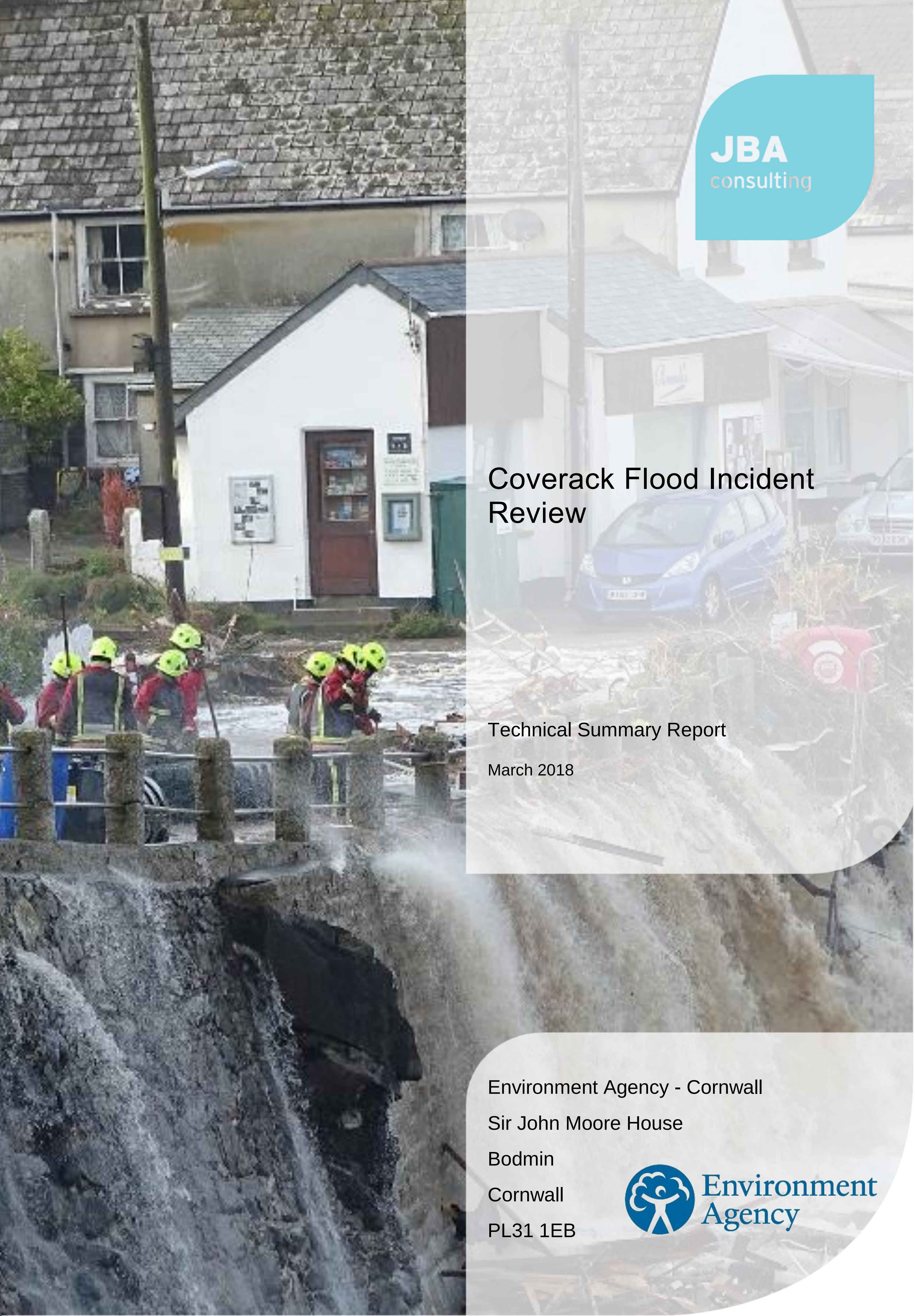

JBA consulting

Coverack Flood Incident Review

Technical Summary Report

March 2018

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Revision History

Revision Ref / Date Issued	Amendments	Issued to
v1.0 / Draft Report / October 2017	-	Julie Dunstan
v2.0 / Final Report / November 2017	Minor amendments based on workshop outcomes	Julie Dunstan
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v1.0 / Technical Summary Report / March 2018	Amendments to align with EA summary report	Julie Dunstan
v2.0 / Technical Summary Report / March 2018	Minor amendments following EA review	Julie Dunstan

Contract

This report describes work commissioned by Julie Dunstan, on behalf of the Environment Agency, by an email and scope of works dated 6th September 2017 (412_13_SD02 Scope_Coverack v1 issued 060917_JBA.doc). The Environment Agency's representative for the contract was Julie Dunstan. Jenni Essex, Daryl Taylor and Lucy Archer-Lock of JBA Consulting carried out this work.

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Purpose

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JBA Consulting has no liability regarding the use of this report except to the Environment Agency.

Acknowledgements

Julie Dunstan, Steve Marks, Mary Pemberton, and Will Hancock plus other Environment Agency staff involved in the study for providing data and answering queries quickly to enable the rapid progression of the work.

Cornwall Council and other organisations involved in the response to the event who have provided information and time attending the site visit.

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Executive Summary

Overview

On 18th July 2017 thunderstorms brought torrential rainfall, large hail and flash flooding to southern England. Emergency services responded to flash flooding in Kent, Berkshire and Cornwall. Coverack and neighbouring communities including Porthallow and St. Keverne, located on the east of the Lizard peninsula in Cornwall, were severely affected by localised intense rainfall, which led to flash flooding during the afternoon of 18th July. The volume of rainfall completely overwhelmed the catchment, resulting in flooding from rivers and surface water and significant erosion. There was high risk to life from dangerous deep fast-flowing water carrying debris. The emergency services rescued residents from homes, including a couple winched to safety by the coastguard helicopter. Over 50 properties have been recorded as being affected by the incident. Pollution from damaged infrastructure, including sewers and domestic oil supplies, also occurred and the road infrastructure was severely damaged. Thankfully, there were no fatalities or serious injuries caused by this event.

The Environment Agency has commissioned a review of the event, to provide a strategic overview of the flooding and document the incident. The review has been supported by all Risk Management Authorities (RMAs) and other partner organisations to learn as much as possible about the event.

JBA Consulting was commissioned to provide:

- A summary of the study area, its physical characteristics and history of flooding
- Information about the meteorological conditions and the hydrology associated with the storm
- An overview of the event, including a summary of the impacts and an approximate timeline
- Discussion regarding the occurrence of this type of event in Cornwall
- Results of a surface water modelling exercise for the 18th July 2017 event and several other observed and design events

Findings

The most extreme storm event recorded in Cornwall and one of the most extreme three hour rainfall events experienced in the UK

Analysis undertaken by the Met Office has concluded that between 165mm and 201mm of rain fell in three hours over Coverack on 18th July 2017. The extreme nature of this event can be put into context by comparing it to the Boscastle August 2004 event.

- A rainfall depth of 165-201mm across Coverack equates to about 0.5-0.6 million m^3 of water moving through the valley to the sea in three hours.
- The raingauge closest to Boscastle, Lesnewth, following correction for underestimation, recorded 148mm in three hours on 16th August 2004. It is estimated that two million m^3 of rainwater flowed through Boscastle on 16th August 2004; from reports of the event this is likely to have been over a period of five hours.
- Although the Boscastle volume is three to four times larger than the Coverack volume, the catchment draining to Boscastle is about seven times larger than that draining to Coverack.

From evidence gathered, no other recorded storm event in Cornwall has been more extreme than that experienced by Coverack in July 2017, further compounded by the localised event being concentrated over a very small area. Met Office records indicate that the upper rainfall value of the range for Coverack has broken the UK rainfall record for the highest three-hour total. The highest three-hour total prior to this was 178mm on 7th October 1960 at Horncastle (Lincolnshire). It must be borne in mind that there will be some uncertainty in the Coverack totals, but several different estimates have generated approximately the same values. Therefore, it is probably safe to assume that this is one of the most extreme, if not the most extreme, three-hour rainfall event experienced in the UK.

A rarity assessment undertaken by the Environment Agency, using the Flood Estimation Handbook (FEH) depth-duration-frequency (DDF) model, indicates that the 18th July 2017 event (rainfall) has an annual exceedance probability (AEP) of lower than 0.1% (return period >1,000yr). However, it should be borne in mind that this is an extreme rainfall and beyond normal categorisation methods. Although the Coverack event is rare, extreme rainfalls occur across south-west England with greater frequency than might be assumed from analysing point rainfall totals using the FEH methods. The 'rarity' is related to the spatial element of the event, i.e. that the rainfall was highly localised over the community, leading to the 'impact'.

The Environment Agency has made an estimate of the flow at the downstream extent of the Main River in Coverack. This gave a value of about $30m^3/s$ compared to design flow estimates for the 0.1% AEP event, using standard flood flow estimation methods, of about $4m^3/s$. This suggests that the flood flow estimation methods used for planning purposes may substantially underestimate the risk. The methods are generalised and were not developed for this type of event on catchments such as that draining Coverack. There is also significant uncertainty in the peak flow estimate derived for the 18th July 2017 event. Other tools may be required to aid in the assessment of likely extreme rainfall impacts.

A basic surface water model has been developed for this study to identify how well this model represents what was seen on the ground during the event and to provide an understanding of how the catchment might respond during extreme rainfall events. The idea was to see if a model providing only a basic representation of the catchment (no channel or topographic survey, or building thresholds), but which is quick and cost-effective to develop, could be useful.

Conclusions

It is not possible to prevent flooding occurring during this type of extreme event. The large volume of water falling in a short space of time will overwhelm any drainage system (natural or manmade) and any flood mitigation interventions. About half a million m^3 of water fell over Coverack during the 18th July 2017 event which would need to be managed. This is a huge volume to be managed within a short, steep-sided valley and, given the nature of these storms, the next time the rainfall may affect an adjacent catchment

The surface water modelling undertaken for this study has shown that, even with limited information, it is possible to obtain a reasonable prediction of flow routes, flood extent, and flood depth, to provide an indication of flooding mechanisms and potential high-risk areas for such extreme and rare events. The benefit that this modelling provides over the national Risk of Flooding from Surface Water (RoFfSW) modelling and mapping is that it models the specific storm event which led to the flood event in Coverack; this is not represented by the national modelling and mapping.

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Abbreviations

ABC .... Area Base Controller
AEP .... annual exceedance probability
CBHE .... Chronology of British Hydrological Events
DDF .... depth-duration-frequency
DTM .... digital terrain model
FAA .... flood alert area
FEH .... Flood Estimation Handbook
FIDO .... Flood Incident Duty Officer

FRA................................flood risk assessment
FWA...............................flood warning area
FWDO............................Flood Warning Duty Officer
ICE.................................Institution of Civil Engineers
IHM ....Integrated Height Model
LiDAR.............................Light Detection And Ranging
MFDO ....Monitoring and Forecasting Duty Officer
NFM ....natural flood management
OS..................................Ordnance Survey
RMAs ....Risk Management Authorities
RoFfSW ....Risk of Flooding from Surface Water (mapping)
RRC ....rapid response catchment
TBR................................tipping bucket raingauge

1 Introduction

On 18th July 2017 thunderstorms brought torrential rainfall, large hail and flash flooding to southern England. Emergency services responded to flash flooding in Kent, Berkshire and Cornwall. Coverack and neighbouring communities including Porthallow and St. Keverne, located on the east of the Lizard peninsula in Cornwall, were severely affected by localised intense rainfall, which led to flash flooding during the afternoon of 18th July. The volume of rainfall completely overwhelmed the catchment, with flooding from rivers and surface water and with significant erosion. There was high risk to life from dangerous deep fast-flowing water carrying debris. The emergency services rescued residents from homes, including a couple winched to safety by the coastguard helicopter. Over 50 properties have been recorded as being affected by the incident. Pollution from damaged infrastructure, including sewers and domestic oil supplies, also occurred and the road infrastructure was severely damaged. Thankfully, there were no fatalities or serious injuries caused by this event.

1.1 Scope of commission

The Environment Agency has commissioned a review of the 18th July 2017 flood event, to provide a strategic overview of the flooding and document the incident. The review has been supported by all Risk Management Authorities (RMAs) and other partner organisations to learn as much as possible about the event.

1.2 What this document covers

This report provides:

- A summary of the study area, its physical characteristics and history of flooding (Section 2)
- Information about the meteorological conditions and the hydrology associated with the storm (Sections 3 and 4)
- An overview of the event, including a summary of the impacts and an approximate timeline (Section 5)
- Discussion regarding the occurrence of this type of event in Cornwall (Section 6)
- Results of a surface water modelling exercise for the 18th July 2017 event and several other observed and design events (Section 7)

1.3 Available data

A wide range of data and information has been supplied for this study, from the Environment Agency, other RMAs, and other partner organisations. All data / information relating to the event has been collated and filed with an individual identification number.

2 Setting the Scene

2.1 Location & characteristics

2.1.1 Watercourses

Coverack is a coastal village located on the eastern side of the Lizard peninsula in west Cornwall. Three small watercourses drain the catchment above the village and flow through the village to discharge into the sea, as detailed in Table 2-1.

Table 2-1 - Coverack watercourses

Name (descriptive)	Route	Designation	Catchment area (km^2)
South Coverack Stream	Due west from Penhallick; discharges into sea at Polcoverack Lane junction with B3294	Main River - lower ~230m	2.2
North Coverack Stream	Due south-west from 'The Coverts'; discharges into sea just south of lower car park	Ordinary Watercourse	<0.5
North Corner Stream	Due south-west from B3293; discharges into the sea at North Corner	Ordinary Watercourse	0.6

St Keverne and Porthallow are also located on the eastern side of the Lizard peninsula, to the north of Coverack. St Keverne lies ~2km inland from the coast, a watercourse runs along the northern edge of the village. Porthallow is situated at the coast; two watercourses join in Porthallow just before the discharge to the sea. Details of the watercourses are provided in Table 2-2.

Table 2-2 - St Keverne and Porthallow watercourses

Name (descriptive)	Route	Designation	Catchment area (km^2)
St Keverne Stream	Due north-west from Crousa Common; discharges into the sea at Porthoustock	Main River - lower ~800m	2.8
South Porthallow Stream	Due north-west from Lanarth; discharges into the sea at Porthallow ~150m downstream of the North Porthallow Stream confluence	Main River - lower ~320m	5.3 (upstream of North Porthallow Stream confluence)
North Porthallow Stream	Roughly due west from Tregarne; joins South Porthallow Stream at Porthallow	Main River - lower ~190m	1.3

The study areas, watercourses and local hydrometric gauges are shown in Figure 2-1. There are small reaches of Main River at the downstream extents of South Coverack Stream, St Keverne Stream and the Porthallow Streams. The Environment Agency is responsible for Main River and Cornwall Council is responsible for Ordinary Watercourses. The watercourses are not named on mapping and have been given descriptive named for the purposes of this study; Figure 2-2 identifies the watercourse to which each name in Table 2-1 and Table 2-2 has been given.

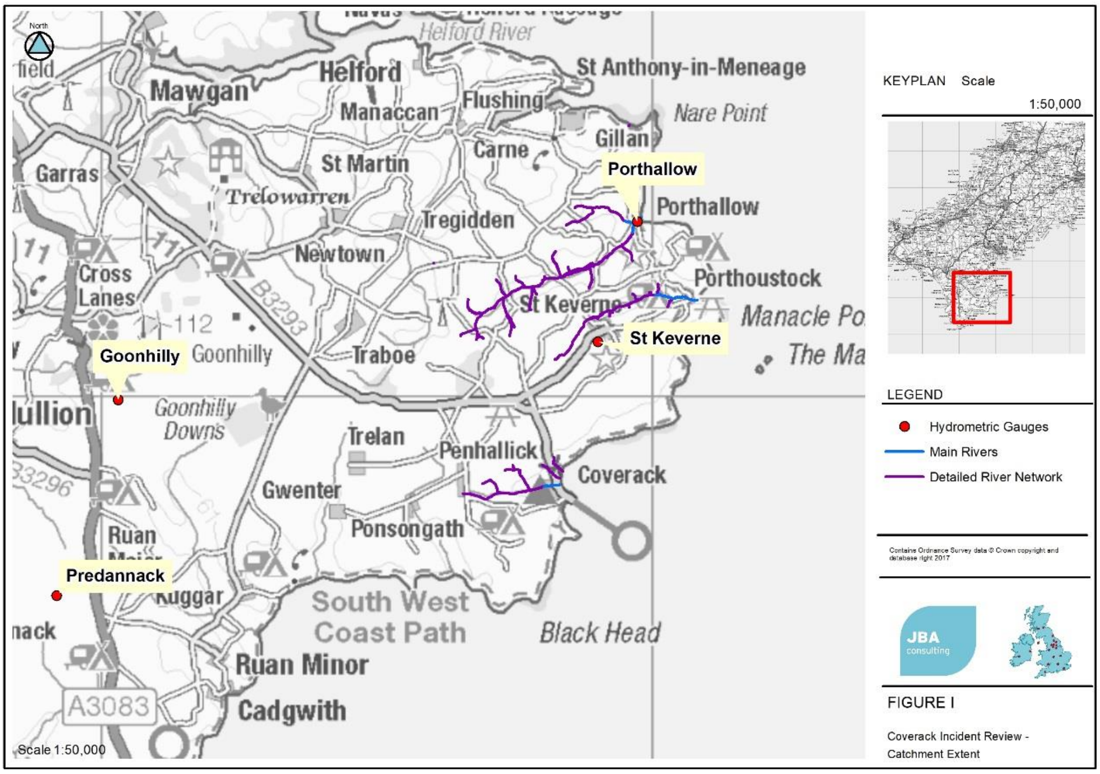

Figure 2-1 - Study area

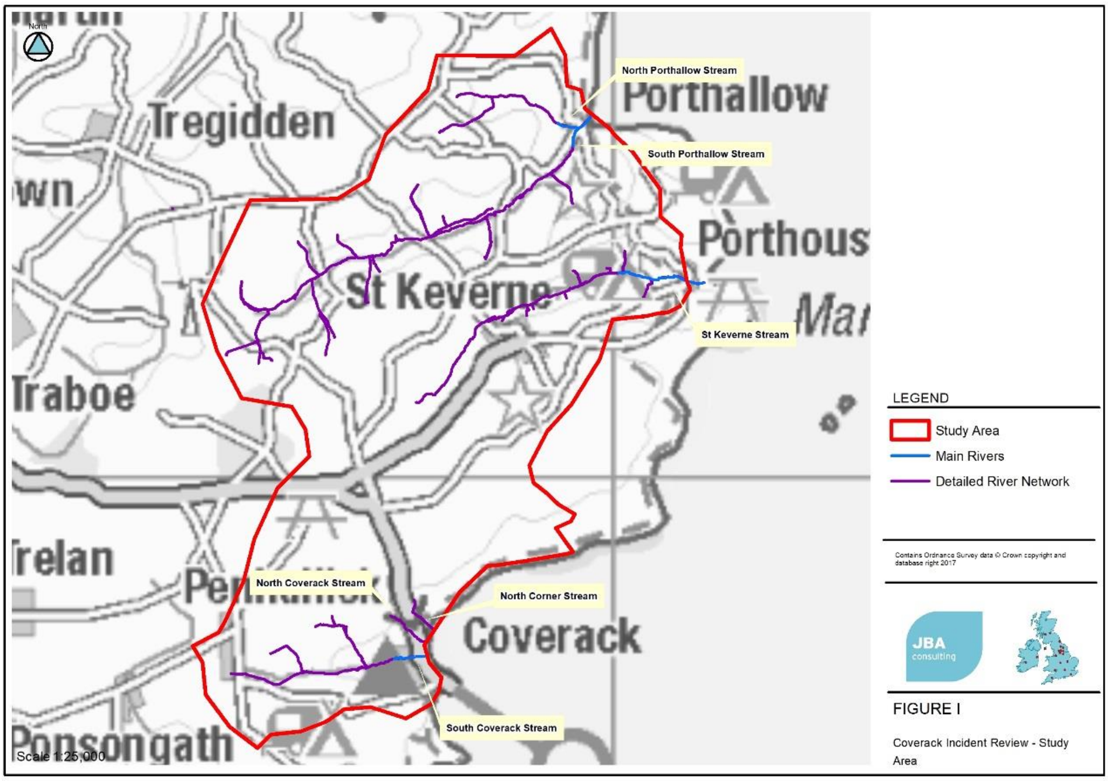

Figure 2-2 - Named watercourses

2.1.2 Topography

At Coverack the topography is steep, particularly in the lower part of the catchment where the village is located. South Coverack Stream has a gradient of ~1:25 and North Corner Stream has a gradient of ~1:16. Steep topography is also characteristic of St Keverne and Porthallow.

2.1.3 Geology

The underlying geology is characterised by Devonian igneous and metamorphic rocks of the Lizard Complex. The Coverack catchment can be approximately split using South Coverack Stream as a divide:

- South of South Coverack Stream - Peridotite and Serpentinite (igneous)
- North of South Coverack Stream - Gabbro (igneous)

The underlying geology of the St Keverne and Porthallow catchments is:

- St Keverne - Gabbro
- Porthallow - Schist, Hornblende (metamorphic) to the north and Gabbro to the south

2.1.4 Soils

The soils underlying Coverack, and those underlying St Keverne and Porthallow, are slightly different in terms of their permeability / wetness:

- Coverack - Slowly permeable seasonally wet acid loamy and clayey soils
- St Keverne and Porthallow - Freely draining slightly acid but base-rich soils

The soils in the St Keverne and Porthallow catchments may potentially provide some storage in the less steep upper parts of the catchments.

2.2 Flood history

There is little information on previous flooding in Coverack, or in St Keverne and Porthallow.

The Environment Agency provided details of a fluvial / surface water flood event in Coverack which occurred on 17th November 2010. This appears to be related to the South Coverack Stream (Main River). At approximately 04:30 the channel capacity was exceeded near a property adjacent to the watercourse. This resulted in flooding of the garden and flood water entering the rear door of the property. High flows led to substantial erosion of the right bank adjacent to the property. The owner of the property noted that there was flooding from the river to a property lower in the village and believed that several other properties had been affected by surface water.

There are two raingauges in the local area, as shown in Figure 2-1. The data from these raingauges has been assessed as part of the current study to determine the depth and intensity of the rainfall for the 17th November 2010 event, as this information was not contained in the Environment Agency flood reconnaissance report.

- Goonhilly tipping bucket raingauge (TBR) - 22.2mm, 16/11/2010 20:30 to 17/11/2010 05:15 (8.75hr)
- St Keverne daily raingauge - 55.6mm, 16/11/2010 09:00 to 17/11/2010 09:00

Rainfall in the area may be localised and the Goonhilly TBR, which is more distant from Coverack than the St Keverne gauge, may underestimate the total rainfall amount. If the St Keverne daily raingauge total was recorded over the same period as the Goonhilly TBR, this gives an average rainfall intensity over the event of 6.4mm/hr, with the largest 1hr intensity being 16.5mm/hr. There is no information to indicate that flooding occurred in St Keverne or Porthallow on 17th November 2010.

An Internet search uncovered little additional information on flood history in the local area. The Chronology of British Hydrological Events (CBHE) website[1] details a local thunderstorm which occurred on 17th October 1920: "…The rainfall was heaviest in a strip about 5 miles wide stretching from Newquay to the Lizard, where the total for the day reached 2 in. (50.8mm). …The storm began at Newquay about 16h GMT, and lasted until 19h. During the first hour 0.93in (23.6mm) fell and 1.19in (30.2mm) in the succeeding hour and a half… A great deal of damage was done by flooding.

[1] http://cbhe.hydrology.org.uk/

At Mullion a large culvert burst, hundreds of tons of stones and earth being carried into the harbour, whilst roads were rendered impassable."

No further information on historical flood events in the local area could be found.

Quotes from residents following the 18th July 2017 flood also suggest that significant flooding has not occurred in recent times:

- "It was nothing like I've ever known in this area..."
- "It has flooded here before but this is by far the worst I have ever seen it."

2.3 Flood forecasting & warning

There are no river level or flow monitoring gauges on the streams which drain through Coverack or St Keverne. A monitoring gauge at Porthallow, as shown in Figure 2-1, records river levels upstream and downstream of the trash screen at the bottom of the catchment; it is believed the gauge is primarily for operational purposes.

A specific flood forecasting and warning service is not currently suitable for the Coverack, Porthallow and St Keverne communities due to several limiting factors:

- Small size of the catchments
- Short length of the watercourses
- Short time to peak
- Response time of Environment Agency staff
- Location of appropriate telemetered equipment

A Flood Alert service is available for the general area (Helford and Fal Rivers). This covers The Lizard, Penryn, Falmouth, Truro, Ladock, Tresillian and Grampound and is triggered by rising river levels on the River Fal. As such, residents in Coverack, Porthallow and St Keverne would be unlikely to receive a timely warning in the event of very localised, extremely heavy rainfall which may cause the streams to rise rapidly.

There is no specific flood warning service available for these communities at present. The Environment Agency typically uses river level gauges and raingauges to detect flooding and issue warnings. There are no river level or flow monitoring gauges on the streams which drain through Coverack or St Keverne. A monitoring gauge at Porthallow, as shown in Figure 2-1, records river levels upstream and downstream of the trash screen at the bottom of the catchment; it is believed the gauge is primarily for operational purposes. During the 18th July 2017 event, the Environment Agency raingauge at Goonhilly (8km from Coverack) recorded no rainfall, demonstrating just how localised and difficult to detect the rainfall was. In addition to this, for communities at risk of flash flooding, warnings from gauges do not provide sufficient lead time to respond.

3 Meteorology

3.1 What caused the storm?

A continuous stream of thundery showers tracked north-east towards west Devon during the day. The Met Office issued the following warning on the day of the flooding:

"Thundery showers are expected to push north across southern parts of the UK through Tuesday evening. Although many places won't see these showers, there is a chance of localised flooding of homes, businesses and susceptible roads. Frequent lightning may be an additional hazard with possible disruption to power networks. Similarly, but very locally, hail may cause impacts."

The heavy rain was extremely localised, as can be seen from the rainfall radar data in Figure 3-1. The storm sat offshore before quickly moving in and stalling over Coverack, then moving back out to sea after a short time. Figure 3-2 shows a closer view of the storm over Coverack; this is the radar-gauge merged accumulation for the 13:30-16:30 18th July 2017 period.

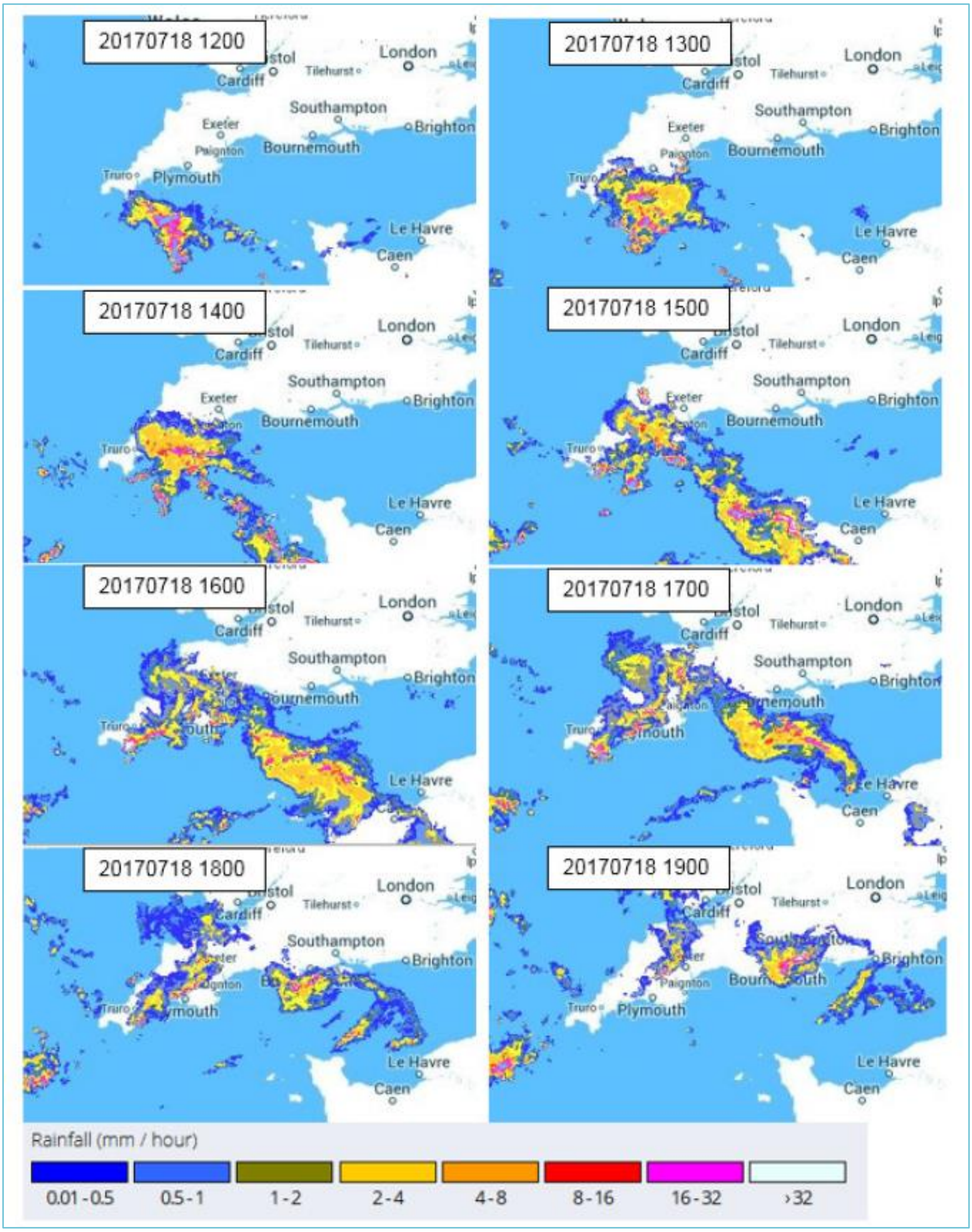

Figure 3-1 - Screenshot of radar rainfall (Source: JBA Risk Management post-event analysis note[2], original source Met Office)

2 JBA Risk Management. 2017. Coverack Flash Flooding - July 2017.

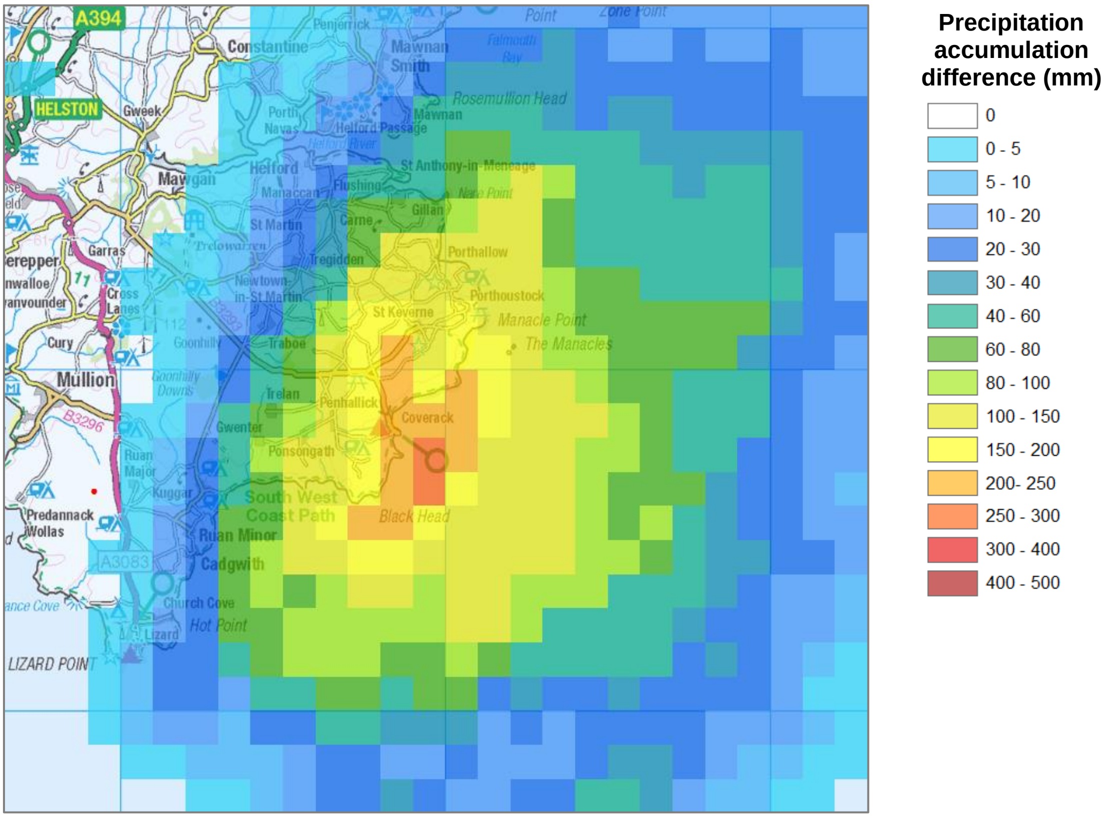

Figure 3-2 - Radar-gauge merged accumulation (Source: Met Office[3])

3.2 Distribution of rainfall & rainfall estimates

The rain which fell on 18th July 2017 was extremely localised. The St Keverne daily raingauge recorded 105.4mm of rainfall in the 24-hour period from 18/07/2017 09:00 to 19/07/2017 09:00; the Goonhilly TBR recorded zero rainfall.

In addition to the two ground-based raingauges, there is a rainfall radar gauge at Predannack. Analysis was undertaken by the Environment Agency, based on the radar rainfall data, to determine the rainfall total at Coverack. The radar rainfall gauge estimated the rainfall total at Coverack to be 332mm over the three hours that rain fell (13:30-16:30). At St Keverne the radar rainfall estimate was 177mm in three hours (13:30-16:30) compared to 105mm recorded at the daily raingauge (09:00-09:00). This suggests that the radar rainfall gauge substantially overestimated the total rainfall. It is also believed that precipitation falling as hail over Coverack will have led to the rainfall total being overestimated by the radar. Adjustments were made to the Coverack rainfall estimate based on these two factors and a value of 182mm/3hr derived.

A separate analysis, based on the average of the radar grid squares, gave an estimate of 170mm/3hr. An independent estimate of the rainfall total was also provided. This used a non-standard 'raingauge' based on water accumulation in a builder's bucket in Coverack, which was empty prior to the storm. Calculations based on the area of the bucket opening and the volume of water collected also gives an estimate of 170mm.

The Met Office also supplied analysis of the radar rainfall data to the Environment Agency, based on catchment area and associated hail-corrected catchment rainfall[3]. This gave a catchment average rainfall accumulation of 165mm/3hr for South Coverack Stream (2.2km^2) and 174mm/3hr for North Corner Stream (0.6km^2). The onshore peak accumulation for a 500m by 500m square centred on Coverack is 201mm.

The localised nature of events such as this make it difficult to determine the 'true' rainfall total. Rainfall measured by the nearest ground raingauge, even one in the local area, may differ substantially from the actual local rainfall. Radar rainfall is useful, particularly in terms of spatial

3 Harrison, D., Jewell, S. and Best, S. (Met Office, Radar Products Team, Observations R&D). 2017. High resolution precipitation estimates, Coverack Storm, 18th July 2017.

distribution, but has its own issues, including higher levels of uncertainty in rainfall totals. This can make short intense rainfall events and their resultant flooding hard to predict.

The analyses detailed above indicate that the three-hour rainfall estimate for the Coverack 18th July 2017 flash flood event is likely to be **in the region of 165mm-201mm**.

Determining the rarity of this type of event is challenging. A rarity assessment undertaken by the Environment Agency, using the Flood Estimation Handbook (FEH) depth-duration-frequency (DDF) model, indicates that the 18th July 2017 event (rainfall) has an annual exceedance probability (AEP) of lower than 0.1% (return period >1,000yr). However, it should be noted that this is an extreme rainfall and beyond normal categorisation methods. The Environment Agency has supplied a figure (Figure 3-3) showing notable past rainfall events, based on a diagram from Hand *et al* (2004)[4]. The three-hour rainfall intensities for the lower and upper end of the range derived for the 18th July 2017 event have been added (approximately) for comparison with these historical events. This shows that the Coverack event lies within the range of the historical events. Extreme rainfall events are defined by Hand *et al* as those exceeding a curve of values (shown by the solid line in Figure 3-3) derived from the Flood Studies Report maximum point rainfalls possible for durations <1hr and the 1% AEP for durations >1hr, as a function of average annual rainfall (1,400mm-2,800mm). This definition of 'extreme' has been assumed for the current study.

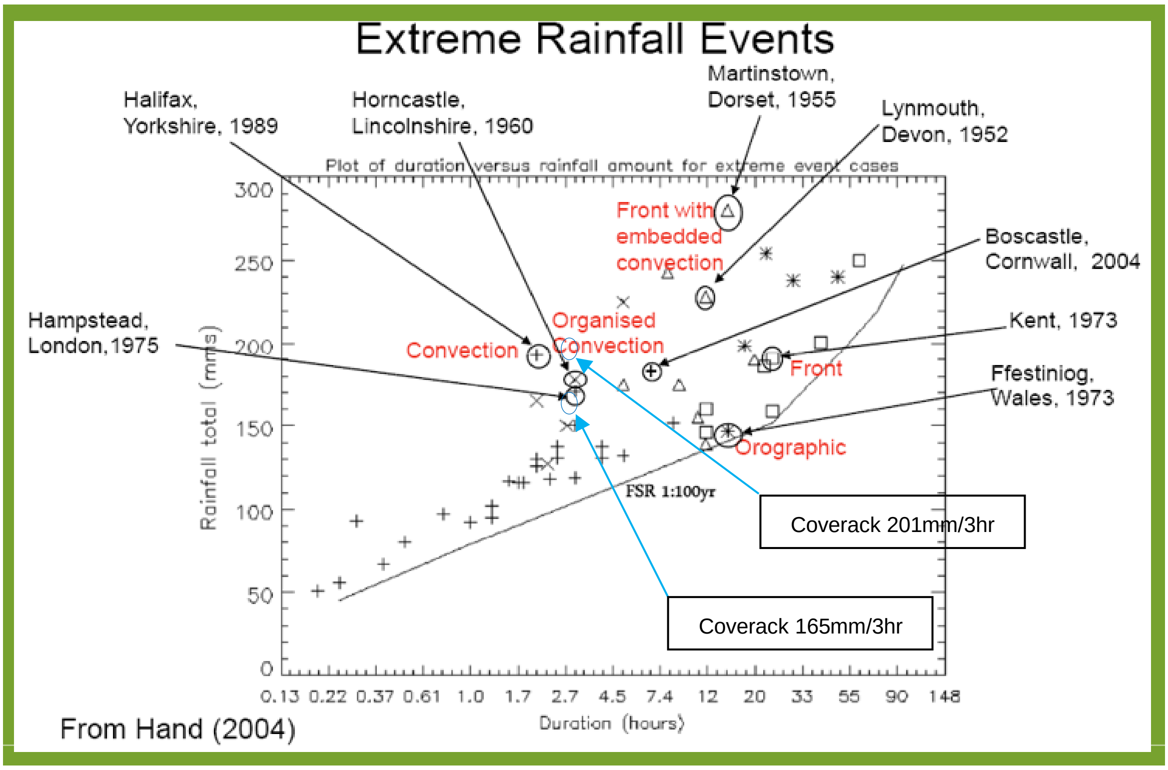

Figure 3-3 - Extreme historical rainfall events (Source: Environment Agency)

[4] Hand, W.H., Fox, N.I., and Collier, C.G. 2004. A study of twentieth-century extreme rainfall events in the United Kingdom with implications for forecasting. Meteorological Applications, 11, 15-31.

4 Hydrology

This section focuses on Coverack as there was substantially more flooding in this community than in St Keverne and Porthallow, and more information on which to base the assessment.

4.1 Fluvial or direct rainfall flood event?

The flooding in Coverack has been likened to that which occurred in Boscastle in August 2004, which resulted from the river system being unable to cope with the volume of water from the steep upstream catchment. However, there has been some debate as to the extent that flooding in Coverack was due to fluvial sources (the streams) or surface water. The evidence collated as part of this study indicates that both sources played a part in Coverack.

In this type of event it is very difficult, sometimes almost impossible, to separate flooding caused by the two sources. There was no possibility of the small watercourses which drain through Coverack being able to cope with the volume of water which fell in such a short time, therefore it would be incorrect to describe this as just fluvial flooding - surface runoff was also significant.

The volume of rain falling over three hours led to rapid overland runoff above and through the village. Photographs and video footage, supplied by the Environment Agency and sourced from the Internet (for example, YouTube, news websites), show the main road into Coverack (B3294) and Polcoverack Lane becoming flowpaths for the water. The surface water flooding was exacerbated by the streams, ditches and drains being overwhelmed by the amount of water and channels becoming blocked with debris, including large boulders. Some of these boulders were lifted out of the channels by the force of the water, and at 'The Croft' on North Corner Stream the watercourse changed direction causing boulders to rip out the gravity sewer.

Figure 4-1 - Flow route down B3294 (Source: Dick Powell (from BBC website))

Figure 4-2 - Aerial view of northern part of Coverack showing flow routes (Source: BBC website)

Figure 4-3 - Level of flooding at the downstream extent of South Coverack Stream (Source: Frank Gzonka)

4.2 Peak flow estimates

The Environment Agency has undertaken analyses to estimate the peak flow of the South Coverack Stream during the 18th July 2017 event. Topographical survey of the sea wall and reference points from photographs taken during the event were used to estimate water levels. The flow estimate was made at the sea wall; during the flood photographs show that the wall had minimal control on upstream water levels. The wall lies at the toe of a relatively steep upstream slope and a waterfall equation from the International Organisation of Standards[5] was deemed to best represent the hydraulics at the sea wall.

[5] International Organisation of Standards (ISO 3847). 1977. Liquid flow measurement in open channels by weirs and flumes - End depth method for estimation of flow in rectangular channels with a free overfall.

This analysis generated a peak flow estimate of approximately 30m^3/s for the South Coverack Stream. A synthesised hydrograph shape using the ReFH1 model was derived (by the Environment Agency) to confirm that the runoff volume associated with this peak flow is plausible and physically realistic. An estimate of 7m^3/s to 8m^3/s has been made for the North Corner Stream based on an area-weighting of the South Coverack Stream peak flow estimate.

The Environment Agency has produced a diagram which shows the Coverack flood event in relation to the Institution of Civil Engineers (ICE) 'Normal Maximum Flood' and 'Catastrophic Flood' curves. This is shown in Figure 4-4; catchment area is plotted against flow per unit area (m^3/s/km^2) for several flood events, **the 18th July 2017 Coverack flood event is highlighted in yellow**. The coloured lines on the figure show 1% AEP peak flow trends estimated for sub-catchments in Devon. No data for Cornish sub-catchments is included but there are similarities in the hydrology. The 'Catastrophic Flood' curve was developed by the ICE in the early days of reservoir safety as an estimated maximum yield for design of high risk dam spillways, i.e. well beyond normal flood defence standards. The 'Normal Maximum Flood' curve has been superseded by FEH methods but was a design tool before these techniques were available and has some relevance in history. It is the pattern shown by the figure that is most important. This shows increasing yield on small catchments where the storm more fully contributes as a proportion of catchment size and where there is less attenuation of runoff.

The Coverack estimate lies between the two ICE curves, although it is closer to the 'Normal Maximum Flood' curve than the 'Catastrophic Flood' curve; this seems reasonable given the impact of the flood. The magnitude of the Coverack estimate also appears to be in the same 'family' of extreme floods experienced in the south-west (shown by the blue squares) over the last 100 years. Although the Coverack event is rare, extreme rainfalls occur across south-west England with greater frequency than might be assumed from analysing point rainfall totals using the FEH methods. The 'rarity' is related to the spatial element of the event, i.e. that the rainfall was highly localised over the community, leading to the 'impact'. This work has identified that Devon and Cornwall have experienced more than ten 'extreme' events within 100 years.

A concern raised by the Environment Agency is that there appears to be a significant discrepancy between design flow estimates derived for extreme floods (0.1% AEP) using standard methodologies and those derived for the July 2017 Coverack flood event. A flood risk assessment (FRA) produced for a site adjacent to the South Coverack Stream[6] estimated the 0.1% AEP event flow to be between 2.7m^3/s and 3.7m^3/s, using two standard flood flow estimation methods (ReFH2 and FEH Statistical, respectively). A FEH Statistical analysis carried out for the current study gives an estimate of 4.4m^3/s. The Environment Agency has stated that the methods used for estimating extreme flows for planning decisions could therefore potentially underestimate by a factor of ten and that there is an issue in using these techniques to assess flows for small catchments due to underestimation of the risk.

The main issue with the standard flood flow estimation methods is that this type of catchment (small, steep, coastal) tends to be ungauged and is not well represented in the datasets used for the methods. Flow measurement of this type of event will be difficult as a gauge will be overwhelmed / bypassed, will not capture all the flow, and may fail. It is unlikely to be possible to manually gauge the flow due to health and safety issues, the fast response of the catchment, and potentially even reaching the catchment in flood conditions.

Small catchments research is ongoing and new methods are due to be published in late 2017/2018. This may provide some improvement to design peak flow estimates for watercourses such as those draining through Coverack. The FEH Local practitioner guidance[7] also attempts to set out a systematic way of allowing for evidence of recent extreme floods in estimation of flood frequency (Pages 25-28). However, no design event method will represent all eventualities and it should also be borne in mind that there is significant uncertainty in the peak flow estimates derived for the July 2017 Coverack flood event.

6 H2OK. September 2016. Proposed development at Riverside, Polcoverack Lane. Flood risk assessment & HEC-RAS modelling report.

7 Environment Agency. 2017. Using local data to reduce uncertainty in flood frequency estimation. Technical guidance.

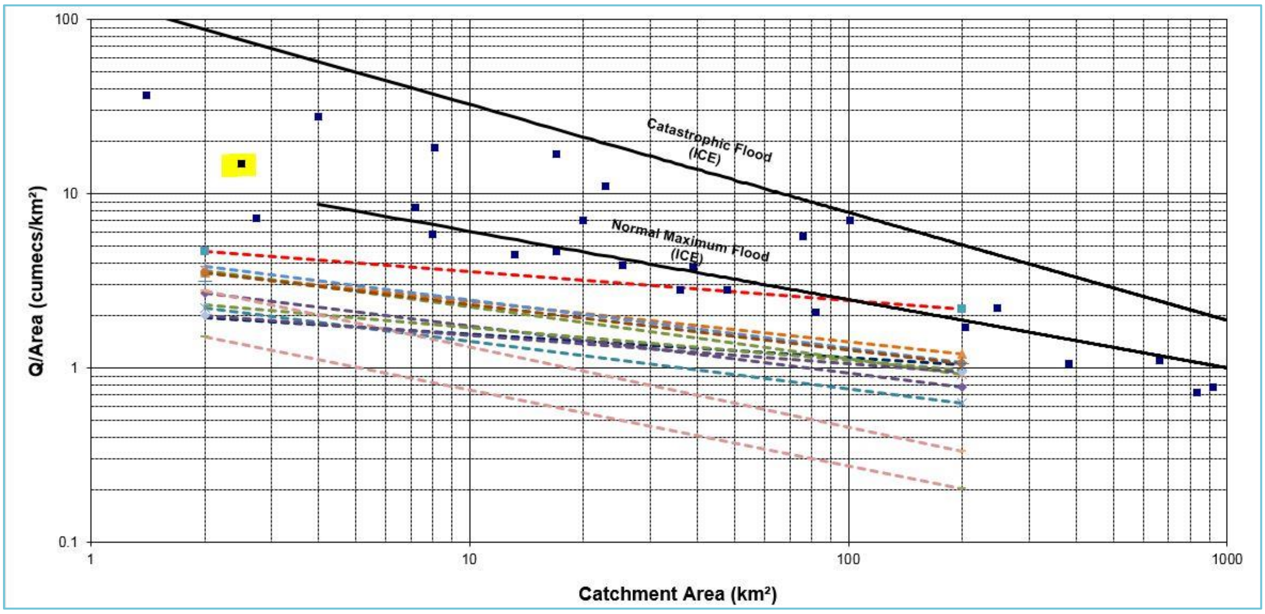

Figure 4-4 - Context for Coverack peak flow estimate (Source: Environment Agency - Tim Hunt)

5 What happened on the ground…?

5.1 Overview

This section looks at the consequences (or impacts) of the event, following on from the description of the storm and the assessment of how extreme it was from a rainfall and flow perspective. The Met Office issued a warning for the whole of southern England for 18th July 2017; it was difficult to accurately forecast where could be affected. The review of the forecast by the Environment Agency Flood Warning Duty Officer (FWDO) on the day of the event indicated that Plymouth looked to be the most likely location for heavy rainfall and any potential proactive response. However, it was decided that the uncertainty was too high to accurately predict where the impact would occur.

The storm moved quickly inland from over the sea, centred on Coverack, and delivered approximately 165-201mm of rainfall in about three hours between 13:30 and 16:30 on 18th July. The extreme nature of the three-hour rainfall total can be demonstrated by putting it into context with the July average rainfall and the Boscastle 2004 event:

- July monthly average rainfall is 60mm - three times the monthly average rainfall fell in only three hours.
- A rainfall depth of 165-201mm across Coverack equates to about 0.5-0.6 million m^3 of water moving through the valley to the sea in three hours.
- The raingauge closest to Boscastle, Lesnewth, following correction for underestimation, recorded 148mm in three hours on 16th August 2004[8]. It is estimated that two million m^3 of rainwater flowed through Boscastle on 16th August 2004[9]; from reports of the event this is likely to have been over a period of five hours.
- Although the Boscastle volume is three to four times larger than the Coverack volume, the catchment draining to Boscastle is about seven times larger than that draining to Coverack.

This volume of water overwhelmed the local drainage networks. There was direct runoff from the catchment leading to considerable erosion of the land, river channels and road network, and pollution from damaged infrastructure, including sewers and domestic oil supplies.

8 HR Wallingford. May 2005. Flooding in Boscastle and North Cornwall, August 2004. Phase 2 Studies Report.

9 Environment Agency. Living with the risk: The floods in Boscastle and North Cornwall 16 August 2004.

Figure 5-1 - Debris on B3294 (Source: Environment Agency)

Figure 5-2 - Damage to B3294 and car park (Source: Environment Agency)

Figure 5-3 - Example of size of material moved by the flood (Source: Environment Agency)

Figure 5-4 - Window washed out of property (Source: Environment Agency)

Figure 5-5 - Damage to driveway caused by North Coverack Stream (Source: Environment Agency)

The risk to life was high due to deep and fast-flowing water carrying large rocks and debris. One property in Coverack was surrounded by fast-flowing water; the elderly couple in the house had to be rescued by the coastguard helicopter. Thankfully, there were no fatalities or serious injuries sustained during the event, however, it occurred during the day and the impacts could have been more serious if it had occurred at night.

Data / information collation and reconnaissance undertaken by the Environment Agency and Cornwall Council has provided details of the number of properties flooded in Coverack, St Keverne and Porthallow during the event. This indicates that internal flooding occurred at 44 properties in Coverack, ten properties in St Keverne, and one property in Porthallow. These numbers do not include buildings such as garages, barn or garden sheds, for example. The property flooding was generally relatively shallow (<50mm deep) but there were several properties where the flooding was more significant (up to 1.5m to 2.0m deep).

In Porthallow prompt clearance of the trashscreen by the Environment Agency, which was blocked by debris, prevented more properties from flooding. Landslips occurred in Coverack and St Keverne. In St Keverne this resulted in the partial closure of Commercial Road. The impact of the landslip in Coverack was more significant, with three properties in the southern part of the village, near Dolor Point, being evacuated and residents unable to return home.

Residents have stated that the rainfall lasted for one-and-a-half to two hours and, when it cleared, a flood of water could be seen coming down the main road into Coverack. In addition to the rain, hail also fell. Residents described hailstones as large as fifty pence pieces falling, breaking small window panes and greenhouses, and shredding leaves on bushes.

5.2 Timeline

An approximate timeline for the event, the forecast and actions prior to it, and the response immediately following it has been generated based on information from a variety of sources (Environment Agency flood reconnaissance, Cornwall Council website, Cornwall Fire and Rescue Service Facebook page, Environment Agency FWDO log book, and the BBC website). The timeline is provided in Table 5-1.

Table 5-1 - Approximate event timeline

Date	Time	Event	Data source & further information
17/07/2017	10:10	Forecast risks of thundery conditions with possible short and intense rainfall on 18/07 PM noted. Low confidence in forecast.	EA Flood Warning Duty Officer (FWDO) Log Book
17/07/2017	11:15	Basic timing information for the storm provided to Cornwall Council Emergency Planning team. Rainfall predicted to start at 13:00 on 18/07. Noted that river levels are low and that there are unlikely to be fluvial issues based on the forecast. Low confidence in the detail of the forecast.	EA FWDO Log Book
17/07/2017	12:20	Still high uncertainty in the current forecast information. Review on 18/07 AM based on latest information.	EA FWDO Log Book
17/07/2017	17:20	Call to Area Base Controller (ABC) to explain general uncertainty in forecast and that "something" could happen. ABC to work from Bodmin on 18/07; discussion to be held AM.	EA FWDO Log Book
17/07/2017	17:40	Call to Flood Incident Duty Office (FIDO) to provide an update on the weather; discussion to be held 18/07 AM.	EA FWDO Log Book
18/07/2017	09:52	Call from Monitoring and Forecasting Duty Officer (MFDO). Rain expected from 13:00. Developing more in channel, further west, high intensities seen but dry atmospheric conditions means that totals may not be seen. Low confidence.	EA FWDO Log Book
18/07/2017	10:50	No change to impacts from 17/07. No heavy rainfall alerts as yet. Low confidence in forecast.	EA FWDO Log Book
18/07/2017	12:15	Call from MFDO. Heavy rainfall alert issued, low confidence. All thresholds. Isolated heavy showers. Heavy rainfall alert in force from 18/07 13:00 to 04:00 19/07.	EA FWDO Log Book
18/07/2017	12:42	Issued Par St Blazey Pilot flood warning at Level 1.	EA FWDO Log Book
18/07/2017	12:43	Issued Mevagissey Pilot flood warning at Level 1.	EA FWDO Log Book
18/07/2017	13:30	Rainfall starts (at Coverack)	Radar rainfall hyetograph
18/07/2017	15:00	Rainfall commences (at Coverack)	Residents observations
		Porthallow flooding commences	EA flood reconnaissance
18/07/2017	15:21	Photograph taken by resident who realised the rainfall was very unusual	Coverack resident

18/07/2017	15:30	15:30 - 16:30 - Storm gathering intensity	Coverack resident
18/07/2017	15:38	Photograph taken of manhole cover lifting with the force of the water	Coverack resident
18/07/2017	15:40	First calls regarding flooding	Cornwall Council
		15:40 - 16:40 - Peak of the storm between these times; hail storm causing bruising to those assisting at Mill Shop	Coverack resident
18/07/2017	15:45	North Corner flooding commences	EA flood reconnaissance
18/07/2017	15:48	First 999 emergency call from Coverack area	Cornwall Fire and Rescue Service Facebook page. In the following 3hr Critical Control received >50 emergency calls from the area. Several were 'life risk' incidents from people trapped by flood water and in immediate danger.
18/07/2017	16:00	St Keverne flooding commences	EA flood reconnaissance
18/07/2017	16:30	Rainfall ceases (at Coverack)	Radar rainfall hyetograph & resident observations
		South Coverack flooding commences	EA flood reconnaissance
		Hail storm	BBC website
18/07/2017	17:00	Sudden surge of water coming down onto the road - speculation that a blockage upstream had been released	Coverack resident
18/07/2017	17:15	North Corner flooding ceases	EA flood reconnaissance
18/07/2017	17:30	Time of peak flooding - South Coverack Stream	EA flood reconnaissance
		Report from Fire & Rescue Service of surface water flooding at Coverack	EA FWDO Log Book
18/07/2017	17:40	Major incident declared	Cornwall Council website
18/07/2017	17:55	Reviewed Hyrad - east Lizard has experienced a period of intense rainfall which is clearing to the north-east	EA FWDO Log Book
18/07/2017	18:00	Porthallow flooding ceases	EA flood reconnaissance
18/07/2017	18:50	Call from Cornwall Council Emergency Planner to explain that the Fire & Rescue Service has declared a major incident at Coverack	EA FWDO Log Book
18/07/2017	19:00	St Keverne flooding ceases	EA flood reconnaissance
		South Coverack flooding ceases	EA flood reconnaissance

6 How common is this for Cornwall?

6.1 Why do these events happen?

The storm which affected Coverack, St Keverne and Porthallow on 18th July 2017 appears to be the most intense rainfall storm event recorded in Cornwall. Met Office records[10] indicate that the upper rainfall value of the range for Coverack has broken the UK rainfall record for the highest three-hour total. The highest three-hour total prior to this was 178mm on 7th October 1960 at Horncastle (Lincolnshire). It must be borne in mind that there is some uncertainty in the Coverack totals, but several different estimates have generated approximately the same values. Therefore, it is probably safe to assume that this is one of the most extreme, if not the most extreme, three-hour rainfall event experienced in the UK.

However, significant and rapidly occurring flooding, such as that which occurred in Coverack particularly, but also in St Keverne and Porthallow, is not uncommon across south-west England. The geography of the area contributes to this - proximity to the sea provides a plentiful source of moisture, winds converge along the coast, and the steep topography generates uplift and orographically enhanced rainfall. This may make Cornwall (and the other south-west counties) more susceptible to flooding from intense local storms.

Cornish coastal areas tend to have small, steep contributing catchments with communities located at the downstream extent, at the coast. This results in many areas potentially being at high risk of flooding from intense rainfall. Climate change may increase the frequency and intensity of coastal storms.

6.2 Other noteworthy events

As discussed in Section 4.2, although the Coverack flood event is rare, there is a history of this type of event occurring across south-west England. The most well-known are those which affected Lynmouth, Devon in August 1952 and Martinstown, Dorset in July 1955, as well as Boscastle in August 2004. Information on these events has been collated from the Internet and various other documents[9, 11]. These events are summarised below.

Lynmouth - August 1952

- 230mm of rainfall in 24 hours.
- Over 100 buildings destroyed and the final death toll reached 34.
- Heavy rainfall associated with a low-pressure area that had formed over the Atlantic Ocean. As it passed the British Isles it manifested as a weather front which caused exceptionally heavy rainfall, the effect of which was intensified because it fell on already saturated ground.
- A wall of water surged down from Exmoor onto Lynmouth

Martinstown - July 1955

- 280mm of rainfall in <24 hours.
- Caused devastating flooding across the area and created a national rainfall record that stood until the Cumbria floods of 2009.
- A volatile weather pattern, called a Spanish plume, brought hot air to the Channel area where it met cooler air. The rainfall was concentrated over an unusually small area and was centred over Martinstown.
- The initial rainfall was absorbed by the Chalk bedrock but the volume of water soon led to surface flow.
- Fast-rising water levels cascaded down the hill from Winterbourne Steepleton to Martinstown, with the road between the two villages becoming a flowpath more than 4m wide.

10 https://www.metoffice.gov.uk/public/weather/climate-extremes/#?tab=climateExtremes
11 Cornwall Council. June 2011. Preliminary Flood Risk Assessment for Cornwall.

Boscastle - August 2004

- 130mm in five hours (12:00-17:00).
- The Met Office had forecast heavy, often torrential downpours developing over the region through the day but were unable to say exactly where these would develop.
- A string of slow-moving thunderstorms caused localised extreme rainfall over north Cornwall. This was extreme in both intensity and duration with up to 200mm of rain falling in 24 hours. However, across north Cornwall, there were wide variations in the rainfall, with extreme amounts in some locations and very little in others. It is estimated that two million m^3 of rainwater flowed through Boscastle on the day.
- About 100 homes and businesses were affected, four properties were destroyed in Boscastle and two in Crackington Haven, 115 vehicles were swept away, and roads, bridges, sewers and other infrastructure were badly damaged. The main channel of the River Valency was widened and deepened; the erosion added a large amount of material to the flow, ranging from silt to large boulders.
- Helicopters rescued about 100 people from rooftops, cars and trees. Swift action by local people and emergency services meant that there were no fatalities.

There are many other examples of this type of event occurring across Cornwall, in addition to the Boscastle 2004 and Coverack 2017 floods. A selection of the most notable and / or recent are described below for context.

Camelford - June 1957

- A severe thunderstorm and heavy rainfall caused flooding in Boscastle, Camelford and Wenford.
- The thunderstorm led to 203mm of rain falling, 140mm of it in two-and-a-half hours and about 70mm in one hour.
- Around 50 properties flooded in Camelford, some bridges were destroyed, but there was no loss of life.
- Hail drifts of up to 0.6m deep were reported.

Helston - June 1993

- Torrential rain caused major flooding.
- At RNAS Culdrose 125mm was recorded in the nine hours to 09:00 as a thundery low moved north from Biscay, with 92mm of this in the two hours to 08:00.

St Austell area - November 1997

- Severe thunderstorms caused flooding.
- An estimated 40mm-85mm of rain fell on saturated ground in 15 minutes.

St Ives - April 2009

- 125mm of rain fell across the Zennor area in the 24 hours of the floods. A resident reported that the torrential downpour began at about 22:30 and lasted until 01:30.
- The worst of the weather was isolated but parts of west Cornwall and the Isles of Scilly experienced half their average monthly rainfall in 12 hours.
- Heavy overnight rain led to flooding in St Ives, where shop owners reported up to 1m of water.
- At Poniou, near Zennor, there were three fatalities when a car was washed off a small bridge.

Cornwall - November 2010

- Widespread flooding across Cornwall following intense rain overnight.
- A deep Atlantic low-pressure system brought a slow-moving weather front from the west of the UK, giving high accumulations over Cornwall. Rainfall associated with the front was particularly intense on the back edge of the rain band, with peak accumulations moving through over a short period of time during the early morning.
- Intense rainfall over steep, wet catchments resulted in rapid surface water runoff, causing significant surface water flows followed by a rapid rise in stream levels.

- Restormel raingauge recorded the most rainfall with 78mm in nine-and-a-half hours; the rainfall was most intense between about 04:45 and 05:15, Heligan raingauge recorded 39mm of rainfall during this time.
- About 350 properties were flooded by rivers, stream and surface water, particularly in some small steep catchments. The worst affected areas were Lostwithiel, Mevagissey, Pentewan, St Blazey and Par Moor; other affected areas included Tregrehan, Portloe, Altarnun and Launceston. There were no reports of serious injury or death.
- Flood reconnaissance showed that there a significant amount of erosion, and transportation of sediment and debris was caused by the rainfall in some localised areas. Where rainfall intensity was greatest, significant quantities of sand, gravel, cobbles, boulders and woody debris were mobilised, which quickly blocked structures, culverts and channels making flooding worse at these locations.

7 Computer modelling

7.1 Introduction

As part of the analysis of the 18th July 2017 flood event in Coverack, St Keverne and Porthallow a basic surface water model of the catchments was developed. The aim of this modelling was to identify how well this model represents what was seen on the ground during the event and to provide an understanding of how the catchment might respond during extreme rainfall events. The idea was to see if a model providing only a basic representation of the catchment (no channel or topographic survey, or building thresholds), but which is quick and cost-effective to develop, could be useful.

7.2 Model overview

A 2D direct rainfall model, with a model domain covering all three catchments, was developed using the InfoWorks-ICM modelling package. This is an industry-standard software package which has been widely used for direct rainfall modelling.

The hydraulic model uses a digital terrain model (DTM) to represent the ground surface. Light Detection and Ranging (LiDAR) data did not cover the whole study area therefore a lower resolution DTM was used. The Integrated Height Model (IHM) dataset (2014) is the best quality full coverage DTM available to the Environment Agency and was used for this study. The data is 5m resolution rescaled to 2m resolution for the entire study area. Checks were made to the DTM to identify any filtering issues. Ordnance Survey (OS) MasterMap data was used in the model to apply hydraulic roughness and infiltration parameters to the ground surface and to create building footprints.

A direct rainfall model was used to account for flows in the study area. Observed rainfall events and design rainfall events were run through the model; rainfall hyetographs are applied directly to the ground model across the study area. Observed rainfall hyetographs were sourced from the Goonhilly TBR for a selection of storm events, focusing on high intensity and high depth storms; 16 observed events were run through the model in addition to the hyetograph generated by the Environment Agency for the 18th July 2017 event. Four design rainfall events have been modelled - 50%, 3.33%, 1% and 0.1% AEP, using both summer and winter storm profiles. Hyetographs are automatically generated within the InfoWorks-ICM software, using catchment rainfall parameters from the FEH CD-ROM; losses are applied using the ReFH1 model. The hyetographs generated by the software were reviewed and appear to generate sensible rainfall intensities for all events.

7.3 Model schematisation

Buildings, roads and structures can offer significant constraints to, or create preferential, flow routes for overland flow and it is important to ensure that they are effectively represented in the model to improve flood routing.

Although channel and topographic survey were not available to improve representation of the channel and structures within the model, dimensions were approximated from site observations. It should be noted that these are predominantly very coarse estimates. Structures have been included in the model using 1D structure units, which are part of the InfoWorks-ICM software. The channel is represented using mesh polygons.

Buildings and roads have been exported from MasterMap data and imported into the model. No detailed property level threshold information is available; threshold levels have been raised 150mm above the maximum level in the DTM beneath the building footprint, to represent the typical raising of property thresholds above surrounding ground levels.

A proportion of the rainfall will be 'lost' through infiltration into the soil and groundwater. Fixed runoff coefficients of 28% and 18% were selected for winter and summer storms, respectively, based on checks against ReFH1 flow estimates. Runoff from roads and roofs was set to 90%; runoff from water bodies was set to 100%.

7.4 Model uncertainty

Although the model is considered to give the best possible representation of flood risk to Coverack, St Keverne and Porthallow with the data available, there are some notable uncertainties which could affect the modelled prediction of flood risk, and hence estimates of flood damages and the number of properties at risk of flooding. A more detailed modelling study would be required to address these points. These uncertainties are discussed below:

- **DTM** - LiDAR was not available for the entire study area and a lower resolution DTM was used.
- **Channel and structure survey** - Not available for the study area. All channel geometry is derived from the DTM; this will not accurately represent detailed topography. During a site visit limited structure information was collected for Coverack, including the shape and rough dimensions of culverts. Invert levels were not collected and were set to the ground model. There are limitations to using a 2D model, notably the difficulty in accurately representing channel flow capacity, which is determined by the accuracy of the ground model. Building a 1D-2D model using channel and structure survey would improve the accuracy of the model results, rather than using mesh zones for the channel.
- **Missing detail in the model** - For example, walls, where these may constrain flows.
- **Model resolution** - The model is showing more flooding for the 50% AEP event than may be expected. This could be due to the resolution represented in the model. Producing a smaller model covering one catchment, rather than all three in one model, would improve representation of features in the model as a smaller mesh size could be used. However, the purpose of this analysis is to look at extreme events where this may be less of an issue.
- **Runoff** - A fixed runoff percentage has been used in the model. This assumes that throughout the storm there is a fixed proportion of rainfall infiltrating into the ground and running off surfaces. In reality, the runoff rate will vary throughout a storm as the soil surface becomes saturated. The use of a fixed runoff rate is, however, considered appropriate for this model as there is no data available to produce a runoff model of the ground surface. In addition, the storm event is very short which means that surfaces are likely to quickly become saturated, with runoff remaining fairly constant after this point.
- **Velocities** - It is not possible to accurately predict velocities with the data available.
- **Resolution of rainfall** - The resolution of the rainfall hyetograph for the observed events is coarse (15-minute interval) which means that conditions may not be accurately represented.
- **Sewerage system** - The sewer system is not modelled so losses to sewers are not accounted for in the model. However, in extreme events this is likely to be less important as sewers become surcharged.
- **Channel geometry changes** - The model represents the channel geometry prior to the 18th July 2017 event. An assessment has not been made of the catchment response to the same rainfall event with the changes to the channel geometry which are known to have occurred. This would require survey of the current channel geometry.

7.5 Results

Note: The figures provided in this section show indicative flow routes produced by the catchment surface water model based on limited data. This information is not suitable for use outside of this study.

Discussion of the model results is focused on Coverack where the most significant flooding occurred and there is the most anecdotal information regarding the extent and depth of flooding. Figure 7-1 shows the modelled flood extent and depths for the 18th July 2017 event. A rainfall hyetograph derived by the Environment Agency from the radar rainfall data has been used as an indicative input to the model for the event. The model shows extensive flooding across the northern part of Coverack but with much of this being relatively shallow (<100mm). This accords with the Environment Agency flood reconnaissance map for this area which generally shows property flooding of <50mm. It is noted that the model results do not show the surface water flow path down the track from 'Medical Care' on the map or flooding of a property in this location (<50mm). The flooding predicted by the model around the properties along the track to the west, just up the main road from Tregiskey Lane, generally looks reasonable based on observations from a site visit.

The flood extents and depths predicted by the model also look reasonable for the southern part of Coverack with affected properties roughly matching those on the Environment Agency flood reconnaissance map. Flood depths are generally reasonable but are potentially underestimated in some locations. This is a limitation of the data available for developing the model. The model also does not show the surface water flooding down Polcoverack Lane, which is noted on the reconnaissance map.

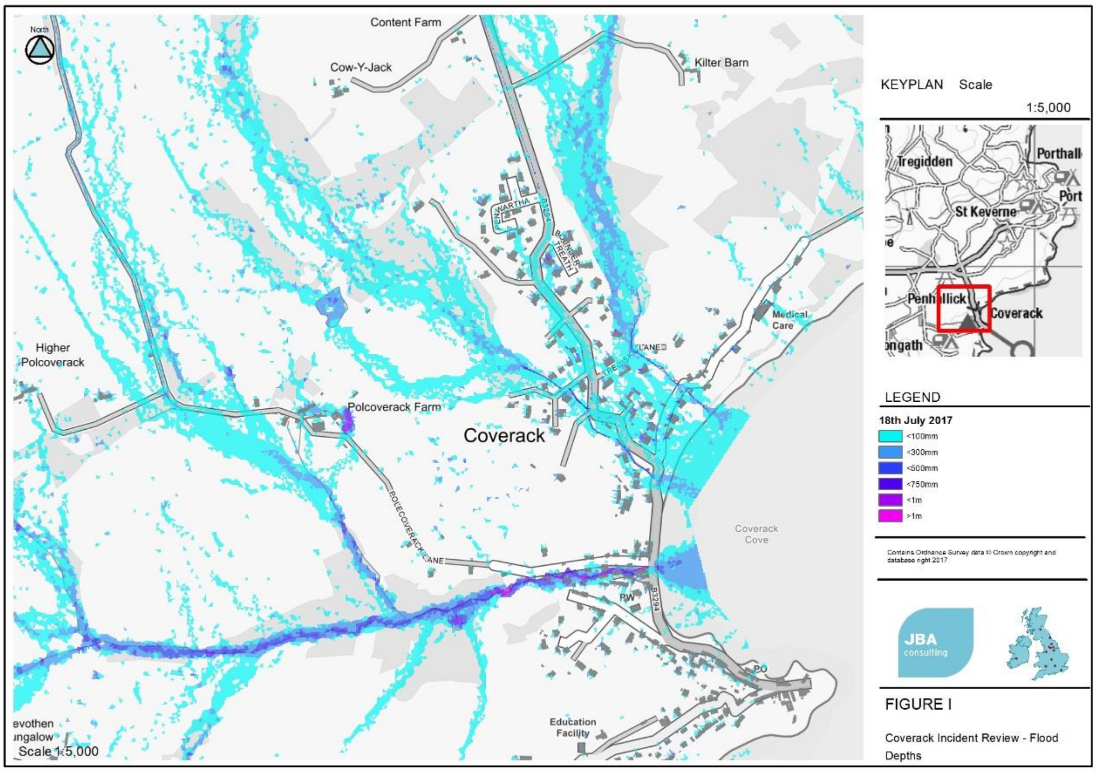

Figure 7-1 - Modelled 18th July 2017 event flood extent and depths

When taking into consideration the limited data available for developing the model it is believed that the model represents flood extents well and generally provides a reasonable representation of the flood depths, although it is not possible to predict velocities well with the data available. With a little more detailed information to input to the model, it is likely that results could be further improved.

To provide an indication of the rarity of the 18th July 2017 event, it has been compared to the 1% and 0.1% AEP design events, as examples of extreme events, as shown in Figure 7-2. The storm duration used for the design events was three hours, which was found to be critical for the catchment and approximates the July event duration. A summer storm profile was used to match the seasonality of the July event.

The figure shows that the 18th July 2017 event predicted flood extent is slightly larger than the 0.1% AEP event extent. Although this is perhaps a lower frequency than expected, it is thought to be reasonable when taking into consideration the extremity of the event and the limitations / uncertainties associated with the model schematisation, design hyetographs and event hyetograph. The hyetographs for the two events are shown in Figure 7-3.

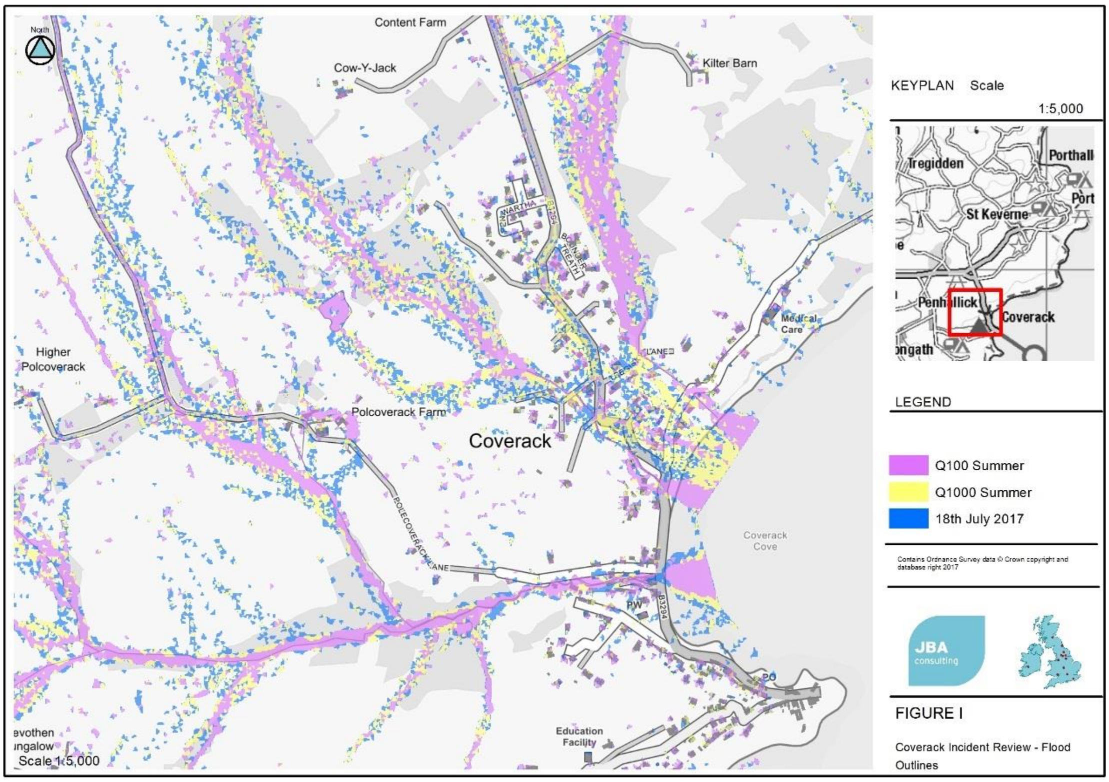

Figure 7-2 - 18th July 2017 event results and extreme design event results

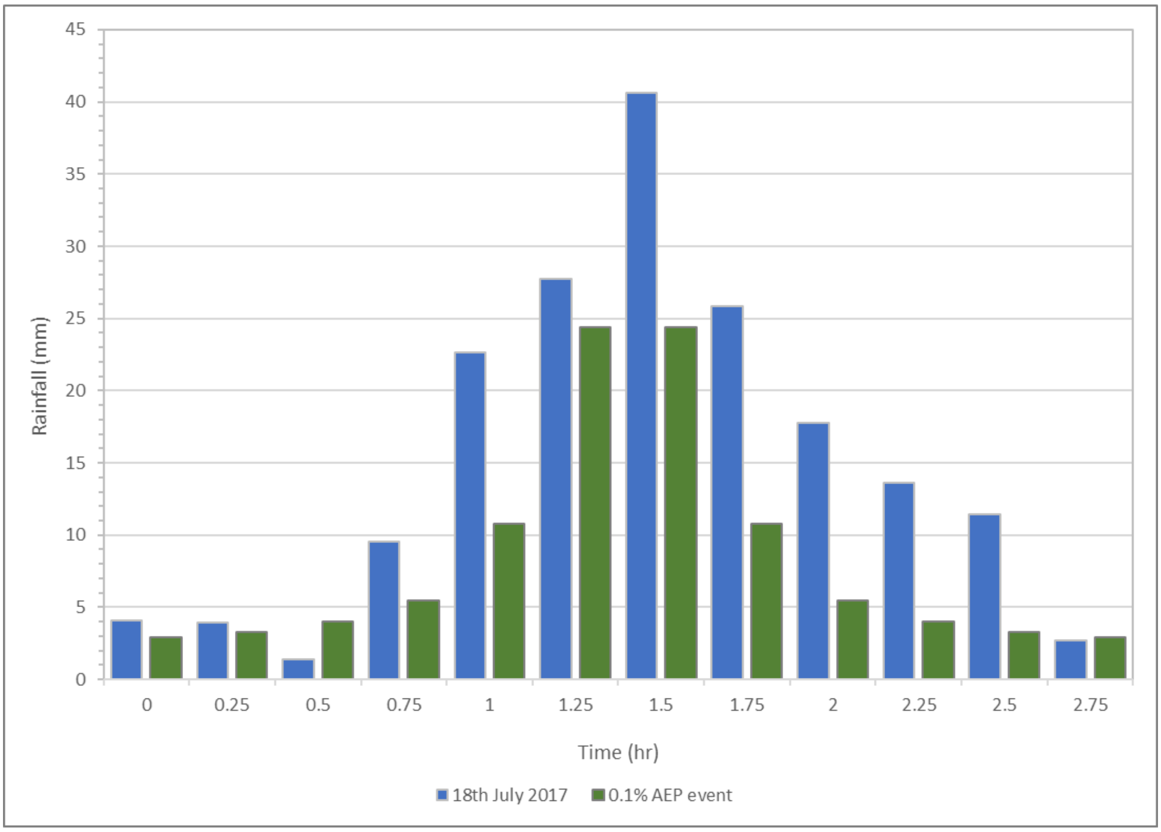

Figure 7-3 - 18th July 2017 and 0.1% AEP event hyetographs

The 18th July 2017 event predicted flood outline has also been plotted with two other rainfall events selected from the 16 extracted from the Goonhilly TBR data and run through the model - 17th August 2016 and 5th August 2013 - to give an idea of how 18th July 2017 compares to other significant rainfall events over the local area. The two events selected are also 'high intensity' events - 17th August 2016 recorded 21.4mm in one-and-a half hours, with 20.4mm of that falling over three-quarters of an hour, and 5th August 2013 recorded 31.6mm in two hours, with 24.4mm of that falling over three-quarters of an hour.

Figure 7-4 shows the flood extents predicted by the model for the three events. This shows how much more significant the flooding was for the 18th July 2017 event, particularly in the northern part of Coverack. It also accords with the understanding that although flooding has been experienced in Coverack before, nothing like the 18th July 2017 impact has been seen before.

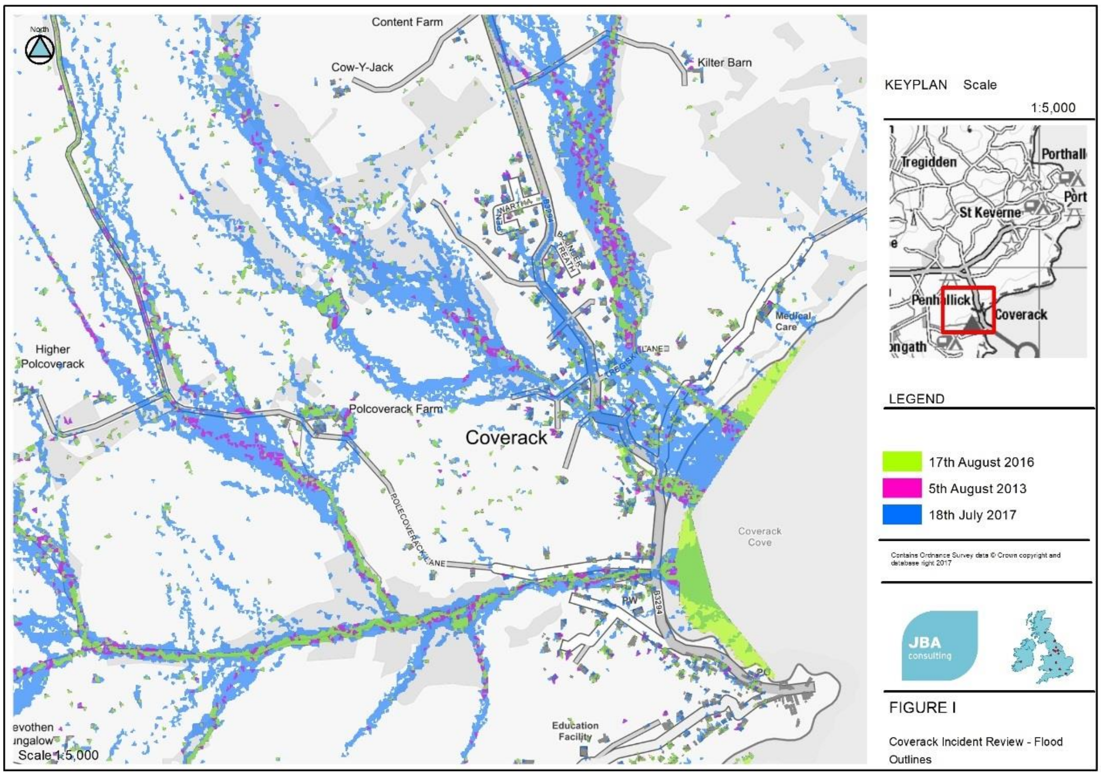

Figure 7-4 - 18th July 2017 event results v other significant rainfall events

8 Conclusions

8.1 Summary

Analysis of the storm which caused flooding in Coverack (and St Keverne and Porthallow) on 18th July 2017 has shown that this type of event is not uncommon for Cornish catchments. The extreme nature of the event, and its rarity, was due to the storm centring over Coverack and stalling, leading to the rain falling over a small geographical area. From the evidence in Section 6.2 no other storm event in Cornwall has been more extreme than that experienced by Coverack in July 2017, due to a localised event being concentrated over a very small area. Comparing the Coverack event to the well-documented Boscastle August 2004 event helps to put it in context.

8.2 Conclusions

It is difficult, if not impossible, to prevent flooding occurring during this type of extreme event. The large volume of water falling in a short space of time will overwhelm any drainage system (natural or manmade) and any flood mitigation interventions. About half a million m^3 of water fell over Coverack and would need to be managed. This is a huge volume to be managed within a short, steep-sided valley and, given the nature of these storms, the next time the rainfall may affect an adjacent catchment.

The surface water modelling undertaken for this study has shown that, even with limited information, it is possible to obtain a reasonable prediction of flow routes, flood extent, and flood depth, to provide an indication of flooding mechanisms and potential high-risk areas for such extreme and rare events. The benefit that this modelling provides over the national Risk of Flooding from Surface Water (RoFfSW) modelling and mapping is that it models the specific storm event which led to the flood event in Coverack; this is not represented by the national modelling and mapping.

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