

Low Crosby

Flood Investigation Report



Aerial photograph taken looking east from Carlisle

Photograph provided by Peter Smith. Taken 06/12/2015 11:00hrs

Flood Event 5th and 6th 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.

Version	Prepared by	Reviewed by	Date
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Executive Summary

Low Crosby and the surrounding area experienced severe flooding on the 5th and 6th of December 2015 following Storm Desmond. This storm caused a period of prolonged, intense rainfall across Northern England, falling on an already saturated catchment, and led to high river levels and flooding throughout Cumbria and beyond. The flow in the River Eden on the 6th December was the highest flow in the data record dating back to the 1960's, with the previous high set in the January 2005 floods. Peak flows in the December 2015 event were 10% greater than those in 2005.

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 Low Crosby on 5th and 6th of December, 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 also includes recommendations for future action.

Approximately 60 properties in Low Crosby and the surrounding area were flooded from the River Eden, when the existing flood defences were overtopped and outflanked. Flooding also occurred as a result of floodwater entering the village from the west along the line of Willow Beck where there are no flood defences. Overtopping of the defences occurred when the water level exceeded the height of the defence and flowed over the structures. Outflanking occurred when the river levels were high enough for water to flow around the furthest extent of the defended line. The flood event exceeded the design level of the existing flood defences within Low Crosby, however, no defences failed or collapsed. The defences may have been useful in delaying the onset of flooding, allowing residents additional time to prepare for the flood.

Eleven actions have been recommended in this report in order to improve future flood risk management. These will require the involvement of a number of organisations and local communities.

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

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

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

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 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 Report outlines recommendations and actions that various organisations and authorities can do to minimise flood risk in affected areas. Once agreed, the report can be used by communities and agencies as the basis for developing future plans to help make the area more resilient to flooding in the future.

For further information on the “Section 19” flood investigations being completed throughout Cumbria following the flooding in December 2015, 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

Low Crosby is a village located approximately 7 km north east of Carlisle and stands on the north bank of the River Eden, Figure 1. There is also a small watercourse, Willow Beck, that drains land north of Low Crosby and discharges into the River Eden, west of Low Crosby. Willow Beck skirts the north and western sides of the village. Low Crosby is located on the former Stanegate Roman road and Hadrian's Wall passes approx. 2km to the north, with Hadrian's Wall Path located within the village. It is a small residential community, with no large commercial enterprises.



Figure 1: Location of Low Crosby and its major rivers

Flooding History

Low Crosby is a village to the northeast of Carlisle and stands on the north bank of the River Eden. There are approximately 110 residential properties in Low Crosby itself. Due to its position and low lying topography the village is prone to flooding from the River Eden and other sources. In recent decades, Low Crosby has suffered serious flooding in 1968, 1995, 2005 and 2009.

The January 2005 event caused widespread flooding in Low Crosby and was estimated to be an event with a 0.6% Annual Exceedance Probability (AEP)*.

The AEP describes the likelihood of a specified flow rate (or volume of water with specified duration) being exceeded in a given year. There are several ways to express AEP as shown in Table 1. Throughout this report AEP is expressed as a percentage. As such an event having a 1 in 100 chance of occurring in any single year (0.01 probability) 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

Partly in response to the flooding in 2005, a new defence scheme was constructed to reduce flood risk. The main component is a 500m long earth embankment to the east of Low Crosby. This scheme included a sump chamber designed to accommodate a pump. This was constructed due to the history of surface water flooding and drainage problems experienced in the village. When the River Eden is in flood the highways and surface water drainage systems cannot discharge freely and require a pumped discharge to operate effectively. CCC are installing a permanent pump at this location.

It should be noted that the 2015 flood level on the River Eden was 0.6m higher than in 2005. Indeed, the 2015 event was of significantly greater magnitude than past events and the flow in the River Eden was the highest recorded.

Flooding Event	Number of Properties Flooded	Peak Flow in River Eden at Sheepmount (m ³ /s) [†]	Peak Flow in River Eden at Warwick Bridge (m ³ /s)	Peak Flow in River Eden at Great Corby (m ³ /s)	Peak Flow in River Irthing at Greenholme (m ³ /s)
March 1968	Unkown	1200*	1104	-	189
February 1995	Unknown	950	812	-	26
January 2005	>60	1516	-	1373	205
November 2009	5	1029	-	816	198
December 2015	>58**	1680	-	1490	229

*based on an extrapolation, not directly from recorded data at this gauging station. **58 in Low Crosby and more nearby.

Table 1: Recent flood events affecting Low Crosby

* 2007 Viability Study by Jacobs

† Flows for past events taken from CEH National River Flow Archive <http://nrfa.ceh.ac.uk/data/search>

The gauging station on the River Eden at Warwick Bridge closed in 1996 and was replaced by a gauge at Great Corby.

Flood Event 5th-6th December 2015

Background

On 6th December 2015, approximately 60 properties in Low Crosby suffered internal flooding as a result of Storm Desmond. Further flooding of property also occurred in surrounding rural areas (e.g. Warwick Holmes and Newby Grange). This storm caused 36 hours of intense rainfall leading to high river levels that overtopped and outflanked flood defences. The main source of the local flooding is attributed to the River Eden, rather than Willow Beck. The River Eden flowed up the course of Willow Beck, entering the western side of the village along Willow Beck's left hand bank. The area affected by the flooding is shown in Photograph 1.

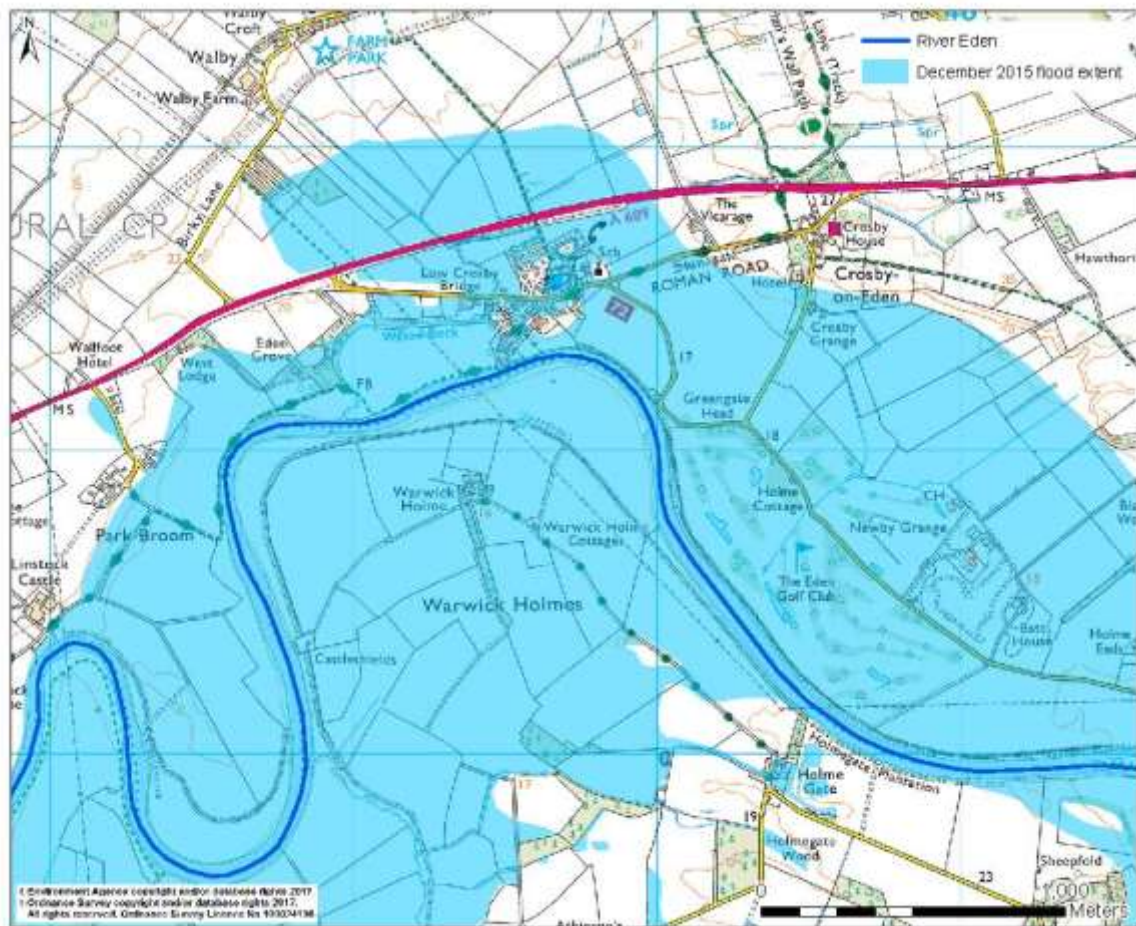


Figure 2: Extent of River (Fluvial) Flooding* in Low Crosby on 5-6th December 2015

*The flood outline identifies the maximum extent of flooding. Not all properties within the extent area were flooded.

The extent of the flooding was greater than that in 2005, with more penetration within the village, particularly on the west / south west side.



Photograph 1 - Aerial View of the Flood Extent at Low Crosby and Warwick Holmes (view looking west)

Rainfall and Fluvial Flow Event

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

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

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

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

Table 2 - UK Rainfall Records

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

	24 hour Rainfall during November 2009 Event	24 hour Rainfall during December 2015 Event	
	mm	mm	Estimated AEP
Scalebeck	60.8	147.6	0.2% to 0.1%
Skelton	42.2	137.8	<0.1%
Brotherswater	200.8	293.4	<0.1%
Aisgil	61.2	105.7	20% to 5%

Table 3 - Rainfall over 24 hours in the Eden catchment prior to the December 2015 event



Figure 3 - Location of Local Rain Gauges

There are a number of river monitoring gauges near Low Crosby measuring river flow and water level. The locations of these are shown in Figure 4.

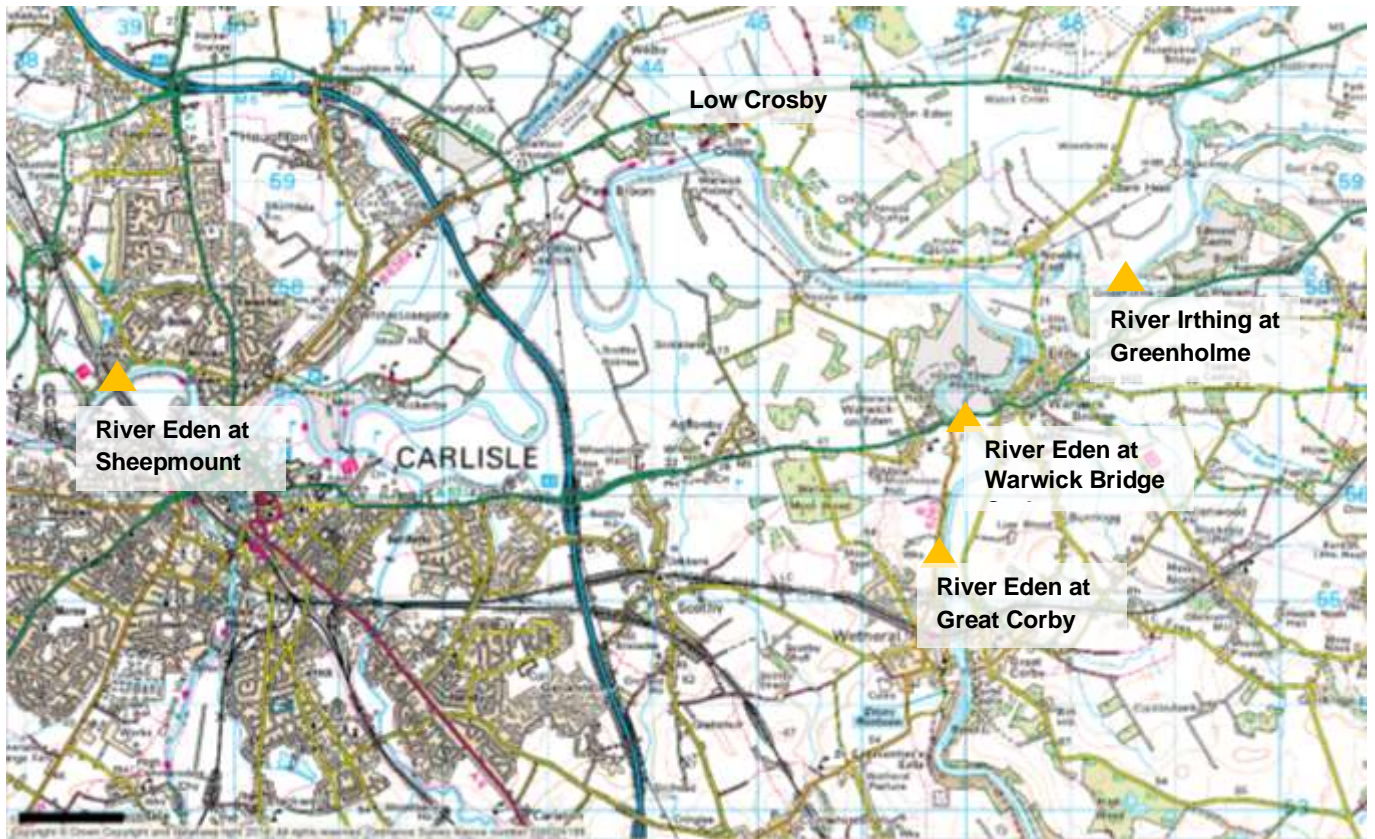


Figure 4 - Location of River Gauges Near Low Crosby

Table 5 shows the peak flows recorded at these gauging stations.

Gauging Station	River	Peak flow (m ³ /s)					Estimated AEP of Dec 2015 event
		Dec 2015	Past events				
			March 1968	Feb. 1995	Jan. 2005	Nov. 2009	
Sheepmount	Eden	1680	1200*	950	1516	1029	0.16%
Warwick B.	Eden	-	1104	812	-	-	-
Great Corby	Eden	1490	-	-	1373	816	0.17%
Greenholme	Irthing	229	189	26	205	198	5.9%

*based on an extrapolation, not directly recorded data at this gauging station

Table 4 - Flows recorded at the gauging stations

All gauges on the River Eden recorded the highest flow rates on record. In the case of the Sheepmount gauge, the records began in 1967. While the December 2015 event was certainly extreme, it should be noted that the estimation of the exact rarity of extreme flood events is subject to a significant degree of uncertainty. This is mainly due to the relatively brief period over which data has been recorded. However, it seems likely that this flood event was of a greater magnitude than that which the 2011-2012 scheme was designed to protect against (1% AEP).

Figure 5 shows the recorded river flows at the three “live” monitoring gauges from the 5th to the 7th of December 2015. This illustrates the relative size of the two rivers and the times of peak flow during the flood event.

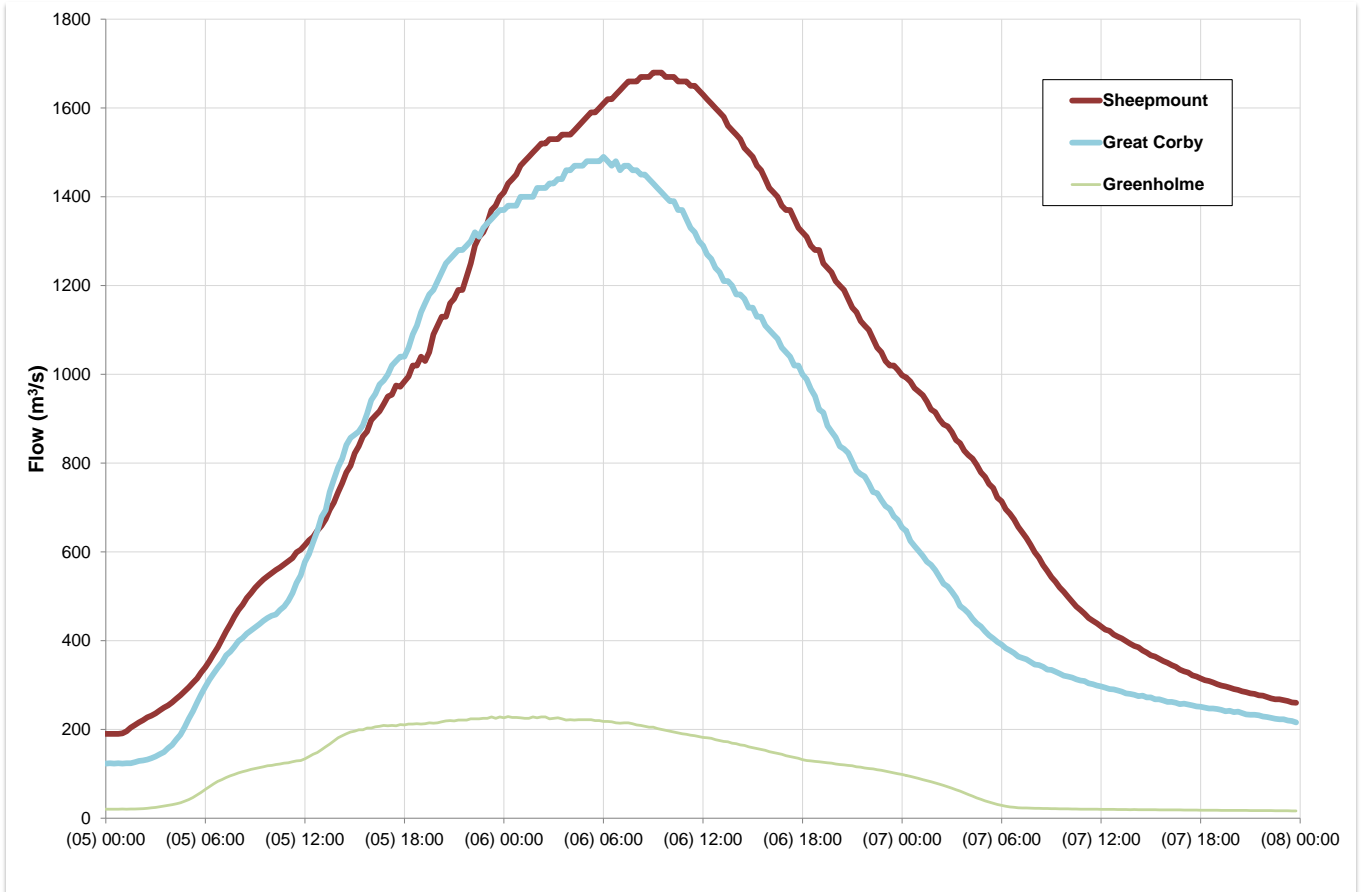


Figure 5 – River Flows near Low Crosby

Existing Flood Defences

There are embankments that reduce flood risk to both the north and south side of the River Eden at Low Crosby, as shown in Figure 6. Natural features also provide flood risk reduction benefit and numerous properties within Low Crosby have had property level protection installed (with limited success), with a supporting automated telephone flood warning service provided by the Environment Agency.

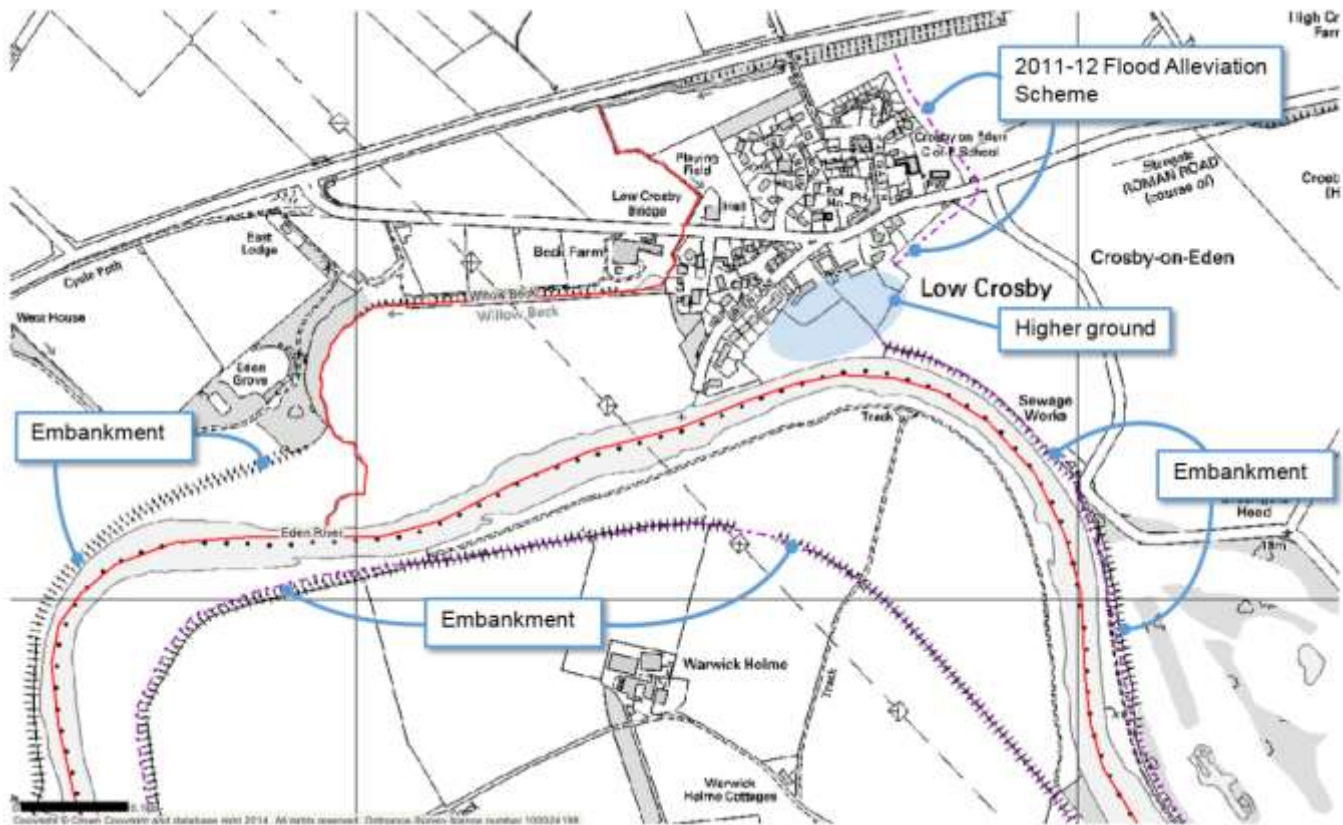


Figure 6 - Flood Defences at Low Crosby

The flood embankment to the east of Low Crosby was constructed in 2011-12, partly in response to the flooding in 2005. It includes approximately 500m of raised embankment, typically 1.5m high. It also includes an area of raised road (to provide continuity of the standard of protection provided) and a sump / chamber to allow deployment of a mobile pump. The scheme ties into higher ground to the south and the A689 road embankment to the north. The scheme was designed to provide protection from flood events on the Eden up to a 1% Annual Exceedance Probability, with a minimum crest level of +19.1mOD* at the raised road areas and +19.4mOD along the embankment (the latter appears to include a 300mm freeboard allowance for settlement etc.).

There are also three lengths of long standing embankments on the banks of the River Eden.

The embankment on the north bank, immediately upstream of Low Crosby offers some protection to a golf course and scattered residential properties and farms. The standard of protection offered is estimated as 10% Annual Exceedance Probability, with embankment crest elevations varying from +18.2mOD near Low Crosby and increasing to +18.6mOD near the (now defunct) sewage treatment works.

* All topographic levels quoted in this section are based on a survey completed in June 2016

The flood embankment on the south bank directly south of Low Crosby (the Warwick Holmes flood defence) reduces flood risk to agricultural land, farm buildings and several residential properties. Historically, this defence was maintained by the Environment Agency and its predecessors. However, in 2008-09, the Environment Agency and the local landowner agreed that the defence would be maintained by the landowner in future. As part of this agreement, the Environment Agency refurbished sections of the embankment prior to responsibility being transferred. A recent topographic survey shows the crest of this defence directly south of Low Crosby to be at approx. +19.0mOD, increasing upstream and decreasing downstream.

The flood embankment on the north bank of the Eden, downstream of Low Crosby, follows the line of the Hadrian's Wall Footpath. The crest elevation is approximately +17.5mOD, most probably offering the lowest level of protection of any of the local embankments. For example, the crest level of the embankment opposite, protecting Warwick Holmes, is +18.1mOD at this location.

There are currently no formal upstream flood storage schemes that provide benefit to Low Crosby. However, there are initiatives within Cumbria examining the viability of reducing flood conveyance within the River Eden catchment. This includes work within the "Slow the Flow" initiative and that by the "Cumbria Floods Partnership".

There are no flood defences to the west of the village around Green Lane or along the course of Willow Beck.

Investigation

This section provides details of the likely local causes of flooding. This investigation was carried out by the Environment Agency through surveys of the area and data collected from the community affected. This report has compiled this data to provide details of the flooding within Low Crosby.

Sources of Flooding, Flow Routes and Event Timing

There were three main flood flow routes in Low Crosby during the event, as shown in Figure 7.

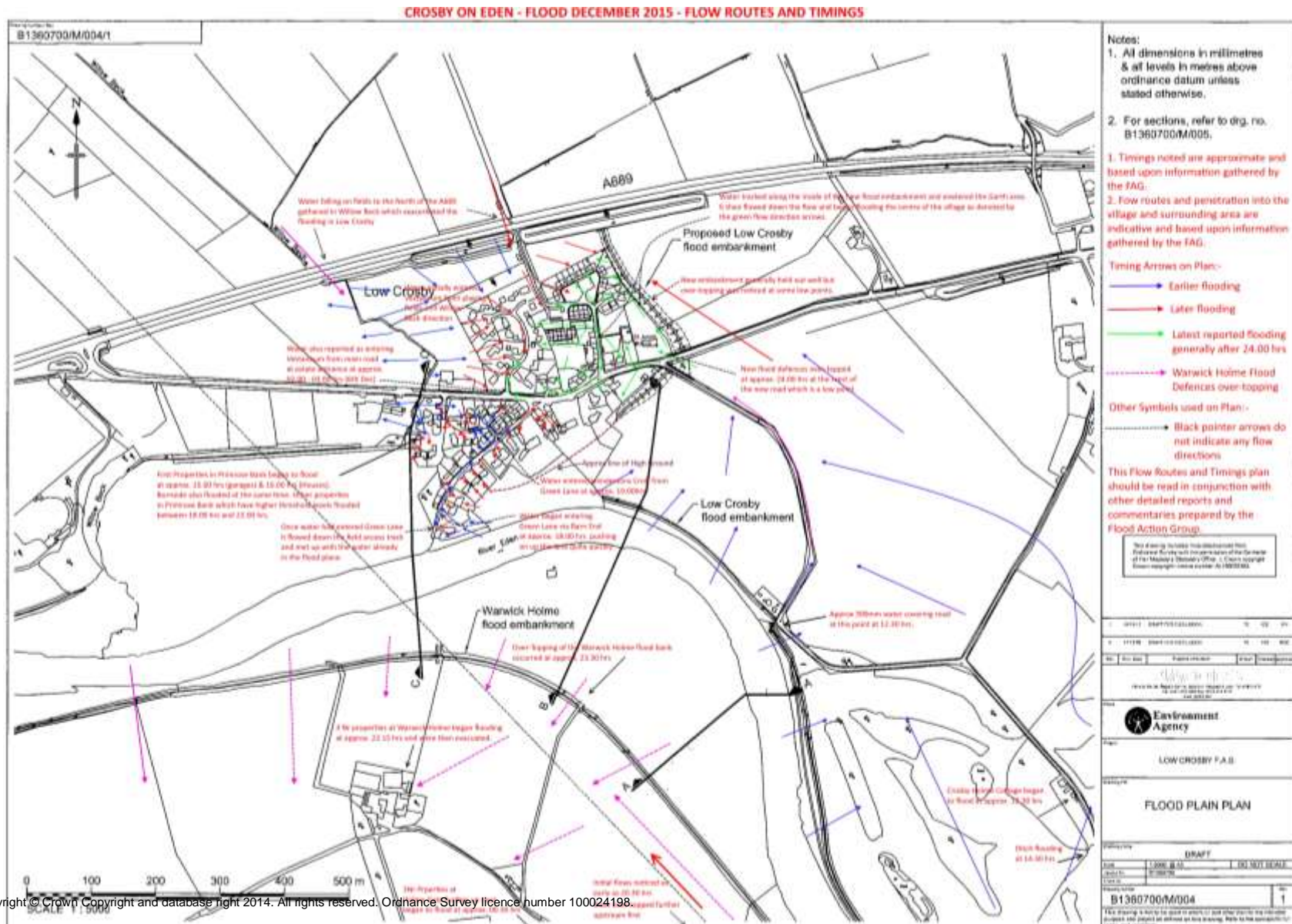


Figure 7 - Map of flood flow routes

Note: The flood outline identifies the maximum extent of flooding. Not all properties within the extent area were flooded.

This figure was prepared by the community through the Flood Action Group. The Environment Agency would like to thank the Flood Action Group and the community for their efforts in putting this image together.

Table 5 below shows the times of key events during the flooding in December 2015.

Thursday 3rd December	Event
14:46	Flood alert issued for the Lower Eden, incl. Low Crosby.
Friday 4th December	Event
20:30	Initial flows noticed as early as 20:30hrs. River overtopped further upstream of Low Crosby first
Saturday 5th December	Event
05:26	Flood warning issued for Low Crosby, Eden Golf Course area.
12:30	Road (from golf course) under approx. 300mm water
14:30	Ditch flooding south of Crosby Holme Cottage
15:00	Properties on Primrose Bank begin to flood (garages)
16:00	Houses on Primrose Bank begin to flood internally
16:49	Flood warning issued for Warwick Holmes area.
17:41	Flood warning issued for at Low Crosby Village, Holme Ends and Holme Gate area.
18:00-22:00	Other properties on Primrose Bank with higher thresholds flood internally
18:00	Flooding to Barn End (south end of Green Lane) from River Eden – flow route onto Green Lane
18:30	Reported flooding at Crosby Holme Cottage
19:00	Water reported to enter Hendersons Croft from Green Lane
TBC	Progressive overtopping of the embankment protecting Warwick Holme area
18:00 onwards	Progressive flooding to the village from the west side along the general line of Willow Beck and outflanking the new flood defences on the east side of Low Crosby.
22:00 onwards	Flood water starts to over top the raised section of Main Street flood defences near Church at the road junction with Newby East Road at 22:00 hrs. Flood waters will have joined with flooding of The Garth from the north / west, worsening existing flooding in The Garth and also flooding properties on Main Street.
22:15	Initial flooding reported of three properties at Warwick Holme
23:30	Properties in Warwick Holmes evacuated
23:30	Reported overtopping of the Warwick Holme flood embankment
Sunday 6th December	Event

00:00	New flood defences overtopped at the crest of the new road which is a low point
00:12	Severe flood warning issued for Low Crosby and Warwick Holmes areas.
02:00-03:00	Water reported to enter Vestaneum from main road at estate entrance
06:00	Peak flow on River Eden reached at Great Crosby gauging station.
09:00	Peak flow on River Eden reached at Sheepmount gauging station.

Table 6 - Timeline of Key events

Likely Causes of Flooding

The cause of the flooding was clear: high fluvial flows and water levels in the River Eden. This was the dominant feature dictating the extent and depth of flooding.

The general pattern flooding is also clear and is described below:

- Water levels in the Eden rose during Saturday 5th December and Sunday 6th December. Embankments will have been subject to overtopping with those offering the lowest standard of protection being overwhelmed first. Although no records exist for this, it is expected that the defences running along the north bank of the Eden, upstream and downstream of Low Crosby, will have been overtopped first, followed by the defences to Warwick Holmes. The overtopping will have occurred at various low spots, with the hinterland areas gradually filling.
- Prior to the direct flooding from the River Eden there were reports of flooding from the drainage system at The Garth and elsewhere in the village. High river levels prevent the local drainage systems from operating effectively. A temporary pump was operated by CCC at the sump in the flood defences opposite the church which helped to manage flooding from local drainage systems at certain locations early in the event.
- During this period, floodwater from the River Eden gradually filled the floodplain and channel associated with Willow Beck, west of Low Crosby. Once sufficiently elevated, this floodwater spilled across the floodplain north of Low Crosby. Based on the available information, this flow route, and the flow route into Green Lane from the Eden direct, accounted for all 18 of the properties flooded in Green Lane, the 5 on Primrose Bank, and potentially some of the 30 properties flooded in The Garth, especially at the northern end.
- Lastly, flood waters overtopped a short section of the new 2011-12 defence to the east of Low Crosby (on the highway), occurring at approximately 24:00hrs. This is the likely route by which 8 properties on Main Street were flooded and the balance of the properties in The Garth. However, this assessment would benefit from specific consultation with the relevant property owners as the properties may have suffered flooding (from the above flow routes) prior to the 2011-12 defence being overtopped, with the further floodwaters from the east only adding to the problem. Inspections shortly after the event appear to show that the flood level reached the crest of the 2011-12 embankment but did not overtop it. This indicates a maximum depth of floodwater of 200~300mm flowing over the highway low spot in the defence. This also provides a basis for assessing the peak flood level reached in the flooded area east of Low Crosby, being approximately 19.3~19.4mOD (19.4mOD being the level of the embankment crest).

Flood Incident Response

A flood alert for the River Eden catchment was issued on 3rd December at 14:46hrs by the Environment Agency. This was followed by the issue of a flood warning on 5th December (at 16:49hrs for the village) and a severe flood warning in the early hours of Sunday 6th December. The community at Low Crosby and the surrounding area is well covered by the Environment Agency's "Floodline Warnings Direct" automated telephone based flood warning service. Of note, 75% of calls made providing the severe flood warning were successful (i.e. were answered).

During the flood event Cumbria County Council operated a mobile pump in the sump chamber that was constructed as part of the Environment Agency flood defence scheme around the eastern and southern part of the village. This helped keep water levels and the drainage system in the eastern part of village lower for longer but the pump was overwhelmed once the flood defence began to overtop later in the flood event.

The actions of other emergency services are not known with certainty but it is thought likely that there were no specific presence or actions that benefitted the local community.

In the period to date following the event:

- The Environment Agency has visited the local community to complete initial consultation with local residents and collect information related to the extent of flooding.
- The Environment Agency has completed a topographic survey of all local raised defences (mainly embankments).
- Cumbria County Council have undertaken;
 - Gulley emptying
 - De-silting and jetting connecting pipework to outfalls
 - Survey and mapping highways drainage system. This includes identification of any defects which will be inform programme of additional works
- Connect Roads who maintain the A689 on behalf of Highways England have confirmed that they will be undertaking an inspection of the culverts running underneath the A689 shortly.

Maintenance Activities

The Environment Agency maintains flood risk management structures and sections of river channel where maintenance actively reduces the risk of flooding to people and property. Local activities undertaken around Low Crosby are summarised below:

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

The Environment Agency also undertakes yearly inspections of river channels and targeted debris clearance when the debris increases the risk of flooding.

Recommended Actions

The following table details recommended actions for various organisations and members of the public to consider. Some of these recommendations may have already been carried out.

Cumbria Flood Partnership Theme	Action By	Recommended Action	Timeline
Strengthening Defences	Cumbria Country Council	Install permanent pump in chamber on Environment Agency flood defences at church in Low Crosby installed and operational	Expected completion of pumping main to river and commissioning of pumps by April 2017
	Environment Agency, County Council, Landowners	<p>Review flood risk and its present management at Low Crosby and Warwick Holmes and work with the local community (e.g. Flood Action Group and landowners) to explore options to further reduce flood risk. This should include;</p> <ul style="list-style-type: none"> • Develop business case for new flood defences on the west and south side of Low Crosby. • examining the performance of the 2011-12 flood defence scheme • How the Warwick Holmes and other rural raised defences influence flood risk in Low Crosby • the possibility of using land north of the A689 as additional storage • consideration of how high river levels interact with the local drainage systems. 	<ul style="list-style-type: none"> • From September 2016 (on-going) • On going • Ongoing after surveys • On going • On going

Cumbria Flood Partnership Theme	Action By	Recommended Action	Timeline
Community Resilience	Environment Agency	Adopt a precautionary approach when considering development proposals.	Ongoing
	County Council and Carlisle District Council	Review Local Development Plans and Strategic Flood Risk Assessment to reflect current understanding of flooding.	2016
	County Council, District Council, Local Residents	Review emergency planning and response arrangements, including road closures and evacuation procedures. The latter point is particularly important given the potential for the village to be cut off in flood events. The local Flood Action Group and Parish Council will be important in such efforts. Clarity on “delegated responsibility” to the local community during flood events would be appropriate.	2016 /On going
	Environment Agency, County Council	Linked to better emergency planning, education / awareness raising to ensure that the local community is made aware of the hazards posed by flood water and how to respond to flood warnings.	2016
	Environment Agency, County Council Community	Promote further take up of property level flood resilience and resistance technology. Including update and review in light of 2015 late warnings issued.	2016/17
	Environment Agency	Ensure all properties at risk can register to receive flood warnings and details are up-to-date.	2016/17
	Environment Agency	Review modelling and forecasting data to ensure that models for the Eden catchment reflect real conditions as accurately as possible and use this information to make any improvements to the flood warnings service. This modelling review will be used to inform future investment plans.	2016 On going
Maintenance	CCC Highways	Inspect drainage systems and repair damaged sections	Work complete

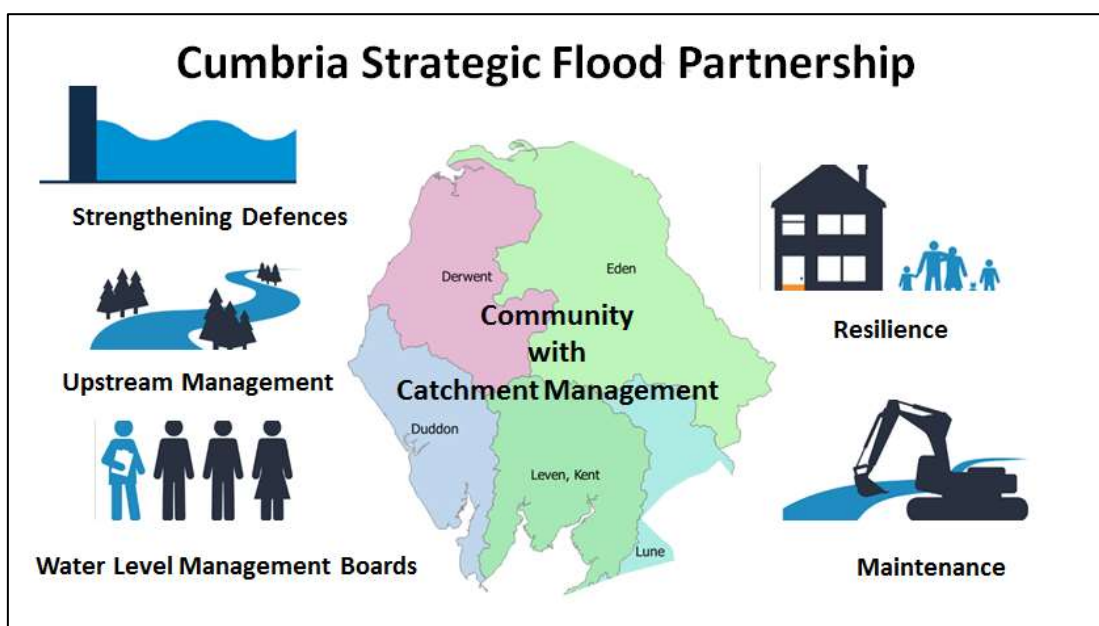
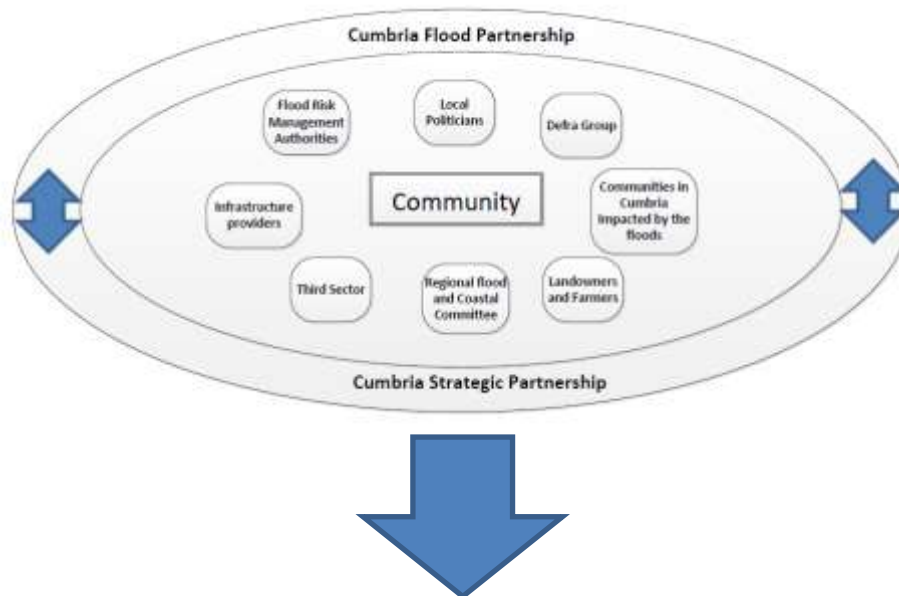
Cumbria Flood Partnership Theme	Action By	Recommended Action	Timeline
Maintenance	Connect Roads (Highways England)	Inspect culverts on A689 Low Crosby By-pass	2016 (completed October 2016 by Connect Roads)
	Environment Agency	Complete on-going inspections and repairs to assets that may have been damaged during the flood event. Includes topping up low spots in existing flood defence embankment at church	September 2016

Table 7-Recommended Actions

Next Steps – Community & Catchment Action Plan

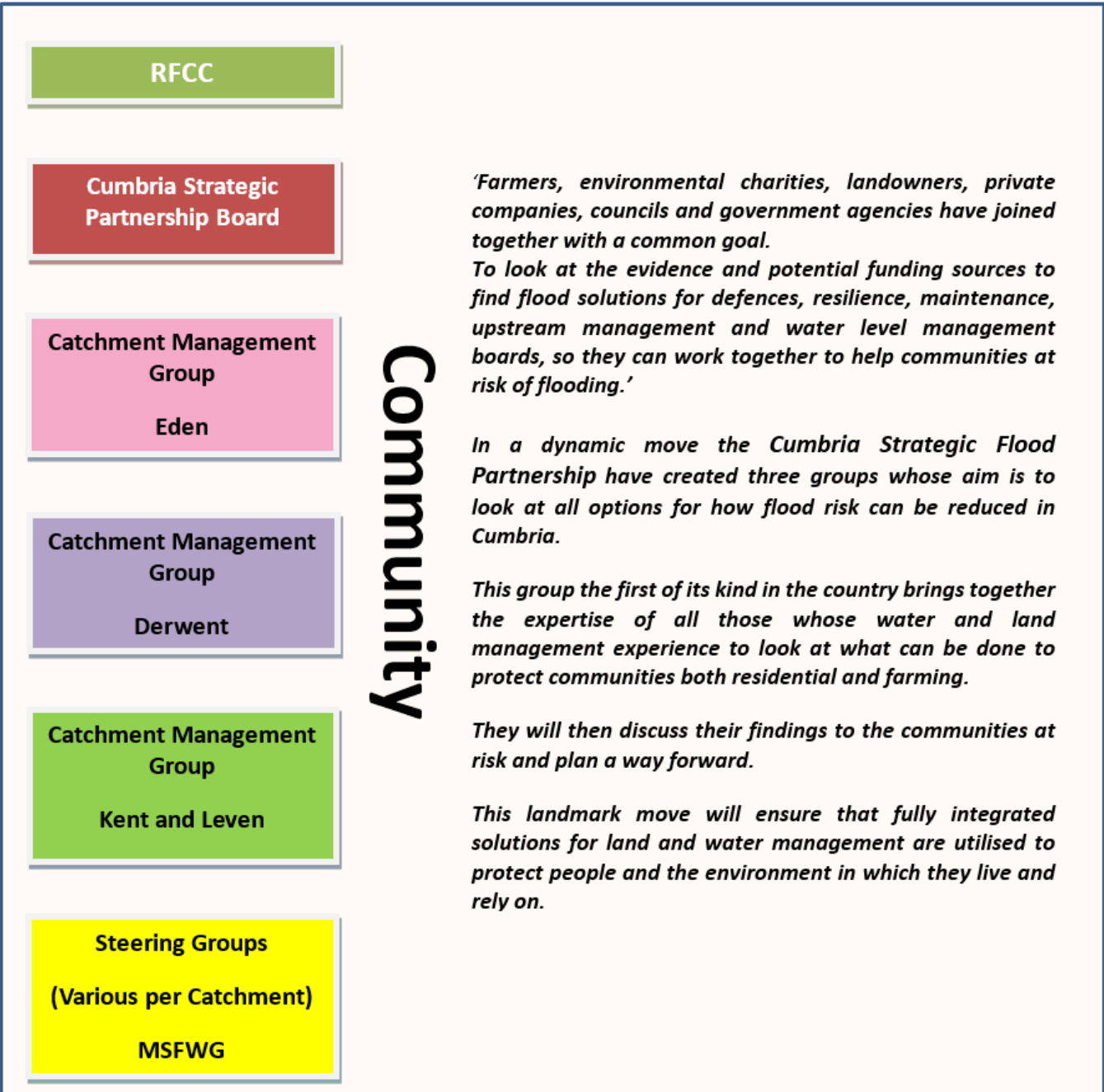
The Cumbria Floods Partnership has brought together a wide range of community representatives and stakeholders from a variety of sectors to plan and take action to reduce flood risk. The Cumbria Floods Partnership, led by the Environment Agency, is producing a 25 year flood action plan for the Cumbrian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



Appendices

Appendix 1: Glossary

AEP	Annual Exceedance Probability
AOD	Above Ordnance Datum
CCC	Cumbria County Council
CFP	Cumbria Floods Partnership
EA	Environment Agency
FAG	Flood Action Group
FWD	Flood Warnings Direct
LLFA	Local Lead Flood Authority
MsfWG	Making space for Water Group

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 Management Plan	Flood 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.

Term	Definition
Flood and Management Act	Water 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 Lancashire 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.

Term	Definition
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 capital programme 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: Feedback from the Community

Details on the following pages are:-

- Questions and answers asked from the community
- Options put forward from the community on flood relief.

Questions and Answers

1 - what was the cost of the scheme and what was the cost of the part of the scheme, which the Environment Agency was not prepared to meet, covering the south and west of the village?

It was not a case of the Environment Agency not being prepared to meet the cost of the work to address flooding via Willow Beck, it was about the fact that the additional cost to the project would have made the business case uneconomic and therefore no part of the scheme would have been approved and built. My understanding is that this was explained to the residents at the time of discussing the engineering options. However, it is fair to say that at the time of securing the scheme approval, we didn't fully appreciate what this would mean in terms of relative standards of protection between Warwick Holme and Low Crosby, especially as negotiations to remove the EA from the legal agreement with Warwick Holme landowners was ongoing.

2 - when that scheme was being developed levels were taken on the village and the bank across the river, can you please provide the data for those levels on both sides of the river and can you also provide the dates on which those levels were taken?

Please see survey data in the Sec19 report. We have surveyed the whole bank but these are just some convenient excerpts.

3 - will you please confirm the date from which the Environment Agency did not assume responsibility for maintenance of the south bank and which was then passed over to the landowner?

The flood embankments at Warwick Holmes were built in 1955 as part of a MAFF scheme to protect agricultural land and increase food production. As part of that scheme, a legal agreement was entered into which required the EA to maintain the embankments to a good standard. Prior to the 2005 flood event, the EA were not aware of the agreement and hadn't been carrying out maintenance to the standard required. Following the 2005 flood event, emergency works were carried out, but without full appreciation of the requirements of the 1955 agreement. Due to the obvious conflict between the terms of the 1955 agreement and the EA's role in prioritising protecting residential property from flooding, the EA entered into negotiations to draw an end to the 1955 agreement. The 1955 agreement ceased in 2007 when a new agreement was put in place identifying a series of works which needed to be carried out in order to remove the EA from any ongoing liability associated with Warwick Holme. During the flood in 2009 however, damage occurred to some of the works that the EA had undertaken as part of the process to end the agreement. This led to the EA undertaking further repairs and carrying out a mediation process in order to meet the terms of the 2007 agreement. The mediation process ended in 2011 at which point the maintenance of the bank passed on to the landowner.

4 - what were the heights of the south bank before the transfer, at the transfer and subsequent to the transfer and what approval was given by the Environment Agency for changes to the heights?

Please see excerpts from two pieces of survey work. One is dated December 2007 and the other June '16. We have the drawings for the entire length of the defence but they are large files and in a format that you may not be able to open (Autocad). The defence levels recorded in the 2007 survey, showed the variability in crest levels which were indicative of the general condition of this bank.

5 - Additionally can you please provide current information on approvals given to flood defence work in the area between the poultry farm and Low Crosby?

The Environment Agency wrote to Carlisle City Council in their capacity as planning authority on the 3rd February asking for clarification of their interpretation of the regulatory process for such structures.

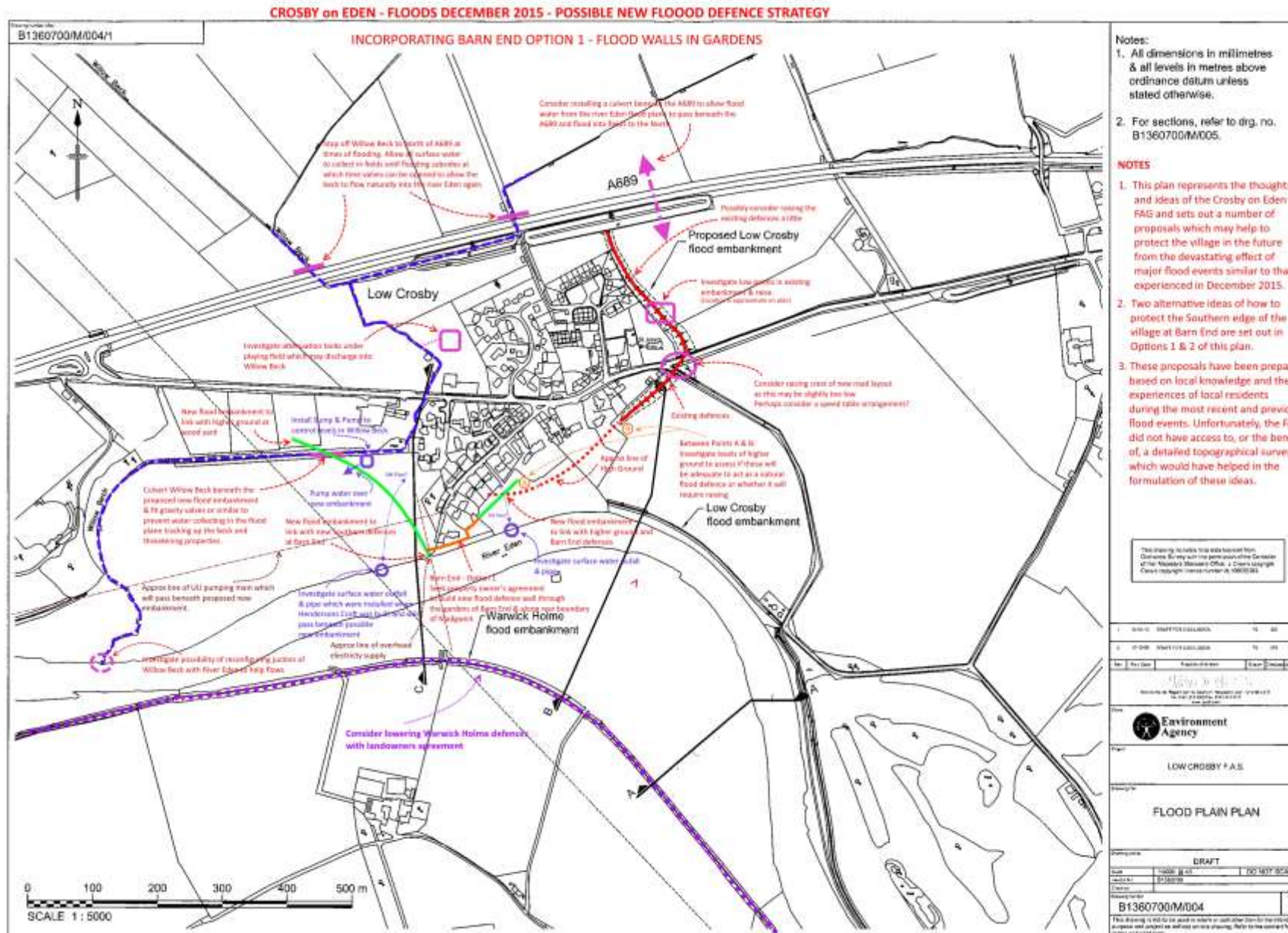
We are extending the scope of the Low Crosby survey work associated with the appraisal we are carrying out in order to include any new defences in the area you describe. This will help us work out what the impact of these works are on Low Crosby.

6 Winter works

- in the documentation produced by Partners there has been reference to Willow Beck work and also to the lower embankment repairs at Low Crosby. Can you throw light on what these elements contain?

The grass and topsoil on a section of the embankment at Low Crosby was damaged by a large tree tearing over it during the floods in December 2015. This damage was repaired in 2016. The work programmed for Willow Beck is to clear some of the vegetation from the channel. When I have a date for these works I will let you know.

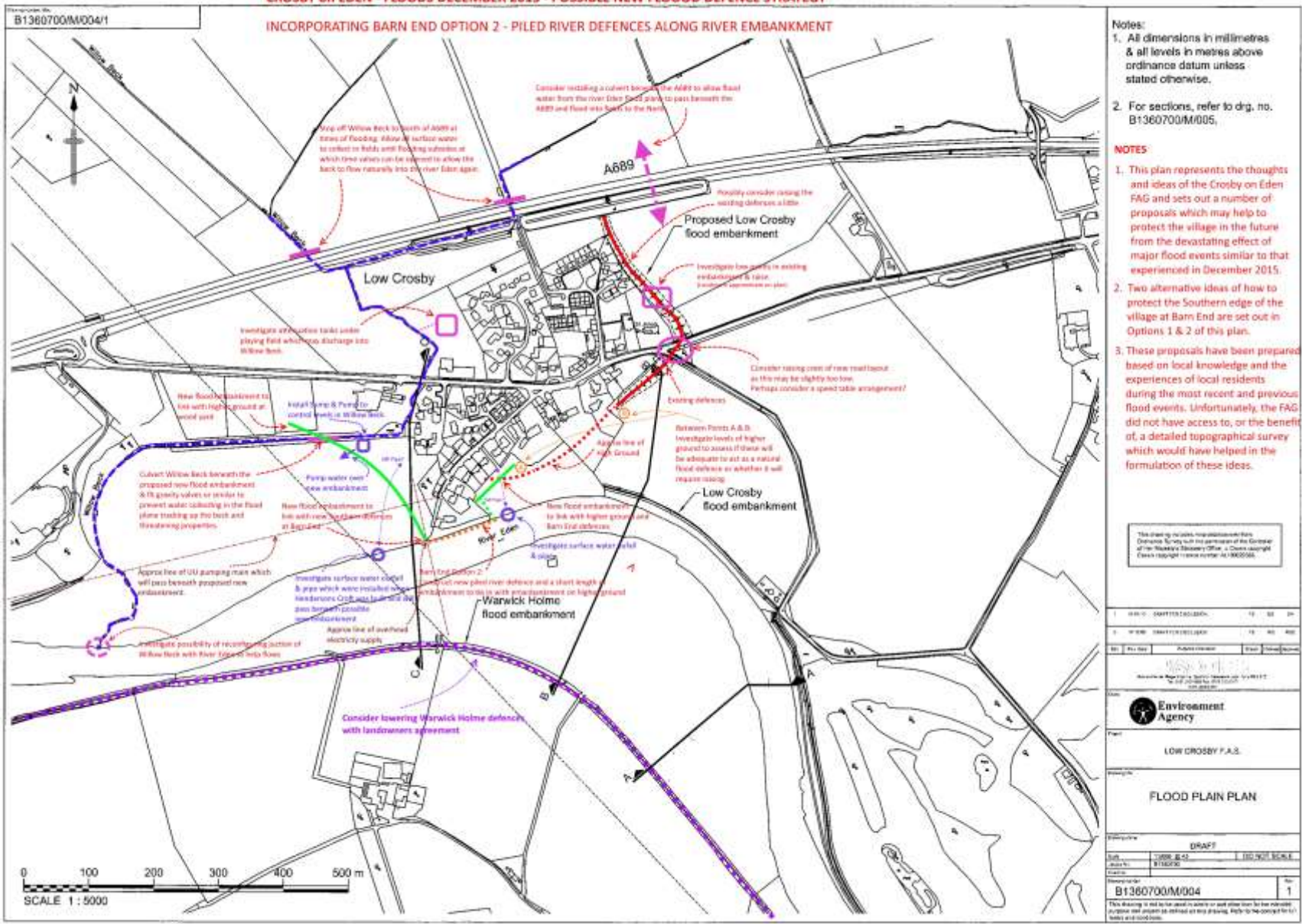
OPTION 1



OPTION 2

CROSBY on EDEN - FLOODS DECEMBER 2015 - POSSIBLE NEW FLOOD DEFENCE STRATEGY

INCORPORATING BARN END OPTION 2 - PILED RIVER DEFENCES ALONG RIVER EMBANKMENT



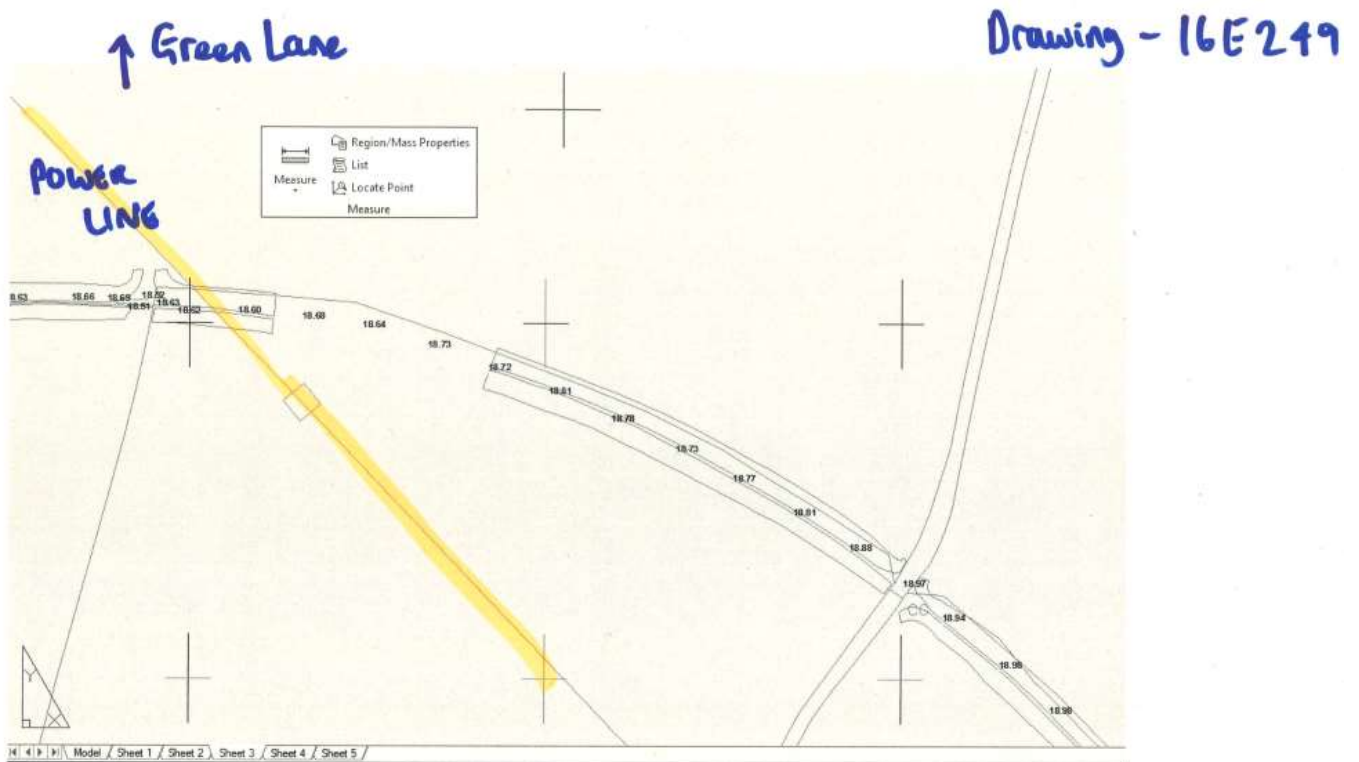
- Notes:**
- All dimensions in millimetres & all levels in metres above ordnance datum unless stated otherwise.
 - For sections, refer to drg. no. B1360700/M/005.

- NOTES**
- This plan represents the thoughts and ideas of the Crosby on Eden FAG and sets out a number of proposals which may help to protect the village in the future from the devastating effect of major flood events similar to that experienced in December 2015.
 - Two alternative ideas of how to protect the Southern edge of the village at Barn End are set out in Options 1 & 2 of this plan.
 - These proposals have been prepared based on local knowledge and the experiences of local residents during the most recent and previous flood events. Unfortunately, the FAG did not have access to, or the benefit of, a detailed topographical survey which would have helped in the formulation of these ideas.

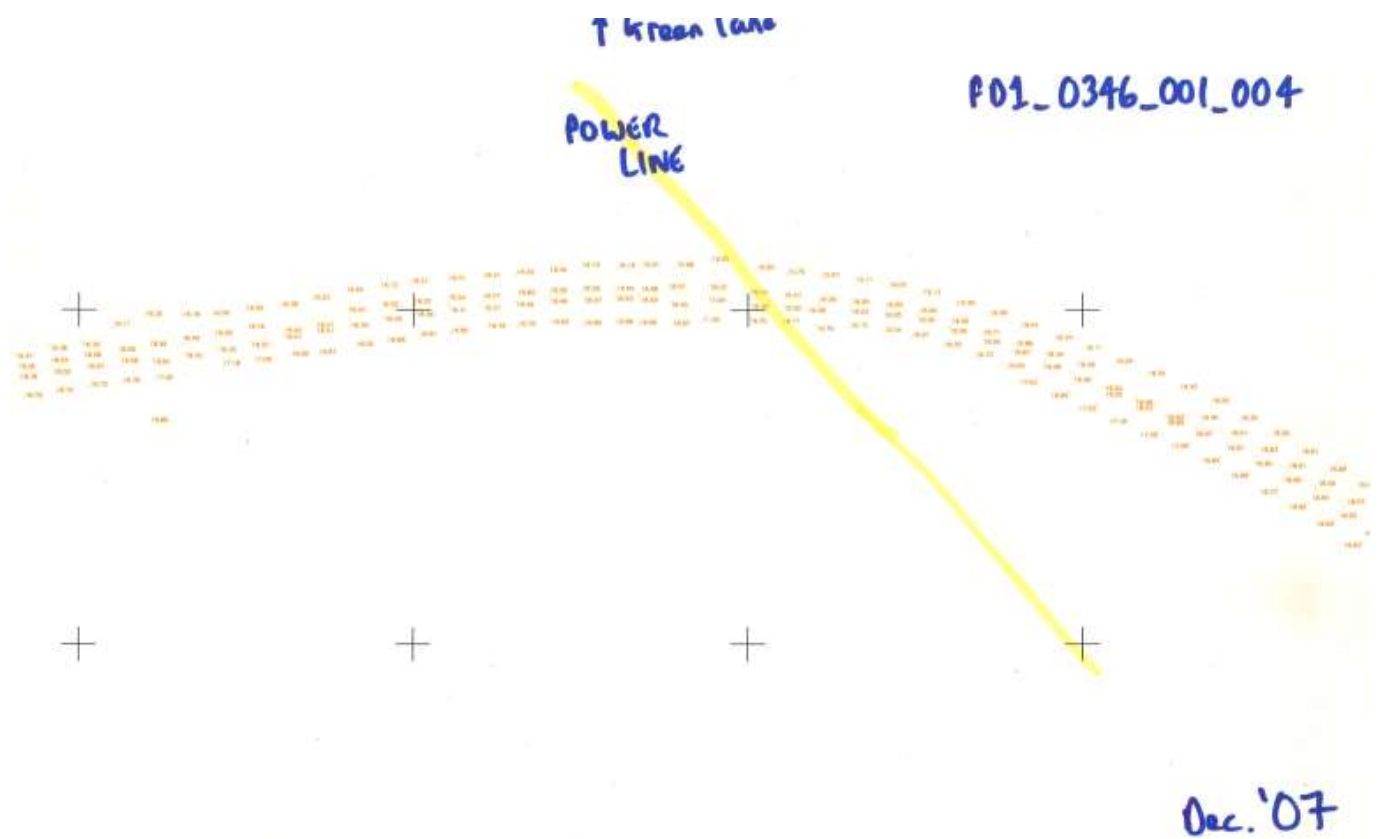
This drawing is the property of the Flood Defence Society and is the property of the Council of the Flood Defence Society. A. Cross copyright. Check register (issue number) 1902598.

1	DATE: 04/11/2015	10	00	00
1	DATE: 04/11/2015	10	00	00
NO	NO	NO	NO	NO
LOW CROSBY F.A.S.				
FLOOD PLAN PLAN				
DRAFT				
DATE:	04/11/2015	10	00	00
SCALE:	1:5000			
PROJECT NO:	B1360700/M/004			
NO				1

Appendix 4: Survey details Warwick Holmes Embankment



June '16



Appendix 5: 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>

Environment Agency – Flood risk maps

<https://www.gov.uk/prepare-for-a-flood>

Environment Agency – Programme of flood and coastal erosion risk management schemes

<https://www.gov.uk/government/publications/programme-of-flood-and-coastal-erosion-risk-management-schemes>

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 6: Flood Warnings and Alerts

Low Crosby and Warwick Holmes are covered by a Flood Alert and Flood Warning service.

Flood Alert for the Lower River Eden (for Low Crosby):

- **011WAFLE- Lower River Eden**

Alert issued on Thursday 03/12/2015 at 14:46

Alert removed on Sunday 13/12/2015 at 10:20

Customers in Flood Alert area registered on FWD: 332

Contacts (landline, mobile, email etc) in Flood Alert area registered on FWD: 1051

Successful contacts: 911

Unsuccessful contacts: 140

Alert Message:

A Flood Alert has been issued by the Environment Agency for the Lower River Eden.

Flooding is possible for River Eden and its tributaries from its confluence with the River Irthing through Crosby-on-Eden and Carlisle to the Solway Firth at Rockcliffe.

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

Flood Warnings for Low Crosby

- **011FWFNC11A- River Eden at Low Crosby, Eden Golf Course Area**

Flood Warning issued on Saturday 05/12/2015 at 05:26

Severe Flood Warning issued on Sunday 06/12/2015 at 00:12

Severe Flood Warning removed on Tuesday 08/12/2015 at 16:49

Date/Time Warning Level Reached: 05/12/2015 13:30

Time customers had to take action: 08:03:20

Customers in Flood Warning area registered on FWD: 39

Contacts (landline, mobile, email etc) in Flood Warning area registered on FWD: 125

Successful contacts: 93

Unsuccessful contacts: 32

Warning Message:

A Flood Warning has been issued by the Environment Agency for the River Eden at Low Crosby, Eden Golf Course Area.

Flooding is expected for Low lying roads, agricultural land, isolated properties and the golf course adjacent to the River Eden near Low Crosby. Immediate action required.

Heavy and persistent rainfall is expected throughout Saturday. River levels will continue to rise and further Flood Warnings are likely. Please check for updates throughout the weekend. Operational Teams have closed flood defences and are checking watercourses for blockages.

- **011FWFNC11B- River Eden at Low Crosby, Warwick Holmes Area**

Flood Warning issued on Saturday 05/12/2015 at 16:49
Severe Flood Warning issued on Sunday 06/12/2015 at 00:12
Severe Flood Warning removed on Tuesday 08/12/2015 at 16:46

Date/Time Warning Level Reached: 05/12/2015 19:15
Time customers had to take action: 02:25:53
Customers in Flood Warning area registered on FWD: 34
Contacts (landline, mobile, email etc) in Flood Warning area registered on FWD: 115
Successful contacts: 88
Unsuccessful contacts: 27

Warning Message:

A Flood Warning has been issued by the Environment Agency for the River Eden at Low Crosby, Warwick Holmes Area.

Flooding is expected for Low lying roads, agricultural land and isolated properties adjacent to the River Eden in the Warwick Holmes area. Immediate action required.

Heavy and persistent rainfall is expected throughout Saturday. River levels will continue to rise and further Flood Warnings are likely. Please check for updates throughout the weekend. Operational Teams have closed flood defences and are checking watercourses for blockages.

- **011FWFNC11C- River Eden at Low Crosby Village, Holme Ends and Holme Gate**

Flood Warning issued on Saturday 05/12/2015 at 17:41
Severe Flood Warning issued on Sunday 06/12/2015 at 00:12
Severe Flood Warning removed on Tuesday 08/12/2015 at 16:48

Date/Time Warning Level Reached: 05/12/2015 20:45
Time customers had to take action: 03:03:12
Customers in Flood Warning area registered on FWD: 188
Contacts (landline, mobile, email etc) in Flood Warning area registered on FWD: 435
Successful contacts: 332
Unsuccessful contacts: 103

Warning Message:

A Flood Warning has been issued by the Environment Agency for the River Eden at Low Crosby Village, Holme Ends and Holme Gate.

Flooding is expected for Low lying roads, agricultural land and properties in Low Crosby Village, Holme Ends and Holme Gate. Immediate action required.

Heavy and persistent rainfall is expected throughout Saturday. River levels will continue to rise and further Flood Warnings are likely. Please check for updates throughout the weekend. Operational Teams have closed flood defences and are checking watercourses for blockages.