

# Ambleside

## Flood Investigation Report



**Old Bridge House, Stock Ghyll, Ambleside**

## Flood Event 5-6<sup>th</sup> December 2015

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



<b>Version</b>	<b>Undertaken by</b>	<b>Reviewed by</b>	<b>Approved by</b>	<b>Date</b>
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## Executive Summary

The flooding experienced in Ambleside on the 5<sup>th</sup> and 6<sup>th</sup> of December 2015 was one of the most significant flood events in the history of the town, and was the result of the effects of Storm Desmond. This storm caused a period of prolonged, intense rainfall across Northern England, falling on already saturated catchments, and led to high river levels and flooding throughout Cumbria. Ambleside was affected by flooding from several mechanisms. The Waterhead and Borrans Road areas were flooded due to high water levels in Lake Windermere. Other areas in Ambleside were badly affected by flooding from a number of watercourses, including the River Rothay, Stock Ghyll, Greenbank Ghyll and Fisher Beck. Due to the steep nature of the local topography in Ambleside, there were also flooding impacts from surface water runoff. Approximately 150 properties in Ambleside were affected by flooding.

In response to the flood event, this *Section 19 – Flood Investigation Report* has been completed by Cumbria County Council as the Lead Local Flood Authority, working in partnership with the Environment Agency as a key Risk Management Authority (RMA), 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 Ambleside on the 5<sup>th</sup> and 6<sup>th</sup> of December 2015, and has used a range of data collected from affected residents, professional partners, site visits, surveys of the area, data collected by observers, and river & rainfall telemetry recorded during the flood event. This data has been compiled by CH2M, specialist consultants in flood risk management, who have provided advice in understanding the event and recommendations for future action.

This report examines the flooding that occurred in Ambleside from the River Rothay, Stock Ghyll, Greenbank Ghyll and Fisher Beck, flooding from Lake Windermere, other minor watercourses and from surface water. It identifies the likely causes of flooding in the following investigated areas:

- Nook Lane
- Greenbank Road
- Stock Ghyll and River Rothay
- Upper Fisher Beck
- Borrans Road
- Under Loughrigg

A total of 16 actions have been recommended in this report to manage future flood risk, which will require the involvement of a number of organisations and the local community.

A draft version of the Ambleside Flood Investigation Report was published online in July 2016 for public consultation. Following the draft publication, a public meeting chaired by Cumbria County Council was held in Ambleside on 28th July, where the Environment Agency formally presented the report to the local community. Other Risk Management Authorities were also present at the meeting to answer any questions raised during a question and answer session following presentation of the report. Through the public meeting and local consultation with the community, a range of feedback has been provided on the report. The Environment Agency and Cumbria County Council have reviewed this feedback and, where appropriate, updated the Final version of the report to reflect the required amendments.

Any additional information that residents and others can provide 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. The scale of this report means that not every piece of information can be incorporated into the document. Any additional information should be provided to:

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

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

## Flooding History

Due to the steep nature of the local watercourse catchments that drain into Ambleside, the various watercourses that flow through the town respond very rapidly to heavy rainfall. The rapid response of the local watercourses to heavy rainfall means that Ambleside is classified as being at high risk of flash flooding.

There are records of flooding from all of the main watercourses that flow through Ambleside, including the River Rothay, Fisher Beck, Stock Ghyll, Kirkfield Drain and Greenbank Ghyll. In November 2009, the flood event that caused widespread flooding across Cumbria affected 16 residential and commercial properties in Ambleside. Prior to November 2009, Ambleside has also experienced flooding in 1999, 2005 and 2008.

Table 1 shows the recorded maximum flows and river level at the Miller Bridge House gauging station, which is situated on the River Rothay in Ambleside, and the numbers of properties affected from the November 2009 and December 2015 flood events.

<b>Flood Event</b>	<b>Number of Properties Flooded</b>	<b>Recorded River Level (m) on the River Rothay</b>
November 2009	16	3.52
December 2015	150	3.71

**Table 1 - Recent Flood Events affecting Ambleside**

# Event background

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

## Flooding Incident

Ambleside is a small town situated in the county of Cumbria in the north west of England, with a population of approximately 2600. The town is within the Lake District National Park, and is located in close proximity to the northern shore of Lake Windermere. The River Rothay flows along the western edge of the town, before joining Lake Windermere to the west of Waterhead. There are also a number of smaller watercourses that flow through populated areas of Ambleside, including Fisher Beck, Kirkfield Drain, Stock Ghyll and Greenbank Ghyll, as well as Scandale Beck just to the north of the town. Due to the steep nature of the local watercourse's catchments, each react very quickly to heavy rainfall.

Due to its position within the floodplains of these watercourses, parts of Ambleside lie within Flood Zone 3 (1% Annual Exceedance Probability or AEP) and are therefore at risk of fluvial flooding (see Figure 3). Parts of the town also lie within Flood Zone 2 (0.1% Annual Exceedance Probability or AEP). The town is also at risk from other sources of flooding, including surface water (see Figure 4).

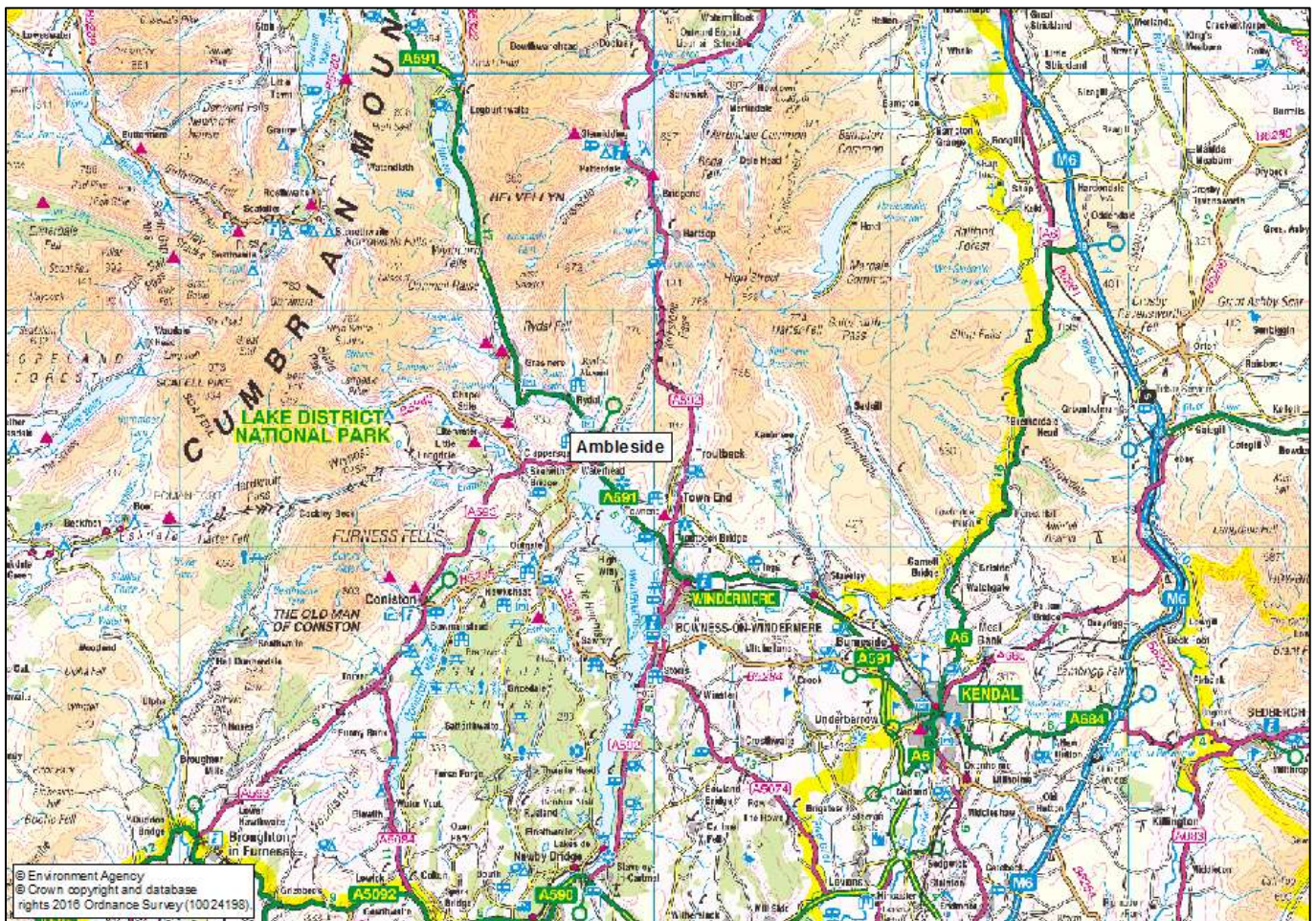


Figure 1 - Location of Ambleside

On the 5<sup>th</sup> and the 6<sup>th</sup> of December 2015, approximately 150 properties in Ambleside were affected by flooding. This flooding can be attributed to a record-breaking rainfall event from Storm Desmond. This

led to flooding from the River Rothay, Stock Ghyll, Greenbank Ghyll and Fisher Beck, as well as flooding directly from Lake Windermere and from surface water. Figure 2 shows the location of the main watercourses in Ambleside.

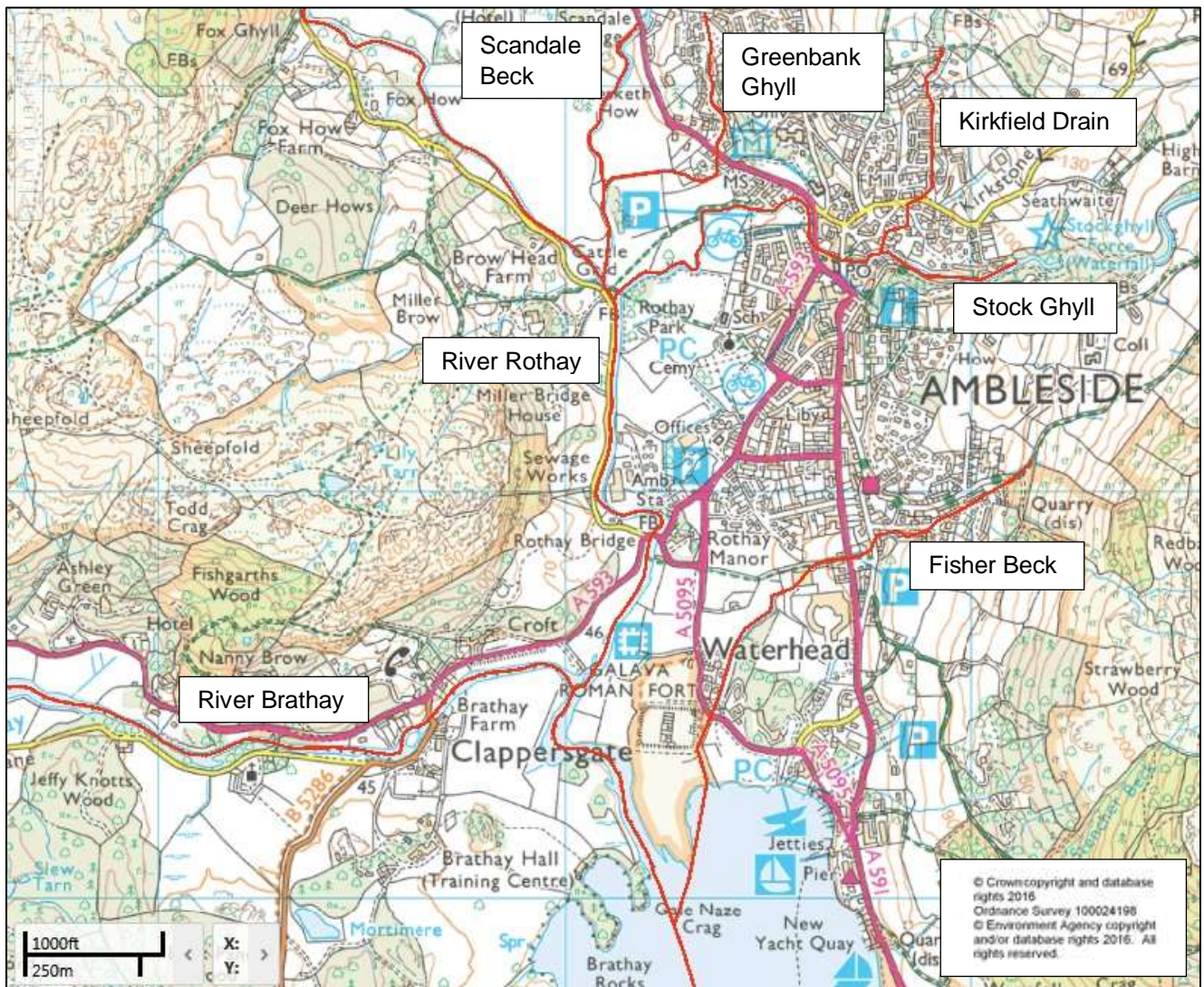


Figure 2 - Location of main watercourses in Ambleside

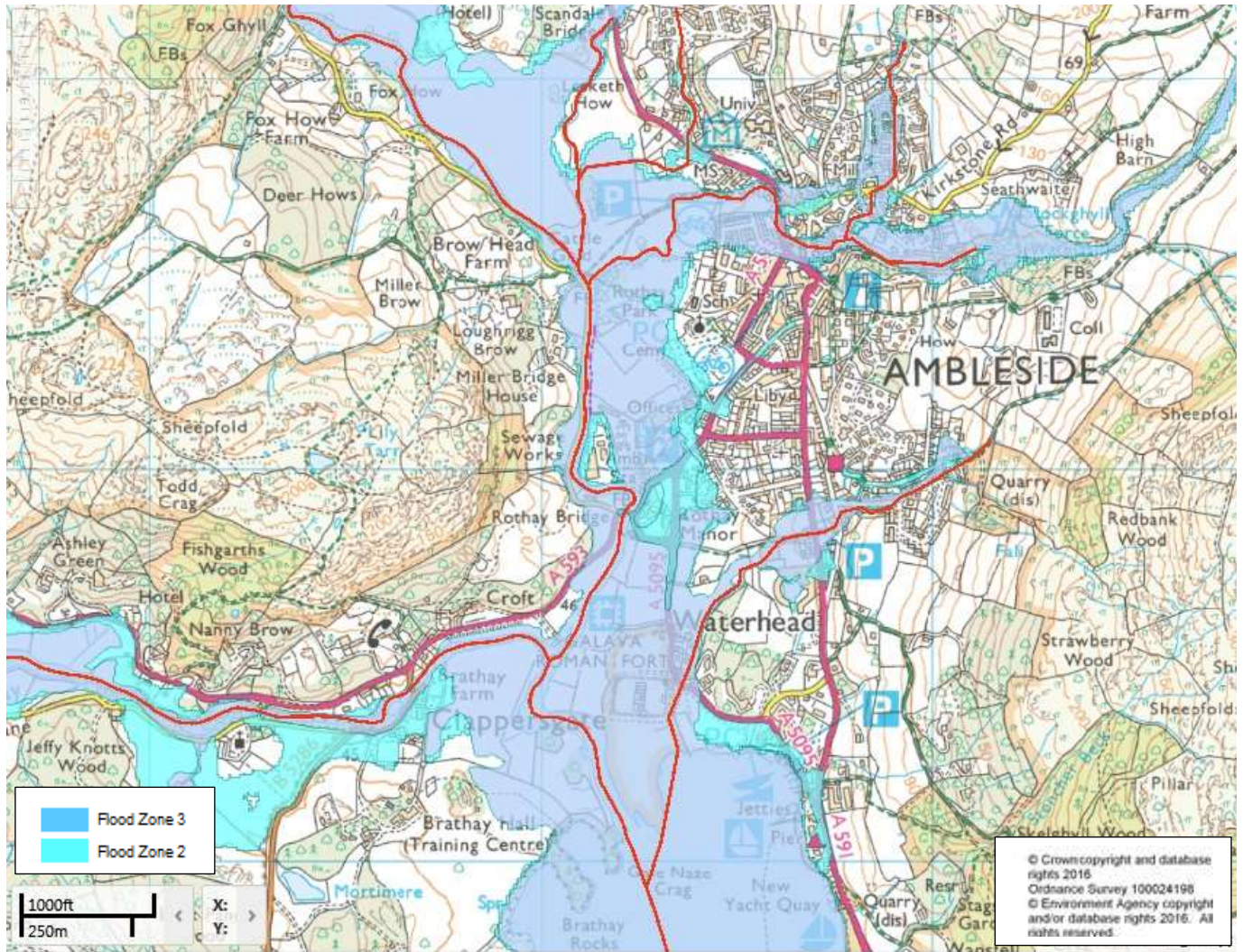
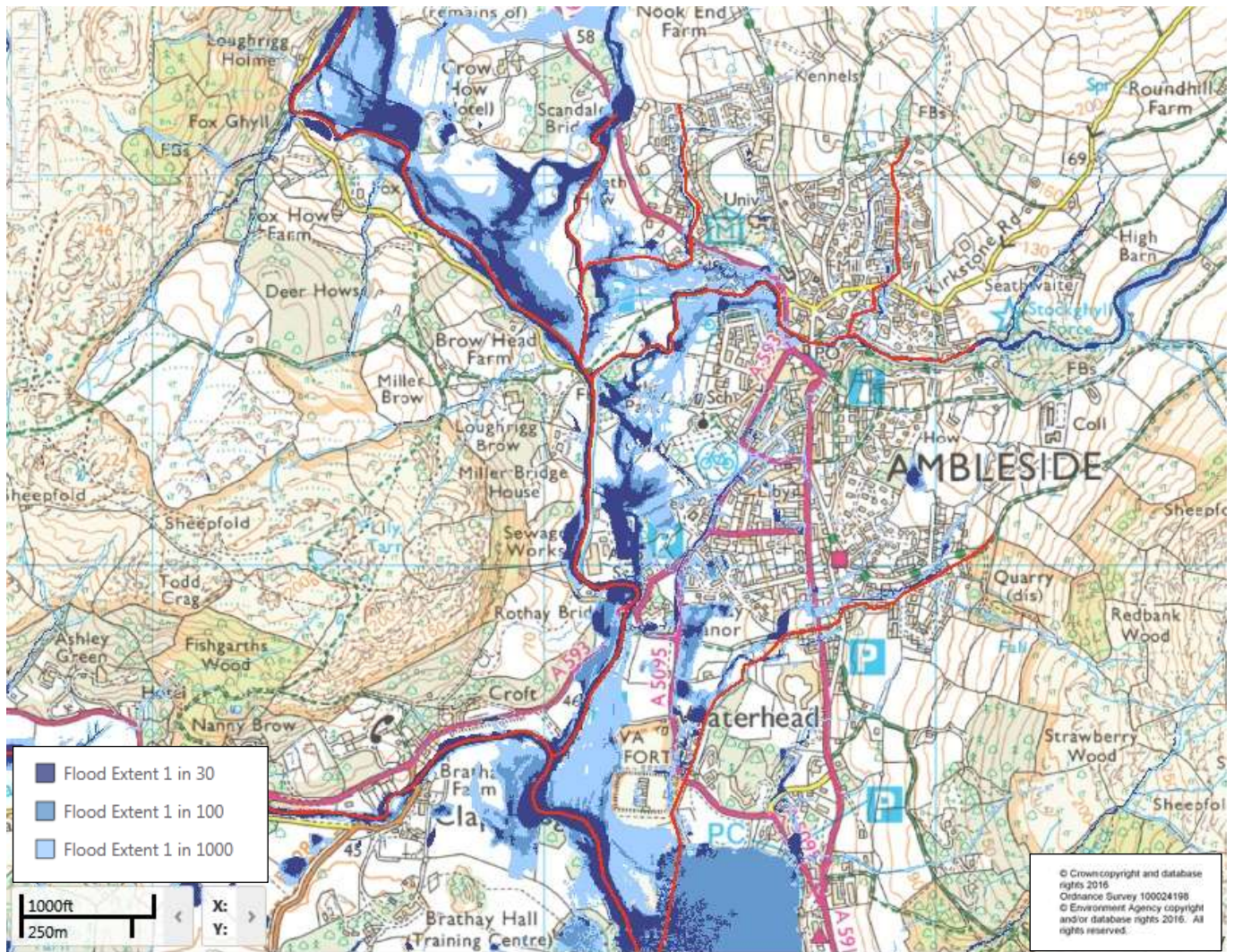


Figure 3 - Indicative risk of flooding to Ambleside from rivers (fluvial)





**Figure 4 - Areas in Ambleside at risk of surface water flooding**

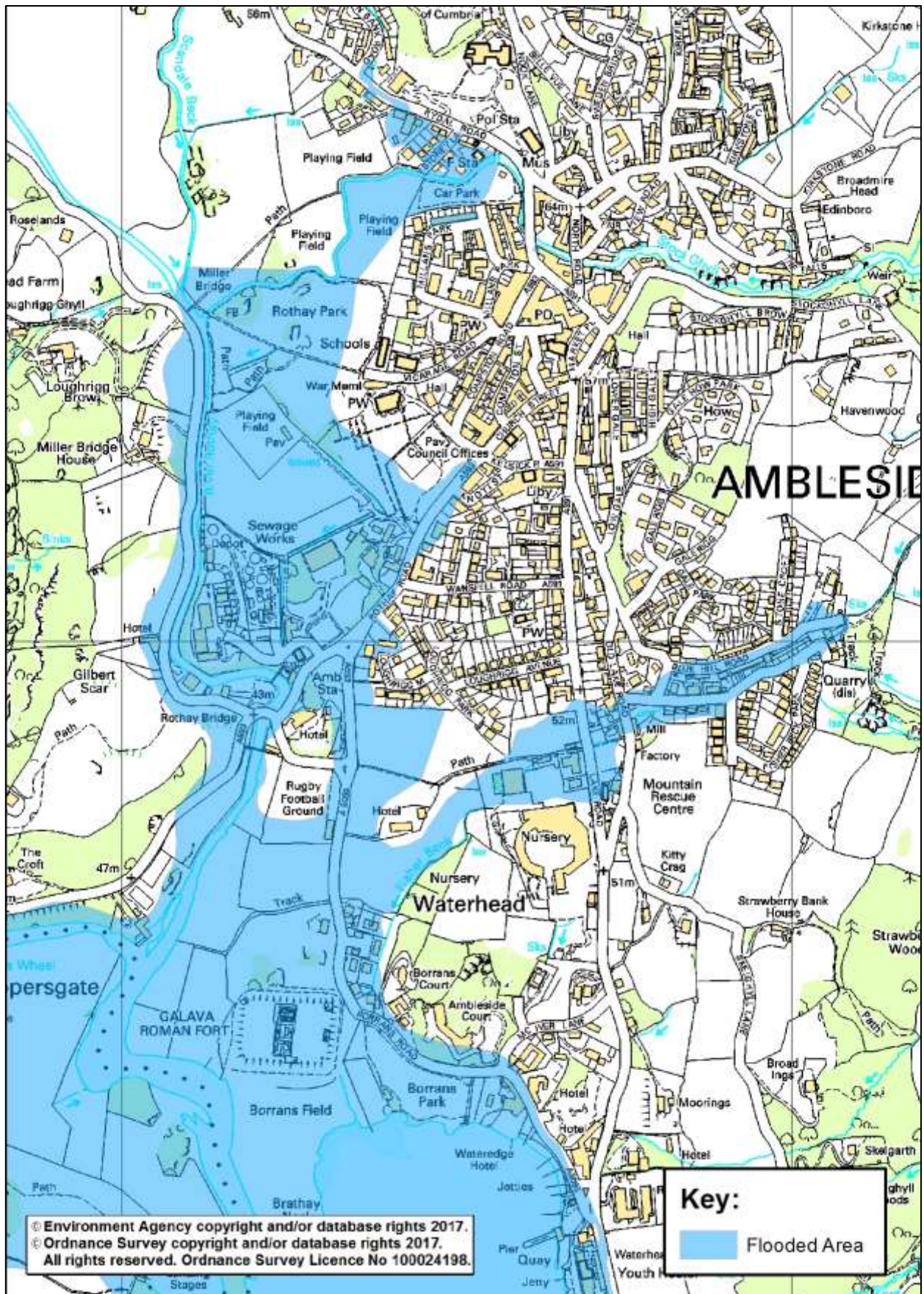


Figure 5 - Extent of flooding in Ambleside on 5-6<sup>th</sup> December 2015

Figure 5 shows the approximate extent of the flooding. For the purposes of this report, the flooded area has been divided into 6 sub-areas. These are shown in Figure 6.

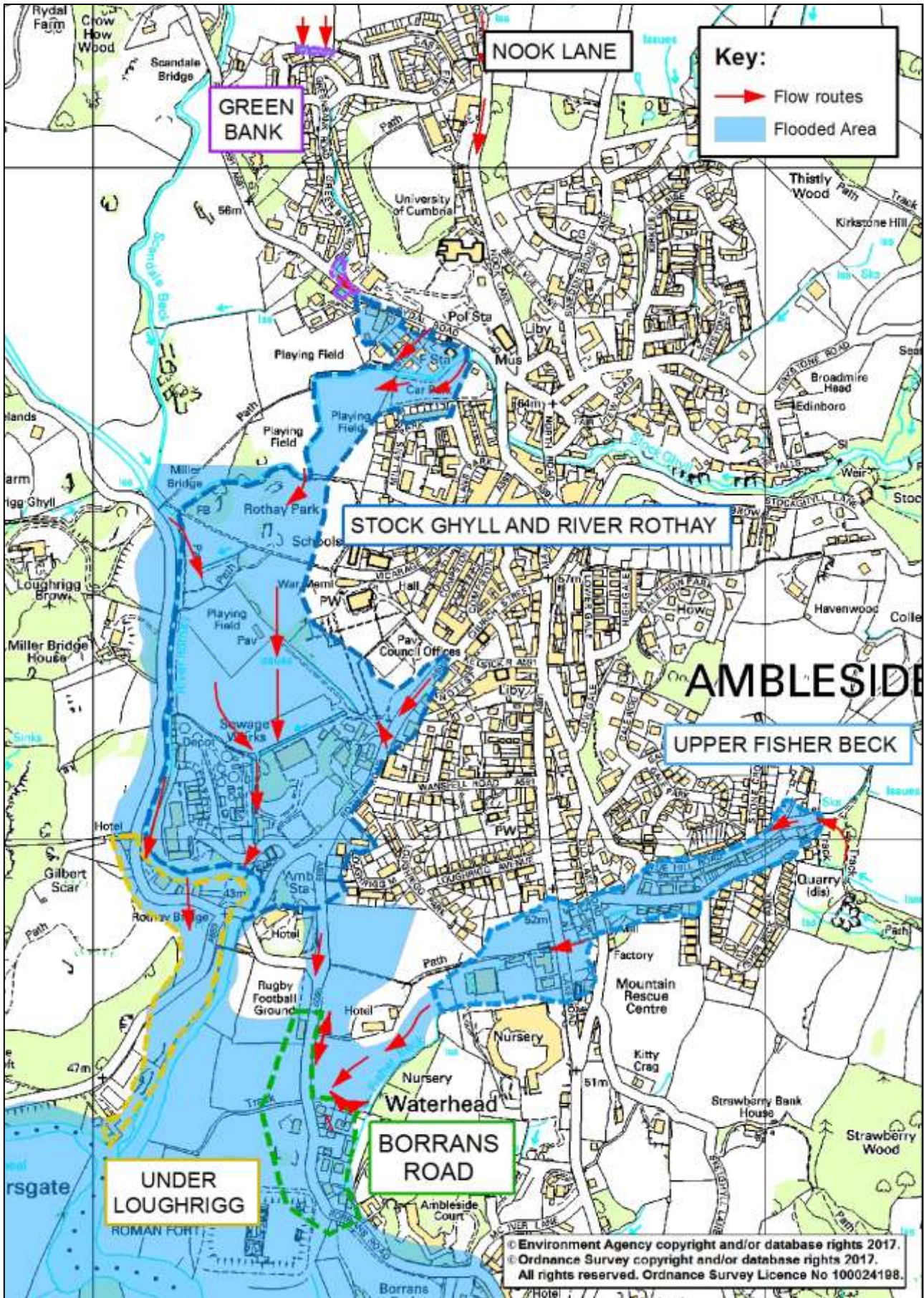


Figure 6 - Identification of Areas Flooded

## Current Flood Defences

There are different measures to help protect against flooding within Ambleside, including walls, embankments as well as natural high ground. In some places along the watercourses, there are privately-owned, informal flood defences in the form of property boundary walls, which may provide some form of protection from flooding. It should be noted that such structures are not formal flood defences, and therefore they cannot be expected to perform as such.

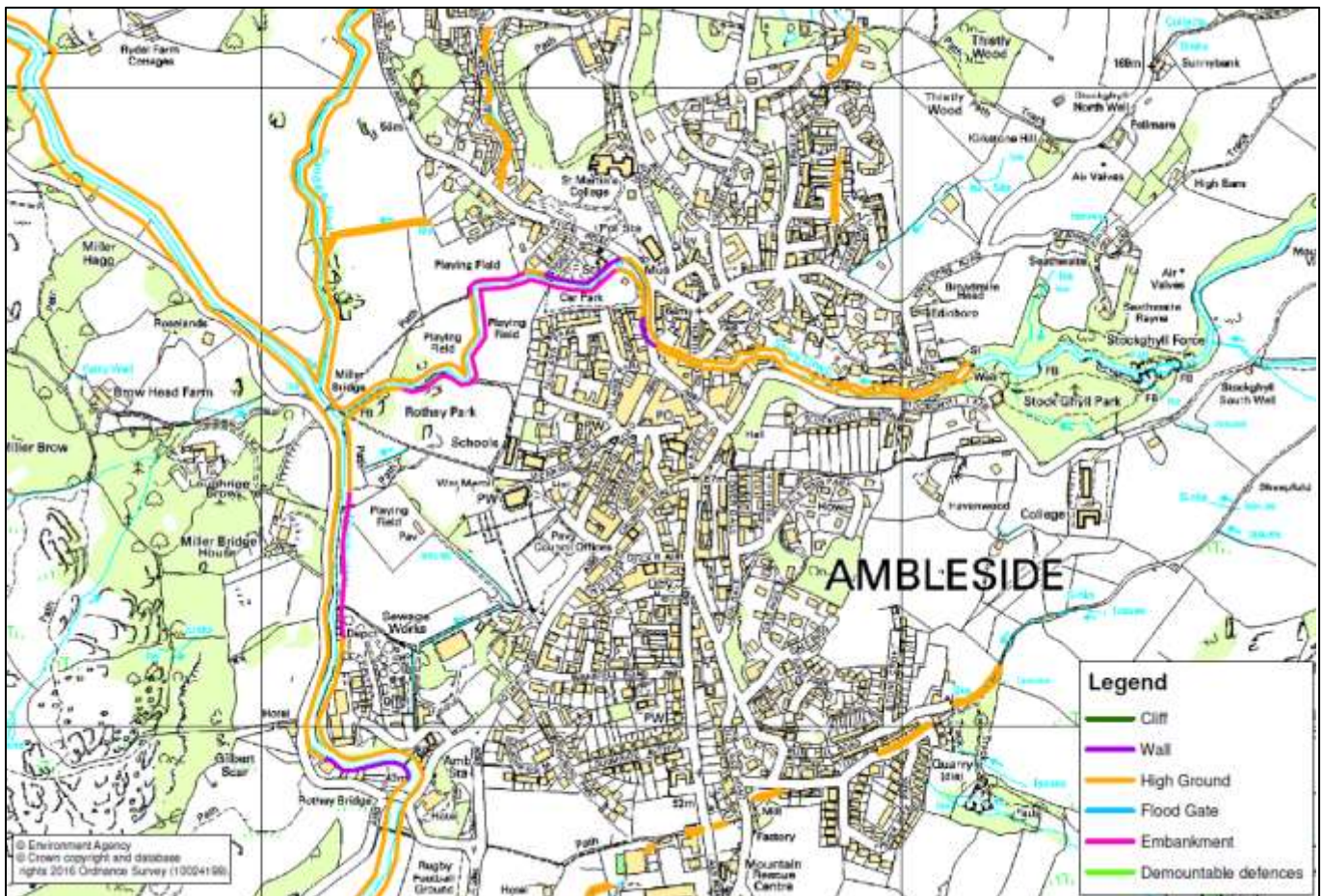
Along Stock Ghyll, there are various informal flood defences made up of privately owned walls and embankments, located mainly in the area from Stoney Lane towards Rothay Park. On the left bank of Stock Ghyll, near Old Bridge House Road, there is an informal flood defence in the form of a 49 metre long section of raised wall. There is a 395 metre section of raised embankment on the left bank of Stock Ghyll, which runs from the car park through the Playing Field and into Rothay Park. On the right bank of Stock Ghyll, there is a 112 metre long section of masonry wall, which is not a formal flood defence but provides a level of protection to properties in the Stoney Lane area.

Along the River Rothay, there is a 234 metre long section of embankment on the left bank of the river, which is maintained by the Environment Agency. The primary purpose of this embankment is to contain flows on the River Rothay in-channel for gauged measurements at the Miller Bridge House gauging station. Further downstream, there is a section of retaining wall on the right bank of the river upstream of Rothay Bridge.

Along Fisher Beck, where it is in an open channel, there are various small raised private walls that have been built to protect nearby properties.

There are also areas of natural high ground, which may offer some protection in localised areas.

Figure 7 shows the location and classification of the existing flood defences in Ambleside by the Environment Agency.



**Figure 7 - Location and classification of existing flood defences in Ambleside**

## Investigation

This section describes the rainfall and fluvial events that occurred in the local Ambleside river catchments, the likely causes of flooding and the Environment Agency response in Ambleside. It also provides a timeline of the events that occurred over 5<sup>th</sup> - 6<sup>th</sup> December 2015.

This investigation was carried out by the Environment Agency using data collected from surveys of the area, and from the communities affected, with help from Cumbria County Council.

This report has been compiled by CH2M from the data collected by the Environment Agency. CH2M are a global civil engineering consultancy providing a full range of flood management consultancy services in the UK and overseas. CH2M's range of experienced specialists have provided input into understanding this event and producing recommendations for future flood management in Ambleside. More details of CH2M's work in the UK is included in Appendix 5.

## Rainfall Event

December 2015 was the wettest calendar month on record, with much of the northern UK receiving double the average rainfall for December. This also followed a particularly wet November with much of the soil within the Cumbria catchments already saturated. The record rainfall that fell in early December could therefore not be absorbed, leading to higher levels of runoff and exceptionally high river flows across the county.

From the 4th to 7th of December there was a period of prolonged and 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.

Rainfall Period	Storm Desmond			Previous Record		
	Date	Location	Total rainfall (mm)	Date	Location	Total rainfall (mm)
24 hour rainfall	December 2015	Honister Pass	341.4	November 2009	Seathwaite	316.4
48 hour rainfall	December 2015	Thirlmere	405.0	November 2009	Seathwaite	395.6

**Table 2 - UK Rainfall Records**

The nearest rainfall monitoring gauge to Ambleside is Brathay Hall, which is situated to the south west of Ambleside close to the north western shore of Windermere. Unfortunately, there were technical issues with this gauge during the December flood event, so for the purposes of this report, data from

the nearest rain gauges at Grasmere Tannercroft and Dale Head Hall has been analysed to provide a local rainfall event context. The location of the Grasmere Tannercroft and Dale Head Hall rain gauges is shown in Figure 8.

The Grasmere Tannercroft rain gauge, which is situated within Grasmere village, recorded a total of 261.1mm of rainfall from 9am on the 4<sup>th</sup> December to 9am on the 6<sup>th</sup> December. This exceeded the previous highest recorded 48 hour total of 240.7mm from the 18<sup>th</sup> and 19<sup>th</sup> November 2009 - a rainfall event which also led to widespread flooding across Cumbria. It is worth noting that the fourth highest recorded 48 hour rainfall total at this gauge was recorded on the 14<sup>th</sup> & 15<sup>th</sup> November 2015, which emphasises that local catchments were saturated prior to the record rainfall from Storm Desmond in early December.

The Dale Head Hall rain gauge, which is situated on the eastern shore of Thirlmere, recorded a total of 329.8mm of rainfall from 9am on the 4<sup>th</sup> December to 9am on the 6<sup>th</sup> December. A maximum 24 hour total of 261.6mm of rainfall was recorded at this gauge between 22:00 on the 4<sup>th</sup> December and 22:00 on the 5<sup>th</sup> December. This again exceeded the previous highest-recorded 24 and 48-hour totals at the Dale Head Hall rain gauge of 186.8mm and 241.6mm, recorded during the November 2009 storm event.

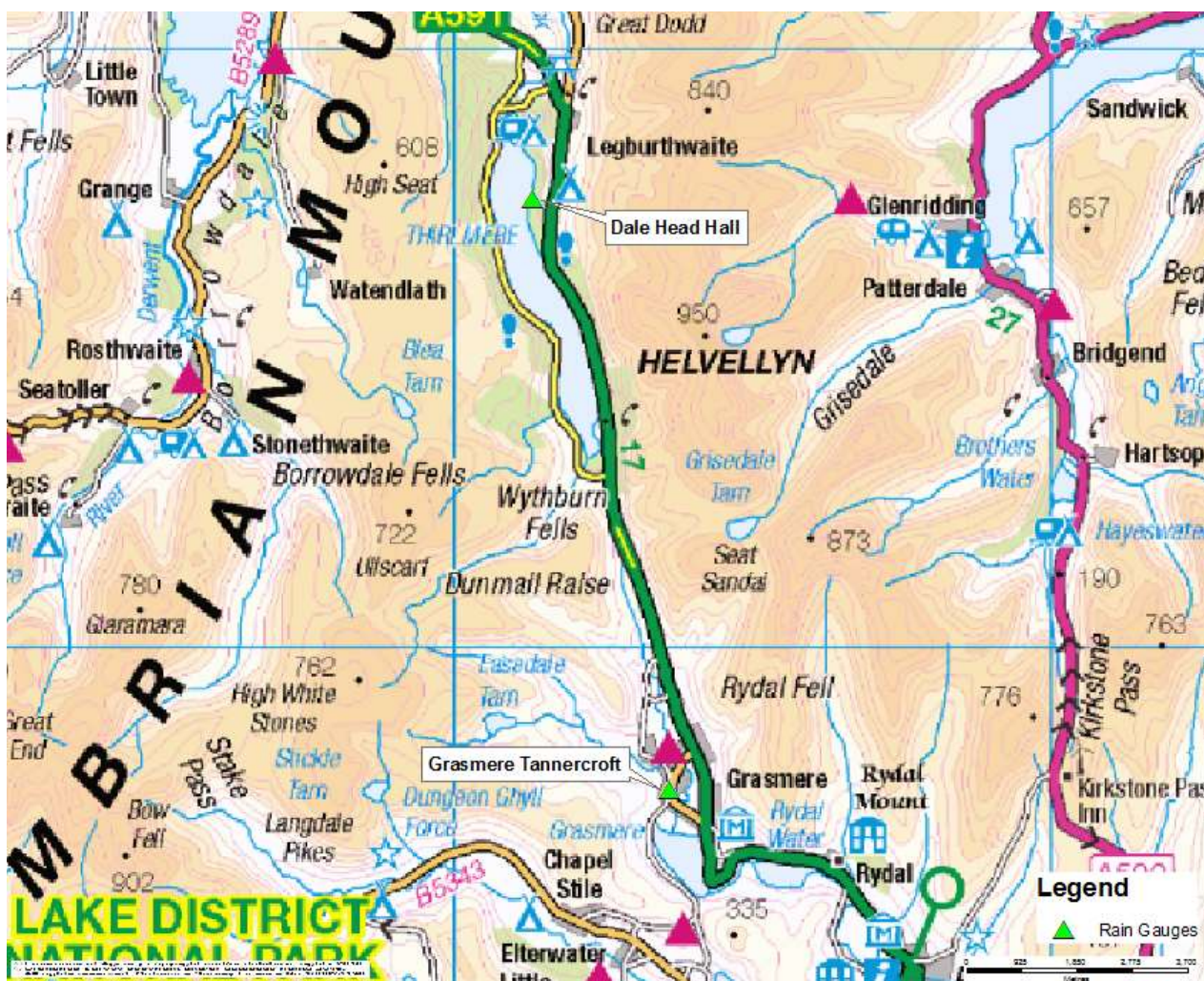
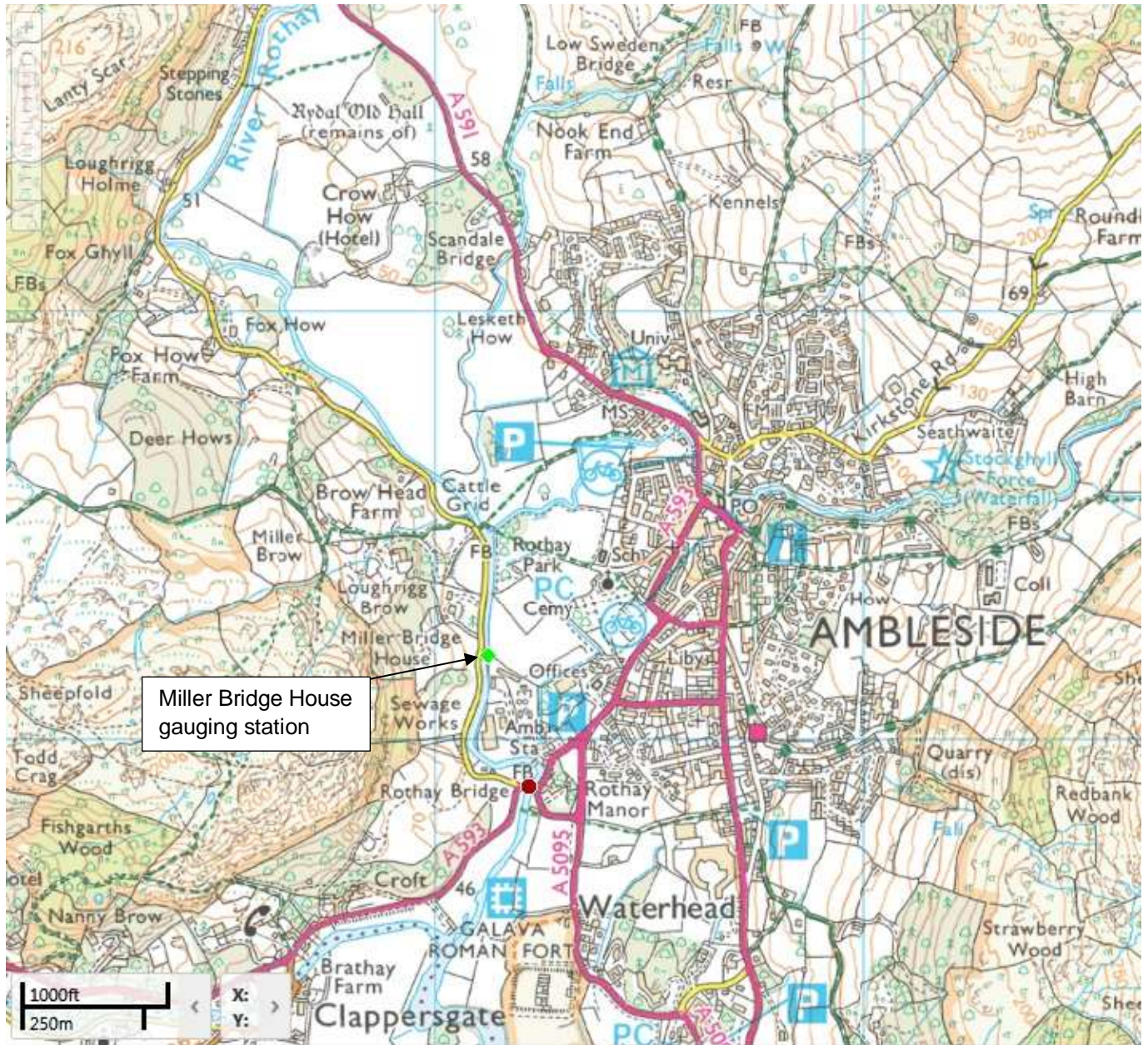


Figure 8 - Location of Rain Gauges to the north of Ambleside

The nearest river monitoring gauge is located on the River Rothay at Miller Bridge House, which is located to the west of the centre of Ambleside as the River Rothay flows past the town. The location of the Miller Bridge House gauging station is shown in Figure 9.



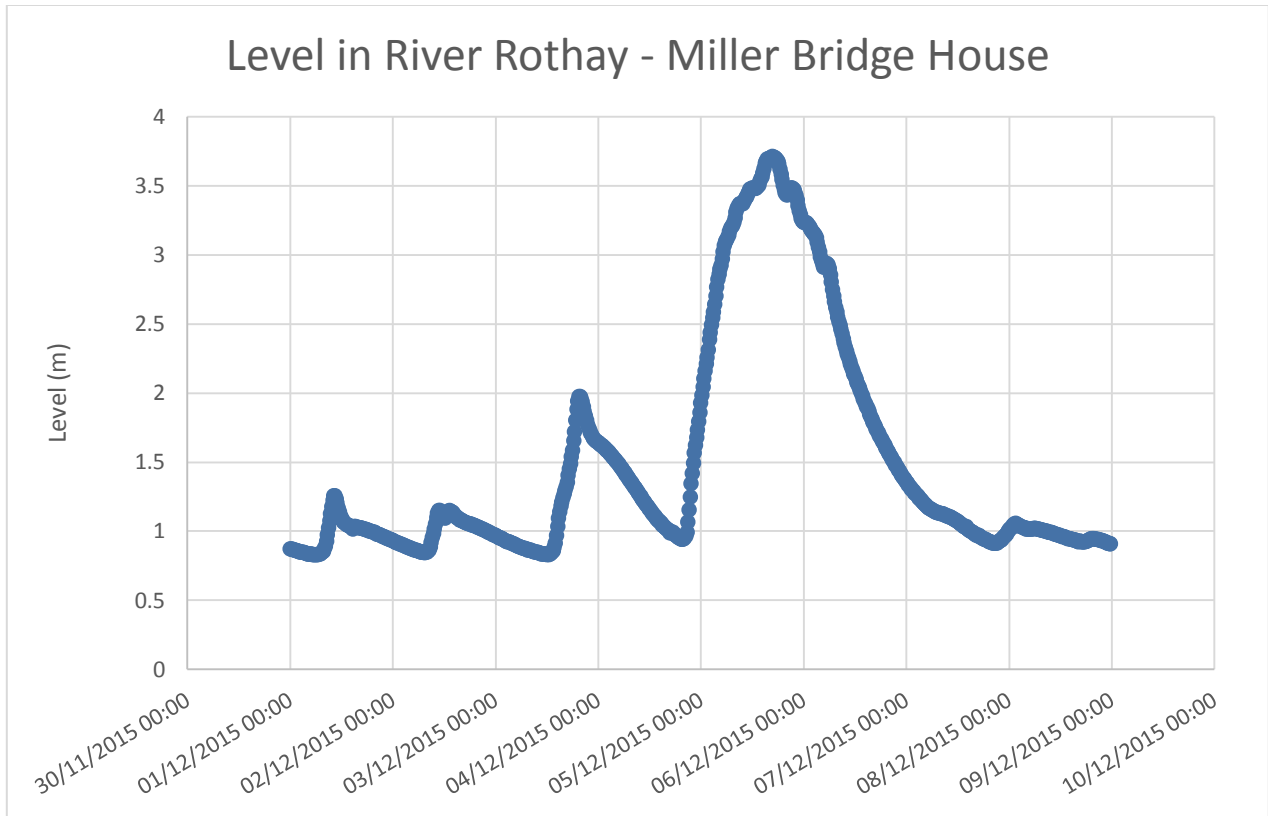
**Figure 9 – Location of Miller Bridge House gauging station on the River Rothay in Ambleside**

A peak level of 3.714m (44.148mAOD) was recorded at Miller Bridge House on the River Rothay during 5th December 2015. This exceeded the previous highest recorded level of 3.517m (43.951mAOD), recorded during the November 2009 flood event. Table 3 shows the highest recorded peak flood levels at the Miller Bridge House gauge.

Gauging Station	Highest Recorded Gauging Dates & Levels		
	December 2015	November 2009	January 2005
Miller Bridge House, River Rothay	3.714m	3.517m	3.432m

**Table 3 - Miller Bridge House, River Rothay, Record Gauged Levels**

Figure 10 shows the levels recorded by the Miller Bridge House river monitoring gauge. This shows the time and duration of the flood event on the 5<sup>th</sup> and 6<sup>th</sup> of December, and illustrates the magnitude of the flood event.



**Figure 10 - Levels Recorded at Miller Bridge House Gauging Station on the River Rothay from 01/12/2015 to 08/12/2015.**



# Sources of Flooding, Flood Flow Routes and Event Timeline

There were a number of different flood flow routes during this event. For this report, the flooded area has been divided into six sub-areas, as shown in Figure 6 earlier in the report.

The details of the flow routes into these areas, the likely causes, and the properties affected are discussed in the 'Impacts and Likely Causes of Flooding' section. Although every effort has been made to accurately identify the likely flooding mechanisms, there may also have been other flooding mechanisms that have not been identified during this investigation.

## Timeline

Table 4 provides a summary timeline of the key events as the flooding affected Ambleside.

<b>4<sup>th</sup> December</b>	<b>Event</b>
15:22	Flood Alert issued for the Rivers Brathay, Rothay and Winster catchments
<b>5<sup>th</sup> December</b>	<b>Event</b>
06:00-07:00	Initial flooding to properties in The Borrans through the floors
09:30	Water enters the Guide Meeting Hut on Rothay Holme
10:00	Water enters properties at Riverside on Under Loughrigg Road
14:20	River levels and flood levels in properties continue to rise
16:45	River Rothay peaks at Miller Bridge House – 3.71m
17:00	Riverside walls and roadside walls collapse on Under Loughrigg Road

**Table 4 - Timeline of collected data**

# Impacts and Likely Causes of Flooding

## Nook Lane

Nook Lane is located in the northern part of Ambleside. As a result of the prolonged, intense rainfall, it was reported that there was surface water flow on Nook Lane. Local residents reported that a property boundary wall had been weakened by flood water. There is an ordinary watercourse that flows across fields to the east of Nook Lane, which is then culverted (piped) under Nook Lane when it reaches the road. Following the flood event, site investigations identified that the culverted watercourse, which flows west towards Greenbank, appeared to be blocked.

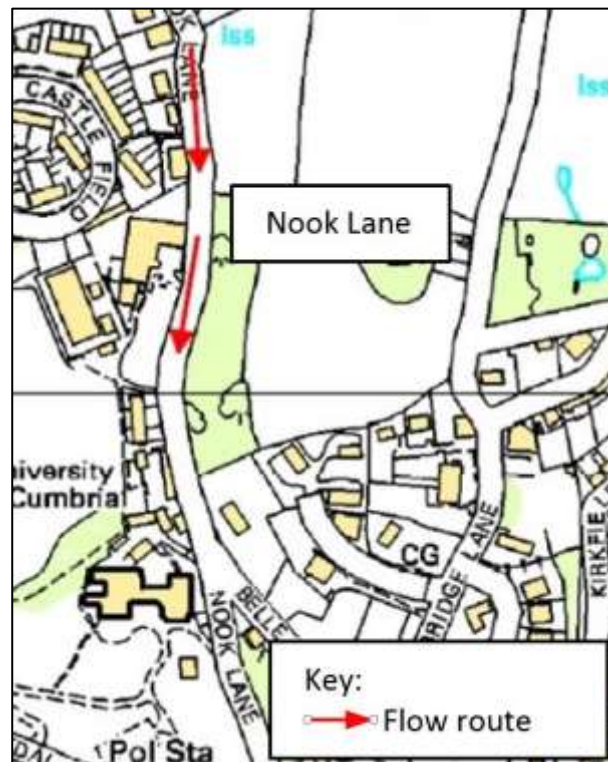


Figure 11 – Flow route down Nook Lane

## Greenbank

This area is located in the northern part of Ambleside, to the west of Nook Lane. Greenbank Ghyll flows from north to south along Greenbank Road in this area, before flowing in a westerly direction downstream of Rydal Road and joining Scandale Beck.

It was recorded that some gardens to the north of Greenbank Road were affected by surface water flooding from the heavy rainfall on the 5<sup>th</sup> and 6<sup>th</sup> of December 2015. Overland flow from the hill to the north of Greenbank Road reportedly flowed between some flats and student accommodation.

At the southern end of Greenbank Road, Greenbank Ghyll enters a culvert which flows under Rydal Road, as illustrated in Figure 14. A local resident reported that during the flood event water levels built up behind the dry stone wall to the north of Rydal Road (the dry stone wall can be seen downstream of the culvert inlet in Figure 14). Eventually the water that had built up behind the dry stone wall made its way onto Rydal Road, and began to pool on Rydal Road in front of the cottages shown in Figure 15. Water was observed to be flowing around the western end of the terrace of cottages and into their rear yards, where it was being retained by the property boundary walls. Due to the drainage holes within the property boundary walls being approximately 18 inches above ground level, this led to water levels building up in the area around the cottages and on Rydal Road. Eventually, the water level stabilised in the area, possibly due to the water level reaching the height of the drainage holes. Subsequently, a section of property boundary wall that had been retaining water collapsed.

Figure 15 shows the recorded water level at the cottages on Rydal Road, as indicated by one of the owners.

Floodwater from this area also reportedly affected the University of Cumbria student accommodation to the east of the cottages, situated to the south of Rydal Road.



Figure 12 – Flood outline and flow route in the Greenbank sub-area



**Figure 13 – Culvert on Greenbank Ghyll, which runs parallel to Greenbank Road**



**Figure 14 – Culvert inlet on Greenbank Ghyll, just upstream of Rydal Road and opposite cottages shown in Figure 15**



**Figure 15 - Recorded water level at row of cottages on Rydal Road, situated opposite the Greenbank Ghyll culvert inlet shown in Figure 14**

### **Stock Ghyll and River Rothay**

Stock Ghyll and the River Rothay is the largest sub-area for this investigation in Ambleside. The sub-area is located to the west of the town centre, and incorporates the downstream reach of Stock Ghyll up to the confluence with the River Rothay, and the flooded area on the left bank of the River Rothay upstream of Rothay Bridge.

Flooding in this sub-area was mainly as a result of overtopping of existing informal flood defences, with some impacts in localised areas from surface water flooding. As detailed earlier in the report in the 'Current Defences' section, there are various informal flood defences in this sub-area which provide some level of flood protection. However, due to the sheer volume of water in both Stock Ghyll and the River Rothay, these informal defences were not able to prevent flooding in this area. There were also reports that the car park bridge, which spans Stock Ghyll immediately upstream of the Fire and Rescue Centre, reached capacity, with water levels in Stock Ghyll reaching the bridge deck.



Figure 17 shows the recorded water level on the building belonging to the Fire and Rescue Centre. Local residents on Stoney Lane reported that they did not believe that the Fire and Rescue Centre flooded internally, despite being surrounded by water during the flood event.



**Figure 17 - Recorded water level at the Fire and Rescue Centre**

Stoney Lane was impacted by surface water runoff originating from the very steep area around Kirkstone Road to the east. Surface water flow from this steep area to the east was channelled down Kirkstone Road, onto Rydal Road and towards Stoney Lane. Local residents reported that surface water flowed into Stoney Lane and gathered behind the raised masonry wall which is situated on the right bank of Stock Ghyll at the bottom of the lane. Due to the high levels in Stock Ghyll, the existing drainage gullies at the bottom of the lane became gravity locked and could not discharge into Stock Ghyll. This led to surface water being trapped behind the raised wall on Stoney Lane. This resulted in the flooding of gardens on Stoney Lane as water passed around the residential properties, however this flow route led to basements of the University of Cumbria student accommodation to the west of Stoney Lane being affected by flooding. Although the gardens of properties on Stoney Lane were affected by flooding, residents confirmed that water depths were not sufficient to flood properties internally.

As referenced in the 'Greenbank' sub-area section, Greenbank Ghyll flooded lower areas of Greenbank Road and Rydal Road, which reportedly added to the flooding impacts at the University of Cumbria student accommodation.

On the left bank of Stock Ghyll, water exceeded channel capacity and flooded the adjacent car park, and continued to flow in a south-westerly direction across the floodplain of the playing field. As a result of the significant out-of-bank flows across the floodplain, the velocity of the flows caused damage to footpaths, retaining walls and railings in the park, as illustrated in Figures 18 and 19. To the rear of the car park, a row of terraces on Millans Park which back onto the car park suffered basement flooding. The resident of Rose Cottage, which is situated immediately upstream of Rydal Road adjacent to Stock Ghyll, reported that the basement of the property flooded through the flag flooring.



**Figure 18 - Flood damage caused to a footpath by Stock Ghyll in Rothay Park. Note the level of the debris in the railings.**





**Figure 19 - Flood damage caused by Stock Ghyll in Rothay Park. Note the level of the debris in the railings.**

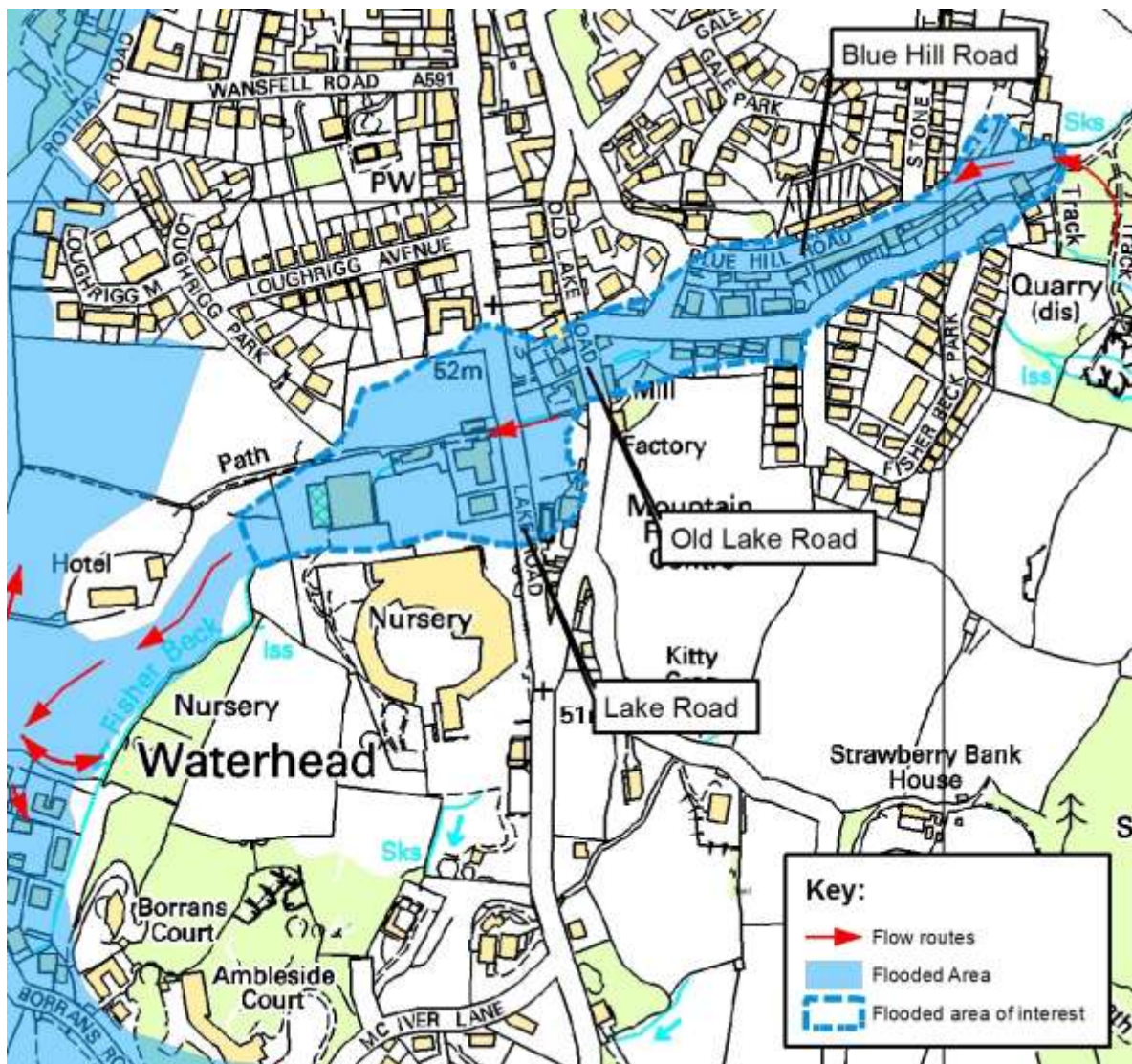
The confluence of Stock Ghyll with the River Rothay is located at the western point of Rothay Park. Due to the high flows on both watercourses on the 5<sup>th</sup> and 6<sup>th</sup> December, there was significant flows on the floodplains of both watercourses, resulting in a less defined confluence in this area.

In the Guide Meeting Hut, which is located to the west of Rothay Road to the rear of Miller Bridge car park, the recorded water depth was approximately 1.5m.

As indicated in Figure 16, there is a portion of high ground at the junction of the A593 and Borrans Road which creates a 'break point' in flows on the floodplain. Flooding from the River Rothay affected the gardens of some properties on Loughrigg Meadow. The Ambulance Station and sewage works were affected by flooding from the River Rothay.

## Upper Fisher Beck

Figure 20 indicates the flood extent and flow routes associated with the Upper Fisher Beck sub-area, which contains the Blue Hill Road, Old Lake Road and Lake Road areas.



**Figure 20 - Flow Routes in the Upper Fisher Beck sub-area**

Fisher Beck flows in and out of sections of culvert (underground pipes) through this area, which could not cope with the sheer volume of water flowing in Fisher Beck during the flood event. In addition, large volumes of debris in the beck further reduced the capacity of the channel, and caused blockages on debris screens. As a result, the channel capacity was not sufficient to take the flood flow, and a number of properties were affected by flooding.

Overland flow along Blue Hill Road was caused by culvert capacity exceedance at the culvert inlet grid, which is located to the rear of properties at the eastern extent of Blue Hill Road. The gravel track located upstream of Blue Hill Road suffered scour damage, resulting in debris being deposited along the flow route of Fisher Beck on Blue Hill Road. As a consequence of the culvert capacity being exceeded on Fisher Beck at the top of Blue Hill Road, a number of properties on Blue Hill Road and Wansfell Road were affected by flooding.

In Figures 21 and 22, flooding affecting the front gardens of properties on Wansfell Road is shown.



**Figures 21 and 22 - Properties affected by flooding from Fisher Beck on Wansfell Road**

Water flowed down the steep Fisher Beck Lane towards the Old Lake Road, before reaching the Fisher Beck Hotel. Because of the limited capacity of the culvert under Lake Road, combined with the overland flood flows from upstream down Bluehill Road and Wansfell Road, water continued to flow overland in a westerly direction over Lake Road.

Figure 24 shows the narrow Fisher Beck channel adjacent to The Log House, where out of channel flows pooled around West Ing on the left bank of Fisher Beck, before flowing through the garden wall and affecting Fisher Beck Cottage downstream. At Fisher Beck Cottage, a culverted section of Fisher Beck surcharged, breaching the culvert roof and creating a hole in the garden.



**Figure 23 – One of the culvert trash screens on Fisher Beck. Note the limited culvert capacity.**



**Figure 24 - Narrow Fisher Beck channel running alongside The Log House  
Borrans Road**

The Borrans Road area is located in the southern part of Ambleside in an area known as Waterhead, and is shown in Figure 25. Fisher Beck flows in open channel through a field to the west of Hayes Garden World, before flowing through the gardens of residential properties located on Borrans Road in open channel. Fisher Beck is then culverted under Borrans Road, before briefly flowing in open channel in Borrans Field and joining Lake Windermere downstream of the Galava Roman Fort.

During the flood event on 5<sup>th</sup> December, in the field downstream of Hayes Garden World, Fisher Beck flowed out of bank, filling the field over a period of time. At the northern boundary of properties in The Borrans development, there is an elevated section of land which provides some protection to properties in this area as water levels in the field rise. Along the western boundary of the field is a dry stone wall, which during the event was holding water from Fisher Beck in the field. During the flood event, at around 09:30-10:00 the Fire Service knocked a hole in this section of dry stone wall upstream of Galava Gate, which helped to release water across Borrans Road in a westerly direction towards the fields opposite. Stone slabs were also removed from the boundary wall at the northern end of the field along the driveway to Borrans Park House at around 11:00-11:30. Initially this helped to release water that was gathering in the field from Fisher Beck in a northerly direction, reducing water levels in the area, however residents reported that as the flood event progressed, by around 14:30 water then flowed back south through this wall resulting in water levels rising again.

Despite the above measures being taken to try and prevent the flood water from entering The Borrans estate, residents reported that in some cases initial flooding occurred through the floors of the properties. Residents of Galava Gate reported that initial flooding through the floors commenced between 06:00-07:00, before ultimately water from the field upstream overtopped the raised ground at the northern boundary of the development and flowed through the area. Residents from The Borrans

also reported that the Fire Brigade attended a flooding incident in November 2015, where water gathering in the field to the north of the development was pumped into the fields across Borrans Road to prevent the properties from flooding.

Properties downstream of The Borrans development located on Borrans Road were affected by flooding from Fisher Beck and Lake Windermere. Due to the high level of Lake Windermere, Fisher Beck could not flow freely into the lake downstream of the properties, causing flow to 'back up' and further affect properties in this area. In addition, the Fisher Beck channel and culvert under Borrans Road did not have sufficient capacity to convey the significant flows on Fisher Beck in this area.

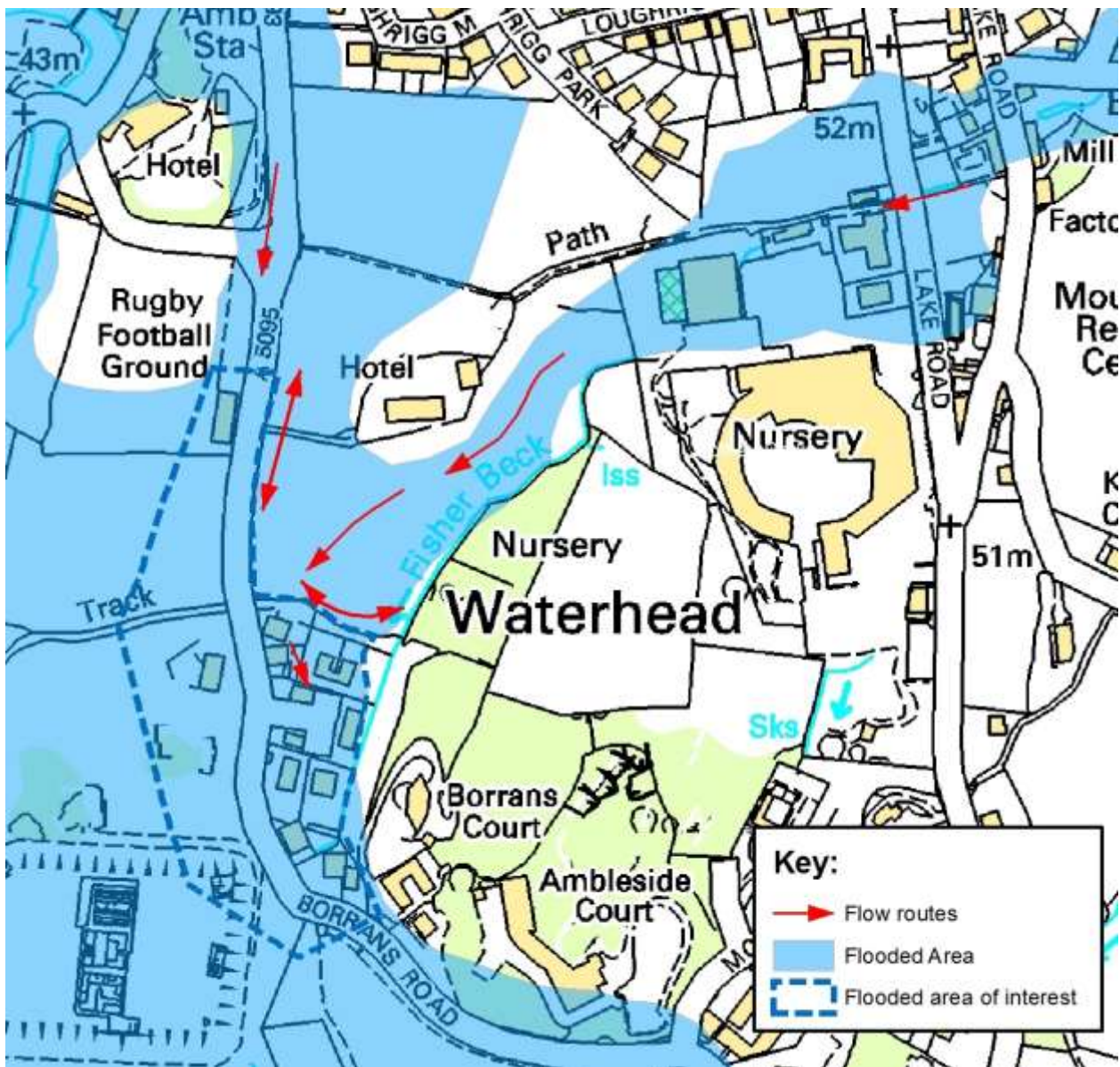


Figure 25 - Flow routes and flood extent in the Borrans Road sub-area

## Under Loughrigg

The Under Loughrigg sub-area is located on the right bank of the River Rothay in the area around Rothay Bridge. The flood extent and flow routes for this area are shown in Figure 26.

Properties on the right bank of the River Rothay on Under Loughrigg Road, upstream of Rothay Bridge, were affected by flooding from the River Rothay during the flood event. Privately-owned riverside retaining walls were damaged along the length of Under Loughrigg Road between Miller Bridge and Rothay Bridge. Close to the junction of Under Loughrigg Road and the A593, floodwater caused major damage, resulting in the road and adjacent dry stone wall to collapse and adjacent fields to be eroded. This damage is shown in Figures 27 and 28. Residents reported that when the highway wall collapsed, releasing water onto the floodplain downstream, this greatly helped to reduce flood levels in the area. The same road was badly affected during a previous flood event in November 2009.

There were several properties affected by flooding in this area, including the Riverside Hotel, Riverside Retreat and Riverside Cottages. Recorded flood depths at these properties range from between 0.6m to 1.5m, which illustrates the significant depth of flooding in this area. Some residents had to be rescued by boat during the flood event.

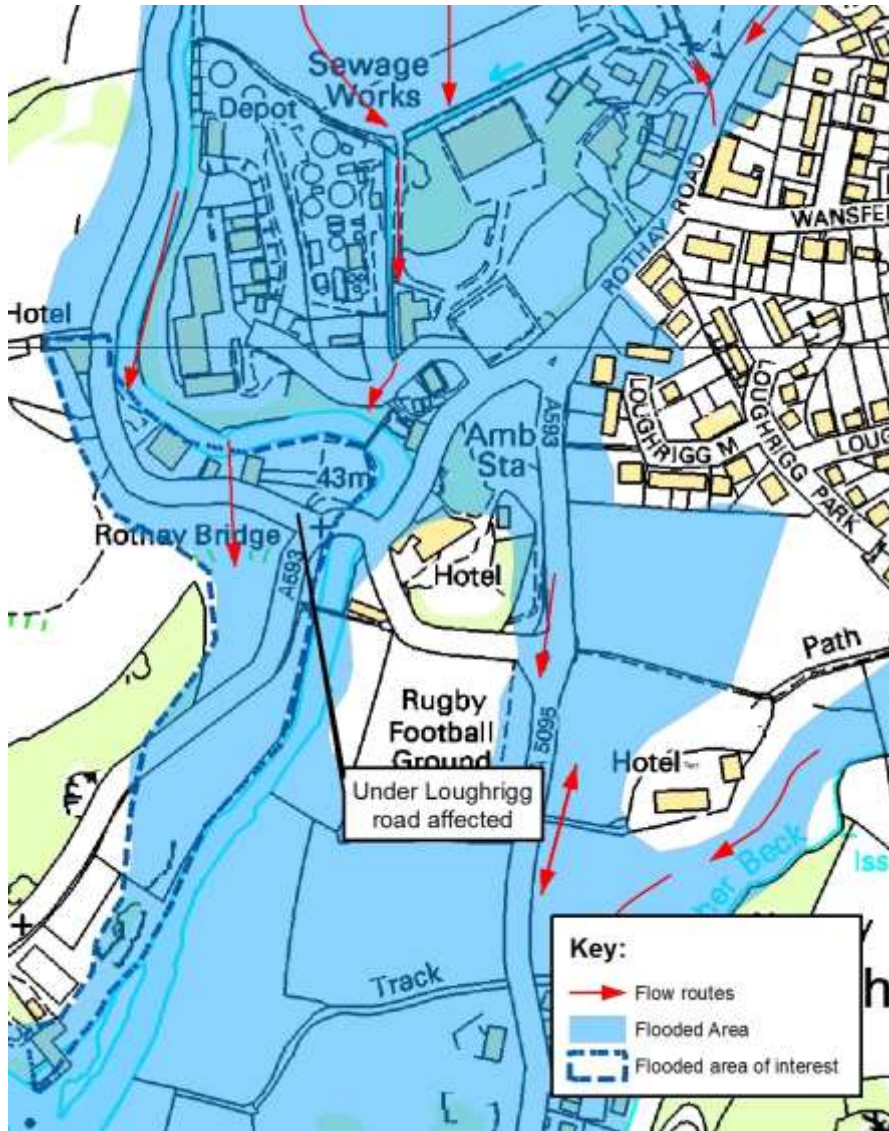


Figure 26 – Flood extent and flow routes in the Under Loughrigg sub-area



**Figure 27 - Flood damage by River Rothay on Under Loughrigg Road**



**Figure 28 - Flood damage by River Rothay on Under Loughrigg Road**



# Environment Agency Flood Incident Response

The Environment Agency, Cumbria County Council and South Lakeland District Council are members of the Cumbria Local Resilience Forum. The Cumbria Local Resilience Forum (LRF) is a partnership, made up of all the organisations needed to prepare for and respond to any major emergency in the LRF area. All services and organisations worked together prior to and during the flooding to ensure that the best possible preparations and plans were in place.

The Environment Agency issued a Flood Alert for the Rivers Brathay, Rothay and Winster catchments on Friday 4<sup>th</sup> December at 15:22. A Flood Alert provides advance notice of possible flooding to low lying land and roads, and also acts as an early notification that river and lake levels are expected to rise and that the Environment Agency are monitoring the situation closely. There are currently no Flood Warning Areas for Ambleside, so during the December flood incident the Environment Agency updated the Flood Alert daily with relevant information. The details of the Flood Alert can be found in Appendix 4.

The debris screens in Ambleside were routinely cleared in the weeks leading up to the flood event and cleared immediately prior to the flood event. The Environment Agency also inspected watercourses to ensure that there were no blockages which may have caused an increase in flood risk. Throughout the duration of the flood event, Environment Agency staff continued to clear debris screens in and around Ambleside.

Immediately after the flood event, the Environment Agency undertook inspections of the watercourses in Ambleside and worked to clear any blockages to aid conveyance. The Environment Agency removed accumulated gravel from Stock Ghyll in the area upstream and downstream of the car park access bridge in October 2016.

# Recommended Actions

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

Cumbria Flood Partnership Theme	Action by	Recommended Action	Timescale
Resilience	Cumbria Local Resilience Forum <sup>1</sup>	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
Resilience	Environment Agency	Continue to work closely with and support the Ambleside Emergency Planning Group to plan and prepare for future flood events, and to understand the various flooding mechanisms observed locally during the December flood event.	Ongoing
Resilience	Environment Agency	Review modelling data to ensure that hydraulic models for the Brathay and Rothay catchments reflect real conditions as accurately as possible and replicate the 5 <sup>th</sup> - 6 <sup>th</sup> December 2015 flood event to ensure the flooding mechanisms identified are reflected in the modelling output. Update the models where required and use this information to make any improvements to the flood forecasting and warning service.	Updated modelling completed 2016.
Resilience	Environment Agency	Investigate options to provide an improved flood warning service for the Ambleside area. This could include the use of community-based triggers to activate emergency plans, as are often used in rapid response catchments.	2016-2017
Resilience	Residents & South Lakeland District Council	Implement flood resilience measures within flooded properties to reduce the impacts of future flooding. South Lakeland District Council is administering the Flood Recovery and Resilience Grants of up to £5000 per property to help people better protect their homes. A further £2000 top up grant can also be applied for from the Cumbria Flood Recovery Fund.	Closing date for grant applications is end of March 2017
Resilience	South Lakeland District Council, Lake District National Park Authority, Cumbria County Council and Environment Agency	Review Local Development Plans and Strategic Flood Risk Assessment to reflect current understanding of flooding.	2016-2017

<b>Cumbria Flood Partnership Theme</b>	<b>Action by</b>	<b>Recommended Action</b>	<b>Timescale</b>
Resilience	Cumbria County Council, United Utilities, Environment Agency and Electricity North West.	Review the resilience of critical transport, utility and power supply infrastructure in relation to flood risk.	2016-2017
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.	CFP Action Plan was published June 2016.
Upstream Management	Cumbria Floods Partnership (CFP), Farmers, Landowners, Community Groups, Trusts.	Explore opportunities for natural flood management solutions to be used upstream of Ambleside in order to 'slow the flow' and manage peak river levels.	Medium term (over next 5 years)
Maintenance	Environment Agency, United Utilities and Cumbria County Council	Carry out inspections and repairs to assets which may have been damaged during the flood event.	Environment Agency inspections completed 2016.
Maintenance	Environment Agency	Review the gravel and channel maintenance programme within the catchment in response to the flooding event of 2015.	2016-2017
Maintenance	Environment Agency	A new Environment Agency system is being developed to make it easier for communities to understand what maintenance work is being carried out in their area. Improvements will show exactly when, where and what maintenance is being planned each year. Make sure that communities understand how they can access information on planned maintenance at: <a href="https://www.gov.uk/government/publications/river-andcoastal-maintenance-programme">https://www.gov.uk/government/publications/river-andcoastal-maintenance-programme</a>	2017
Strengthening Defences	Cumbria County Council, South Lakeland District Council and United Utilities	Review the performance of the existing drainage and sewerage systems during the event to better understand where improvements are required.	2016-2017
Strengthening Defences	Cumbria County Council in partnership with the Environment Agency and United Utilities	Conduct a detailed assessment for Ambleside under the Surface Water Management Plan process and identify solutions to mitigate surface water flood risk in high risk areas that will integrate with fluvial flood risk mitigation options as part of a joined up approach.	2016-2017

<b>Cumbria Flood Partnership Theme</b>	<b>Action by</b>	<b>Recommended Action</b>	<b>Timescale</b>
Strengthening Defences	Environment Agency in partnership with Cumbria County Council and South Lakeland District Council	Undertake an appraisal of options to investigate the viability of improving the existing Standard of Protection in Ambleside.  Defence options to be appraised will include upstream storage, improvements to flood channel conveyance, culvert improvements, raised flood defences and natural flood management.	2016-2017
Strengthening Defences	Cumbria County Council & Environment Agency	Assess the impact of the road bridges and footbridges in Ambleside on flood flows, and investigate options to increase their flood capacity, taking into account the potential effects on flood risk downstream.	2016-2017

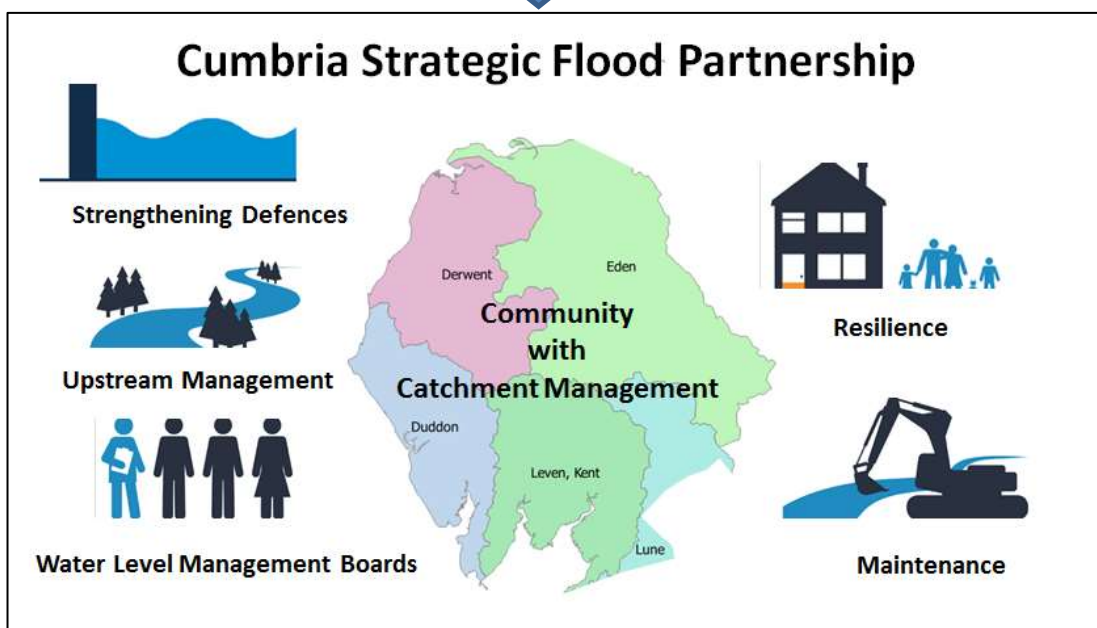
**Table 1 - Recommended actions for consideration**

<sup>1</sup> 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.

# Next Steps – Community & Catchment Action Plan

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, including Carlisle. 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.

The diagrams below helps demonstrate how the two partnerships have now come together:





# Cumbria Strategic Flood Partnership



RFCC

Cumbria Strategic Partnership Board

Catchment Management Group  
Eden

Catchment Management Group  
Derwent

Catchment Management Group  
Kent and Leven

Steering Groups  
(Various per Catchment)  
MSFWG

## Community

*'Farmers, environmental charities, landowners, private companies, councils and government agencies have joined together with a common goal.*

*To look at the evidence and potential funding sources to find flood solutions for defences, resilience, maintenance, upstream management and water level management boards, so they can work together to help communities at risk of flooding.'*

*In an dynamic move the Cumbria Strategic Flood Partnership have created three groups whose aim is to look at all options for how flood risk can be reduced in Cumbria.*

*This group the first of its kind in the country brings together the expertise of all those whose water and land management experience to look at what can be done to protect communities both residential and farming.*

*They will then discuss their findings to the communities at risk and plan a way forward.*

*This landmark move will ensure that fully integrated solutions for land and water management are utilised to protect people and the environment in which they live and rely on.*

# Appendices

## Appendix 1: Acronyms and Glossary

Acronym	Definition
EA	Environment Agency
CCC	Cumbria County Council
SLDC	South Lakeland District Council
LLFA	Lead Local Flood Authority
FLAG	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
UU	United Utilities

Term	Definition
Aquifer	A source of groundwater comprising water-bearing rock, sand or gravel capable of yielding significant quantities of water.
Attenuation	In the context of this report - the storing of water to reduce peak discharge of water.
Catchment Flood Management Plan	A high-level planning strategy through which the EA works with their key decision makers within a river catchment to identify and agree policies to secure the long-term sustainable management of flood risk.
Culvert	A channel or pipe that carries water below the level of the ground.
De Facto Flood Defence	A feature or structure that may provide an informal flood defence benefit but is not otherwise designed or maintained by the Environment Agency
Flood Defence	Infrastructure used to protect an area against floods as floodwalls and embankments; they are designed to a specific standard of protection (design standard).
Floodplain	Area adjacent to river, coast or estuary that is naturally susceptible to flooding.
Flood Resilience	Measures that minimise water ingress and promotes fast drying and easy cleaning, to prevent any permanent damage.
Flood Risk	The level of flood risk is the product of the frequency or likelihood of the flood events and their consequences (such as loss, damage, harm, distress and disruption)
Flood Risk Regulations	Transposition of the EU Floods Directive into UK law. The EU Floods Directive is a piece of European Community (EC) legislation to specifically address flood risk by prescribing a common framework for its measurement and management.

<b>Term</b>	<b>Definition</b>
Flood and Water Management Act	Part of the UK Government's response to Sir Michael Pitt's Report on the Summer 2007 floods, the aim of which is to clarify the legislative framework for managing surface water flood risk in England.
Flood Storage	A temporary area that stores excess runoff or river flow often ponds or reservoirs.
Flood Zone	Flood Zones are defined in the NPPF Technical Guidance based on the probability of river and sea flooding, ignoring the presence of existing defences.
Flood Zone 1	Low probability of fluvial flooding. Probability of fluvial flooding is < 0.1%
Flood Zone 2	Medium probability of fluvial flooding. Probability of fluvial flooding is 0.1 – 1%. Probability of tidal flooding is 0.1 – 0.5 %
Flood Zone 3a	High probability of fluvial flooding. Probability of fluvial flooding is 1% (1 in 100 years) or greater. Probability of tidal flooding is 0.5%(1 in 200 years)
Flood Zone 3b	Functional floodplain. High probability of fluvial flooding. Probability of fluvial flooding is >5%
Fluvial	Relating to the actions, processes and behaviour of a water course (river or stream)
Fluvial flooding	Flooding by a river or a watercourse.
Freeboard	Height of flood defence crest level (or building level) above designed water level
Functional Floodplain	Land where water has to flow or be stored in times of flood.
Groundwater	Water that is in the ground, this is usually referring to water in the saturated zone below the water table.
Inundation	Flooding.
Lead Local Flood Authority	As defined by the FWMA, in relation to an area in England, this means the unitary authority or where there is no unitary authority, the county council for the area, in this case Cumbria County Council.
Main River	Watercourse defined on a 'Main River Map' designated by DEFRA. The EA has permissive powers to carry out flood defence works, maintenance and operational activities for Main Rivers only.
Mitigation measure	An element of development design which may be used to manage flood risk or avoid an increase in flood risk elsewhere.
Overland Flow	Flooding caused when intense rainfall exceeds the capacity of the drainage systems or when, during prolonged periods of wet weather, the soil is so saturated such that it cannot accept any more water.
Residual Flood Risk	The remaining flood risk after risk reduction measures have been taken into account.
Return Period	The average time period between rainfall or flood events with the same intensity and effect.
River Catchment	The areas drained by a river.



<b>Term</b>	<b>Definition</b>
Sewer flooding	Flooding caused by a blockage or overflowing in a sewer or urban drainage system.
Sustainability	To preserve /maintain a state or process for future generations
Sustainable drainage system	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques.
Sustainable development	Development that meets the needs of the present without compromising the ability of future generations meeting their own needs.
Sustainable Flood Risk Management	Sustainable Flood Risk Management promotes a catchment wide approach to flooding that uses natural processes and systems (such as floodplains and wetlands) to slow down and store water.
Topographic survey	A survey of ground levels.
Tributary	A body of water, flowing into a larger body of water, such as a smaller stream joining a larger stream.
Watercourse	All rivers, streams, drainage ditches (i.e. ditches with outfalls and capacity to convey flow), drains, cuts, culverts and dykes that carry water.
Wrack Marks	An accumulation of debris usually marking the high water line.
1 in 100 year event	Event that on average will occur once every 100 years. Also expressed as an event, which has a 1% probability of occurring in any one year.
1 in 100 year design standard	Flood defence that is designed for an event, which has an annual probability of 1%. In events more severe than this the defence would be expected to fail or to allow flooding.

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

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
<b>Rivers</b>					
Main river					
Ordinary watercourse					
<b>Surface Runoff</b>					
Surface water					
Surface water on the highway					
<b>Other</b>					
Sewer flooding					
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 the LLFA's work relating to flood risk.

**Environment Agency:** Strategic overview of all sources of flooding and coastal erosion as defined in the Flood and Water Management Act (2010). As part of its role concerning flood investigations, this requires providing evidence and advice to support other RMAs. The Environment Agency also collates and reviews assessments, maps and plans for local flood risk management (normally undertaken by LLFA).

**Lead Local Flood Authorities:** Cumbria County Council is 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 RMA 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 RMAs 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. These organisations are classed as RMA's.

**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 now responsible for a larger number of sewerage than prior to the regulation. These organisations are classed as RMAs.

**Highway Authorities:** 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. These organisations are classed as RMAs.

Flood risk in Cumbria is managed through the Making Space for Water (MSfW) process, which involves the co-operation 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 MSfW Groups will meet approximately 4 times per year to co-ordinate operations and work together to mitigate flood risk in the vulnerable areas identified in this report by completing the recommended actions. As LLFA, CCC 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 partner's own capital investment process.

Flood Action Groups are usually formed by local residents who wish to work together to help reduce flood risk in their area. The FAGs are often supported by either CCC or the Environment Agency and provide a useful mechanism for residents to forward information to the MSfW Group.

## Appendix 3: Links to Other Information on Flooding

### **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>

## Appendix 4: Flood Alerts

### Flood Alert Issued

#### Flood Alert Area - 011WAFBR - Rivers Brathay, Rothay and Winster

Alert issued on Friday 04/12/2015 at 15:22

**Customers in Flood Alert area registered on FWD: 98**

**Contacts (landline, mobile, email etc) in Flood Alert area registered on FWD: 303**

**Successful contacts: 267**

**Unsuccessful contacts: 36**

#### Alert Message:

A Flood Alert has been issued by the Environment Agency for the Rivers Brathay, Rothay and Winster. Flooding is possible for Rivers Brathay, Rothay and Winster.

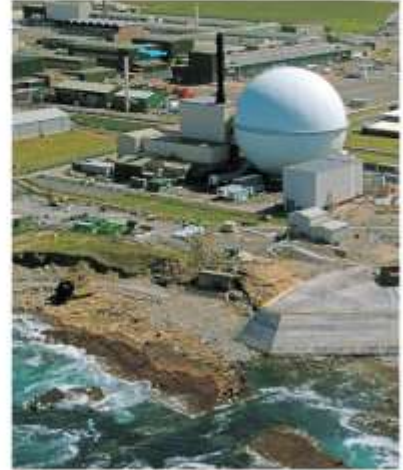
Low lying land and roads will be affected first. Be prepared to protect yourself, family, pets and property.

Heavy and persistent rainfall along with strong South-Westerly winds are forecast to continue this evening (Friday 04/12/2015) through until Sunday (06/12/2015). With the ground already saturated the river and lake levels are expected to rise further and we may see some significant impacts. Newby Bridge Sluices remain open (opened 9th November). The forecast is likely to result in Flood Warnings being issued on Saturday (05/12/2015). We advise that you keep an eye on the situation by listening to weather forecasts, checking our web pages or calling Floodline. We are continuing to monitor the situation and have workers on site operating defences and clearing blockages where required.

## Appendix 5: CH2M Hill UK Projects and Flood Risk Management brochure

# CH2MHILL.

## Key Projects in the UK



### We partner with your industry

- Municipal Water, Wastewater, and Water Supply
- Aviation, Ports, Transit, and Rail
- Nuclear Decontamination and Decommissioning
- Chemical Manufacturing
- Environmental Remediation and Compliance Management
- Environmental Industrial Systems
- Commercial Nuclear
- Oil and Gas
- Electronics and Advanced Technologies
- Manufacturing
- Life Sciences
- Communications Infrastructure
- Security Systems

Employee-owned CH2M HILL is one of the world's leading consulting, design, design-build, operations, and programme management companies serving government, civil, industrial and energy clients, employing over 28,000 people worldwide. Our work is concentrated in the areas of water, transportation, environmental, energy, facilities and resources.

Having operated in the UK for over 20 years, we acquired Halcrow in 2011 and continue to base our European headquarters in London, now employing over 3,300 people in the UK. CH2M HILL is working on some of the most iconic infrastructure programmes including High Speed 2, Thames Tideway Tunnels, the decommissioning of Dounreay and was one of the leading partners in CLM, Delivery Partner to the ODA for the London 2012 Olympic & Paralympic Games.

We serve as a single point of contact and responsibility, managing your project through planning, financing, permitting, design, construction, and operations. We use technology transfer and leverage established relationships with local firms to deliver industrial and enterprise management solutions throughout the United Kingdom.

CH2M HILL is an active member of Business in the Community and the Employee Ownership Association.

## Urban Programmes

### Key endorsements:

*"From the outset of the project, the Olympic Park has set new standards in sustainability, including delivery of lightweight venues, recycling or reuse of waste materials, using concrete with a high recycled content and delivering materials by rail or water. We have achieved new standards for a project of this size and scale and have raised the bar for the industry."*

– John Armitt, ODA Chairman

*"The ODA did a fantastic job in delivering the Olympic venues and infrastructure on time and within budget. They did our nation proud."*

– Margaret Hodge MP, Chair of the Public Accounts Select Committee



### London 2012 Olympic and Paralympic Games

CH2M HILL was one of the three first constituting the international consortium CLM, the Delivery Partner to the Olympic Delivery Authority (ODA). CLM oversaw the design and construction of the nine venues across the 500-acre Olympic Park for the London 2012 Olympic and Paralympic Games. CH2M HILL provided the consortium and ODA with global engineering, construction and programme management expertise.

Completed one year ahead of the games, the programme was delivered at an impressive £1Bn under the baseline budget of £7.2Bn with notably zero construction fatalities, the first of such records of any modern Olympics.



## Water

### Thames Tideway Tunnel and Lee Tunnel

CH2M HILL is the programme manager for the London Tideway Tunnels Programme, one of the biggest and most historic public works initiatives in London's history. With the Rivers Lee and Thames currently overflowing approximately 50-60 times annually, the London Tideway Tunnels Programme looks to reduce overflows to three or less per year.

The programme will see the construction of the Lee Tunnel and the Thames Tideway Tunnel and aims to greatly improve the river quality and reduce the environmental impact of sewerage overflows. Both tunnels will be more than seven metres wide, running beneath a vast network of existing tunnels, including six Underground lines and utilities. The programme includes constructing numerous collection and diversion facilities, a large high-head underground pumping station, and a major upgrade at Beckton sewage treatment works. Ultimately, CH2M HILL will manage over 300 work packages. So far, CH2M HILL have delivered £700M of savings on a £4.1Bn budget and carried out exemplary stakeholder relations across 14 London Boroughs.



## Transport

### Crossrail

As Europe's largest engineering project, Crossrail will connect 37 stations, including Heathrow airport and Maidenhead in the west with Canary Wharf, Abbey Wood and Shenfield in the east—reducing journey times across London while delivering extensive economic benefits.

The Transcend team, which includes CH2M HILL, AECOM and The Nichols Group, was appointed as the programme partner to work alongside Crossrail to oversee the construction of a 21 kilometre-long tunnel beneath central London, build eight new stations and integrate Crossrail with London's existing transport systems. Additionally, the team is responsible for programme controls, encompassing the functions of scope, cost and schedule control, as well as risk and value management.

When Crossrail opens in 2018, the £14.8Bn rail link will boost London's rail-based network capacity by ten percent—transporting 200 million passengers annually, bolster the capital's position as a world-leading financial center, and significantly reduce journey times across the city.



### High Speed 2 (HS2)



HS2 will be the UK's new high speed rail network and is being designed and built to resolve impending capacity issues for both passengers and freight on existing routes, particularly the West Coast Main Line.

The network will provide enhanced infrastructure links between London and the West Midlands (Phase One), as well as the Channel Tunnel, expanding in future to connect Manchester, Leeds and the North with Birmingham, the south of England and Heathrow Airport (Phase Two).

CH2M HILL is development partner with HS2 Ltd and is leading the development of the next phase of engineering, design and environmental work on the London to the West Midlands line. The 80 strong team, working alongside HS2 Ltd, largely consists of project management and engineering specialists from the UK. The team project manage the professional services companies who are carrying out the design, environmental and land referencing work for the London to West Midlands line. CH2M HILL's expertise ensures that the work is fully integrated and delivered to the required quality.

On appointing CH2M HILL, HS2 Ltd's Chief Executive Alison Munro said: "The appointment means that we will have world class project managers and technical experts working alongside us to deliver the design, engineering and environmental work necessary for the hybrid bill. They will bring, in particular, their highly regarded experience of working on HS1 and Crossrail, two major UK infrastructure projects that have direct relevance to our work."

#### We provide services for your success

- Programme and Project Management
- Site Selection
- Infrastructure Planning
- Economic Development
- Energy Management and Planning
- Information Systems
- Master Planning
- Licensing and Permitting
- Management Consulting
- Project Financing
- Project Development
- Architecture and Programming
- LEED and BREEAM Facility Certification
- Civil, Structural, Mechanical, and Electrical Engineering



## Water Resources-Ecosystem Management Services

### Flood Risk Management

CH2M is a world leader in flood risk management, providing integrated and sustainable solutions for both the built and natural environment. Our large team of specialists and scientists, who are primarily based in the UK and USA, deliver projects around the world. They are supported by environmental scientists, surveyors, geotechnical engineers, and business planning, finance and contract, and other specialists. Our work includes the full cycle of flood risk mapping and strategic planning; capital works delivery; and operation, maintenance and asset management.

The solutions we develop recognize the effect climate change is increasingly having on the built and natural environment within river catchments and estuaries, and thus our focus is on developing long-term solutions that work with nature and continue to leave a sustainable legacy to protect future generations from the effects of climate change.

A core focus is delivering fully integrated solutions that maximize both direct and indirect benefits for the clients that we serve in WBG, TBG and Strategic Consulting. This means we are linked with several technologies including IWRM, Dams and Levees (Conveyance), Water Resilience, H&H modeling (Software Applications and Integration), Urban Watershed Management, and Coastal Planning and Engineering.

#### Sub-technologies

The FRM technology group has three key sub-technology areas that we steward, offering several capabilities in each:

#### Flood mapping and appraisal

- Watershed-scale flood risk management planning
- Flood hazard modeling/mapping and hydraulic analysis
- Flood risk management alternatives development and testing
- Risk vulnerability and damage analysis
- Flood forecasting/warning
- Flood incident management and exercise

#### Capital works delivery

- Program/project management
- Conceptual, preliminary and final design
- Contract preparation and administration
- Construction supervision
- Due diligence and other pre-bid assistance

#### O&M and asset management (AM)

- Asset management
- Strategic and tactical investment advice
- Disaster recovery

#### Challenges, Trends, Opportunities

Floods are increasing in frequency around the world and it is forecast that these will only get worse as a result of climate change. As the frequency of floods increases, the tolerance of the public, governments, the private sector, and insurance companies is reducing, prompting action.

A key market differentiator is being able to deliver multiple outcomes to clients through a river basin management approach which links together flood risk management needs with regeneration, recreational, and environmental enhancement opportunities and combines the associated available funding to generate both efficiencies and the financial support necessary for scheme delivery.

To achieve this we need to combine our flood risk management capabilities and technology with our knowledge of what the issues are within the river basins.

#### Did You Know?

- A review by the Organization for Economic Cooperation and Development on 136 coastal cities found that the estimated damage from sea level rise, storm surge and subsidence for 1 in 100 year flood event in 2070 was estimated at \$35,000 billion.
- In 2070 it is estimated that over 150 million people will live in these 136 coastal cities at risk.
- River flooding is the most common type of flood event.
- Floods are the number one natural disaster in the US, and just a few inches of water from a flood can cause tens of thousands of dollars in damage.
- The flooding in Alberta, Canada in 2013 flooded displaced 100,000 people and is estimated to cost \$6 billion.
- According to the House of Commons library, £2.34 billion has been spent on new flood defenses in England alone since 2011.