



North Yorkshire
County Council

Flood Investigation Report

Scarborough August 2017



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Acknowledgements

North Yorkshire County Council Flood Risk Management Team would like to thank the following for their cooperation and assistance in this investigation:

Scarborough Borough Council

Yorkshire Water Services Ltd

The Environment Agency

North Yorkshire County Council Highways Department

North Yorkshire County Council Resilience & Emergencies Team

North Yorkshire Fire & Rescue Service

The Met Office

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Records of the public sewer system included are a facsimile of the statutory record provided by Yorkshire Water Services Ltd (YWSL). For the purposes of this report minor sewers and other non-relevant data have been omitted from the plans for clarity

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1.0 Executive summary

On the morning of the 23rd August 2017 a storm formed over the central Pennines, and tracked north and east over Yorkshire causing flooding in a number of locations. The storm was characterised by short, intense bursts of rainfall and caused flooding across Yorkshire, with Scarborough being the place most seriously affected.

73% of the average August rainfall for Scarborough fell in under 2 hours. The short duration, high intensity storm produced a peak one minute rainfall rate of 132mm/hr, with most of the rain falling in one 15 minute period. Local watercourses responded rapidly and Scarborough's drainage network was overwhelmed, resulting in flooding to commercial and residential properties and damage to infrastructure and the highway network. The flooding created hazardous conditions for the public.

At least 139 calls were made to the authorities to report flooding to property and places affected included homes, businesses, schools and an ambulance station. Although some of those calls were duplications, 70 of those reports have been identified as individual locations through this investigation. The actual number of properties which suffered internal flooding has not been independently verified.

The flooding also caused damage to infrastructure and the road network. The localised nature of the storm, and the fact that the flooding resulted from a surcharging drainage network rather than from rivers or the sea, meant that the flooding was not predicted and no flood warnings issued.

The rapid onset of the flooding together with the lack of warning meant that there was not sufficient time to mobilise a co-ordinated multi-agency response. Nevertheless North Yorkshire Fire and Rescue Service, Scarborough Borough Council, North Yorkshire County Council's Highways and Resilience & Emergencies Teams, Yorkshire Water and the Environment Agency all contributed to the incident response.

No defects have been reported on the drainage network, and it is not thought that Scarborough's watercourses played a significant role in the flooding. The cause of the flooding was rather that more water fell in Scarborough than the drainage network had the capacity to convey, and the excess duly flowed down through the streets towards the sea.

The flood event in Scarborough did not result from an unprecedented amount of rainfall, with August 23rd 2017 being only the 5th highest recorded August daily rainfall total. Scarborough is vulnerable to short, intense summer storms owing to its topography and the impermeable nature of the catchment. If climate change predictions are accurate there is a likelihood of further such flood events in the future.

Increasing the capacity of the existing drainage network to a level where it could cope with this type of flood event is not realistic in the short term. This report therefore makes a number of recommendations with the aim of improving preparedness, resilience and recovery. We also recommend that every opportunity should be taken to reduce the pressure on the drainage network and ensure that the existing infrastructure functions to its full capacity.

1.1 Scope/purpose of report

This document has been prepared specifically for the purpose of meeting the requirements of Section 19 of the Flood and Water Management Act 2010.

The purpose of this report is to investigate which Risk Management Authorities (RMAs) had relevant flood risk management functions during the flooding in Scarborough on 23rd August 2017, and whether the relevant RMAs have exercised, or propose to exercise, their risk management functions (as per section 19(1) of the Flood and Water Management Act 2010). It does not address wider issues beyond that remit. The report focusses on the flooding in Scarborough town, and does not extend to other parts of the district or county.

The supporting data has been put together based on reports of flooding and road closure information from a variety of sources. Whilst every effort has been made to verify the locations that were flooded, the nature of the data and the methods used to collate this information mean that it does not include every occurrence of flooding. Private individual properties which flooded are not identified in this report. This data only identifies general areas where flooding has been reported to the Lead Local Flood Authority (LLFA) and is indicative only.

1.2 Flood and Water Management Act (2010)

In his review of the summer 2007 floods, Sir Michael Pitt recommended that local authorities should be given a duty to investigate flooding.

The Flood and Water Management Act 2010 (FWMA), defines the roles and responsibilities of 'Risk Management Authorities' and designates the unitary or upper tier authority for an area as Lead Local Flood Authority (LLFA).

The LLFA has responsibility for leading and co-ordinating local flood risk management. Local flood risk is defined as the risk of flooding from surface water runoff, groundwater and small ditches and watercourses (collectively known as ordinary watercourses). The responsibility to lead and co-ordinate the management of tidal and fluvial flood risk remains that of the Environment Agency (EA).

The Act also implements the recommendations made by Sir Michael Pitt that local authorities should have a duty to investigate flooding from all sources.

1.3 Section 19 Investigation Requirement

North Yorkshire County Council (NYCC), as LLFA, has a responsibility under Section 19 of the FWMA to investigate significant flood incidents in its area. Section 19 states:

(1) On becoming aware of a flood in its area, a lead local flood authority must, to the extent that it considers it necessary or appropriate, investigate —

(a) which risk management authorities have relevant flood risk management functions, and

(b) whether each of those risk management authorities has exercised, or is proposing to exercise, those functions in response to the flood.

(2) Where an authority carries out an investigation under subsection (1) it must —

(a) publish the results of its investigation, and

(b) notify any relevant risk management authorities.

Section 14 of the FWMA grants the LLFA power to request information associated with its functions. These powers have been exercised in the preparation of this report.

1.4 Trigger for Section 19 Report

The incident has been assessed in line with the criteria set out in Section 3 of the North Yorkshire County Council Local Flood Risk Strategy (2015) and has been judged to warrant a formal Section 19 investigation on the basis of:

- a. The relationship with the functions of other Risk Management Authorities.
- b. Number of properties internally flooded.
- c. The depth, area or velocity of flooding reported.
- d. The nature and extent of critical infrastructure impacted by the flood.

2 Event background

2.1 Location of this investigation

Scarborough (grid reference TA 04389 88568) is a seaside town of approximately 61,000 residents on the North Sea coast of North Yorkshire. The town is a popular tourist destination with a harbour, seafront and modern commercial town centre and is connected towards York and Malton by the A64, towards Thirsk by the A170 and north towards Whitby by the A171. There is also a train service which connects to both York and Hull. See figure 1.

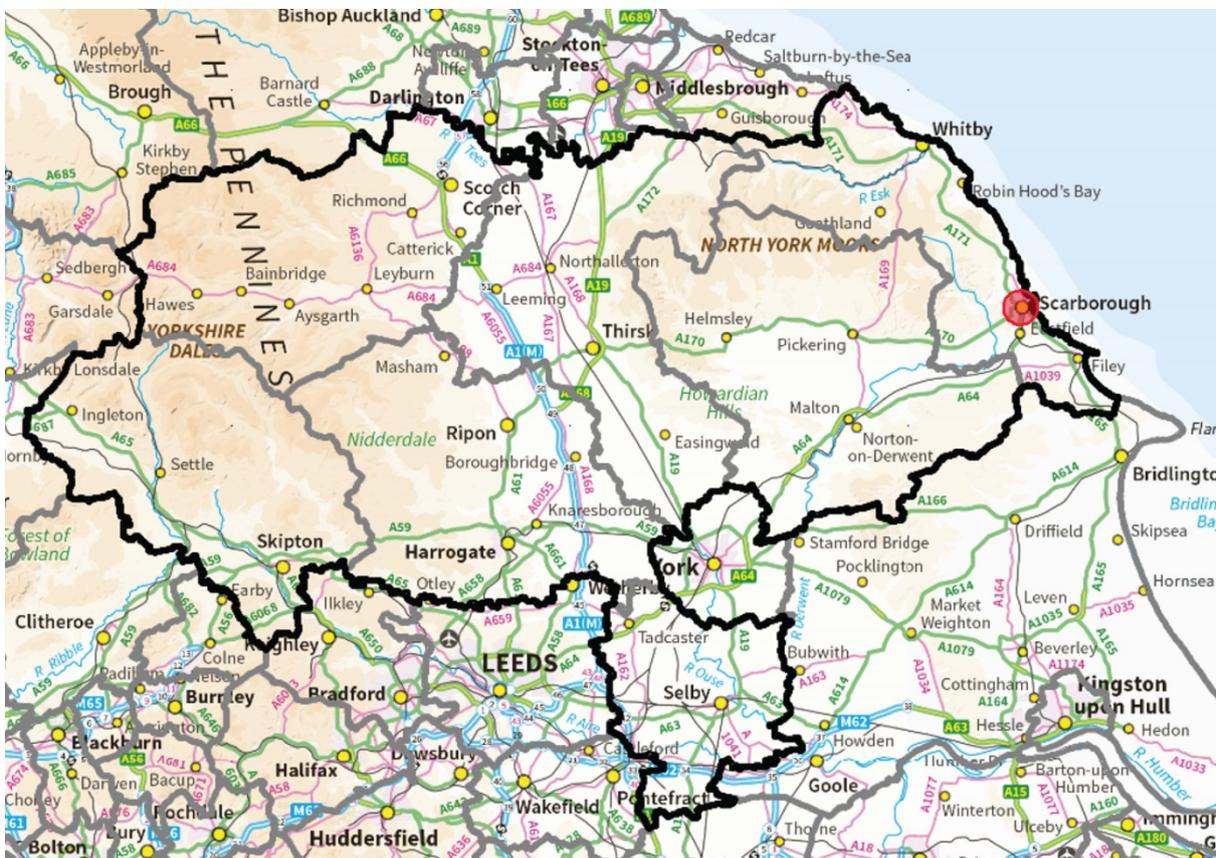


Figure 1: Scarborough location

The town rises steeply away from the seafront, which is split into 2 bays by a rocky promontory. The hinterland which drains to the North Sea is a relatively narrow strip, extending approximately 3km inland from the coast. Within Scarborough town itself the catchment is heavily urbanised and highly impermeable, and is dependent on sewers and culverts for drainage. Scarborough receives 686mm of rain annually on average. There are a number of watercourses which run west – east across the town including Scalby Beck, also known as the Sea Cut, and

Peasholm Beck or Woodlands Vale Beck. These watercourses tend to be in steep and narrow cloughs or ravines; hence the area of flood risk associated with them is relatively constrained.

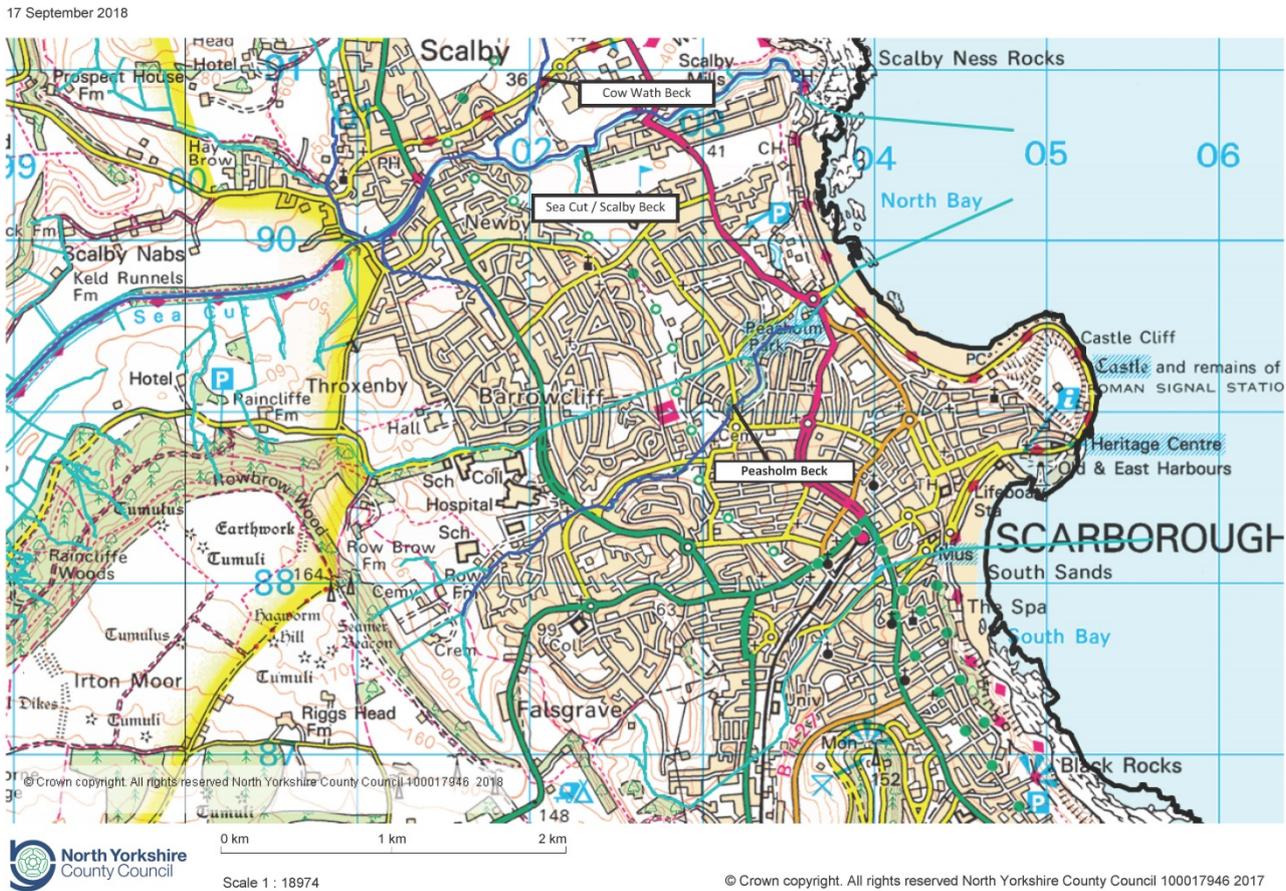


Figure 2 – Scarborough Town & Watercourses

Scarborough’s drainage network is predominantly a combined system, meaning foul and surface water are conveyed together. Combined sewerage from the whole town flows downhill towards the sea front, to the Toll House pumping station where there is a 4000m³ storm tank. From there, sewerage is pumped to another pumping station at Scalby Mills, which then pumps it on to the treatment works at Scalby Lodge¹.

2.2 History of flooding

Scarborough has experienced multiple floods in recent years. Areas along the sea front have been affected by tidal flooding - in the December 2013 storm surge, in January 2017 and again in March 2018. There have been a number of flood incidents associated with heavy rainfall in recent years. On the 10th of August 2002 flash flooding caused road damage and motorists had to be rescued. In July 2007 Peasholm Lake overflowed and that happened again in July 2012. Further localised surface water flooding happened in August 2011 and again in December 2011, and Scarborough experienced more flooding in November 2012 when Scalby Rd and Columbus Ravine were

¹ http://www.waterprojectsonline.com/case_studies/2012/Yorkshire_Scarborough_2012.pdf

closed with the Fire and Rescue Service having to assist around 30 motorists in vehicles in floodwater. In 2015 rainfall associated with the Boxing Day floods caused problems in Scalby, Eastfield and at Cayton Bay.

2.3 Current understanding of flood risk

Scarborough is known to be at risk of flooding from the sea (tidal flooding), from watercourses (fluvial flooding) and from surface water (pluvial flooding). As the land rises steeply away from the sea front, the area at risk of flooding from the sea is confined to a narrow strip along the sea front. On the North Bay this does not appear to impact on property, with the exception of the Sea Life Centre; parts of which are within flood zone 3 (greater than 0.5% chance of being flooded in any given year for flooding from the sea).

South of Scarborough Castle, tidal flood risk zone 3 encompasses the area around the old harbour, with shops and businesses along Foreshore Rd being within flood zone 2 (between 0.1 and 0.5% chance of being flooded in any given year). Tidal flooding may be exacerbated by the action of wind and waves, so that places within these flood zones can experience flooding more regularly than the Annual Exceedance Probability (AEP) might suggest.

The main area at risk of fluvial flooding is along Newby Beck in Scalby. There are more than 90 properties within flood zone 3 (greater than 1% chance of being flooded for flooding from rivers) along Hackness Rd and in the vicinity of Laurence Close and Linden Rd including Newby & Scalby primary school and a nursing home. Other areas at risk of fluvial flooding according to the flood risk mapping include Valley Rd and Peasholm Gap.

Areas at risk of surface water flooding are harder to predict than for areas at risk from tidal or fluvial flooding. Small changes such as raising or lowering a kerb can alter the way surface water flows through a catchment. Pluvial flood risk is widespread across Scarborough and follows the natural topography of the town. Surface water risk maps are available to see online at <https://flood-warning-information.service.gov.uk/long-term-flood-risk>, notable areas at risk include: Edgehill Rd, Weaponness Valley Rd, Whin Bank, Scalby Rd outside Scarborough General Hospital, Columbus Ravine, St Johns Rd and Peasholm Gap.

2.4 Current flood defences

Scarborough is protected from tidal flooding by a sea wall, and there are a number of assets on the local watercourse network which provide protection against fluvial flooding. Of the 33 assets in or along main rivers in Scarborough, 8 are structures - 2 flapped outfalls and 6 debris screens. 2 of these screens are maintained by the Environment Agency and 4 by Scarborough Borough Council. The remainder of the assets are all either sections of high ground which act as a defence, or lengths of culvert. There are no raised defences in the form of walls or embankments.²

Scarborough Borough Council also maintains a number of debris screens on ordinary watercourses, on Woodlands Vale Beck, Lady Edith's Drive and at Edgehill Road. There are currently no known assets constructed specifically for the purpose of protection against surface water flooding.

² Environment Agency, section 14 information request return.

3 Investigation

3.1 Maintenance responsibilities

A “watercourse” is any river, stream or channel – including ditches, dikes, drains, culverts, cuts, sluices, sewers (excepting public sewers) through which water flows either permanently or periodically. Watercourses are designated as either being “main” rivers or “ordinary” watercourses. Responsibility for maintenance of a watercourse rests with the owner or owners of the land through which that watercourse flows. Often a watercourse will be the boundary between two adjacent landowners and where this is the case the boundary is deemed to be the centre of the channel, the owner of the land or property on each side being responsible for maintenance of their side. Culverts under roads are usually the responsibility of the relevant Highway Authority, either Highways England or North Yorkshire County Council.

The Environment Agency has powers, but not a duty, to carry out maintenance on watercourses which have been designated as “Main” rivers and also the power to build and maintain flood defences on these rivers where deemed necessary and proportionate. Within the district of Scarborough the following watercourses have been designated as main rivers:

- Esk
- Derwent
- Sea Cut (Scalby Beck)

There are also a number of smaller watercourses, which are also designated as main river. Within Scarborough these are:

- Church Beck, Scalby
- Newby Beck
- Peasholm / Woodland Vale Beck
- Burniston / Cow Wath Beck

Watercourses which are not listed above are ordinary watercourses, and responsibility for these rests with their riparian owners. North Yorkshire County Council as Lead Local Flood Authority has powers to enforce riparian owners to undertake maintenance, which are exercised proportionally according to the degree of flood risk.

Yorkshire Water is responsible for managing and maintaining the network of public sewers throughout Scarborough. Public sewer networks are either combined systems, where foul and surface water drain through the same pipes to the local waste water treatment works, or are separate systems where foul water is conveyed to the sewage works and surface water is conveyed either to a local watercourse or other receiving body of water, or to a point at which it joins the combined sewer network. Scarborough is mostly served by a combined system.

North Yorkshire County Council as the Highway Authority is responsible for maintaining drainage assets on the road network around Scarborough.

Scarborough Borough Council maintains a number of smaller debris screens and Peasholm Lake.

3.2 Rainfall event – location, depth & duration

The UK MET Office reports that summer 2017 was wetter than average across England, with 133% of the long term average rainfall falling across the country. The area around Scarborough was one of the wetter parts of the country across the whole summer, experiencing more than 170% of the long term average rainfall. The average annual rainfall for Scarborough is 686mm, and the long term average August rainfall for Scarborough is 67.6mm. It was generally warm and dry throughout June. From July a pattern of unsettled and cooler weather set in. In the week leading up to the 22nd August, the ground was not saturated. Soil moisture conditions (the Soil Moisture Deficit) was classed as “Normal” for Scarborough & Ryedale, and “Dry” for York. On the 23rd August thunderstorms were experienced over North Yorkshire. The storms tracked across Yorkshire from the Pennines in the south west, across Leeds and West Yorkshire and up through York, across Ryedale to the north east and out over Scarborough into the North Sea. The storms were not widespread, as can be seen in the radar images in figures 3 - 6³, and they produced intense and localised downpours.

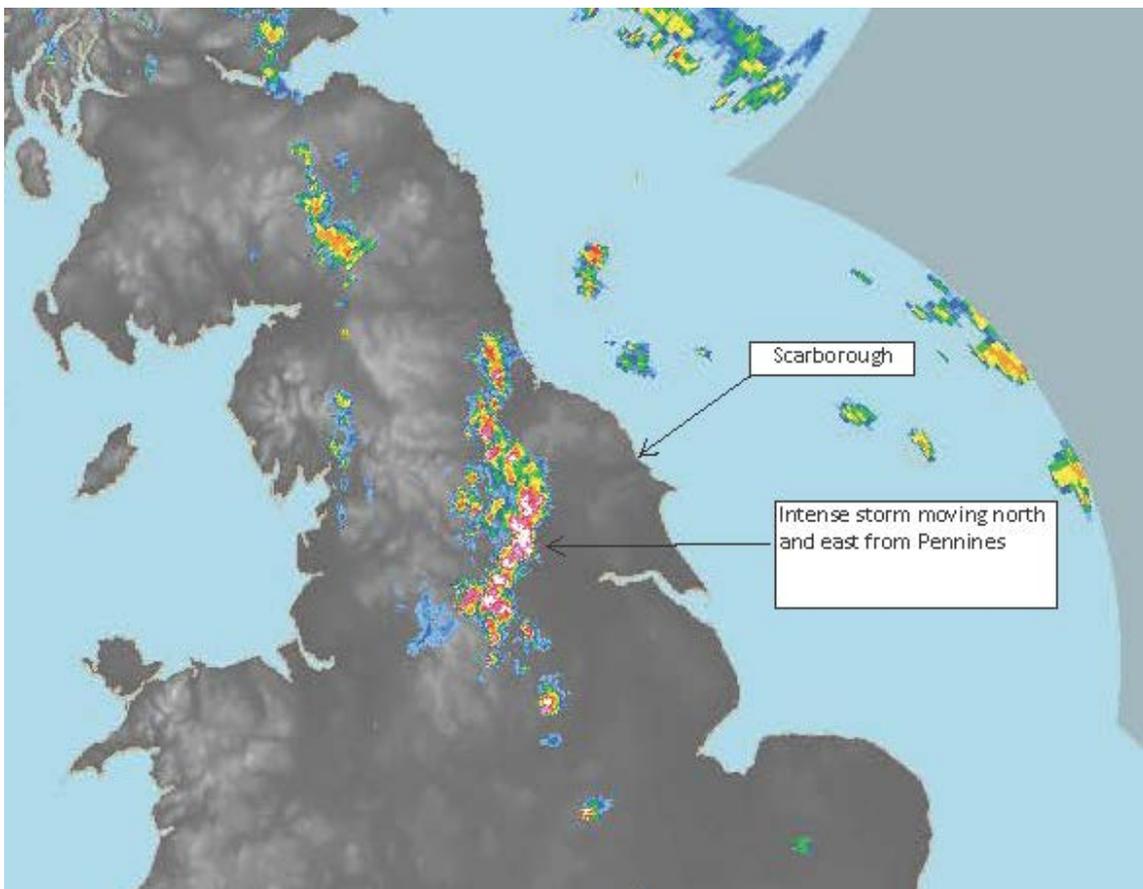


Figure 3 – radar rainfall picture at 09:00 on 23/08/2017. Storms have formed and are moving north and east from the Pennines. Source UK MET Office

³ Sourced from UK MET Office

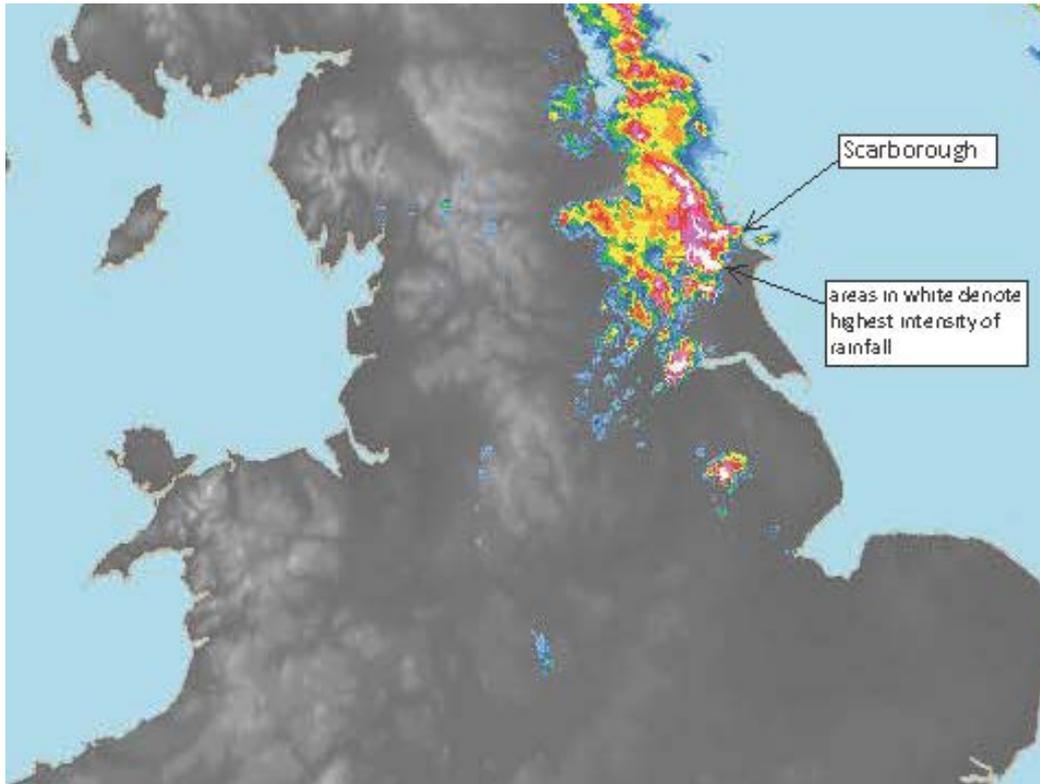


Figure 4 - radar rainfall picture at 10:30 on 23/08/2017 immediately before rain started to fall in Scarborough. Areas shaded white show the highest intensity rainfall. Source UK MET Office.

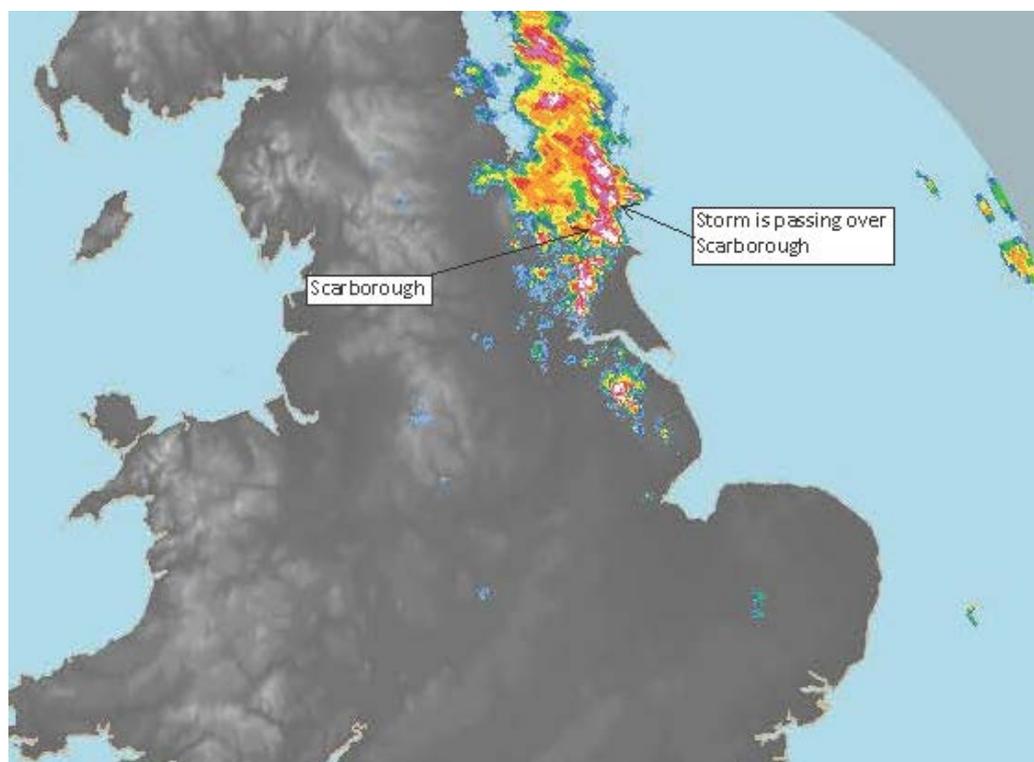


Figure 5 – radar rainfall picture at 11:00 on 23/08/2017. Storm is over Scarborough and has deposited the majority of the 37.4mm of rain which fell in the first 15 minutes.

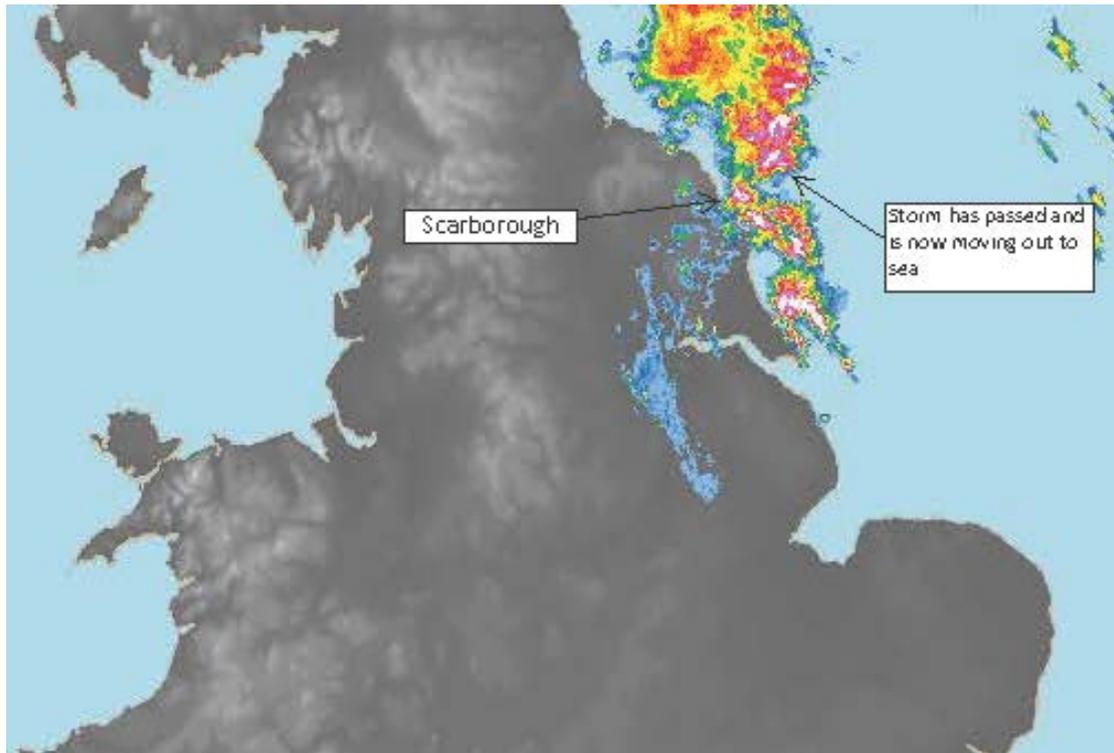


Figure 6 – radar rainfall picture at 12:00 on 23/08/2017. Storm has passed over Scarborough and is moving out to sea.

3.3 EA rain gauge

Rainfall totals from the Scarborough rain gauge show that no rain fell on the gauge throughout the morning of August the 23rd until 10:30. 16mm of rain fell in the 15 minutes from 10:30 until 10:45, and a further 12.6mm between 10:45 and 11:00. The intensity of the rainfall then tailed off and the storm had passed by midday, with no rain falling between 11:45 and 12:00. A total of 37.4mm of rain was picked up by the gauge in under an hour, the majority of it falling in just one 15 minute period. This means that were that intensity of rainfall replicated over the approximately 20 square kilometres of Scarborough 748 million litres – enough rain to fill 300 Olympic swimming pools – fell in a very short period of time.

The rain gauge indicates that Scarborough received 73% of the average August rainfall in an hour, and 30% of the long term average within one 15 minute period. The peak 1 minute rainfall rate in Scarborough was 132mm/hr (see figure 7) and could have been higher locally – a rainfall gauge in High Mowthorpe on the River Hull catchment recorded a peak rainfall intensity of 228mm/hr from the same storm, indicating that the intensity of rainfall varied within the storm. The return period for the 1 hour rainfall rate for Scarborough was 96 years⁴.

⁴ Environment Agency, Flood Hydrology Facts: Yorkshire Area Factsheet 24

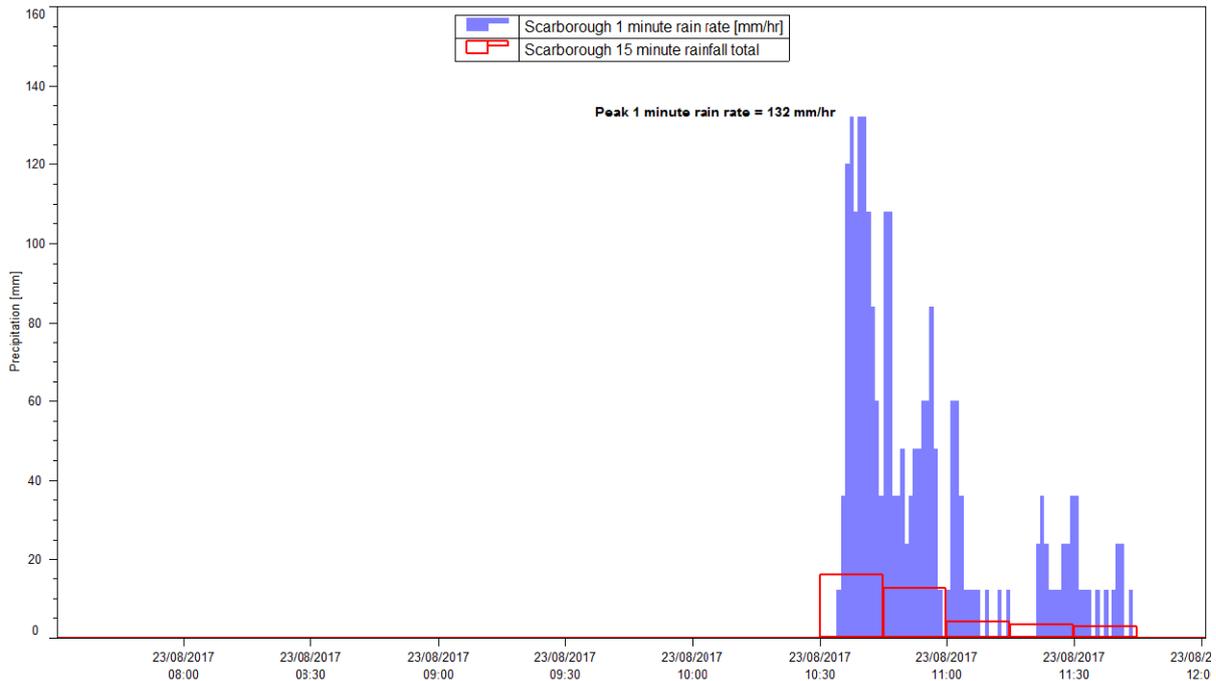


Figure 7 – Scarborough rain gauge data

Despite the amount of rain which fell during the event, the rainfall total for the day was only the 5th highest daily August rainfall total recorded in recent years for Scarborough (see figure 8⁵):

Date	Daily rainfall mm	Rank
09/08/2002	62.1	1
01/08/2002	50.5	2
07/08/2001	48.8	3
09/08/2004	39.5	4
23/08/2017	39.2	5
10/08/2014	34.6	6
25/08/2016	34.6	7
05/08/1993	30.3	8
08/08/2017	30	9
21/08/1996	27.3	10

Table 1 – Scarborough top ten August daily rainfall totals

The implication of this is that although rainfall in this event may have been particularly intense, it is not that unusual to see this volume of rainfall during an August summer storm.

⁵ Environment Agency, Section 14 information request return.

3.4 River gauge levels and flows

The Environment Agency operates two river flow gauges on the Sea cut, at the Hackness Rd Bridge in Scalby and at the weir just downstream of the A165 Burniston Rd Bridge. The gauge at Hackness Bridge records the level of the river, and the gauge in Scarborough records both river levels and flows. As can be seen from the graph in figure 9, river levels at both Hackness Rd bridge and at the A165 rose sharply from 10:45am. The Sea Cut continued to rise, peaking at 13:00 at Hackness Rd Bridge and at 13:30 at the A165. As the most intense rainfall occurred between 10:30 and 10:45 it is clear that the rivers responded rapidly, and then gradually fell over the course of the afternoon. The graph demonstrates that river levels rose again from 19:00 although it is not clear why this happened as no further rainfall was recorded by the EA’s rainfall gauge.

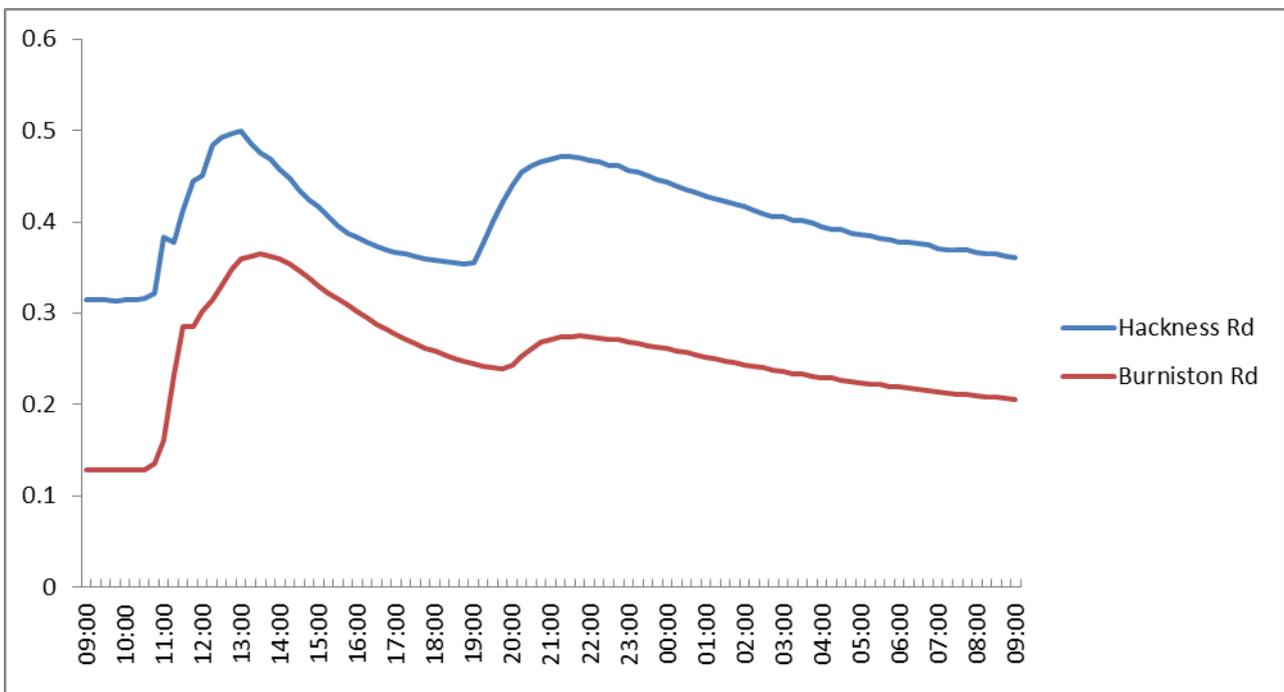


Figure 9 - river level above gauge zero.

The A165 Burniston Rd bridge gauge also records volume of flow. Throughout the morning of the 23rd August flows were around 0.186m³/s or 186 litres per second. The flow rate rose sharply from 10:45 and peaked at 4.07 m³/s or 4070 litres per second at 13:30⁶.

No reports were received of the Sea Cut coming out of bank and it is understood that river levels and flows did not significantly contribute to the flooding. Peasholm Lake did rise to a level where it overflowed onto the A165 roundabout and down to Peasholm gap, and there is evidence that the unnamed ordinary watercourse upstream of Edgehill Road came out and flowed down Edgehill Road.

⁶ Environment Agency, Section 14 Information request return

3.5 Groundwater levels

Due to the rapid onset of the flood event, groundwater levels are not thought to have played a role and groundwater levels have not been investigated for the purposes of this report.

3.6 Coastal levels and tidal influence

At the time of the rainfall on the 23rd, and during the flooding which followed, the tide at Scarborough was out. The Scarborough tidal level gauge recorded -11.466m at 11am on 23/08/2017, true tidal level was likely lower than this. High tides on the 23rd August 2017 were at approximately 05:00 and 17:15⁶. Tidal influence and wave action have therefore been discounted as a contributing factor in this flood event as outfalls to the beach would not have been affected by sea level.

3.7 Forecasts and flood warnings

The weekly MET Office advisory for the week ahead noted that there was the possibility of unsettled weather later in the week, although no warning of potential for storms was given. Similarly, the Flood Guidance Statements, the National Severe Weather Warning System and Flood Warnings Direct did not forecast storms over Scarborough in advance⁷. Fluvial flood warnings were issued by the Environment Agency for the rivers Rye and Esk, at 11:10 and 11:20 respectively. Flood warnings were not issued for Scarborough. The flood warning system for Scarborough only covers areas at risk of tidal flooding, and issuing a flood warning could have led people to wrongly believe that flooding from the sea was imminent. Flood warnings are issued only for potential tidal or fluvial flood events; surface water flooding is not covered by the current flood warning system.

⁷ NYCC Resilience & Emergencies information request return.

4 Flooding consequences

Flooding to property was reported right across Scarborough town. Reports of internally flooded properties were received from the Fire Service, from Yorkshire Water, from Scarborough Borough Council and from North Yorkshire County Council's Resilience & Emergencies and Highways departments. In total 139 reports of internal property flooding were received and many of these reports referred to multiple properties being affected. A summary of the flood reports received is presented below in table 2.

Summary of flood reports to Risk Management Authorities				
RMA	Total calls received	Internal	External	Other
Fire Service	57	43	5	1 x dangerous structure 4 x vehicles stuck in flood 1 x automatic alarm 2 x advice
Yorkshire Water	49	38	11	
NYCC Highways	70	12	58	
NYCC Resilience & Emergencies	40	Not known	Not known	
Scarborough Borough Council	4	4		

Table 2 – properties reported affected by flooding

It is not possible to say exactly how many individual properties were affected by flooding following this event. Some properties reported flooding multiple times, and to more than one agency. Some reports of flooding to property were made when flooding was threatened though had not actually occurred. There are some restrictions in terms of the data that authorities can share which could be used to identify individual properties. However the best indication from the analysis available is that internal property flooding was reported concerning 70 discrete addresses within Scarborough to various risk management authorities.

An indication of the location of those properties is given on the map in figure 10 – please note the map does not identify individual properties and the locations marked are indicative only.

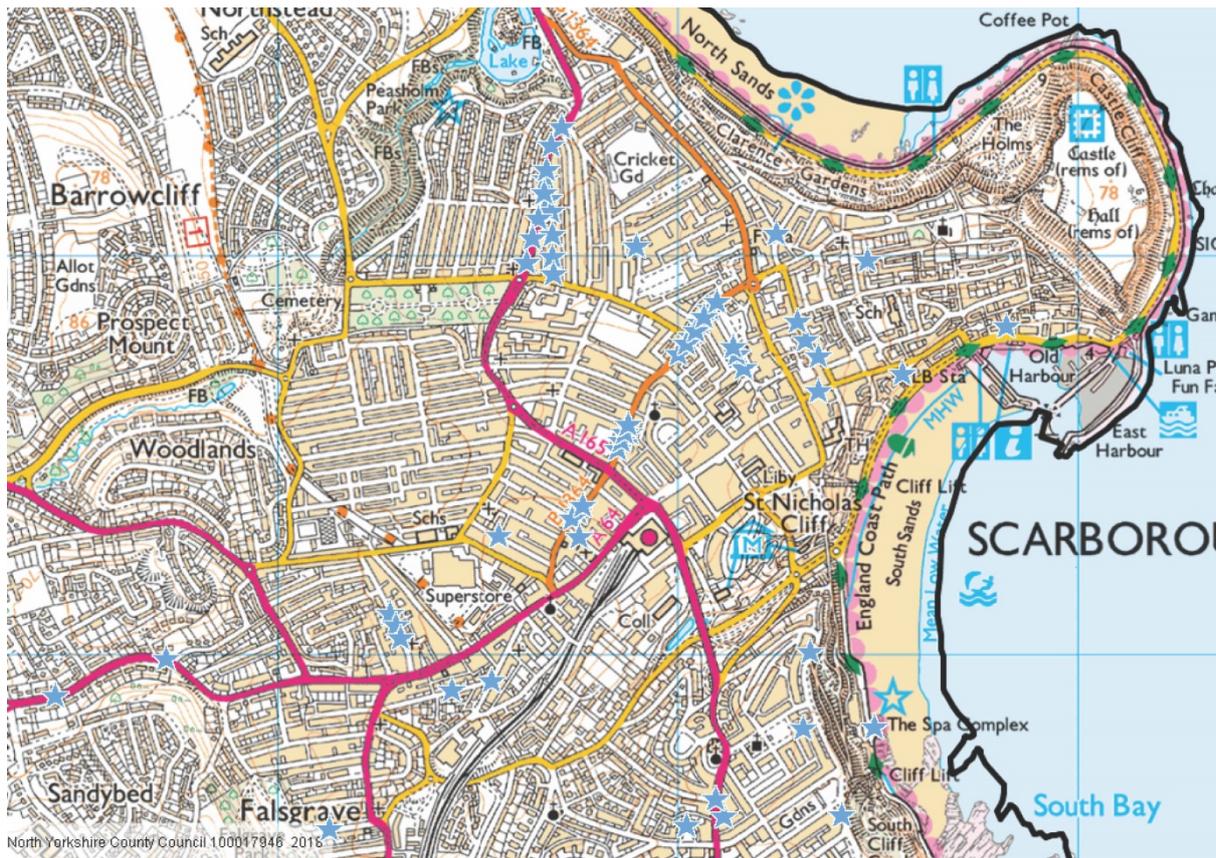


Figure 10 – indicative locations where internal flooding has been reported.

There are certain areas where multiple properties have been reported as having flooded, and these include Castle Rd, Columbus Ravine, Langdale Rd, Victoria Avenue and St Johns Road. In addition to the property level flooding, serious structural damage was reported as a result of the rainfall. The fire service responded to a report of a roof collapsing due to the rain, and a gas pipe at Peasholm Gap was damaged causing a leak which required Northern Gas Networks to attend. A number of manhole covers were lifted clear from their chambers, creating a hazard for motorists and pedestrians. In some cases vehicles driving through flood water exacerbated the problem by creating waves as they passed through too quickly.

Vehicles were trapped in the floods, and damage was reported to roads throughout the town. The list of roads which were damaged by the flood water includes:

Trafalgar Road, Sandybed Lane, Ramshill Road junction with Cambridge Terrace, Westbourne Grove, Valley Road, Briardene Ave junction with Burniston Road, High Street- Scalby, Barrowcliffe Road, Trinity Road (nr Church), Scalby Mills Road, Eastborough and Newlands Park Grove.

Flood flow routes have been inferred from reports of flooding, and damage reports received from Yorkshire Water, North Yorkshire Highways and calls to NYFRS, as well as post flood walkovers and footage of the flooding from social media. Flood flows were reported throughout the town and followed the natural topography using the roads as flood pathways, converging on The Valley, Columbus Ravine, Burnsiton Rd and Peasholm Gap.

A number of videos of the flooding were recorded, on dash cams and mobile phones, and have been posted on the internet. These give a very good impression of the flooding and can be used to identify particular locations. In some cases the footage is time stamped.

https://www.youtube.com/watch?v=4-mx9_1RLaA - shows dash cam footage taken over a 15 minute period from 11:45 to 12:00. This corresponds to the period just after the rain had stopped and when the river levels were climbing quickly, but before the maximum accumulation of flood water in low spots such as the roundabout at Peasholm Park. Deep and fast flowing water is seen flooding down Manor Rd, Scalby Rd, Columbus Ravine and manholes are seen to be surcharging with some force.

https://www.youtube.com/watch?v=To-de1qpL_g - shows water flowing rapidly between buildings and down West Sandgate, from the direction of Princess Square and a number of pedestrians are caught in the flood. Again water is surcharging from manholes under considerable pressure.

<https://www.youtube.com/watch?v=JhWxN7KZIHg> – shows flood water flowing along Edgehill Rd, from the direction of the small watercourse which flows in to a culvert through a small debris screen at the end of the road. Further footage of the flooding at various locations around Scarborough can be found on video sharing websites.

4.1 Likely causes of flooding

There have been no defects reported to this investigation on the public sewer network, and no problems reported with the drainage on the public highways network⁸. The condition of ordinary watercourses where they flow through culverts, such as the culvert downstream of Lady Edith Drive, and the culvert carrying the watercourse beneath the road on The Valley is not known.

It is understood that Peasholm Lake overflowed over the roundabout towards Peasholm Gap, and there were reports and footage on the internet of flooding from the watercourse upstream of Edgehill Rd. It is not known what condition the debris screens on the various watercourses were in, however given the rapid onset of flooding it would not have been possible to inspect and clear these during the course of the flood. There were 25 calls to North Yorkshire Highways which cited blocked gullies as being the cause of localised flooding. Of these, 4 were confirmed on inspection to actually be blocked, although as they were inspected after the event had passed it is not clear that they were blocked before the rain fell or whether they became blocked during the course of events as debris washed off the roads.

Highway drainage is designed to cope with rain which falls on the highway only, and is typically designed to cope with rainfall events up to the 1 in 30 year scale. Similarly, the public sewer network is designed to contain up to the 1 in 30 year level of rainfall event. Rainfall in excess of this will inevitably overwhelm the system, and with rainfall at a rate close to a 1 in 100 year event the capacity of the drainage network was greatly exceeded.

⁸ Yorkshire Water & NYCC Highways Section 14 information request return.

4.2 Failure of drainage systems and the mechanisms of failure

As noted above, no blockages or structural failures of the drainage system were reported. The drainage system failed to convey water away quickly enough to avert the flooding as it is simply not designed with the capacity to cope with the amount of water which was present. Although 25 reports of blocked highway gullies were received by North Yorkshire County Council Highways, only 4 of these were substantiated after the event and it is not clear whether the gullies were blocked before the event, or became blocked during it.

4.3 Flood incident response - risk management functions undertaken

The roles and responsibilities of the various risk management authorities are set out in the Flood and Water Management Act 2010, and are included in the appendices.

The flooding in Scarborough was not forecast and occurred immediately following the start of the rainfall at 10:45am. The Environment Agency opened the Incident Room in York, sent out flood warnings at 11:10 and 11:20 and despatched a patrol to monitor the situation. The patrols were necessarily focussed on monitoring the risk of river flooding in the two catchments where the flood warnings were issued, and were not in Scarborough town. An offer of assistance was made by the Environment Agency to North Yorkshire County Council⁹.

The response to the floods was primarily an emergency response, with NYFRS receiving approximately 60 calls relating to flooding inside properties and despatching 50 Fire Service personnel in 8 appliances. The Fire Service convened a “Bronze Hub” at Scarborough Fire Station to co-ordinate the actions of the Risk Management Authorities.

The rapid onset and relatively short duration of the event meant that liaison officers from partner organisations were not sent to Scarborough Fire Station.

North Yorkshire Highways Area Office responded to more than 70 phone calls during the flooding and in the immediate aftermath.

The local Highways Office team assisted with emergency road closures and associated signage, as well as monitoring the flood events and co-ordinating actions with North Yorkshire Police at road closures and continually monitored flood extents.

Once flood levels had subsided and roads were re-opened clean-up operations were requested by NYCC highways of SBC, NYCC’s contractors, Ringway Infrastructure Services, cleared gullies at Valley Road (beneath Valley Bridge).

Additional road closures were required following the subsiding of the water at Trafalgar Road due to damage from a surcharging sewer. Approximately 150m of carriageway surface had lifted.

⁹ Environment Agency Section 14 information request return

NYCC’s local highways team continued to visit all known flooding ‘black-spots’ throughout the late afternoon to afford an indication of localised flooding, all of which had cleared by this time & to ensure roads were safe/passable.

Jetting and clearing of any affected highway gullies and drainage was undertaken over the next day. Street cleansing followed where applicable.

Yorkshire Water responded to nearly 50 calls, and their Engineers and Technicians monitored telemetry to confirm that their assets were operating. They attended the Aquarium Top CSO to check on the chamber and valve mechanism, and attended a number of locations to make manhole chambers safe¹⁰.

4.4 Flood event timeline

A timeline of the flood event has been put together from information received from the Section 14 information request returns, NYCC Resilience & Emergencies and call logs from NYCC Area 3 Highways. It is illustrative and does not detail all calls made or every significant occurrence.

Wednesday 23 rd August 2017		
10:45	First rainfall recorded by Scarborough gauge	16mm of rain falls in first 15 minutes, peak rate of 132mm/hr recorded
10:45	Levels and flow in the Sea Cut start to rise steeply	The sea cut responded rapidly to the downpour. Because data is recorded in 15 minute intervals it is not clear just how quick the response was, but certainly within only a few minutes
11:10	Flood alerts issued by the EA for Rye and Esk catchments	No flood alerts sent out for Scarborough as flood warning areas cover tidal risk only
11:15	Rainfall rate decreases significantly	Rainfall rate decreases sharply
11:22	First call received by Area 3 Highways office	Customer advised that gullies could not cope with all rainfall and should wait 48 hours.
11:45	First call received by Fire service 57 flood related calls to Fire Service between 11:45 and 13:58	Caller reports dangerous structure – roof collapsing due to heavy rain, Seamer Rd
11:50	Internal property flooding and occupants requiring rescue	Fire service rescue occupants of flats on Castle Rd, who are trapped by rising flood water
12:00	Rain stops falling	No rain recorded by gauge from 12:00 onwards. Rain could have continued to fall away from the gauge but the event was passing by this point
12:22	Severe flooding on Hackness Rd reported to Area 3 Highways	Flooding had subsided by the time Highways Officer reached site, officer replaced dislodged manhole lid. Indicates water came from sewers and had sufficient force to lift the lid.

¹⁰ Yorkshire Water, Section 14 information request return

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12:24	Severe flooding reported Barrowcliffe Rd	Caller reports an adult seen swimming in flood water.
12:42	Internal property flooding reported on Nelson St	Caller reports shin high water coming through 5 or 6 front doors on Nelson St
12:50	Internal property flooding reported on Langdale Road	Multiple properties reported as being flooded
12:53	Internal flooding reported at The Spa	Fire Service respond to report of Scarborough Spa flooding.
12:56	Internal property flooding reported on Northcliffe Avenue	Drains reported as being blocked and multiple properties flooding
13:06	Ambulance station reported flooding	Ambulance Station on Queen Margarets Rd reported vehicle damage, operations affected
13:12	Manhole covers reported missing on Trafalgar Rd	Manhole covers lifted by the force of the water
13:30	Peak flow recorded on Sea Cut	2.75 hours after rain started, maximum flow rate of 4.07m ³ recorded at the A165 Burniston Bridge
13:38	Internal property flooding reported South St, Scalby	Area 3 Highways receives report of internal property flooding in Scalby
14:26	Internal property flooding reported Northcliffe	Caller reports water coming from golf course has flooded properties
16:48	Hazardous conditions reported on Valley Rd	Customer advised that Highways officers were on site and working with emergency services
18:00	River levels and flows fully subsided	Levels and flows are slightly higher than before the event, as base flow input continues

Table 3- Flood event timeline

5 Summary of impacts & findings

The flooding in Scarborough on the 23rd August 2017 caused damage to a number of roads.

Following the incident immediate critical emergency repairs were undertaken to Valley Road, Ramshill Road, Scalby Mills Road, Barrowcliff Road, Trinity Road and at Scalby Road, junction with High Street. These repairs were all undertaken by NYCC in its capacity as Highway Authority, to ensure the safety of the road network.

In addition, Yorkshire Water undertook emergency repairs to the roads at Sandy Bed Road and Westbourne Grove.

Post flood Highways inspections and damage assessments revealed that repairs were required to flood damaged surfaces at a number of locations, including:

- Ramshill Rd Junction with Cambridge Terrace
- Trinity Road
- Westbourne Grove
- Valley Road
- Briardene Ave junction with Burniston Rd
- Eastborough
- Newlands Park Grove
- Whin Bank to Scalby Road – Footpath repairs
- Prospect Mount Road

- Columbus Ravine
- Trafalgar Road
- Sandybed Lane

The total value of the work required was approximately £240k.

Infrastructure was damaged and vital services were affected, notably the Ambulance station on Queen Margaret's Road. Manhole covers were lifted and the flood flowed swiftly creating a hazard to pedestrians and motorists. At least 70 individual properties reported internal flooding though the actual numbers of properties which did flood have not been verified. There are particular locations where these were concentrated.

5.1 Conclusions

The flooding in Scarborough on 23rd August was caused by a torrential downpour which dumped most of a month's worth of rain in a very short time. The storm was not forecast or predicted, and flood warnings could not be sent out for this type of flood event. The fact that the event was not predicted, that no warnings were issued and the rapid onset of the flooding meant that there was not time for a co-ordinated response. Forecasting and warning technology is developing all the time and there may be new technologies or methods which could be of assistance.

The rainfall experienced greatly exceeded the capacity of the drainage system to convey it, causing the system to surcharge, lift manhole lids and damage road surfaces. The drainage system is built to a water industry standard capacity which means it should be able to cope with up to a 1 in 30 year rainfall event. The rainfall event which occurred was almost a 1 in 100 year event and yet was only the 5th highest August daily rainfall event in recent years. There have also been flood events in recent history in July 2007 and July 2012, and it would appear that Scarborough is vulnerable to intense summer storms.

If climate change predictions are accurate undoubtedly more of these intense, short duration, summer storms will be experienced. Upgrading Scarborough's drainage system so that it has sufficient capacity to cope with these types of events would require changes in national policy and legislation, and huge levels of investment, along with major on-going disruption while the work was undertaken. It is not realistic at this time to expect drainage infrastructure to be upgraded to a capacity sufficient to cope with this level of event.

In the absence of significant improvements to the capacity of drainage infrastructure, and given the highly impermeable nature of the urban environment, every effort must be made to keep as much water as possible out of the drainage network and only allow it in at a rate that the system can cope with.

Although no flooding was reported as a result of problems with assets on ordinary watercourses, it is not known what the current condition of some of the debris screens and culverts is. There may be material works that could be carried out to get the existing system working to its full capacity.

The steep topography in Scarborough means that when water escapes from the drainage system, it flows along the roads to collect in low lying areas. This caused significant damage to roads, most of which has now been repaired with the remainder likely to be completed by the time this report is published. There may be material improvements that could be made to highways to formalise these exceedance flood flow routes, including raising kerbs and using a more resilient surface when repairing key routes.

There are limited opportunities in an urban, highly impermeable catchment such as Scarborough for attenuating water in flood basins. Nevertheless there are some areas which could lend themselves to this approach and there is the opportunity through the development process to seek a higher degree of benefit than the usual 30% reduction of flows from brownfield sites. This would not have an immediate effect but over time has the potential to reduce pressure on the drainage network and make it more resilient.

5.2 Recommendations

The following recommendations are made following the findings of this report:

1. The LLFA to work with NYCC Resilience & Emergencies and the Environment Agency to support the work of ICASP (Yorkshire Integrated Catchment Solutions Programme) to investigate any relevant developing technologies in short term forecasting, and surface water risk warning, particularly in relation to other identified “rapid response” catchments with the aim of improving forecasting of intense, localised storms.
2. The LLFA to work with NYCC Highways to investigate the potential to adapt roads to formalise their role as exceedance pathways and utilise more resilient materials to mitigate future damages. Particular locations where this should be considered include Peasholm Gap, Eastborough and Columbus Ravine.
3. LLFA and Scarborough Borough Council should undertake further investigations into the condition of assets associated with ordinary watercourses. Blockage consequence modelling and condition surveys should be carried out on screens and culverts associated with ordinary watercourses, with the intention of informing a program of improvement and maintenance.
4. LLFA and Scarborough Borough Council to work together to identify opportunities to hold back water in attenuation areas during extreme rainfall. Locations where this could be viable include The Mere, Throxenby Mere and land upstream of Edgehill Road. The potential costs and benefits of this approach should be explored so as to inform any future requests for regional or national funding.
5. Scarborough LPA, the LLFA and Yorkshire Water seek a greater level of attenuation on brownfield sites as they come through for redevelopment where sites are discharging surface water to the public sewer network. Greenfield rates of discharge should be achieved wherever possible.
6. LLFA to make an assessment of the potential for property level resilience in areas where multiple properties are at risk from repeated events. In particular key services such as the ambulance station should be made resilient to flooding.

6 Appendices

6.1 Rights & responsibilities (authorities and landowners)

Environment Agency

Under the FWMA the Environment Agency (EA) has a strategic overview role for all sources of flooding as well as an operational role in managing flood risk from Main Rivers, reservoirs and the sea. As part of this role the EA has developed a National Flood and Coastal Erosion Risk Management Strategy for England – ‘Understanding the Risks, Empowering Communities, Building Resilience.’

This national strategy outlines the EA’s strategic functions as:

- Ensuring that flood risk management plans (FRMPs) are in place and are monitored to assess progress. The plans will set out high-level current and future risk management measures across the catchment.
- Publishing and regularly updating its programme for implementing new risk management schemes and maintaining existing assets.
- Supporting Risk Management Authorities’ understanding of local flood risk by commissioning studies and sharing information and data.
- Supporting the development of local plans and ensuring their consistency with strategic plans.
- Managing and supporting Regional Flood and Coastal Committees and allocating funding.

The EA’s operational functions are/include:

- Risk-based management of flooding from main rivers including permissive powers to do works including building flood defences.
- Regulation of works in main rivers through the consenting process.
- Regulation of reservoirs with a capacity exceeding 10,000m³.
- Working with the Met Office to provide severe weather warnings – available to Risk Management Authorities.
- Provide warning of flooding on main rivers.
- The maintenance and operational management of main river assets including flood defences.
- Statutory consult-tee to the development planning process.
- The power to serve notice on any person or body requiring them to carry out necessary works to maintain the flow in main rivers.

'Main Rivers' are defined through an agreed map which is updated annually. These tend to be the larger rivers in the country, though some smaller watercourses in sensitive locations are also defined as 'Main Rivers'.

The EA are also category 1 responders regarding flood risk (Civil Contingencies Act 2004). They are required to warn and inform of flood risk.

Water Company

Water companies in England and Wales are named as a Risk Management Authority under the Flood and Water Management Act 2010 and must have regard to the Local Strategy of the LLFA. They are required to manage risks associated with assets or processes that may cause or be affected by flooding, and must share relevant data with other flood risk authorities.

They also have flood risk management functions under the Water Resources Act (1991). Relevant actions of water companies include: the inspection, maintenance, repair and any works to their drainage assets which may include watercourses, pipes, ditches or other infrastructure such as pumping stations.

The Civil Contingencies Act 2004 (CCA) also designates water and wastewater undertakers as statutory category 2 responders to national disasters and emergencies, placing on them duties to share assured information with other responders in an appropriate manner.

North Yorkshire County Council (NYCC)

NYCC, as Lead Local Flood Authority, has flood risk management functions which include (but are not limited to);

- Provision of a Local Flood Risk Management Strategy (LFRMS).
- Designation and maintenance of a register of structures or features that have a significant effect on flood risk.
- Consenting and enforcement works on Ordinary Watercourses.
- Responding to statutory consultations on drainage proposals in planning applications.
- Undertaking Section 19 investigations.

NYCC also has responsibilities as a Highways Authority and as an Emergency Responder (under the Land Drainage Act 1991 and the Civil Contingencies Act 2004 respectively) which may relate to flooding.

Highway Authorities are responsible for providing and managing highway drainage which may include provision of roadside drains and ditches, and must ensure that road projects do not increase flood risk.

The Highways Authority has a duty under the Highways Act 1980 to maintain highways that are maintainable at public expense. This includes a duty to maintain existing highways drainage. Highway drainage systems are designed to take highway surface water. Highway drainage systems are not designed as "storm drains", and do not have the capacity for the level of rainfall from an extreme flash flood. The Highway Authority has powers to improve drainage systems but no duty to do so.

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Roadside gullies are subject to routine maintenance in accordance with the NYCC Highway Asset Management Plan. The frequency of cleaning is dependent on an evidence based categorisation of risk, determined by factors relating to the consequence of failure and a range of other operational factors. NYCC are investigating drainage improvements in critical locations with a history of flooding.

District or Borough Council

District and Borough Councils are named as Risk Management Authorities within the Flood and Water Management Act 2010, and are required to comply with the LLFA Local Strategy. Through the planning processes, they control development in their area, ensuring that flood risks are effectively managed.

In addition, in relation to the Civil Contingency Act (2004), the District and Borough Council:

- Are a Category 1 Responder. On a priority basis, they will provide sandbags to residents and businesses where property is at risk of flooding.
- Support the Emergency Services on request by providing Incident Liaison Officers.
- Provide emergency accommodation – i.e. set up rest centres as required and other welfare provision.
- Assist with arranging transport or evacuating areas.
- Participate in vulnerable people searches.
- Assist with co-ordination of recovery.

The NYCC Resilience & Emergencies Unit provides support to the District Council.

Internal Drainage Board

Internal Drainage Boards (IDBs) are local operating authorities established in areas of special drainage need (typically low lying areas) in England and Wales.

IDBs have permissive powers to undertake works to secure clean water drainage and water level management in designated drainage districts. In managing water levels IDBs have an important role in reducing flood risk in areas beyond their administrative boundary.

All Risk Management Authorities

All RMAs under the Flood and Water Management Act (2010) have a responsibility to cooperate and coordinate with regards to their flood risk management functions, including raising awareness of flood risk and the sharing of information.

Riparian Owners

Landowners whose land is adjacent to a watercourse are known as 'riparian owners'.

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A landowner can be an individual e.g. home owner or farmer, private business or an organisation e.g. the district council as park owner, on school grounds the county council as property owner.

A watercourse is defined as every river, stream, ditch, drain, cut, dyke, sluice, sewer (other than a public sewer) and feature through which water flows, but which does not form part of a Main River.

Riparian owners have legal duties, rights and responsibilities under common law and the Land Drainage Act 1991 for watercourses passing through or adjoining their land. These responsibilities are to:

- Pass on the flow of water without obstruction, pollution or diversion affecting the rights of others.
- Accept flood flows through their land, even if these are caused by inadequate capacity downstream.
- Maintain the banks and bed of the watercourse and keep structures maintained.
- Keep the bed and banks free from any artificial obstructions that may affect the flow of water including clearing litter, heavy siltation or excessive vegetation.

Guidance on the rights and responsibilities of riparian ownership are outlined in the Environment Agency publication 'Living on the edge', available at:

<http://www.environment-agency.gov.uk/homeandleisure/floods/31626.aspx>

6.2 Useful contacts & links

Flood Forecasting Centre

The Flood Forecasting Centre (FFC) is a partnership between the Environment Agency and the Met Office, combining our meteorology and hydrology expertise into a specialised hydrometeorology service. The centre forecasts for all natural forms of flooding - river, surface water, tidal/coastal and groundwater.

Online Flood Risk Mapping

This service uses computer models to assess an area's long term flood risk from rivers, the sea, surface water and some groundwater.

<https://flood-warning-information.service.gov.uk/long-term-flood-risk/map>

National Flood Forum

A charity to help, support and represent people at risk of flooding.

<https://nationalfloodforum.org.uk/>

North Yorkshire Local Resilience Forum

NYLRF is a partnership of local agencies working together to prepare for, respond to and recover from potential major incidents and emergencies via the duties stated in the Civil Contingencies Act 2004 (CCA).

<http://www.emergencynorthyorks.gov.uk/>

NYCC Resilience & Emergencies Unit

The resilience and emergencies unit is responsible for planning for a wide variety of potential incidents and emergencies that could affect the population of North Yorkshire.

NYCC Flood & Water Management

As lead local flood authority, we investigate and assess flood risks, including flooding from surface water, groundwater and existing watercourses. We work with partners involved in flood and water management to protect communities from the impact of flooding.