Workington including Barepot

Flood Investigation Report

Barepot and Hall Park View, Workington 6/12/15
Photograph provided by Peter Smith Photography. Taken 06/12/2015 12:45

Flood Event 5-7th December 2015

This flood investigation report has been produced by the Environment Agency as a key Risk Management Authority under Section 19 of the Flood and Water Management Act 2010 in partnership with Cumbria County Council as Lead Local Flood Authority.

Version	Prepared by	Reviewed by	Date
Working Draft for discussion with EA	Rachel Gerrard	Chris Evans	May 2016
Draft incorporating EA feedback	Rachel Gerrard	Chris Evans	20 June 2016

Contents

Executive Summary

Workington and Barepot experienced severe flooding on the 5th, 6th and 7th of December 2015 during and after Storm Desmond. This storm caused a period of prolonged, intense rainfall across Northern England, falling on an already saturated catchment, and led to high river levels and flooding throughout Cumbria and beyond. The flow in the River Derwent on the 6th December was the highest flow ever recorded, with the previous record set in the November 2009 floods. Record levels were also observed in Derwentwater and Bassenthwaite Lake.

In response to the flood event, this Flood Investigation Report has been completed by the Environment Agency as a key Risk Management Authority (RMA) working in partnership with Cumbria County Council as the Lead Local Flood Authority, under the duties as set out in Section 19 of the Flood and Water Management Act 2010. This report provides details on the flooding that occurred in Workington on the 5th, 6th and 7th of December 2015, and has used a range of data collected from affected residents, site visits, surveys of the area, and data collected by observers, along with river and rainfall telemetry during the flood event.

Within the Hall Park View area, 28 residential properties, the Cricket club, Bowling club, and the Cumbria Constabulary West Area Headquarters were reported as having suffered internal flooding. The flooding in Hall Park View was from the River Derwent and via Soapery Beck, a millrace from the River Derwent. Hall Park View does not benefit from any flood defences.

Environment Agency constructed defences, and personal property level protection defend 23 properties in Barepot. However, 7 properties were reported as being internally flooded from the River Derwent and via overland flow into Barepot Reservoir. Defences in Barepot leaked and were outflanked due to the high river levels. The rapid response and actions of the local residents blocked off a flow route which would have lead to much greater volumes outflanking the defences. No defences were breached, and defences are seen to have reduced damage and delayed the onset of flooding, allowing residents additional time to prepare and reduce the impact of the flood.

Please note that references to left and right bank are taken looking downstream with the flow of water.

Seventeen actions have been recommended in this report to manage future flood risk. These will require the involvement of a number of organisations and local communities. These include a review of the performance of the Barepot defended line in order to identify any areas that can be improved. This review will also include potential improvements to processes such as flood warnings and recovery. This review is being undertaken by the Environment Agency separately to this report.

In response to the flooding, community meetings have taken place, and these will continue in order to ensure that all those affected are given the opportunity to be involved in reducing the flood risk to the town.

Any additional information that can be provided to the Environment Agency and Cumbria County Council to help develop our understanding of the flooding is welcomed. A lot of information has already been provided, much of which has been used to inform this report. Any additional information should be provided to;

http://www.cumbria.gov.uk/planning-environment/flooding/floodriskassessment.asp

Introduction

Under Section 19 of the Flood and Water Management Act (2010) Cumbria County Council, as Lead Local Flood Authority (LLFA), has a statutory duty to produce Flood Investigation Reports for areas affected by flooding. Section 19 of the Flood and Water Management Act 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.

This section of the Act leaves the determination of the extent of flood investigation to the LLFA. It is not practical or realistic for Cumbria County Council to carry out a detailed investigation into every flood incident that occurs in the County, but every incident, together with basic details will be recorded by the LLFA.

Only those with 5 or more properties/businesses involved will have investigations published.
An investigation will be carried out, and a report prepared and published by the LLFA when the flooding impacts meet the following criteria:

- where there is ambiguity surrounding the source or responsibility of flood incident,
- internal flooding of one property that has been experienced on more than one occasion,
- internal flooding of five properties has been experienced during one single flood incident and
- there is a risk to life as a result of flooding.

As a flood Risk Management Authority (RMA), the Environment Agency have partnered with Cumbria County Council (CCC) to produce the 53 flood investigation reports across Cumbria.

Scope of this report

This Flood Investigation Report **is**:

- an investigation on the what, when, why, and how the flooding took place resulting from the 5th-7th December 2015 flooding event and
- a means of identifying potential recommendations for actions to minimise the risk or impact of future flooding.

This Flood Investigation Report **does not**:

- interpret observations and measurements resulting from this flooding event. Interpretation will be undertaken as part of the subsequent reports,
- provide a complete description of what happens next.

The Flood Investigation Reports outline recommendations and actions that various organisations and authorities can do to minimise flood risk in affected areas. Once agreed, the reports can be used by communities and agencies as the basis for developing future plans to help make areas more resilient to flooding in the future.

For further information on the S19 process, including a timetable of Flood Forum events and associated documentation, please visit the County Council website at:

http://www.cumbria.gov.uk/floods2015/floodforums.asp

To provide feedback on the report please email **LFRM@cumbria.gov.uk**.

Flooding History

Prior to the 2009 flood event, neither Hall Park View or Barepot had any history of flooding from the River Derwent. The November 2009 flood event was estimated to be an event with a rarity greater than 0.2% Annual Exceedence Probability (AEP)[1]. The AEP describes the likelihood of a specified flow rate (or volume of water with specified duration) being exceeded in a given year. There are several ways to express AEP as shown in Table 1. Throughout this report AEP is expressed as a percentage. As such, an event having a 1 in 100 chance of occurring in any single year will be described as a 1% AEP event.

Table 1-Probabilities of Exceedance

AEP (as percent)	AEP (as probability)
50%	0.5
20%	0.2
10%	0.1
4%	0.04
2%	0.02
1%	0.01
0.1%	0.001

At the time, the November 2009 event produced the highest recorded flow in the River Derwent. It occurred following torrential rainfall with 1 month of average rainfall falling on the 19th November 2009. Prior to 2009, modelling was completed to produce a flood map to show the limit of the predicted 1% AEP flood extent. Both the 2009 and 2015 events have exceeded estimates and have changed the nature of the river corridor through erosion and deposition.

In November 2009, the flooding from the River Derwent washed away bridges (Navvis Bridge and A597 in Workington) and resulted in the loss of life to a member of Cumbria Constabulary. 31 premises, including 30 residential properties, were flooded in the Seaton Mill and Barepot areas. In Workington, properties in Hall Park View and Forgehammer Court were flooded, with the Bowling and Cricket Club also inundated. Flooding was reported in Hall Park View (30mm deep), the Cumbria Constabulary Headquaters, Fusion Nightclub, Coopers Walk, Ladies Walk Brewery and Wilkinson's Opera/Bingo House building. Flooding was also reported at Workington Hall Mill and Seaton Mill.

During the 2009 flood event, the raised riverside track in Barepot that ran along the bank top of the River Derwent was destroyed. This ran from the United Utilities intake above the Yearl to Crossings House, offering protection from floodwater (see Figure 2). The destruction of this track, in conjunction with the passage of flows back into the river near Crossings House, reopened the floodplain East of Barepot. The protection offered by the raised track was replaced by a length of embankment in 2010, constructed opposite the Meadow View properties. This embankment was tied into a sandstone wall to the rear of Glenfield place. The wall was reinforced with a blockwork skin to the rear.

The flow re-entry point, just upstream of Crossing House suffered a large amount of erosion during the 2009 flood event. To prevent further erosion of the river bank at the re-entry point, large logs were used to stabilise the river bank.

[1] Estimate taken from CEH briefing note **http://nora.nerc.ac.uk/s510223/1/Nov09Floods-CEH-briefing-note.pdf**

Event background

This section describes the location of the flood incident and identifies the properties that were flooded.

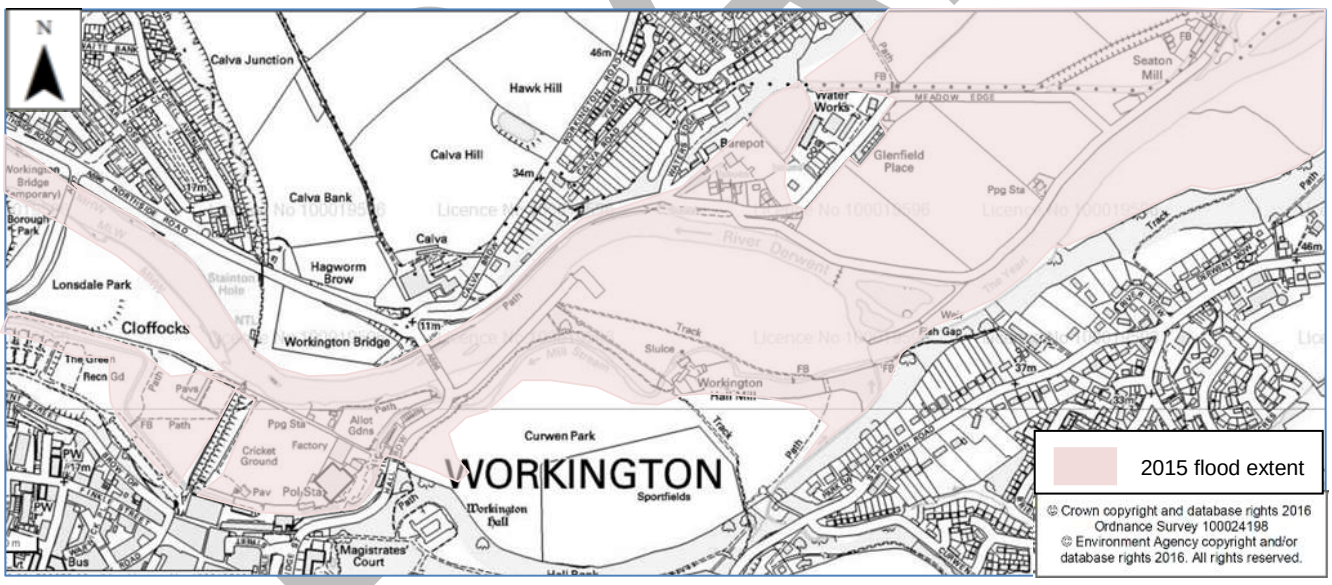
Flooding Incident

Workington is a port town of 28,000 people located at the mouth of the River Derwent on the West Coast of Cumbria. The River Derwent catchment has an area of 617km^2 and includes the tributaries of the Rivers Marron, Cocker, Greta, and Glenderamackin. The catchment also includes the lakes, Thirlmere, Derwentwater, Bassenthwaite, Buttermere, Crummock Water and Loweswater. The towns of Keswick and Cockermouth are located on the Derwent, upstream of Workington.

The River Derwent passes to the north of Workington town centre which is on high ground. Historically water was diverted from the River Derwent into mill races at the Yearl weir. These feed Soapary Beck, and the Seaton Mill / Salmon Hall weirs feed Barepot Reservoir. These mill races, although now currently unused by industry, still provide waterways though residential areas.

On 5-7th December 2015, 36 properties suffered internal flooding in the Workington and Barepot area, while others experienced flooding of gardens, footpaths and roadways. The area affected by the flooding is shown in Figure 1. Storm Desmond caused 36 hours of intense rainfall leading to high river levels on the River Derwent. The extent of the flood is similar to that of the 2009 event.

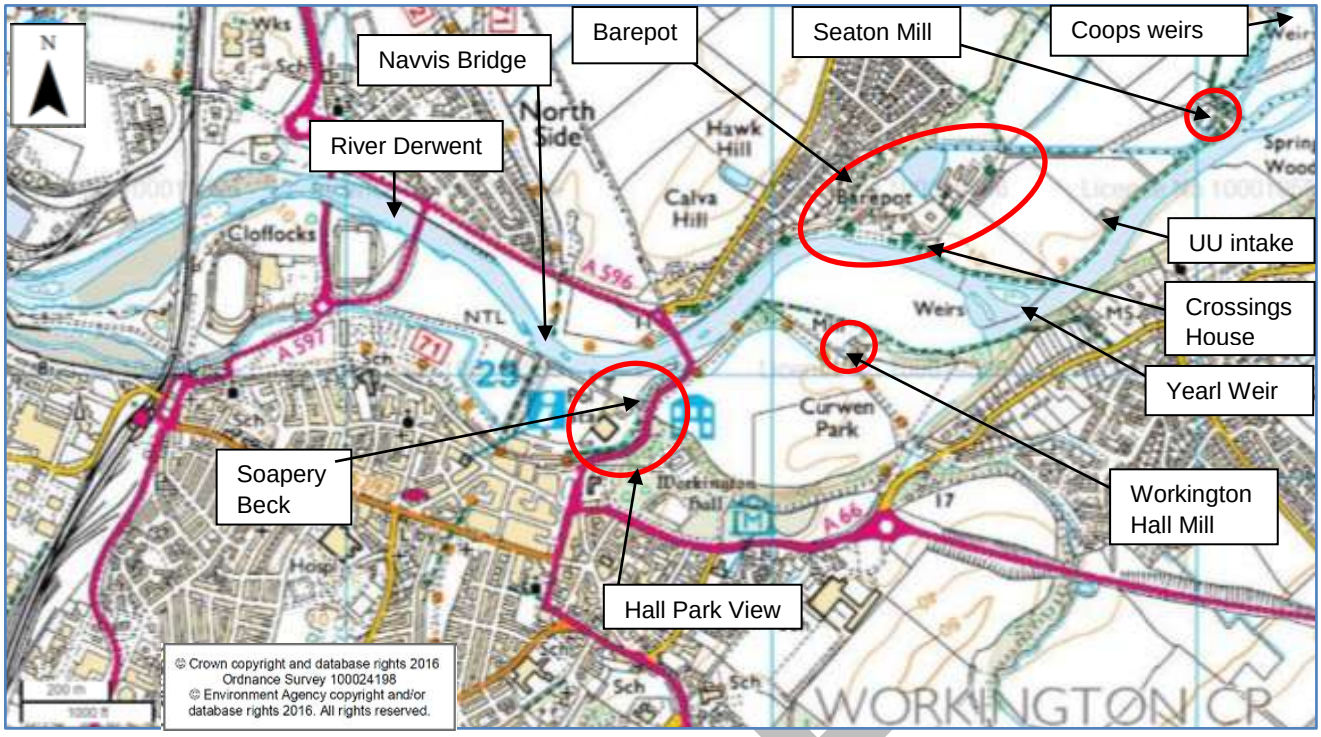
Figure 1- Extent of River (Fluvial) Flooding* in Workington 5-7th December 2015
*The flood outline identifies the maximum extent of flooding. Not all properties within the extent area were flooded.



For this report, the flooded area has been divided into 5 sub-areas for investigation. These are based on flood flow routes. These sub-areas are shown in Figure 2:

- **Hall Park View –** The area on the left bank of the River Derwent and road to Workington Bridge.
- **Cricket Ground & Cumbria Constabluary –** The area around Soapery Beck flow route.
- **Workington Hall Mill –** The area on the left bank of the River Derwent downstream of the Yearl.
- **Barepot –** The right bank of the River Derwent upstream of Workington Bridge.
- **Seaton Mill** – Upstream of Barepot, downstream of the Coops Weirs.

Figure 2- Identification of Areas Flooded (and key features)

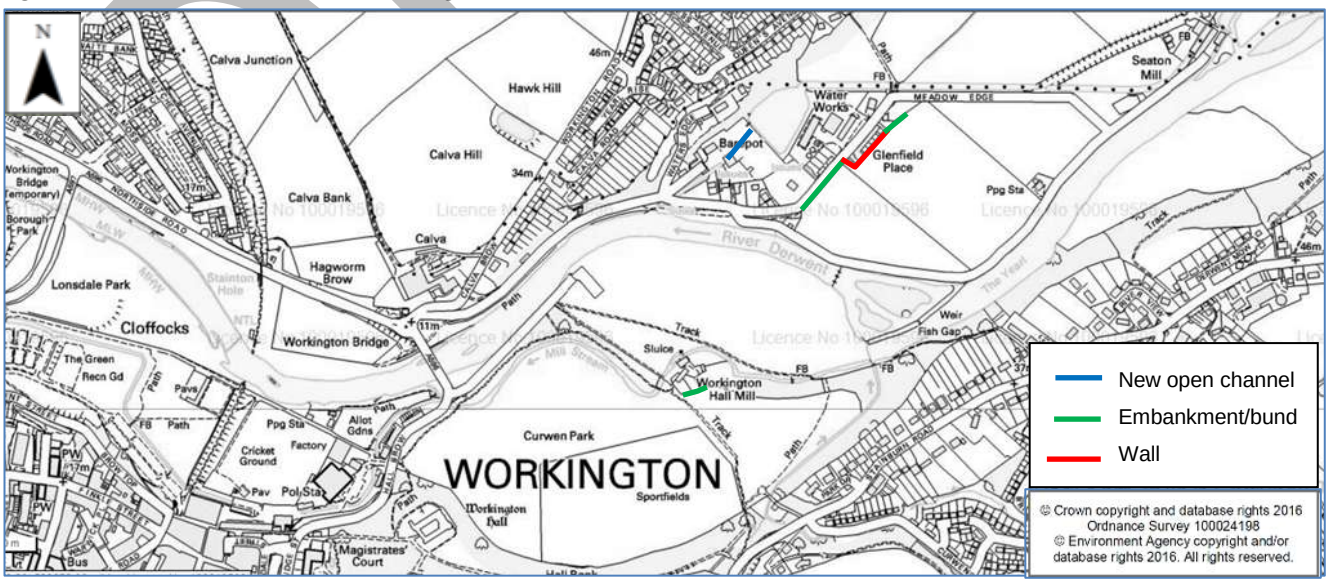


Existing Flood Defences

Barepot benefits from Environment Agency flood defences, constructed after the 2009 floods. This includes an embankment constructed opposite the Meadow View properties tying into the old railway embankment behind Crossings house. This embankment was tied into a sandstone wall to the rear of Glenfield place. The wall was reinforced with a blockwork skin. In 2014 work was carried out to reduce the risk of flooding from Barepot reservoir by opening up a culvert to a larger capacity open channel. See Figure 3.

A small bund was also constructed by Allerdale Borough Council at Workington Hall Mill. Hall Park View does not benefit from flood defences. Many residents also used property level protection.

Figure 3- Flood Defences in Workington



Investigation

This section provides details of the rainfall event and the likely causes of flooding in the area.

This investigation was carried out by the Environment Agency through surveys of the area, and data collected from the community affected. This report has compiled this data to provide details of flooding from the River Derwent which is a Main River.

Rainfall Event

December 2015 was the wettest calendar month on record for the UK, with much of northern England receiving double the average December rainfall. This also followed a particularly wet November and as such, much of the ground within the Cumbria catchments was already saturated.

From the 4th to the 7th of December there was a period of prolonged, intense rainfall caused by Storm Desmond. Over this period, new 24 hour and 48 hour rainfall records were set for the UK. Both of these were within Cumbria and broke the previous records, also within Cumbria, set during the November 2009 floods.

Table 2 shows the record levels of rainfall that fell prior to the flooding event. Table 3 shows the rainfall more widely recorded over the catchment on the 4th and 5th December 2015. Figure 4 shows the location of these rain gauges in the Derwent Catchment.

Table 2-UK Rainfall Records

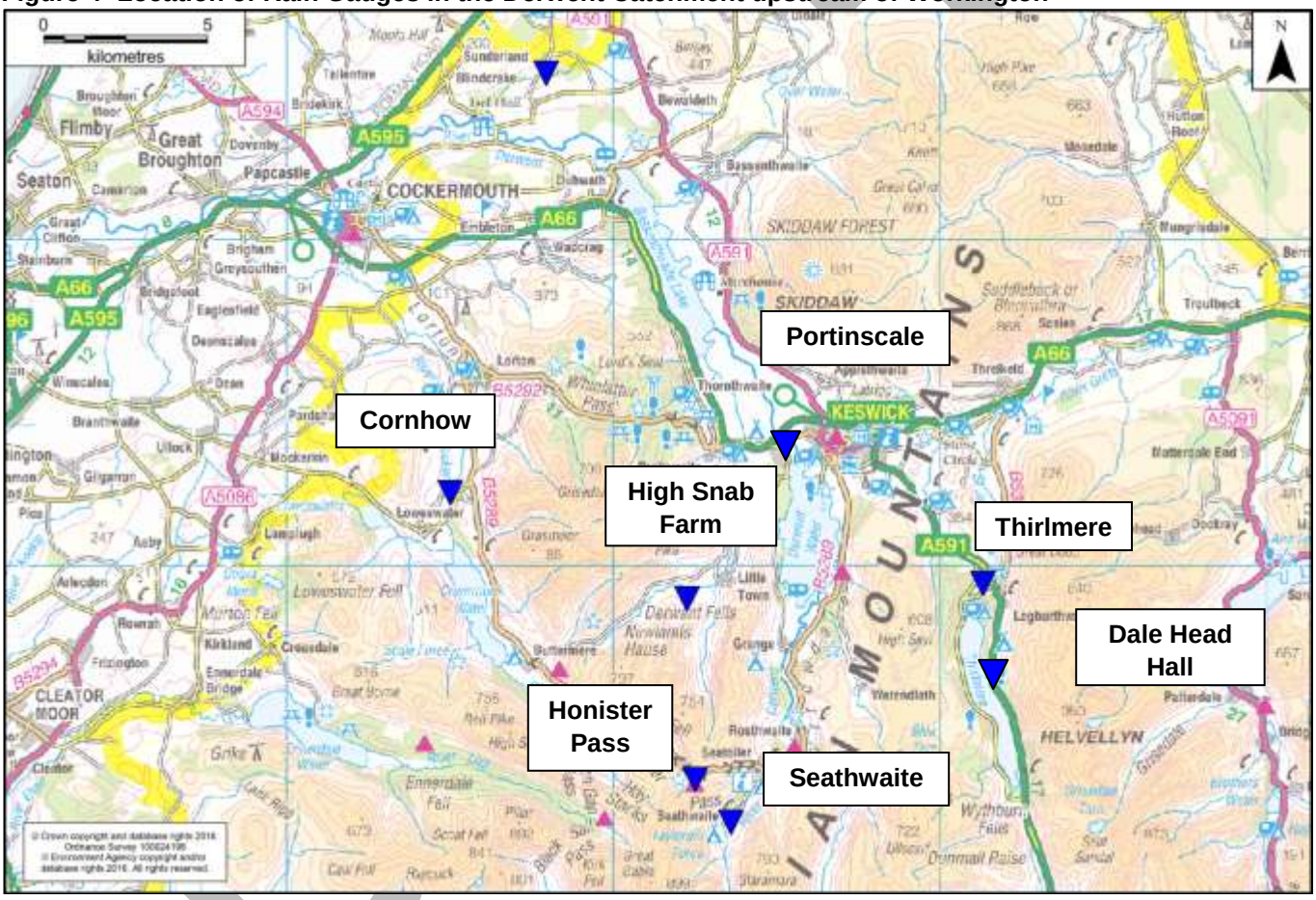
	Previous record November 2009		Current Record December 2015	
	Location	**mm**	**Location**	**mm**
24 hour rainfall	Seathwaite	316.4	Honister Pass	341.4
48 hour rainfall	Seathwaite	395.6	Thirlmere	405

Return periods (calculated using historical rainfall event data) have been calculated for this event. Two of these locations have recorded rainfall that is estimated to be rarer than 0.1% AEP.

Table 3-Rainfall recorded at gauges in the Derwent Catchment upstream of Workington

Monitoring Station	Rainfall (mm)			Estimated Annual Exceedance Probability[2]
	4th December	5th December	Rolling 24 hour Rainfall	
Cornhow	12.8	81.8	94.4	7.1%
High Snab Farm	39.6	159.2	193.0	0.7%
Honister Pass	58.6	294.4	341.4	**<0.1%**
Seathwaite	36.6	185.2	214	1.33%-1.67%
Thirlmere	35.0	317.6	324.8	**<0.1%**

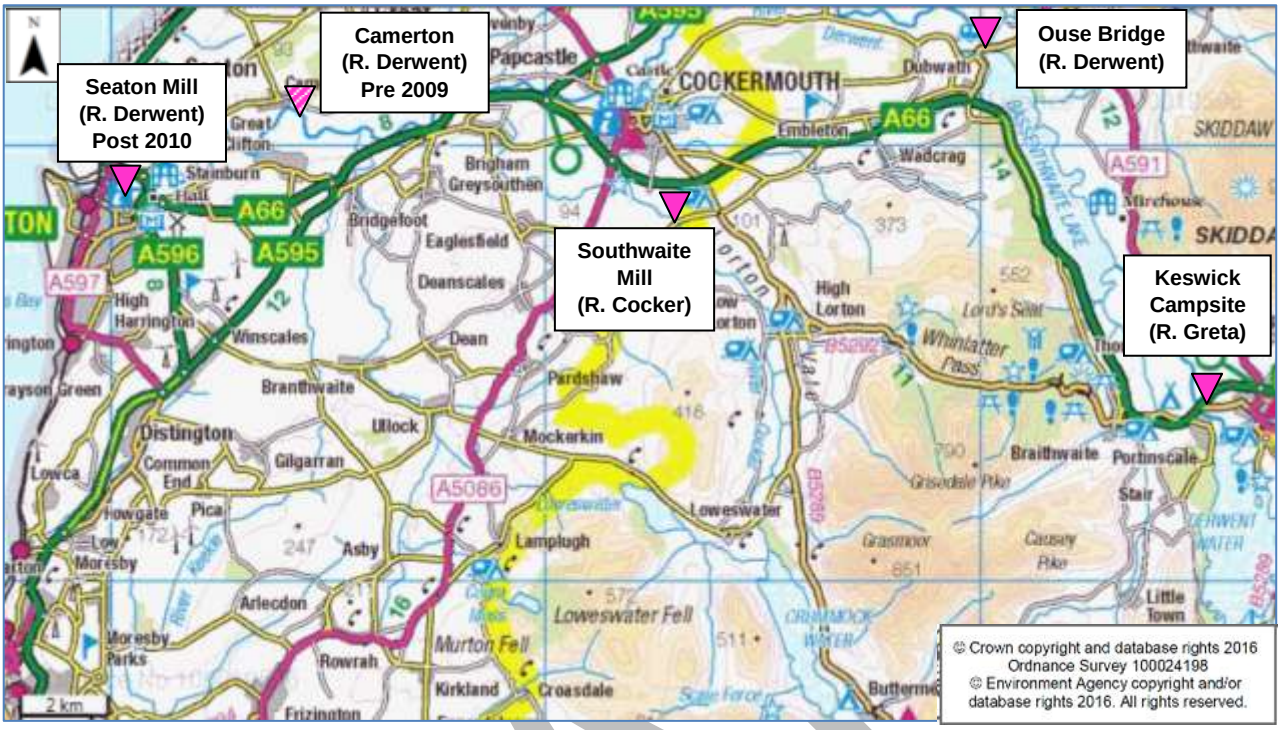
Figure 4- Location of Rain Gauges in the Derwent Catchment upstream of Workington



[2] Calculated using FEH DDF methodology, this estimation is not calibrated for values with an AEP less than 0.1%

There are a number of river monitoring gauges upstream and within Workington measuring flow and level on the River Derwent. The locations of these are shown in Figure 5.

Figure 5- Location of River Gauging stations upstream of Workington



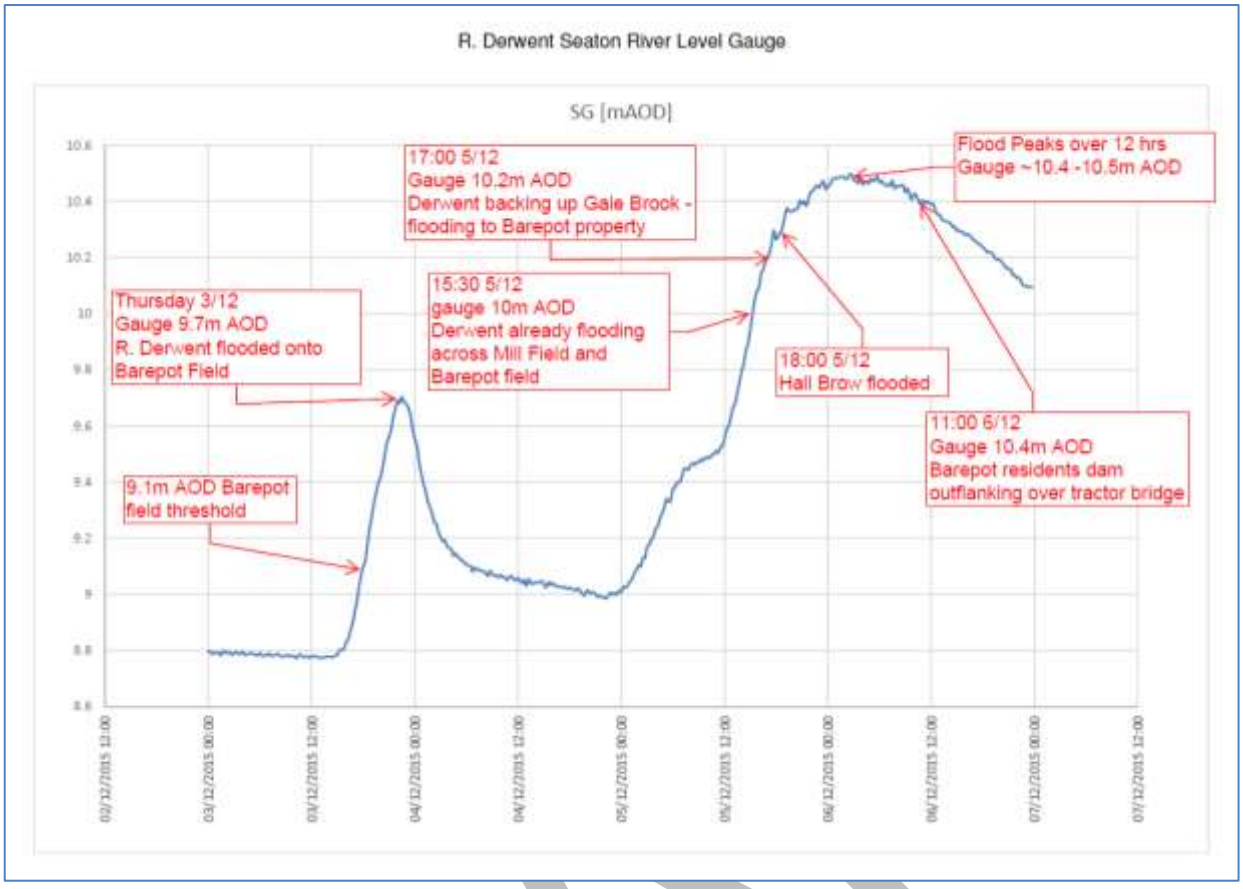
For the Ouse Bridge gauging station on the River Derwent, the flows on 5th December 2015 were higher than those for any previous flood event. See Table 4 for River Derwent flows.

Table 4- Peak Flows recorded on the River Derwent

Gauging Station	River	Peak flow (m3/s)					Estimated return period of Dec 2015 event (years)
		Dec 2015	Past Events				
			June 2012	Nov 2009	October 2008	Jan 2005	
Seaton Mill	Derwent	410	215	-	-	-	TBC
Camerton	Derwent	-	-	-	301	293	TBC
Ouse Bridge	Derwent	395	154	378	187	196	TBC

NB Camerton gauge was destroyed during the 2009 flooding, Seaton Mill is the replacement.

Figure 6- Seaton Mill River gauge 3-7th December 2015



The National Tide Limit for Workington is shown extending to Navvies Bridge on the River Derwent (for location, see Figure 2). High tides that coincided with the peak of the flood were at 19:15 on Saturday 5th December and 07:30 on Sunday 6th December 2015.

Map of Flow Routes

There were a number of flooding flow routes during the event, shown in Figures 7 and 9, with supporting aerial photographs, Figures 8 and 10. The details of these flow routes, and the flooding within each of the identified areas, is discussed in the 'Impacts and Likely Causes of Flooding' section.

Figure 7- Flood flow routes over Workington Hall Park and through Hall Park View

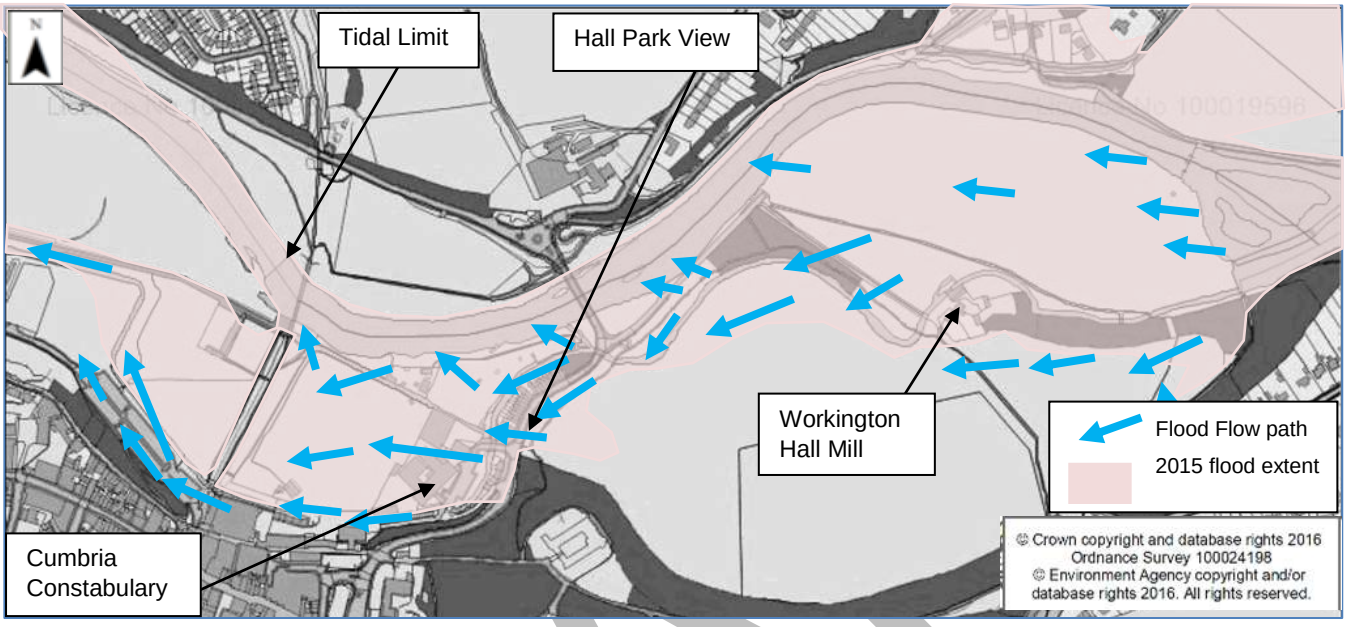


Figure 8- Aerial Photo of the River Derwent through Workington
Photograph provided by Peter Smith Photography. Taken 06/12/2015 12:45

Figure 9- Flood flow routes Seaton Mill and Barepot

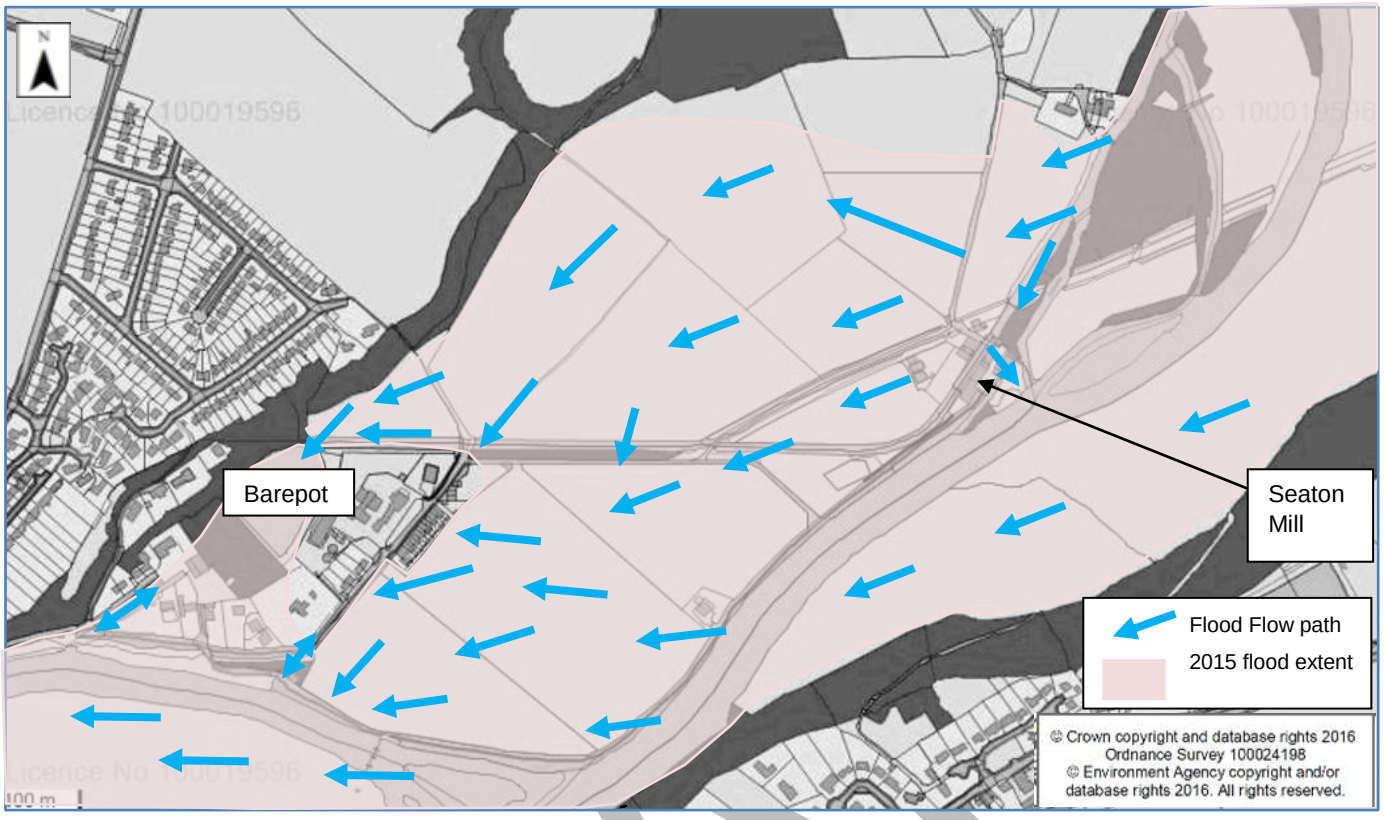


Figure 10- Aerial Photo Barepot **Photograph provided by Peter Smith Photography. Taken 06/12/2015 12:45**

Impacts and Likely Causes of Flooding

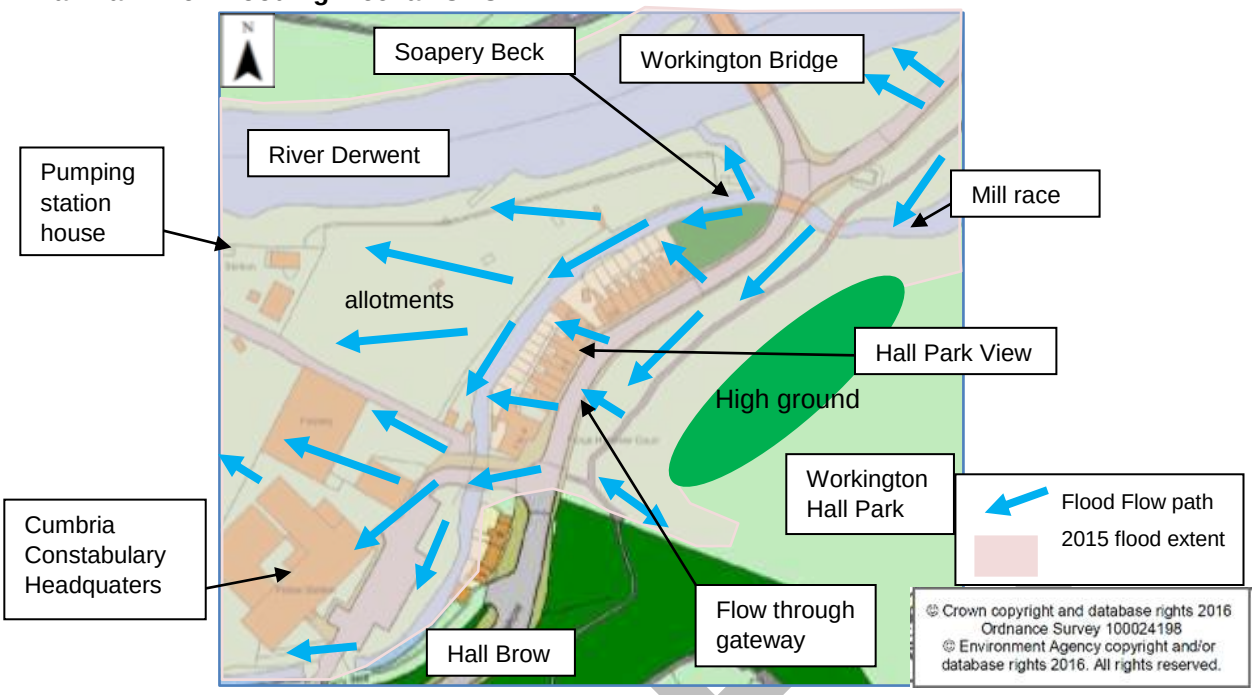
Timeline

Table 5- Timeline of events and actions, before, during and after Storm Desmond, in the Workington and Barepot area.

Friday 4th December	**Event**
15:30	Flood Alert issued
Saturday 5th December	**Event**
~13:00	Barepot field starts to flood
14:00	Seaton Mill Gauge reads 9.8m AOD
15:30	Seaton Mill Gauge reads 10m AOD
~ 16:00	Workington Hall Mill evacuated. Mill Field flooding
17:00	Seaton Mill Gauge reads 10.2m AOD
~ 17:00	Gale Brook floods Crossing House due to high levels in the River Derwent Flow fro the Derwent returns up the culvert to add to flooding in Barepot.
~ 18:00	Hall Park View area now flooded – no access to Workington Bridge
21.01	Flood Warning Issued
21:15	Seaton Mill Gauge reads 10.4m AOD
Sunday 6th December	**Event**
~11:00	Barepot residents dam Tractor crossing to prevent outflanking flows
11:30	Seaton Mill Gauge reads 10.4m AOD
17:56	Flood Warning update
19:30	Seaton Mill Gauge reads 10.2m AOD
15:30	Flood waters receding – no longer flowing through Crossings House
20:12	Flood Alert updated
19:50	Flood Warning update
Tuesday 8th December	**Event**
Tuesday 8 Dec at 17:32	Flood Warning removed

Hall Park View

Figure 11- Hall Park View flooding mechanisms



The area of flooding at Hall Park View is similar to that of the 2009 event. In the Hall Park View area 32 properties, 28 residential, the Cumbria Constabulary West Area Headquarters, the Cricket Club, and Bowling club experienced internal flooding. Floodwaters from the River Derwent filled Mill Field and then flowed overland to surround Workington Hall Mill, finally overwhelming the mill race downstream of the Mill to Hall Park View, see Figure 11.

At Hall Park View, the mill race flows under the road and becomes Soapery Beck. The bridge over this section had insufficient capacity during the 2015 event. This resulted in floodwaters to flow out of the banks and along the park wall, through a gateway from the park onto the road. From here, floodwater flowed across through the properties and into Soapery Beck at the rear. Soapery Beck follows the rear of Hall Park View, past the police station and Bingo hall, past the new Leisure Centre, Allerdale House and Tesco to outfall at the Town Quay.

The River Derwent flooded through Hall Park View for over 24 hours before the water level started to recede. After passing through Hall Park View, floodwaters from the River Derwent inundated Soapery Beck which channelled flow to the rear of Hall Park View properties, flooding their basement rooms. Overland flow also flooded the allotments, pumping station house and Cumbria Constabulary Headquarters.

During the 2009 flood event, erosion under Workington Bridge (Calva Bridge) almost caused the bridge to collapse. Extensive works were carried out to rebuild the bridge pier rather than demolish the historic bridge. Without modelling, the influence of the bridge on flood levels is difficult to determine as Hall Park View threshold levels are below the level of the bridge arches. On this occasion (see figure 12), the bridge still had capacity whilst at the same time flood waters were flowing through Hall Park View.

Figure 12- Workington Bridge during the flooding

Flood flows returning to the river have caused substantial erosion to the river bank both upstream and downstream of Workington Bridge. Downstream of the bridge, on the left bank between the allotments and the river, a strip of land is owned by Iggesund for access to their pumping station intake. Upstream of the bridge, the land is owned by Allerdale Borough Council with the road access to Mill Field and Workington Hall Mill on the edge of the riverbank.

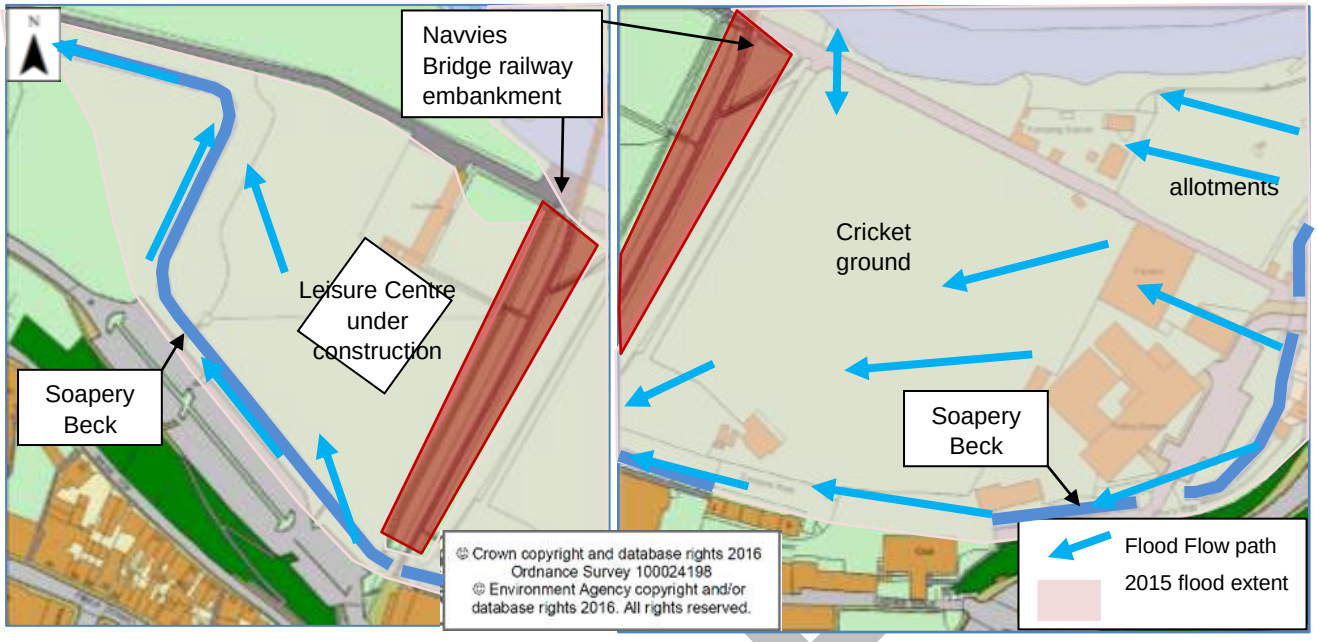
Property numbers 1-5 Hall Brow, are built into the hillside with their basements at ground level at the rear, and first floor at ground level at the front. In these properties the basements flooded from Soapery Beck at the rear. Additionally, property numbers 1 & 2 were reported to have flooded prior to the main flooding event, on the night of the 3rd/4th December due to the intense rainfall impacting surface water drains.

The wrack mark surveyed post December 2015 at Hall Park View was 7m AOD.

Figure 13- Aerial Photo Hall Park View
Photograph provided by Peter Smith Photography. Taken 06/12/2015 12:45

Cricket Ground and Cumbria Constabulary Headquarters

Figure 14- Cricket Ground and Cumbria Constabulary Headquarters flooding mechanisms



Downstream of Hall Park View, the mill race that flows through the park becomes Soapery Beck. Flood waters passing across Hall Park View overwhelmed Soapery Beck, and flowed overland through the allotments and through the Police Station into the Cricket Ground. Soapery Beck assists in draining the area but has limited capacity, and bridge obstructions, which cause the water to flow out of the channel when the capacity is exceeded. The Leisure Centre, currently under construction, is divided from the cricket ground by the old railway embankment leading to Navvies Bridge.

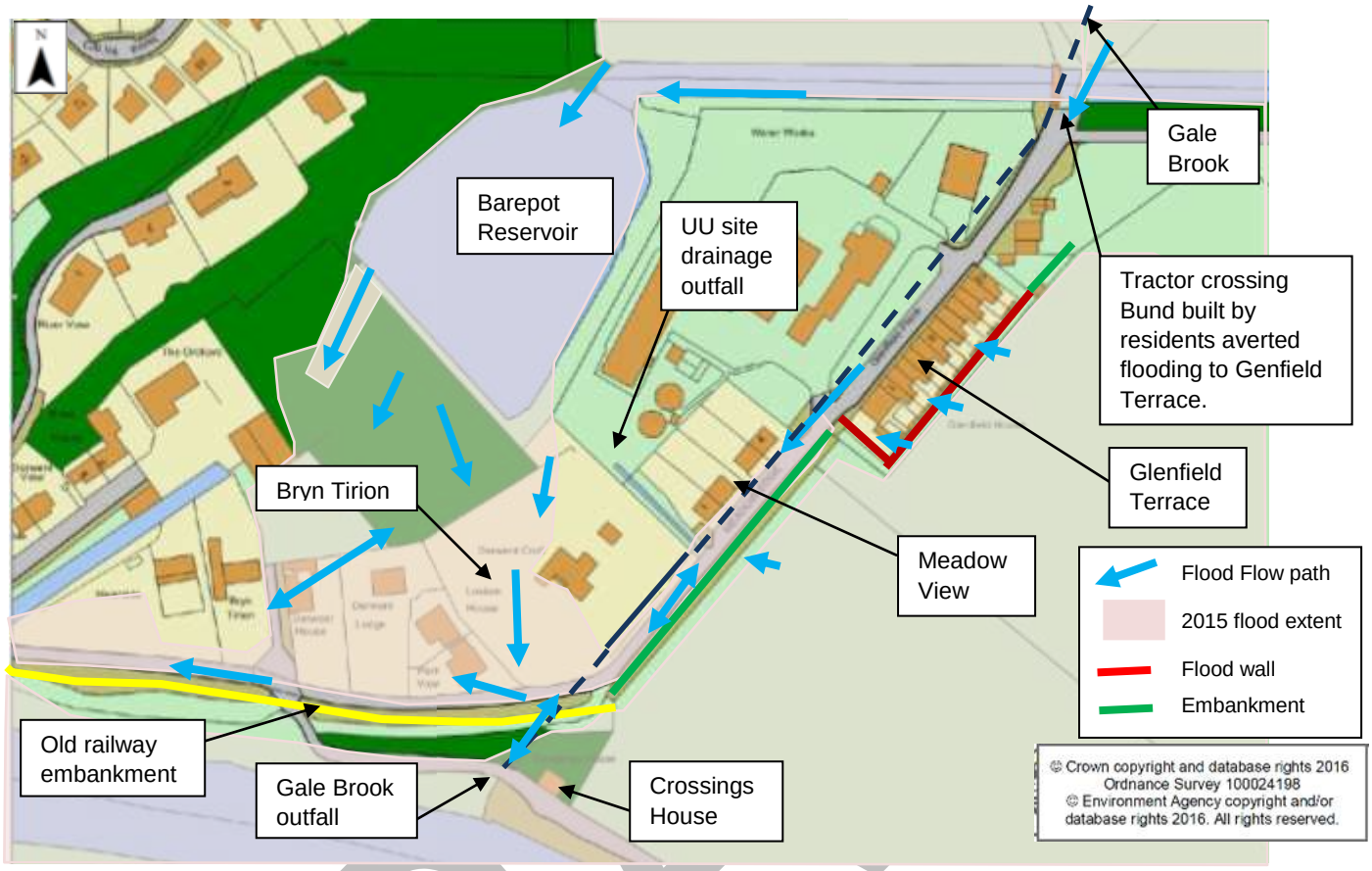
Contractors thoroughly inspected the Leisure Centre site, and established that it did not receive any overflow of water from the River Derwent. Floodwater from the Soapery Beck flowed towards the main entrance of the leisure centre, but did not enter the building.

The only areas of the Leisure Centre that were flooded were near places where the blockwork was incomplete so that the contractors had access to different parts of the building. There was some water in the incomplete swimming pool area, which was still exposed to the elements as its windows have not yet been installed. In addition, part of the bund wall had not yet been built to its correct height. This meant that the water could enter that area.

Figure 15- Cricket Ground / Cumbria Constabulary
Photograph provided by Peter Smith Photography. Taken 06/12/2015 12:45

Barepot

Figure 16- Barepot Flooding Mechanisms



Out of 23 properties in Barepot, seven are recorded as having been flooded as a result of Storm Desmond. The flooding came from a number of directions, see Figure 16 and 17.

- The embankment and wall constructed in 2010, following the loss of the raised riverside track in 2009, provided protection from the force of the flood flow and kept out the majority of the floodwater. However, seepage occurred through the wall, see Figure 23. Water was against the wall and embankment for over 12 hours. The seepage through the wall ran down the road and into Gale Brook.
- At Approximately 17:00 hrs on Saturday 5th December, river levels rose to approximately 10.2m AOD (Seaton Gauge), submerging the Gale Brook outlet into the River Derwent. Flood water from the River Derwent returned up the outlet of Gale Brook through the culvert under the old railway embankment, adding to the impact of flooding.
- The flow across the fields to the North of Barepot entered the reservoir and mill race. The work to de-culvert, carried out below Barepot Reservoir in 2014, contained the majority of this flow although some flow overtopped, again adding to the flooding impact in Barepot, see Figures 19 and 20. Flood waters also leaked through the reservoir wall. See Figure 21
- The overland flows from the fields also crossed over the mill race at the tractor crossing, see Figure 22, and flowed down the road past Glenfield Terrrace. The quick actions of residents constructing a bund across the tractor crossing prevented more serious flooding.
- Personal property protection measures were used by residents, and this helped to keep floodwater out of many properties. However, the size of the flood meant that the efforts at some properties were insufficient to keep the water out.

The wrack mark surveyed following the event on the river side of the embankment was 9.3m AOD

Figure 17 Barepot
Photograph provided by Peter Smith Photography. Taken 06/12/2015 12:45

Figure 18 Flooding at Crossings House

Figure 19 Flooding outside Bryn Tiron

Figure 20 Overland flow from Barepot Reservoir

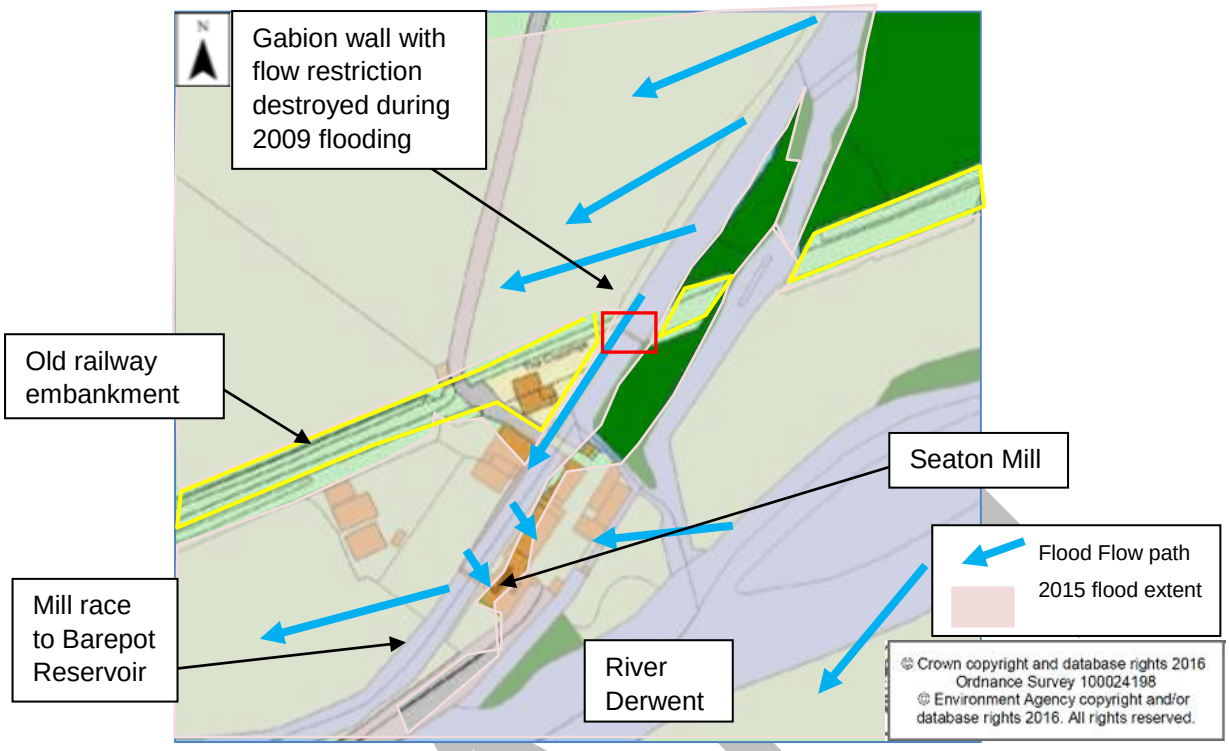
Figure 21 Barepot Reservoir wall leaking

Figure 22 Meadow View and Flood Bank

Figure 23 Wall to rear of Glenfield Place

Seaton Mill

Figure 24 Seaton Mill Flooding Mechanisms

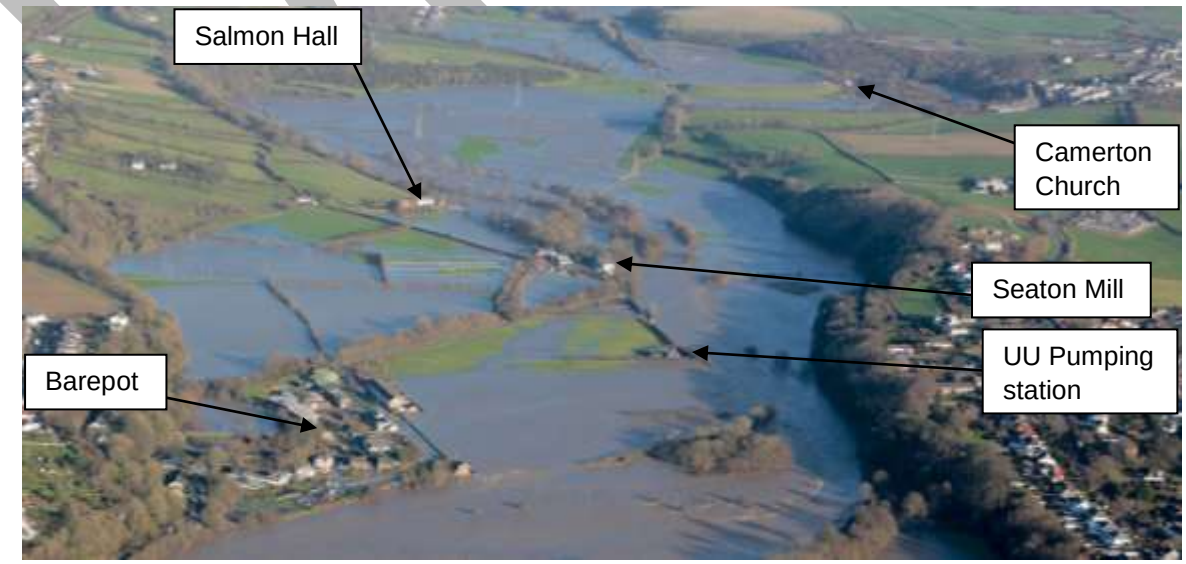


Seaton Mill has flowing water on both sides of the property, see Figure 24. The River Derwent flows to the front of the buildings, with the mill race to Barepot Reservoir flowing to the rear. The mill race is approximately 2-3m higher than the river. During the 2009 flood event, a gabion wall on the mill race was washed away, leaving the flow to Barepot reservoir uncontrolled and governed wholly by the water levels on the River Derwent upstream. During very high river levels, the gabion structure is outflanked by overland flow, which crosses the fields to re-enter the mill race and reservoir downstream.

The 2015 flood event resulted in water overtopping from the mill race to join floodwaters from the River Derwent in the front yard of Seaton Mill. Personal property protection measures were used to keep the majority of the water out of the buildings.

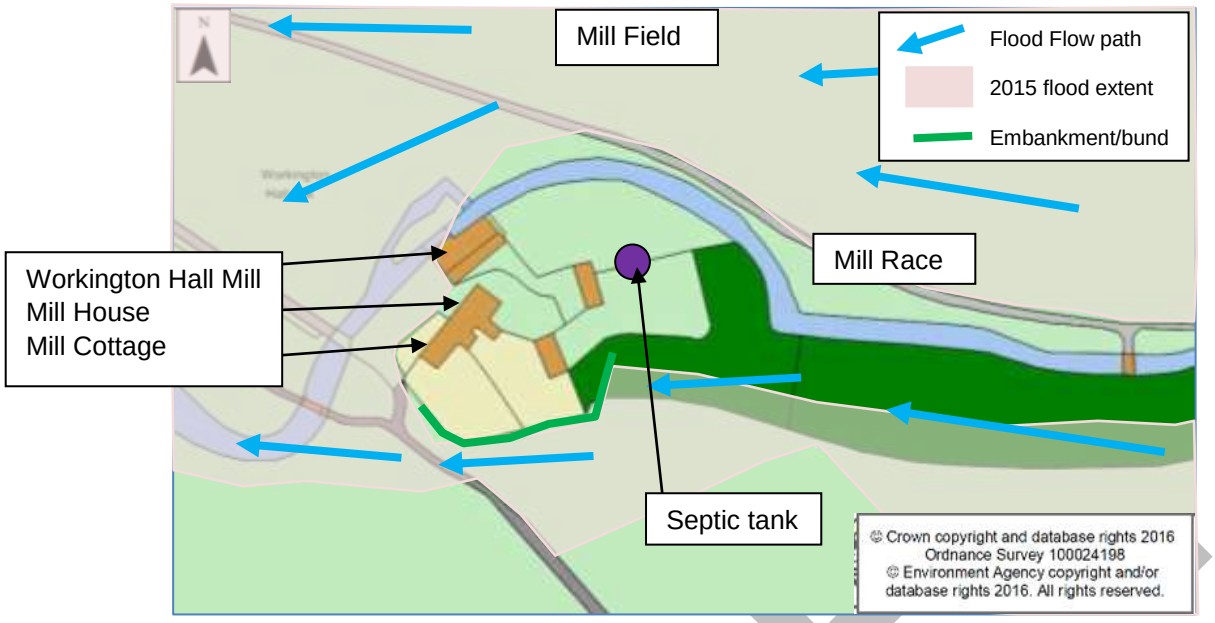
Figure 25 Seaton Mill

Photograph provided by Peter Smith Photography. Taken 06/12/2015 12:45



Workington Hall Mill

Figure 26 Workington Hall Mill flooding mechanisms



Workington Hall Mill consists of three residential properties built on raised ground in the middle of Workington Hall Park, see Figure 26. Mill Field lies to the north, making up the flood plain of the River Derwent which is just beyond. The mill race is fed from the Yearl Weir on the River Derwent. The Workington Hall Mill buildings flooded in 2009. Following this event, a small bund was constructed to protect the properties. In addition to this, residents also installed personal property protection measures. During the 2015 event no properties at Workington Hall Mill flooded. Some water was seen to flow through the yard of the Mill which is suspected to be back flow, overflowing from the septic tank.

Figure 27 Workington Hall Mill and Mill Field

Photograph provided by Peter Smith Photography. Taken 06/12/2015 12:45

Environment Agency Flood Incident Response

The first flood alert was issued for the rivers Cocker, Marron and Derwent on Thursday 3rd December 2015. The Flood warning for Barepot and Hall Park View was issued at 21.01 on Saturday the 5th December, by which time properties had already been flooded.

Maintenance Activities

During May 2015, Cumbria County Council and the Environment Agency have carried out CCTV inspections of culverts and highways drains.

The Environment Agency maintains flood risk management structures and sections of river channel where maintenance actively reduces the risk of flooding to people and property. Activities we undertake are summarised below:

- We conduct visual inspections of flood defence embankments and walls and deliver a variety of maintenance tasks which include, as necessary:
    - grass cutting,
    - tree and bush management,
    - invasive species control,
    - vermin control and
    - expansion joint repairs.

- We deliver targeted maintenance on River Channels where the activity is beneficial to the reduction in flood risk. This could include:
    - Weed Control,
    - Grass Control,
    - Tree and Bush Management,
    - Invasive Non Native Species Control,
    - Gravel Removal, when justified through investigation and survey.

In Workington we undertake grass cutting of the embankment opposite Meadow View and weed control at Barepot reservoir open channel. Weed control is also undertaken along Soapery Beck and checks/inspections are undertaken along Ling and Scale Becks.

United Utilities: Thirlmere Reservoir

Background

Thirlmere reservoir was built in 1894 to supply drinking water for Manchester. The reservoir can store up to 40,000 megalitres (million litres) of water and approximately 700,000 people – about 10% of the region's water users - receive drinking water supplies from Thirlmere. Most are in Manchester but other communities include Blackpool and the Fylde coast, Lancaster and of course local communities such as Keswick and Borrowdale.

At the southern end of Thirlmere is the Thirlmere aqueduct. This is a 134 mile long gravity tunnel which links Thirlmere to Manchester. The aqueduct extracts up to 220 million litres per day of water from Thirlmere.

Thirlmere discharges into St John's Beck, which is a tributary of the River Greta. The River Greta flows through Keswick and joins the River Derwent just after it leaves Derwent Water as it flows towards Bassenthwaite Lake. St John's Beck accounts for about one fifth of the water in the River Greta.

How Thirlmere is operated

Thirlmere reservoir is maintained and managed according to legislation and the local arrangements agreed with Keswick Flood Action Group (KFAG). United Utilites operate to a set of flood level drawdown rules agreed with KFAG.

These rules specify reservoir levels for each month at which United Utilities will release more water into St John's Beck. Releases continue until the relevant month's target level is achieved and continues in order to maintain it if necessary. This is a best endeavours effort, as incoming water from rainfall and the catchment may be greater than the maximum possible releases

In November, this level is 3.0m below top water level – equivalent to 76% full. The idea being that this spare capacity can absorb some of the heavy rain which falls during these months. United Utilities operated the reservoir to these agreed levels prior to the December flood event.

However, the catchment is in a delicate environmental balance and there is a natural limit to the amount of water that United Utilities can release without causing damage to St Johns Beck which is part of the River Derwent and Bassenthwaite Lake Special Area of Conservation. The normal compensation flow in St John's Beck is 13.64 million litres per day. United Utilities can increase this to 100 million litres per day.

Even at this level, it causes some flooding to farmland. Any more than 100 million litres per day and more farmland will flood on a more frequent basis. United Utilities also have to consider the impact increased flows have on those who use the beck for fishing. All releases, except for the 13.64 million litres per day compensation, are ceased if the reservoir starts to spill

November 2015- Levels in Thirlmere Reservoir.

United Utilities can increase the rate at which water is removed from the reservoir up to a certain limit. When the Thirlmere Aqueduct is open, the safe and environmental limit is 320 million litres a day. If the rain falls faster than this then the reservoir will start to fill until it eventually overflows.

In November 2015, there had already been more than twice the normal level of rainfall expected for the month. Thirlmere reservoir was filling throughout November, and started to spill over on Monday 30 November. The reservoir level reached 1.56m above the weir crest during Storm Desmond, the highest recorded level. This level was still within the design parameters of the dam, and below the potential maximum flood for which it was designed. The parapet (roadside) wall is designed to be an integral part of the dam. It is a substantial, water tight structure that will retain the maximum still-water flood during the probable maximum flood. Studies and inspection reports indicate that the wall is sufficient to withstand the effects of waves to the top, and just spilling over the wall. This is how the wave wall operated during Storm Desmond, and the wall has not suffered damage.

On 5th December alone, around 14,000 million litres of water entered the reservoir, which is more than a third of its capacity. The average rainfall for Cumbria for the month of December is 146.1mm, and more than this fell during one day. Over the course of the weekend, flows down St Johns Beck were higher than ever recorded before. Given the amount of rainfall, increasing the outflow beyond 320 million litres per day would have made little material difference.

Future investment

United Utilities have been considering options for further flood drawdown releases, and possible modifications to the infrastructure at Thirlmere as part of the new pipeline scheme to West Cumbria.

Limitations to the speed of reservoir drawdown, caused by constraints at the dam outlet to St John's Beck, are well understood and following studies, potential solutions have been identified. These solutions will be considered as part of the detailed design of the modifications to abstraction infrastructure, new water treatment works, and pipelines for the Thirlmere to West Cumbria transfer.

Current flood drawdown releases are approximately 100 million litres per day. The limitation is not the outflow from the low level scour valves on the dam, which can release up to 900 million litres per day in emergency draw down for reservoir safety. The issue at present is infrastructure downstream of the valves, including a bridge that could be washed away if flows higher than the currently agreed releases are made.

Work has progressed to develop the long term provision of water to West Cumbria, which will include a solution that could allow a higher rate of release. In essence, this is to engineer a channel to accommodate the higher flows, and make modifications to the valves to enable better control. This would allow approximately 500 million litres per day of flood drawdown release to be made whilst still maintaining flows to the Water Treatment Works to supply customers.

United Utilities are committed to ongoing engagement with KFAG, the Environment Agency, and Natural England regarding the volumes of water that can be released into St. Johns Beck in the future. An environmental assessment will need to be conducted in to the impact of releases downstream of the reservoir and this will involve all parties mentioned above, as well as local residents who could potentially be impacted by any changes.

St John's Beck is part of a Special Area of Conservation and therefore any solution needs to be compliant with the Habitats Directive.

United Utilities currently estimate that construction of new infrastructure will begin in 2017 and take an estimated 12 months to deliver the work to accommodate the releases in to St John's Beck.

Recommended Actions

The following table details recommended actions for various organisations and members of the public to consider using the Cumbria Floods Partnerships 5 Themes: Community Resilience, Upstream Management, Strengthening Defences, Maintenance, and Internal Drainage Boards (IDB's). Some of these recommendations may have already been carried out or are ongoing.

Table 5 Recommended Actions

Cumbria Flood Partnership Theme	Action by	Recommended Action	Timescale
Community Resilience	Cumbria Local Resilience Forum *	Review and update plans to enable homes & business to be better prepared for flooding & reduce the impacts of flooding. For example, review of evacuation procedures / emergency response.	2016
	Environment Agency, Cumbria County Council Highways, and Electricity North West.	Review the flood risk and resilience of infrastructure.	2016
	Cumbria Planning Group, Allerdale Borough Council, Cumbria County Council, and Environment Agency	Review Local Development Plans and Strategic Flood Risk Assessment to reflect current understanding of flooding.	2016
	Environment Agency	Ensure all properties at risk can register to receive flood warnings and details are up-to-date.	2016
	Environment Agency	Raise awareness/engagement with community on gravel management activities and the influence of the Yearl weir and tides on flood flows.	2016
Upstream Management	Cumbria Floods Partnership (CFP)	The CFP action plan will consider natural flood management options to reduce flood risk across the catchment. This may also include land use changes and or flood storage.	2016
	Environment Agency	Investigate if catchment lake levels can be managed differently to reduce flood risk.	2016

Cumbria Flood Partnership Theme	Action by	Recommended Action	Timescale
Maintenance	Cumbria County Council, United Utilities, and Allerdale Borough Council	Review and investigate drainage and sewage systems to better understand where improvements are required to help reduce surface water flooding.	2016
	Environment Agency, United Utilities, and Cumbria County Council	Complete on-going inspections and repairs to assets that may have been damaged during the flood event.	2016
	Environment Agency	Review maintenance programme within the catchment in response to the flooding event of 2015.	2016
Strengthening Defences	Environment Agency	Review modelling and forecasting data to ensure that models for the Derwent catchment reflect real conditions as accurately as possible and use this information to make any improvements to the flood warnings service. This will be used to inform future investment plans.	2016
	Environment Agency	Complete repairs to flood defence assets that were damaged during the floods as part of the c.£10m Asset Recovery Programme which covers Cumbria and Lancashire.	Winter 2016/17
	Environment Agency / Allerdale Borough Council/ Iggesund	Investigate low flow and flood flow mechanisms/problems of mill race/ Soapery Beck at old Intake, under Hall Brow and through allotments.	2016/17
	Environment Agency	Carry out a Flood Risk Assessment /Review Study (see table 6) for Hall Park View area and Barepot including partnership funding scoring and AEP.	2016/17
	Residents	Review effectiveness and improve flood resilience/ resistance measures for properties to reduce impacts of future flooding.	
	United Utilities	Carry out work to prevent flows from eroding around the Yearl – consider permanent access track from Pumping station.	TBC
	Landowners	Review issues caused by river bank erosion up and downstream of Workington Bridge	2016

* The Cumbria Local Resilience Forum includes emergency services, local authorities, Cumbria County Council, Environment Agency, Maritime Coastguard Agency and health agencies along with voluntary

and private agencies. Under the Civil Contingencies Act (2004) every part of the United Kingdom is required to establish a resilience forum.

Table 6 Flood Risk Assessment / Review Study – Specific actions

No	Action
1	Carryout topographic survey at Hall Park View including Workington Bridge to determine viability of landscaped defences in Hall Park and use of Workington Bridge pedestrian underpass for flood flows.
2	Investigate possibility of flood wall with flow limiter at Soapery Beck inlet by Hall Park View to protect rear of Hall Park View from flooding and prevent flood flows entering Soapery Beck.
3	Investigate possibility of landscaping park to remove River Derwent flood flow route across Hall Brow.
4	Carryout topographic survey of Barepot defended line including threshold level of properties, areas of outflanking and raised features acting as flood defence/ barriers to flows escaping.
5	Investigate possible solutions to improve/ extend Barepot defences and reduce infiltration through defences.
6	Investigate landscaping and flow limiting measures to prevent high flows entering Barepot Reservoir including overland flow routes to rear of reservoir, and across mill stream in conjunction with barrier to limit flow along millstream into Barepot reservoir.
7	CCTV Gale Brook and investigate possibility of flapped outfall to prevent back flow from River Derwent.
8	Revisit the influence of Yearl weir and Yearl gravel Islands on flood risk.
9	Assess the impact of the Coops Weir on flood risk in Barepot.
10	Assess reinstatement of the barrier on millstream to limit flows behind Seaton Mill.
11	Look at flood flow routes across the floodplain from Salmon Hall downstream with a view to increasing active floodplain and diverting flows away from property.
12	Carry out work to prevent flows from eroding around the Yearl – consider permanent access track from pumping station.
13	Investigate practicality of community pumps for Barepot.
14	Investigate the possibility of diverting Gale Brook outside of the defended area in Barepot.
15	Produce Partnership Funding scores for Barepot and Hall Brow.

Next Steps

The Cumbria Floods Partnership has brought together a wide range of community representatives and stakeholders from a variety of sectors to plan and take action to reduce flood risk. The Cumbria Floods Partnership, led by the Environment Agency, is producing a 25 year Flood Action Plan for the Cumbrian catchments worst affected by the December 2015 flooding.

The plan will consider options to reduce flood risk across the whole length of a river catchment including upstream land management, strengthening flood defences, reviewing maintenance of banks and channels, considering water level management boards, and increasing property resilience. The Cumbria Floods Partnership structure below details how these 5 themes are being delivered in the Flood Action Plans which will be completed in July 2016.

The 'Cumbria Floods Partnership' was set up by Flood Minister Rory Stewart MP following December's floods, and includes all of Cumbria's Flood Risk Management Authorities. They are working alongside the existing 'Cumbria Strategic Partnership', which was formed as part of the Flood and Water Management Act 2010 and comprises of the County's Flood Risk Management Authorities (RMAs) including the Environment Agency, Cumbria County Council, Local Authorities, and United Utilities. Both partnerships are working with communities, businesses, and relevant stakeholders to understand and reduce flood risk across Cumbria.

Figure 29 below helps demonstrate how the two partnerships are working together:

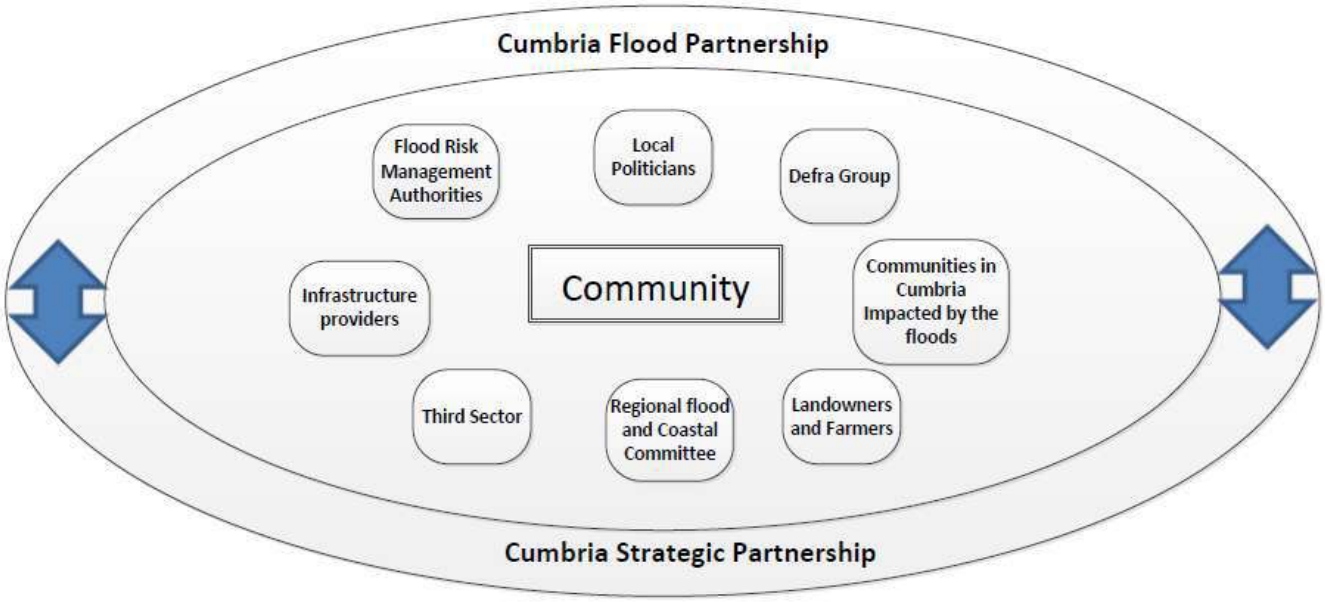


Figure 28-Cumbria Flood Partnership and Cumbria Strategic Partnership

Appendices

Appendix 1: Glossary

Acronyms

EA	Environment Agency
CCC	Cumbria County Council
UU	United Utilities
ABC	Allerdale Borough Council
LLFA	Lead Local Flood Authority
MSfWG	Making Space for Water Group
FAG	Flood Action Group
LFRMT	Local Flood Risk Management Team
FWMA	Flood and Water Management Act 2010
LDA	Land Drainage Act 1991
WRA	Water Resources Act 1991

Appendix 2: Summary of Relevant Legislation and Flood Risk Management Authorities

The Flood Regulations 1999 and the Flood and Water Management Act 2010 (the Act) have established Cumbria County Council (CCC) as the Lead Local Flood Authority (LLFA) for Cumbria. This has placed various responsibilities on the EA including section 18 of the Act which states:

The Environment Agency must report to the Minister about flood and coastal erosion risk management.

(2) In particular, the report must include information about the application of the national flood and coastal erosion risk management strategies under sections 7 and 8.

(3) The Minister may make regulations about—

(a) the times or intervals at which a report must be made, and
(b) the content of a report.

(4) In this section "the Minister" means—

(a) the Secretary of State in relation to flood and coastal erosion risk management in England, and
(b) the Welsh Ministers in relation to flood and coastal erosion risk management in Wales**.**

The table below summarises the relevant Risk Management Authority and details the various local source of flooding that they will take a lead on.

Flood Source	Environment Agency	Lead Local Flood Authority	District Council	Water Company	Highway Authority
RIVERS					
Main river					
Ordinary watercourse					
SURFACE RUNOFF					
Surface water					
Surface water on the highway					
OTHER					
Sewer flooding					
The sea					
Groundwater					
Reservoirs					

The following information provides a summary of each Risk Management Authority's roles and responsibilities in relation to flood reporting and investigation.

Government – Defra develop national policies to form the basis of the Environment Agency's and Cumbria County Council's work relating to flood risk.

Environment Agency has a strategic overview of all sources of flooding and coastal erosion as defined in the Act. As part of its role concerning flood investigations this requires providing evidence and advice to support other risk management authorities. The EA also collates and reviews assessments, maps and plans for local flood risk management (normally undertaken by LLFA).

Lead Local Flood Authorities (LLFAs) – Cumbria County Council are the LLFA for Cumbria. Part of their role requires them to investigate significant local flooding incidents and publish the results of such investigations. LLFAs have a duty to determine which risk management authority has relevant powers to investigate flood incidents to help understand how they happened, and whether those authorities have or intend to exercise their powers. LLFAs work in partnership with communities and flood risk management authorities to maximise knowledge of flood risk to all involved. This function is carried out at CCC by the Local Flood Risk Management Team.

District and Borough Councils – These organisations perform a significant amount of work relating to flood risk management including providing advice to communities and gathering information on flooding.

Water and Sewerage Companies manage the risk of flooding to water supply and sewerage facilities and the risk to others from the failure of their infrastructure. They make sure their systems have the appropriate level of resilience to flooding and where frequent and severe flooding occurs they are required to address this through their capital investment plans. It should also be noted that following the Transfer of Private Sewers Regulations 2011 water and sewerage companies are responsible for a larger number of sewers than prior to the regulation.

Highway Authorities have the lead responsibility for providing and managing highway drainage and certain roadside ditches that they have created under the Highways Act 1980. The owners of land adjoining a highway also have a common-law duty to maintain ditches to prevent them causing a nuisance to road users.

Flood risk in Cumbria is managed through the Making Space for Water process which involves the cooperation and regular meeting of the Environment Agency, United Utilities, District/Borough Councils and CCC's Highway and LFRM Teams to develop processes and schemes to minimise flood risk. The MSfWGs meet approximately 4 times per year to cooperate and work together to improve the flood risk in the vulnerable areas identified in this report by completing the recommended actions. CCC as LLFA has a responsibility to oversee the delivery of these actions

Where minor works or quick win schemes can be identified, these will be prioritised and subject to available funding and resources will be carried out as soon as possible. Any major works requiring capital investment will be considered through the Environment Agency's Medium Term Plan process or a partners own capital investment process

Flood Action Groups are usually formed by local residents who wish to work together to resolve flooding in their area. The FAGs are often supported by either CCC or the EA and provide a useful mechanism for residents to forward information to the MSfWG.

Appendix 3: Links to other information on Flooding

Cumbria County Council (Local Flood Risk Management):
lfrm@cumbria.gov.uk, www.cumbria.gov.uk, tel: 01228 211300

Cumbria County Council (Highways):
highways@cumbria.gov.uk, www.cumbria.gov.uk, tel: 0845 609 6609

United Utilities: tel: 0845 746 2200

Flood and Water Management Act 2010:
http://www.legislation.gov.uk/ukpga/2010/29/contents

Sign up for Flood Warnings
https://www.gov.uk/sign-up-for-flood-warnings

Environment Agency – Prepare your property for flooding; a guide for householders and small businesses to prepare for floods
https://www.gov.uk/government/publications/prepare-your-property-for-flooding

Environment Agency – What to do before, during and after a flood: Practical advice on what to do to protect you and your property
https://www.gov.uk/government/publications/flooding-what-to-do-before-during-and-after-a-flood

Environment Agency – Living on the Edge: A guide to the rights and responsibilities of riverside occupiers
https://www.gov.uk/government/publications/riverside-ownership-rights-and-responsibilities

Flood and Water Management Act 2010:
http://www.legislation.gov.uk/ukpga/2010/29/contents

Water Resources Act 1991:
http://www.legislation.gov.uk/all?title=water%20resources%20act

Land Drainage Act:
http://www.legislation.gov.uk/all?title=land%20drainage%20act

Highways Act 1980:
http://www.legislation.gov.uk/all?title=highways%20act

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Appendix 4: Flood Warnings and Alerts

The following section show additional details on the flood alerts and warnings issued during this event.

Flood Alert

011WAFCD- Rivers Cocker, Marron and Derwent.

Alert issued on Thursday 03/12/2015 at 14:46
Alert removed on Friday 04/12/2015 at 06:47
Alert issued on Friday 04/12/2015 at 15:30

Customers in Flood Alert area registered on FWD: 233
Contacts (landline, mobile, email etc) in Flood Alert area registered on FWD: 823
Successful contacts: 714
Unsuccessful contacts: 109
Alert Message:

A Flood Alert has been issued by the Environment Agency for the Rivers Cocker, Marron and Derwent.
Flooding is possible for Lower Derwent from Bassenthwaite Lake to the coast at Workington. The Cocker from Crummock Water to Cockermouth. The River Marron from Ullock to its confluence with the Derwent near Bridgefoot. Low lying land and roads will be affected first.

Heavy and persistent rainfall is forecast to continue throughout today until this evening. With the ground already saturated the river levels are expected to rise and we may see some localised flooding to low lying land and roads. An outlook for the weekend shows although Friday is looking a relatively dry day, the rain will again become heavy and persistent in the early hours of Saturday continuing right through until Sunday. As River levels are already high, we may see some localised flooding throughout Cumbria.

Flood Warning

011FWFNC22- River Derwent at Workington, Seaton Mill and Barepot

Area covered: The River Derwent at Workington, Seaton Mill and Barepot

Flood Warning issued on Saturday 05/12/2015 at 21:01
Flood Warning updated on Sunday 06/12/2015 at 17:56
Flood Warning updated on Monday 07/12/2015 at 19:50
Flood Warning removed on Tuesday 08/12/2015 at 17:32

Customers in Flood Warning area registered on FWD: 113
Contacts (landline, mobile, email etc) in Flood Warning area registered on FWD: 304
Successful contacts: 235
Unsuccessful contacts: 69
Flood Warning Message (05/12/2015 21:01) :

A Flood Warning has been issued by the Environment Agency for the River Derwent at Workington, Seaton Mill and Barepot.
Flooding is expected for Low lying roads, agricultural land, commercial and residential properties adjacent to the River Derwent including Glenfield Place, Meadow Edge, Workington Hall Mill, Hall Brow and Curwen Park. Immediate action required.
Heavy and persistent rainfall is expected throughout Saturday and into Sunday morning. River levels will continue to rise and further Flood Warnings are likely. Please check for updates throughout the weekend. Operational Teams have closed flood defences and are checking watercourses for blockages.