

BROADLAND FLOOD ALLEVIATION PROJECT

Summary of 1st November 2006 Flood Event

The 1st November Event was the third highest since 1953. The flood defences throughout Broadland performed exceptionally well given the volume of overtopping that was experienced, with breaches only occurring where improvement works have not yet been carried out. Effects on the progress of the project works were minimal.

Flood levels and flooding through the system were comparable with similar historic flood events with overtopping occurring at similar locations. This meets the Project aim of not increasing water levels through maintaining the same frequency and pattern of overtopping in the system whilst minimising the risk of breach.

Confidence in the hydraulic modelling has been further confirmed by comparing modelled results with actual levels observed during the event. This comparison shows good correlation. BESL is currently working with the Environment Agency to utilise this tool to advance flood forecasting within Broadland.



Overtopping at Postwick Marshes



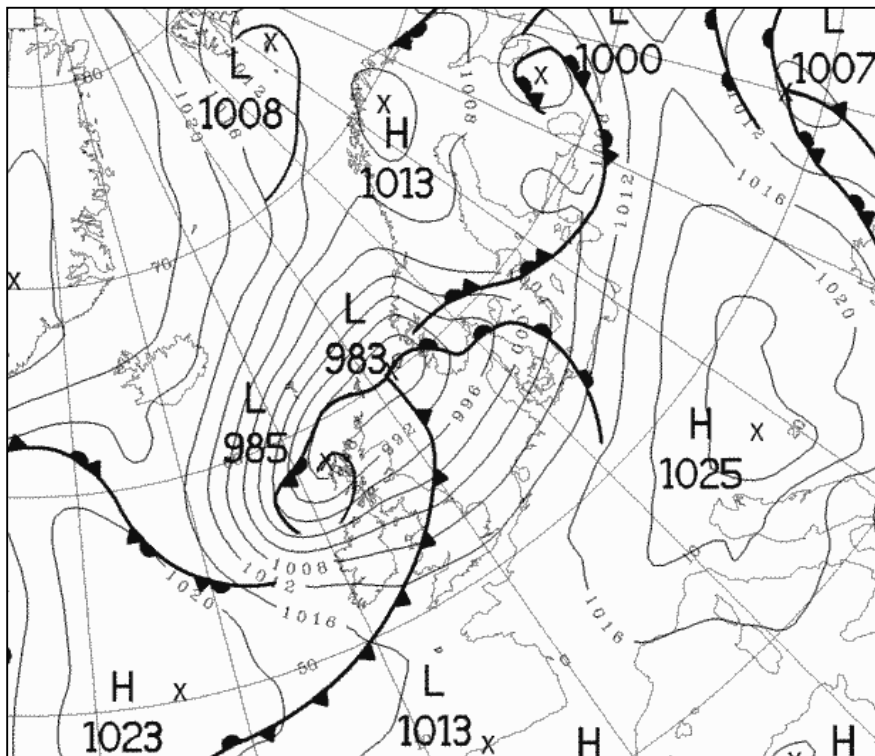
Breach at Haddiscoe Bridge

Surge Development

The surge that created the event originated from a depression which developed north-west of Scotland on Monday, 30th October 2006. This depression deepened and joined a second depression heading south from Scandinavia on Tuesday, 31st October 2006. The two depressions travelling with a strong south-westerly wind generated a current which pushed water to the right of the wind direction. This caused a build up of water known as a positive surge.

The surge travelled around into the North Sea during Tuesday and as the depression moved eastwards, so the winds on the southern side of the low (travelling in a westerly direction) drove the surge southwards and down the East Coast. As the surge travelled into the shallower southern North sea in the early hours of Wednesday morning, 1st November 2006, so the water levels were elevated with maximum surge levels recorded at Great Yarmouth of 1.75 m.

Fortunately, travelling behind the depression was a significant band of high pressure which quickly pushed the offending weather system into the continent bringing water level quickly back to normal.



Pressure Map for 31st October 2006

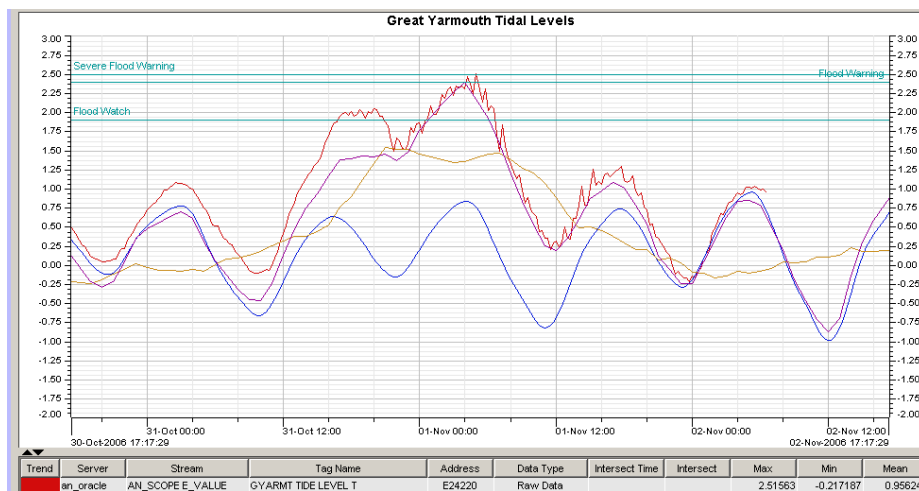
Tide Levels

Tide levels across Broadland are monitored by a series of tide gauges with the main gauge situated in Great Yarmouth. On the day of the event the tidal cycle was rising from neaps at the 1st Quarter on the 29th October towards higher Spring tides on the 5th November 2006. Tide level predictions in Great Yarmouth were low for the afternoon of the 31st October through to 1st November 2006 varying between 0.64 – 0.85 m AOD.

As the surge began to develop so tide levels at Great Yarmouth began to rise from mid-day on 31st October 2006. At 1800 hours the Environment Agency issued a Flood Warning across Broadland for the morning high tide.

The graph shown below is produced by the Environment Agency's 'swantel' software and shows both the astronomical tides prediction and the actual recorded levels in Great Yarmouth. .

As can be seen from both the graph tide levels returned to normal very quickly as the depression moved away and was following immediately by high pressure.



Extract from Environment Agency's 'Swantel' system

Forecast

- Astronomical Tide
- Surge
- Combined Ast. + surge

Actual

- Tide Gauge Readings Surge

Comparison with Other Flooding Events

To put the scale of this event into perspective we need to look at recent historic flooding events which have happened since 1953. Historic flooding events have typically been generated by similar low pressure systems developing in north Atlantic and swinging round over Scotland and into the North Sea.

The surge in 1953 was in the order of 2 m above the predicted tide level. This was generated by one of the lowest ever recorded pressure drops, 968mb, and produced water levels at the mouth of the Haven of 3.28 m OD, 1.53 m OD at Haddiscoe and 1.28 m at Rockland. At the time defences through the system were significantly smaller and lower than the existing defences.

The 1st November 2006 event produced the third highest water level at Great Yarmouth since 1953 and peak levels through the system were also comparable with the other major events in January '76, February '83 and January '93. A comparison of these events is shown in Table 1 below¹.

Date	Areas Flooded	Water Level (mOD)
November 2006	Haddiscoe Cut, Limpenhoe, Postwick, Peto's	Yarmouth 2.52 Haddiscoe 1.74 Postwick 1.35
January 1976	Breydon North Wall, Cantley, Blundeston, Somerleyton and Burgh Marshes	Yarmouth 2.69 Haddiscoe 1.76
February 1983	Beauchamp Arms, Postwick, New Cut, Breydon North Wall	Yarmouth 2.59 Haddiscoe 1.70 Rockland 1.13
January 1993	North Breydon, Hassingham, Haddiscoe Cut	Yarmouth ? Haddiscoe 1.58 Rockland 1.30

Table 1 - Comparison with Historic Events

¹ Information from *The Landuse, Ecology and Conservation of Broadland*, Dr. Martin George (Packard Publishing, 1994)

Performance of Flood Defences

Across Broadland the defences performed exceptionally well. Significant overtopping occurred throughout the southern river system :

River Yare – Limpenhoe Marshes, Cantley Marshes and Postwick Marshes, flooding of grazing marshes. Floodwater overtopped the bank at Strumpshaw Fen and flooded the freshwater lagoons and reedbed causing significant fish kills due to the high saline levels. Flooding also occurred within Brundall itself.

Significant overtopping at Limpenhoe resulted in excessive amounts of rear face scouring. Despite this the bank did not breach. Remedial works were subsequently carried out to address the damage.

Localised flooding of the road at Reedham has been traced to the surface water drains and BESL are working closely with Norfolk County Council to rectify the problem.

River Waveney – Flooding of grazing marshes at Geldeston, Shipmeadow, Oulton, Blundeston Marshes and Dunburgh Marshes.

There were breaches in only two sections of floodbank; Compartment 22 –Adjacent to A143 road bridge on Haddiscoe Cut and Compartment 28 - White Cast Marshes at the Suffolk Wildlife Trust's Carlton Marshes Nature Reserve. Both these section have yet to receive improvement works and were repaired quickly after the event passed.

On the River Chet, water levels flowed up the boat yard slipways and flooded a number of boat sheds before draining onto the lower laying marshes to the east. A scheme to protect these undefended properties is currently being designed for construction towards the end of this year.



Overtopping Flooding of Oulton, Peto's and Share Marshes

Model Development

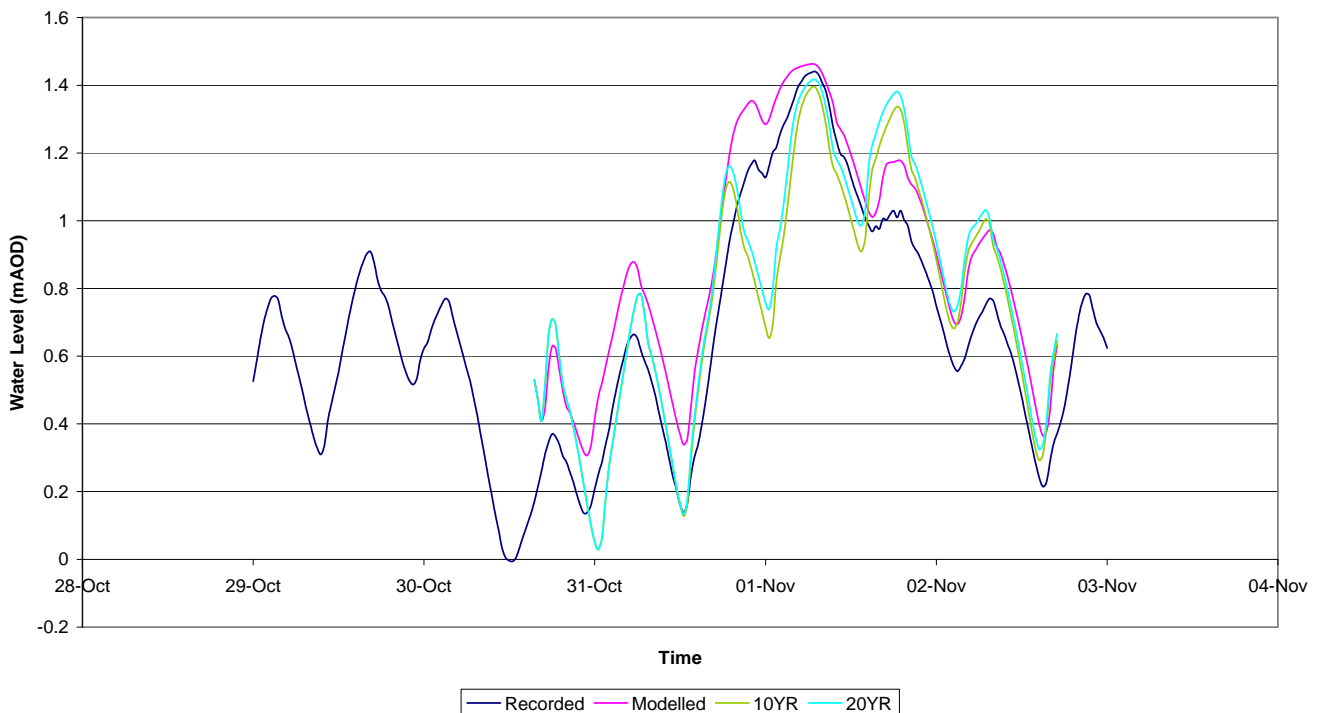
The Broadland Hydraulic Model was run with the recorded water level at Great Yarmouth as the downstream boundary for the period 16.00 on 30th October to 18.00 2nd November.

A nominal fluvial inflow was used for the run – identical to that used for the 1 in 20 year tidal model run. The modelled results were compared with the gauged and measured water levels and showed a good comparison and certainly within the tolerances of the original calibration runs. As this event was considerably greater in magnitude than those calibration events, and as some overtopping occurred during this event, an increased level of confidence can be held in the models ability to replicate out of bank flood events.

Further work has been carried out using the hydraulic model to compare the shapes and durations of hydrographs from the gauged sites and from the model results. An example of this is shown below.

This actual and modelled levels suggest an average peak return period for the 1st November event of around a 1 in 20 year return period.

Comparison of Recorded and Modelled Levels Cantley



Example of Model Run for 1st November Event

Effects on Saline Incursion

The surge tide steadily increased salinity levels through the system. Salinity levels started to increase at Acle from 23:00 on Tuesday, 31st October, reaching 49,000uS/cm by 01:30 and 51,000uS/cm shortly afterwards (North sea water standard is 51,000uS/cm). Salinity levels at Repps started to increase from 9,000uS/cm at 06:30 on Wednesday 1st November reaching a high of approximately 42,000uS/cm by 10:30. Levels in Acle and Upton dykes were recorded in excess of 40,000uS/cm by 12:30.

Toxic levels of salt were also recorded in the River Bure at Horning Old Staithe (25,000uS/cm top, 45,000uS/cm bottom) and in the River Ant at Ludham Bridge (47,000uS/cm top and bottom). On the River Chet at Loddon Marina levels of 16,000uS/cm top and 42,000uS/cm bottom were recorded. Fish were observed aggregated in the freshwater flow passing through Loddon Mill.

The salt water barrier was raised at Potter Heigham at around 09:00 on Wednesday morning and remained in place until Monday morning. The co-operation of the Herbert Woods Boatyard was essential in helping to protect the large number of fish within the marina.

The Environment Agency undertook extensive monitoring of salinity levels throughout the event, which will help to inform management of future incursions.



Fish Mortalities at Upton Dyke

Field observations suggest that several thousand fish perished during the event in the lower Thurne, Ant, Yare and Bure. However, given the size of the population in the Broads system no long term effects are anticipated. Further additional routine fisheries surveys are being carried out throughout the system will enable the Agency to monitor and assess changes in Broads fish populations.