South Forty Foot Drain, Boston and the South Forty Foot Drain Fens

Flooding 6th to 7th January 2025 – Evidence Based Review

Date: 9th May 2025

Version No. 7

Contents

Introduction

This review has been undertaken following a rainfall event on the 5th and 6th of January 2025 resulting in flooding to residential property at Boston and to agricultural land and roads within the South Forty Foot Drain Fens on the 6th and 7th January 2025. It has been undertaken by staff in the Witham Partnerships and Strategic Overview (PSO) team at the Environment Agency (EA) and is based on available and relevant information at the time.

Figures (graphs, photos, tables) considered pertinent to the text have been included within the main report. Figures considered useful but which provide additional evidence to support understanding have been included in Appendix 1.

For feedback or any further information, please contact PSOLincs@environment-agency.gov.uk.

Purpose and what will happen next

The purpose of this investigation is:

- To understand how the flooding happened. It has been initiated by the Environment Agency because we believe flooding from a designated main river occurred resulting in properties being flooded internally.
- To provide the direction for any further work the Environment Agency will undertake following flooding (see Next Steps section).
- To share with Lincolnshire County Council to support any Section 19 investigation undertaken and with communities who were impacted by flooding. It is a public document and will be shared on request.

Section 1: The South Forty Foot Drain Catchment and Boston

The South Forty Foot Drain is an artificial channel, originally cut through the fenland in the 17th Century, and modified in the 18th, 19th and 20th centuries. Running north from the Black Hole Drove IDB Pumping Station, the river passes along an embanked channel to Boston, being joined by several 'high level carriers' taking water across the Fen from the higher ground to the west.

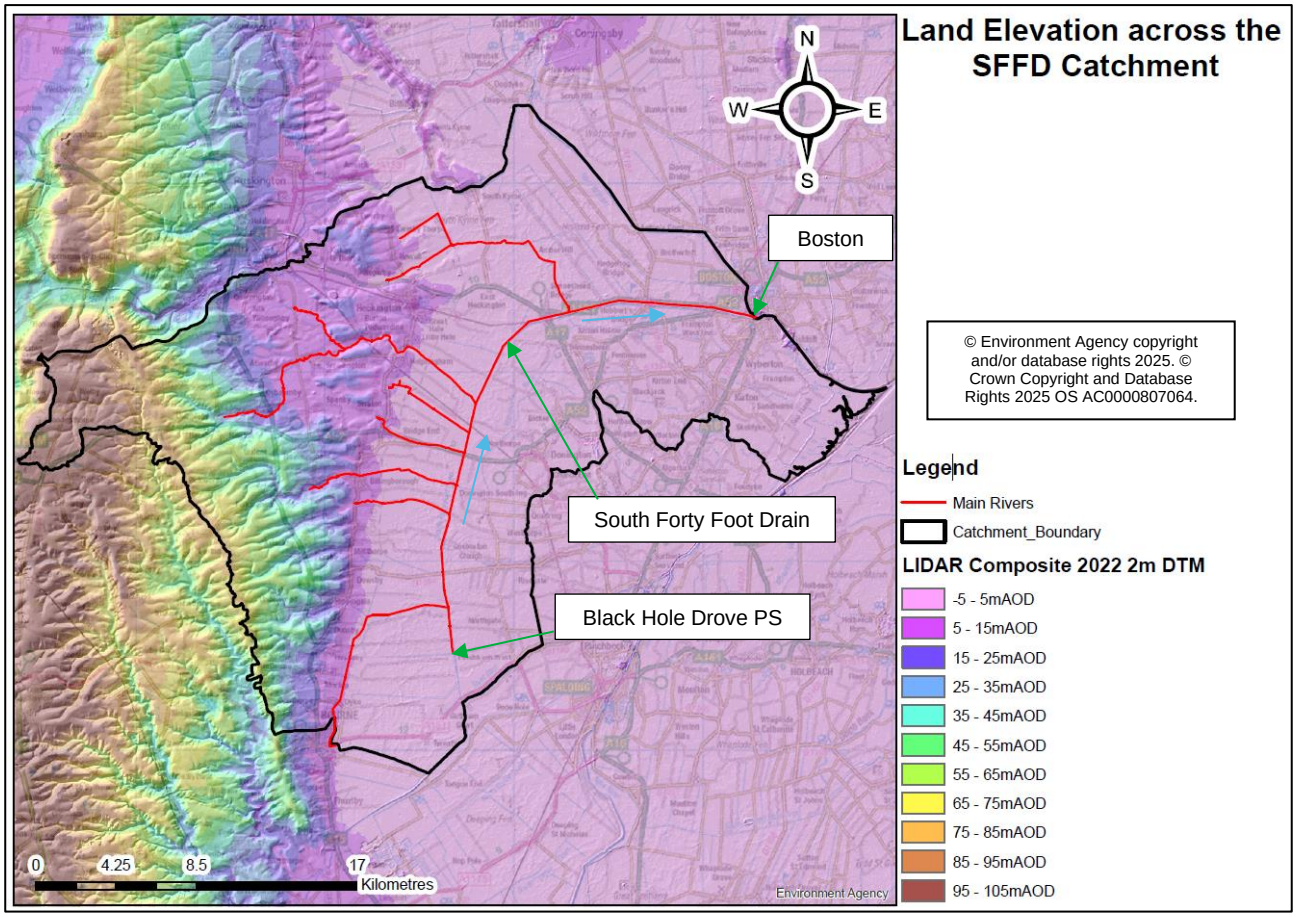


Figure 1: Topography of the South Forty Foot Drain Catchment and key locations

All main rivers (shown in red in the above diagram), are lined with raised embankments. These contain river water flowing from the high ground, allowing most flows to pass across the lowland areas and out to sea at Boston. River flows and levels can exceed the capacity and height of the embanked channels, which generally contain river levels up to a 1 in 10 (or 10%) probability of occurring in any one year in rural areas.

Boston is a market town and inland port, located in the Boston Borough in the county of Lincolnshire with an approximate central grid reference of TF329437. It lies to the southeast of Lincoln and is the point at which several Fenland main rivers outfall to the sea via the Witham Haven, including the River Witham, the Maud Foster Drain and the South Forty Foot Drain.

Boston and the South Forty Foot Drain Fens are extremely low lying, located from sea level up to 5m above sea level (as can be seen by the pink coloured areas shown in Figure 1 above.

The following schematic shows some of the key features of the catchment.

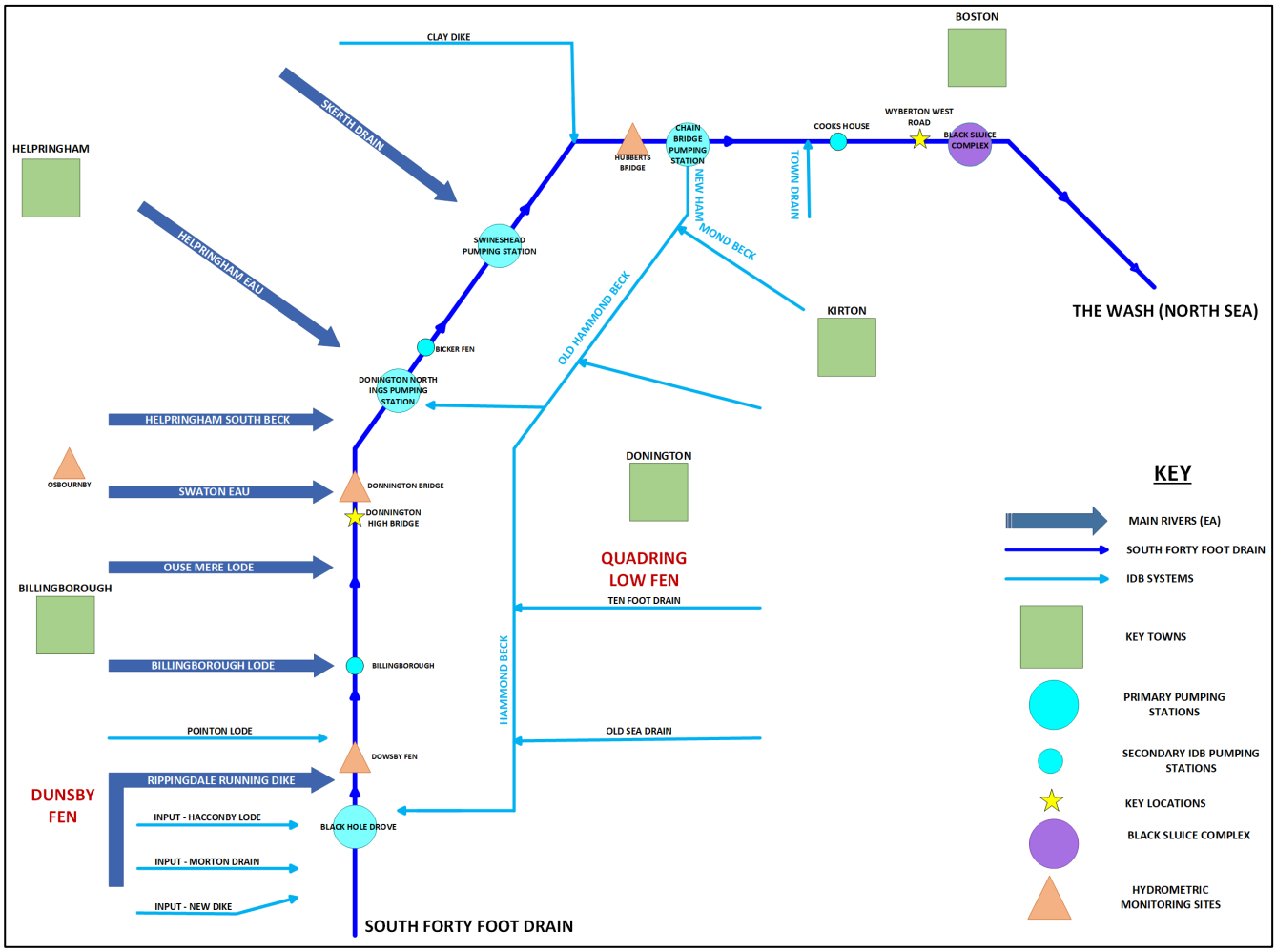


Figure 2 – South Forty Foot Drain Schematic (also see larger version in Appendix 2)

As the South Forty Foot Drain meets the Witham Haven at the Black Sluice Complex, water is normally discharged to sea via one of two gravity sluices (the second sluice doubles as a navigation lock). During periods of high flow, both gravity sluices are fully opened as high tides recede. The South Forty Foot Drain remains 'tide locked' with gravity discharges stopped during periods of high 'spring' tides (usually c.3 hours, 2 times a day), during high 'neap' tides discharge is reduced but not stopped at high tide. Each time this happens river levels will build upstream of the Black Sluice Complex, until the sluices can fully open again. The sluices comprise a combination of controlled guillotine gates and tidal mitre doors which open when the river is higher than the tidal level, and close when the reverse is true. The following figure 3 shows a plan of the sluice gates.

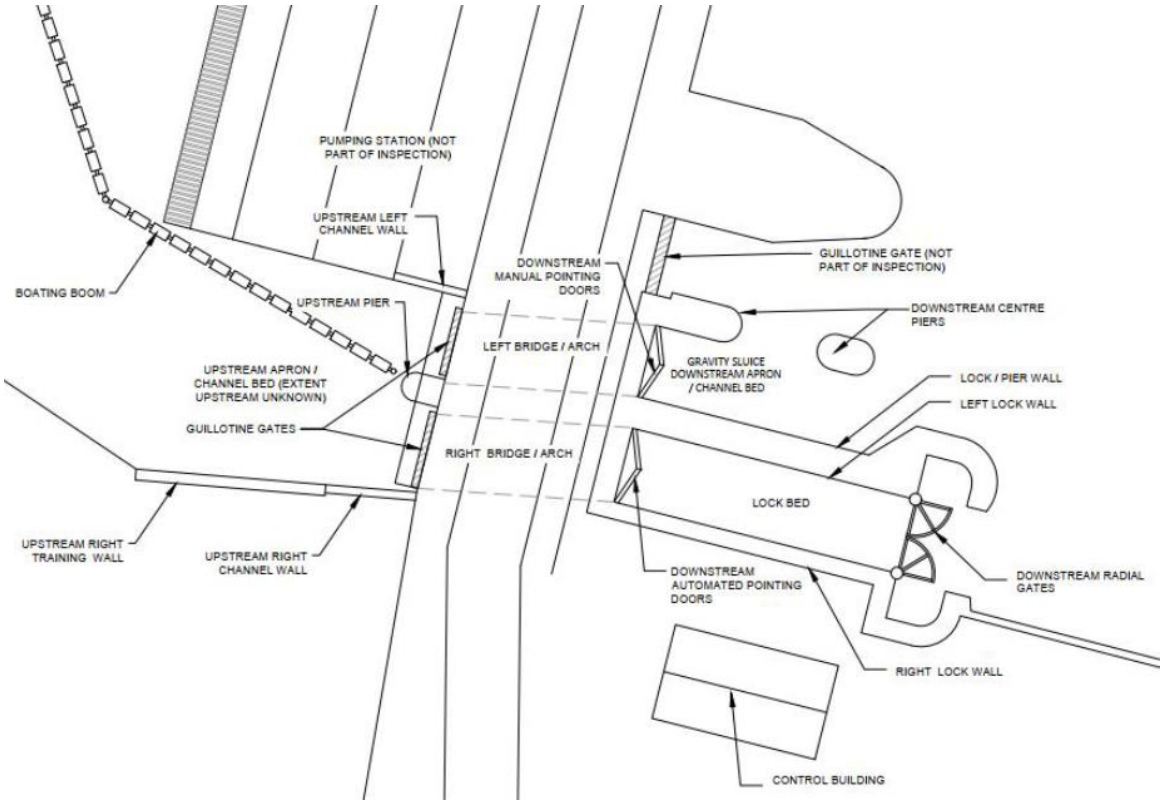


Figure 3 - Plan of Black Sluice site including both sluice (guillotine) gates

Section 2: Summary of prevailing weather and catchment conditions

United Kingdom

The period from late December 2024 to early January 2025 brought some very wet and windy weather, with significant cold spells and snowfalls across upland areas in the north. Several long-running rainfall gauging stations in eastern England recorded their wettest January day on record on the 5th January. The very wet weather was accompanied by some strong winds and near freezing temperatures and rain fell on extremely saturated and frozen ground. The heavy rain between the 4th to 6th January led to significant flooding problems. Worst hit areas included parts of Leicestershire and Lincolnshire with major incidents being declared by the Lincolnshire Resilience Forum. Map (Source: Met Office. Crown copyright, 2025).

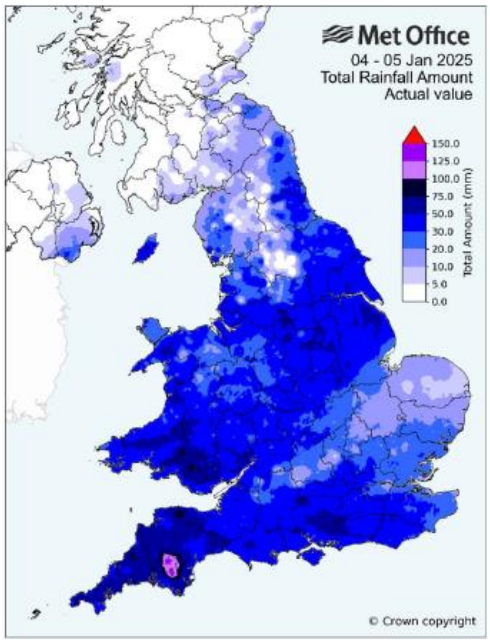


Figure 4: National rainfall 4th to 5th January 2025

Rainfall in Lincolnshire

The heavy rain and snowfall on the 5th and 6th January led to significant flooding problems in Lincolnshire. In Edenham, near Bourne, 50 children were taken to safety after their school was cut off by floodwater. 30 to 50mm of rain fell very widely across the country but it was especially wet across parts of Lincolnshire with over 50mm in some locations and the whole-month's average rainfall falling in just two days. On the 5th January, several weather stations recorded their wettest January day on record including Cranwell, (30.8mm, 111 years of recorded data) and Coningsby (33.2mm, 60 years of recorded data).

Catchment conditions

The ground conditions across the catchment were already saturated. The soil had the capacity to absorb less than 5mm of rainfall (known as the soil moisture deficit). The actual amount of water the soil can absorb is also dependant on other factors such as soil type, evaporation rates and rainfall intensity. Temperatures overnight on the 5th and 6th January were around 0°C and snow had fallen on the higher ground, meaning the surface of the ground was frozen and, in some places covered with a layer of snow. Vegetation cover in January is significantly reduced, with no leaves on trees. These factors resulted in rainfall running overland and straight into watercourses rather than infiltrating into the ground and reaching watercourses at a slower rate. This caused rapidly rising river levels and flooding.

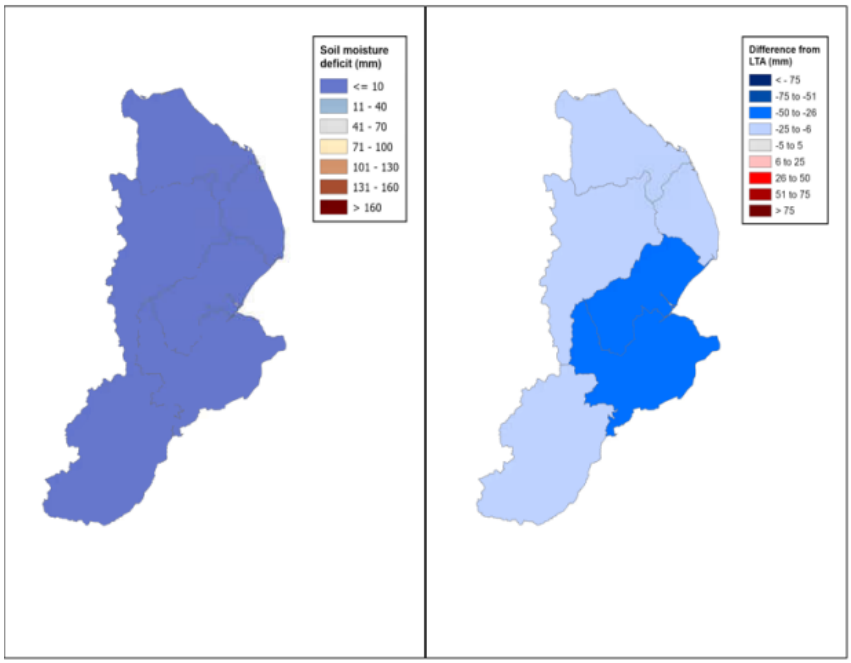


Figure 5: Lincolnshire Soil Moisture Deficit during December 2024 compared to the long-term average

Section 3: What happened and impacts

Rainfall in the South Forty Foot Drain Catchment

The very high rainfall (over 50mm in places) fell onto snow and frozen ground during Sunday the 5th and Monday 6th January 2025, leading to very high levels of run off with little or no infiltration. The highest rainfall totals were recorded on the west of the South Forty Foot Drain Catchment, on higher ground. 43.6mm of rain was recorded at the Osbournby Rain Gauge between the 4th and 6th January 2025. Of this 32mm fell in 9.5 hours between 22:15 hrs on the 5th January 2025 and 09:45hrs on the 6th January 2025.

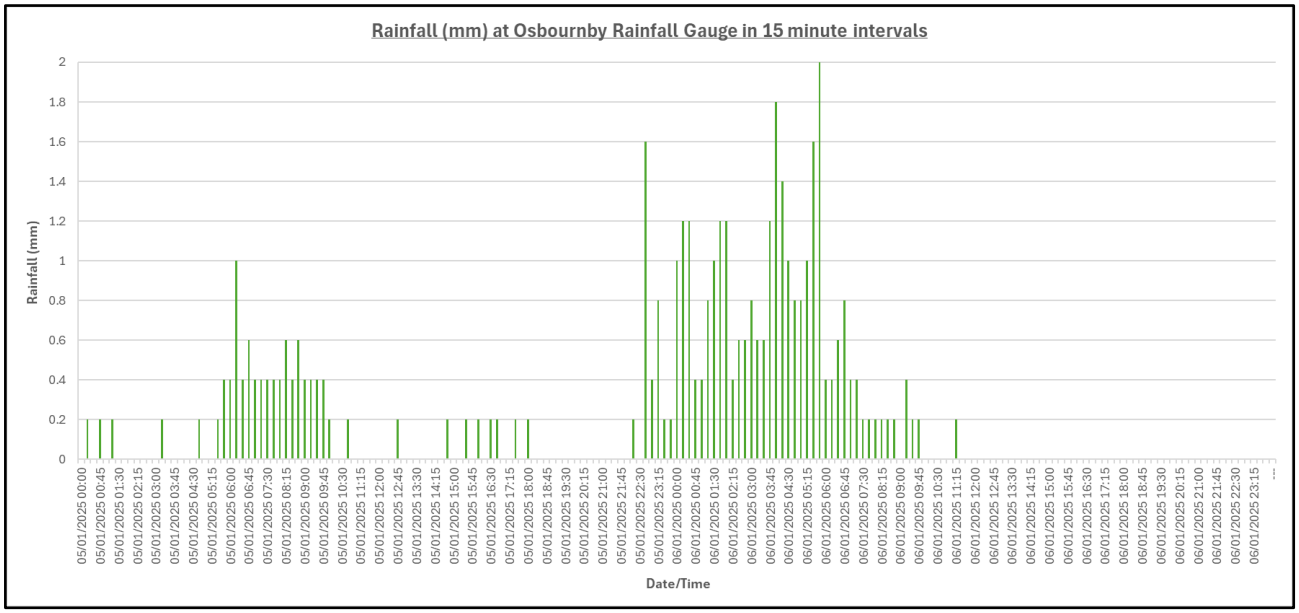


Figure 6 – Rainfall 5th to 6th January 2025 at Osbournby Rain Gauge in the South Forty Foot Catchment

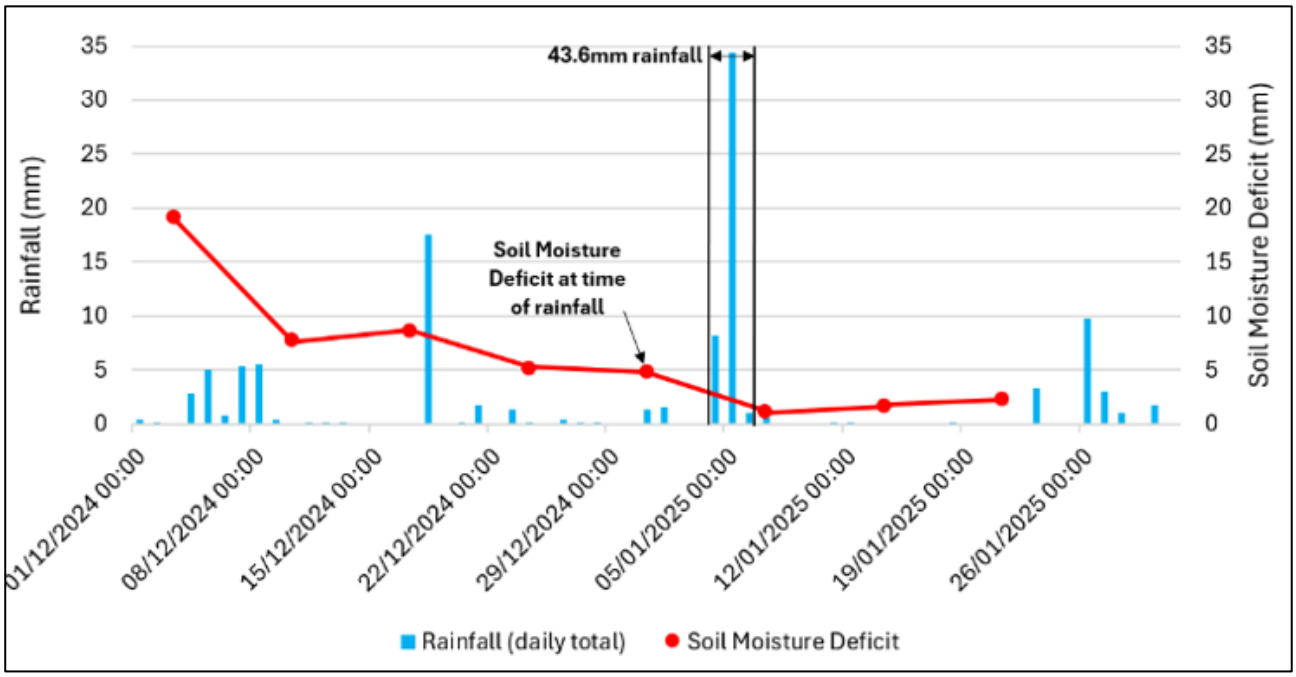


Figure 7 – Rainfall daily totals and soil moisture deficit in the South Forty Foot catchment December 2024 to January 2025

South Forty Foot Drain and flooding

Preceding the rainfall and snow on the 5th and 6th January, the South Forty Foot Drain had been at a relatively normal level. Low level alarms were received by the Flood Incident Duty Officer warning that levels were dropping below required winter retention levels on the 1st January. Action was taken to adjust the discharge at Boston to ensure levels were retained at the correct level. The South Forty Foot Drain only began to respond to the rainfall and rise from normal retention levels at the Black Sluice outfall in Boston on the evening of the 5th January 2025.

As the high flows moved through the catchment during the 6th January 2025, the South Forty Foot Drain's Fenland drainage system also filled to record levels. In the fenland arable area of the catchment, water levels had reached 'bank full', with overtopping occurring in some locations. Overtopping was observed at 11:57 on the 6th at Dunsby Fen (left bank – level estimated 2.9 to 3mAOD) and Quadring Low Fen (right bank – level estimated 2.9 to 3mAOD). These two locations also overtopped during the floods in winter 2023/24 and had suffered damage from the erosion. Temporary protection was placed on these low spots in 2023/24 to prevent further erosion damage and this was still in place during the January 2025 floods. Flooding problems were also reported at West Pinchbeck Water Treatment works, where site surface water drainage became river locked and/or back flow from the river through the drainage system started to flood the site.

Late on the 6th January 2025, at around 23:30, properties on Wyberton West Road and Park Road in Boston began to flood internally. At around the same time water was observed to be overtopping Chain Bridge Road at the discharge point for Towns Drain into the South Forty Foot Drain, where the road is set lower than the main river embankments. Black Sluice Internal Drainage Board recorded a river level at Chain Bridge Pumping Station, located near to Wyberton West Road of 2.94mAOD at 23:30 peaking at 3.02mAOD at midnight. Levels at the Environment Agency Hubberts Bridge Gauging Station, slightly further upstream, peaked at 3.192mAOD at 00:15hrs on the 7th January 2025.

Due to the flooding in Boston happening at night, it has not been possible to obtain any photographs or other similar evidence of the flood extent. We have therefore been unable to produce a mapped flood outline. It can be estimated from accounts of residents, that water roughly filled the lowest land (blue areas) as shown by the LiDAR image in Figure 11, bottom left corner. The flooding is likely to have then moved in a southwestern direction and into the local drainage system.

Astronomical high tide on the evening of the 6th January 2025, occurred at 22:27. As properties in Boston started to flood at 23:30, the South Forty Foot Drain had been tide locked for around an hour.

The next astronomical low tide on the 7th January 2025 occurred at 06:07. South Forty Foot Drain Levels at Chain Bridge Pumping Station had fallen to 1.71mAOD and continued to fall to 1.56mAOD at 08:20 when the tide had begun to rise again causing levels to start building in the river. Fortunately, enough water had been discharged during this low tide period to avoid levels reaching the high of the preceding day after the system became tide locked at the next high tide (at 11:21). Maximum levels this time reached 2.72mAOD at around 12:15 on the Chain Bridge Pump Station gauge. Property flooding did not reoccur at this level, although water was observed to be rising again in the gardens of Wyberton West Road.

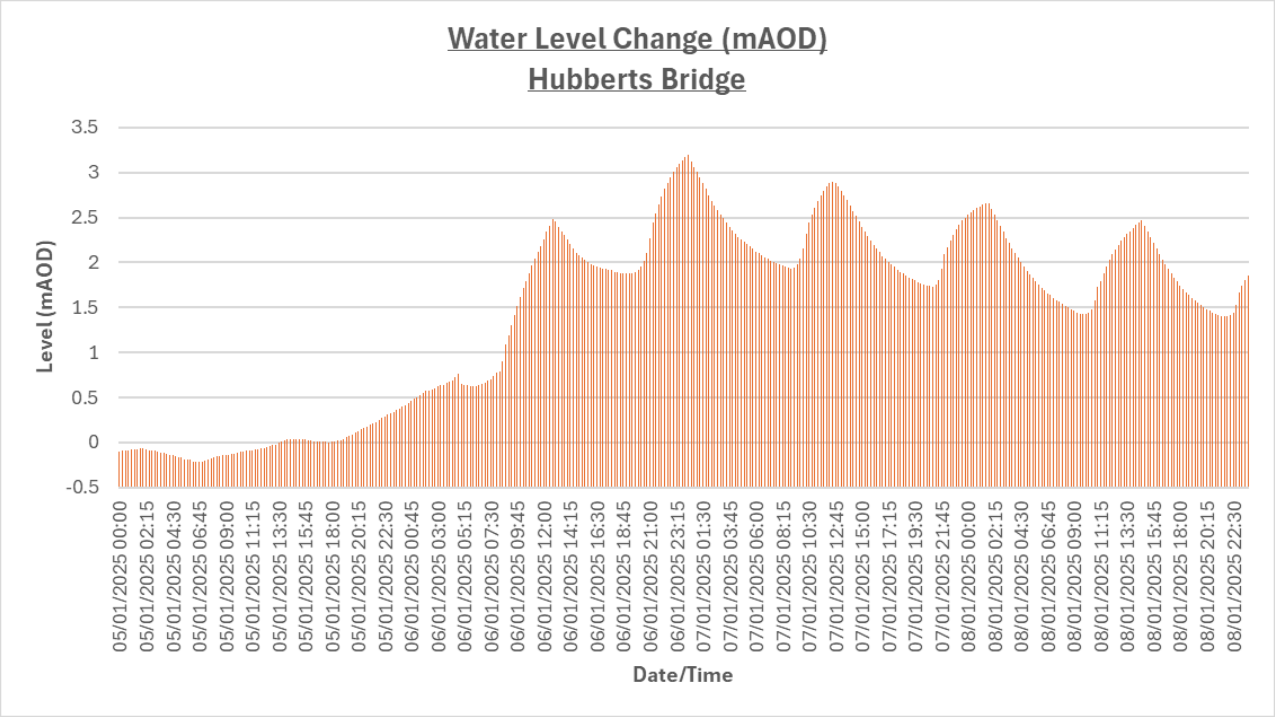


Figure 8 – Peak River Levels at Hubberts Bridge Gauging Station 05/01/2025 – 08/01/2025

River level gauges across the catchment showed record levels were matched or exceeded. When compared with the Environment Agency modelling the probability of some of these river levels would be more than a 1 in 1000 chance of flooding in any one year plus an allowance for climate change (our most extreme model scenario).

River Level Gauge	Peak river level recorded January 2025 (mAOD)
Hubberts Bridge	3.192
Donnington Bridge	3.103
Dowsby Fen	3.219

Figure 9: Peak South Forty Foot Drain levels January 2025

		South Forty Foot Drain modelled river levels at various probabilities from 1 in 2 to 1 in 1000+climate change allowances									
River Level Gauge	**Node Reference**	**1_in_2**	**1_in_5**	**1_in_10**	**1_in_20**	**1_in_50**	**1_in_100**	**1_in_100CC**	**1_in_200**	**1_in_1000**	**1_in_1000CC**
Hubberts Bridge	SF105750	2.151	2.517	2.624	2.647	2.689	2.744	2.768	2.767	2.792	2.799
Donnington Bridge	SF120000	2.183	2.632	2.778	2.907	3.04	3.08	3.099	3.099	3.126	3.133
Dowsby Fen	SF126447 d	2.198	2.699	2.827	2.95	3.077	3.128	3.153	3.153	3.191	3.203

Figure 10: Modelled South Forty Foot Drain levels

Flooding Impacts

Lincolnshire County Council had a total of 36 homes reported as flooded in Boston. Wyberton West Road and Park Road were both flooded for around 4-5 hours, and several homes had water on driveways and in gardens narrowly avoiding internal flooding. A large extent of agricultural land was also flooded within the South Forty Foot Drain Fenland.

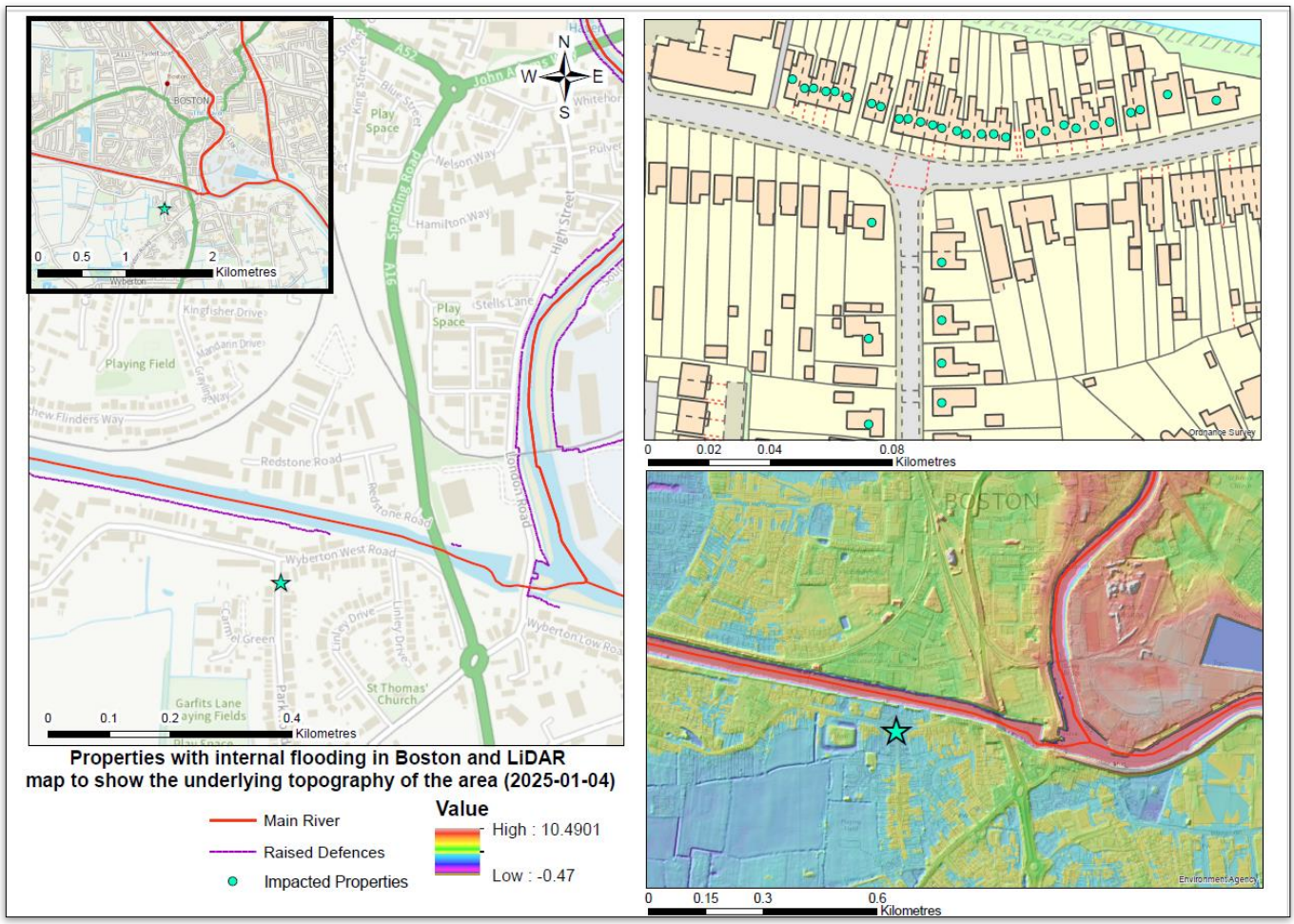


Figure 11 – Flooded properties

Several residents were spoken with in the days immediately after the flooding, by Environment Agency staff visiting the area to collect evidence and eyewitness accounts. Key information from these conversations is summarised below:

- Floodwater was observed entering one home adjacent to the South Forty Foot Drain, at the end of the road near to the flood wall at about 23:30 on 6 January. By around 04:00 on 7 January, the resident said the water was mostly gone leaving wet floors / carpets. It had reached levels internally of around 0.3m. The flood or 'wrack' marks outside in the back garden indicated deeper water of around 0.5m (7+ brick courses deep).

- It appears most houses impacted by internal flooding were on the north side of Wyberton West Road adjacent to the South Forty Foot Drain with those opposite having water reaching their houses but no water ingress.
- Properties in Park Road which joins Wyberton West Road at a slightly lower point, also suffered internal flooding presumably as water flowed through the lowest land.
- Some houses were impacted more significantly than others, according to one resident who said whilst they had water in their house, they felt they got off lightly compared to others.
- One elderly couple advised they had lived in the same house for 57 years and this is the first time they have flooded. They were in the process of cleaning up and moving out.
- Residents believed water from the South Forty Foot Drain had overtopped the areas of 'low walls' at the back of properties.

Flood Warnings

There isn't currently a fluvial (river) Flood Warning to let people know when flooding from the South Forty Foot Drain could affect properties here because there are no triggers in this specific area. Therefore, the properties flooded on the 6th/7th January in Boston, received no flood warnings. Following this incident, the Environment Agency's flood resilience team will assess whether it's possible to adjust the Flood Warning Service.

These properties are covered by a tidal Flood Warning, but this couldn't be used for this very localised flooding from the river as it covers a very large area and would give a false warning to thousands of people. The Environment Agency did issue the early-stage Flood Alert for this area, which warns people of flooding on low-lying land and roads. However, Flood Alerts are generally not issued to homeowners and would only be noticed if a resident were to check online.

Section 4: Potential Causes of Flooding Review

Review Scope

We have reviewed the following potential contributory factors to the flooding on 6th and 7th January 2025:

- Rainfall, preceding catchment conditions and river response
- Embankment seepage in Boston
- Flood walls in Boston
- Overtopping of main river defences in Boston and the South Forty Foot Drain Fens
- Operation of Environment Agency flood risk assets
- Operation of BSIDB assets and high level cut off arrangements
- Black Sluice Pumping Station decommissioning

Rainfall 5th to 6th January 2025, preceding catchment conditions and river response

January 2025 started with an Arctic maritime airmass bringing cold temperatures and wintry showers. From the 4th to the 6th January a low-pressure system brought extensive rain, sleet and snow to the county. The South Forty Foot Drain catchment recorded 43.6mm of precipitation at the Osbournby Rain Gauge from the 4th to the 6th January 2025. Most of this fell on the 5th January 2025. Although this rainfall total was high, in the context of previous high rainfall events it wasn't the biggest recorded. However, most other high rainfall events recorded in this catchment occurred at milder times of year (except for Storm Henk in January 2024), without the additional factor of frozen ground. Vegetation cover is also at its lowest during this part of the winter, leading to less rainfall being intercepted by trees and other plants.

Rainfall Event	Total rainfall
18th to 21st October 2023 (Storm Babet)	66.8mm
19th to the 21st July 2007	61.2mm
4th to 6th July 2012	54.8mm
8th to 11th February 2024	46.2mm
13th to 16th January 2021	44.8mm
4th to 6th January 2025	**43.6mm**
1st to 2nd January 2024 (Storm Henk)	37.4mm
21st to 24th December 2020	35.6mm
26th to 29th January 2021	30.2mm
25th to 26th October 2019	28.6mm

Figure 12 – Comparison of previous rainfall events in the South Forty Foot Catchment (at the Osbournby Rain Gauge)

The combined effect of the high rainfall falling directly onto saturated, frozen ground without interception by trees and other vegetation, produced the highest river levels ever recorded on several river level gauges in this catchment. Other examples of high rainfall at this time of year, such as Storm Henk, produce a similar amplified effect in river levels.

Dowsby Fen River Level Gauge			Donnington Bridge River Level Gauge			Hubberts Bridge River Level Gauge		
Date	Peak River Level (mAOD)	Total Event Rainfall at Osbournby Rainfall Gauge(mm)	Date	Peak River Level (mAOD)	Total Event Rainfall at Osbournby Rainfall Gauge(mm)	Date	Peak River Level (mAOD)	Total Event Rainfall at Osbournby Rainfall Gauge(mm)
07/01/2025	**3.219**	**43.6**	**07/01/2025**	**3.103**	**43.6**	**07/01/2025**	**3.192**	**43.6**
03/01/2024	3.195	37.4	03/01/2024	3.08	37.4	**06/01/2025**	**3.136**	**43.6**
02/01/2024	3.175	37.4	02/01/2024	3.058	37.4	11/02/2024	2.94	46.2
06/01/2025	**3.145**	**43.6**	**06/01/2025**	**3.033**	**43.6**	03/01/2024	2.839	37.4
27/10/2019	2.981	28.6	11/02/2024	2.852	46.2	04/01/2024	2.823	37.4
24/12/2020	2.969	35.6	04/01/2024	2.816	37.4	21/10/2023	2.804	66.8
04/01/2024	2.938	37.4	12/02/2024	2.727	46.2	02/01/2024	2.787	37.4
29/01/2021	2.929	30.2	21/10/2023	2.695	66.8	**08/01/2025**	**2.66**	**43.6**
26/10/2019	2.927	28.6	15/01/2021	2.623	44.8	23/02/2024	2.658	22.4
11/02/2024	2.911	46.2	23/02/2024	2.569	22.4	09/02/2024	2.578	28.2

Figure 13 – South Forty Foot Drain level comparison of recent high river level and rainfall events

We can compare the above data with a river level gauge in a nearby catchment, the Upper Witham, which demonstrates rainfall totals are not the only factor contributing to river levels. This catchment had similar catchment conditions and rainfall in January 2025. The rainfall was not the highest ever recorded, but river levels were, underlining the importance of considering catchment conditions to understand how the flooding happened.

North Witham River Level Gauge		
Date	River Level (mAOD)	Total Event Rainfall South Witham Rainfall Gauge(mm)
06/01/2025	**95.79**	**48**
19/07/2021	95.765	70.2
01/01/2024	95.679	35.8
21/11/2016	95.602	47.8
03/04/2000	95.307	48
14/06/2019	95.066	107.8
24/12/2020	94.712	40.8
16/01/2021	94.708	41
21/07/2007	94.685	51
23/07/2013	94.493	42.2
24/08/2015	94.467	38.6
10/08/2004	94.304	86.2
21/10/2023	94.213	62.5
06/06/2008	94.114	43.4
16/10/2002	94.02	48

Figure 14 – Upper Witham level comparison of recent high river level and rainfall events

South Forty Foot Drain Response

The South Forty Foot Drain response to the rainfall of the 5th and 6th January 2025 resulted in flooding not previously evidenced and the highest river levels recorded at several river level gauges in the catchment (Figures 13 and 15).

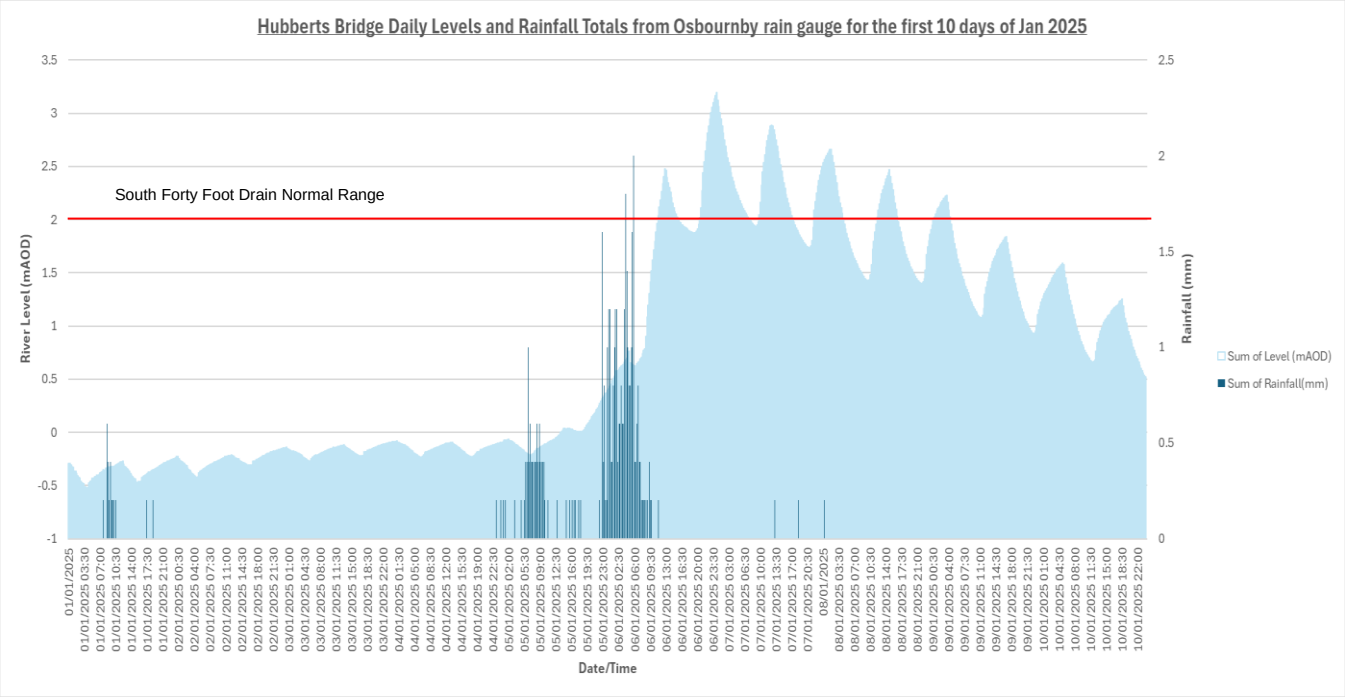


Figure 15 - South Forty Foot Drain levels and rainfall totals January 1st - 10th 2025

To understand the magnitude of the flood event, analysis of the Black Sluice Catchment Model, 2016 has been undertaken to estimate two things:

- The Annual Exceedance Probability (AEP) of flooding (the chance of the flood event occurring in any one year).
- The timing of the river reaching channel capacity and when and where overtopping occurred compared to levels of the right bank walls in Boston.

Figure 16 below shows information regarding the modelled scenarios used from South Forty Foot Model, 2016, and the comparative timing of actual river levels from January 2025.

River level date/ time from event	Actual river levels (mAOD)	Modelled river levels (mAOD)	Modelled Scenario	Annual chance of river level occurring
06/01/2025 21:30	2.544	2.624	L10	10% chance in any one year
06/01/2025 21:45	2.645	2.647	L20	5% chance in any one year
06/01/2025 22:00	2.734	2.728	L75	1.3% chance in any one year
06/01/2025 22:15	2.815	2.792	Exceeds L1000_CC20	0.1% chance in any one year with climate change allowance
06/01/2025 22:30	2.882	2.764	Exceeds L1000_CC20	0.1% chance in any one year with climate change allowance
07/01/2025 00:15	**3.192**	**Record Peak**		

Figure 16 – Comparison of actual and modelled river levels during the January 2025 flood incident at Hubbert's Bridge river level gauge

Figure 17 below shows the modelled and actual river levels from 01/01/2025 to 10/01/2025. Flood wall levels at Boston to the rear of Wyberton West Road are also included.

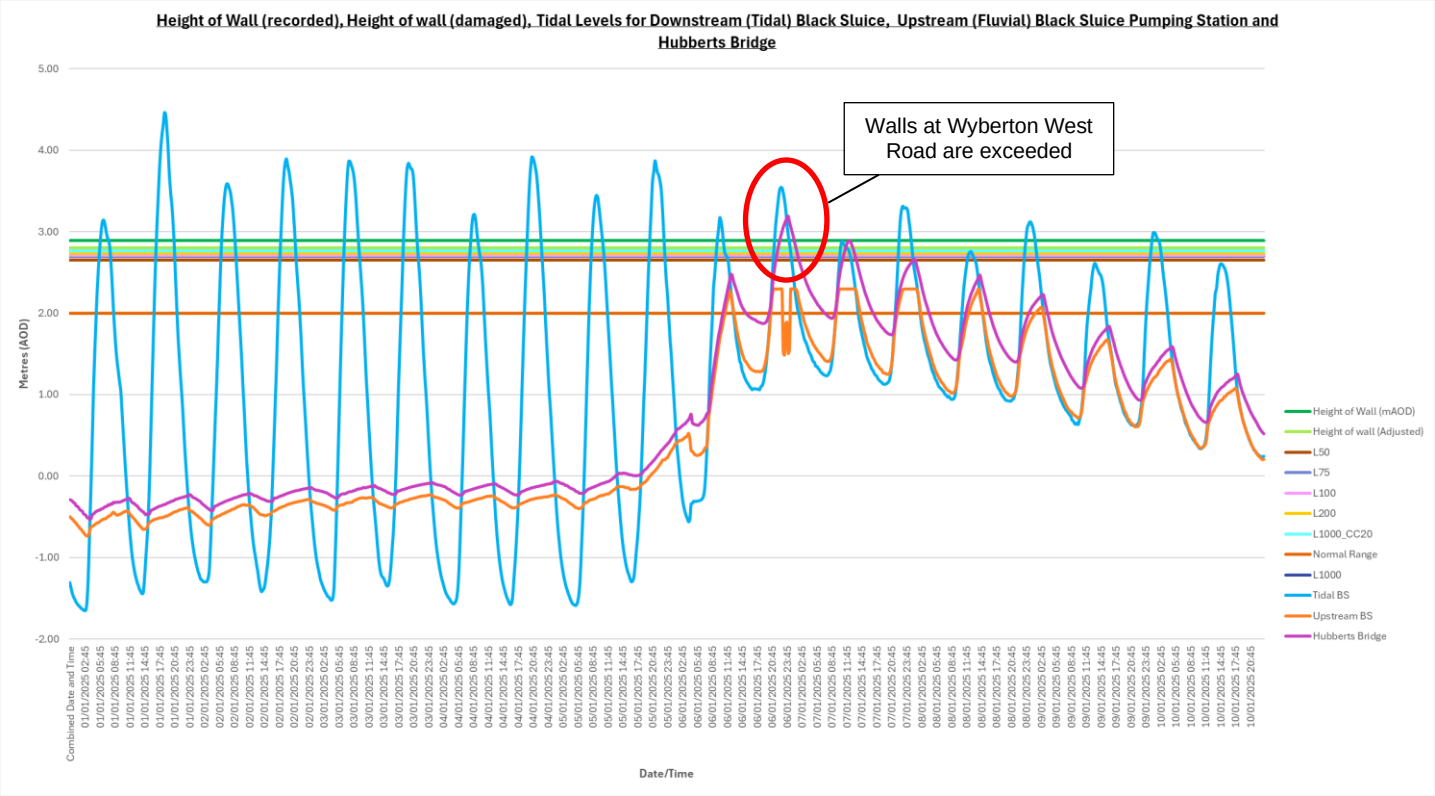


Figure 17 – South Forty Foot Drain actual river levels against recorded and indicative wall height bank levels

The Black Sluice Catchment model 2016 shows that river levels at Hubbert's Bridge Gauging Station on the 6th January 2025 peaked at 0.428m above the modelled level of 1:1000 (0.1%) chance of occurring in any one year plus a climate change allowance. This river response is not typical, and the fact flooding has not previously been recorded in this location in Boston from the river, shows the scale and magnitude the rainfall event and catchment conditions had on the South Forty Foot Drain catchment.

Embankment seepage in Boston

Seepage through the right bank of the South Forty Foot Drain has been observed and reported to the Environment Agency since 2021. Residents of Wyberton West Road previously experienced a build-up of water in their gardens when river levels became high. During the flooding on the 6th/7th January 2025, where river levels exceeded local records significantly, it is assumed that this seepage became worse and contributed to the water build up in the flood plain.

In response to the earlier reports of seepage, a project had already been put onto the Environment Agency's capital maintenance programme and funding allocated to begin to address these issues this year. Initially geophysical and drone surveys are due to be carried out to assess the extent of the problem. Funding is currently allocated to undertake a permanent repair in financial year 2025/26.

Flood walls in Boston

Two flood walls are located on top of the river embankments to the rear of Wyberton West Road. It is likely that these were constructed in the 1960s, by the Lincolnshire River Board when a large amount of investment went into the flood defences and drainage systems in the South Forty Foot Drain Catchment.

Figure 18: West (left) and east (right) flood walls, to the rear of Wyberton West Road

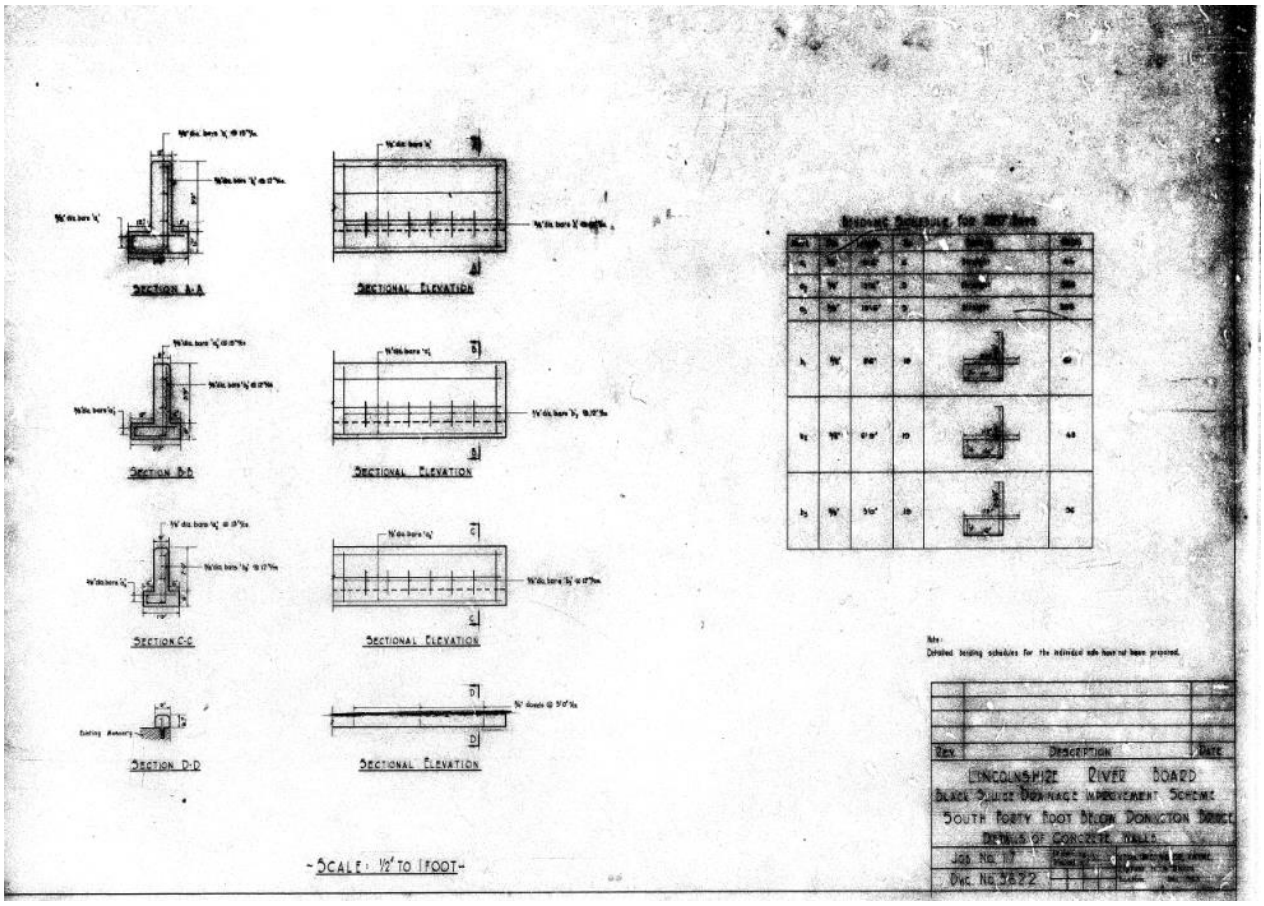


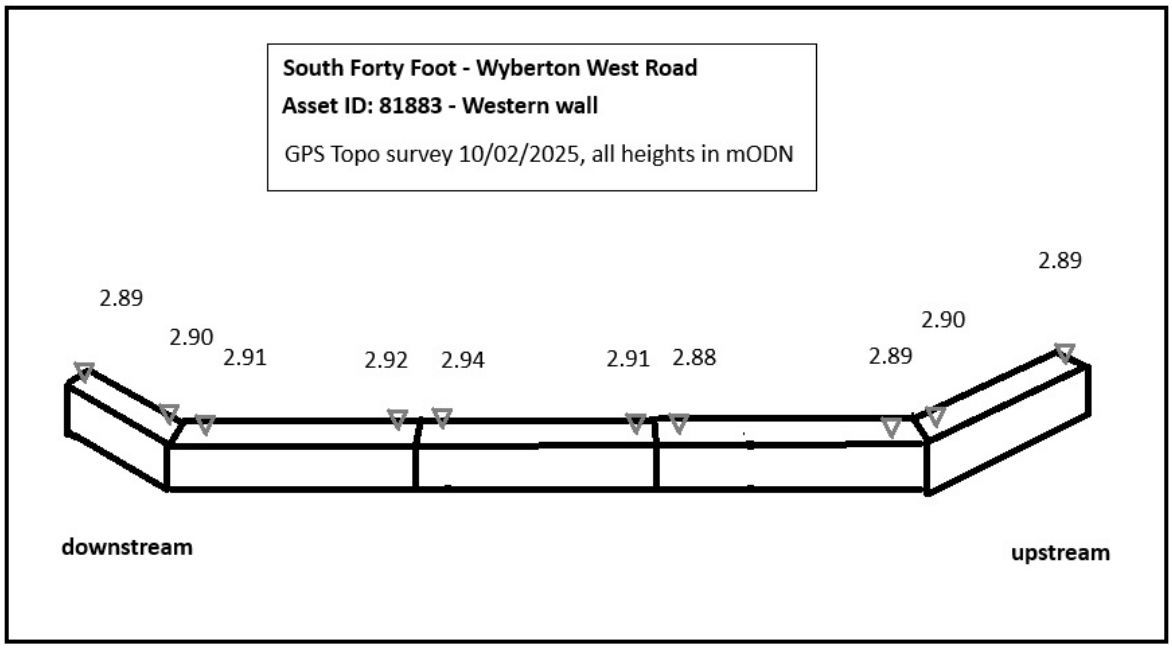
Figure 19: Historic design drawings for walls installed on the South Forty Foot Drain in the 1960s

If the design of these two walls matches the archived drawings above, it does not include any form of embankment stabilisation or flow path cut off. There is a possibility that the point at which the concrete walls meet the softer embankment below, water flows could be concentrated, when river levels are high. This could lead to erosion of embankment material, creating seepage paths.

Routine inspections, in June 2024, by the Environment Agency had reported settlement and joint failures in these walls, although works to address this issue had not yet been programmed at the time the flooding on the 6th January 2025. High water levels, against these walls, would lead to water flowing through any failed joints and there is a higher chance of overtopping taking place due to the settlement of sections of wall. Since the flooding a work order was placed for the Environment Agency's field team to reseal these joints in advance of any future works to the embankment.

Figure 20: Wall settlement and joint failure in concrete walls.

Post flooding site visits included surveys (figure 21 below) to measure the current height of the walls, to allow this to be compared with the known peak water level in the South Forty Foot Drain on the 6th January 2025.



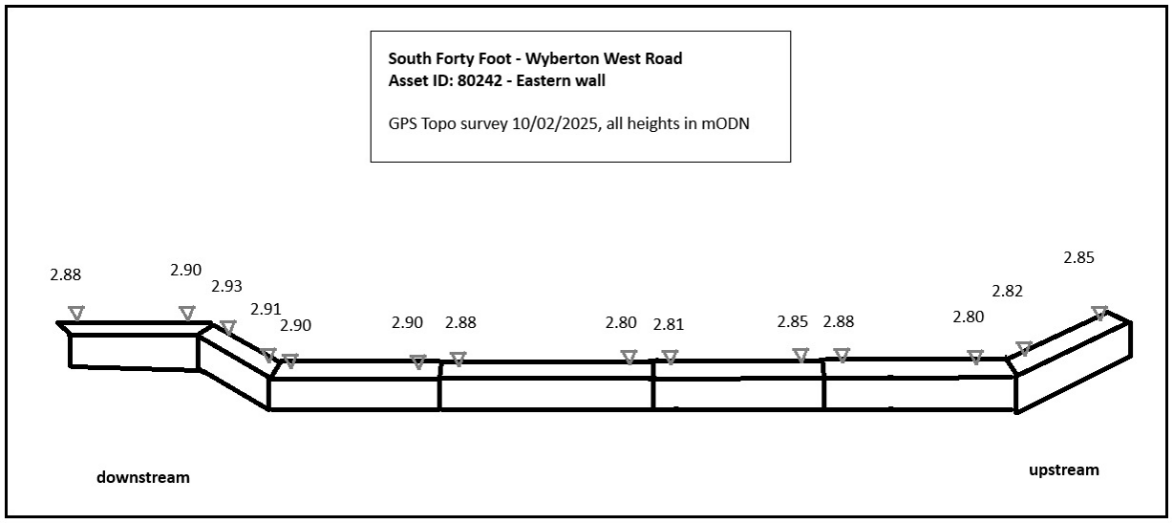


Figure 21 – Post incident flood wall surveys at Wyberton West Road

Overtopping of main river defences in Boston and the South Forty Foot Drain Fens

There is clear evidence of overtopping of the main river defences in several locations. At Dunsby and Quadring photographs on the 6th January 2025 show the overtopping of the South Forty Foot Drain taking place. Field teams were quickly instructed by Environment Agency duty officers to attend these locations and replace temporary erosion protection measures, put in place following damage that had occurred during Storm Henk. Recovery works have been completed here in March 2025, and include permanent erosion protection to avoid future bank failures should overtopping happen again.

Eyewitness accounts, clear wrack marks (debris) and erosion damage confirm the overtopping at Chain Bridge Road, over the right bank of the South Forty Foot Drain. Further down the channel at Wyberton West Road, there were also clear wrack marks on the concrete walls located on top of the right bank, indicating overtopping here too.

Figure 22 – Evidence of overtopping on South Forty Foot Drain – L to R (and U/S to D/S) Dunsby left bank overtopping, Chain Bridge Road right bank wrack marks on bridge railings, Boston right bank, wrack marks on walls to rear of Wyberton West Road.

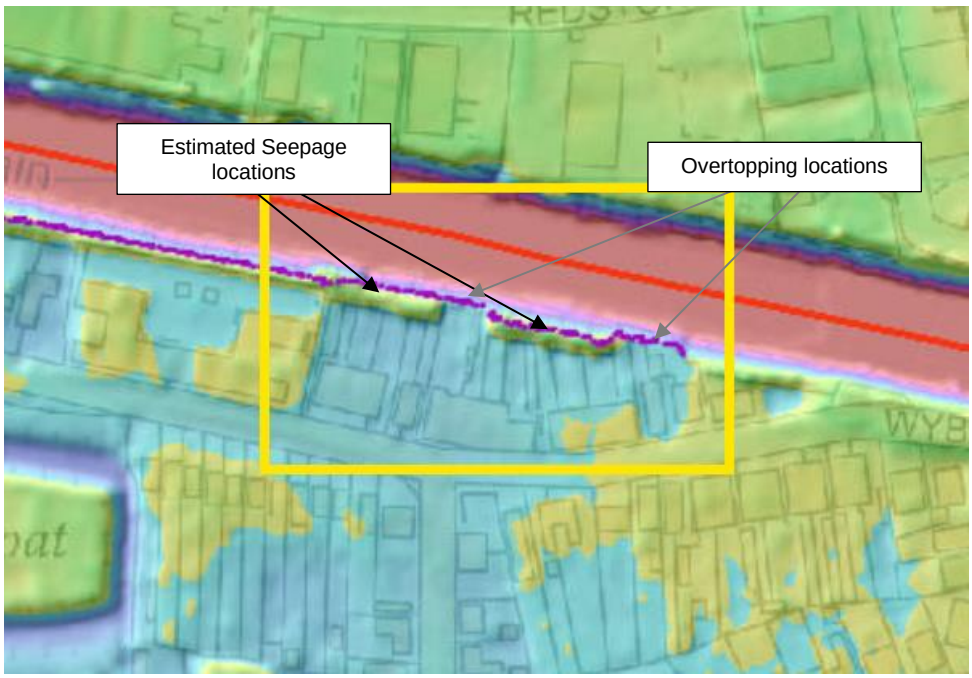


Figure 23 – Overtopping/seepage locations on the South Forty Foot Drain in Boston, plus LiDAR mapping showing the lower lying areas immediately behind the embankment (in blue).

At Boston, the two flood walls appear to be the lowest points in the defences adjacent to Wyberton West Road. The lowest points on the eastern wall were measured at approximately 2.80mAOD, and on the western wall at around 2.88mAOD, although due to the subsidence of these structures there were higher elevations up to around 2.94mAOD.

With peak levels near to this location, at Chain Bridge Pumping Station, recorded at 3.02mAOD at midnight on the 6th January 2025, it is likely that wall levels were exceeded by between 8 and 22cm.

Operation of Environment Agency flood risk assets

Flows and levels on the South Forty Foot Drain are normally controlled through Gate 1 (see red text on diagram below). This comprises of a sluice gate upstream of the road bridge, and a set of tidal ‘pointing’ doors downstream of the road bridge which open when the river is higher than the tidal level and close when the reverse is true. This sluice gate is designed to operate automatically, adjusting as required to maintain levels on the South Forty Foot Drain at a target retention level of 0mAOD in summer, and -0.6m AOD in winter at Black Sluice.

In periods of high flow, Gate 2 is used to increase gravity discharge. Gate 2 also doubles as a Navigation Lock. This comprises of a sluice gate upstream of the road bridge, a set of tidal ‘pointing’ doors downstream of the road bridge, and a pair of radial ‘sector’ gates.

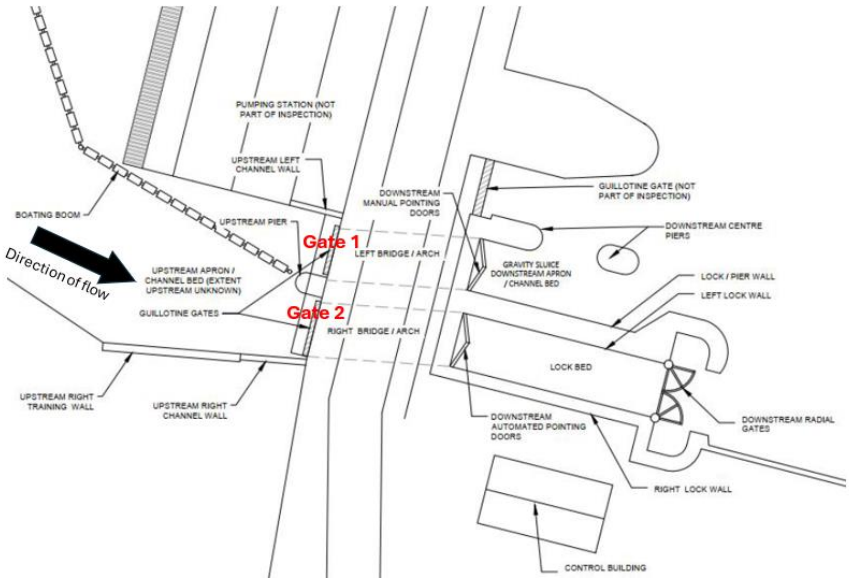


Figure 24 – gravity discharge gates 1 and 2 at Black Sluice

Works to relocate the automatic controls for Gate 2 – Navigation Sluice, to the Environment Agency Control Building, were taking place prior to December 2024. This meant that this asset would be operated manually until the works were completed. On the 16th December 2024, Gate 1 suffered a gear box issue, the gear box was refurbished and a replacement part ordered, although due to these needing to come from Europe, there was a substantial delay of more than a month. To avoid stressing the refurbished gear box, this too was put into 'manual' mode and kept closed with flows temporarily being controlled by Gate 2 still in its manual mode. All duty staff were updated on the temporary arrangements, via the Flood Incident Duty Officer handover report.

On the 1st January 2025 low level alarms were received by Environment Agency duty officers, warning that water levels were getting too low to meet our required water levels. Gate 2 was adjusted to be partially open and reduce discharge, and levels stabilised.

On the 5th January 2025 at 10:30, the Flood Forecasting Centre issued a 'green' Flood Guidance Statement to the Environment Agency, indicating a low likelihood of minor impacts from rivers and surface water during the 6th and 7th January.

During the night of the 5th and 6th January 2025, Flood Incident Duty Officers received multiple alarms across Lincolnshire as the rainfall and river response was greater than forecast. At 01:07 an alarm was received to consider the use of the second gravity discharge at Black Sluice as river levels had started to rise. This 'consider' instruction allows duty officers to check conditions, prioritise duty field staff resources and arrange for them to attend site to undertake the activity at a suitable time. At this point, duty officers discussed the alarm and agreed to act in the morning. This decision was based on the observed situation with rivers levels not high or rising quickly, and low astronomical tide due at 05:29 so river levels were expected to fall. In the following hour, further alarms were received, and water level gauges in the upper catchment indicated that river levels were rising further. At 02:14 duty officers agreed to open the second gravity discharge before dawn if possible. At 04:13, the field team fully opened Gate 2. In response river levels at Black Sluice dropped to around 0.3mAOD, which is the trigger for considering the use of a second gravity discharge. Water levels upstream however continued to rise, and the decision was made at 06:25 to fully open Gate 1 as well as Gate 2. This operation was

completed at 07:45. Gate 2 was fully open approximately 19 hours before the flooding began in Boston, and Gate 1 was fully open approximately 16 hours before the flooding. This allowed discharge from both gates for a full tidal cycle before the peak flow and levels reached Boston.

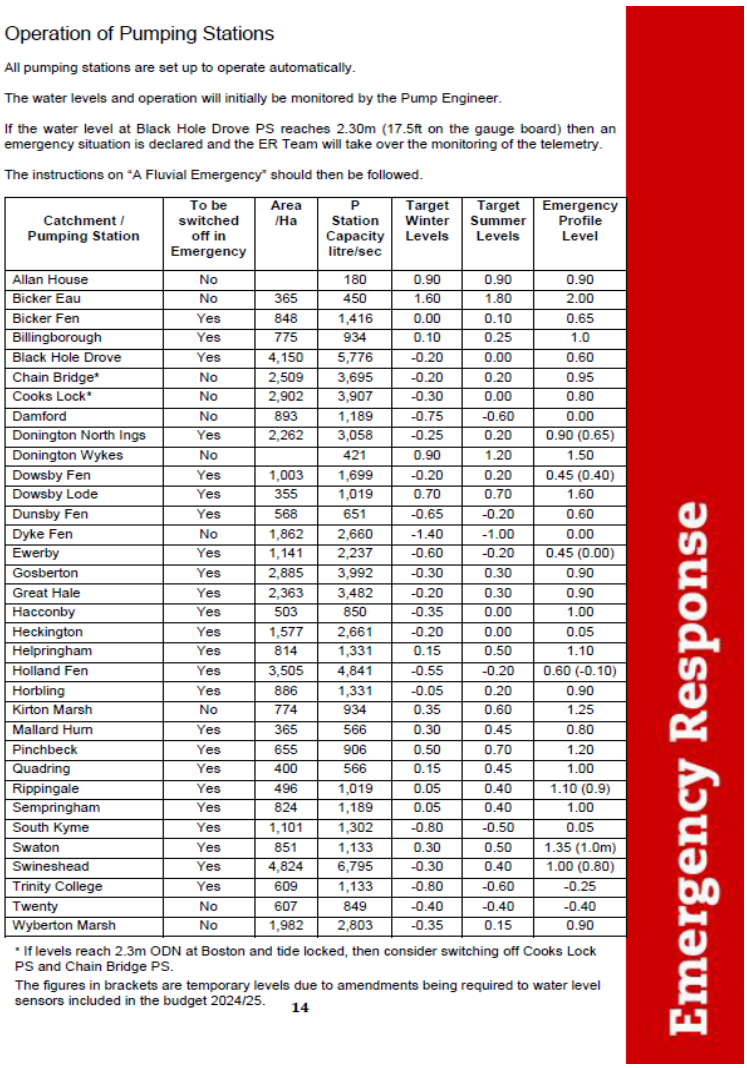
As is standard practice a simulation of the event will be undertaken, using the Black Sluice Modelling, the rainfall and catchment conditions to assess whether any further adjustments are needed in our operational procedures. Having reviewed duty officer logs and river level data, duty officers acted in accordance with Environment Agency procedures and reacted in a timely and effective way to discharge as much water as possible to the Boston Haven from the South Forty Foot Drain.

Operation of BSIDB assets and high level cut off arrangements

Black Sluice IDB have supplied up to date details of their emergency response plan and pump records for the January 2025 incident. Key principles and practices relevant to the main river are as follows:

- The plan covers major incidents in the board's district, and for the main river this is defined as "A fluvial event where the level of the South Forty Foot Drain at Black Hole Drove exceeds 2.70m (19ft)."
- The South Forty Foot Banks are seen to be at risk of breaching if water levels are allowed to rise above 2.70 metres O.D.N. Therefore, the Board has agreed the following course of action if these high-water levels occur:
  (1) When the level of the South Forty Foot Drain reaches **2.70 mODN on the telemetry system whilst the pumps are running.** In the discharge bay of Black Hole Drove Pumping Station (South Forty Foot Drain), then the pumps at the pumping stations shall start to be switched to their Emergency Profile Level as shown in the table on page 14. If the remote Telemetry Control fails, then pumps will be switched off manually. In this instance, the Environment Agency Lincoln Incident Room will need to be informed. If not open, then the FIDO or Area Based controller will need informing. **If levels reach 2.3m ODN at Boston and tide locked, then consider switching off Cooks Lock PS and Chain Bridge PS.**
  (2) The pumps shall remain at their emergency profile until the level of the water in the South Forty Foot Drain at BHD has dropped to:
    a. **2.30 mODN on the telemetry system with the pumps switched off. The pumps will remain in emergency profile until the level drops to 2.3 mODN at Black Hole Drove PS.**
  (3) If the situation continues the Board's Pumping Stations shall only pump sufficient water to hold water levels at the emergency profile level shown on page 14, until water levels begin to fall at Black Hole Drove PS in the South Forty Foot Drain.

  If the event becomes more extreme, then a decision will need to be made by the ER Team in conjunction with the Chairman of the Board on whether water levels in the Fens should be allowed to rise higher than the figures shown in the table on page 14.



Operation of Pumping Stations

All pumping stations are set up to operate automatically.

The water levels and operation will initially be monitored by the Pump Engineer.

If the water level at Black Hole Drove PS reaches 2.30m (17.5ft on the gauge board) then an emergency situation is declared and the ER Team will take over the monitoring of the telemetry.

The instructions on "A Fluvial Emergency" should then be followed.

Catchment / Pumping Station	To be switched off in Emergency	Area /Ha	P Station Capacity litre/sec	Target Winter Levels	Target Summer Levels	Emergency Profile Level
Allan House	No		180	0.90	0.90	0.90
Bicker Eau	No	365	450	1.60	1.80	2.00
Bicker Fen	Yes	848	1,416	0.00	0.10	0.65
Billingborough	Yes	775	934	0.10	0.25	1.0
Black Hole Drove	Yes	4,150	5,776	-0.20	0.00	0.60
Chain Bridge*	No	2,509	3,695	-0.20	0.20	0.95
Cooks Lock*	No	2,902	3,907	-0.30	0.00	0.80
Damford	No	893	1,189	-0.75	-0.60	0.00
Donington North Ings	Yes	2,262	3,058	-0.25	0.20	0.90 (0.65)
Donington Wykes	No		421	0.90	1.20	1.50
Dowsby Fen	Yes	1,003	1,699	-0.20	0.20	0.45 (0.40)
Dowsby Lode	Yes	355	1,019	0.70	0.70	1.60
Dunsby Fen	Yes	568	651	-0.65	-0.20	0.60
Dyke Fen	No	1,862	2,660	-1.40	-1.00	0.00
Ewerby	Yes	1,141	2,237	-0.60	-0.20	0.45 (0.00)
Gosberton	Yes	2,885	3,992	-0.30	0.30	0.90
Great Hale	Yes	2,363	3,482	-0.20	0.30	0.90
Hacconby	Yes	503	850	-0.35	0.00	1.00
Heckington	Yes	1,577	2,661	-0.20	0.00	0.05
Helpringham	Yes	814	1,331	0.15	0.50	1.10
Holland Fen	Yes	3,505	4,841	-0.55	-0.20	0.60 (-0.10)
Horbling	Yes	886	1,331	-0.05	0.20	0.90
Kirton Marsh	No	774	934	0.35	0.60	1.25
Mallard Hurn	Yes	365	566	0.30	0.45	0.80
Pinchbeck	Yes	655	906	0.50	0.70	1.20
Quadring	Yes	400	566	0.15	0.45	1.00
Rippingale	Yes	496	1,019	0.05	0.40	1.10 (0.9)
Sempringham	Yes	824	1,189	0.05	0.40	1.00
South Kyme	Yes	1,101	1,302	-0.80	-0.50	0.05
Swaton	Yes	851	1,133	0.30	0.50	1.35 (1.0m)
Swineshead	Yes	4,824	6,795	-0.30	0.40	1.00 (0.80)
Trinity College	Yes	609	1,133	-0.80	-0.60	-0.25
Twenty	No	607	849	-0.40	-0.40	-0.40
Wyberton Marsh	No	1,982	2,803	-0.35	0.15	0.90

* If levels reach 2.3m ODN at Boston and tide locked, then consider switching off Cooks Lock PS and Chain Bridge PS.

The figures in brackets are temporary levels due to amendments being required to water level sensors included in the budget 2024/25.

14

Emergency Response

Figure 25: Extract from Black Sluice IDB Emergency Response Plan

From reviewing the pump data, it appears that due to the extreme nature of the January 2025 rainfall, runoff event, despite IDB pumps being switched to emergency profile levels, most pumping stations in the catchment continued to pump water to some extent into the South Forty Foot Drain to avoid flooding from ordinary watercourses. The IDB provide both land drainage to farmland and reduce the risk of ordinary watercourse flooding within their district. To fully turn off pumps until levels in the main river had fallen back to 2.3mAOD, could have led to further homes flooding in the area from ordinary watercourses.

The above understanding does raise some questions that the Environment Agency, the Black Sluice IDB and others need to review, and it is recommended that this is part of the model review work currently being commissioned and longer-term strategic planning:

- Is the Black Sluice IDB Emergency Response Plan accurately represented in the current modelling?
- Can there be a further refinement of Environment Agency and IDB procedures to avoid overloading the embanked channels during an extreme event?
- Longer term, working with other partners such as Anglian Water who are developing major changes to the main river and drainage system here, can more water storage be formally identified to further reduce the pressure on the embanked main rivers?

Black Sluice Pumping Station decommissioning

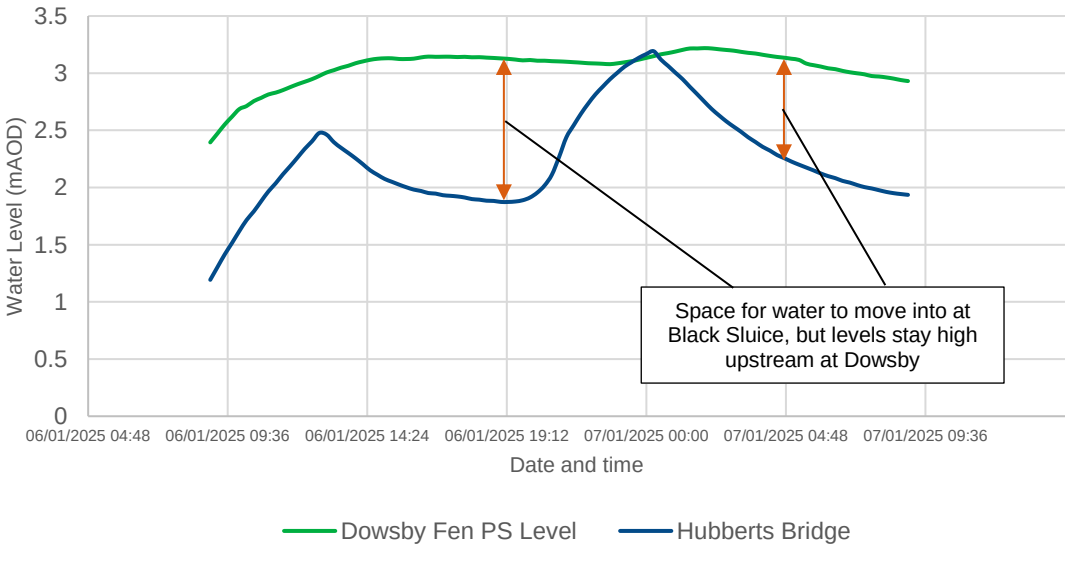
The station officially ceased operation following a joint decision by risk management authority partners including Black Sluice Internal Drainage Board, the Environment Agency, Lincolnshire County Council, Boston Borough Council and the NFU in 2018. This decision was based on a 4-year modelling study, which showed that whilst the pumping station makes a small difference to flood risk, this reduction in risk did not outweigh the cost of refurbishing and running the asset into the future.

Members of the community and partners have now questioned the previously modelled impacts; however, they continue to appreciate the challenges funding a refurbishment and subsequent operation would bring. We intend to commission a review of the existing model to see if observed conditions match with the previous predictions.

Despite our plan to review our modelling information, from observation and data on river levels collected over many years, we can already be certain of several key points as follows:

- Overtopping of low banks along most of the South Forty Foot Drain would not be prevented by the operation of the Black Sluice Pumping Station in large flood events
- When the pumping station was operated in the past the effect that could be observed on levels, diminished as you moved upstream away from the station. This effect became unnoticeable upstream of Donnington Bridge, around 20km from the pumping station.
- Levels in the upstream section of the South Forty Foot Drain, around Dunsby, were not high because of backing up from the Black Sluice Complex. Rather the inflows from highland carriers and drainage pump stations kept levels high here. Despite levels in Boston dropping on each low tide, making space for water to flow downstream, levels at the top of the South Forty Foot Drain did not show a corresponding fall as can be seen in Figure 26 below.

Figure 26 Water Levels in the South Forty Foot Drain at Dowsby Fen Pumping Station and Hubberts Bridge



Some partners and residents in Billingborough, and other villages located on higher ground within the South Forty Foot Drain Catchment have asked whether the decommissioning of the Black Sluice Pumping Station led to their flooding during the January 2025 incident. This is not the case, and a model is not needed to evidence this. A briefing note titled “Billingborough Flood 6 January 2025 and Black Sluice Pumping Station” containing evidence and an explanation of why this is the case is included as an appendix to this review report.

Section 5: Review Conclusions and next steps

Conclusions

In summary, the effects of the rainfall of the 5th and 6th January 2025 and the preceding catchment conditions of a low soil moisture deficit, frozen ground and reduced rainfall interception by vegetation:

- led to a large quantity of run off generating in less than 24 hours causing the South Forty Foot Drain to exceed its channel capacity. This resulted in overtopping and flooding of properties, gardens, outbuildings, businesses, and farmland.
- caused an extreme exceedance flood event with levels greater than the modelled 1 in 1000 (0.1%) chance of occurring in any one year levels. Flood defences in the catchment have a standard of protection of between a 1 in 10 and 1 in 50 chance of being exceeded in any one year. This event exceeded that standard significantly.

Whilst we plan to review the South Forty Foot Drain catchment modelling, reviews of flooding that took place in other catchments (with their own separate modelling) at the same time have also shown similar extreme river levels and flooding, consistent with modelled levels of a 1 in 1000 chance of occurring.

The impacts of this extreme event could have been reduced, but not prevented by:

- The availability of a Flood Warning for the Wyberton Road and Park Road area.
- Main river defences being in better condition both in Boston and in the Fenland area at Dunsby and Quadring.
- Further attenuation of lowland water in arable areas during the peak flood

Actions which would have made the incident easier for Environment Agency duty staff, but which did not have a bearing on the impacts include:

- Further refinement of duty officer procedures and mitigation plans for asset operation in the catchment particularly for damaged assets
- Quicker repair of mechanical assets, by ensuring spares are pre-purchased and available.

Actions taken by risk management authorities during the incident that helped reduce flood risk are noted as follows:

- Action by Flood Incident Duty Officers on the morning of the 6th January, to instruct field teams to open both gravity sluices fully to discharge rising river water around 16 hours ahead of the highest peak levels.
- Action by Black Sluice Internal Drainage Board to implement their Emergency Response Plan, to reduce the volume of water being pumped into the South Forty

Foot Drain during the incident, whilst continuing to manage risk of ordinary watercourse flooding.
- Action by Environment Agency Field Teams to replace temporary sheeting and sandbagging at Dunsby and Quadring damaged embankments, to prevent full breaches from occurring.

It is acknowledged that the levels in the South Forty Foot Drain at Black Sluice may have been reduced very locally had the Black Sluice Pumping Station still been operational. However, this asset was not and is not available to be used, due to its condition, and the decommissioning decision. This decision was taken in 2018, by a collective of all risk management and local authorities, with a role in the area and was based on the fact that the cost of retaining, refurbishing and running this station was not outweighed by the benefit it would provide. It would be wrong to state that the Black Sluice Pumping Station was decommissioned because EA evidence showed it provided 'no benefit' as some have implied recently. EA modelling shows a small reduction in levels close to Boston in an extreme event could be achieved, but the additional damage estimated to be avoided over time did not exceed the multi-million-pound refurbishment cost of the station.

Issues for further investigation and action

Whilst it is clear the flooding of the 6th and 7th January 2025, on the South Forty Foot Drain was an extreme event, exceeding flood defences, the incident has highlighted areas for further investigation and actions that can be taken to improve the area's resilience to similar events in the future.

- Flood warnings: the Environment Agency's Flood Resilience Team are already investigating how a flood warning can be provided for this area in the future. If this can be provided, homeowners in Wyberton West Road and Park Road will be contacted and invited to register their details to sign up for this service.
- Current model review: the Environment Agency's Partnerships and Strategic Overview Team will commission a piece of work to simulate the 5th/6th/7th January 2025 flood incident to see how well the impacts experienced were predicted. This work will also help to inform the discussion about the Black Sluice Pumping Station decommissioning decision.
- Embankments and walls at Wyberton West Road: work required to bring these defences into a better condition has already been identified and programmed. The flooding experienced in January has provided further justification for these works to be completed as soon as possible.
- Storm Henk recovery works: outstanding repair works at Dunsby and Quadring have now been completed as of March 2025.
- Incident procedures in case of asset failure have been reviewed by Environment Agency Operational staff, to assess whether any further improvements can be made to mitigate risks.
- Emergency response plans should be reviewed by partners to understand whether these can be refined to reduce risk further.
- Update to the South Forty Foot model: at 10 years old the current model is due an update and will be scheduled for a full update on our modelling programme. Latest climate change projections, more advanced modelling software and new data from recent flooding incidents will help us to improve our understanding of the catchment as it is now. However, modelling is a time-consuming process, and the outputs may take several years to finalise. In addition, catchment changes because of Anglian Water's proposed new reservoir will need to be considered.

Next Steps

We have set out below several proposed steps the Environment Agency intend to action in 2025/26 (indicative timescale).

Short term [up to 3 months]

- Undertake surveys, and preparation for embankment seepage and wall stabilisation works, returning wall heights to their design levels on the South Forty Foot Drain right bank in Boston.
- Replace wall joint seals. *Update 19/03/2025 joint seals have been repaired by the Environment Agency's Field Team.*
- Complete Storm Henk recovery works at Dunsby and Quadring. *Update 18/03/2025 works at these sites have now been completed.*
- Provide this review and supporting data and evidence to Lincolnshire County Council for their statutory Section 19 reporting process for flood incidents.
- Initial review of incident procedures amending if required. *Update February 2025: incident procedures updated accordingly.*

Medium Term [3 to 6 months]

- Investigate, define and request an update to the Flood Warning System for properties affected.
- Commission and undertake a model review and simulation of the January 2025 incident.

Longer Term [6 months +]

- Seek to undertake embankment seepage and wall stabilisation works on the right bank of the South Forty Foot Drain in Boston, under the 'Asset recondition programme' subject to funding availability.
- Review emergency response plans and operational decisions once model review is completed.
- Continue to discuss the possibility of making more space for water within the catchment, through the design process for the new Anglian Water Lincolnshire Reservoir proposals.
- Programme funding for a new South Forty Foot Drain model, incorporating data from the January 2025 incident (rainfall, flows and river levels). If this shows that things have changed and the risk to the area has increased, we will look to see if there are options to reduce the risk again. Though it must be stressed we can never eliminate the risk as there will always be flood events at magnitudes greater than design events where formal flood defences are in place.

For a scheme to receive centrally funded Government Grant in Aid (GiA), options considered will need to have a strong cost benefit ratio, in line with Treasury rules. In simple terms the economic assessment will look at damages caused by predicted flooding, including a monetary value for stress, social impacts, and property damage. The two key factors which will determine how much money can be justified are the number of properties at risk and the frequency with which they are predicted to flood.

There may be improvement options that can be progressed, but that cannot be funded using government funding and could only be progressed by the community themselves.

Main Rivers rights and responsibilities

You can find out more information about the rights and responsibilities of owning a river bank here: Your watercourse: rights and roles | Engage Environment Agency

How resilient are you?

Are you prepared for future floods?

Although defences reduce the likelihood of flooding, the risk can never be removed entirely. To begin to be more resilient take some practical steps to help reduce the impact of flooding to your home or business.

To find out if you are at risk, how to prepare, and check what flood warnings are available to sign up for (free) visit Flooding - GOV.UK or call Floodline on 0345 988 1188.

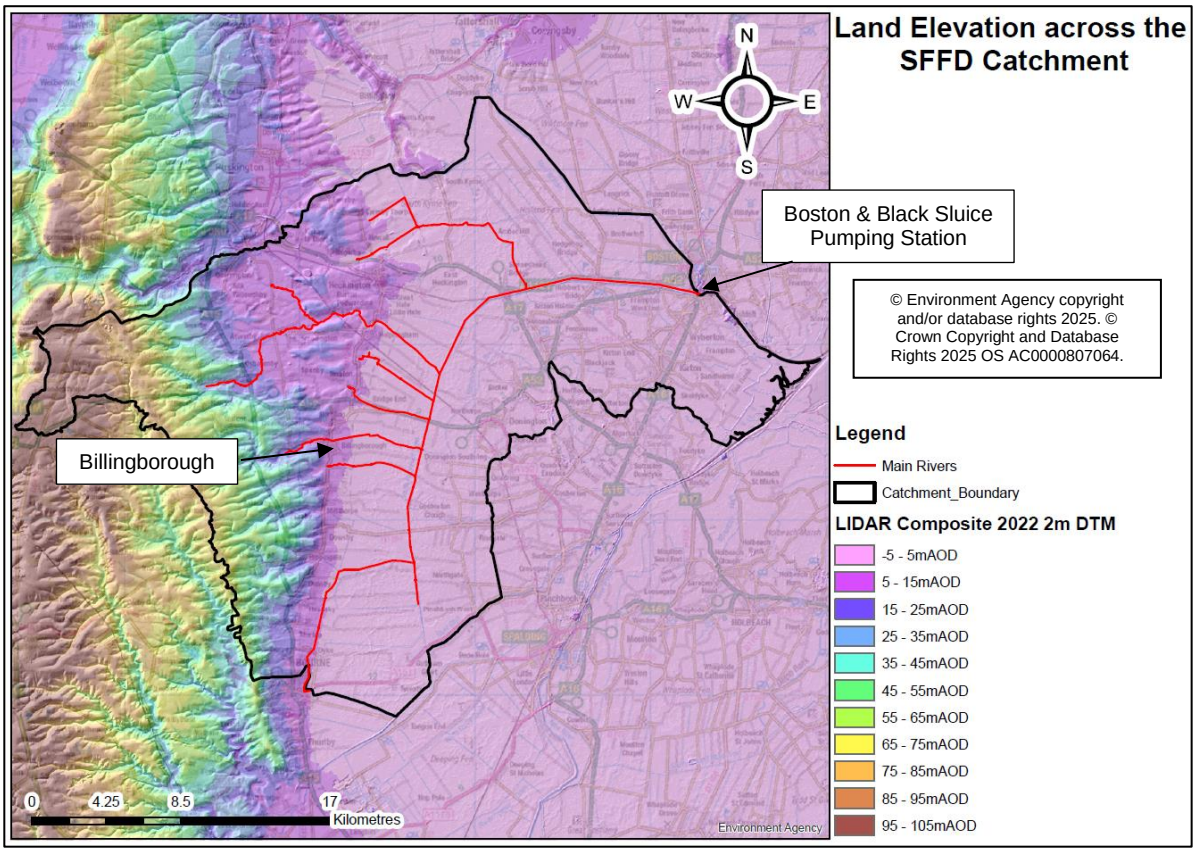
The Environment Agency intend to provide improved coverage of fluvial (river) flood warnings in this area this year, so please check back after the summer to see if you can register for additional warnings. Sign up for flood warnings - GOV.UK

You can find out how to put together Flood Plans for your home, business or community here www.gov.uk/prepare-for-flooding Call Floodline on 0345 988 1188 for a hard copy. You can also check with your parish, ward or borough council to see if they have or are developing a Community Emergency Plan.

There is guidance on measures that can be taken to improve homes and businesses resilience to flooding on this website https://thefloodhub.co.uk/pfr/. There is also further information on Flood Products to help reduce the impact of flooding on your home e.g. flood doors, airbrick covers, at www.bluepages.org.uk.

Appendix 1

Billingborough Flood 6 January 2025 and Black Sluice Pumping Station



This document addresses specific concerns that flooding to the village of Billingborough of the 5th and 6th January 2025 could have been prevented had the Black Sluice Pumping Station in Boston been operational.

Background

15 homes were flooded in Billingborough between the 5th and 6th January 2025. An initial published response by Black Sluice Internal Drainage Board suggested that due to the decommissioning of the Black Sluice Pumping Station in Boston, highland carriers such as the Billingborough Ouse Mere Lode could not discharge into the South Forty Foot Drain main river during times of high flow leading to village flooding.

In this document the Environment Agency sets out the evidence for our view, which is that the Black Sluice Pumping Station decommission decision did not lead to flooding in Billingborough. Our aim is to aid understanding of the facts, allowing the focus to be on the true causes of the flooding and measures that can make a difference in the future, for the community in Billingborough and the other villages located on the ‘Fen edge’.

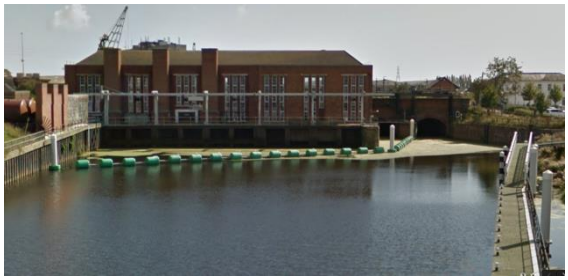
The Ouse Mere Lode and the South Forty Foot Drain

The Ouse Mere Lode, which runs to the north of Billingborough village, is a main river tributary of the South Forty Foot Drain. It carries flows from the high ground of the catchment up to 72 metres above sea level, to the South Forty Foot Drain. River levels crossing the fen in the South Forty Foot Drain to Boston can vary between 0 metres (normal levels) and 3 metres (extreme high flows) above sea level. At Billingborough the Ouse Mere Lode is around 9 to 10 metres above sea level.

The Ouse Mere Lode has a flood defence earth embankment, constructed in 2000 to offer protection to the village up to a 1 in 25 chance of flooding in any one year.

The Black Sluice Pumping Station

This facility, constructed in 1947, offered the ability to pump out water from the lower end of the South Forty Foot Drain, during high tide periods.



The station was decommissioned in 2018, following years of work by the Environment Agency, Black Sluice Internal Drainage Board and others to try to make the case for its refurbishment. All the evidence prepared showed that whilst the station could lower water levels slightly during tide locked periods the impact that made on flood risk was small.

The costs of refurbishing and continuing to run the station were much larger than the damages avoided by doing so.
The station is in Boston, approximately 27km downstream of Billingborough. It is at sea level, with water levels in the channel upstream varying between -0.6 and 3 metres above sea level depending on the time of year and whether the river is carrying high flows.

Reasons

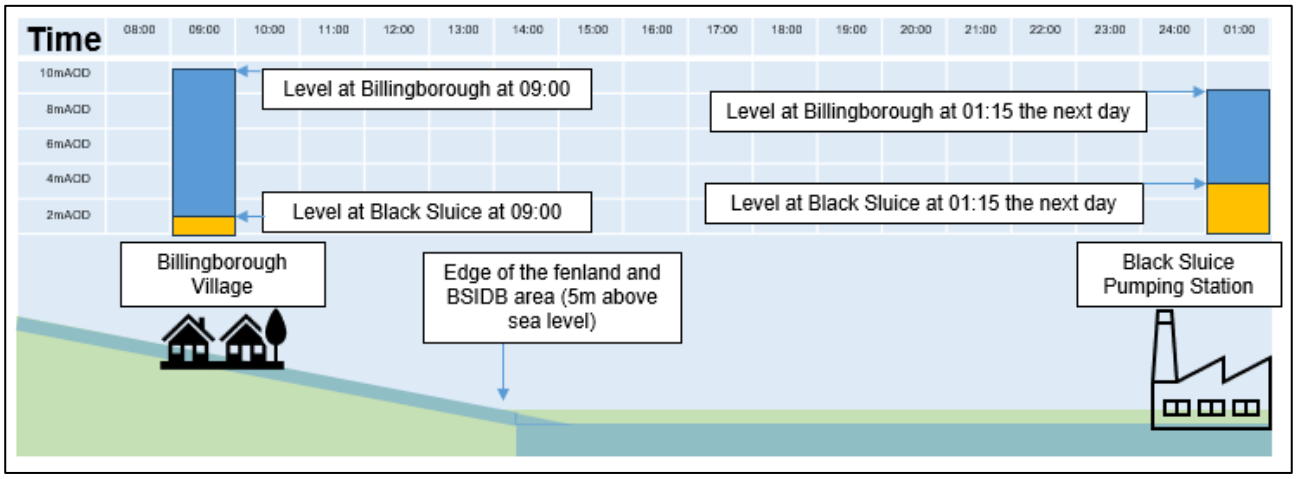
There are 3 main reasons why the Black Sluice Pumping Station cannot influence flows or flooding in Billingborough. These are:

- ***Time***: the time that rainfall takes to move through the South Forty Foot Drain Catchment
- ***Elevation***: the height of Billingborough Village in relation to the Black Sluice Pumping Station
- ***Distance***: how far up the South Forty Foot Drain the effect of pumping at Black Sluice can be seen.

Time

The Ouse Mere Lode at Billingborough reached its record peak of 9.79m above sea level at 09:00hrs on the morning of the 6th January 2025. Reports of homes flooding were received before this at 07:30hrs.

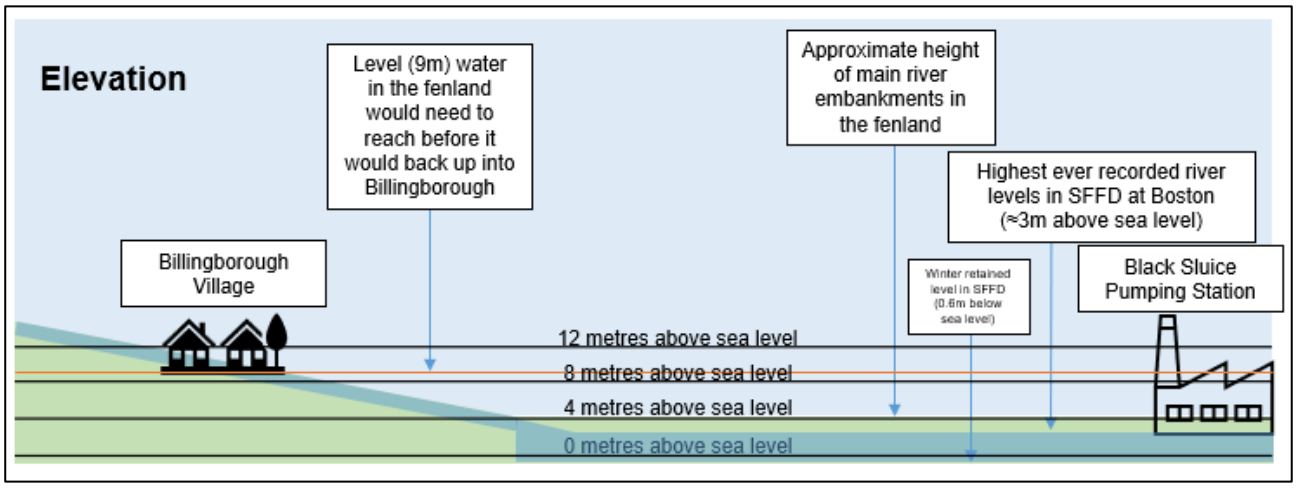
At the same time, levels in the South Forty Foot Drain at Black Sluice Pumping Station were much lower at 1.04m above sea level. Levels did not rise, and peak here at around 3.0m above sea level, until 01:15 hours on the 7th January 2025, more than 16 hours later. By this time levels had dropped in Billingborough by 1.69m, as water had been able to flow towards the South Forty Foot Drain.



Elevation

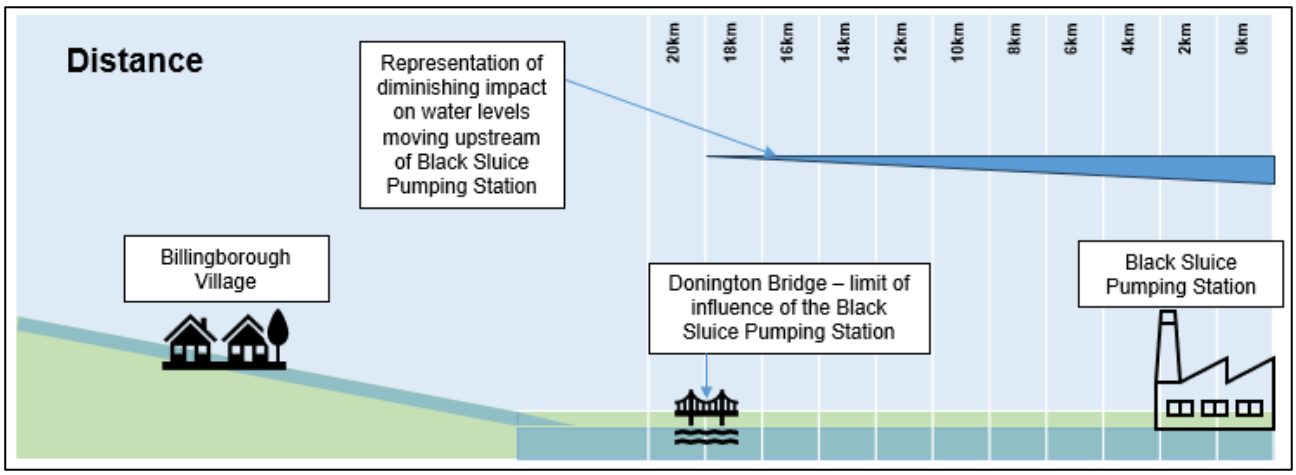
The diagram below shows the relative heights above sea level of the pumping station and Billingborough.

For water backing up in the South Forty Foot Drain to affect Billingborough, it would need to rise to the level of the village. This would be around 6m higher than the highest ever recorded levels in the South Forty Foot Drain, by which point the entire Fen would be under 5-6m of flood water.



Distance

The Black Sluice Pumping Station is around 27km downstream of Billingborough. When the pumping station was operated in the past the effect that could be observed on levels diminished as you moved upstream away from the station. This effect became unnoticeable upstream of Donington Bridge, around 20km from the pumping station, and 7.2km downstream of Billingborough.



Appendix 2

Figure 1 – South Forty Foot Drain Topography

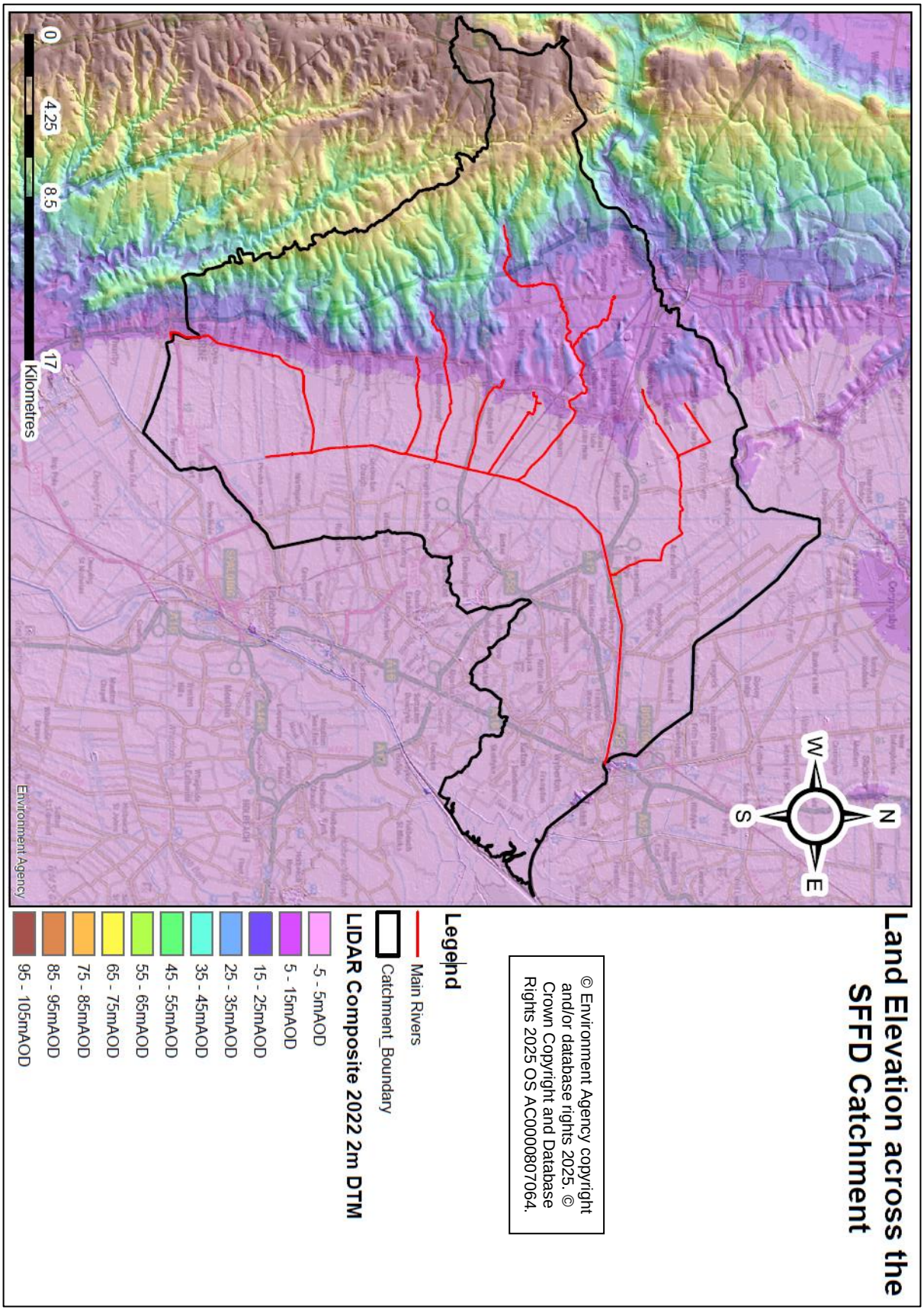


Figure 2 – South Forty Foot Drain Catchment Map