

Windermere

Flood Investigation Report



The Swan Hotel, Newby Bridge

Flood Event 5-6th 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.

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Executive Summary

As a result of Storm Desmond, there was a period of prolonged, intense, rainfall across Northern England during the 5th and 6th of December 2015. The rainfall fell on already saturated catchments, which led to high river and lake levels causing flooding throughout Cumbria.

On 6th of December 2015, water levels in the River Leven at Newby Bridge nearly reached the record levels set during the November 2009 flood event, with flood levels in the area adjacent to Windermere Lake being reported as only 100mm lower than in November 2009. The flooding in the area adjacent to the River Leven was mostly fluvial.

An estimated 132 properties around the periphery of Windermere Lake were affected by flooding. In addition, 45 properties in Windermere town were affected by flooding from Mill Beck and surface water. Downstream of Windermere Lake on the River Leven, 4 properties in Newby Bridge and 30 properties in Backbarrow were affected by flooding.

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 the Windermere area on the 5th and 6th 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.

This report examines the flooding that occurred, and details the flow routes and causes of flooding. The key features of the flooding event are summarised below.

- **Bowness-on-Windermere:** water overtopped the lakeshore, causing damage to properties close to the Lake itself. Properties around Glebe Road, along The Promenade, Ferry Nab and at the Windermere Marina Village were affected by flooding.
- **Newby Bridge:** flooding initially occurred from water discharged from the storm drains. This was then followed by flood water directly from the River Leven, flowing through gaps in the wall next to the bridge, around the sides of the bridge parapet and over Newby Bridge, flooding adjacent properties.
- **Backbarrow:** local eyewitnesses reported that Backbarrow Bridge restricted the water flow and raised the water level in the River Leven, causing more damage than experienced in previous events. The water came over the parapet wall of the bridge and stone walls on the left and right banks of the River Leven.
- **Windermere Town:** the water level in Mill Beck rose quickly, exceeding the channel capacity of the watercourse and flooding several properties and gardens. A number of properties around the town were flooded as a result of surface water.
- **Lakeside:** water overtopped the lakeshore causing damage to a number of residential and commercial properties.
- Transport links, including the **A591**, were affected by surface water and high Lake levels.
- A large number of boats moored on the Lake and within marinas were affected.

- A large number of boat houses were affected in various locations in and around Windermere Lake.

A total of 14 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, and will include an examination of the potential for improvements to processes.

A draft version of the Windermere 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 Windermere on the 26th 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, including with the Windermere Lake Levels Group, 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. The authors of the report are grateful for the information provided by the Windermere Lake Levels Group, and the photos provided by Zan Fell, which have been used to inform the report.

In response to the flooding, a number of 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 in their area of the town.

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>

The Flood Investigation Report

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-6th 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.

Introduction

Geographical setting

Windermere Lake is the largest natural lake in England, stretching 16.9 kilometres in length and reaching a maximum depth of 66.7 metres at its deepest point. It is located within the Lake District National Park, in the county of Cumbria, North West England. The Lake is drained by the River Leven at its southern tip, which discharges into Morecambe Bay. **Figure 1** provides an overview of the Windermere area.



Figure 1: Overview of the Windermere area detailed in the report

Flooding History

The area around Windermere Lake is at risk of flooding. Since the late 1990's this area has been subject to flooding on several occasions, notably in 1999, 2005, 2008 and 2009. The villages of Newby Bridge and Backbarrow, situated on the River Leven downstream of Windermere Lake, were also affected by flooding in November 2009, whilst Newby Bridge was also impacted in October 2008.

The November 2009 event was estimated to be an event with a rarity between 0.5-0.2% Annual Exceedence Probability (AEP)¹. The annual exceedence probability (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, two of which are shown in **Table 1**. Throughout this report AEP is expressed as a percentage. As such, an event that has a 1 in 100 chance of occurring in any single year will be described as a 1% AEP event.

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

Table 1: Probabilities of Exceedance

¹ Estimate taken from CEH briefing note <http://nora.nerc.ac.uk/s510223/1/Nov09Floods-CEH-briefing-note.pdf>

Flood Event 5-6th December 2015

Background

On the 5th and 6th of December 2015, an estimated 132 properties around the periphery of Windermere Lake were affected by flooding. The majority of this flooding was in Bowness-on-Windermere, and the numerous residential and commercial properties located on the shoreline around Windermere Lake. The very high levels experienced in and around Windermere Lake were caused by extensive and prolonged rainfall over a 36 hour period. In addition, 45 properties in Windermere town were affected by flooding from Mill Beck and surface water. Downstream of Windermere Lake on the River Leven, 4 properties in Newby Bridge and 30 properties in Backbarrow were affected by flooding. The flooding in Newby Bridge and Backbarrow was primarily associated with the River Leven.

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, as illustrated in **Table 2**.

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

Table 3 shows the depth of rainfall falling in 24 hours at gauges within the Windermere catchment. The location of the rain gauges can be seen in **Figure 2**. The rainfall recorded in the immediate catchment, at Blackmoss, during the 2015 event is greater than the 24 hour period recorded in 2009. It is also worth noting that 62.7mm of rainfall was recorded at Blackmoss on 4th December 2015.

The Grasmere Tannercroft rain gauge, which is situated within Grasmere village in the upstream River Rothay catchment, recorded a total of 261.1mm of rainfall from 9am on the 4th December to 9am on the 6th December. This exceeded the previous highest recorded 48 hour total of 240.7mm from the 18th and 19th November 2009. As Grasmere Tannercroft is a 'daily read' rain gauge, 24 hour recordings are taken for the 24 hour period from 9am to 9am. Table 3 illustrates that the 24 hour rainfall total recorded at the Grasmere Tannercroft rain gauge was greater in November 2009, however given the above 48 hour event totals it is clear that the 48 hour total over the event duration was greater in December 2015.

Location	24 hour Rainfall during November 2009 Event	24 hour Rainfall during December 2015 Event
	mm	mm
Grasmere Tannercroft*	155.5	133.7
Blackmoss*	72.8	111
Tower Wood	76.2	Data not available

Table 3: 24 hour rainfall within the Windermere catchment**

*Daily read rain gauge, with 24 hour recordings taken for the 24 hour period from 9am to 9am.

**Please note that rainfall data from the Brathay Hall and Mickleden rain gauges has been omitted from this report due to uncertainties over the recorded data in the December 2015 event. Alternative gauges within the catchment have therefore been used.

River and Lake Levels

Record river levels were recorded at the Miller Bridge House gauging station on the River Rothay and Calgarth gauging station on Trout Beck, illustrated in **Table 4**. The peak river level recorded at Miller Bridge House reached 3.714m, exceeding the previous record of 3.517m recorded during the November 2009 flood event. The peak level recorded at Calgarth gauging station reached 2.234m, exceeding the 2.085m record level previously set during the same 2009 event. However, river levels recorded at Jeffy Knotts on the River Brathay and at Newby Bridge on the River Leven did not exceed the previous records set in November 2009.

Gauging Station	Highest Recorded Gauging Dates & Levels		
	January 2005	November 2009	December 2015
Miller Bridge House, River Rothay	3.432m	3.517m	3.714m*
Jeffy Knotts, River Brathay	3.656m	4.500m*	3.871m
Calgarth, Trout Beck	1.986m	2.085m	2.234m*
Newby Bridge, River Leven	1.884m	2.541m*	2.480m

*Record level

Table 4: Windermere catchment, record gauged river levels

Gauging Station	Highest Recorded Gauging Dates & Levels		
	January 2005	November 2009	December 2015
Far Sawrey, Windermere Lake	1.853m	2.904m*	2.820m

*Record level

Table 5: Windermere Lake levels taken from the gauge at Far Sawrey

Table 5 shows lake levels for Windermere Lake recorded at the Far Sawrey gauging station. The maximum level recorded during the December 2015 flood event was 84mm lower than the record lake level, reached during the flooding of November 2009. This can be correlated with the flows draining the lake recorded at Newby Bridge gauging station on the River Leven, recording a peak level 61mm lower in 2015 than in 2009.

The location of river level and lake level gauges can be seen along with the catchment rain gauges in **Figure 2**.

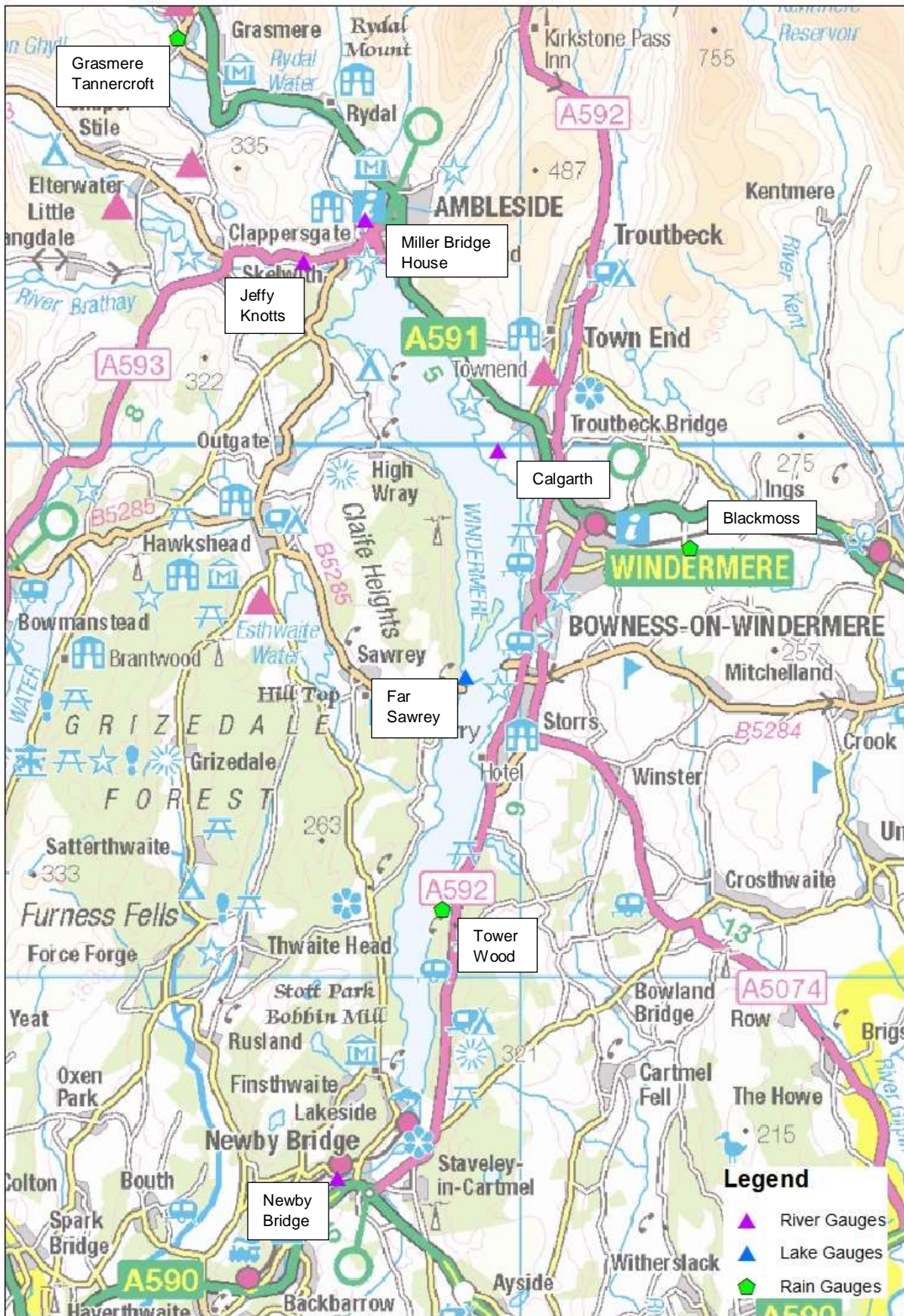


Figure 2: Location of Rainfall, River Level and Lake Level Gauging Stations

Figure 3 shows changes in the river levels at the gauging stations around Windermere Lake during the December flood event.

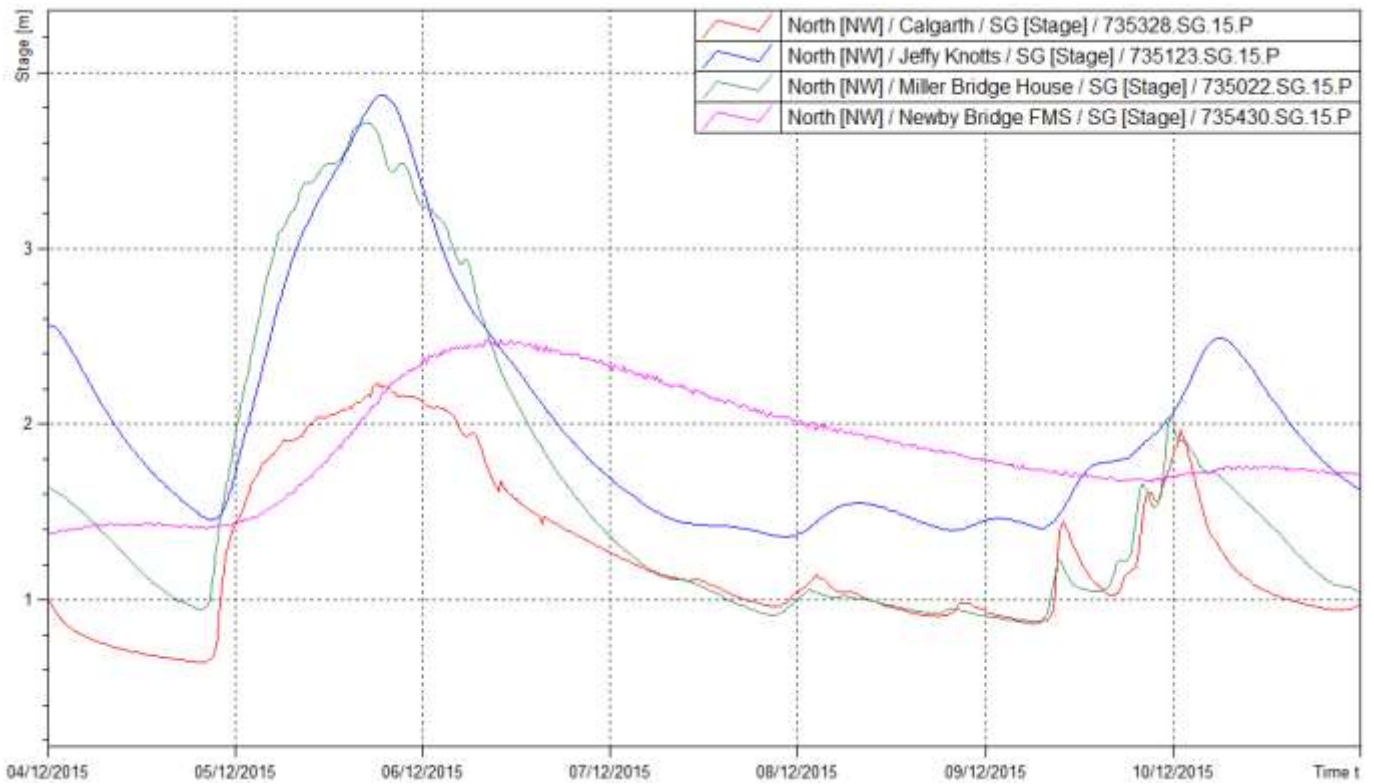


Figure 3: River levels recorded at the gauging stations

Investigation

This investigation was carried out by the Environment Agency through surveys of the area and data collected from the local communities. The Windermere Lake Levels Group (consisting of local residents and businesses) also provided a great deal of information on the flooding, which is greatly appreciated. This report has been compiled by CH2M Hill, specialist flood risk consultants, from the data collected by the Environment Agency.

Figure 4 shows the 2015 flood extent for the Windermere area. The flood outline identifies the maximum extent of flooding. Not all properties within the flood outline were flooded.

Flooding was reported at 19 locations within the Windermere catchment, as summarised below and in **Figure 4**. For the purposes of this report, locations where multiple properties were flooded have been divided into sub-areas. Seven sub-areas have been identified and referenced A-G, detailed in **Table 6**. These sub-areas are examined in detail in the following sections of this report.

Sub-area	Sub-area name	Map reference
A	Ambleside's waterfront	Figure 5
B	Bowness-on-Windermere: The Promenade and Glebe Road	Figure 6
C	The Marina and Storrs	Figure 7
D	Windermere Town	Figure 8
E	Lakeside	Figure 11
F	Newby Bridge	Figure 12
G	Backbarrow	Figure 14

Table 6: Identified sub-areas for investigation

The additional 12 locations refer to reports of smaller scale flooding. These are referenced 1-12, detailed in **Table 7**, and are located as shown in **Figure 4**.

Location	Description
1	Flooding on to the A591 road. Occasional debris on the road and wrack marks were visible
2	Boathouses affected by flooding
3	Boathouses affected by flooding
4	Some properties and boathouses affected by flooding. Debris marking the maximum flooding extent evident on the A591.
5	Properties and boathouses affected by flooding
6	Windermere Steamboat Museum affected by flooding
7	Boathouses affected by flooding
8	Boathouses affected by flooding
9	Boathouses affected by flooding
10	Boathouses affected by flooding
11	Flooding on to the road
12	Properties in Clappersgate affected by flooding

Table 7: Additional areas of flooding

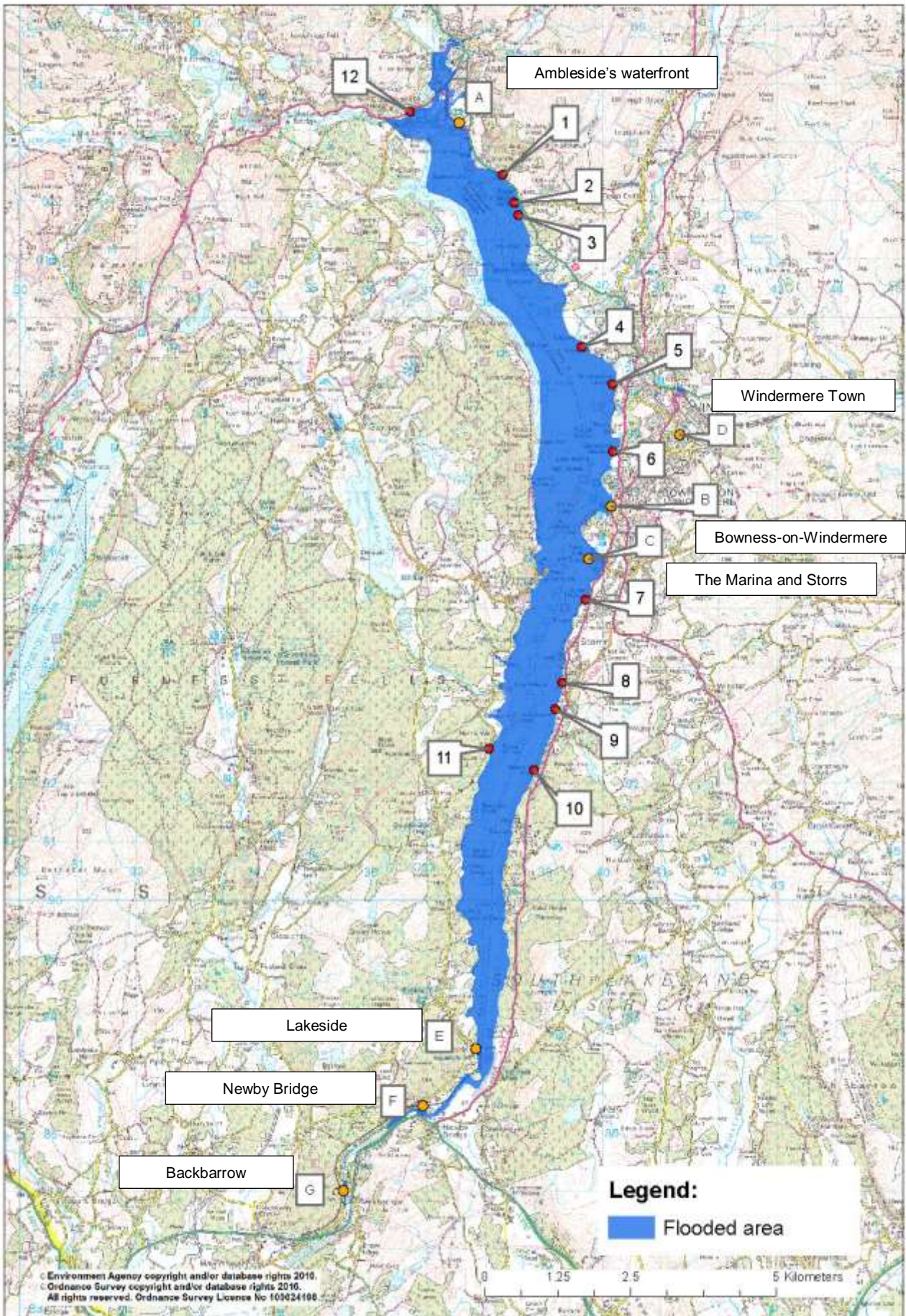


Figure 4: Flood Outline for the Windermere area and River Leven

Timeline

Table 8 below shows the times of key events during the flood incident.

5 th December	Event
16:45	River Rothay peak at Miller Bridge House – 3.714m
18:15	Trout Beck peak at Calgarth – 2.234m
18:45	River Brathay peak at Jeffy Knotts – 3.871m
6 th December	Event
08:30	River Leven peak at Newby Bridge - 2.480m

Table 8: Windermere 5th – 6th December flood incident timeline

Sub-area A: Ambleside's waterfront

Location shown as Point A on Figure 4.

Ambleside's Waterfront was flooded directly from Windermere Lake as a result of high water levels in the Lake. In addition to flooding from the Lake, employees from the Youth Hostel reported that their basement was flooded, which they felt was due to high groundwater levels. Overland surface water flows from the hillside east of Waterhead Cottages and the A591 was also reported, with resulting surface water flow observed along the A591. As well as surface runoff from the hillside, overland flow from an ordinary watercourse which is culverted (piped) through fields to the east of the A591 may well have been a contributory factor in this area. Waterhead Cottages were reportedly affected by flooding to their basements. **Figure 5** shows the flood extent and flow routes.

Several commercial properties and boat houses were affected in this area, as illustrated in **Photograph 1**. The locally recorded water level was about 10mm lower than in November 2009, shown in **Photograph 2**.

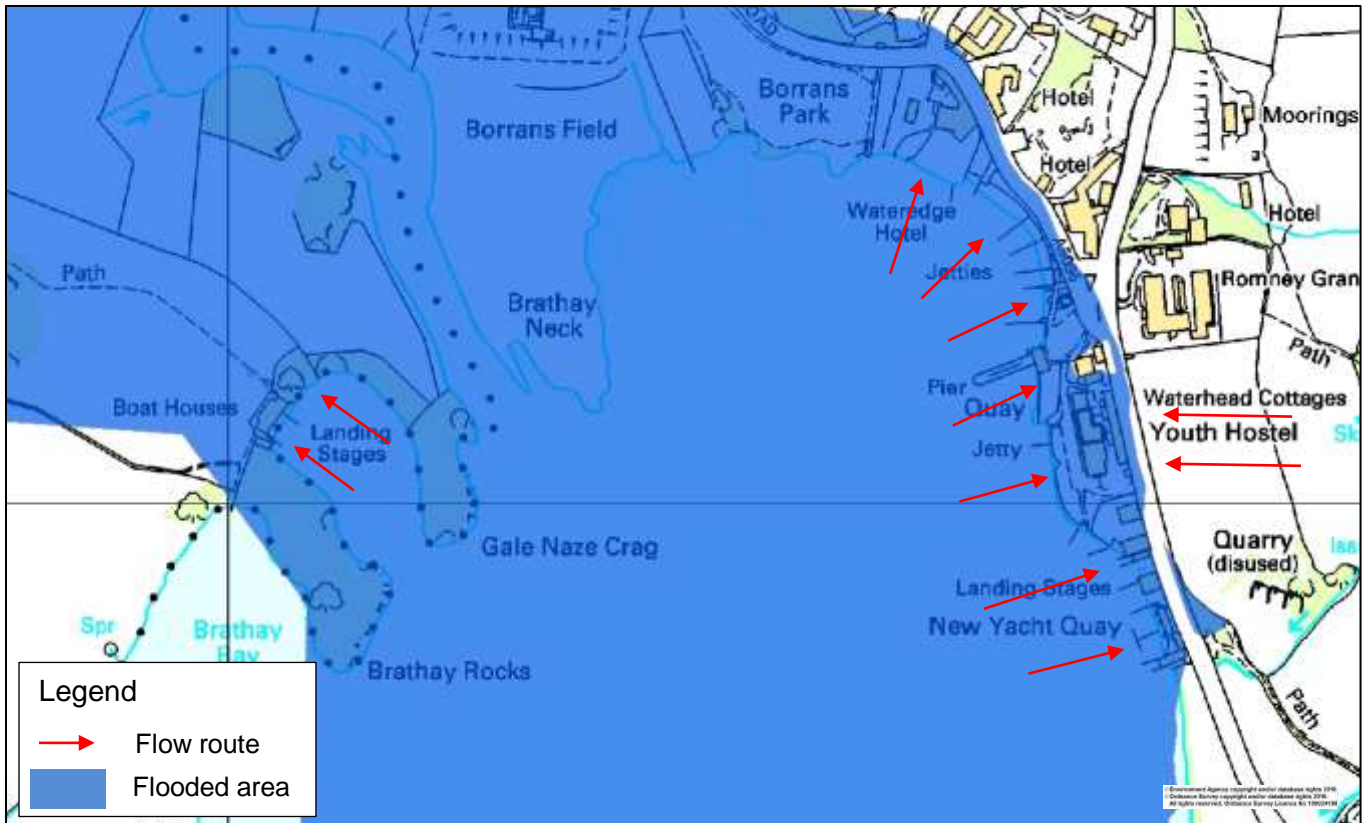


Figure 5: Flood flow routes - Ambleside's waterfront



Photograph 1: Debris near the Wateredge Inn shortly after flooding



Photograph 2: Water level in 2015 in comparison with the flooding in November 2009

Sub-area B: Bowness-on-Windermere – The Promenade and Glebe Road

Location shown as Point B on Figure 4.

Bowness-on-Windermere is a small town of approximately 2500 inhabitants, located on the eastern shore of Windermere Lake. The area flooded is comprised of mostly commercial properties, but there were also a few residential properties affected. The area was flooded directly from the Lake as a result of the rising water level due to the prolonged, intense rainfall. When the water level in the Lake rose, the area close to the lakeshore was inundated. Observed water levels in the flooded properties were lower than in the November 2009 event.

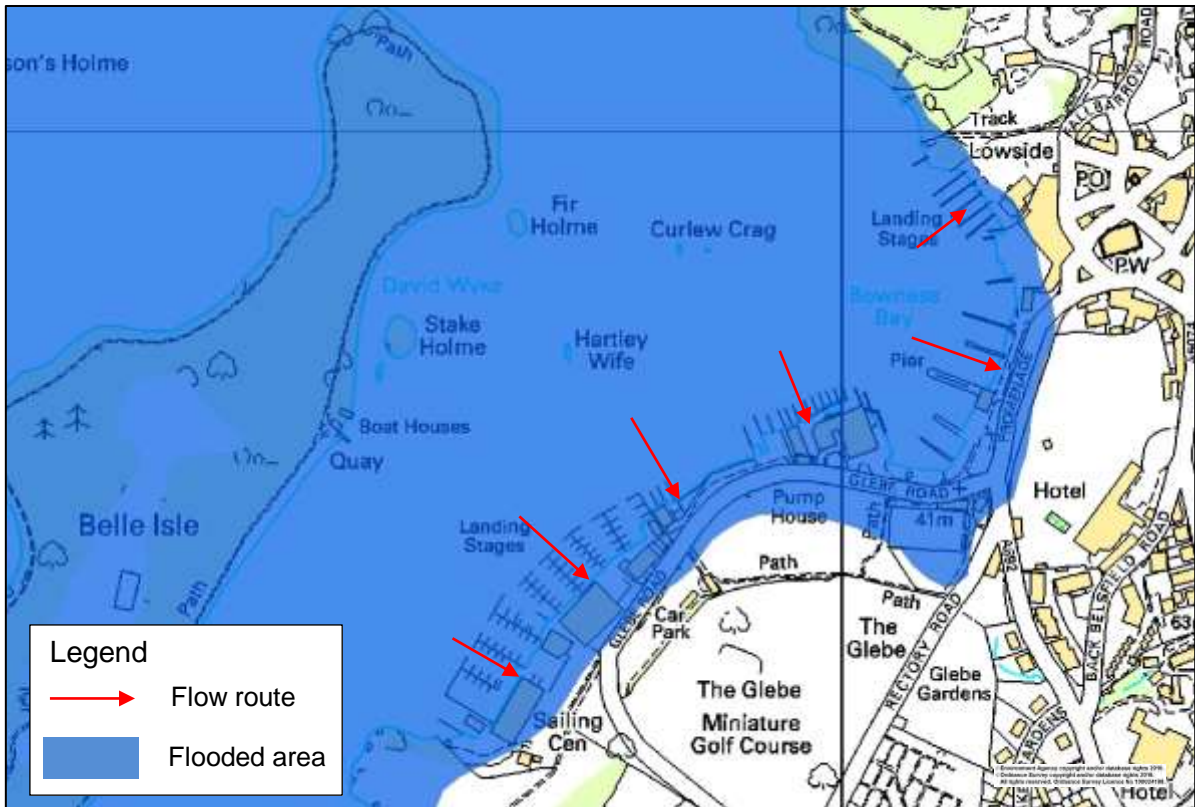


Figure 6: Flood flow routes – The Promenade and Glebe Road

Photograph 3, Photograph 4, and Photograph 5 show flooding in the Glebe Road area on Sunday 6th December 2015.



Photograph 3: Glebe Road – picture by Allan Winrow (The Westmorland Gazette)



Photograph 4: Windermere Lake Cruises – picture by Gordon Shoosmith (Alamy Live News)



Photograph 5: The Promenade and Glebe Road on 6th December 2015 – picture by Gordon Shoosmith (Alamy Live News)



Photograph 6: Debris line on the area adjacent to Glebe Road



Photograph 7: Debris line on the grass area at junction of Glebe Road and The Promenade

Sub-area C: Bowness-on-Windermere – The Marina and Storrs

Location shown as Point C on Figure 4.

The flooding mechanism for this area was very similar to The Promenade and Glebe Road area, with flooding directly from the Lake as a result of increased water levels. The water level in the Lake rose and flooded the surrounding area, which is lower than the majority of the town by necessity for the boathouses and marina situated on the lakeshore.

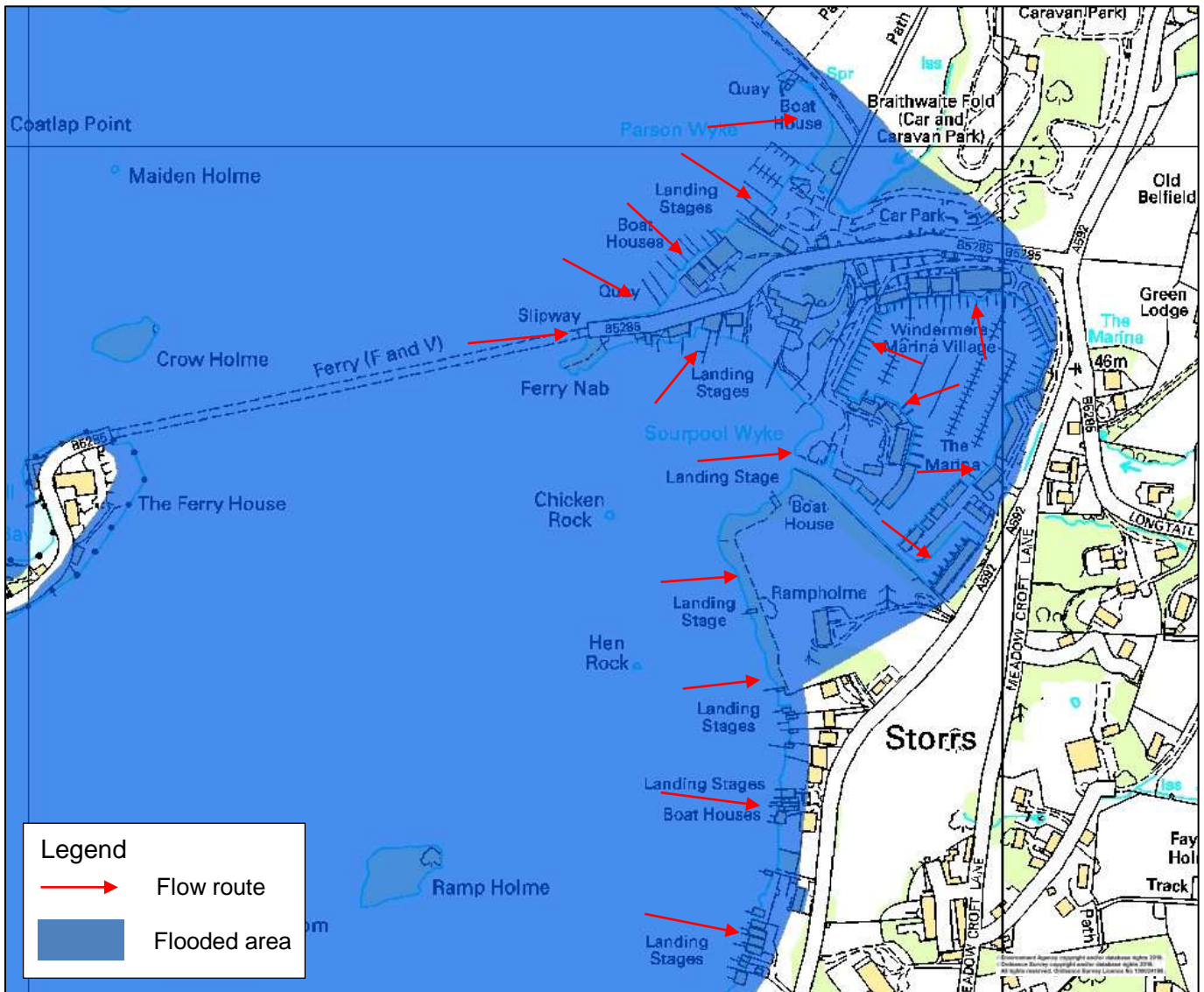


Figure 7: Flood flow routes - The Marina and Storrs

It was recorded that 22 commercial properties and 75 residential properties located in this area were affected by flooding, including:

- 21 residential properties around Storrs Park
- 38 residential properties on Windward Way
- 14 properties in the Windermere Marina Village
- 2 residential properties around Ferry Nab

A further 10 residential properties, located a short distance to the south of this investigation area, were also flooded. Reportedly, water levels in these properties were 100 mm lower than recorded in November 2009.



Photograph 8: Flood level on one of the buildings in The Marina

Sub-area D: Windermere Town

Location shown as Point D on Figure 4.

Windermere is a small town of about 5000 inhabitants, located approximately 1.5 kilometres east of Windermere Lake to the north-east of Bowness-on-Windermere. The town was not affected by flooding associated with rising lake levels as it is significantly higher in elevation. Properties in Windermere town were affected by flooding from Mill Beck and from surface water. The intensity of the rainfall on the 5th and the 6th of December 2015 resulted in the capacity of Mill Beck and the local drainage systems being exceeded, resulting in flooding to a number of locations, as illustrated in **Figures 8, 9 and 10**. Approximately 45 properties in Windermere town were reported to have been affected by flooding.

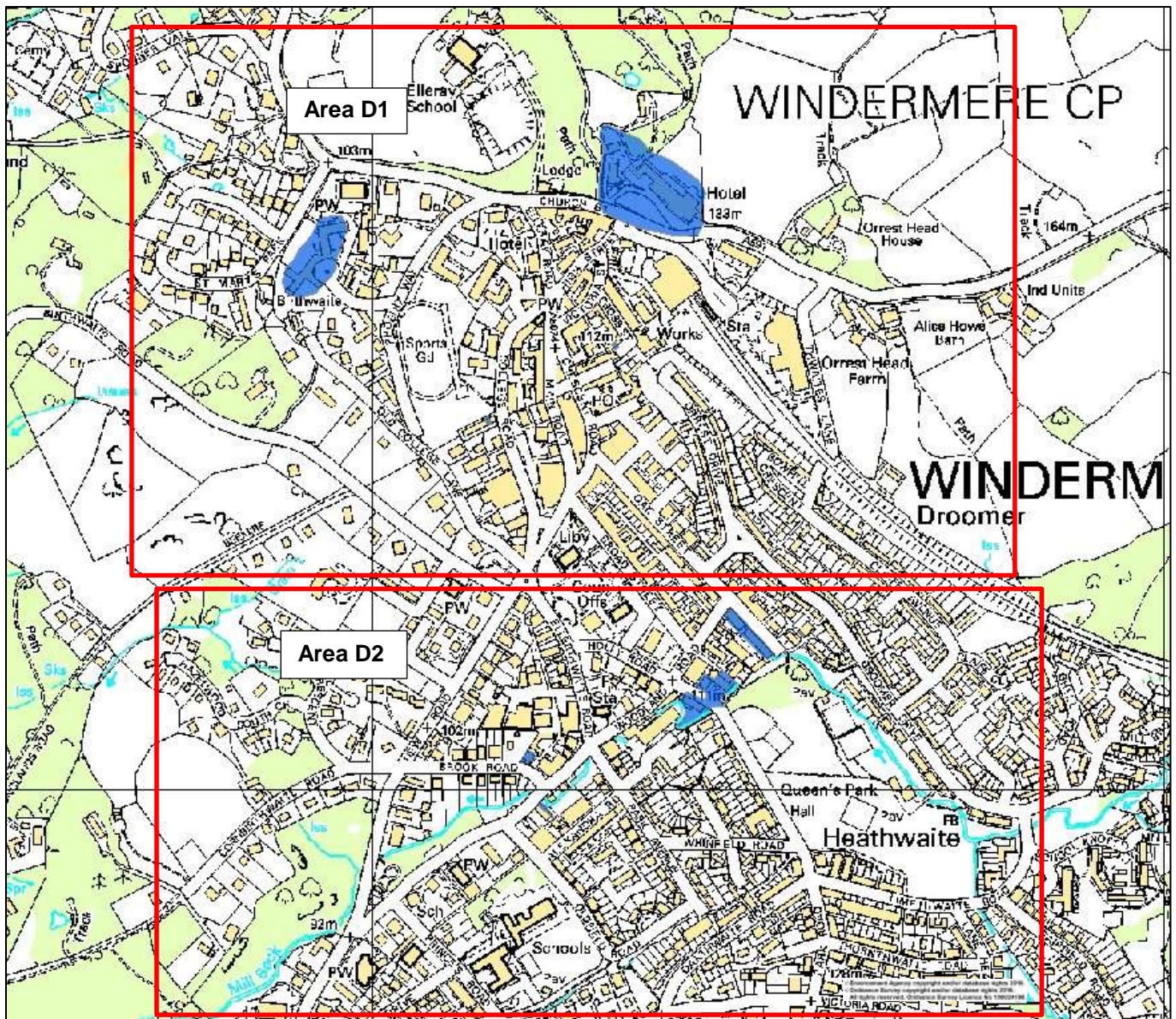


Figure 8: Locations affected by flooding in Windermere town

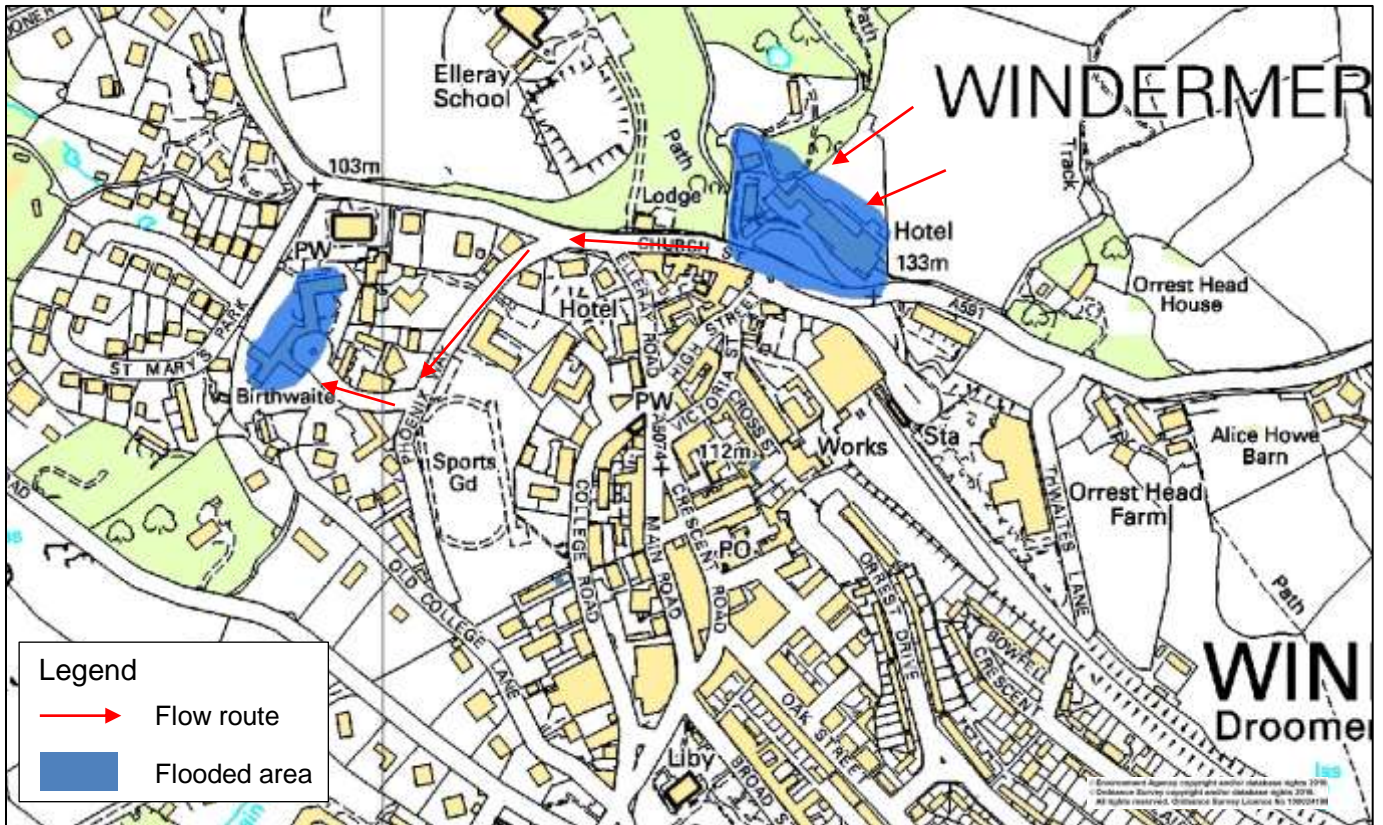


Figure 9: Locations affected by flooding in Windermere town, Area D1

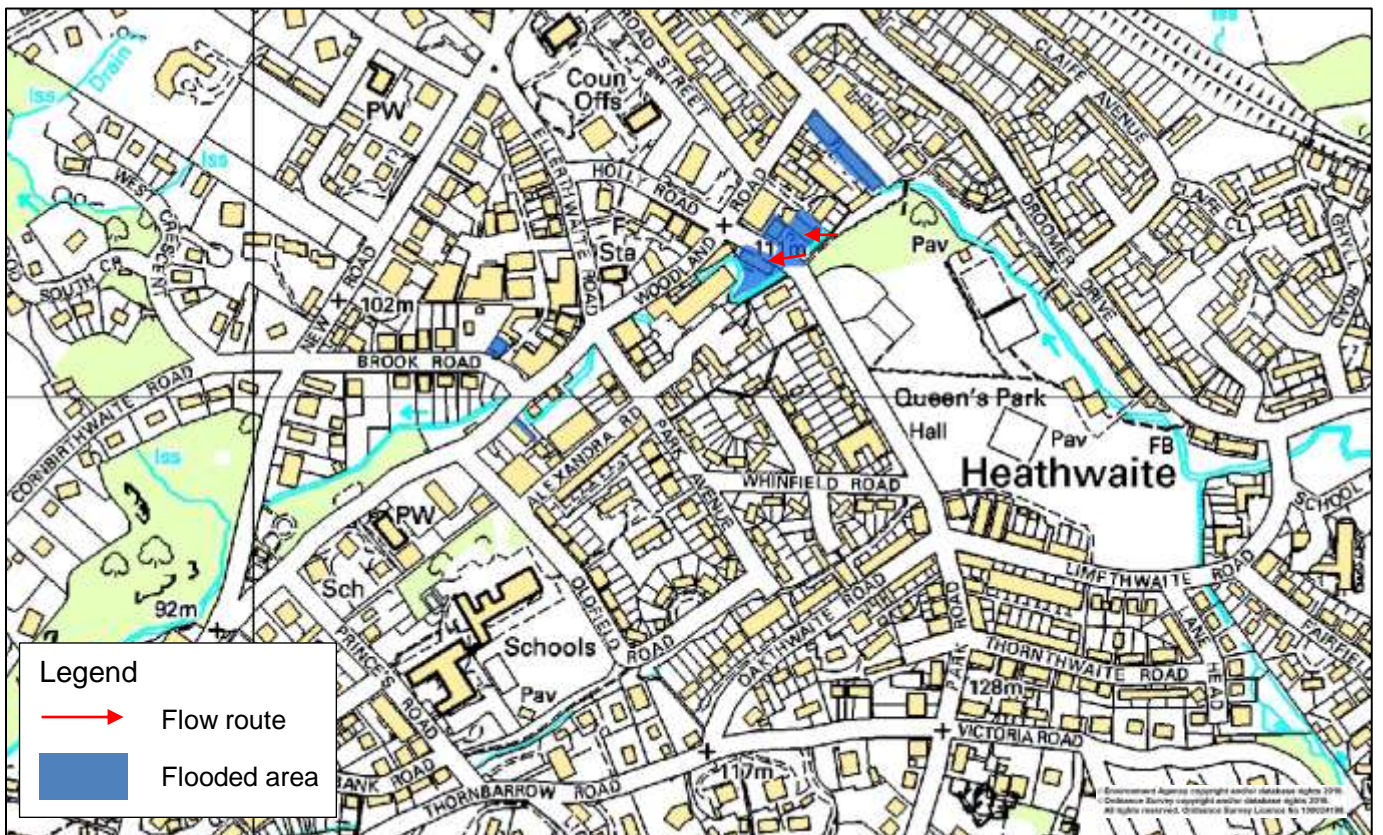
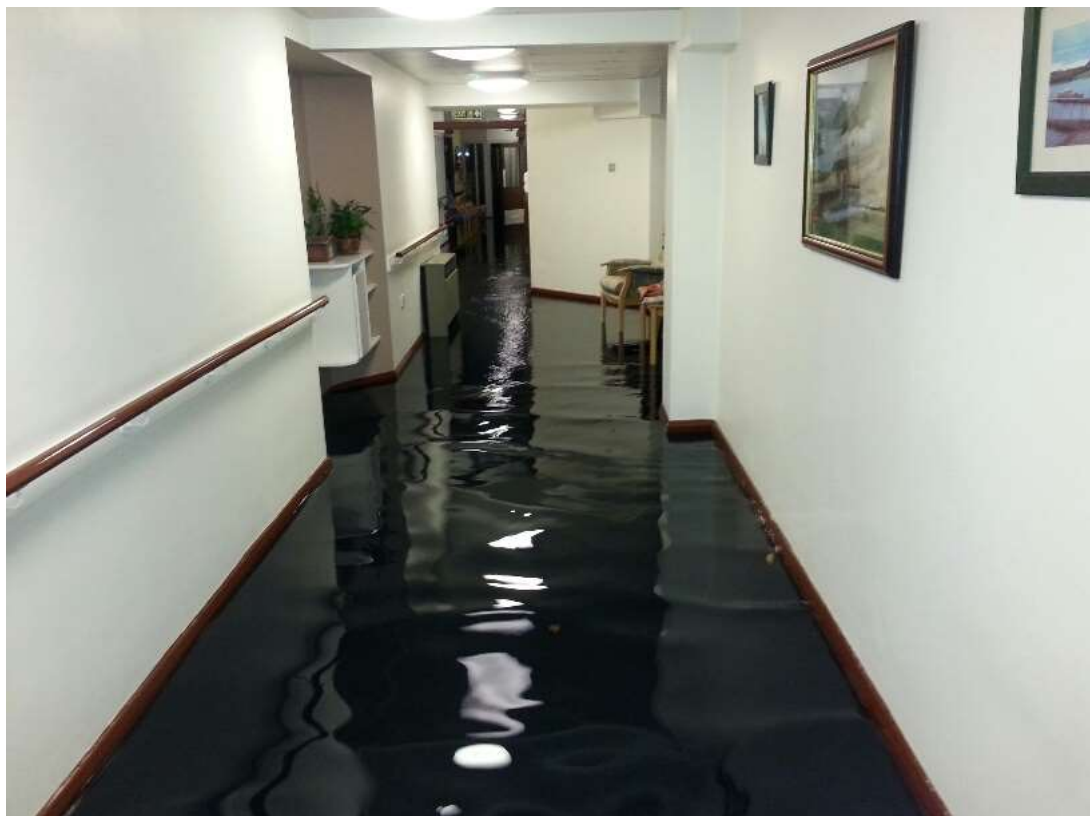


Figure 10: Locations affected by flooding in Windermere town, Area D2

In the north of Windermere town on Patterdale Road, residents of Fernrigg reported that their garden was flooded as a result of water flowing from Wynlass Beck. Wynlass Beck is an ordinary watercourse that flows to the east of Patterdale Road in this locality. During the flood event, a fence which crosses Wynlass Beck upstream of Patterdale Road at the Stepping Stones caused a blockage, resulting in water flowing out of bank in a westerly direction across Patterdale Road towards Fernrigg. The residents reported that following the flood event, the landowner was going to replace the fencing across the watercourse with swing gates to reduce the risk of future blockages and resulting flooding.

To the north of the A591 on Church Street, the Windermere Hotel and a group of adjacent properties were affected by flooding from overland surface water flows from the fellsides to the north. **Photograph 9** shows a hallway on the ground floor in Birthwaite Flats sheltered housing on 5th December, where eight flats were reportedly flooded by surface water. Local residents reported that the surface water flow route from the fellsides to the north of the Windermere Hotel continued in a westerly direction along the A591 Church Street before flowing south along Phoenix Way towards Birthwaite Flats.

Properties situated along Mill Beck were affected by flooding as water levels in the beck rose, and in places exceeded the channel capacity of the watercourse. On Upper Oak Street, the cellars of a terrace of properties were flooded as water entered the cellars through the floors. Just downstream from Upper Oak Street, properties situated upstream and downstream of Park Road were affected by flooding from Mill Beck. Properties on the upstream side of Park Road adjacent to Mill Beck flooded initially from the rear as the watercourse flowed out of bank. Residents of the properties downstream of Park Road reportedly erected a makeshift barrier on the gated entrance to Queen's Park, located on the upstream side of Park Road, to protect their properties from flooding. The barrier reportedly had the effect of increasing water levels upstream of Park Road, where properties were being impacted by flooding from Mill Beck. Residents from the properties upstream of Park Road therefore removed the barrier to reduce water levels in their area. Three properties on the downstream side of Park Road were also affected by flooding from Mill Beck as water levels continued to rise in the area. Further downstream on Mill Beck, Rock Lea Guest House was impacted as a result of water entering the property through the cellar.



Photograph 9: Hallway on the ground floor of Birthwaite Flats

Sub-area E: Lakeside

Location shown as Point E on Figure 4.

Lakeside is a small village located on the south-west shore of Windermere Lake, approximately 1.5 kilometres north of Newby Bridge.

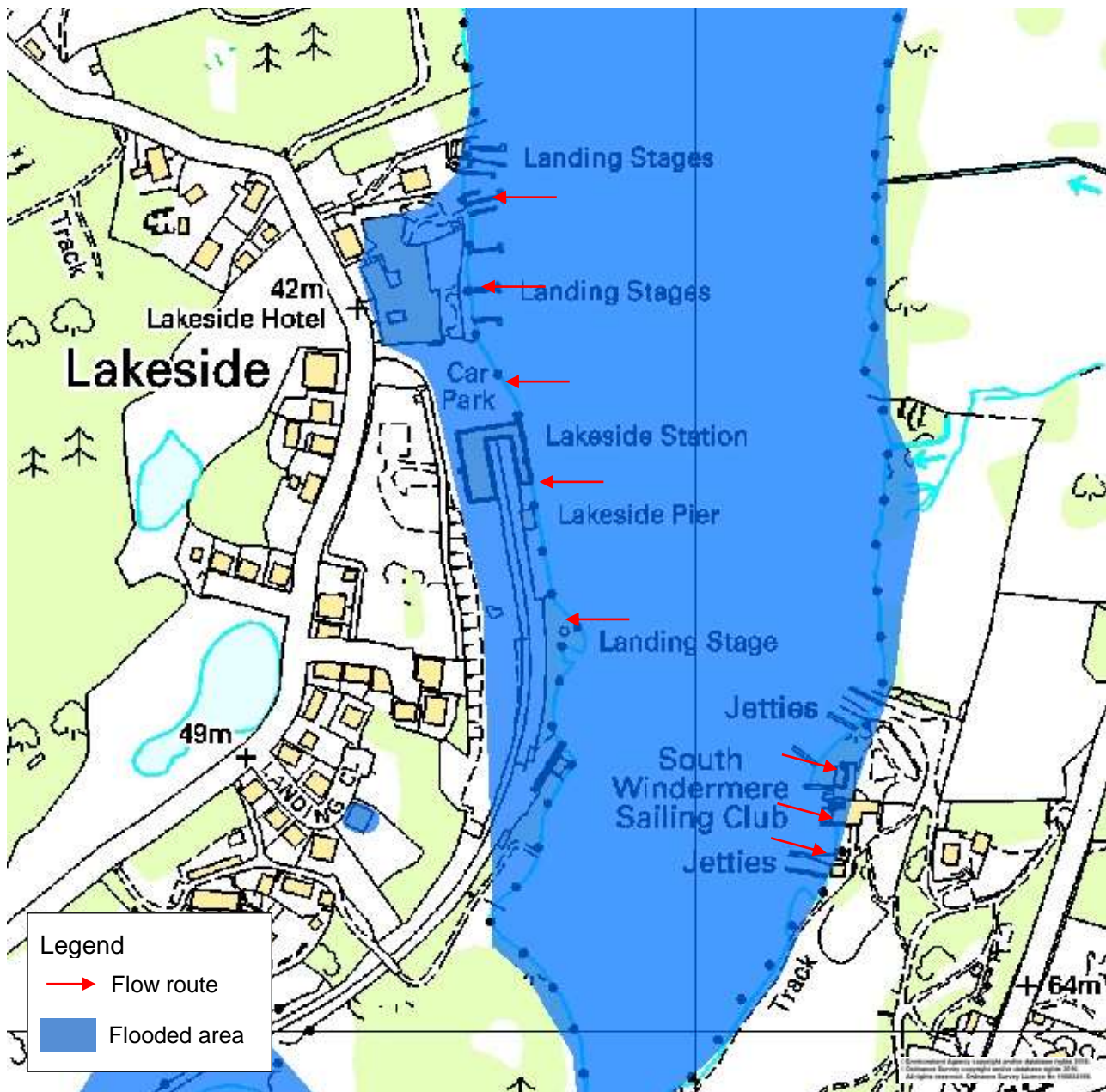


Figure 11: Flood flow routes - Lakeside

Figure 11 shows flood flow routes in Lakeside, with flow from water ingress sourced from the Lake itself. Flooded properties were mostly commercial and included the Lakeside Hotel, Windermere Lake Cruises, the Lakeside and Haverthwaite Railway and Lakes Aquarium. There are no flood defences along the lakeshore.

Flooding also impacted properties and boathouses, including South Windermere Sailing Club and Fell Foot Park, located on the south-eastern shore of the Lake.

Photograph 10 shows the Lakeside Hotel and Photograph 11 shows the Lakes Aquarium and its car park. Both of these properties were flooded due to the high water level in Windermere Lake.



Photograph 10: Lakeside Hotel (Photo courtesy of Zan Fell)



Photograph 11: Lakes Aquarium (Photo courtesy of Zan Fell)

Sub-area F: Newby Bridge

Location shown as Point F on Figure 4.

Newby Bridge is a small village to the south of Windermere Lake, located next to the River Leven. Due to the prolonged, intense rainfall on the 5th and 6th of December, water levels increased in the Lake. This led to increased water levels in the River Leven, the outlet from Windermere Lake, which then led to flooding at Newby Bridge. Although the floodwater levels were lower than in 2009, significant damage was sustained in the area, with four properties reportedly affected by flooding.

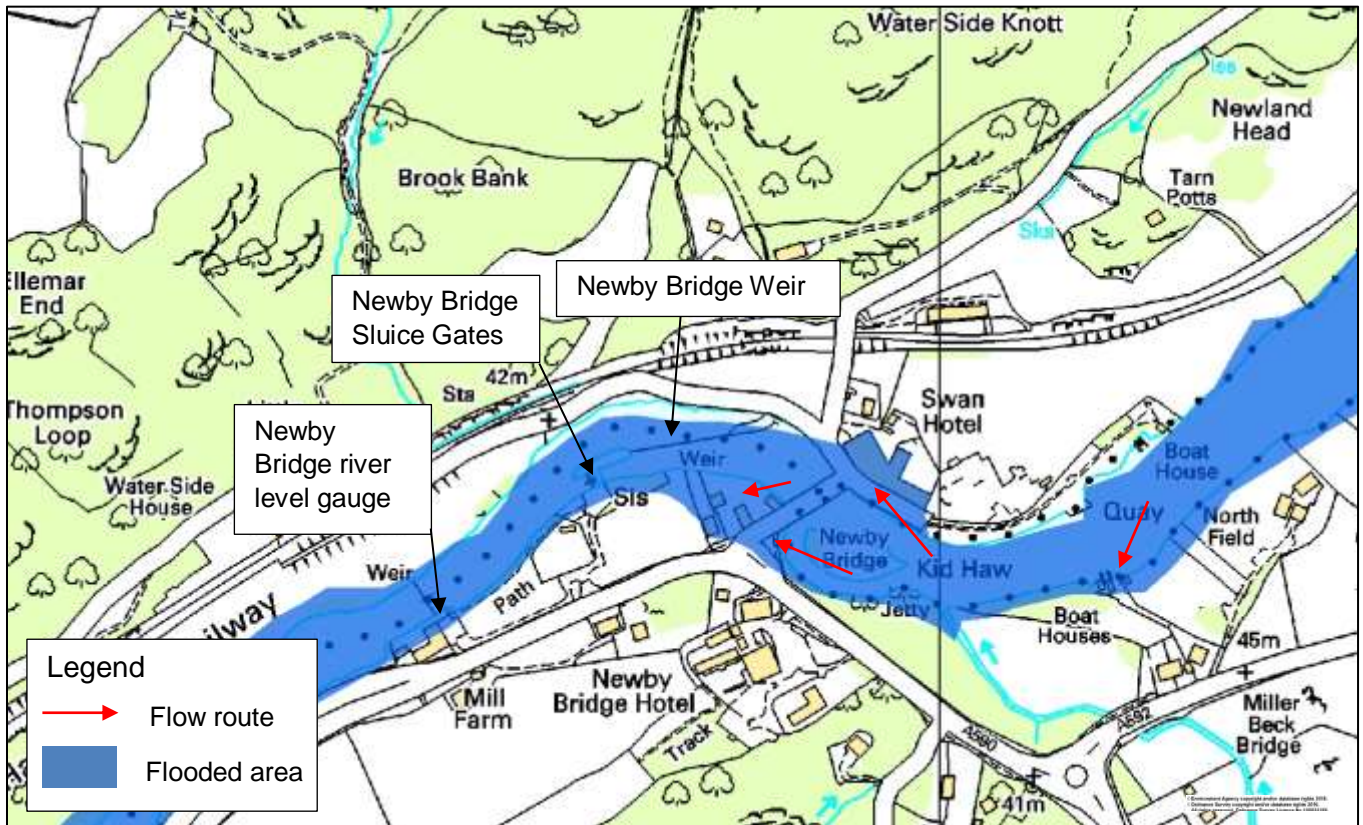


Figure 12: Flood flow routes - Newby Bridge

Figure 12 shows the flood flow routes in Newby Bridge.

It was observed by local residents that as the water level in the River Leven rose, water swept round the side of the bridge parapet and onto the road. **Photograph 12** shows the water level in the bridge section. At the same time, water came through a gap between the bridge wall and a property boundary wall, located on the left bank of the River Leven, causing flooding to the road and to properties on the left bank.

Flooded properties are shown in **Photograph 14** and **Photograph 15**. The Swan Hotel, shown in **Photograph 16**, was flooded to ankle depth on the ground floor. Local residents reported that water came up through the drains before floodwater inundated properties from the river.

Newby Bridge Weir was built across the River Leven to manage the water levels in Windermere Lake, and includes the operation of Newby Bridge Sluice Gates. **Figure 13** shows the location of Newby Bridge Weir and Sluice Gates.



**Photograph 12: Newby Bridge, looking upstream from the right bank
(Photo courtesy of Zan Fell)**



**Photograph 13: Looking downstream at Newby Bridge Weir from Newby Bridge
(Photo courtesy of Zan Fell)**



Photograph 14 and Photograph 15: Flooded properties in Newby Bridge



Photograph 16: The Swan Hotel, Newby Bridge

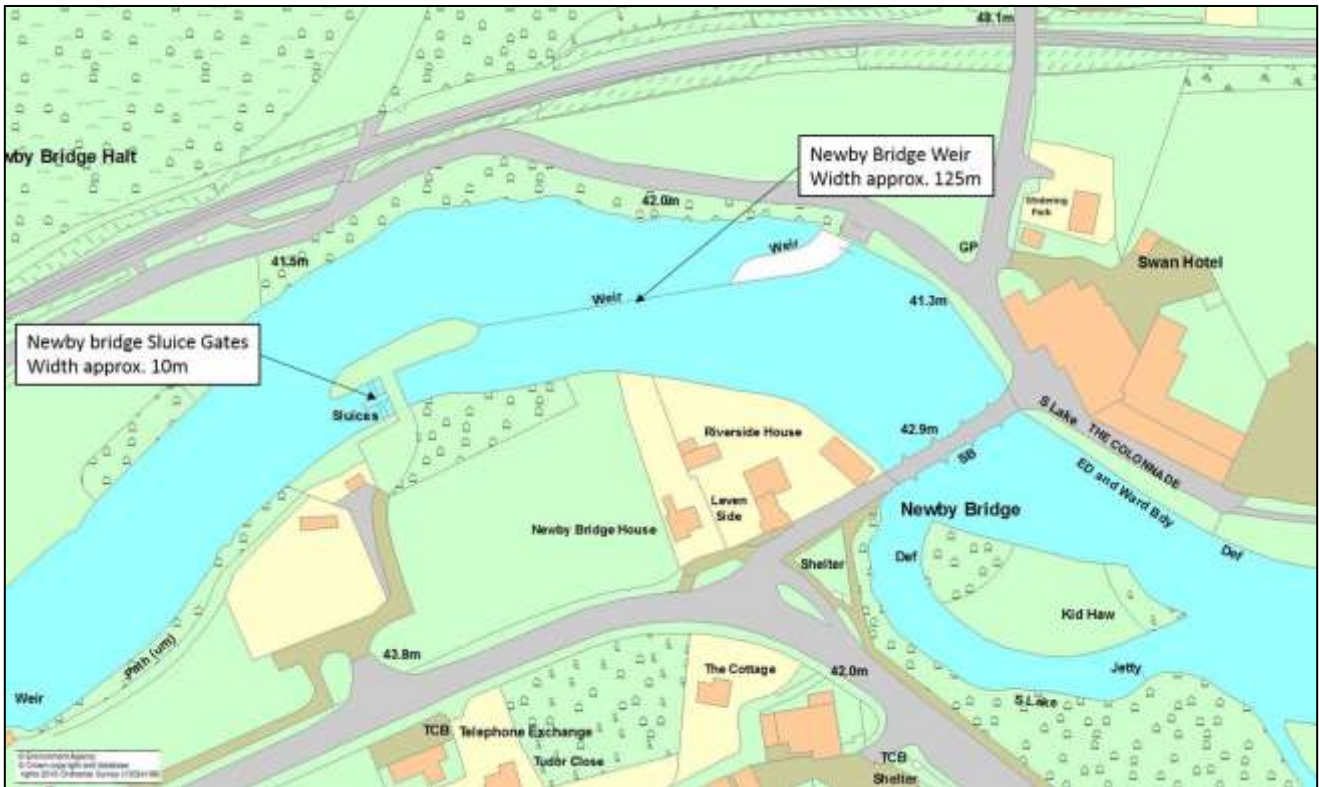


Figure 13: Newby Bridge Weir and Sluice Gates - General Location Plan

Newby Bridge Weir and Sluice Gates

The 1966 Windermere & Ullswater Water Order allowed Manchester Water Corporation (MWC) to impound and abstract water from Windermere Lake. This was followed by the MWC increasing the height of the weir by 150mm in 1972, and the subsequent construction of the sluice gates in the mid 1970's to better control lake levels. The sluice gates are owned and operated by the Environment Agency. The amount of water entering the Lake, and the volume of water stored in the Lake, means that the sluice gates have a limited amount of control on Lake levels during periods of prolonged very wet weather. After the flood event in November 2009, the Environment Agency, working in partnership with the Windermere Lake Levels Group, reviewed different options for operating the Newby Bridge sluices. As a result, the Environment Agency's operational procedures were amended, which has led to the sluice gates being opened sooner during periods of very wet weather, enabling better management of Lake levels. The Environment Agency and the Windermere Lake Levels Group continue to work together to address flood risk issues in Windermere, Newby Bridge and Backbarrow, and are presently carrying out a further modelling review of Windermere Lake levels. This modelling review will inform any future investment plans to manage flood risk from Windermere Lake, and on the River Leven downstream at Newby Bridge and Backbarrow.

Sub-area G: Backbarrow

Location shown as Point G on Figure 4.

The village of Backbarrow straddles the River Leven, and is located downstream of Newby Bridge. Approximately 30 properties in the village were affected by flooding due to the River Leven exceeding its channel capacity through the village.

During the 2009 flood event the parapet walls on Backbarrow Bridge were seriously damaged and washed away by water overtopping the bridge. The bridge parapet walls were subsequently repaired by Cumbria County Council.

Backbarrow Bridge is a typical traditional stone built Lakeland bridge, and is shown in **Photograph 17**. The bridge was built many years ago, and with that comes many challenges in how best to maintain and adapt the structure to meet the modern day needs of vehicle access, public safety and flood risk. The capacity of Backbarrow Bridge to convey significant flood flows is widely recognised as being one of the main flood risk problems affecting the Lakeland Village, the Whitewater Hotel and residential properties located close to the bridge. Flood flow routes are shown in **Figure 14**. The bridge is a restriction to large flood flows, and in combination with the bridge parapet walls, prevents flood water from overtopping the bridge leading to higher flood levels affecting adjacent properties. The December 2015 flood event replicated the November 2009 flooding, with the bridge causing flood water to back up, submerging the bridge and overtopping river walls causing flooding to properties, illustrated in **Photographs 18 to 22**. The bridge parapet walls remained in place during the December flood, which was said by the local community to have made the flooding worse. A stone wall to the south east of Backbarrow Bridge failed over about five metres, leading to the loss of foundations to the electricity transformer immediately downstream. This resulted in the loss of power locally until the foundations had been repaired.

The Environment Agency, working in partnership with the Windermere Lake Levels Group (WLLG), have already identified the need to update the Windermere flood risk model to include Backbarrow Bridge. The modelling work will be used by both the Environment Agency and Cumbria County Council (CCC) to investigate what work could be potentially carried out to help reduce flood risk for properties around Windermere Lake, Newby Bridge and Backbarrow. This will include looking at possible options to improve flood flow conveyance at Backbarrow Bridge. The modelling information will also be used by the WLLG to inform what flood risk works they can do to make their properties more flood resilient.

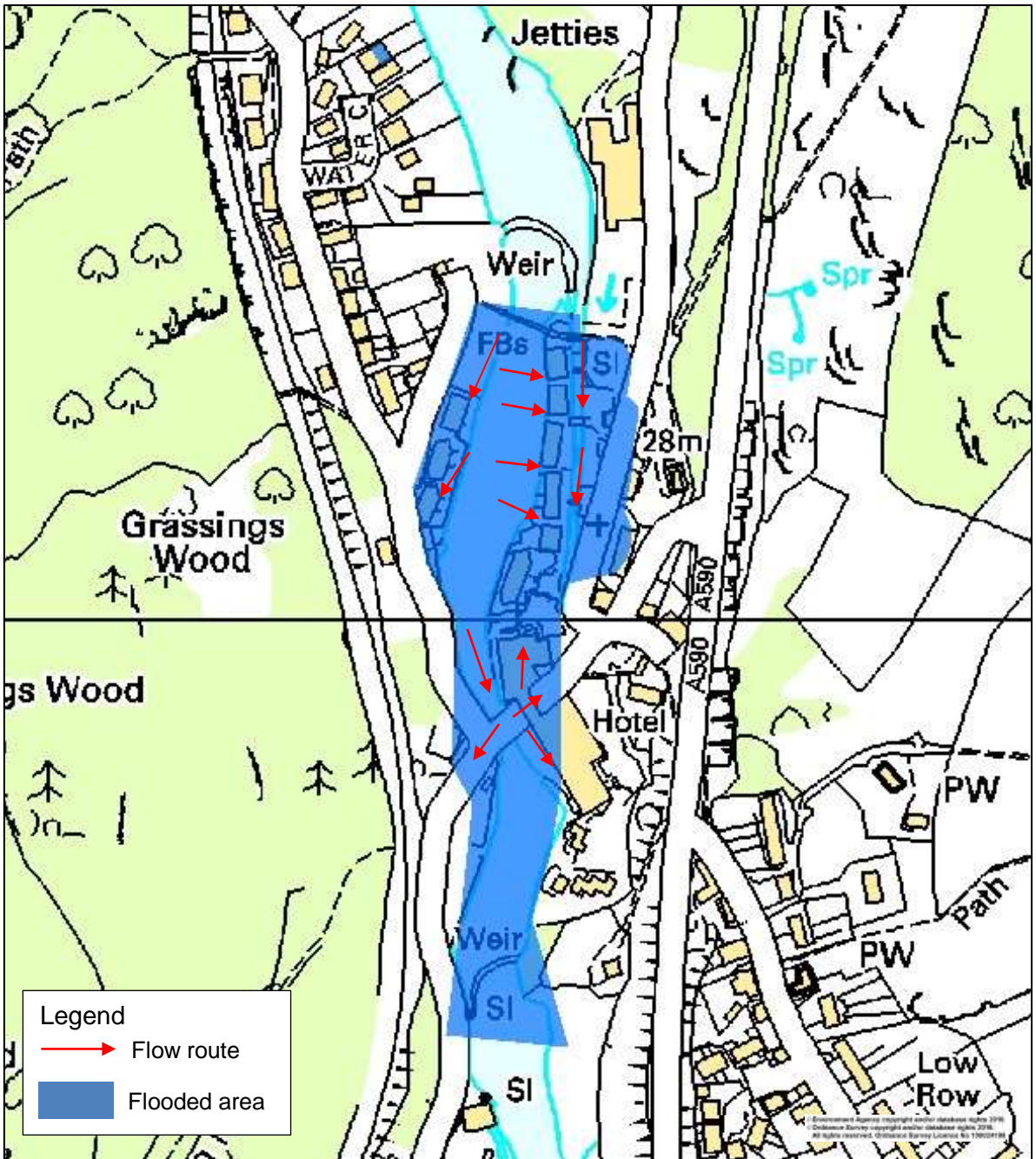


Figure 14: Flood flow routes – Backbarrow



Photograph 17: Backbarrow Bridge



**Photograph 18: Backbarrow Bridge – Water overtopping the bridge parapets
(Photo courtesy of Zan Fell)**

The Whitewater Hotel, shown in **Photographs 18 and 20**, as well as a number of timeshare properties at The Lakeland Village, shown in **Photographs 21 and 22**, were flooded on the left bank of the River Leven. The recorded water levels in these properties ranged from between approximately 120mm to 1000mm.

On the right bank of the River Leven at Backbarrow Bridge, Bridge House and Bridge Cottage were affected by flooding, shown in **Photograph 19**.



**Photograph 19: Backbarrow – Water affecting Bridge House and Bridge Cottage
(Photo courtesy of Zan Fell)**



**Photograph 20: Backbarrow – Whitewater Hotel
(Photo courtesy of Zan Fell)**



Photograph 21: Backbarrow – Lakeland Village timeshare estate with water mark



**Photograph 22: Backbarrow – Lakeland Village timeshare estate
(Photo courtesy of Richard Guzinski)**

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 4th 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. During the December 2015 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.

Newby Bridge sluices had already been operated between the 9th and 24th November 2015, and were open again from 30th November 2015 until 8th January 2016.

The debris screens in Windermere 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 Windermere.

Immediately after the flood event, the Environment Agency undertook inspections of the watercourses in Windermere and worked to clear any blockages to aid conveyance.

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 *	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
	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
	Environment Agency and Residents	Ensure all properties at risk are registered to receive flood warnings and that all details are up-to-date.	2016 - Ongoing
	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 £2,000 top up grant can also be applied for from the Cumbria Flood Recovery Fund.	Closing date for grant applications is end of March 2017
	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.	Action Plan published Summer 2016
	Cumbria Strategic Floods Partnership (CSFP), Farmers, Landowners, Community Groups, Trusts.	Explore opportunities for natural flood management solutions to be used upstream of Windermere in order to 'slow the flow' and manage peak river levels.	Medium term (over next 5 years)
Maintenance	Environment Agency,	Carry out inspections and repairs to assets which	2016 – 2017

	United Utilities and Cumbria County Council	may have been damaged during the flood event. Carry out improvements to replace the debris screen on Mill Beck, Upper Oak Street, Windermere.	(EA inspections completed)
	Environment Agency	Review the gravel and channel maintenance programme within the catchment in response to the flooding event of 2015.	2016 - 2017
	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: https://www.gov.uk/government/publications/river-andcoastal-maintenance-programme	2017
Strengthening Defences	Environment Agency in partnership with Cumbria County Council and South Lakeland District Council	Undertake an appraisal to investigate a range of options to manage flood risk in Windermere, Newby Bridge and Backbarrow. The appraisal will include investigations on Mill Beck in Windermere to understand if improvements are required to manage flood risk. Reviewing a range of options to manage flood risk from Windermere Lake and on the River Leven at Newby Bridge and Backbarrow will also be undertaken. This will include reviewing the operation of Newby Bridge sluices alongside investigating the potential to improve flood flow conveyance at Newby Bridge and Backbarrow Bridge. The appraisal will develop technically feasible, economically viable and environmentally sustainable options to manage flood risk.	2016 - 2017
	Environment Agency & Cumbria County Council in partnership with the Windermere Lake Levels Group (WLLG)	Throughout the appraisal of possible options to manage flood risk, continue to work closely with the WLLG.	Ongoing
	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
	Environment Agency	Review modelling data to ensure that hydraulic models for Windermere Lake and the River Leven catchments reflect real conditions as accurately as possible and replicate the 5 th -6 th 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.	2016 - 2017

*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

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)

Term	Definition
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.
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.

Term	Definition
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.
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
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 the LLFA'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 (RMA's). 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 is the LLFA for Cumbria under the Flood & Water Management Act 2010. 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 RMA's to maximise knowledge of flood risk to all involved. This function is carried out at CCC by the Development 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 responsible for a larger number of sewers than prior to the regulation. These organisations are classed as RMA's

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 RMA's

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

Cumbria County Council Community Services

Alison.Meadows@cumbria.gov.uk, www.cumbria.gov.uk, tel: 01229 407576

United Utilities: tel: 0845 746 2200

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 Warnings and Alerts

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.

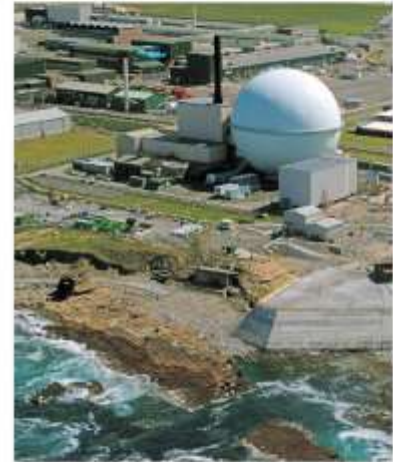
Heavy and persistent rainfall along with strong South-Westerly winds are forecast to continue this evening (Friday 04/12/2015) through until Sunday (06/12/2015). With the ground already saturated the river and lake levels are expected to rise further and we may see some significant impacts. Newby Bridge 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.

¹Contact Successful if at least one attempt to contact a fully-registered recipient registered to the property returned a status of "Acknowledged", "Successfully Received", "Successfully Sent" or "Unacknowledged"

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 Armit, 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.

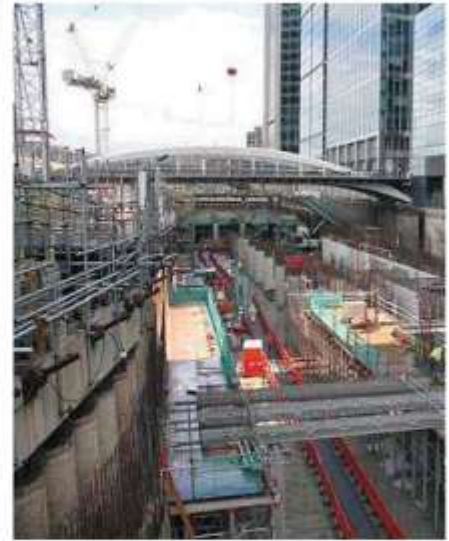
Transport

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 billions.
- 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.

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