels based on this calculation for the Lower Nene catchment. The figure shows the starting levels for different subcompartment as well as the limiting level with 95% of the catchment area inundated by the 3.9m AOD limiting level. The defined permanent inundation levels for each subcompartment 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)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland West
Year 0: Environment Agency and IDB cease maintenance of assets (incl. pumping); fluvial water begins to pond across the catchment					
0	2.19	2.19	0.79	2.19	2.19
1	2.69	2.69	1.29	2.69	2.69
2	3.19	3.19	1.79	3.19	3.19
3	3.69	3.69	2.29	3.69	3.69

Appraisal Year (yr)	Water Level (m AOD)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland West
Year 0: Environment Agency and IDB cease maintenance of assets (incl. pumping); fluvial water begins to pond across the catchment					
4	3.90	3.90	2.79	3.90	3.90
5	3.90	3.90	3.29	3.90	3.90
6	3.90	3.90	3.79	3.90	3.90
7	3.90	3.90	3.90	3.90	3.90
19	3.90	3.90	3.90	3.90	3.90
99	3.90	3.90	3.90	3.90	3.90



**Figure 8: Do Nothing permanent flood extents for the Lower Nene 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 FRM 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, failure 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, fluvial and tidal events. This risk is represented using the existing local model. 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 focuses on the rate of inundation of low-lying areas. The rate of inundation has been 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**

The baseline economic study will also consider a maintain scenario. This scenario will represent the benefits of existing assets being maintained to continue to provide their existing Standard of Service. There will be no allowance for adaption to climate change. It is assumed that this would form the basis of a short-term approach to protecting the area whilst the longer-term strategy is developed. In a maintain scenario, the study area will remain at risk from infrequent flooding in events exceeding the design standard of the existing FRM assets.

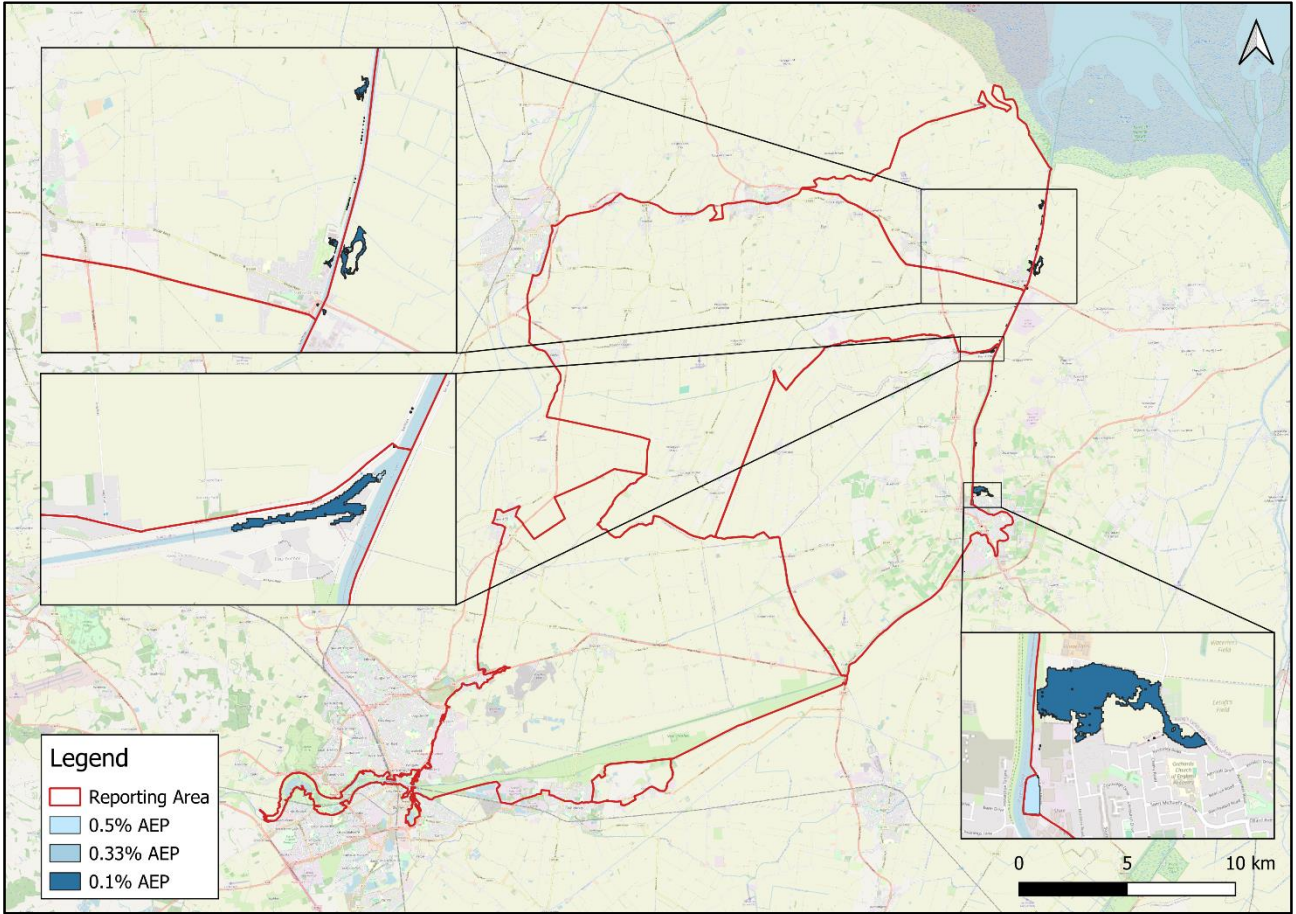
### **3.2.2 Description**

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

This scenario will be based on the Tidal Nene modelling results using the model produced by Arup in 2021.

### **3.2.3 Flood extents**

Local model data is used to inform a depth damage assessment as defined in the Multi-Coloured Manual. The Maintain scenario will be defined by the baseline model results from the Tidal Nene model.



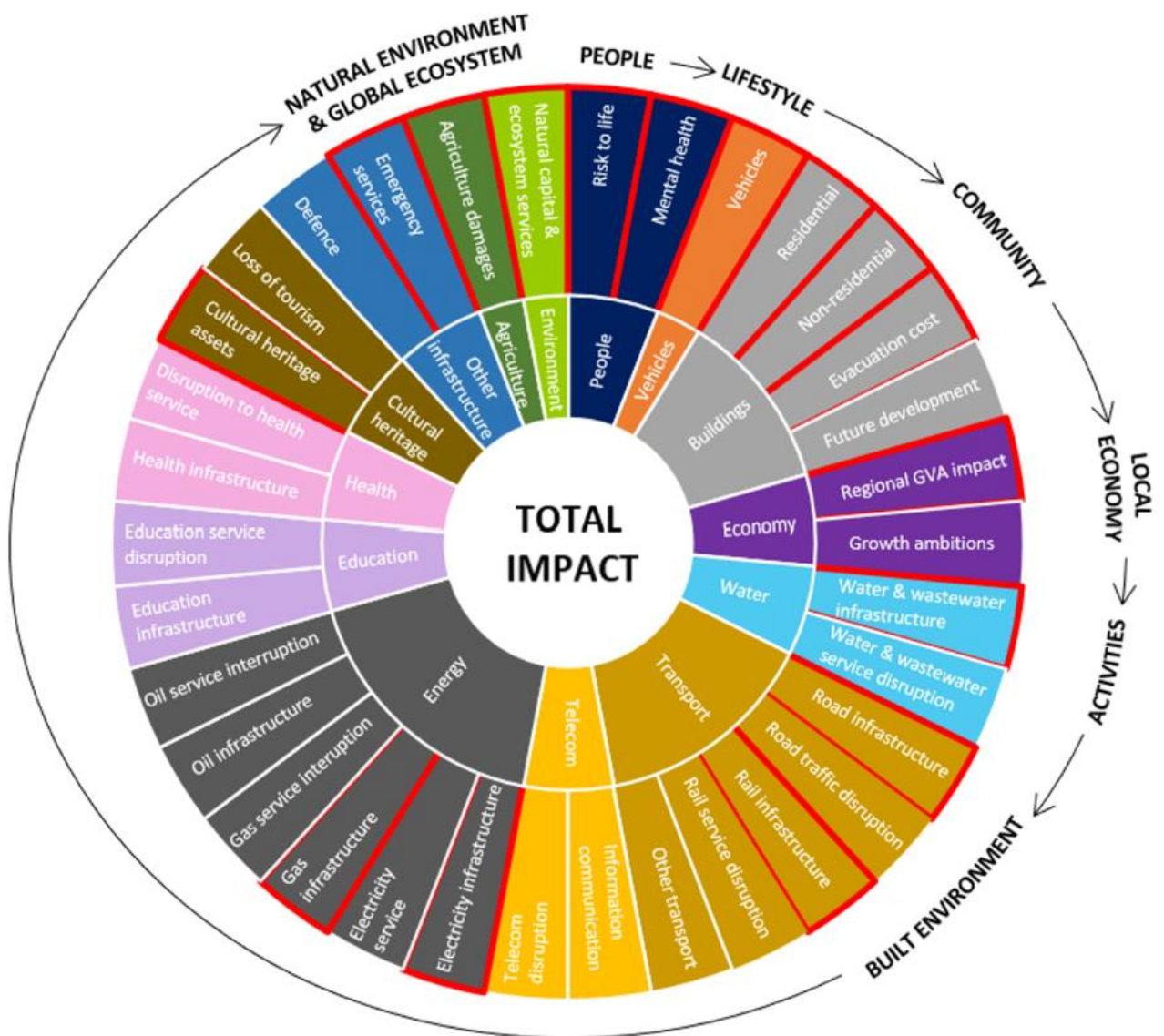
**Figure 9: Defended model results from the Tidal Nene model**

# 4. Appraisal Receptors

## 4.1 Economic appraisal receptors

The Total Impact Framework in Figure 10 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 Lower Nene 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 10: Total Impact Framework**

© Arup 2020

## 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>6</sup> (AG) (2022), and HM Treasury Green Book<sup>7</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	Emergency service costs
Section 5.11	Risk to life
Section 5.12	Evacuation and temporary accommodation costs
Section 5.13	Vehicle damages
Section 5.14	Utility disruption
Section 5.15	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>8</sup>. Where historic data has been used, this has been uplifted to a 2025 price base using GDP Deflator data.

It should be noted that in the Lower Nene catchment, no receptors were found to be at risk in the Maintain scenario for educational disruption or health service disruption and these damages have therefore not been included in this reporting. In addition, no intangible

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<sup>6</sup> [FCERM appraisal technical guidance - GOV.UK](#)

<sup>7</sup> [The Green Book: appraisal and evaluation in central government - GOV.UK](#)

<sup>8</sup> [GDP deflators at market prices, and money GDP December 2024 \(Quarterly National Accounts\) - GOV.UK](#)

impacts to human health have been calculated as residual risk is sufficiently low that it would be disproportionate to estimate these losses.

## 5.1 Direct residential and non-residential property damages

Across the Lower Nene catchment, there are several settlements benefiting from the existing FRM activities, including, among others, Peterborough, Whittlesey, Wisbech, Long Sutton, Holbeach, and Crowland. 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 11: Aerial image of Thorpe Meadows looking towards the start of the Whittlesey Washes**

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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 5.1.5.

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 9.

As local model data was available, a depth damage approach was taken, as defined in the MCM. This requires an assessment of the depth of flooding at each individual property in each Annual Exceedance Probability (AEP) event modelled. This depth is cross referenced to the depth damage data in the MCH to determine the direct damages it would cause. The damages calculated from this are used alongside the probability of the events to determine Annual Average Damages for each individual property.

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.

AAD 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 AAD. The AAD value has then been forecast across the appraisal period and discounted to understand Present Value (PV) damages to properties.

### **5.1.1 Maintain scenario 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 AAD as detailed in Section 5.1 with no reduction in AAD over time given that there is no permanent inundation assumed in the Maintain scenario. It has been assumed that there is no flood warning for this assessment. The AAD value has been forecast across the appraisal period and discounted to understand PV damages to properties.

## 5.1.2 Key assumptions

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

Key assumptions:		
Residential property values	Property Type	Market Value (£)
	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	Type	Market Value £/m <sup>2</sup>
	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		
Key datasets:		
<ul style="list-style-type: none"> <li>• Tidal Nene 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>		

### 5.1.3 Do-Nothing scenario outcomes

**Table 5-2: Do Nothing – number of residential properties impacted (cumulative)**

Appraisal year (Year)	Number of residential properties				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	4,087	1,709	-	13	-
1	5,948	2,146	-	571	-
2	7,259	2,668	-	2,705	-
3	8,585	3,337	-	4,899	-
4	9,765	3,671	5	5,547	-
5	9,765	3,671	5	5,547	-
6	9,765	3,671	5	5,547	-
7	9,765	3,671	5	5,547	307
99	9,765	3,671	5	5,547	307

**Table 5-3: Do Nothing - PV Residential property losses (cumulative) (£k)**

Appraisal year (Year)	PV Property losses (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	1,314,563	538,340	-	4,099	453,660
1	1,885,644	661,066	-	172,842	1,088,384
2	2,258,087	795,016	-	778,808	2,109,764
3	2,604,310	958,550	653	1,343,783	2,908,164
4	2,882,105	1,032,511	653	1,502,728	2,992,188
5	2,882,105	1,032,511	2,652	1,502,728	2,992,188
6	2,882,105	1,032,511	5,671	1,502,728	2,992,188
7	2,882,105	1,032,511	6,482	1,502,728	2,992,188
99	2,882,105	1,032,511	6,482	1,502,728	2,992,188

**Table 5-4: Do Nothing – number of non-residential properties impacted (cumulative)**

Appraisal year (Year)	Number of non-residential properties				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	263	131	0	4	0
1	349	221	0	24	0
2	487	424	0	106	0
3	638	585	0	226	0
4	708	631	0	280	0
5	708	631	0	280	0
6	708	631	0	280	0
7	708	631	0	280	14
99	708	631	0	280	14

**Table 5-5: Do Nothing - PV Non-residential losses (cumulative) (£k)**

Appraisal year (Year)	PV Property losses (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	63,834	64,137	-	10,057	37,313
1	86,603	94,775	-	49,081	82,741
2	230,213	159,376	-	95,026	115,007
3	361,322	232,270	-	128,091	147,778
4	408,913	265,447	-	139,995	151,669
5	408,913	265,447	-	139,995	151,669
6	408,913	265,447	-	139,995	151,669
7	408,913	265,447	-	139,995	151,669
99	408,913	265,447	-	139,995	151,669

A total of 19,295 residential and 1,633 non-residential properties are written-off due to inundation in the Do Nothing.

This amounts to a total of £8,416,013k and £966,024k of residential and non-residential property losses respectively over the 100-year period.

### 5.1.4 Maintain scenario outcomes

**Table 5-6: Maintain scenario – number of residential properties impacted (cumulative)**

Annual Exceedance Probability	Residential properties impacted				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
50%	-	-	-	-	-
20%	-	-	-	-	-
10%	-	3	-	1	-

**Table 5-7: Maintain scenario - cash property damages (£k)**

Annual Exceedance Probability	Cash property damages (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0.5%	-	-	-	-	-
0.33%	-	-	-	-	-
0.1%	-	54	-	47	-

A total of £7k in residential PV damages is accrued when discounted over the full 100-year appraisal period. No non-residential properties are impacted, so neither property damages nor indirect commercial losses are observed.

### 5.1.5 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 5-8: Do Nothing – number of non-residential properties (including MCM code 999) impacted (cumulative)**

Appraisal year (Year)	Number of non-residential properties				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	2,293	1,455	-	25	-
1	2,938	1,721	-	233	-
2	3,320	2,095	-	970	-
3	3,687	2,427	-	1,935	-
4	3,903	2,555	4	2,169	-
5	3,903	2,555	4	2,169	-
6	3,903	2,555	4	2,169	-
7	3,903	2,555	4	2,169	78
99	3,903	2,555	4	2,169	78

**Table 5-9: Do Nothing - PV Non-residential losses (including MCM code 999)  
(cumulative) (£k)**

Appraisal year (Year)	PV Property losses (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	390,248	359,990	-	20,207	267,208
1	844,937	762,826	353	93,155	721,530
2	1,441,415	1,239,150	1,017	250,895	1,334,756
3	2,223,239	1,806,054	2,910	514,407	2,027,442
4	3,040,342	2,394,478	5,583	792,268	2,703,565
5	3,040,342	2,394,478	8,955	792,268	2,703,565
6	3,040,342	2,394,478	12,289	792,268	2,703,565
7	3,040,342	2,394,478	15,955	792,268	2,703,565
99	3,040,342	2,394,478	15,955	792,268	2,703,565

## 5.2 Agricultural losses

The Nene catchment and wider Fens 2100+ study area 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 12: Agricultural land north of Sutton St Edmund**

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### 5.2.1 Do-Nothing scenario 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) for non-agricultural land, and a sensitivity analysis has been undertaken to assess potential economic benefits generated from the change in land use of agricultural land in Section 5.2.6.4.

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 5.11. 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 during previous projects. 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 10. 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 10). 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 5.3.6.3).

**Table 5-10: 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 5-11: 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	
	Potatoes	Arable	26,087	
	Other Crops	Arable	26,087	
	Grass	Pasture	18,028	
Source: Knights Frank, 2021 – Farmland Market Values for Lincolnshire <a href="https://www.fwi.co.uk/business/markets-and-trends/land-markets/find-out-average-farmland-prices-where-you-live">https://www.fwi.co.uk/business/markets-and-trends/land-markets/find-out-average-farmland-prices-where-you-live</a>				
Annual Agricultural Losses per Hectare for Short Term	Agricultural Losses per Hectare for Short Term Infrequent Flooding (£) – it is assumed good drainage is available throughout the catchment during the existing maintain scenario.			

Infrequent Flooding (£)	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 5-12: Do Nothing – Area of agricultural write off for the Do Nothing scenario (ha) (cumulative)**

Appraisal year	North Level (East) (ha)	North Level (West) (ha)	Feldale (ha)	South Holland (East) (ha)	South Holland (West) (ha)
0	7,931	13,264	162	75	6,763
1	8,985	13,797	178	525	11,707
2	9,255	14,141	193	1,955	14,418
3	9,792	14,387	216	4,355	15,921
4	10,052	14,463	245	4,508	15,994
5	10,052	14,463	275	4,508	15,994
6	10,052	14,463	305	4,508	15,994
7	10,052	14,463	313	4,508	15,994
99	10,052	14,463	313	4,508	15,994

**Table 5-13: Do Nothing – Agricultural write off PV damages for the Do Nothing scenario with basin fill (£k) (cumulative)**

Appraisal year	North Level (East) (£k)	North Level (West) (£k)	Feldale (£k)	South Holland (East) (£k)	South Holland (West) (£k)
0	223,783	358,653	4,684	18,482	312,494
1	241,487	367,379	5,065	58,366	383,672
2	255,017	373,413	5,608	118,276	420,997
3	262,441	376,879	6,280	123,098	423,356
4	262,898	377,986	6,928	123,367	423,558
5	262,916	378,097	7,579	123,389	423,571
6	262,933	378,204	8,385	123,410	423,584
7	262,949	378,307	8,606	123,431	423,596
8	262,965	378,307	8,632	123,450	423,608
9	263,439	382,702	8,657	123,877	423,895
10	263,439	382,702	8,681	123,877	423,895
11	263,439	382,702	8,705	123,877	423,895
12	263,439	382,702	9,951	123,877	423,895
99	263,439	382,702	9,951	123,877	423,895

**Table 5-14: Do Nothing – Residual agricultural PV damages in Nene model extents with basin fill (£k) (cumulative)**

Appraisal year	North Level (East) (£k)	North Level (West) (£k)	Feldale (£k)	South Holland (East) (£k)	South Holland (West) (£k)
0	0*	-	-	0*	0*
1	0*	-	-	0*	0*
2	0*	-	-	0*	0*
3	0*	-	-	0*	0*
4	0*	-	-	0*	0*
5	0*	-	-	0*	0*
6	0*	-	-	0*	0*
7	0*	-	-	0*	0*
8	0*	-	-	0*	0*
99	0*	-	-	0*	0*

\*These losses accrued as part of the residual agricultural PV damages in the Do Nothing scenario fall below the £1,000 threshold to be listed in the table above.

**Table 5-15: Do Nothing – Total PV Damages (£k)**

North Level (East) (£k)	North Level (West) (£k)	Feldale (£k)	South Holland (East) (£k)	South Holland (West) (£k)	Total (£k)
263,439	382,702	9,951	123,877	423,895	1,203,865

A total of 45,322 ha of agricultural land is written off due to inundation in the Do Nothing. This amounts to a total of £1,203,865k of agricultural losses over both the 100-year appraisal period and the 20-year technical plan period.

## 5.2.5 Maintain scenario outcomes

**Table 5-16: Maintain scenario – Total agricultural area inundated (cumulative) (ha)**

Annual Exceedance Probability	Area flooded (ha)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0.5%	-	-	-	-	-
0.33%	-	-	-	-	-
0.1%	0*	-	-	3	0*

\*These areas inundated in the Maintain fall below the 1 ha threshold to be listed in the table above.

**Table 5-17: Maintain scenario - Total agricultural cash damages (cumulative) (£k)**

Annual Exceedance Probability	Agricultural cash damages (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0.5%	-	-	-	-	-
0.33%	-	-	-	-	-
0.1%	0*	-	-	5	0*

\*These losses accrued in the Maintain fall below the £1,000 threshold to be listed in the table above.

**Table 5-18: Maintain scenario – Total PV Damages (£k)**

North Level (East) (£k)	North Level (West) (£k)	Feldale (£k)	South Holland (East) (£k)	South Holland (West) (£k)	Total (£k)
-	-	-	0*	0*	0*

\*These losses accrued in the Maintain fall below the £1,000 threshold to be listed in the table above.

## 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 2020 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 5-19: Do Nothing – Total PV damages for the Do Nothing scenario using a lost productivity approach (£k)**

North Level (East) (£k)	North Level (West) (£k)	Feldale (£k)	South Holland (East) (£k)	South Holland (West) (£k)	Total (£k)
223,415	263,970	6,421	166,864	433,480	1,094,150

The results of this sensitivity analysis indicate that areas with high value crops (potatoes and 'other' under the CEH Land Cover plus Crop data classifications) tend to see higher long-term damages when lost productivity is used in place of land valuation write off. Areas with lower value crops tend to see lower overall damages for the productivity loss method.

### 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 5-20: Do Nothing – Total PV damages for the Do Nothing scenario with no subsidy (£k)**

Subsidy total of £0					
North Level (East) (£k)	North Level (West) (£k)	Feldale (£k)	South Holland (East) (£k)	South Holland (West) (£k)	Total (£k)
269,481	391,521	10,179	126,490	433,398	1,231,068

**Table 5-21: Do Nothing – Total PV damages for the Do Nothing scenario with an increased subsidy (£1200) (£k)**

Subsidy total of £1,200					
North Level (East) (£k)	North Level (West) (£k)	Feldale (£k)	South Holland (East) (£k)	South Holland (West) (£k)	Total (£k)
257,398	373,883	9,724	121,265	414,393	1,176,662

**5.2.6.3 Land subject to bad drainage conditions converting to pasture**

The assessment has assumed that land subject to bad drainage conditions will be written off after five years of these conditions (see Table 5-10). 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 5-11).

**Table 5-22: Do Nothing – Total PV damages for the Do Nothing scenario with land subject to bad drainage converting to pasture land (£k)**

North Level (East) (£k)	North Level (West) (£k)	Feldale (£k)	South Holland (East) (£k)	South Holland (West) (£k)	Total (£k)
263,084	379,409	8,999	123,548	423,676	1,198,715

**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 5-11. 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 5-23 shows the additional ecosystem service benefits which would be accrued should the area change to coastal habitat after 50 years.

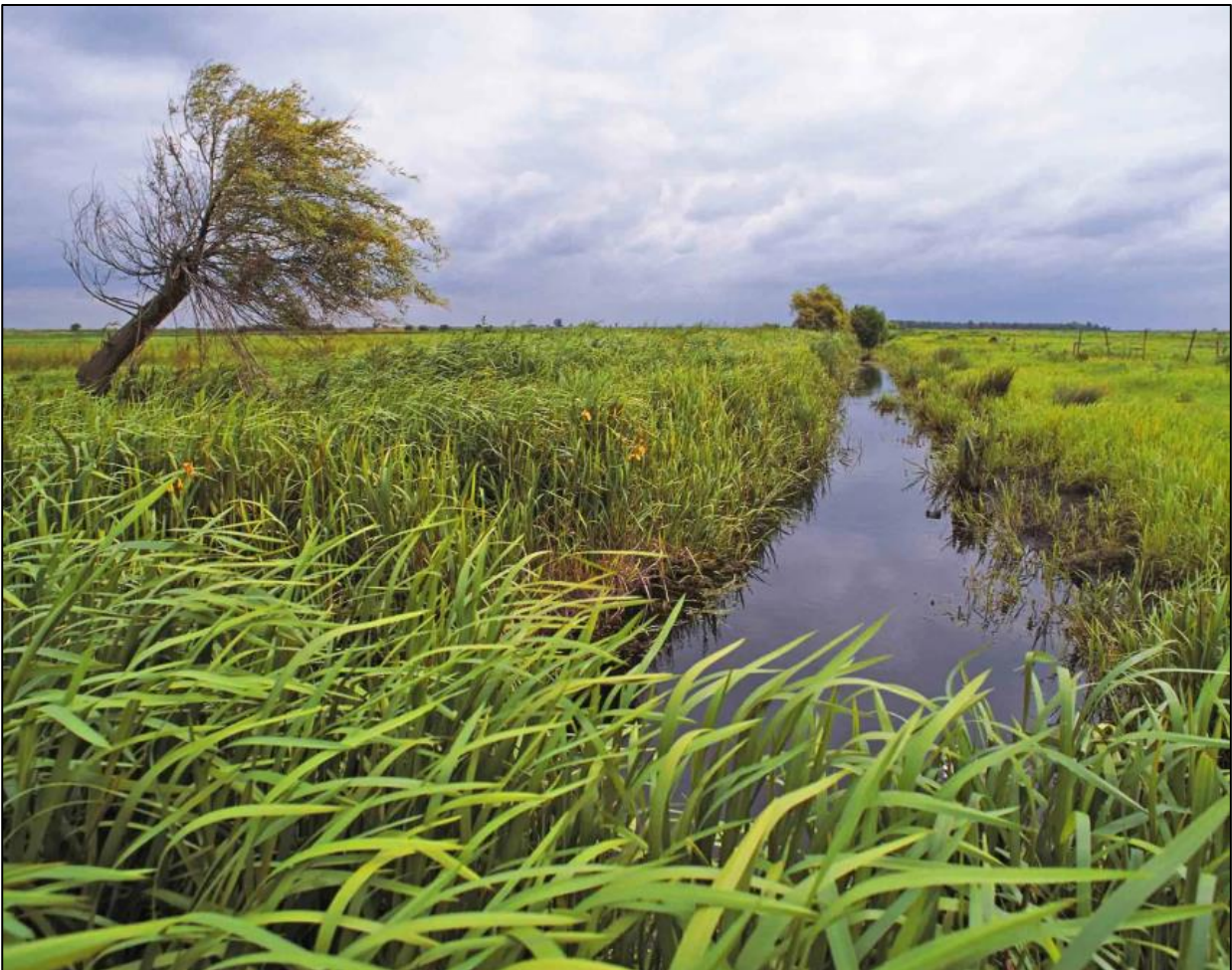
**Table 5-23: Do Nothing – Total PV benefits as a result of habitat created in the Do Nothing scenario (£k)**

North Level (East) (£k)	North Level (West) (£k)	Feldale (£k)	South Holland (East) (£k)	South Holland (West) (£k)	Total (£k)
314,262	452,137	8,700	140,920	500,027	1,416,046

### 5.3 Environment and recreational losses

The Lower Nene catchment is a distinct, historic and human influenced wetland landscape lying to the south-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 Tidal River Nene. There are a number of local nature reserves across the catchment as well as a national nature reserve and several sites designated as SSSIs. 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 which could be lost.

It should be noted that the damages and benefits calculated for environmentally designated sites in this section differ from the valuation of ecosystem services 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 13: Nene Washes Nature Reserve**

Source: RSPB (The Royal Society for the Protection of Birds) 2025, Nene Washes

### 5.3.1 Do-Nothing scenario 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>9</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 5.2.6.4).

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>10</sup> and ORVal tool<sup>9</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 FRM 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>9</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.

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<sup>9</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/>.

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 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 5-24: Habitat designation type and sites impacted**

Habitat Designation	Sites
Semi-natural grassland	Bassenhally Pit The Shrubberies
Enclosed farmland	Eye Gravel Pit
Wetlands / Freshwater	Adventurers' Land Eye Green Nene Washes The Boardwalks Woodston Ponds
Coastal	The Wash

For recreational losses, wellbeing values associated with the PRowWs and open spaces identified in ORVal<sup>9</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 PRowWs, 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 50% Annual Exceedance Probability (AEP) event, 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 50% AEP event. The Lower Nene, and 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 5-25: Environmental assumptions**

Key assumptions:			
Environmental benefit valuations (DEFRA NCRAT, ENCA <sup>10</sup> , ORVal <sup>9</sup> )	Economic values drawn from research literature and the ENCA Services data book <sup>10</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>9</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:			

<sup>10</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:**

- Natural Capital Baseline assessment
- National Nature Reserves in England
- Local Nature Reserves in England
- Site of Special Scientific Interest (SSSI)
- ORVal Valuation Data (University of Exeter)<sup>9</sup>
- DEFRA ENCA<sup>10</sup>
- OS Greenspaces Sites<sup>11</sup>
- Rowmaps: Public Rights of Way<sup>12</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 5-26, Table 5-28, and Table 5-30 respectively.

**Table 5-26: Do Nothing - area of environmental sites impacted (cumulative) (ha)**

Appraisal year (Year)	Environmental sites impacted (ha)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	-	1,209	-	0.37	-
1	-	1,322	-	0.91	-
2	-	1,392	-	4.46	-
3	-	1,466	-	4.54	-
4	-	1,482	-	4.56	-
5	-	1,482	-	4.56	-
6	-	1,482	-	4.56	-
7	-	1,482	-	4.56	-
99	-	1,482	-	4.56	-

<sup>11</sup> <https://www.ordnancesurvey.co.uk/products/os-mastermap-greenspace-layer>

<sup>12</sup> Cornelius, B. (no year). Rowmaps: Maps, KML and GPX showing rights of way. Retrieved from: <https://www.rowmaps.com/>

**Table 5-27: Do Nothing - PV losses from environmental sites (cumulative) (£k)**

Appraisal year (Year)	PV Environmental losses (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	-	2,387	-	1	-
1	-	4,902	-	2	-
2	-	7,461	-	5	-
3	-	10,064	-	8	-
4	-	12,606	-	11	-
5	-	15,062	-	13	-
6	-	17,434	-	16	-
7	-	19,727	-	18	-
99	-	38,294	-	-50	-

**Table 5-28: Do Nothing – area of recreational sites impacted (cumulative) (ha)**

Appraisal year (Year)	Recreational sites impacted (ha)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	42	1,288	-	1	27
1	84	1,402	-	4	34
2	124	1,476	-	25	47
3	142	1,586	-	40	60
4	147	1,648	-	42	61
5	147	1,648	-	42	61
6	147	1,648	0	42	61
7	147	1,648	0	42	61
99	147	1,648	0	42	61

**Table 5-29: Do Nothing - PV damages to recreational sites (cumulative) (£k)**

Appraisal year (Year)	PV Recreation damages (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	9,323	1,099	-	2,836	10,415
1	13,052	1,304	-	2,768	21,521
2	18,283	1,451	-	28,352	39,627
3	20,204	1,850	-	52,940	55,454
4	20,921	1,934	-	55,307	58,370
5	20,921	1,934	-	55,307	58,370
6	20,921	1,934	0*	55,307	58,370
7	20,921	1,934	0*	55,307	58,270
99	20,921	1,934	0*	55,307	58,370

\*These losses fall below the £1,000 threshold to be listed in the table above.

**Table 5-30: Do Nothing – length of public rights of way impacted (cumulative) (m)**

Appraisal year (Year)	Public rights of way impacted (m)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	36,201	15,765	-	441	14,225
1	41,816	19,298	-	2,575	34,612
2	44,956	21,191	3	6,520	45,096
3	49,094	23,897	12	12,688	49,420
4	51,218	25,885	112	16,322	50,908
5	51,218	25,855	624	16,322	50,908
6	51,218	25,885	1,547	16,322	50,908
7	51,218	25,885	1,768	16,322	50,908
99	51,218	25,885	1,768	16,322	50,908

**Table 5-31: Do Nothing - PV damages to public rights of way (cumulative) (£k)**

Appraisal year (Year)	PV Recreation damages (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	32,168	14,009	-	392	12,640
1	37,065	17,090	-	2,254	30,423
2	39,754	18,711	2	5,631	39,398
3	43,231	20,985	10	10,814	43,032
4	44,983	22,624	93	13,810	44,259
5	44,983	22,624	507	13,810	44,259
6	44,983	22,624	1,239	13,810	44,259
7	44,983	22,624	1,412	13,810	44,259
99	44,983	22,624	1,412	13,810	44,259

The losses associated with impacted environmental and recreational sites as well as public rights of way result in total damages of £301,863k by the end of the appraisal period. Discounted over the 20-year appraisal period in line with a tactical plan period, the total environmental and recreational damages amount to £264,383k.

### 5.3.5 Maintain scenario outcomes

**Table 5-32: Maintain scenario - area of recreational sites impacted (cumulative) (ha)**

Annual Exceedance Probability	Recreational sites impacted (ha)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0.5%	-		-	-	-
0.33%	-		-	-	-
0.1%	-		-	0.07	-

**Table 5-33: Maintain scenario - cash damages (£k) associated with recreational sites**

Annual Exceedance Probability	Cash damages (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0.5%	-	-	-	-	-
0.33%	-	-	-	-	-
0.1%	-	-	-	0*	-

\*These losses fall below the £1,000 threshold to be listed in the table above.

**Table 5-34: Maintain scenario - length of public rights of way impacted (cumulative) (m)**

Annual Exceedance Probability	Public rights of way impacted (m)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0.5%	-	-	-	-	-
0.33%	5	-	-	-	-
0.1%	63	-	-	298	-

**Table 5-35: Maintain scenario - cash damages (£k) associated with public rights of way**

Annual Exceedance Probability	Cash damages (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0.5%	-	-	-	-	-
0.33%	0*	-	-	-	-
0.1%	0*	-	-	0*	-

\*These losses fall below the £1,000 threshold to be listed in the table above.

Due to the limited flood risk in the Maintain scenario, these cash damages produce AAD losses of just £2. This gives PV losses of £51 when discounted across the 100-year appraisal period and £25 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 5-36: Do Nothing - Area of environmental sites impacted (cumulative) (ha) with a 25% reduction in ecosystem service benefits for all habitat types**

Appraisal year (Year)	Environmental sites impacted (ha)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	-	1,209	-	0.37	-
1	-	1,322	-	0.91	-
2	-	1,392	-	4.46	-
3	-	1,466	-	4.54	-
4	-	1,482	-	4.56	-
5	-	1,482	-	4.56	-
6	-	1,482	-	4.56	-
7	-	1,482	-	4.56	-
99	-	1,482	-	4.56	-

**Table 5-37: Do Nothing - PV losses from environmental sites (cumulative) (£k) with a 25% reduction in ecosystem service benefits for all habitat types**

Appraisal year (Year)	PV Environmental losses (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	-	1,790	-	1	-
1	-	3,677	-	2	-
2	-	5,596	-	4	-
3	-	7,548	-	6	-
4	-	9,454	-	8	-
5	-	11,296	-	10	-
6	-	13,076	-	12	-
7	-	14,795	-	14	-
99	-	28,271	-	-38	-

**Table 5-38: Do Nothing - area of environmental sites impacted (cumulative) (ha) with a 50% reduction in ecosystem service benefits for all habitat types**

Appraisal year (Year)	Environmental sites impacted (ha)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	-	1,209	-	0.37	-
1	-	1,322	-	0.91	-
2	-	1,392	-	4.46	-
3	-	1,466	-	4.54	-
4	-	1,482	-	4.56	-
5	-	1,482	-	4.56	-
6	-	1,482	-	4.56	-
7	-	1,482	-	4.56	-
99	-	1,482	-	4.56	-

**Table 5-39: Do Nothing - PV losses from environmental sites (cumulative) (£k) with a 50% reduction in ecosystem service benefits for all habitat types**

Appraisal year (Year)	PV Environmental losses (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	-	1,194	-	0	-
1	-	2,451	-	1	-
2	-	3,730	-	2	-
3	-	5,032	-	4	-
4	-	6,303	-	5	-
5	-	7,531	-	7	-
6	-	8,717	-	8	-
7	-	9,863	-	9	-
99	-	19,147	-	-25	-

### 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. This has tested a change in displacement by ten and 20 percentage points, both as an increase and a decrease. This sensitivity test only concerns the Maintain scenario as no displacement factor is considered in the Do Nothing methodology for recreational assets. The results of this sensitivity test are shown in Table 5-40 to Table 5-47. As all values are below the £1,000 threshold, the following tables are all reported in £ rather than £k.

**Table 5-40: Maintain – Cash damages to welfare values of recreational sites when the displacement factor is increased by 20 percentage points (£k)**

Annual Exceedance Probability	Cash damages (£k): +20 percentage points				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0.5%	-	-	-	-	-
0.33%	-	-	-	-	-
0.1%	-	-	-	0*	-

\*These losses fall below the £1,000 threshold to be listed in the table above.

**Table 5-41: Maintain – Cash damages to welfare values of recreational sites when the displacement factor is decreased by 20 percentage points (£k)**

Annual Exceedance Probability	Cash damages (£k): -20 percentage points				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0.5%	-	-	-	-	-
0.33%	-	-	-	-	-
0.1%	-	-	-	0*	-

\*These losses fall below the £1,000 threshold to be listed in the table above.

**Table 5-42: Maintain – Cash damages to welfare values of public rights of way when the displacement factor is increased by 20 percentage points (£k)**

Annual Exceedance Probability	Cash damages (£): +20 percentage points				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0.5%	-	-	-	-	-
0.33%	0*	-	-	-	-
0.1%	0*	-	-	0*	-

\*These losses fall below the £1,000 threshold to be listed in the table above.

**Table 5-43: Maintain – Cash damages to welfare values of public rights of way when the displacement factor is decreased by 20 percentage points (£k)**

Annual Exceedance Probability	Cash damages (£): -20 percentage points				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0.5%	-	-	-	-	-
0.33%	0*	-	-	-	-
0.1%	0*	-	-	0*	-

\*These losses fall below the £1,000 threshold to be listed in the table above.

**Table 5-44: Maintain – Cash damages to welfare values of recreational sites when the displacement factor is increased by 10 percentage points (£k)**

Annual Exceedance Probability	Cash damages (£): +10 percentage points				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0.5%	-	-	-	-	-
0.33%	-	-	-	-	-
0.1%	-	-	-	0*	-

\*These losses fall below the £1,000 threshold to be listed in the table above.

**Table 5-45: Maintain – Cash damages to welfare values of recreational sites when the displacement factor is decreased by 10 percentage points (£k)**

Annual Exceedance Probability	Cash damages (£k): -10 percentage points				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0.5%	-	-	-	-	-
0.33%	-	-	-	-	-
0.1%	-	-	-	0*	-

\*These losses fall below the £1,000 threshold to be listed in the table above.

**Table 5-46: Maintain – Cash damages to welfare values of public rights of way when the displacement factor is increased by 10 percentage points (£k)**

Annual Exceedance Probability	Cash damages (£k): +10 percentage points				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0.5%	-	-	-	-	-
0.33%	0*	-	-	-	-
0.1%	0*	-	-	0*	-

\*These losses fall below the £1,000 threshold to be listed in the table above.

**Table 5-47: Maintain – Cash damages to welfare values of public rights of way when the displacement factor is decreased by 10 percentage points (£k)**

Annual Exceedance Probability	Cash damages (£k): -10 percentage points				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0.5%	-	-	-	-	-
0.33%	0*	-	-	-	-
0.1%	0*	-	-	0*	-

\*These losses fall below the £1,000 threshold to be listed in the table above.

Changing the displacement factor by ten percentage points results in the PV recreational damages over the 100-year appraisal period to change by 14 percent, that is an increase to £58 and a decrease to £44 from £51. 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 £66 and a decrease to £36.

### 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 5-48: Do Nothing - area of environmental sites impacted (cumulative) (ha) where non-coastal/marine habitats shift to wetlands/freshwater habitat**

Appraisal year (Year)	Environmental sites impacted (ha)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	-	1,209	-	0.37	-
1	-	1,322	-	0.91	-
2	-	1,392	-	4.46	-
3	-	1,466	-	4.54	-
4	-	1,482	-	4.56	-
5	-	1,482	-	4.56	-
6	-	1,482	-	4.56	-
7	-	1,482	-	4.56	-
99	-	1,482	-	4.56	-

**Table 5-49: Do Nothing - PV Losses from environmental sites (cumulative) (£k) where non-coastal/marine habitats shift to wetlands/freshwater habitat**

Appraisal year (Year)	PV Environmental losses (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	-	2,387	-	1	-
1	-	4,902	-	2	-
2	-	7,461	-	5	-
3	-	10,064	-	8	-
4	-	12,606	-	11	-
5	-	15,062	-	13	-
6	-	17,434	-	16	-
7	-	19,727	-	18	-
99	-	72,569	-	51	-

As shown in Table 5-48, where the habitat type changes to wetlands/freshwater as opposed to coastal after 50 years of reaching the maximum contour level per subcompartment, there is a 90% increase in losses associated with ecosystem service benefits across all subcompartments. This is likely explained by the large proportion of existing habitat within the catchment being wetlands/freshwater, thus the increase in ecosystem benefits seen from changing to coastal habitat type after 50 years is lost here.

## 5.4 Heritage losses

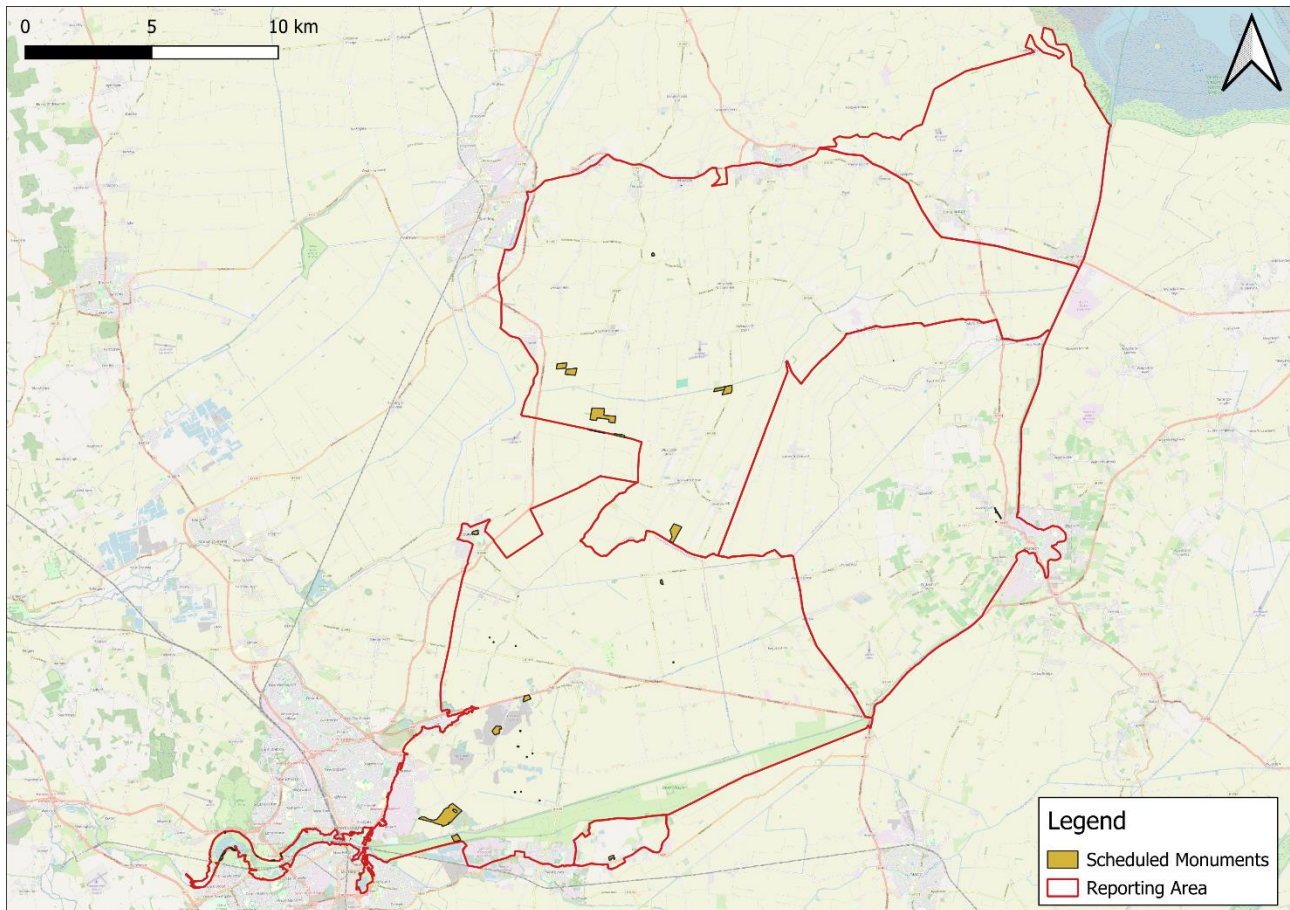
The Lower Nene catchment contains several heritage sites at risk of flooding. The catchment area is covered by many listed buildings and scheduled monuments. These structures often include elements of timber construction that might be considered more susceptible to flood conditions. In total, there are 537 listed buildings, 22 being listed as Grade I, with all others being Grade II or Grade II\*. There is also a Grade II asset on the list of registered parks and gardens.



**Figure 14: Peckover House on North Brink by the River Nene in Wisbech**

Source: Theyellowtulip / CC BY-SA 3.0

Figure 15 shows that there are a total of 42 scheduled monuments in the Lower Nene catchment area.



**Figure 15: Location of scheduled monuments in the Lower Nene 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 5-50. The value of these heritage assets will be calculated using the DCMS Culture and Heritage Capital Evidence Bank<sup>13</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 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 have been written off.

<sup>13</sup> [Rapid Evidence Assessment: Culture and Heritage Valuation Studies - GOV.UK \(www.gov.uk\)](https://www.gov.uk)

### 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 assets being unavailable for a short period of time.

### 5.4.3 Key assumptions

**Table 5-50: 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 5-51: Do Nothing - number of heritage assets impacted (cumulative)**

Appraisal year (Year)	Heritage assets impacted				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	-	-	-	-	-
1	-	-	-	-	-
2	-	18	-	-	10
3	96	45	-	20	65
4	110	49	-	28	73
5	110	49	-	28	73
6	110	49	3	28	73
7	110	49	3	28	73
99	110	49	3	28	73

**Table 5-52: Do Nothing - PV heritage losses (cumulative) (£k)**

Appraisal year (Year)	PV heritage losses (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	-	-	-	-	-
1	-	-	-	-	-
2	-	5,470	-	-	2,959
3	35,025	12,689	-	7,492	27,974
4	40,461	14,052	-	10,059	30,982
5	40,461	14,052	-	10,059	30,982
6	40,461	14,052	532	10,059	30,982
7	40,461	14,052	532	10,059	30,982
99	40,461	14,052	532	10,059	30,982

The losses associated with impacted heritage assets in the Do Nothing are shown in Table 5-52. Approximately 263 heritage assets are impacted resulting in total damages of £96,087k by the end of the appraisal period. There is no residual risk to heritage assets.

#### **5.4.5 Maintain scenario outcomes**

There are no heritage damages in the Maintain scenario.

## 5.5 Infrastructure damages

The catchment plays host to mostly minor country roads, with the most prominent major roads being limited to the A16, A17, A47, and A1101. Major railway lines such as the Ely to Peterborough line, Nene Valley Railway, and a small section of the East Coast Main Line are present, though these are entirely limited to the south-west of the catchment area near Peterborough. Other major infrastructure, such as major electrical and gas 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 16: Town Bridge, Wisbech – a historic transport connection and Grade II listed building**

Source: Historic England (2018 Steve Turner)

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 aren't 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 5-53: 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 5-54: Do Nothing - length of road network impacted (cumulative) (m)**

Appraisal year (Year)	Length of road impacted (m)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	89	13,053	-	59	1,094
1	94	15,582	-	59	2,208
2	96	16,224	-	541	6,292
3	154	17,202	-	1,925	10,619
4	495	17,449	-	2,161	14,374
5	495	17,449	-	2,161	14,374
6	495	17,449	-	2,161	14,374
7	495	17,449	-	2,161	14,374
99	495	17,449	-	2,161	14,374

**Table 5-55: Do Nothing - PV road network damages (cumulative) (£k)**

Appraisal year (Year)	PV Highways damages (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	1,967	288,757	-	1,312	24,191
1	2,085	342,820	-	1,312	48,016
2	2,109	356,076	-	11,258	132,350
3	3,264	375,594	-	38,870	218,685
4	9,855	380,348	-	43,423	291,070
5	9,855	380,348	-	43,423	291,070
6	9,855	380,348	-	43,423	291,070
7	9,855	380,348	-	43,423	291,070
99	9,855	380,348	-	43,423	291,070

**Table 5-56: Do Nothing - length of rail network impacted (cumulative) (m)**

Appraisal year (Year)	Length of rail impacted (m)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	-	45	-	-	-
1	-	63	-	-	-
2	-	69	-	-	-
3	-	280	-	-	-
4	-	329	-	-	-
5	-	329	-	-	-
6	-	329	-	-	-
7	-	329	-	-	-
99	-	329	-	-	-

**Table 5-57: Do Nothing - PV rail network damages (cumulative) (£k)**

Appraisal year (Year)	PV Railway damages (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	-	282	-	-	-
1	-	391	-	-	-
2	-	428	-	-	-
3	-	1,626	-	-	-
4	-	1,895	-	-	-
5	-	1,895	-	-	-
6	-	1,895	-	-	-
7	-	1,895	-	-	-
99	-	1,895	-	-	-

The damages associated with impacted road and rail networks for the Do-Nothing scenario are seen in Table 5-54 and Table 5-56. Approximately 34,479m of road network is impacted, resulting in total damages of £724,696k by the end of the appraisal period. Around 329m of rail network is impacted over the same period, leading to an observed £1,895k of damages. When combined, these damages give us a transport damage total of £726,591k.

### 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 5-58 to Table 5-61.

**Table 5-58: Do Nothing - PV road network damages (cumulative) (£k) with a 25% decrease in valuations**

Appraisal year (Year)	PV Highways damages (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	1,475	216,567	-	984	18,143
1	1,564	257,115	-	984	36,012
2	1,582	267,057	-	8,443	99,263
3	2,448	281,696	-	29,153	164,014
4	7,392	285,261	-	32,567	218,302
5	7,392	285,261	-	32,567	218,302
6	7,392	285,261	-	32,567	218,302
7	7,392	285,261	-	32,567	218,302
99	7,392	285,261	-	32,567	218,302

**Table 5-59: Do Nothing - PV rail network damages (cumulative) (£k) with a 25% decrease in valuations**

Appraisal year (Year)	PV Railway damages (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	-	211	-	-	-
1	-	293	-	-	-
2	-	321	-	-	-
3	-	1,220	-	-	-
4	-	1,422	-	-	-
5	-	1,422	-	-	-
6	-	1,422	-	-	-
7	-	1,422	-	-	-
99	-	1,422	-	-	-

**Table 55-60: Do Nothing - PV Road network damages (cumulative) (£k) with a 25% increase in valuations**

Appraisal year (Year)	PV Highways damages (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	2,459	360,946	-	1,640	30,239
1	2,606	428,525	-	1,640	60,019
2	2,636	445,095	-	14,072	165,438
3	4,081	469,493	-	48,588	273,356
4	12,319	475,435	-	54,279	363,837
5	12,319	475,435	-	54,279	363,837
6	12,319	475,435	-	54,279	363,837
7	12,319	475,435	-	54,279	363,837
99	12,319	475,435	-	54,279	363,837

**Table 5-61: Do Nothing - PV Rail network damages (cumulative) (£k) with a 25% increase in valuations**

Appraisal year (Year)	PV Railway damages (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	-	352	-	-	-
1	-	489	-	-	-
2	-	535	-	-	-
3	-	2,033	-	-	-
4	-	2,369	-	-	-
5	-	2,369	-	-	-
6	-	2,369	-	-	-
7	-	2,369	-	-	-
99	-	2,369	-	-	-

With a 25% decrease in road valuation, there is a total damage value of £543,522k by the end of the appraisal period. This means that there was a decrease in PV damages of £181,174k, a 25% decrease. Similarly, a 25% decrease in rail valuation resulted in a decrease in PV damages of £473k, also a 25% decrease resulting in a total of £1,422k. When combined, these damages give us a transport damage total of £544,944k.

With a 25% increase in road valuation, there is a total damage value of £905,870k by the end of the appraisal period. This means that there was an increase in PV damages of £181,174k, a 25% increase. Similarly, a 25% increase in rail valuation resulted in an increase in PV damages of £473k, also a 25% increase resulting in a total of £2,369k. When combined, these damages give us a transport damage total of £908,239k.

Overall, a 25% decrease or increase in road and rail valuation results in a +/-1.8% change in total damages for the Do Nothing scenario, demonstrating the assessment has relatively low sensitivity to valuation of road and rail infrastructure.

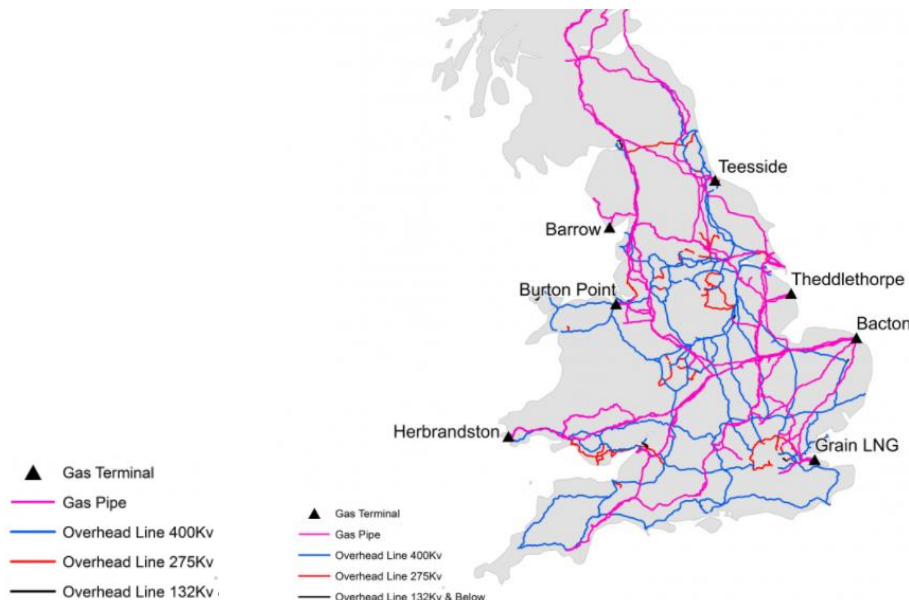
## 5.7 Utilities damages

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>14</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 5-62.



**Figure 17: 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.

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.

<sup>14</sup> <https://www.gov.uk/government/publications/electricity-generation-costs-2023>

### 5.7.3 Gas

Damages have 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.

### 5.7.4 Key assumptions

**Table 5-62: Do Nothing utilities assumptions**

Key assumptions:			
Electrical asset replacement costs	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.		
	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	
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.		
Gas replacement costs	In the absence of UK specific data, losses associated with the gas replacement costs have been based on a collection of 30" gas pipeline projects in the US for large gas transmission pipeline. The cost of the reference pipeline is seen below, with £/m in 2025 values.		
	Valuation	Cost	Comments
	Construction 30" pipeline (\$ per mile (2017))	5,340,000	Source: Oil and Gas Pipeline Construction Costs - Global Energy Monitor (gem.wiki)
£ / m	3,327	Conversion to present day £ and meters. Source: 1 USD to GBP - US Dollars to British Pounds Exchange Rate (xe.com) (Conversion date	

**Key assumptions:**

			used- 01/07/2017) Uplifted to 2025 price
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**Key datasets:**

- Electricity: Western Power Distribution and National Grid geographical datasets of their assets
- How close does an energy scheme need to be to an electricity network? | Roadnight Taylor
- Typical constructions of overhead lines (electrical-engineering-portal.com)
- Gas: National Grid Gas Distribution Network

**5.7.5 Do-Nothing outcomes****Table 5-63: Do-Nothing - length of gas pipe impacted (cumulative) (m)**

Appraisal year (Year)	Length of overhead conductors impacted (all) (m)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	29,912	33,722	-	85	1,900
1	33,461	34,360	-	261	1,928
2	33,727	34,788	-	918	1,952
3	40,286	35,197	-	7,654	5,154
4	44,356	35,635	-	7,748	5,320
5	44,356	35,635	-	7,748	5,320
6	44,356	35,635	-	7,748	5,320
7	44,356	35,635	-	7,748	5,320
99	44,356	35,635	-	7,748	5,320

**Table 5-64: Do-Nothing - PV gas network damages (cumulative) (£k)**

Appraisal year (Year)	PV Gas damages (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	99,507	112,180	-	283	6,321
1	110,914	114,231	-	849	6,409
2	111,738	115,559	-	2,888	6,485
3	131,418	116,785	-	23,098	16,091
4	143,217	118,056	-	23,372	16,575
5	143,217	118,056	-	23,372	16,575
6	143,217	118,056	-	23,372	16,575
7	143,217	118,056	-	23,372	16,575
99	143,217	118,056	-	23,372	16,575

**Table 5-65: Do-Nothing – Number of pole towers impacted (cumulative)**

Appraisal year (Year)	Number of pole towers impacted (all)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	379	163	-	26	859
1	449	221	-	140	1,930
2	480	240	-	361	2,617
3	489	247	-	645	2,869
4	490	249	-	703	2,898
5	490	249	-	703	2,898
6	490	249	-	703	2,898
7	490	249	-	703	2,898
99	490	249	-	703	2,898

**Table 5-66: Do-Nothing – Number of substations impacted (cumulative)**

Appraisal year (Year)	Number of substations impacted (all)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	170	68	-	1	118
1	216	83	-	18	257
2	243	99	-	59	403
3	264	117	-	108	476
4	268	120	-	135	489
5	268	120	-	135	489
6	268	120	-	135	489
7	268	120	-	135	489
99	268	120	-	135	489

**Table 5-67: Do-Nothing – Length of overhead conductors impacted (cumulative) (m)**

Appraisal year (Year)	Length of overhead conductors impacted (all) (m)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	118,292	119,869	2,659	1,970	174,856
1	142,655	131,416	2,706	12,008	282,555
2	150,676	137,895	2,776	32,364	342,277
3	160,385	143,086	3,371	69,969	368,574
4	167,066	145,177	3,963	76,286	371,023
5	167,066	145,177	4,624	76,286	371,023
6	167,066	145,177	5,700	76,286	371,023
7	167,066	145,177	5,828	76,286	371,023
99	167,066	145,177	5,828	76,286	371,023

**Table 5-68: Do-Nothing – Length underground cables impacted (cumulative) (m)**

Appraisal year (Year)	Length of underground cables impacted (all) (m)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	5,605	5,986	-	318	9,700
1	10,389	7,497	-	2,781	29,161
2	11,433	9,585	-	10,766	62,358
3	12,616	10,218	-	18,620	85,638
4	13,019	10,510	-	23,000	92,973
5	13,019	10,510	-	23,000	92,973
6	13,019	10,510	-	23,000	92,973
7	13,019	10,510	-	23,000	92,973
99	13,019	10,510	-	23,000	92,973

**Table 5-69: Do-Nothing - PV electrical network damages (cumulative) (£k)**

Appraisal year (Year)	PV Electricity damages (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	12,336	9,415	298	245	23,189
1	15,991	11,085	303	1,924	44,016
2	17,344	16,027	310	5,837	59,411
3	18,897	16,990	368	11,572	67,760
4	19,284	17,238	402	13,434	69,806
5	19,284	17,238	438	13,434	69,806
6	19,284	17,238	470	13,434	69,806
7	19,284	17,238	474	13,434	69,806
99	19,284	17,238	474	13,434	69,806

The total lengths of gas utilities impacted for the Do-Nothing scenario can be found in Table 5-63 with damage totals observed in Table 5-64. Similarly, the total lengths and counts of electrical utilities impacted for the Do-Nothing scenario can be found in Table 5-65, with damage totals for both located in Table 5-69. By the end of the appraisal period,

approximately 93,059m of gas pipes are impacted during the final inundation level, resulting in total gas damages of £301,220k. Over the same period, around 4,340 pole towers and 1,012 substations are impacted during the final inundation level, whilst approximately 904,882m of overhead conductor and underground cables are impacted, resulting in total electricity damages of £120,237k. When combining damage totals of gas and electrical utilities, this gives a total utilities damage value of £421,456k.

### 5.7.6 Sensitivity testing

A sensitivity test has been undertaken to assess the impact of varying the valuation of gas distribution assets by 10% and 25%, both as an increase and a decrease. The damages associated with decreasing and increasing the valuation by 10% can be seen in Table 5-70, whilst the damages associated with decreasing and increasing the valuation by 25% can be seen in Table 5-72.

Another 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 5-74.

**Table 5-70: Do-Nothing - PV gas network damages with -10% valuations (cumulative) (£k)**

Appraisal year (Year)	PV Gas damages with -10% valuation (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	89,556	100,962	-	255	5,689
1	99,822	102,808	-	764	5,768
2	100,564	104,003	-	2,599	5,837
3	118,276	105,107	-	20,788	14,482
4	128,895	106,250	-	21,035	14,917
5	128,895	106,250	-	21,035	14,917
6	128,895	106,250	-	21,035	14,917
7	128,895	106,250	-	21,035	14,917
99	128,895	106,250	-	21,035	14,917

**Table 5-71: Do-Nothing - PV gas network damages with +10% valuations (cumulative) (£k)**

Appraisal year (Year)	PV Gas damages with +10% valuation (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	109,457	123,398	-	311	6,953
1	122,005	125,654	-	933	7,050
2	122,912	127,115	-	3,177	7,134
3	144,560	128,464	-	25,408	17,700
4	157,539	129,861	-	25,709	18,232
5	157,539	129,861	-	25,709	18,232
6	157,539	129,861	-	25,709	18,232
7	157,539	129,861	-	25,709	18,232
99	157,539	129,861	-	25,709	18,232

**Table 5-72: Do-Nothing - PV gas network damages with -25% valuations (cumulative) (£k)**

Appraisal year (Year)	PV Gas damages with -25% valuation (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	74,630	84,135	-	212	4,741
1	83,185	85,673	-	636	4,807
2	83,803	86,669	-	2,166	4,864
3	98,564	87,589	-	17,324	12,068
4	107,413	88,542	-	17,529	12,431
5	107,413	88,542	-	17,529	12,431
6	107,413	88,542	-	17,529	12,431
7	107,413	88,542	-	17,529	12,431
99	107,413	88,542	-	17,529	12,431

**Table 5-73: Do-Nothing - PV gas network damages with +25% valuations (cumulative) (£k)**

Appraisal year (Year)	PV Gas damages with +25% valuation (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	124,383	140,225	-	354	7,901
1	138,642	142,788	-	1,061	8,012
2	139,672	144,449	-	3,610	8,107
3	164,273	145,982	-	28,873	20,114
4	179,021	147,570	-	29,215	20,718
5	179,021	147,570	-	29,215	20,718
6	179,021	147,570	-	29,215	20,718
7	179,021	147,570	-	29,215	20,718
99	179,021	147,570	-	29,215	20,718

**Table 5-74: Do-Nothing - PV electrical network damages with -10% valuations (cumulative) (£k)**

Appraisal year (Year)	PV Electricity damages with -10% valuation (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	11,103	8,474	268	220	20,870
1	14,392	9,976	273	1,732	39,615
2	15,610	14,424	279	5,253	53,470
3	17,007	15,291	331	10,415	60,984
4	17,356	15,515	362	12,091	62,825
5	17,356	15,515	394	12,091	62,825
6	17,356	15,515	423	12,091	62,825
7	17,356	15,515	426	12,091	62,825
99	17,356	15,515	426	12,091	62,825

**Table 5-75: Do-Nothing - PV electrical network damages with +10% valuations (cumulative) (£k)**

Appraisal year (Year)	PV Electricity damages with +10% valuation (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	13,570	10,357	328	269	25,508
1	17,591	12,193	333	2,117	48,418
2	19,079	17,630	341	6,420	65,352
3	20,786	18,689	404	12,729	74,536
4	21,213	18,962	442	14,777	76,787
5	21,213	18,962	482	14,777	76,787
6	21,213	18,962	517	14,777	76,787
7	21,213	18,962	521	14,777	76,787
99	21,213	18,962	521	14,777	76,787

With a 10% decrease in gas distribution asset valuation, there is a total damage value of £271,098k by the end of the appraisal period. This means that there was a decrease in PV damages of £30,122k, a 10% decrease. With a 10% increase in gas distribution asset valuation, there is a total damage value of £331,342k by the end of the appraisal period. This means that there was an increase PV damages of £30,122k, a 10% increase. This adjustment of the gas distribution asset valuation results in a +/-0.3% change in total PV damages for the Do Nothing scenario demonstrating the assessment has a low sensitivity to changes in the valuation of gas distribution infrastructure.

With a 25% decrease in gas distribution asset valuation, there is a total damage value of £225,915k by the end of the appraisal period. This means that there was a decrease in PV damages of £75,305k, a 25% decrease. With a 25% increase in gas distribution asset valuation, there is a total damage value of £376,525k by the end of the appraisal period. This means that there was an increase PV damages of £75,305k, a 25% increase. Increasing or decreasing the value of gas distribution assets by 25% results in a +/- 0.75% change in total PV damages further strengthening the conclusion that the assessment is robust towards changes in the value of gas distribution assets.

With a 10% decrease in electrical distribution asset valuation, there is a total damage value of £108,213k by the end of the appraisal period. This means that there was a decrease in PV damages of £12,024k, a 10% decrease. With a 10% increase in electrical distribution asset valuation, there is a total damage value of £132,261k by the end of the appraisal period. This means that there was an increase in PV damages of £12,024k, a 10% increase. Overall, a 10% decrease or increase in electricity distribution asset valuations results in a +/-0.12% change in total PV damages in the Do Nothing scenario demonstrating the assessment has a low sensitivity to changes in the valuation of electricity infrastructure.

## 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 NRD receptors with a non-9/999 value.

### 5.8.1 Do-Nothing scenario approach

In accordance with HM Treasury Green Book<sup>15</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 5.6. 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). 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>15</sup> [The Green Book: appraisal and evaluation in central government - GOV.UK](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/362822/green-book-2015.pdf)

## 5.8.2 Key assumptions

**Table 5-76: Key assumptions for isolated property damages**

Key assumptions									
Isolated community connection costs	<p>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.</p> <table border="1"> <thead> <tr> <th>Element</th> <th>Cost / m</th> </tr> </thead> <tbody> <tr> <td>Road</td> <td>£44,244</td> </tr> <tr> <td>Electricity Distribution</td> <td>£1,399</td> </tr> <tr> <td>Water Utilities</td> <td>£1,786</td> </tr> </tbody> </table>	Element	Cost / m	Road	£44,244	Electricity Distribution	£1,399	Water Utilities	£1,786
Element	Cost / m								
Road	£44,244								
Electricity Distribution	£1,399								
Water Utilities	£1,786								
Defining isolated properties	<p>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.</p>								

## 5.8.3 Do-Nothing scenario outcomes

The total PV costs for isolated communities are shown in Table 5-77. Isolated communities and properties were determined whilst observing the maximum contour level flood extents for a given subcompartment, this being 3.90m across all subcompartments.

**Table 5-77: 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	4,890	7	329	Yes	No	259
2	7,902	21	982	Yes	No	856
3	5,004	133	6,313	No	Yes	4,361
4	6,326	416	19,721	No	Yes	5,513
5	21,775	533	25,271	No	Yes	18,975
6	5,547	183	8,684	No	Yes	4,834
7	7,908	188	8,914	No	Yes	6,891
8	27,806	415	19,674	Yes	No	17,145
9	5,913	376	17,823	No	Yes	5,153
10	10,149	40	1,880	Yes	No	1,638
11	4,436	1	56	Yes	No	49
12	30,947	731	34,657	No	Yes	26,968

Community	Write-off costs (£k)	Distance for reconnection (m)	Reconnection costs (£k)	Reconnected	Abandoned	Total Discounted Costs (£k)
13	22,930	432	20,466	Yes	No	17,835
14	29,875	450	21,364	Yes	No	18,617
15	16,203	331	15,686	Yes	No	13,669
16	12,770	201	9,521	Yes	No	8,297
17	14,199	291	13,804	Yes	No	12,030
18	3,982	67	3,198	Yes	No	2,787
19	45,853	155	7,369	Yes	No	6,422
20	17,958	169	8,001	Yes	No	6,972
21	57,061	439	20,822	Yes	No	18,145
22	112,885	3,681	174,571	No	Yes	98,372
23	45,722	522	24,736	Yes	No	21,556
24	3,169	106	5,040	No	Yes	2,762
25	16,280	208	9,855	Yes	No	8,588
26	48,733	342	16,238	Yes	No	14,151
27	24,694	517	24,509	Yes	No	21,358
28	10,062	92	4,367	Yes	No	3,805
29	6,108	148	7,038	No	Yes	5,322
30	15,521	2,176	103,212	No	Yes	13,526
31	35,148	456	21,611	Yes	No	18,833
32	18,745	1,516	71,918	No	Yes	16,336
33	7,210	243	11,532	No	Yes	6,283
34	20,365	427	20,230	Yes	No	17,630
35	5,013	300	14,251	No	Yes	4,368
36	3,417	366	17,338	No	Yes	2,978
37	2,866	199	9,458	No	Yes	2,497
38	7,644	2,840	134,710	No	Yes	6,661
39	23,327	1,278	60,622	No	Yes	20,328
40	5,068	354	16,777	No	Yes	4,416

Total PV Damages for communities at risk of isolation is £487,186k.

**Table 5-78: Do-Nothing - summary of 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)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	-	-	-	-	-
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	82,130	22,843	-	105,177	48,092
5	82,130	22,843	-	105,177	48,092
6	82,130	22,843	-	105,177	48,092
7	82,130	22,843	-	105,177	48,092
99	82,130	22,843	-	105,177	48,092

**Table 5-79: Do-Nothing - summary of non-residential cumulative write-off costs for isolated properties as well as the discounted costs (£k) per year**

Appraisal year (Year)	Non-residential write-off costs (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	-	-	-	-	-
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	32,826	38,960	-	47,757	16,625
5	32,826	38,960	-	47,757	16,625
6	32,826	38,960	-	47,757	16,625
7	32,826	38,960	-	47,757	16,625
99	32,826	38,960	-	47,757	16,625

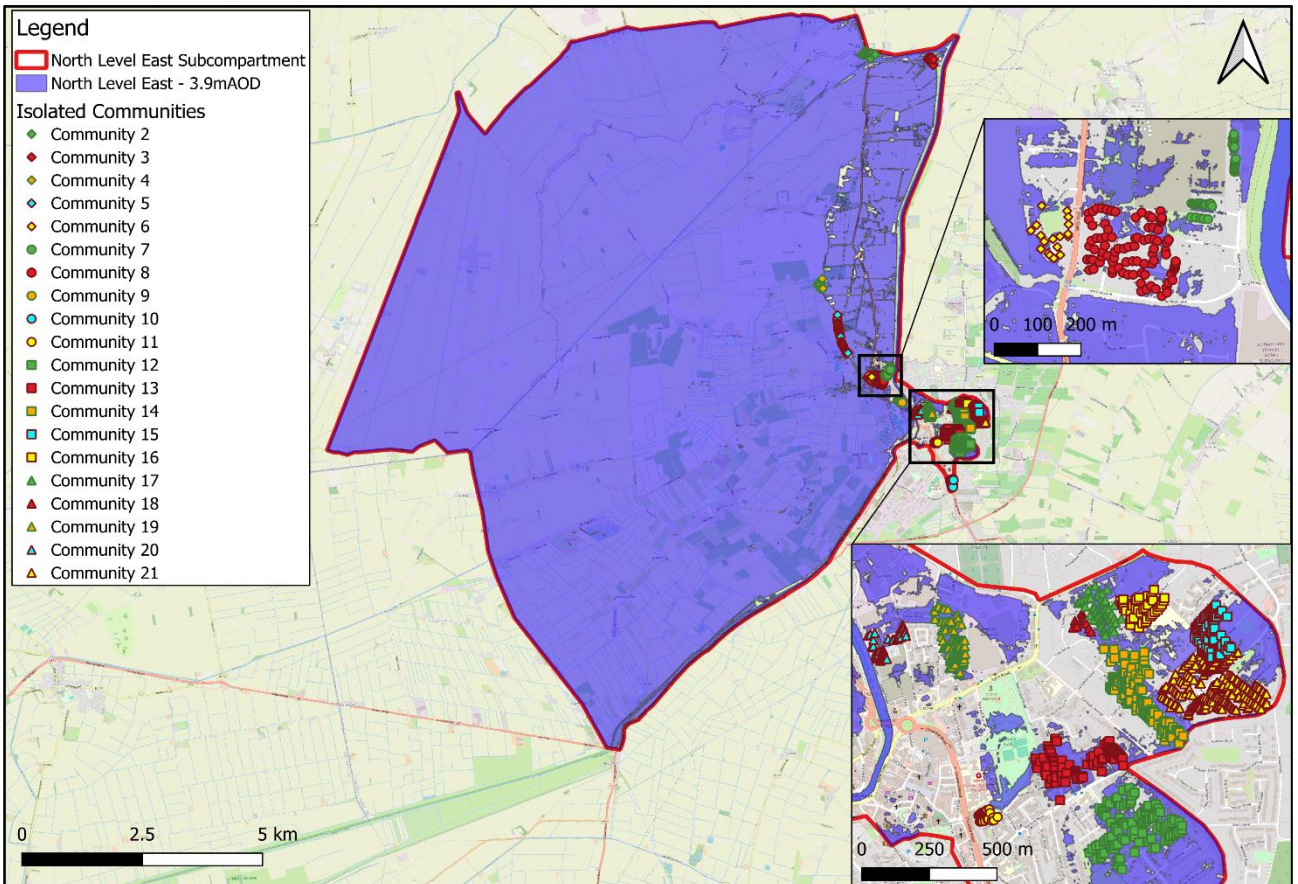
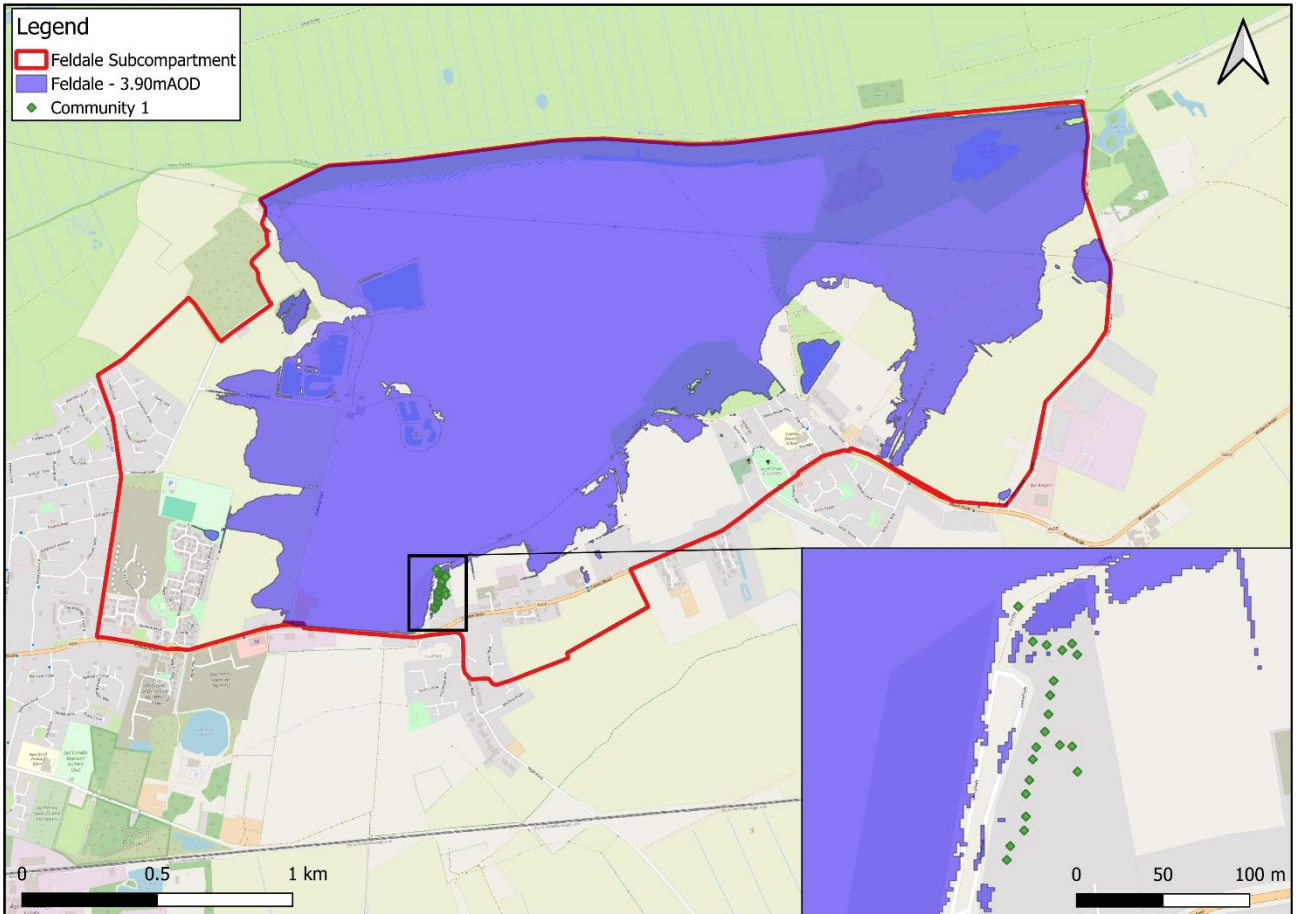
**Table 5-80: Do-Nothing - summary of total cumulative write-off costs for isolated properties as well as the discounted costs (£k) per year**

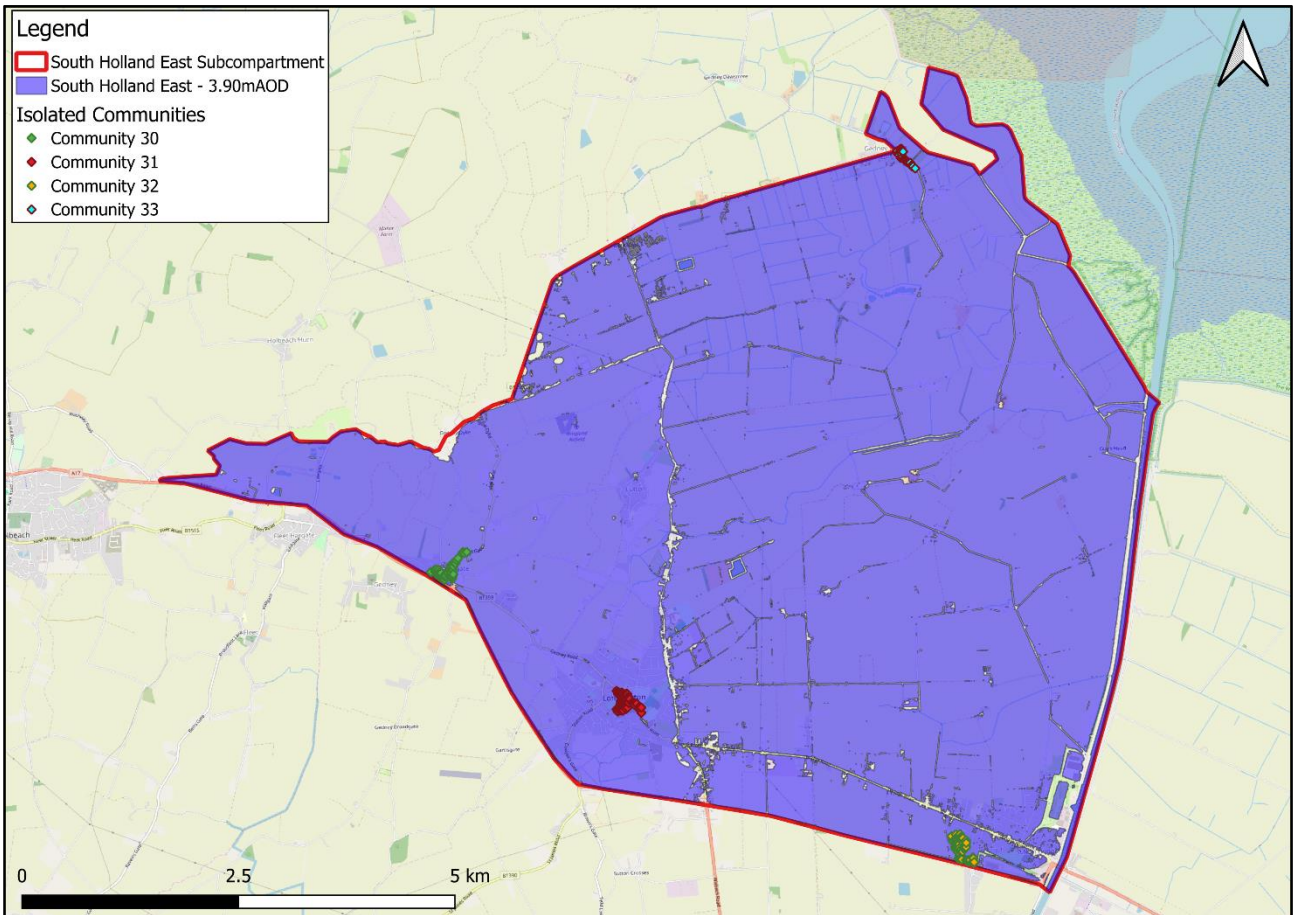
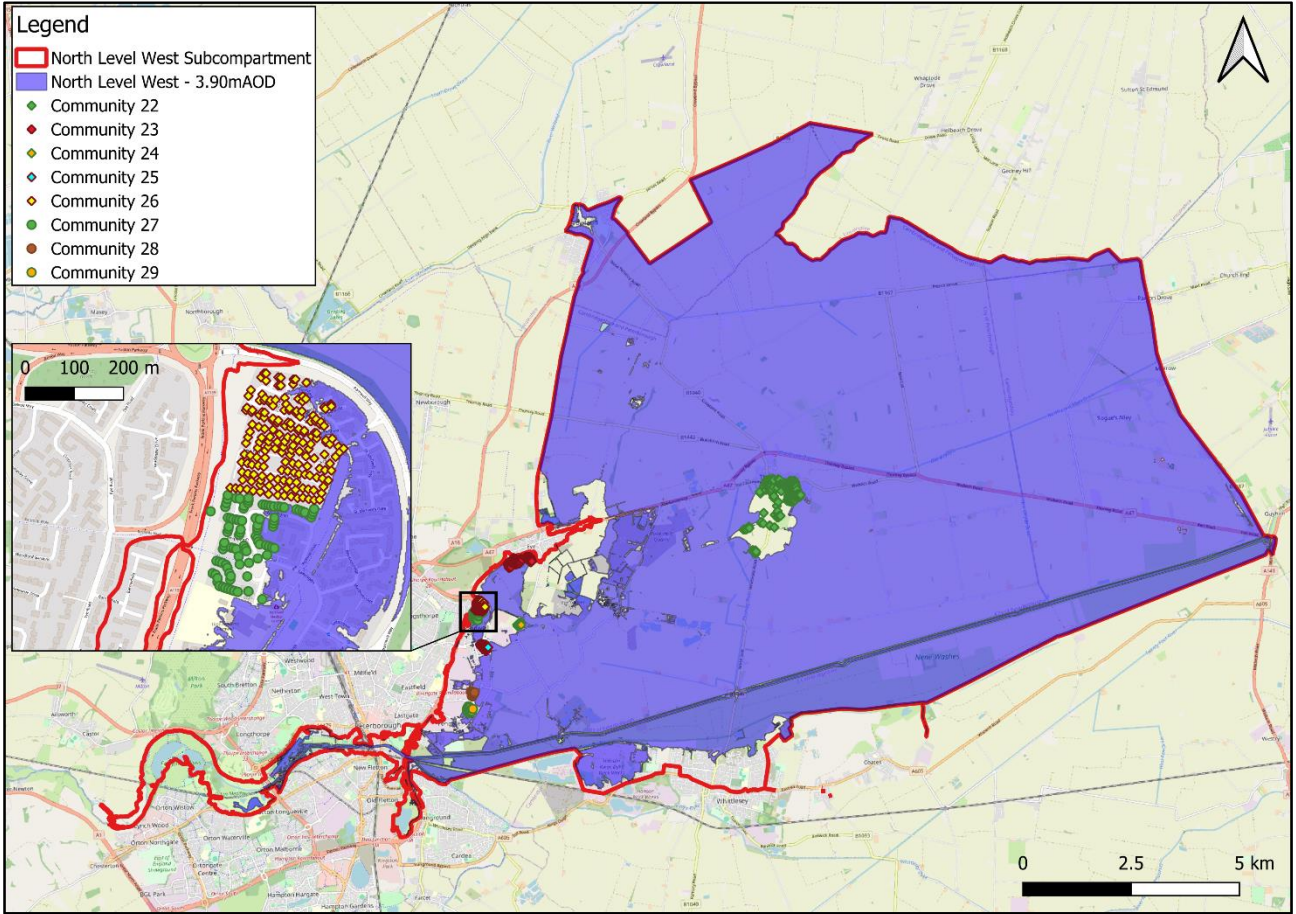
Appraisal year (Year)	Total discounted write-off costs (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	-	-	-	-	-
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	114,956	61,803	-	152,934	64,717
5	114,956	61,803	-	152,934	64,717
6	114,956	61,803	-	152,934	64,717
7	114,956	61,803	-	152,934	64,717
99	114,956	61,803	-	152,934	64,717

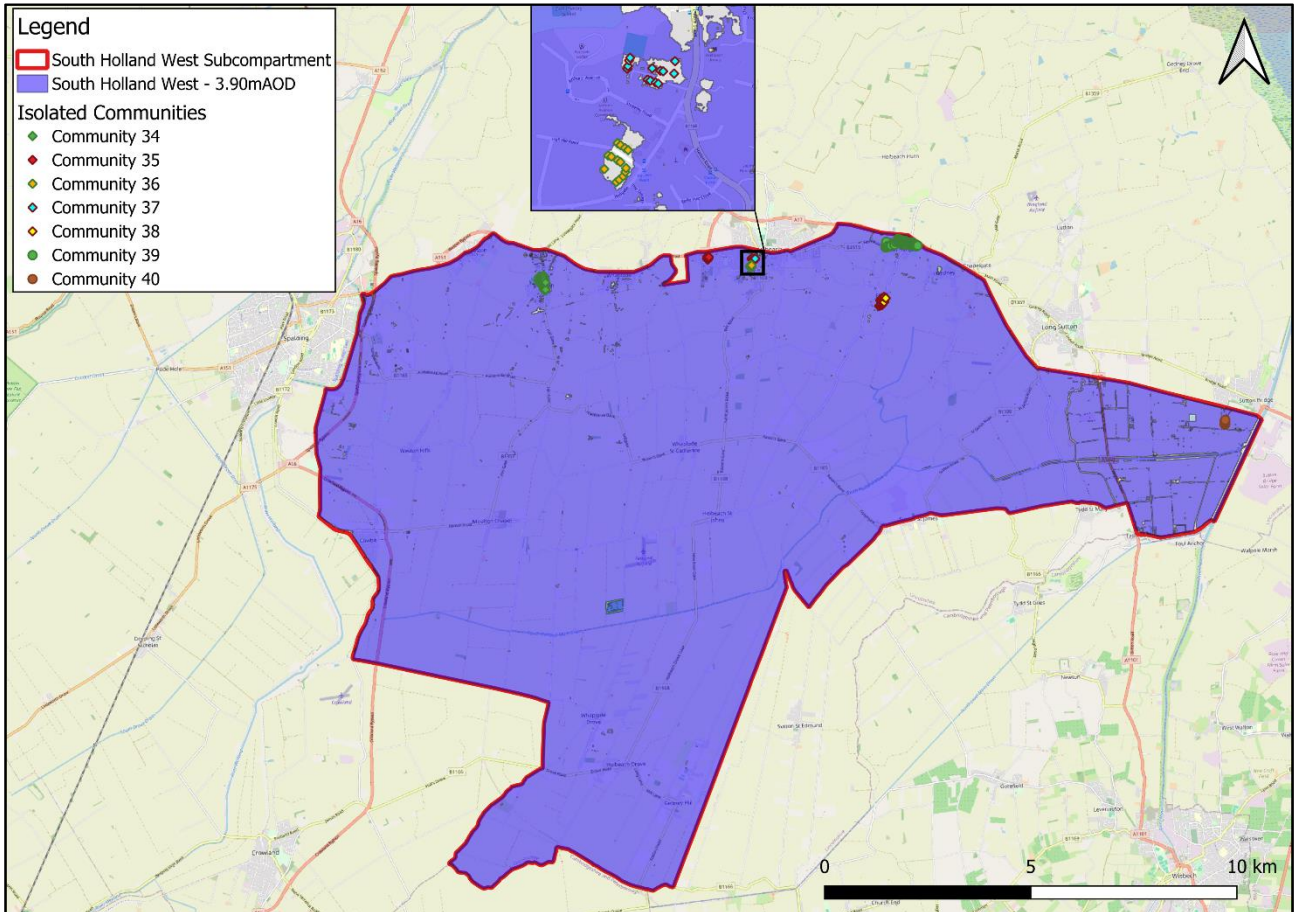
Across all subcompartments, there were 40 isolated communities identified. The location of these isolated communities is shown in Figure 18. For 19 communities, it was found to be more cost-effective to write-off the communities than to reconnect them to nearby road networks through building raised roads.

For isolated properties not within a wider confined community like those in Table 5-77, write-off costs were totalled and can be seen in Table 5-78. By year 4 of the appraisal period, total discounted PV write-off costs of £394,411k are observed across all subcompartments.

Therefore, total PV Damages for Isolated land and properties, accounting for those in communities and those not, are £881,598k.







**Figure 18: Locations of the isolated communities per subcompartment**

#### 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 5-82.

**Table 5-81: 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	4,890	7	329	Yes	No	259
2	7,963	21	982	Yes	No	856
3	5,004	133	6,313	No	Yes	4,361
4	6,326	416	19,721	No	Yes	5,513
5	21,775	533	25,271	No	Yes	18,975

Community	Write-off costs (£k)	Distance for reconnection (m)	Reconnection costs (£k)	Reconnected	Abandoned	Total Discounted Costs (£k)
6	5,547	183	8,684	No	Yes	4,834
7	7,908	188	8,914	No	Yes	6,891
8	27,851	415	19,674	Yes	No	17,145
9	5,913	376	17,823	No	Yes	5,153
10	10,149	40	1,880	Yes	No	1,638
11	4,516	1	56	Yes	No	49
12	30,947	731	34,657	No	Yes	26,968
13	22,930	432	20,466	Yes	No	17,835
14	29,875	450	21,364	Yes	No	18,617
15	16,231	331	15,686	Yes	No	13,669
16	12,770	201	9,521	Yes	No	8,297
17	14,199	291	13,804	Yes	No	12,030
18	3,982	67	3,198	Yes	No	2,787
19	45,853	155	7,369	Yes	No	6,422
20	18,614	169	8,001	Yes	No	6,972
21	57,061	439	20,822	Yes	No	18,145
22	116,528	3,681	174,571	No	Yes	101,547
23	45,722	522	24,736	Yes	No	21,556
24	3,169	106	5,040	No	Yes	2,762
25	16,280	208	9,855	Yes	No	8,588
26	48,733	342	16,238	Yes	No	14,151
27	24,694	517	24,509	Yes	No	21,358
28	10,062	92	4,367	Yes	No	3,805
29	7,102	148	7,038	Yes	No	6,134
30	15,678	2,176	103,212	No	Yes	13,663
31	35,186	456	21,611	Yes	No	18,833
32	18,782	1,516	71,918	No	Yes	16,367
33	7,271	243	11,532	No	Yes	6,337

Community	Write-off costs (£k)	Distance for reconnection (m)	Reconnection costs (£k)	Reconnected	Abandoned	Total Discounted Costs (£k)
34	20,693	427	20,230	Yes	No	17,630
35	5,013	300	14,251	No	Yes	4,368
36	3,417	366	17,338	No	Yes	2,978
37	3,089	199	9,458	No	Yes	2,692
38	7,897	2,840	134,710	No	Yes	6,882
39	23,431	1,278	60,622	No	Yes	20,419
40	5,068	354	16,777	No	Yes	4,416

**Table 5-82: Do-Nothing - summary of 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)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	-	-	-	-	-
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	82,130	22,843	-	105,177	48,092
5	82,130	22,843	-	105,177	48,092
6	82,130	22,843	-	105,177	48,092
7	82,130	22,843	-	105,177	48,092
99	82,130	22,843	-	105,177	48,092

**Table 5-83: Do-Nothing - summary of 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)	Non-residential write-off costs (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	-	-	-	-	-
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	42,481	47,455	-	61,386	20,612
5	42,481	47,455	-	61,386	20,612
6	42,481	47,455	-	61,386	20,612
7	42,481	47,455	-	61,386	20,612
99	42,481	47,455	-	61,386	20,612

**Table 5-84: Do-Nothing - summary of total 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)	Total discounted write-off costs (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
0	-	-	-	-	-
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	124,612	70,298	-	166,563	68,704
5	124,612	70,298	-	166,563	68,704
6	124,612	70,298	-	166,563	68,704
7	124,612	70,298	-	166,563	68,704
99	124,612	70,298	-	166,563	68,704

## 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.

This damage was only calculated for the Maintain scenario as it is assumed that under the Do-Nothing scenario residents will have left the catchment.

The number of adults in each residential property was determined and this was then multiplied by the mental health costs per adult for each flood depth band. The methodology defined in the Environment Agency’s mental health costs of flooding and erosion guidance was followed.

**Table 5-85: Mental health costs**

Mental health losses per adult by flood depth	Depth	Mental health cost (£)	Source: Environment Agency Mental health costs of flooding and erosion guidance <sup>16</sup> (2025 values)
	0 - 0.3m	£1,924	
	0.3 - 1m	£3,102	
	More than 1m	£4,237	

### 5.9.1 Maintain scenario outcomes

**Table 5-86: Maintain - PV Mental health costs (£k)**

Appraisal period (years)	PV Mental health costs (£k)					
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)	Total
100	-	1	-	1	-	2

Total PV mental health costs over the 100-year appraisal period are £2k.

<sup>16</sup> [Mental health costs of flooding and erosion - GOV.UK](#)

## 5.10 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 only calculated for the Maintain scenario as it is assumed that under the Do-Nothing scenario residents will have left the catchment and so do not require the emergency services.

### 5.10.1 Maintain scenario outcomes

**Table 5-87: Maintain - PV Emergency services costs (£k)**

Appraisal period (years)	PV Emergency services costs (£k)					
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)	Total
100	-	1	-	1	-	1

Total PV emergency service costs over the 100-year appraisal period are £1k.

## 5.11 Risk to life

Risk to life assesses the potential for loss of life as a result of flooding. The analysis defines a value for the number of fatalities likely, taking into account the severity of flooding defined by the depth of flooding and hazard, as well as the demographics and characteristics of the area at risk. This value is multiplied by the valuation of a life.

This damage was only calculated for the Maintain scenario as it is assumed that under the Do-Nothing scenario residents will have left the catchments. The methodology has followed the Defra supplementary guidance note 'Assessing and Valuing the Risk to Life from Flooding' (May, 2008).

This damage was only calculated for the Maintain scenario as it is assumed that under the Do-Nothing scenario residents will have left the catchment.

**Table 5-88: Risk to Life parameters and assumptions**

Parameter name	Parameter	Source
Average number of people per property	~2.19	Defined using data from Census 2021 and varies between each subcompartment
Percentage elderly (> 75yrs) (k%)	~14	
Percentage disabled or infirm (%)	~22	
Reference value of a life	£2,209,537	Reference Table A 4.1.1: Source: DfT Webtag parameters, November 2021 (2010 value), uplifted to 2025 using projected GDP deflator <sup>17</sup>
Flood warning	England – 2.15	Defra/Environment Agency.2006). R&D Outputs: Flood Risks to People, Phase 2, FD2321/TR1, The Flood Risks to People Methodology. <sup>18</sup>
Speed of Onset	2 – Gradual	
Nature of area	Typical residential area (2 storey homes); industrial & commercial properties	
Nature of catchment	Pasture / Arable	

<sup>17</sup>

<https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fassets.publishing.service.gov.uk%2Fmedia%2F67350f5e54652d03d51610db%2Ftag-data-book-v1.24-nov-2024-v1.0.xlsm>

<sup>18</sup>[https://assets.publishing.service.gov.uk/media/602bbc768fa8f50383c41f80/Flood\\_risks\\_to\\_people\\_-\\_Phase\\_2\\_The\\_flood\\_risks\\_to\\_people\\_methodology\\_technical\\_report.pdf](https://assets.publishing.service.gov.uk/media/602bbc768fa8f50383c41f80/Flood_risks_to_people_-_Phase_2_The_flood_risks_to_people_methodology_technical_report.pdf)

### 5.11.1 Maintain scenario outcomes

**Table 5-89: Maintain - PV Risk to Life (£k)**

Appraisal period (years)	PV Risk to Life (£k)					
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)	Total
100	-	1	-	1	-	2

Total PV risk to life over the 100-year appraisal period is £2k.

## 5.12 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. To calculate this, the full-scale mid values stated in the MCM 2024 handbook for the cost of temporary accommodation and relocation were used.

This damage was only calculated for the Maintain scenario as it is assumed that under the Do-Nothing scenario residents will have left the catchment and so do not need to be relocated.

### 5.12.1 Maintain scenario outcomes

**Table 5-90: Maintain - PV Evacuation and temporary accommodation costs (£k)**

Appraisal period (years)	PV Evacuation and temporary accommodation costs (£k)					
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)	Total
100	-	0	-	0	-	1

Total PV evacuation and temporary accommodation costs over the 100-year appraisal period is £1k.

## 5.13 Vehicle damages

Economic losses associated with damage to vehicles are estimated for all residential properties. Guidance suggests that flood depths of greater than 0.39m are almost certain to lead to a vehicle being written off. Damage equal to the average write-off value of a vehicle at the property are therefore assumed for all properties where flood depth exceeds this threshold, with the number of vehicles per household estimated at 1.43, representative of more rural communities.

This damage was only calculated for the Maintain scenario as it is assumed that under the Do-Nothing scenario residents will have left the catchments. The methodology defined in the MCM was followed.

**Table 5-91: Data used in the vehicle damages assessment**

Vehicle Data	Assumed Value	Source
Vehicles per household	1.43	Rural Town and Fringe. Household car ownership by region and Rural-Urban Classification: England, 2002/03 and 2018/19
Threshold for vehicle write off	0.39m	As recommended by MCM
Probability a car is at a household if flood warning given	75%	As recommended by MCM
Average value per vehicle	£6,444	As recommended by MCM. £5600 uplifted to 2025 using latest GDP deflators from December 2024.
Average Car damages per household	£9,215	Vehicle per household multiplied by average value per vehicle

### 5.13.1 Maintain scenario outcomes

**Table 5-92: Maintain – PV Vehicle damages (£k)**

Appraisal period (years)	PV Vehicle damages (£k)					
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)	Total
100	-	-	-	0	-	0

Vehicle damages in the South Holland (East) subcompartment amount to £430 over the 100-year appraisal period, thus are shown as 0 in Table 5-92. Even though there are property damages in the North Level (West) subcompartment, there are no vehicle damages as the low depth of flooding at residential properties is below the threshold for vehicle damages.

## 5.14 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.

The total PV utilities disruption calculated for the Maintain scenario in the Lower Nene catchment are £328. For the Do Nothing scenario, residual damages for utilities disruption across the catchment are sufficiently low that it is deemed disproportionate to assess them within this scenario.

## 5.15 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.

### 5.15.1 Do-Nothing scenario 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>19</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>20</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 5-93). 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.

### 5.15.2 Key assumptions

**Table 5-93: 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	

<sup>19</sup> [The Green Book: appraisal and evaluation in central government - GOV.UK](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/101321/gb17-001.pdf)

<sup>20</sup> [FD2662\\_full\\_toolkit.pdf](#)

**Key assumptions:**

	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;	-	16,368

Key assumptions:					
		undifferentiated goods- and services-producing activities of households for own use			
		U - Activities of extraterritorial organisations and bodies		-	-
Sources:					
Homes & 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)					
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%				
Key datasets:					
<ul style="list-style-type: none"> <li>National Receptor Database</li> </ul>					

### 5.15.3 Do-Nothing scenario outcomes

**Table 5-94: Do Nothing - High-level estimates of number of jobs impacted (GVA - direct and indirect) (cumulative)**

Appraisal period (years)	Number of jobs				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
10	6,467	7,377	1	4,803	6,870

**Table 5-95: Do Nothing - High-level PV GVA losses (direct and indirect) (cumulative) (£k)**

Appraisal period (years)	Total PV GVA losses (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
10	1,534,384	1,963,455	175	1,203,655	1,806,348

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 5-94. During this period an estimated 25,517 jobs are impacted whilst total GVA losses in excess of £6,508,017k are accrued.

#### 5.15.4 Maintain scenario outcomes

**Table 5-96: Maintain - High-level estimates of number of jobs impacted (GVA - direct and indirect) (cumulative)**

Appraisal period (years)	Number of jobs				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
10	-	58	-	157	-

**Table 5-97: Maintain - high-level PV GVA losses (direct and indirect) (cumulative) (£k)**

Appraisal period (years)	Total PV GVA losses (£k)				
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)
10	-	1	-	2	-

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 5-96. During this period an estimated 215 jobs are impacted whilst total GVA losses in excess of £3k 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)					
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)	Total
Residential properties	2,882,105	1,032,511	6,482	1,502,728	2,992,188	8,416,013
Non-residential properties	408,913	265,447	-	139,995	151,669	966,024
Agricultural losses	263,439	382,702	9,951	123,877	423,895	1,203,865
Environment and recreational losses	65,903	62,852	1,412	69,067	102,629	301,863
Heritage losses	40,461	14,052	532	10,059	30,982	96,087
Transport damages	9,855	382,243	-	43,423	291,070	726,591
Utilities damages	162,501	135,294	474	36,806	86,381	421,456
Isolated land and properties	312,115	237,718	259	207,911	123,596	881,598
<b>Total (excludes losses to the local economy)</b>	<b>4,145,293</b>	<b>2,512,819</b>	<b>19,110</b>	<b>2,133,866</b>	<b>4,202,410</b>	<b>13,013,498</b>
Losses to the local economy (GVA)	1,534,384	1,963,455	175	1,203,655	1,806,348	6,508,017

Total damages in the Do Nothing scenario exceed £13 billion across all five subcompartments.

## 6.2 Summary of Maintain Damages

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

Type	Maintain Damages (£k)					
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)	Total
Residential properties	-	4	-	3	-	7
Non-residential properties	-	-	-	-	-	-
Indirect commercial losses	-	-	-	-	-	-
Agricultural losses	-	-	-	0*	0*	0*
Environment and recreational losses	0*	-	-	0*	-	0*
Heritage losses	-	-	-	-	-	-
Mental health costs	-	1	-	1	-	2
Emergency service costs	-	1	-	1	-	1
Risk to life	-	1	-	1	-	2
Evacuation and temporary accommodation	-	0*	-	0*	-	1
Vehicle damages	-	-	-	0*	-	0*
Intangibles	-	-	-	-	-	-
Utilities disruption	-	0*	-	0*	-	0*
<b>Total (excludes losses to the local economy)</b>	<b>0*</b>	<b>6</b>	<b>-</b>	<b>7</b>	<b>0*</b>	<b>13</b>
Losses to the local economy (GVA)	-	1	-	2	-	3

\*These losses accrued in the Maintain fall below the £1,000 threshold to be listed in the table above.

A total of £13k in damages are accrued in the Maintain scenario over the 100-year appraisal period.

## 6.3 Summary of Maintain Benefits

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

Type	Benefits (£k)					
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)	Total
Residential properties	2,882,105	1,032,508	6,482	1,502,725	2,992,188	8,416,007
Non-residential properties	408,913	265,447	-	139,995	151,669	966,024
Indirect commercial losses* avoided	-	-	-	-	-	-
Agricultural losses avoided	263,439	382,702	9,951	123,877	423,895	1,203,865
Environment and recreational losses avoided	65,903	62,852	1,412	69,067	102,629	301,863
Heritage losses avoided	40,461	14,052	532	10,059	30,982	96,087
Transport damages avoided	9,855	382,243	-	43,423	291,070	726,591
Utilities damages avoided	162,501	135,294	474	36,806	86,381	421,456
Isolated land and properties	312,115	237,708	259	207,911	123,596	881,598
Mental health costs* avoided	-	-1	-	-1	-	-2
Emergency service costs* avoided	-	-1	-	-1	-	-1
Risk to life*	-	-1	-	-1	-	-2
Evacuation and temporary accommodation*	-	-0	-	-0	-	-1
Vehicle damages avoided	-	-	-	-0	-	-0
Intangibles	-	-	-	-	-	-
Utilities disruption avoided	-	-0	-	-0	-	-0
<b>Total (excludes benefits to the local economy)</b>	<b>4,145,293</b>	<b>2,516,809</b>	<b>19,110</b>	<b>2,133,952</b>	<b>4,202,410</b>	<b>13,013,484</b>
Benefits to the local economy (GVA)	1,534,384	1,963,454	175	1,203,654	1,806,348	6,508,016

*\*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 these damages are unlikely to be accrued as there is enough time for people to retreat from the area that is going to be permanently inundated.*

There are benefits in excess of £13 billion accrued over the 100-year appraisal period with an additional £6.5 billion of avoided impacts on the local economy within the first ten years.

## **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 Increase in limiting level to 6m**

A sensitivity test was conducted across all subcompartments to determine the impact of increasing the limiting level of 3.9m AOD to 6.0m AOD in an extreme inundation scenario. The year in which this limiting level is reached is determined once a level of 6m AOD is reached when adding 0.5m per year from previously established starting levels per subcompartment. The result to this sensitivity test can be seen in Table 6-4.

**Table 6-4: Summary of PV Do Nothing damages (£k) with a limiting level of 6m across all subcompartments**

Type	Do Nothing Damages (£k)					
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)	Total
Residential properties	3,309,823	1,840,914	137,728	1,594,253	3,048,094	9,930,812
Non-residential properties	614,458	748,840	5,972	147,496	159,517	1,676,283
Agricultural losses	263,669	386,586	10,363	124,136	424,169	1,208,922
Environment and recreational losses	111,459	118,499	4,970	81,141	125,786	441,855
Heritage losses	109,100	32,607	532	22,572	51,016	215,827
Transport damages	281,048	465,830	15,882	123,668	416,639	1,303,068
Utilities damages	166,202	152,586	612	39,669	89,855	448,924
Isolated land and properties	74,420	148,882	30,060	550	2,477	256,389
<b>Total (excludes losses to the local economy)</b>	<b>4,930,179</b>	<b>3,894,744</b>	<b>206,119</b>	<b>2,133,485</b>	<b>4,317,553</b>	<b>15,482,080</b>
Losses to the local economy (GVA)	1,666,358	4,099,172	175	1,221,822	1,806,348	8,793,876

#### 6.4.2 Change in subcompartment fill rate

A further two sensitivity tests were conducted where the rate of inundation is set to either 0.25m (lower estimate) or 0.75m (upper estimate) every year in order to better understand the potential impacts of inundation being less or more rapid than expected. The results of both sensitivity tests can be seen in Table 6-5 and Table 6-6.

The results of this sensitivity test may not result in the expected outcome with regard to agricultural losses, i.e., some subcompartments are a higher or lower value when it would be expected the other way round. The reason for this observation is that a longer or shorter period of the loss of productivity in bad drainage conditions for high value crops may outweigh the increase or reduction in discounting of written off land.

**Table 6-5: Summary of PV Do Nothing damages (£k) with a fill rate of 0.25m per year across all subcompartments**

Type	Do Nothing Damages (£k)					
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)	Total
Residential properties	2,795,963	1,002,357	5,458	1,403,229	2,856,478	8,063,486
Non-residential properties	382,845	252,121	-	132,229	146,484	913,678
Agricultural losses	263,888	381,943	9,396	125,270	424,945	1,205,442
Environment and recreational losses	64,849	66,996	1,278	64,801	98,682	296,606
Heritage losses	36,530	12,858	434	9,082	28,064	86,967
Transport damages	9,095	378,791	-	40,235	272,101	700,221
Utilities damages	140,506	134,664	453	34,220	83,427	393,271
Isolated land and properties	281,510	214,408	210	187,524	111,477	795,128
<b>Total (excludes losses to the local economy)</b>	<b>3,975,186</b>	<b>2,444,138</b>	<b>17,229</b>	<b>1,996,590</b>	<b>4,021,658</b>	<b>12,454,799</b>
Losses to the local economy (GVA)	1,202,675	1,579,071	54	928,625	1,580,786	5,291,212

**Table 6-6: Summary of PV Do Nothing damages (£k) with a fill rate of 0.75m per year across all subcompartments**

Type	Do Nothing Damages (£k)					
	North Level (East)	North Level (West)	Feldale	South Holland (East)	South Holland (West)	Total
Residential properties	2,911,431	1,042,597	6,847	1,538,998	3,039,563	8,539,436
Non-residential properties	415,505	269,856	-	141,897	153,479	980,737
Agricultural losses	263,354	382,968	10,158	123,384	423,631	1,203,495
Environment and recreational losses	66,129	61,289	1,458	69,979	103,113	301,968
Heritage losses	41,865	14,350	570	10,408	31,954	99,146
Transport damages	10,127	383,378	-	44,549	298,041	736,095
Utilities damages	163,715	135,599	482	37,874	87,429	425,100
Isolated land and properties	323,039	246,038	277	215,188	127,922	912,464
<b>Total (excludes losses to the local economy)</b>	<b>4,195,165</b>	<b>2,536,075</b>	<b>19,792</b>	<b>2,182,277</b>	<b>4,265,132</b>	<b>13,198,441</b>
Losses to the local economy (GVA)	1,652,062	2,069,966	208	1,284,284	1,886,194	6,892,715

## 7. Costing

This section sets out the approach to defining the estimated capital cost interventions required for all FRM assets in the Lower Nene 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>21</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>21</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>22</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 Lower Nene 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>22</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 Lower Nene catchment and each subcompartment (£k)**

	Lower Nene (£k)	North Level East (£k)	North Level West (£k)	Feldale (£k)	South Holland East (£k)	South Holland West (£k)
Capital costs	231,570	96,342	86,924	1,752	20,835	25,717
Appraisal costs	118,456	45,407	47,273	1,101	9,586	15,090
Risk contingency	210,016	85,049	80,518	1,712	18,252	24,484
Future costs	36,584	27,611	8,972	-	-	-
Maintenance and operational costs	243,790	132,611	74,242	1,575	10,457	24,906
<b>Whole life cost</b>	<b>840,416</b>	<b>387,019</b>	<b>297,929</b>	<b>6,140</b>	<b>59,130</b>	<b>90,197</b>

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

	Lower Nene (£k)	North Level East (£k)	North Level West (£k)	Feldale (£k)	South Holland East (£k)	South Holland West (£k)
Lower bound cost	690,351	329,663	236,838	4,728	47,944	71,178
Best estimate cost	840,416	387,019	297,929	6,140	59,130	90,197
Upper bound cost	1,074,109	499,003	376,568	7,436	80,160	110,942

## 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 – Lower Nene</b>				
Do Nothing	13,013,498	-	-	-
Maintain	13	13,013,485	840,416	15.48
<b>North Level East</b>				
Do Nothing	4,145,293	-	-	-
Maintain	-	4,145,293	387,019	10.71
<b>North Level West</b>				
Do Nothing	2,512,819	-	-	-
Maintain	6	2,512,813	297,929	8.43
<b>Feldale</b>				
Do Nothing	19,110	-	-	-
Maintain	-	19,110	6,140	3.11
<b>South Holland East</b>				
Do Nothing	2,113,866	-	-	-
Maintain	7	2,133,859	59,130	36.09
<b>South Holland West</b>				
Do Nothing	4,202,410	-	-	-
Maintain	-	4,202,410	90,197	46.59

## 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>23</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 and Table 9-2 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 – Lower Nene catchment - at risk today**

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	2,705	-	-	-
21% to 40% most deprived	-	13,183	-	-	-
60% least deprived	-	9,019	-	-	-
All deprivation bands	-	24,907	-	-	-

**Table 9-2: Outcome Measure 2 – Lower Nene catchment - at risk after duration of benefits**

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	2,705	-	-	-	-
21% to 40% most deprived	13,183	-	-	-	-
60% least deprived	9,019	-	-	-	-
All deprivation bands	24,907	-	-	-	-

<sup>23</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 – North Level East - at risk today**

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	1,902	-	-	-
21% to 40% most deprived	-	6,836	-	-	-
60% least deprived	-	682	-	-	-
All deprivation bands	-	9,420	-	-	-

**Table 9-4: Outcome Measure 2 – North Level East - at risk after duration of benefits**

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	1,902	-	-	-	-
21% to 40% most deprived	6,836	-	-	-	-
60% least deprived	682	-	-	-	-
All deprivation bands	9,420	-	-	-	-

**Table 9-5: Outcome Measure 2 – North Level West - at risk today**

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	84	-	-	-
21% to 40% most deprived	-	1,818	-	-	-
60% least deprived	-	1,685	-	-	-
All deprivation bands	-	3,587	-	-	-

**Table 9-6: Outcome Measure 2 – North Level West - at risk after duration of benefits**

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	84	-	-	-	-
21% to 40% most deprived	1,818	-	-	-	-
60% least deprived	1,685	-	-	-	-
All deprivation bands	3,587	-	-	-	-

**Table 9-7: Outcome Measure 2 – Feldale - at risk today**

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	-	3	-	-	-
60% least deprived	-	28	-	-	-
All deprivation bands	-	31	-	-	-

**Table 9-8: Outcome Measure 2 – Feldale - 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	3	-	-	-	-
60% least deprived	28	-	-	-	-
All deprivation bands	31	-	-	-	-

**Table 9-9: Outcome Measure 2 – South Holland East - at risk today**

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	659	-	-	-
21% to 40% most deprived	-	1,624	-	-	-
60% least deprived	-	2,506	-	-	-
All deprivation bands	-	4,789	-	-	-

**Table 9-10: Outcome Measure 2 – South Holland East - at risk after duration of benefits**

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	659	-	-	-	-
21% to 40% most deprived	1,624	-	-	-	-
60% least deprived	2,506	-	-	-	-
All deprivation bands	4,789	-	-	-	-

**Table 9-11: Outcome Measure 2 – South Holland West - at risk today**

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	60	-	-	-
21% to 40% most deprived	-	2,902	-	-	-
60% least deprived	-	4,118	-	-	-
All deprivation bands	-	7,080	-	-	-

**Table 9-12: Outcome Measure 2 – South Holland West - at risk after duration of benefits**

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	60	-	-	-	-
21% to 40% most deprived	2,902	-	-	-	-
60% least deprived	4,118	-	-	-	-
All deprivation bands	7,080	-	-	-	-

Table 9-13 details the maximum eligible GiA and the raw PF score for the whole of the Lower Nene catchment and each subcompartment.

**Table 9-13: Partnership funding calculator results**

	pv maximum eligible FCERM GiA (£k)	raw PF score (%)
Lower Nene	790,439	94
North Level East	253,071	65
North Level West	152,007	51
Feldale	1,155	19
South Holland East	129,784	219
South Holland West	254,422	282

# 10. Limitations

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

- The model data used for the Lower Nene catchment economic assessment is representative of tidal flood risk only. As such there is potential under estimation of flood risk relative to other catchments which use Risk of Flooding from Multiple Sources data for the Maintain scenario. It is considered that this under estimation will be relatively marginal given the standard of protection offered by existing defences, and therefore a low probability of exceedance events occurring.
- Additionally, the model data used for the Lower Nene catchment economic assessment only comprises of three events, i.e., the 0.5% (200-year), 0.33% (300-year), and 0.1% (1,000-year) AEP events. As a result, the calculated annual average damages are of limited accuracy, and there is no representation of risk in higher probability events.
- 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 £13 billion, compared to just over £13k under the Maintain scenario. By continuing the current FRM approach, the Maintain scenario delivers estimated benefits of £13 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, 19,295 residential properties as OM2a are protected by the FRM assets maintained under this scenario. Benefits include:

- £9.4 billion of property damages avoided<sup>24</sup>, including 19,295 residential and 1,633 non-residential properties avoiding write off
- £1.2 billion of agricultural losses avoided, and 45,322 ha of land protected
- £301.9m of environmental and recreational losses avoided
- £96.1m of heritage losses avoided
- £726.6m of transport damages avoided
- £421.5m of utilities damages avoided
- £881.6m of land lost to isolation being avoided.

In addition to these economic benefits, there is an estimated £6.5 billion of financial losses to the local economy avoided in the first ten years.

To provide this level of protection, a total of 22 pumping stations, 66 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 £840 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. South Holland West demonstrates the highest level of benefit, with a strong return on investment for the FRM interventions implemented. In contrast, Feldale shows a less good return on investment, with the lowest cost benefit ratio of 3.11. This is likely due to the limited amount of benefits generated in the smallest subcompartment. In reality, the nature of this catchment is such that the benefits afforded by coastal assets should be split across all assets and therefore the overall Lower Nene catchment level BCR and PF score is considered more representative of value for money for sustaining the assets, and a better indication of eligibility for FCERM GiA funding, than the individual compartment values.

Given the high value of benefits and large numbers of residential properties protected, the catchment is eligible for £790 million of GiA funding with a PF score of 94%. Consequently, there is a funding gap of £50 million that needs to be closed when compared to the total whole life cost of sustaining the FRM assets.

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<sup>24</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

