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February 2020 Floods in Wales: Flood Event Data Summary

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Executive summary

Overview

This is a factual report providing a concise reference of what happened during the storm events of February 2020. It will also help inform the recovery and review work related to these events and can be a source of information for flood risk management in Wales.

During February 2020, Wales experienced several noteworthy rainfall events on the back of a very wet autumn and winter period. The named storms, Ciara, Dennis and Jorge, affected Wales within a period of just four weeks, with record rainfall and river flows causing some of the most significant flooding impacts in Wales since the 1970's.

February 2020 was the wettest February on record in Wales and the UK as well as the fifth wettest month ever recorded. The Vyrnwy rain gauge in Powys saw 515mm of rainfall in February, making it the wettest February for that area since records began in 1908, while Bala in Gwynedd, recorded four times (407%) the long-term average rainfall for February.

Rainfall in the catchment areas of Wales during these events was of such intensity that many rivers reacted extremely quickly, reaching record levels and flows. Notably, catchments were already saturated from the previous months of near continuous rain.

Storm Ciara

Storm Ciara impacted the catchments of North Wales most severely.

Betws y Coed gauge in the Conwy catchment received 79.2mm of rainfall in 15 hours, the equivalent to 73% of an entire month's rainfall. Also in the Conwy catchment, Llanrwst gauge received 100.2mm of rainfall in 16 hours, equating to 76% of an entire month's rainfall.

The River Elwy at Pont Y Gwyddel reached its highest level since the start of records in 1974. It's estimated that the Elwy at this location was flowing at 220 cubic metres (or tonnes) of water per second (m^3/s).

Storm Dennis

Storm Dennis resulted in substantial and intense rainfall with significant impacts on river flows, river levels and flooding in South Wales.

Nant yr Ysfa gauge, situated between the Cynon and Rhondda Fach catchments, received 130.4mm of rainfall in 24 hours, the equivalent to 72% of an entire month's rainfall in a single day. At the top of the Rhondda Fawr catchment, Tyn Y Waun gauge received 132.4 mm of rainfall in 24 hours, this equates to 62% of a month's rainfall in a single day.

In Pontypridd, the River Taff reached its highest level since records began in 1968. Peak flow passing through Pontypridd was estimated at 805 m^3/s , enough to fill an Olympic size swimming pool in just over three seconds. This river level is 78cm higher than the previous record-level set during the 1979 floods.

Flood Warnings

February 2020 became the busiest month on record for issuing Flood Warnings in Wales; 243 Flood Alerts, 181 Flood Warnings and six Severe Flood Warnings were issued. These reached 55,784 individuals, helping people to prepare and take action to save themselves and protect their property. However, due to the intense nature of events, a small number of flood warnings were issued late, or not at all. On the Lower Taff and the River Teifi, three communities in each location had late warnings, whilst 11 locations on the River Rhymney and one on the River Towy received none at all. The reasons behind this are being assessed and will then need to be addressed accordingly.

Property Flooding

A total of 3,130 properties were flooded during February 2020 in Wales. These included 224 properties flooded during Storm Ciara, 2,765 properties during Storm Dennis, and 141 during Storm Jorge. Of these, an estimated 2,527 were households, with average claims data from the insurance industry valuing around £81 million of flood damage.

During Storm Ciara, the River Elwy in St Asaph experienced higher river levels than those which caused extensive flooding in 2012. The newly constructed NRW flood alleviation scheme, however, worked well and protected the vast majority of the community.

Similarly, during Storm Dennis many rivers were at historically high levels, exceeding the 1979 levels which caused extensive flooding and damage across South Wales and in particular Cardiff. However, although significant flooding still occurred, it is estimated that NRW defences across South Wales protected over 19,000 properties.

NRW defences overtopped in a number of locations and some properties behind them did flood, in some instances properties were flooded from other or a combination of flood sources. Importantly NRW defences did not structurally fail. Whilst our defences are built to provide industry-standard levels of protection, the expected impacts of climate change require us to re-assess these standards. However, this must be in line with other considerations such as the consequences of building ever higher defences, given the visual impact of bigger walls in communities, and the greater concerns should they fail. Indeed, higher defences in many cases may simply push the problem downstream to the next community.

Media Coverage

Storms Ciara and Dennis generated 499 articles in a wide range of media outlets which were supported by NRW communications. These included coverage in almost all of the major print and online news outlets - some of this coverage even extended globally, reaching news outlets in the USA. There were 42 media interviews given by NRW staff which appeared multiple times across Welsh and UK broadcast outlets. It is estimated that NRW reached 5.7 million people through its social media channels on Twitter and Facebook. However, we did experience some problems with our website during periods of peak demand, which again will need to be addressed.

Conclusion

The facts contained in this report highlight that the last 10 years, and this winter in particular, were record breaking in many geographic areas for rainfall totals, intensity, river levels and flows. The consensus from climate change scientists is that extreme weather events, such as the storms that hit Wales in February, are becoming more frequent. Climate change is increasingly impacting the way we live and work around rivers, catchments and the coast, and the way we manage water. Therefore, we need to understand how to adapt the way we live and work in these locations.

Many of our structures and systems worked well, protecting large numbers of communities and properties. However, the scale of these weather events was such that some flooding was unavoidable; significant flooding still occurred, resulting in trauma and considerable long-term impacts on individuals, businesses, families and communities.

NRW is therefore undertaking extensive work, including detailed flood investigations at a local scale, to understand where there are opportunities to further improve our infrastructure and systems in order to reduce the impact of future weather events. We will continue to invest in people, technology, infrastructure, systems and processes to undertake our flood risk management role.

The scale of these events also serves to highlight the increasing levels of risk associated with the climate emergency. Managing this challenge to mitigate and adapt to climate change will require effective policy, availability of sufficient resources and active prioritisation of those resources for maximum benefit. Most importantly we all have to work together, operating across the responder organisations and with the local communities themselves to plan for and manage future events

Introduction

This report contains a national overview of the extent, scale and impacts of the flood events which impacted Wales throughout February 2020. Its purpose is to act as a reference document, capturing the key facts and data available from this significant period of intense wet weather, which led to some of the largest flood impacts Wales has experienced since 1979. It will inform 'lessons learnt' reviews and recommendations for change.

The consensus from climate change scientists is that we can expect more extreme weather events in the future. This prompts some significant challenges for communities, decision-makers and society as a whole in terms of how we respond to such events. Whilst this report focuses on the facts from the February 2020 storms in Wales, it sits in the wider context of the global Climate Emergency and the need for climate change adaptation, mitigation and improved community resilience.

During February 2020, Wales experienced four noteworthy rainfall events, on the back of a very wet winter period. Three of these storms fell under the naming convention introduced by the Met Office and its European counterparts:

- Storm Ciara – 8 – 9 February 2020
- Storm Dennis – 15 – 17 February 2020
- Unnamed Storm – 21 – 24 February 2020
- Storm Jorge – 28 February – 1 March 2020

This report focusses on Storms Ciara and Dennis as the two most significant events of the month due to their relative impacts. Storm Ciara was the third named storm of the 2019/2020 period, with weather warnings issued by the Met Office for both strong winds and heavy rain. The main impacts from Storm Ciara were in North Wales, with severe flooding inland and on the coast.

A week after Storm Ciara, Storm Dennis brought heavy and persistent rain across much of Wales, with the South Wales Valleys, Brecon Beacons and Usk Valley particularly impacted. The Met Office issued a red warning for rain across parts of South Wales with some areas receiving more than 130mm of rain falling onto saturated ground, leading to major and widespread flooding.

The flooding impacts from these storms had substantial and, in many cases, long-lived impacts on individuals, communities and businesses. The exceptional rainfall and challenging conditions also stretched the organisations involved. However, the efforts of the affected communities and the responder organisations throughout was huge and should be acknowledged.

Whilst over 3,000 properties did unfortunately flood across Wales, a significant number were protected by NRW flood defences. The flood warnings sent out to individuals across Wales helped many people to protect themselves, their families and their properties, as well as assist partner organisations with their response.

As with the nature of any analysis of post-event data and information, this report contains the best information currently available to NRW. Some statistics and figures may change, in time, as further detailed analysis is undertaken and local flood investigations are progressed.

Environmental conditions

Rainfall

The winter of 2019/20 was persistently wet. Analysis undertaken by the Met Office¹ shows that this winter was the fifth wettest on record since records began in 1862. A strong jet stream sitting further south than normal brought a succession of weather systems across the Atlantic, impacting many areas across the UK.

February 2020 was the wettest February on record according to the Met Office, as well as being the fifth wettest of all months since records began. Records show Wales received 288mm of rainfall during February with some areas receiving three and a half to four times the long-term monthly average, as shown in Figure 1 below.

Wettest months on record
1. October 1903
2. December 2015
3. November 2009
4. December 1929
5. February 2020

Table 1 – Met Office records of wettest months in the UK since records began in 1862
Source: Met Office¹

Significant rainfall totals were reached over the entire month, but crucially some considerable rainfall amounts were recorded in extremely short periods of time. This intensity of rain falling on already saturated catchments, combined with the rapidly responding nature of the river catchments in Wales, led to some of the most extensive flooding in a generation.

For example, the Vyrnwy rain gauge in Powys recorded 515mm of rainfall in February making it the wettest February, and 2nd wettest 30-day period, for that area since records began in 1908. The rain gauge at Bala in Gwynedd recorded more than four times the long-term average (LTA) rainfall for February (407%).

¹ Met Office 2020, *Record Breaking Rainfall*, viewed June 2020, < <https://www.metoffice.gov.uk/about-us/press-office/news/weather-and-climate/2020/2020-winter-february-stats> >

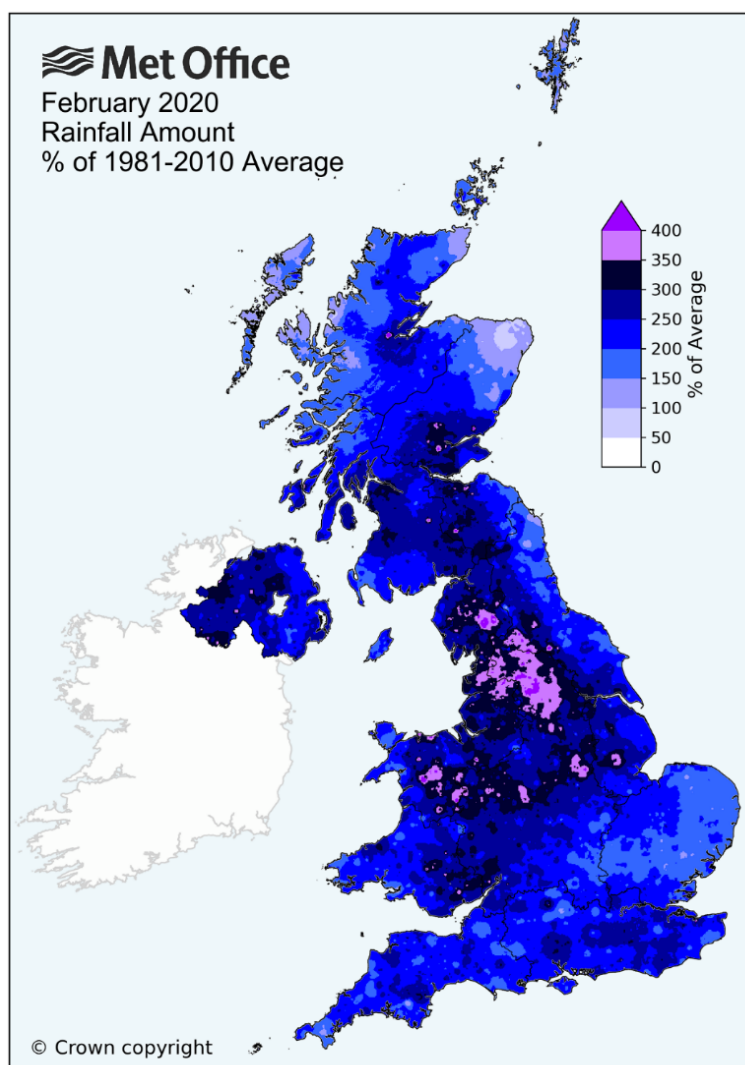


Figure 1 – February 2020 Rainfall Amounts as a percentage of the long-term average
 Source: Met Office

During Storm Ciara:

- **Betws y Coed** gauge in the Conwy catchment received 79.2mm of rainfall in 15 hours, the equivalent to 73% to an entire month's rainfall²
- **Brynhyfryd** gauge in the Clwyd catchment received 38.4mm of rainfall in 15 hours, equivalent to 72% of an entire month's rainfall²
- **Alwen** gauge in the Dee catchment received 67mm of rainfall in 15 hours, equivalent to 68% of an entire month's rainfall²
- **Llanrwst** gauge in the Conwy catchment received 100.2mm of rainfall in 16 hours, equivalent to 76% of an entire month's rainfall²
- **Plas Pigot** gauge in the Conwy catchment received 57.6mm of rainfall in 16 hours, equivalent to 76% of an entire month's rainfall²
- **Brynhyfryd, Alwen and Betws y Coed** gauges received the average of a typical entire month's rainfall in just the first 10 days of February²

² Based on the Long-Term Average (LTA) for February as provided by the Met Office, using the period 1981-2010

Rain gauge	Catchment	Local Authority	Time Period (hours)	Rainfall within duration (mm)	% of Feb LTA rainfall (1981-10)
Cwm Dyli	Glaslyn	Gwynedd	12	117.6	53
Llanrwst	Conwy	Conwy	16	100.2	76
Hafod Wydr	Glaslyn	Gwynedd	16	90.7	53
Betws y Coed	Conwy	Conwy	15	79.2	73
Gwytherin	Elwy	Conwy	14	74.2	64
Alwen	Dee	Conwy	15	67	68
Pant Gwyn	Dee	Gwynedd	17	63.6	25
Ysbyty Ifan	Conwy	Conwy	16	58.6	37
Plas Pigot	Elwy	Conwy	16	57.6	76
Clawddnewydd	Clwyd	Denbighshire	16	50.6	61
Brynhyfryd	Clwyd	Denbighshire	15	38.4	72

Table 2 – Rainfall data recorded on NRW’s Hydrometric Network during Storm Ciara

During Storm Dennis:

- **Tyn Y Waun** gauge at the top of the Rhondda Fawr catchment received 132.4mm of rainfall in 24 hours, the equivalent of 62% of an entire month’s rainfall in a single day²
- **Nant yr Ysfa** gauge situated between the Cynon and Rhondda Fach catchments received 130.4mm of rainfall in 24 hours, the equivalent of 72% of an entire month’s rainfall in a single day²
- **Carno** gauge in the Usk Catchment received the equivalent of half a month’s rainfall in 12 hours - 68mm of rain - and the equivalent of an entire month’s rainfall in 36 hours - 128 mm of rain²
- **Crai** gauge in the Usk Catchment received the equivalent of half a month’s rainfall in 12 hours - 87mm of rain - and the equivalent of 85% of an entire month’s rainfall in 72 hours - 170mm of rain²
- **Tafalog** gauge in the Wye Catchment received the equivalent of half a month’s rainfall in 18 hours - 60mm of rain - and the equivalent of 85% of an entire month’s rainfall in 72 hours - 88mm of rain²

Rain gauge	Catchment	Local Authority	Time period (hours)	Rainfall within duration (mm)	% of Feb LTA rainfall (1981-10)
Crai	Usk	Powys	24	136.6	69
Tyn Y Waun	Taff	RCT	24	132.4	62
Nant yr Ysfa	Taff	RCT	24	130.4	72
Hirwaun	Tawe	RCT	24	119.8	75
Croeserw	Afan	Neath Port Talbot	48	117.2	n/a
Storey Arms	Usk	Powys	24	116.6	63
Carno	Usk	Blaenau Gwent	24	115	89
Ystradfellte	Tawe	Powys	24	111.4	62
Cwmtillery	Usk	Blaenau Gwent	24	108.2	95
Ponsticill	Taff	Merthyr Tydfil	24	103.8	73
Ciloerwynt	Wye	Powys	24	78	51
Tafalog	Wye	Monmouthshire	24	74.2	73
Bleddfa	Wye	Powys	36	73.6	78
Gowerton	Loughor	Swansea	24	71	73
Abernant	Wye	Powys	24	69.4	53
Machen Waterloo	Rhymney	Caerphilly	24	67.4	65
Pant Mawr	Wye	Powys	24	66.8	32
Upper Lliw	Loughor	Swansea	24	65.2	53
Bwlch y Sanau	Wye	Powys	24	51	61

Table 3 – Rainfall data recorded on NRW’s Hydrometric Network during Storm Dennis

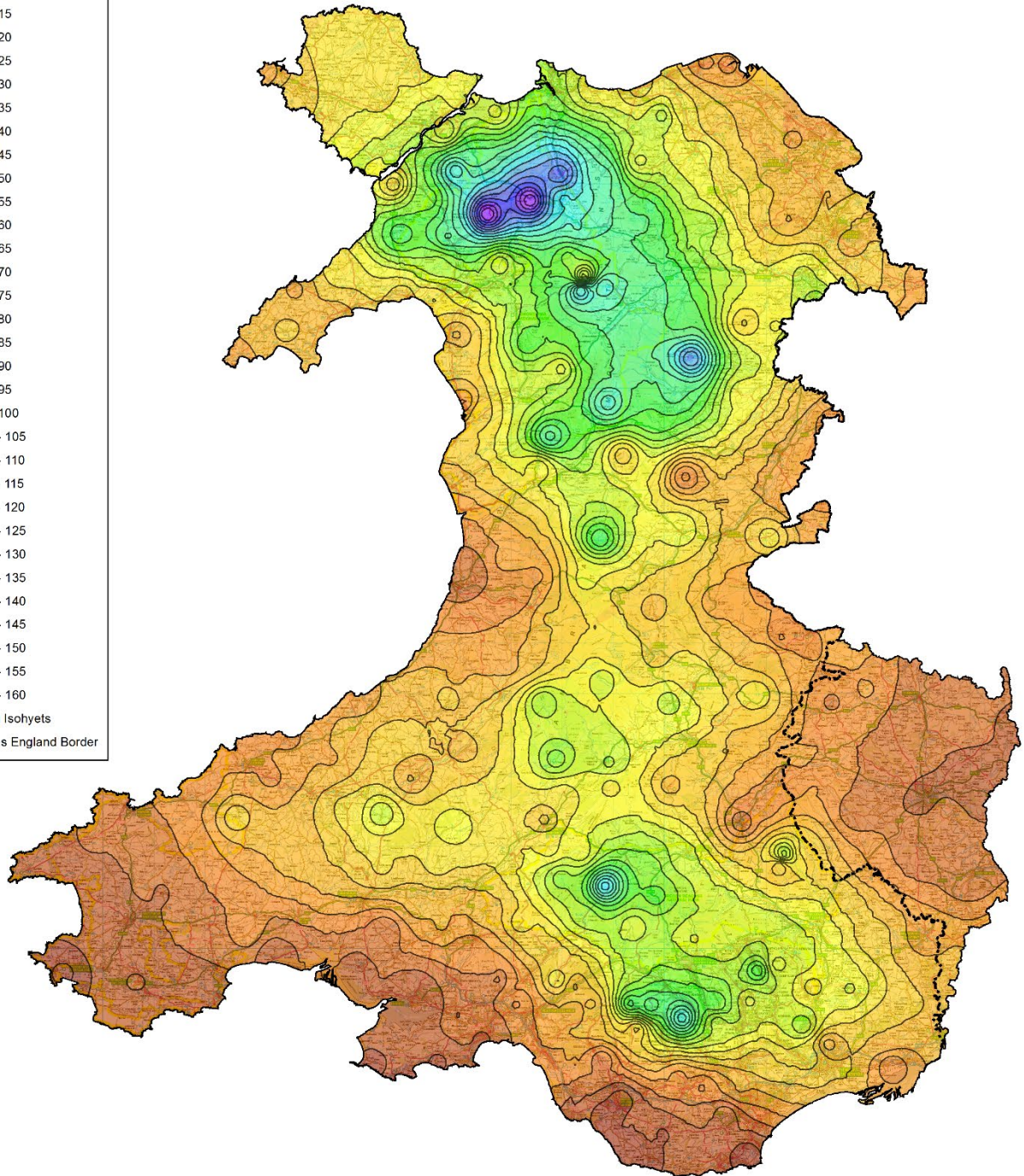
Figures 2, 3, 4 and 5 below illustrate the distribution of rainfall during Storm Ciara and Storm Dennis, highlighting the significant rainfall totals within a 48-hour period in areas of Wales. Storm Ciara led to heavy rainfall over Snowdonia and particularly the headwaters of the River Conwy. Storm Dennis produced extreme rainfall across the top of the South Wales Valleys and Brecon Beacons with a particular focus on the River Rhondda Catchment and high up within the River Usk Catchment.



Legend

Rainfall depth (mm)

- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60
- 60 - 65
- 65 - 70
- 70 - 75
- 75 - 80
- 80 - 85
- 85 - 90
- 90 - 95
- 95 - 100
- 100 - 105
- 105 - 110
- 110 - 115
- 115 - 120
- 120 - 125
- 125 - 130
- 130 - 135
- 135 - 140
- 140 - 145
- 145 - 150
- 150 - 155
- 155 - 160
- 5mm Isohyets
- Wales England Border



0 2.5 5 10 15 20 Miles

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Figure 2 – Rainfall Isohyet Map showing rainfall over a 48-hour period during Storm Ciara

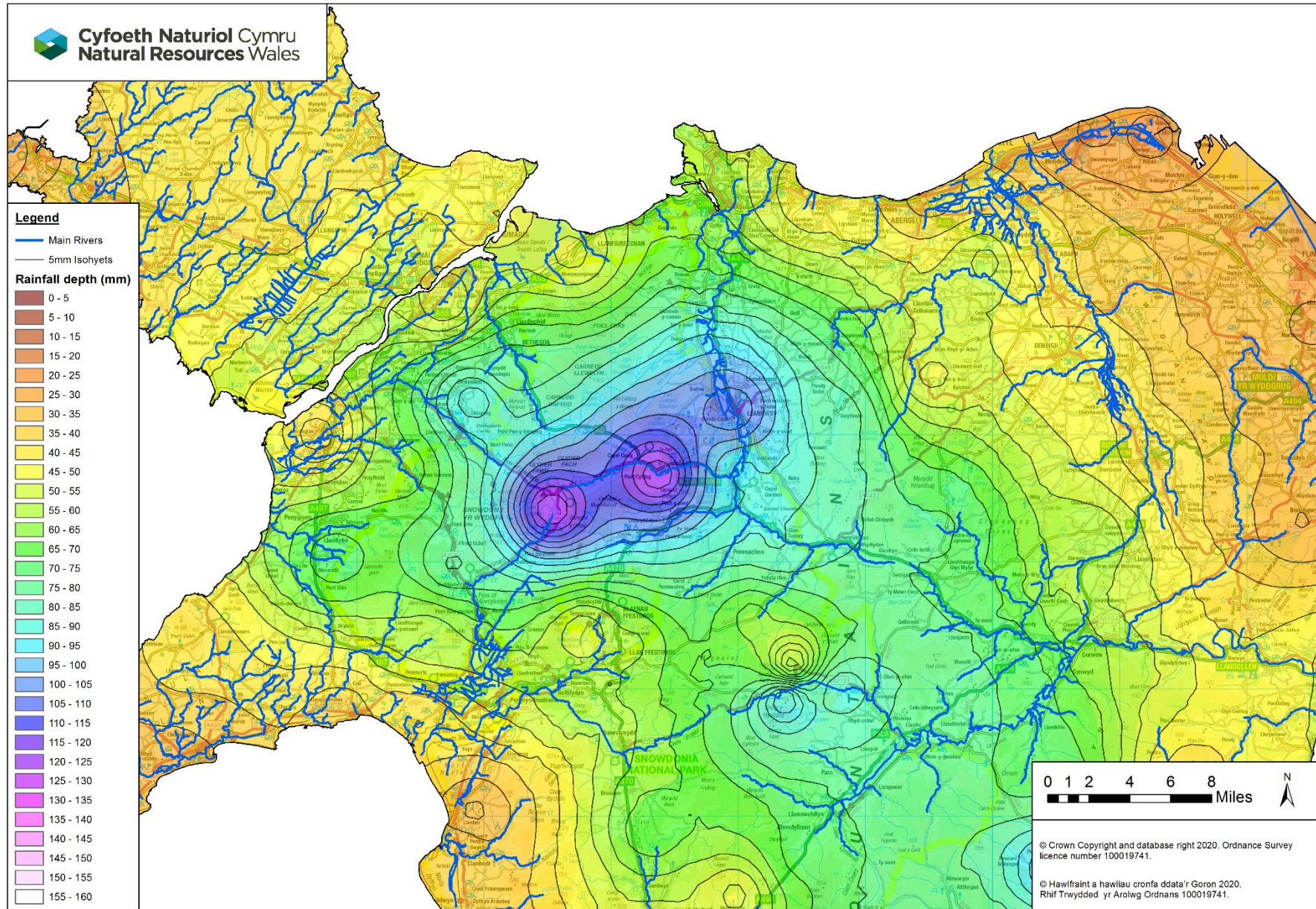


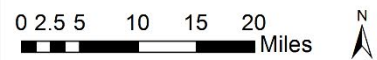
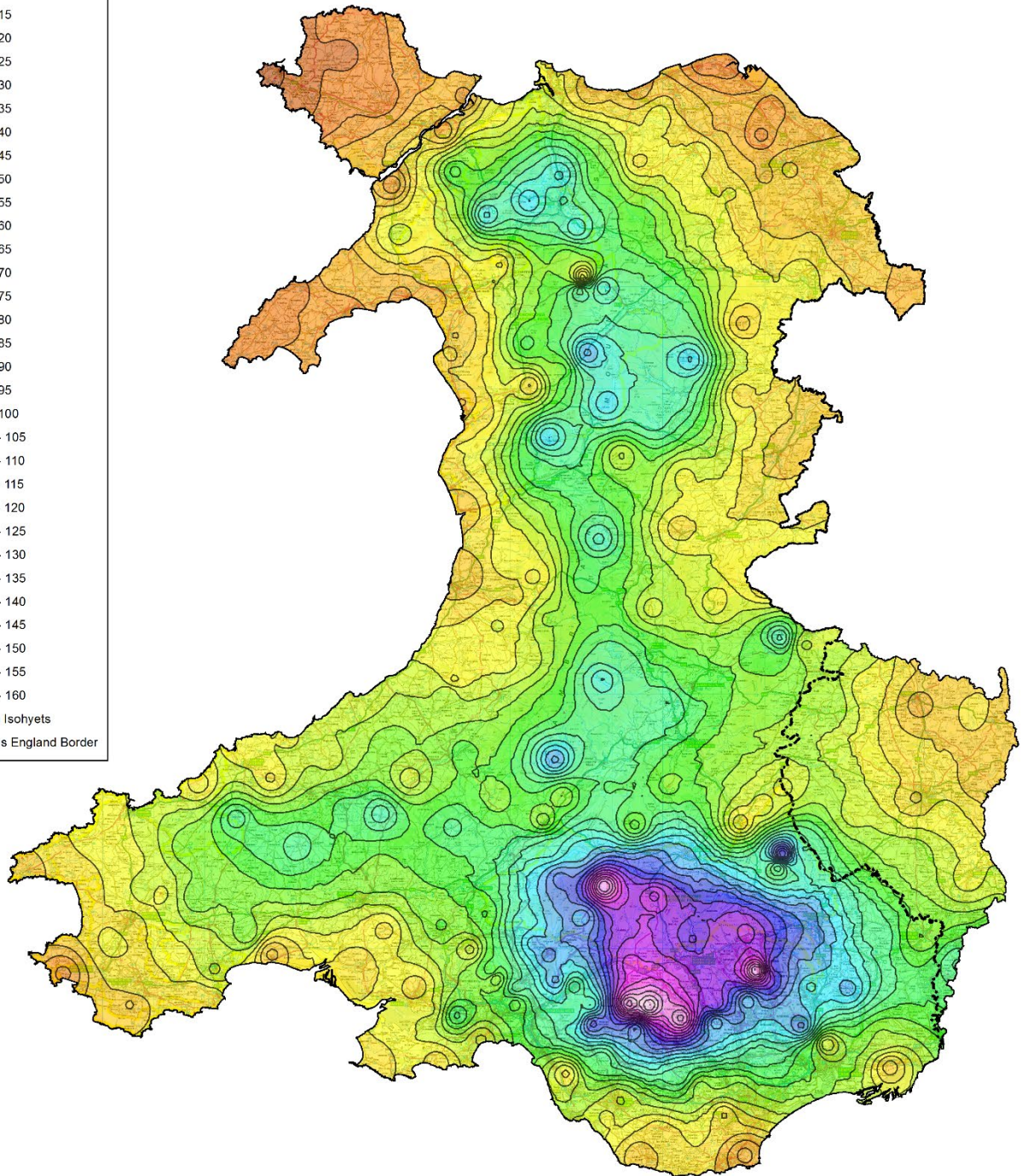
Figure 3 – Rainfall Isohyet Map showing rainfall over a 48-hour period during Storm Ciara in North Wales



Legend

Rainfall depth (mm)

- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60
- 60 - 65
- 65 - 70
- 70 - 75
- 75 - 80
- 80 - 85
- 85 - 90
- 90 - 95
- 95 - 100
- 100 - 105
- 105 - 110
- 110 - 115
- 115 - 120
- 120 - 125
- 125 - 130
- 130 - 135
- 135 - 140
- 140 - 145
- 145 - 150
- 150 - 155
- 155 - 160
- 5mm Isohyets
- - - Wales England Border



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Figure 4 – Rainfall Isohyet Map showing rainfall over a 48-hour period during Storm Dennis

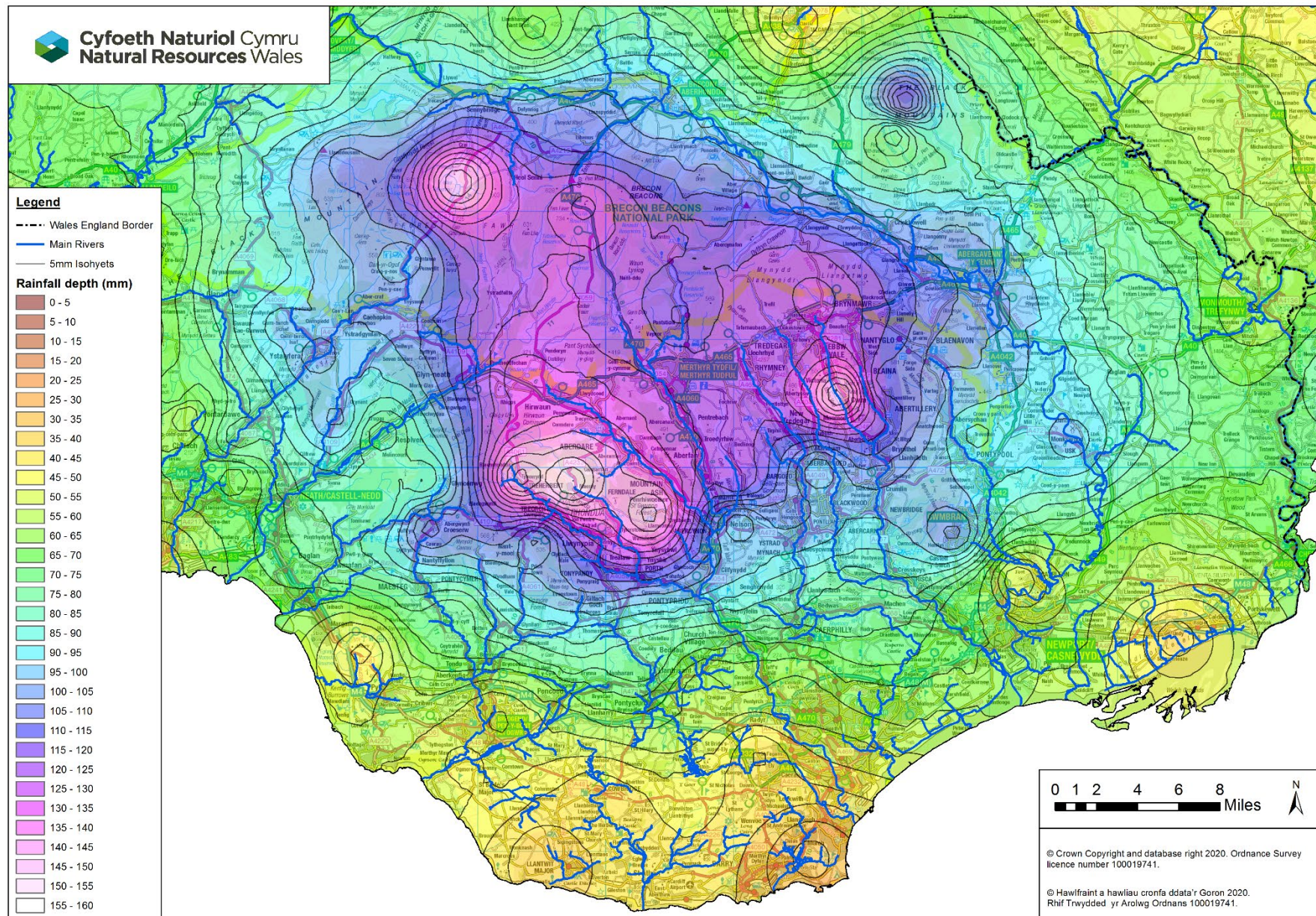


Figure 5 – Rainfall Isohyet Map showing rainfall over a 48-hour period during Storm Dennis in South Wales

Figure 6 below, from the Met Office, demonstrates the significant combined rainfall totals experienced in Storm Ciara and Storm Dennis. It also allows comparison to the events experienced across the rest of the UK during this period.

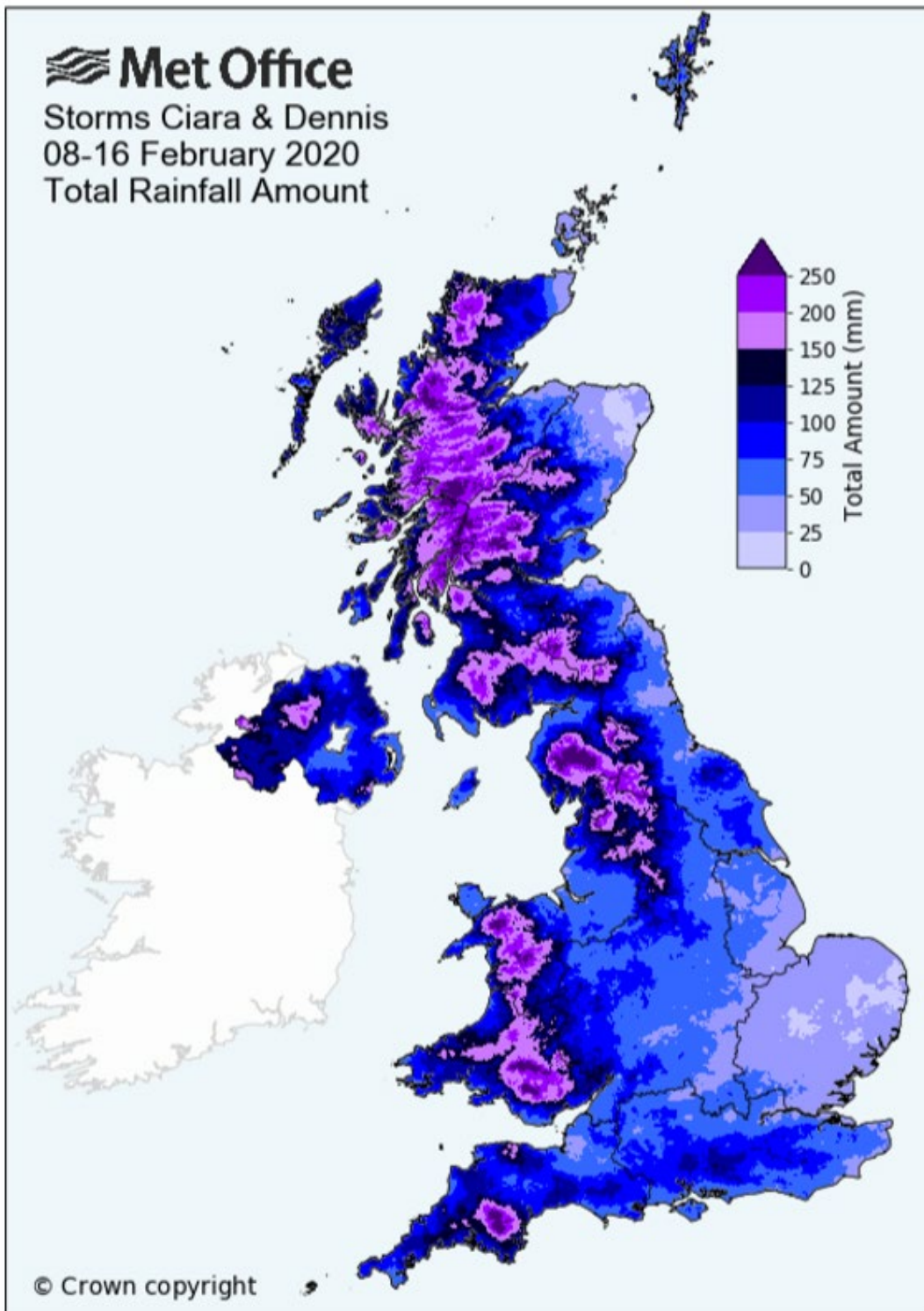


Figure 6 – Total Rainfall amounts experienced during Storm Ciara and Dennis in the UK
Source: Met Office

River Levels and Flows

Across the network of 231 NRW river gauging stations in Wales, 51 (or 22%) recorded the highest ever levels during Storm Dennis. Two record river levels were also set during Storm Ciara (1%).

Many rivers in Wales, particularly in the South Wales Valleys and parts of North Wales, are relatively steep and flow through narrow valleys that are underlain by impermeable geology. As a consequence, runoff from headwaters rapidly reaches main rivers, and river levels respond quickly following intense rainfall. In a matter of hours, they rose from normal river levels to some of the highest on record. Due to this impermeable geology and the limited amount of groundwater, there is little in the way of base flow, which means when the rainfall ceases, river levels recede quickly. Figures 7, 8 and 9 below highlight how quickly river levels rose in some catchments during both storms in just a few hours, they also show how quickly the levels then fell.

For steep catchments, this rapid response to rainfall limits the time available to issue warnings. The volume and force of water associated with these water depths make them particularly dangerous.

In contrast, for large river systems, such as the River Wye with flatter gradients, wider flood plains and deeper soils, the system has a much longer rise to peak over the course of several days (Figure 10). Here, runoff is slower and flooding is more prolonged due to the contribution of base flow.

Estimating flow rates from river levels is not straightforward, particularly for extreme flows where there is little or no historic data. The data presented here is based on industry standard approaches but may be subject to change given further analysis.

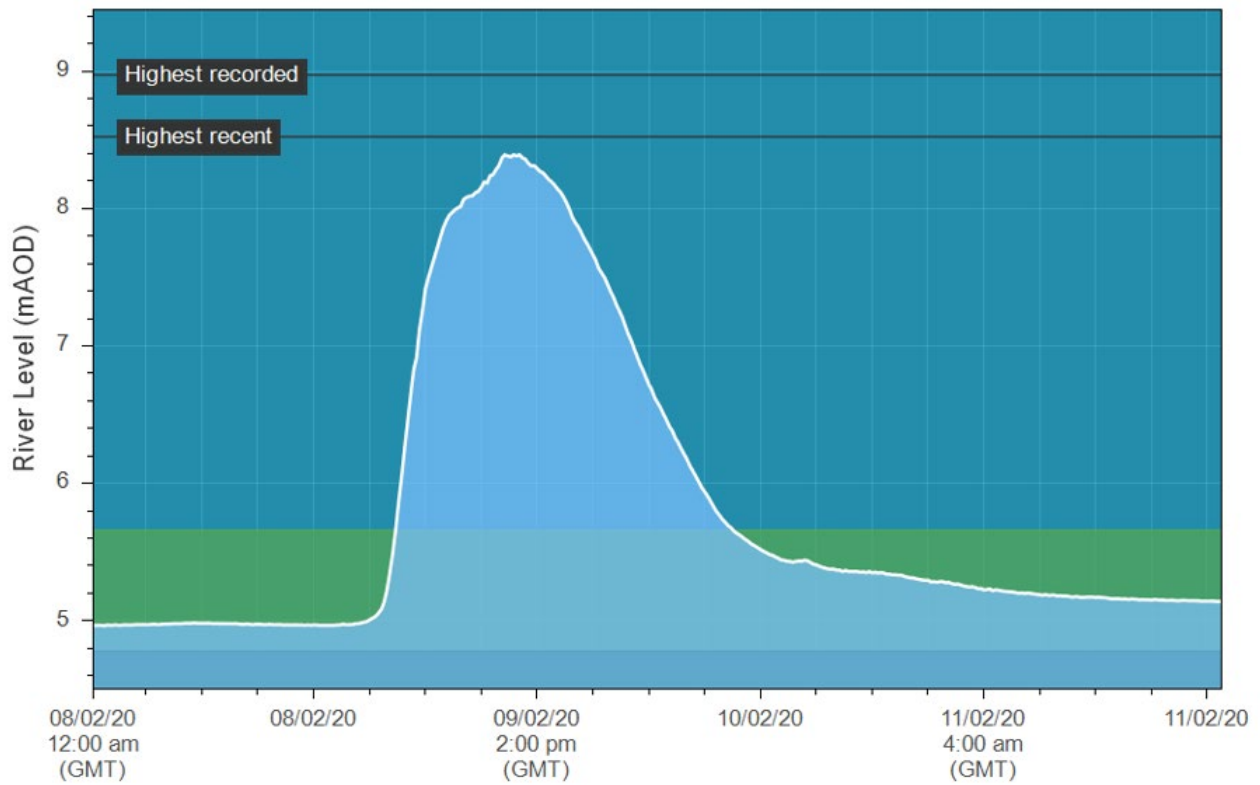


Figure 7 – River level records for River Conwy at Pont Fawr, Llanrwst during Storm Ciara

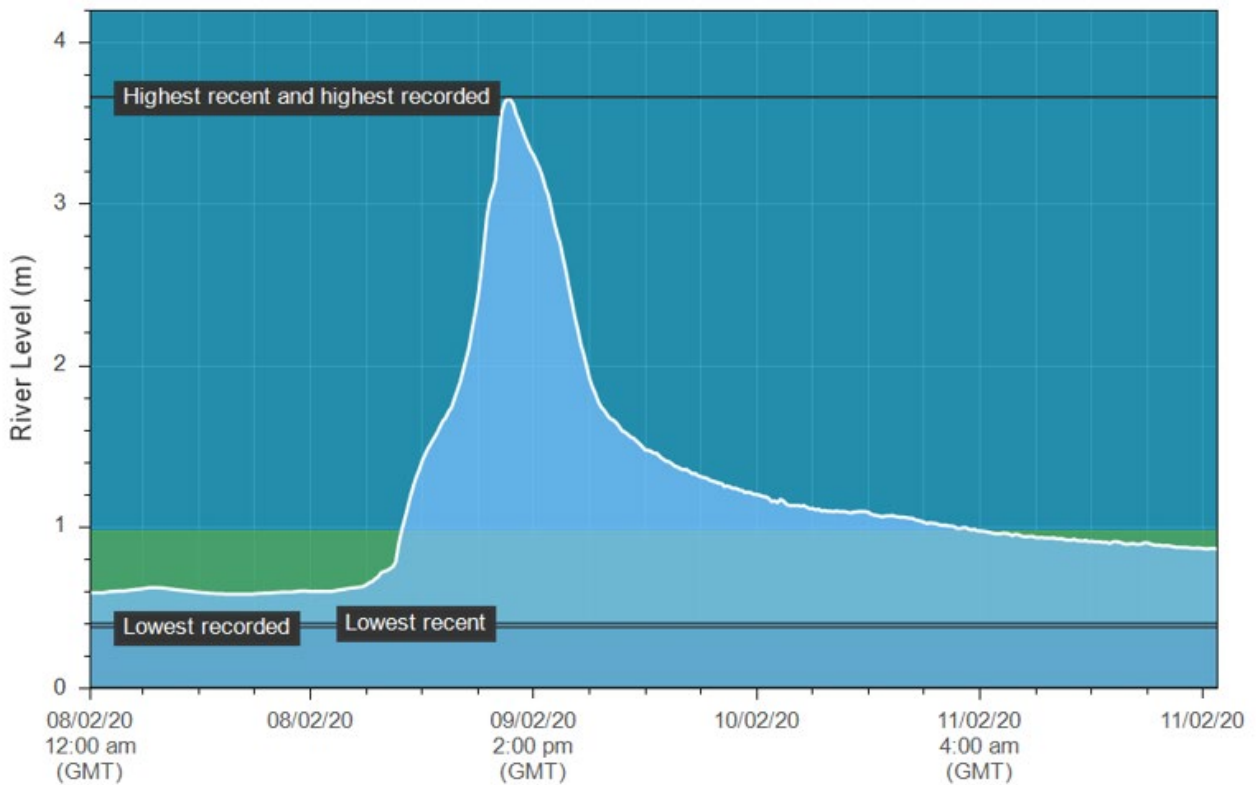


Figure 8 – River level records for River Elwy at Pont y Gwyddel, upstream of St Asaph during Storm Ciara

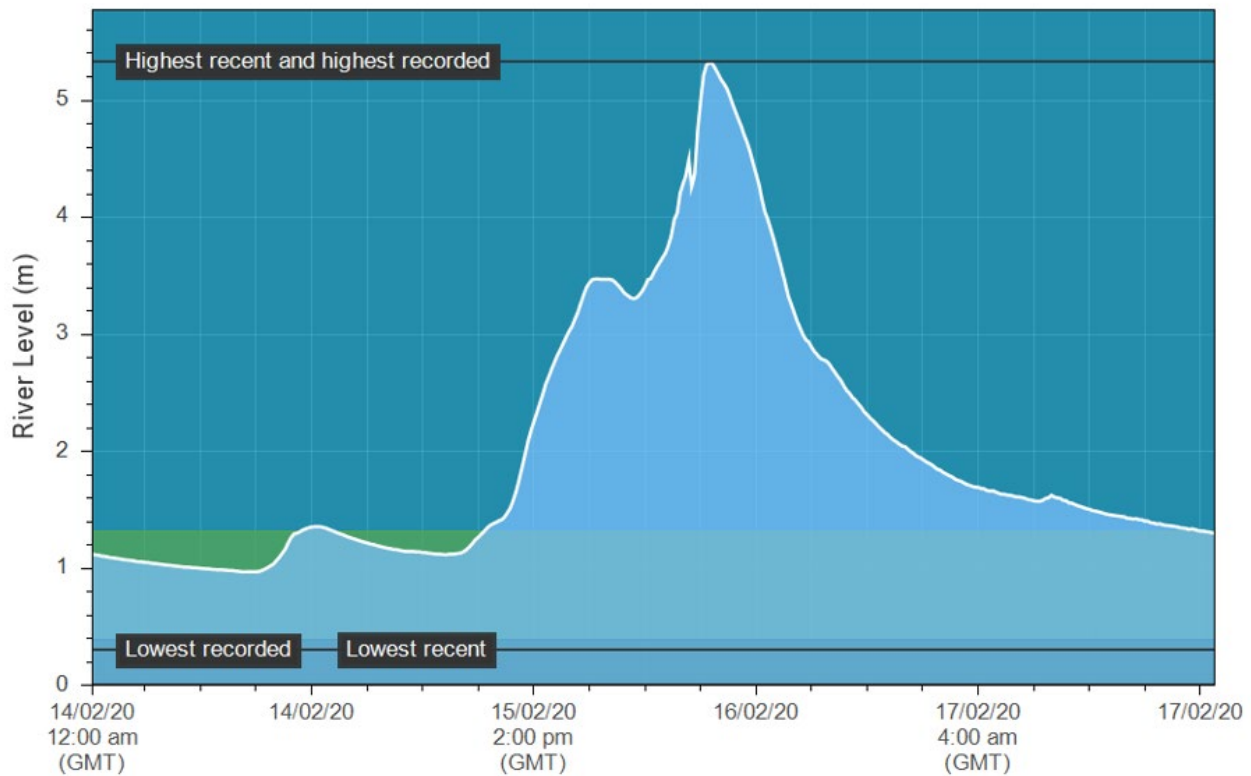


Figure 9 – River level records for River Taff at Pontypridd during Storm Dennis

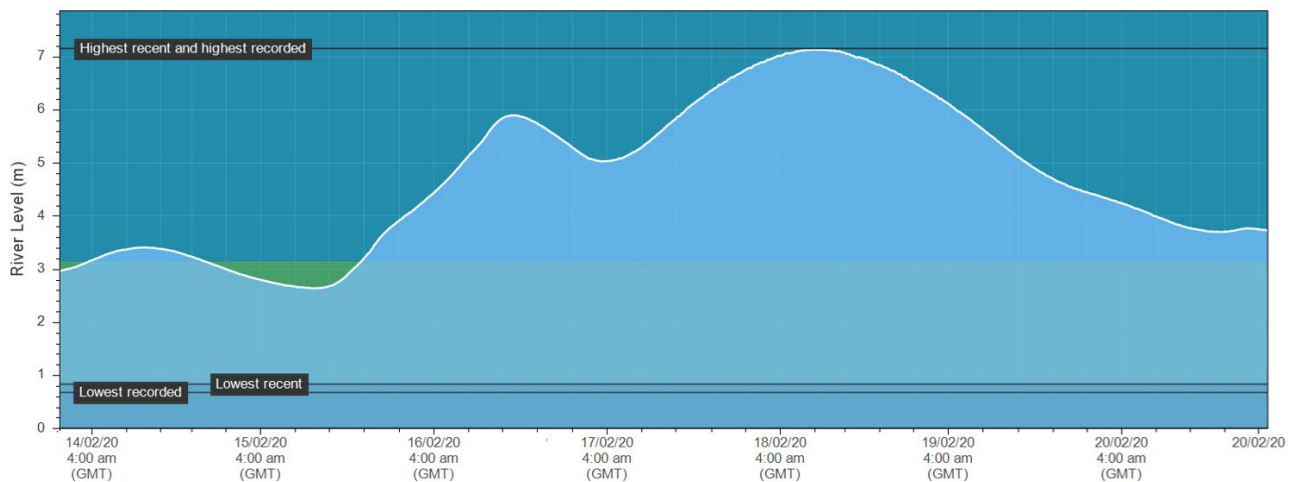


Figure 10 – River level records for River Wye at Monmouth during Storm Dennis

During Storm Ciara:

River levels responded quickly to the heavy rain falling across much of North Wales, in particular the River Conwy and River Elwy catchments which reached high levels and experienced flooding in some locations.

- On the River Elwy, **Pont Y Gwyddel** gauging station reached its highest level since the start of records in 1974. The peak at Pont Y Gwyddel (3.652m) exceeded the November 2012 peak by 17cm. The Elwy at this location was flowing at an estimated 220 cubic metres (or tonnes) of water per second (m^3/s).

- Unfortunately, the level gauge at St Asaph failed and missed the peak. However, onsite observations both during and after the event suggest the peak at St Asaph was in excess of 4.8m, the highest on record and consistent with the upstream data from Pont y Gwyddel. Despite reaching those levels, widespread flooding in St Asaph was largely avoided due to the flood alleviation scheme constructed by NRW following the November 2012 floods.

It is estimated that river levels and flows on the River Elwy were potentially equivalent to a 1:200 flood (0.5% chance in any one year of an event of this scale happening). Table 4 below provides further high river levels of note experienced during Storm Ciara.

Gauging Station	River	Date/Time of peak	Peak stage (m)	Peak stage historical ranking	Peak Flows (m ³ /s)	Record Start
Pont y Gwyddel	Elwy	09/02/2020 11:30	3.652	1	220	1974
St Asaph	Elwy	09/02/2020 15:30	Gauge failed, but likely the highest peak on record, exceeding the previous maximum of 4.352m in Nov 2012			
Ruthin Weir	Clwyd	09/02/2020 16:30	1.129	3	22.7	1971
Pont y Cambwll	Clwyd	10/02/2020 00:15	2.792	6	59.3	1973
Cwmlanerch	Conwy	09/02/2020 10:15	4.729	4	544	1964
Pont Fawr	Conwy	09/02/2020 11:30	8.406	7	-	1999
Beddgelert	Glaslyn	09/02/2020 08:30	2.15	5	117	1967
Druid	Alwen	09/02/2020 10:30	2.176	5	131	1970
Brynkinalt Weir	Ceiriog	09/02/2020 12:30	1.449	3	52.6	1971
Manley Hall	Dee	09/02/2020 20:15	2.816	8	363	1969

Table 4 – River level and flow data recorded on NRW’s Hydrometric Network during Storm Ciara (the peak flow values for some stations are estimates based on modelled data, level and flow data may be subject to change following further validation work)

During Storm Dennis:

Across South Wales, rivers responded quickly to the rainfall falling across already saturated catchments. Record levels were recorded across most catchments in the South Wales valleys and further north in the River Usk and Wye.

- At **Pontypridd**, the River Taff reached its highest level since records began in 1968. At its peak flow it is estimated that 805 m³/s were passing through Pontypridd, enough to fill an Olympic size swimming pool in just over three seconds or alternatively the equivalent of 600 average sized cars per second. The river level was 78cm higher than the previous highest level set during the 1979 floods.
- The River Taff at **Pontypridd** went from an estimated flow of 55 m³/s at 7:00am on 15 February, in relatively normal conditions, to a peak flow estimated at 805 m³/s in just 22 hours during Storm Dennis - an increase of 4.2m in height by 4:45am on 16 February.

- Between 10:15pm (15 Feb) and its peak in **Pontypridd** at 4:45am (16 Feb), the River Taff went from an estimated 405 m³/s to the peak of 805 m³/s, it therefore nearly doubled in flow in just 6.5 hours and increased in height by 2m.
- Along the River Usk, the highest levels were logged at **Brecon, Crickhowell, Llanfoist** and **Usk** since records began in 2013, 2005, 1994 and 2000 respectively. At **Llandetty** and **Chainbridge**, stations recorded the second highest levels behind the 1979 floods.
- At **Monmouth**, the River Wye peaked 67cm higher than the previous record set in 2002. Further downstream at **Redbrook**, the River Wye is estimated to have been flowing at 925 m³/s. This was the highest flow on record since they began in 1969.

Table 5 below highlights many of the river level gauges which set new records during Storm Dennis. Peak levels and flows during Storm Dennis were higher than the significant flood events that impacted the South Wales Valleys and Cardiff in December 1979 and October 1998.

Gauging Station	River	Date/Time of peak	Peak stage (m)	Peak stage historical ranking	Peak Flows (m ³ /s)	Record Start
Tynewydd	Rhondda Fawr	16/02/2020 02:45	1.624	1	38	2001
Trehafod	Rhondda	16/02/2020 04:00	3.977	1	258	1983
Aberdare	Cynon	16/02/2020 03:00	2.125	1	121	1989
Abercynon	Cynon	16/02/2020 07:00	3.067	1	211	1961
Merthyr Tydfil	Taff	16/02/2020 03:15	2.811	1	205	1978
Fiddlers Elbow	Taff	16/02/2020 04:00	3.368	1	427	1973
Pontypridd	Taff	16/02/2020 04:45	5.324	1	805	1968
Upper Boat	Taff	16/02/2020 05:30	5.489	1	-	2001
Tongwynlais	Taff	16/02/2020 07:30	5.085	1	-	1999
Western Avenue	Taff	16/02/2020 08:00	4.843	1	720	1999
Bargoed	Rhymney	16/02/2020 03:30	2.298	1	116	1988
Waterloo Bridge	Rhymney	16/02/2020 06:45	3.352	1	-	1989
Llanedeyrn	Rhymney	16/02/2020 10:45	3.726	1	143	1982
Aberbeeg	Ebbw	16/02/2020 04:00	1.819	1	76	1975
Ynysddu	Sirhowy	16/02/2020 04:30	2.498	1	-	2000
Risca	Ebbw	16/02/2020 04:45	3.517	1	-	1987
Rhiwderin	Ebbw	16/02/2020 06:15	3.089	1	198	1957
Pontnewynydd	Lwyd	16/02/2020 03:15	1.690	1	-	2000
Ponthir Star	Lwyd	16/02/2020 05:30	2.733	1	-	2007
Brecon Promenade	Usk	16/02/2020 00:45	4.117	1	-	2013
Crickhowell	Usk	16/02/2020 02:30	4.508	1	-	2005
Llanfoist Bridge	Usk	16/02/2020 09:15	5.614	1	-	1994
Usk Town	Usk	16/02/2020 13:15	5.797	1	-	2000
Grosmont	Monnow	16/02/2020 07:00	4.630	1	220	2009
Mitchel Troy	Trothy	16/02/2020 07:30	4.296	1	-	1981

Gauging Station	River	Date/Time of peak	Peak stage (m)	Peak stage historical ranking	Peak Flows (m ³ /s)	Record Start
Disserth	Wye	16/02/2020 11:00	3.469	1	155	1968
Builth Wells	Wye	16/02/2020 08:30	5.045	1	-	1988
Glasbury	Wye	16/02/2020 08:45	4.083	1	-	1988
Hay on Wye	Wye	16/02/2020 13:00	5.066	1	-	1988
Monmouth	Wye	18/02/2020 08:30	7.146	1	-	1992
Redbrook	Wye	18/02/2020 08:45	7.681	1	925	1936
Dutlas	Teme	16/02/2020 03:15	2.535	1	-	2006
Knighton	Teme	16/02/2020 06:15	2.852	1	102	2002
Login	Taf	16/02/2020 02:45	3.365	1	104	1999
Glasfryn Ford	Taf	16/02/2020 05:00	2.179	1	-	1982
Llandybie	Loughor	16/02/2020 02:30	1.405	1	-	2011
Teddy Bear Bridge	Tawe	16/02/2020 02:00	2.947	1	167	2000
Ystradgynlais	Tawe	16/02/2020 01:45	2.262	1	-	2013
Glyn Neath	Neath	16/02/2020 03:00	4.236	1	-	2012
Ynys Fach Bridge	Neath	16/02/2020 03:00	1.227	1	-	2007
Resolven	Neath	16/02/2020 05:15	3.287	1	529	1978
Cilfrew	Neath	16/02/2020 03:15	1.988	1	107	1972
Felindre Road	Ewenny	16/02/2020 05:15	1.971	1	33	1999

Table 5 – River level and flow data recorded on NRW's Hydrometric Network during Storm Dennis (Some stations were known to fail as in some case they were overwhelmed, recorded peaks may therefore have been higher in some instances, the peak flow values for some stations are estimates based on modelled data, level and flow data may be subject to change following further validation work)

Figure 11 below highlights the record levels set during the autumn and winter period across NRW's hydrometric river level gauge network. Across a network of 231 river gauging stations, 63 (27%) recorded their highest levels on record between September 2019 and February 2020. Further, 55% of the gauges have recorded their highest ever levels within the last ten years.

Figure 12 below highlights the wide scale spread of these records being set during Storm Dennis. It is estimated that the lower River Taff experienced the equivalent of a 1:200 flood (0.5% chance in any one year of an event of this scale happening) event storm, whilst the River Ebbw is likely to have been a 1:40 event storm and the River Usk in some locations of the upper catchment experiencing a 1:90 event storm.

It is clear from this section, and the previous, that there were exceptional levels of rain that caused record-breaking river levels in many locations. Plus, extreme events are becoming more frequent, and therefore we need to be prepared for more in the future.



- 10 ROCHESTER
- 11 MANCHESTER
- 12 TAMESIDE
- 13 OLDHAM
- 18 DUDLEY
- 19 BIRMINGHAM
- 20 SOLIHULL
- 21 COVENTRY

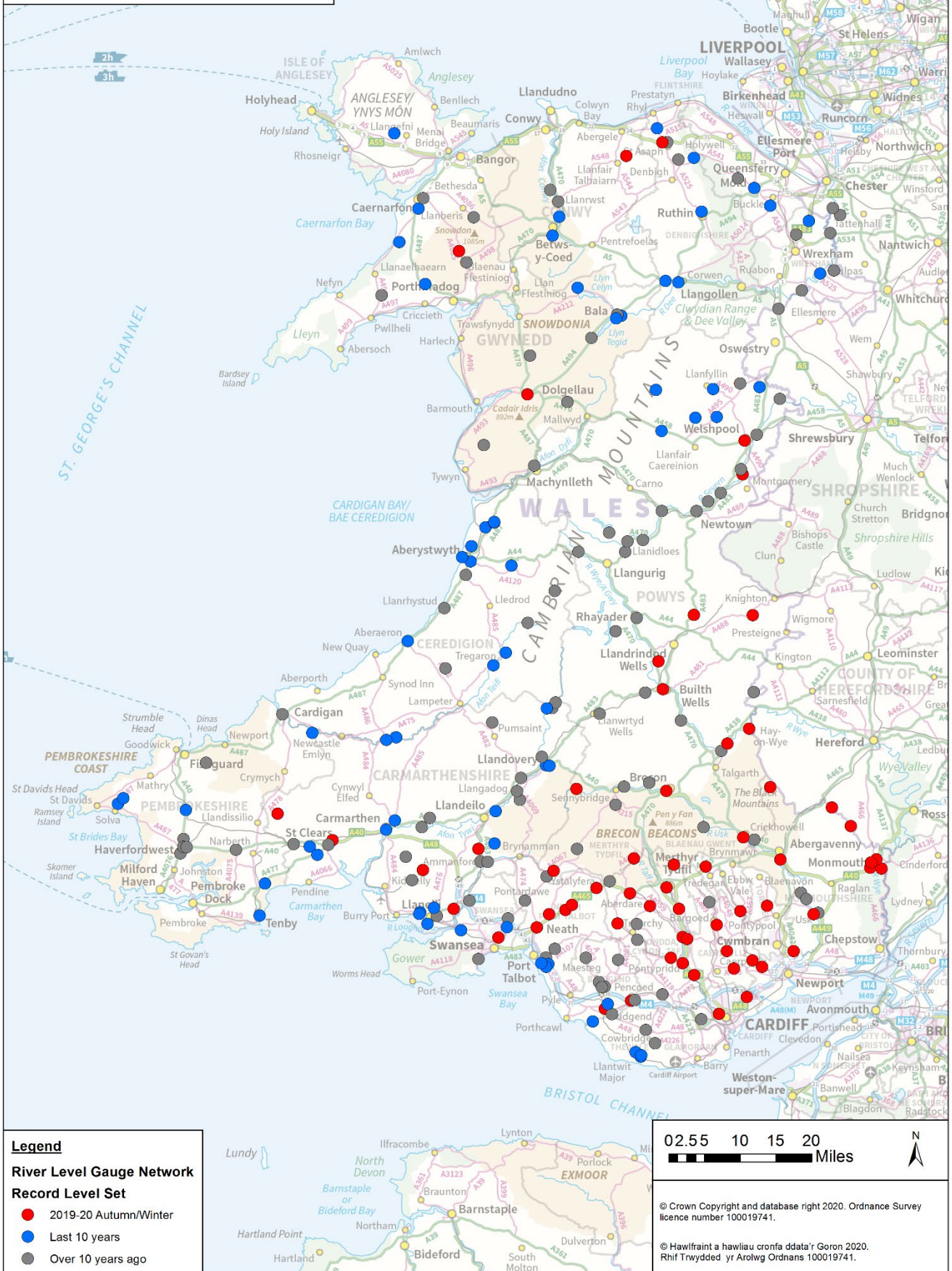


Figure 11 – River level records set across the NRW Hydrometric Network

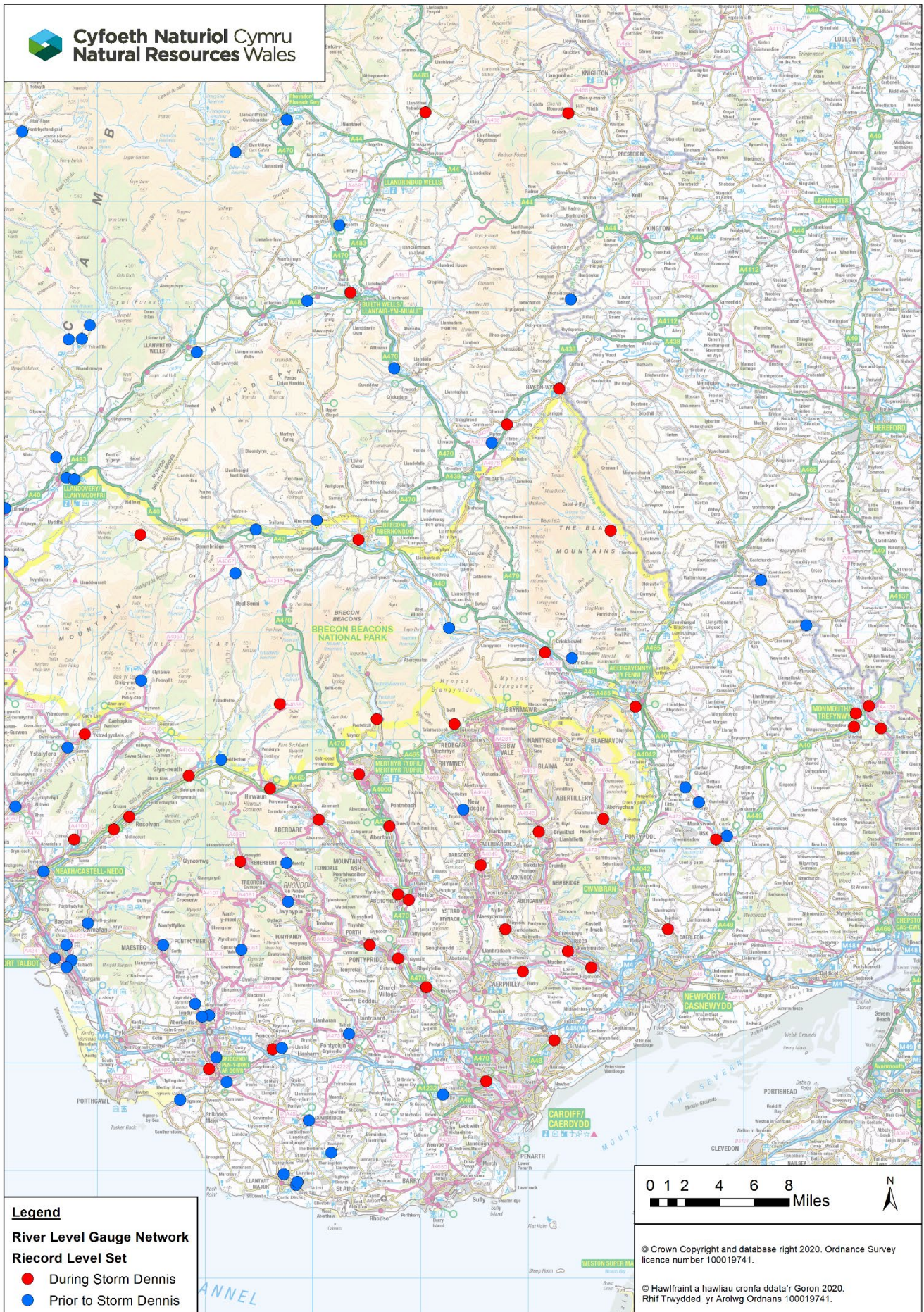


Figure 12 – River level records set during Storm Dennis

Raising Awareness and Warning

An important part of the role that NRW plays is to make other responders and the public aware that an event is coming and that they need to take action. The system is multi-layered; no one approach is perfect, but by adopting a number of complementary approaches, we aim to maximise the number of people who are aware of, and prepared for, a possible approaching event.

The system begins with early warnings from the Met Office and NRW to trigger increased readiness among other organisations and give the public advance warning that a flood event may be coming. These advance warnings are disseminated by a range of means, including traditional and social media, weather reports, press briefings and the five day flood forecast on the NRW website.

As the event becomes more imminent, direct flood warnings are issued for designated flood risk areas.

Throughout the process, we utilise traditional and social media, the internet and our websites to both raise awareness of current risks, as well as encourage the public and our partners to take the actions they can to protect themselves and their properties.

Flood Forecasting

An extremely important element of managing the impacts of weather events, such as those experienced in February, is the ability to forecast rainfall more accurately and further into the future. This is an area that has seen significant enhancement and development in recent years and NRW works with the Flood Forecasting Centre (FFC) (a partnership between the Met Office and Environment Agency) to analyse the latest forecast information. Together, NRW and the FFC assess the weather forecast and flood risk in Wales, summarising the information in the daily Flood Guidance Statement (FGS). The FGS goes to local authorities and emergency responders and is also replicated on NRW's website. It serves as an early warning and allows organisations to prepare for possible impacts.

Figures 13 to 15 are taken from the FGSs issued in the lead up to and during Storm Ciara and Storm Dennis. The content of the specific FGSs highlight the areas forecast to be impacted by each storm and the forecast impact and likelihood in each case. Figure 14 shows the build-up to Storm Dennis in more detail and that stormy weather was being forecast five days prior (Tuesday 11 February), and that the signals for significant impacts increased on the Thursday (13 February). This did help partner organisations prepare since moving to 'Medium' risk is a relatively rare occurrence that acts as a trigger for action. The FGS issued on Saturday 15 February indicated severe impacts but remained at 'Medium' status due to the forecast likelihood. However, the overall flood risk only went to the 'High' risk (indicating a high likelihood of severe impacts) on the Sunday morning.

Figure 13 below, is taken from the FGS from the morning of the 8 February in advance of Storm Ciara. Whilst only showing 'Low' risk for much of Wales the forecast of 'Significant' impacts for 'Risk Area A' should be noted albeit highlighted at 'Low' likelihood at this stage in the weather event.

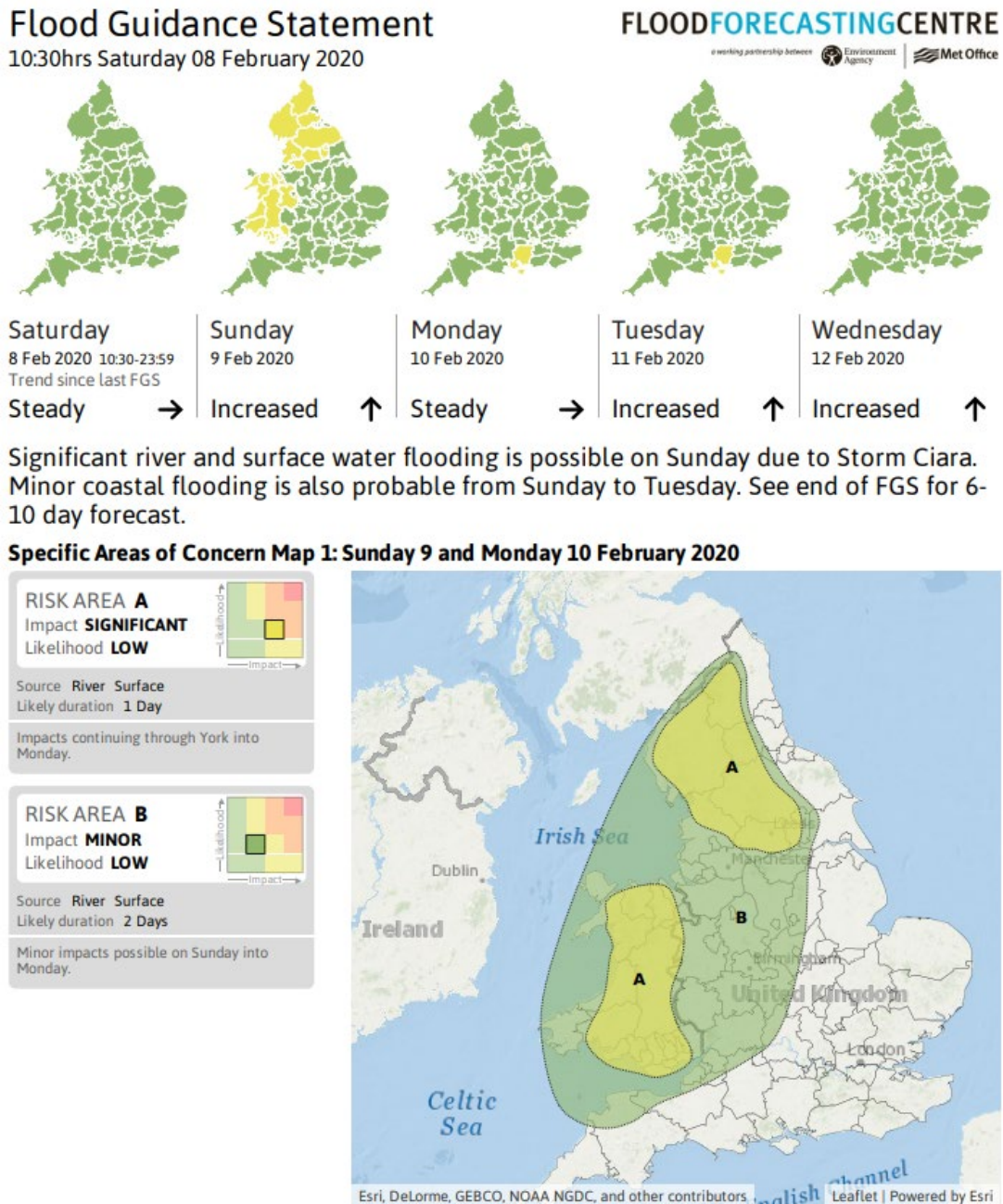


Figure 13 – Content from Flood Guidance Statement Issued on Saturday 8 February at 10:30am
 Source: Flood Forecasting Centre

Flood Guidance Statement issued on:

FLOODFORECASTINGCENTRE

a working partnership between  

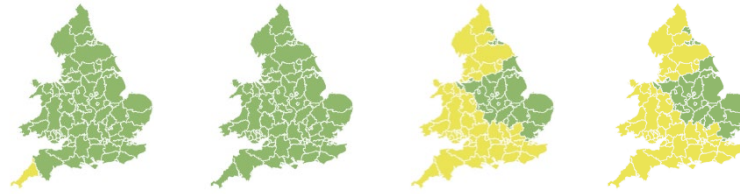
Tuesday 11 Feb



Thursday 13 Feb 2020 Increased ↑
 Friday 14 Feb 2020 Increased ↑
 Saturday 15 Feb 2020 Increased ↑

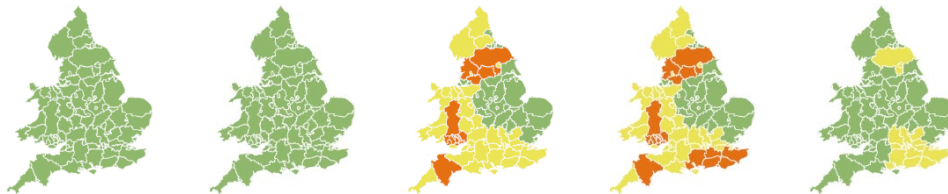


Wednesday 12 Feb



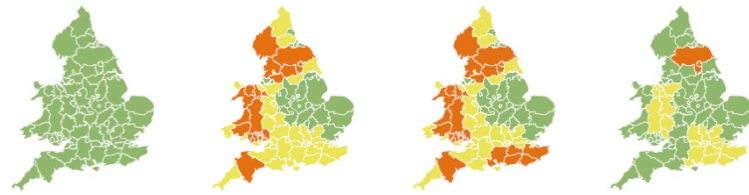
Thursday 13 Feb 2020 Increased ↑
 Friday 14 Feb 2020 Steady →
 Saturday 15 Feb 2020 Increased ↑
 Sunday 16 Feb 2020 Increased ↑

Thursday 13 Feb



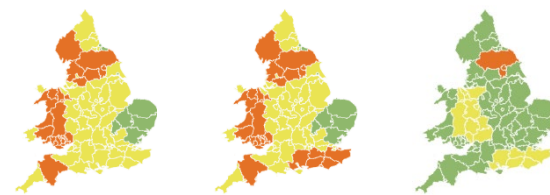
Thursday 13 Feb 2020 10:30-23:59 Trend since last FGS Decreased ↓
 Friday 14 Feb 2020 Steady →
 Saturday 15 Feb 2020 Increased ↑
 Sunday 16 Feb 2020 Increased ↑
 Monday 17 Feb 2020 Increased ↑

Friday 14 Feb



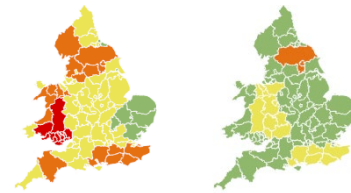
Friday 14 Feb 2020 10:30-23:59 Trend since last FGS Steady →
 Saturday 15 Feb 2020 Increased ↑
 Sunday 16 Feb 2020 Increased ↑
 Monday 17 Feb 2020 Increased ↑

Saturday 15 Feb



Saturday 15 Feb 2020 10:30-23:59 Trend since last FGS Increased ↑
 Sunday 16 Feb 2020 Increased ↑
 Monday 17 Feb 2020 Steady →

Sunday 16 Feb



Sunday 16 Feb 2020 06:00-23:59 Trend since last FGS Increased ↑
 Monday 17 Feb 2020 Steady →

Figure 14 – Five day forecast summary from Flood Guidance Statements leading up to and during Storm Dennis (taken from daily 10:30am updates)
 Source: Flood Forecasting Centre

Flood Warnings

In terms of flood warnings, Storm Dennis is the biggest fluvial event NRW has experienced. The previous highest total of warnings issued came in January 2014, when Wales experienced significant coastal flooding. More Severe Flood Warnings were issued in the specific 2014 event, but the same number of flood warnings were issued in both events.

Flood Event	Flood Alerts	Flood Warnings	Severe Flood Warnings	Total
Storm Ciara	52	29	2	83
Storm Dennis	65	89	4	158
Storm Jorge	47	27	0	74
Unnamed events in February 2020 (including the weekend of 21 st – 24 th)	79	36	0	115
Total issued in February 2020	243	181	6	430
1 st -6 th January 2014 Coastal Event	43	89	6	138
Monthly average since 2005	36	8	0	44

Table 6 – Number of Flood Warnings and Alerts issued in Wales

February 2020 has been the busiest period for Flood Warnings and Alerts in Wales since the system took its current format in 2005. To enable accurate and timely warnings, a significant amount of effort and expert knowledge is required. This includes the expertise of flood forecasting in the days leading up to an event, as well as real time monitoring and analysis that was undertaken by Flood Warning Duty Officers responsible for issuing warnings and providing the latest updates to professional partners. All of this is supported by NRW's network of rainfall and river level hydrometric gauges and operational workforce, who are out on the ground performing manual monitoring and checks.

Figures 16 – 21 below highlight the volume, distribution and impact of the Flood Warnings being issued. Note, like the river levels themselves, figures 16 and 17 show the extremely short time frame within which Flood Warnings were issued. Whilst a record number of warnings were issued during this time period (158 in total during Storm Dennis), in the rapidly escalating events that occurred during Storm Dennis, some flood warnings were issued late (after the onset of flooding) or not issued at all. The best available data shows that three warnings were issued late in the Lower Taff Valley, three late in the Teifi Valley, 11 warnings were not issued in the Rhymney Valley, and one was not issued on the River Towy. This is clearly below desired performance levels; our systems were overwhelmed during periods of peak demand and improvements to managing the risk of this happening again are being identified.

It is estimated that at the beginning of February 2020 over **126,000** properties were registered to receive flood warnings in Wales.

- During **Storm Ciara**, of the **9,838** properties registered in relevant areas to receive the warnings, **92%** were successfully contacted, with **14,491** customers reached.
- During **Storm Dennis**, of the **15,272** properties registered in relevant areas to receive the warnings, **79%** were successfully contacted, with **19,476** customers reached.
- During **Storm Jorge**, of the **5,615** properties registered in relevant areas, **86%** were successfully contacted, with **7,768** customers reached.
- Overall, during the whole of **February 2020**, of the **38,996** properties registered in relevant areas, **86%** were successfully contacted, with **55,784** customers reached.

Successful contacts include answered telephone calls and received email and text messages. Thus, success is related to the message being received, and not just sent.

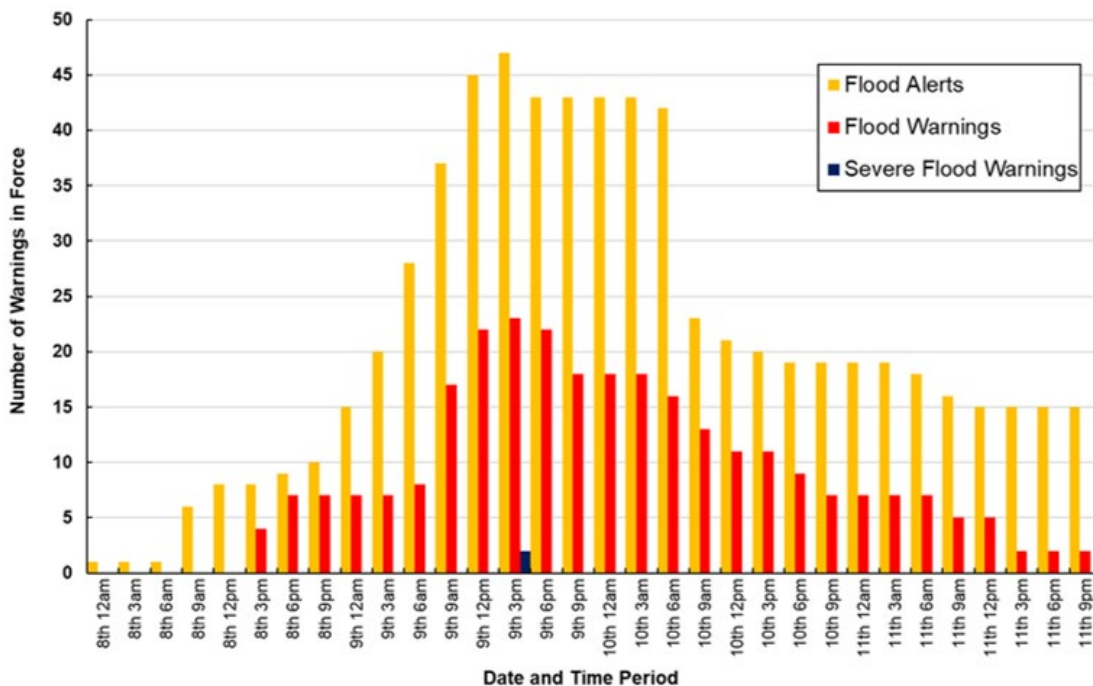


Figure 16 – Flood Warnings and Alerts in force in Wales during Storm Ciara

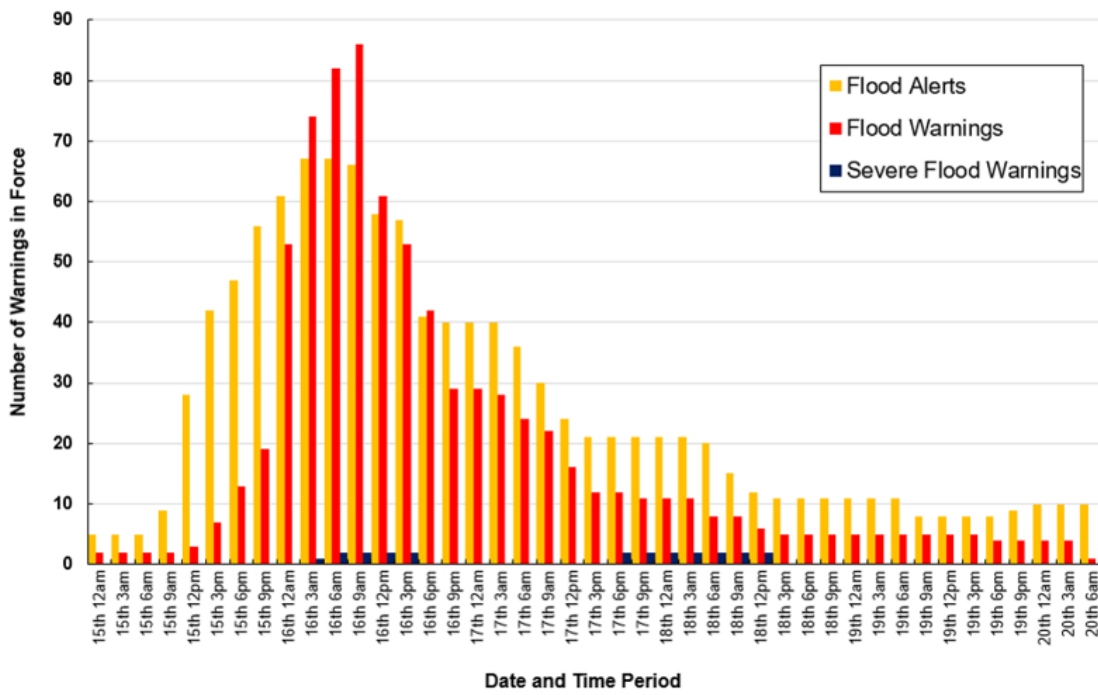


Figure 17 – Flood Warnings and Alerts in force in Wales during Storm Dennis

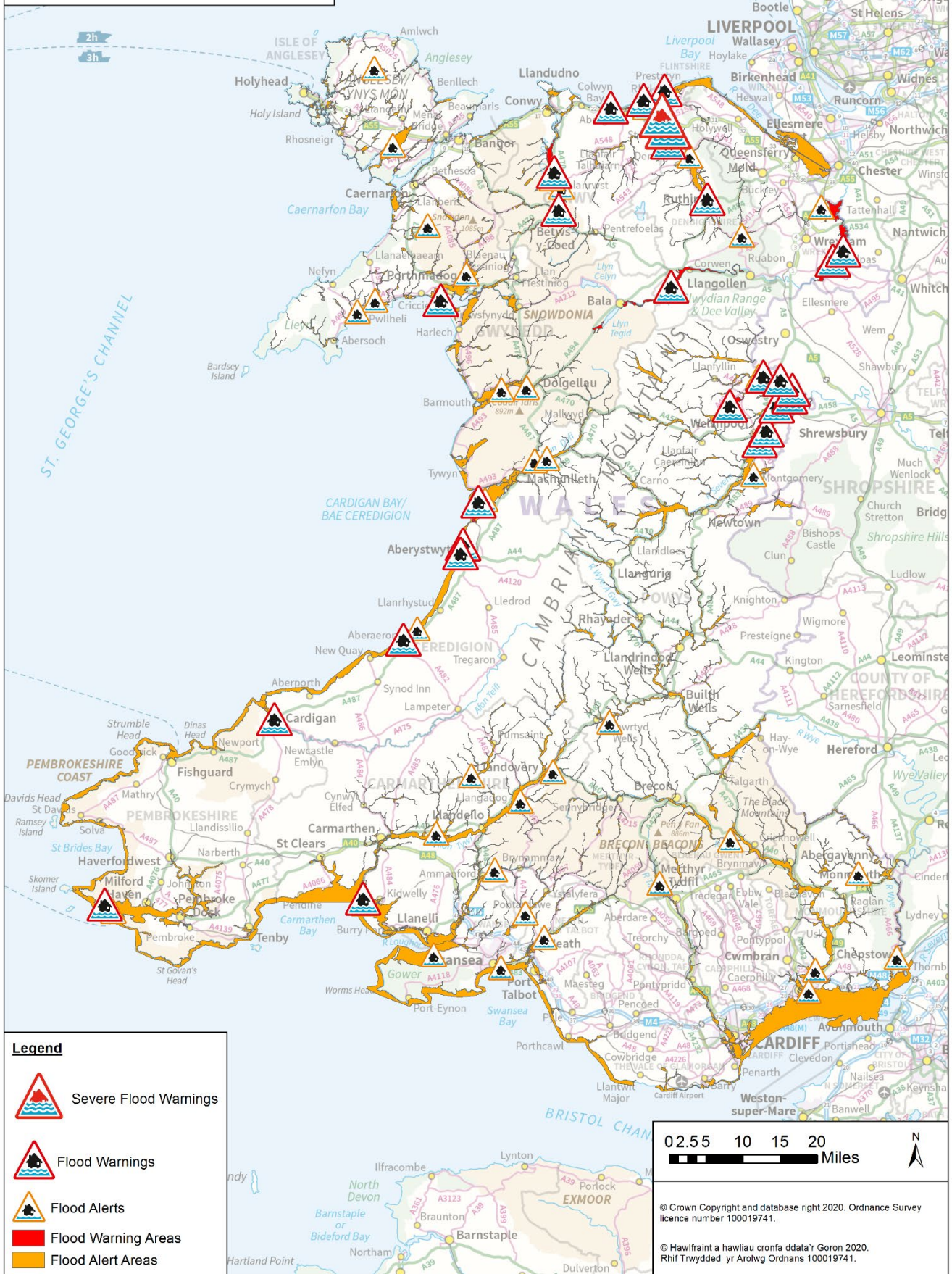


Figure 18 – Flood Warnings issued during Storm Ciara

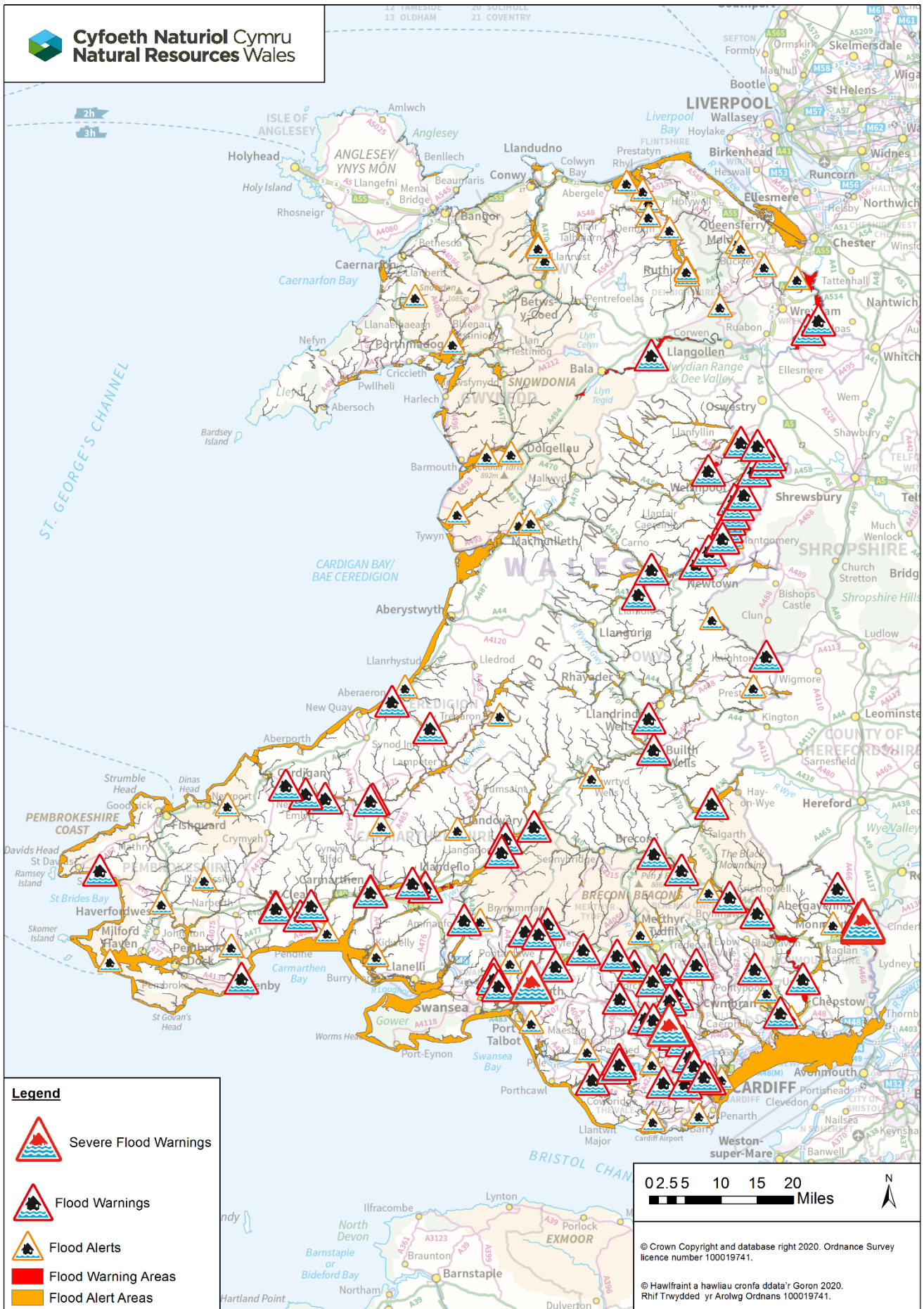


Figure 19 – Flood Warnings issued during Storm Dennis

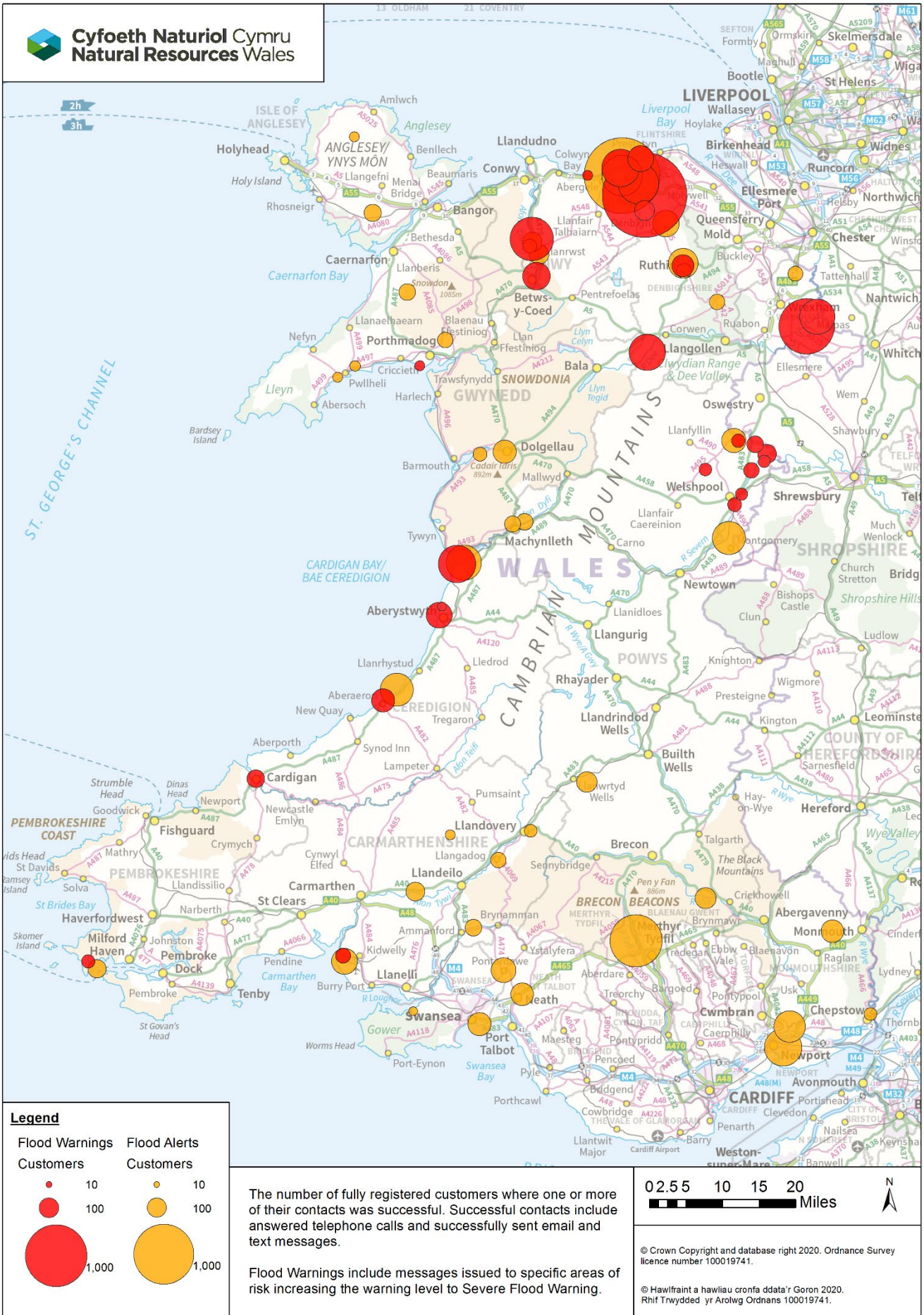


Figure 20 – Number of customers issued with Flood Warnings during Storm Ciara

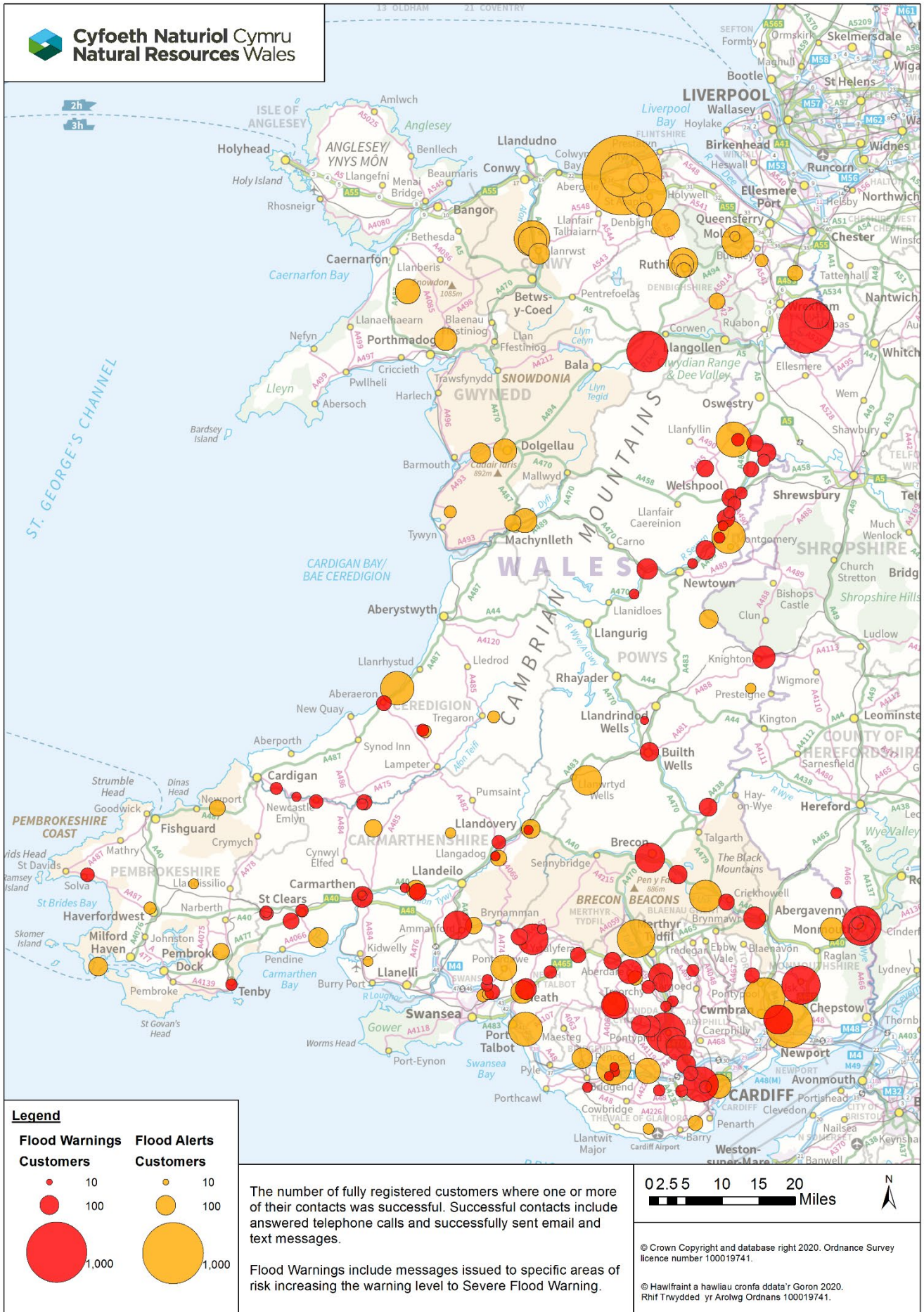


Figure 21 – Number of customers issued with Flood Warnings during Storm Dennis

Communications and Social Media

Storms Ciara and Dennis generated 499 articles in a wide range of media outlets which were supported by NRW communications. These included coverage in almost all of the major print and online news outlets - some of this coverage extended globally, even reaching news outlets in the USA. NRW staff gave 42 media interviews, appearing multiple times across Welsh and UK broadcast outlets.

Storm Dennis in particular generated a very high level of media interest and a huge surge in the number of people looking for more information about the flooding, the warnings being issued and seeking updates on the latest situation.

Over the period of 14 to 18 February 2020, during Storm Dennis, over 164,000 users visited the NRW website, with over 577,000 unique page views. At the peak of Storm Dennis on the 16 February, over 84,000 users visited the website, more than double the number that visited during Storm Callum (October 2018). The top five pages visited on the NRW website during this period were:

- Check flood warnings – information regarding the latest status of warnings
- Five day flood forecast – the flood guidance statement issued daily
- Check river levels – live data from our river level hydrometric network
- What to do before, during and after a flood – information to help develop resilience
- Long term flood risk maps – maps highlighting areas at risk of flooding

During February 2020, the number of views of the “Check flood warnings” page was 13 times higher (over 615,000) than the usual monthly page views on the English version of the NRW website and 26 times higher (nearly 7,000) than the monthly average on the Welsh version. The volume of hits on our website contributed to some network problems, and the website did go down twice at critical times for short periods. This is being reviewed and addressed.

Over 1,900 calls were received by the Floodline interactive voice service over the 15 and 16 February, as well as 397 calls directly to Floodline agents. This service provides further information to the public regarding flood warnings and other information regarding flood risk management.

NRW’s Incident Contact Centre received 659 calls between the 14 and 18 February and dealt with over 800 alarms triggered by the rain and river level gauges on the Hydrometric network. Between the 14 and 27 February, NRW’s Customer Contact Centre received 63 calls, 120 emails and 16 enquiries relating to the flooding from members of the public. The three main themes from these queries related to flood defences, incident management and flooding advice.

NRW reached 5.7 million people through its social media channels on Twitter and Facebook, with 3,300 users sharing posts issued by NRW. During February 2020, NRW obtained 4,780 new followers on Facebook, 2869 on Twitter and 191 on Instagram. NRW received 2,412 messages through Facebook and Twitter during this period.

Impacts

The impacts of the extreme rainfall and subsequent rapid increases in river levels led to significant impacts across Wales during the entire month of February 2020. Flood water poses a high risk to life and can devastate homes, businesses and communities; affected areas and properties will take a long time to recover.

Flooding often occurs from a range of sources and this means that managing and reducing flood risk is complex. There are many organisations responsible for managing flood risk in Wales. Their roles and responsibilities can be summarised as follows:

- NRW has powers to manage flooding from main rivers (typically the larger rivers in Wales), the sea, and reservoirs they operate.
- Lead Local Flood Authorities, the 22 Local Authorities in Wales, manage flooding from ordinary watercourses (smaller watercourses), surface water and groundwater. They also carry out coastal protection work in response to coastal erosion.
- Water companies in Wales manage flooding from water and sewerage systems.
- Highway authorities in Wales manage the drainage of highways.

The causes and mechanisms of specific flood instances can require detailed investigative work to understand. Given the extent of these events, it is likely to take some time before all of the sources and mechanisms of flooding in February have been fully understood. All Risk Management Authorities across Wales are working to deliver this and are considering potential future measures that need to be taken.

Flooding has a very significant negative and lasting impact on people's mental and physical wellbeing, their homes and their businesses. It also has noteworthy impacts on the wider infrastructure that all communities rely on. During February 2020 widespread impacts were seen across the railway and road networks, as well as utility provision including gas, electricity and drinking water. Whilst this report does not address these impacts (these will be covered in the Local Authority and Water Company reports), it is noted that significant disruption was evident across all of these wider elements of infrastructure, with many bridges, for example, still out of use.

The data in Table 7 below gives an overview of the impacts to properties across Wales from all sources of flooding during the named storm events. This information has been collated from a combination of NRW survey work and submissions from the Welsh Government, Local Authorities and the Welsh Local Government Association. It reflects the current understanding at the point of publishing this report, however, this is subject to change as more information and further impacts are identified. This report is based on information available at the end of July 2020.

Storm Dennis was one of the most significant weather events to hit Wales in over a generation. The other most notable flooding in Wales was during the winter storms of 2013/14 (305 properties flooded), October 1998 (750 properties flooded) and December 1979 which brought impacts across Mid and South Wales and flooded over 3,000 properties in Cardiff alone.

Local Authority Area	Storm Ciara	Storm Dennis	Storm Jorge	February Total
Blaenau Gwent County Borough Council	0	125	0	125
Bridgend County Borough Council	0	16	13	29
Caerphilly County Borough Council	0	203	0	203
Carmarthenshire County Council	2	63	0	65
Cardiff Council	0	21	5	26
Ceredigion County Borough Council	1	3	0	4
Conwy County Borough Council	172	0	0	172
Denbighshire County Borough Council	23	0	0	23
Flintshire County Council	0	20	0	20
Gwynedd Council	10	0	0	10
Isle of Anglesey Council	6	0	0	6
Merthyr Tydfil County Borough Council	0	225	0	225
Monmouthshire County Borough Council	0	215	11	226
Neath Port Talbot County Borough Council	0	88	3	91
Newport City Council	0	11	0	11
Pembrokeshire County Council	0	0	0	0
Powys County Council	0	232	0	232
Rhondda Cynon Taf County Borough Council	10	1,476	90	1,576
Swansea	0	45	0	45
Torfaen County Borough Council	0	21	0	21
Vale of Glamorgan County Council	0	1	19	20
Wrexham County Borough Council	0	0	0	0
Storm Totals	224	2,765	141	3,130
Overall February Total	3,130			

Table 7 – Properties flooded in Wales
(based on best available evidence)

Properties known to have flooded include 224 properties during Storm Ciara, 216 being households and eight non-residential. During Storm Dennis, 2,765 properties flooded, including 2,200 households and 565 non-residential properties. During Storm Jorge, 141 properties flooded, of which 111 were households and 30 were non-residential. The distribution of these impacts is shown in Figures 22 and 23 below.

Overall economic damages are difficult to calculate given the scale and diversity of the impacts of flooding on properties and infrastructure. However, the Association of British Insurers estimates the average household flood claim to be £32,000³. Therefore, given an estimated 2,527 households flooded during February 2020, the flood damage to household property alone is estimated to be £81 million. This will not include the substantial economic costs felt by businesses, other non-residential properties and infrastructure across Wales.

³ Association of British Insurers 2020, Insurance pay outs to help customers recover from Storms Ciara and Dennis set to top £360 million, viewed June 2020, < <https://www.abi.org.uk/news/news-articles/2020/03/insurance-pay-outs-to-help-customers-recover-from-storms-ciara-and-dennis-set-to-top-360-million> >

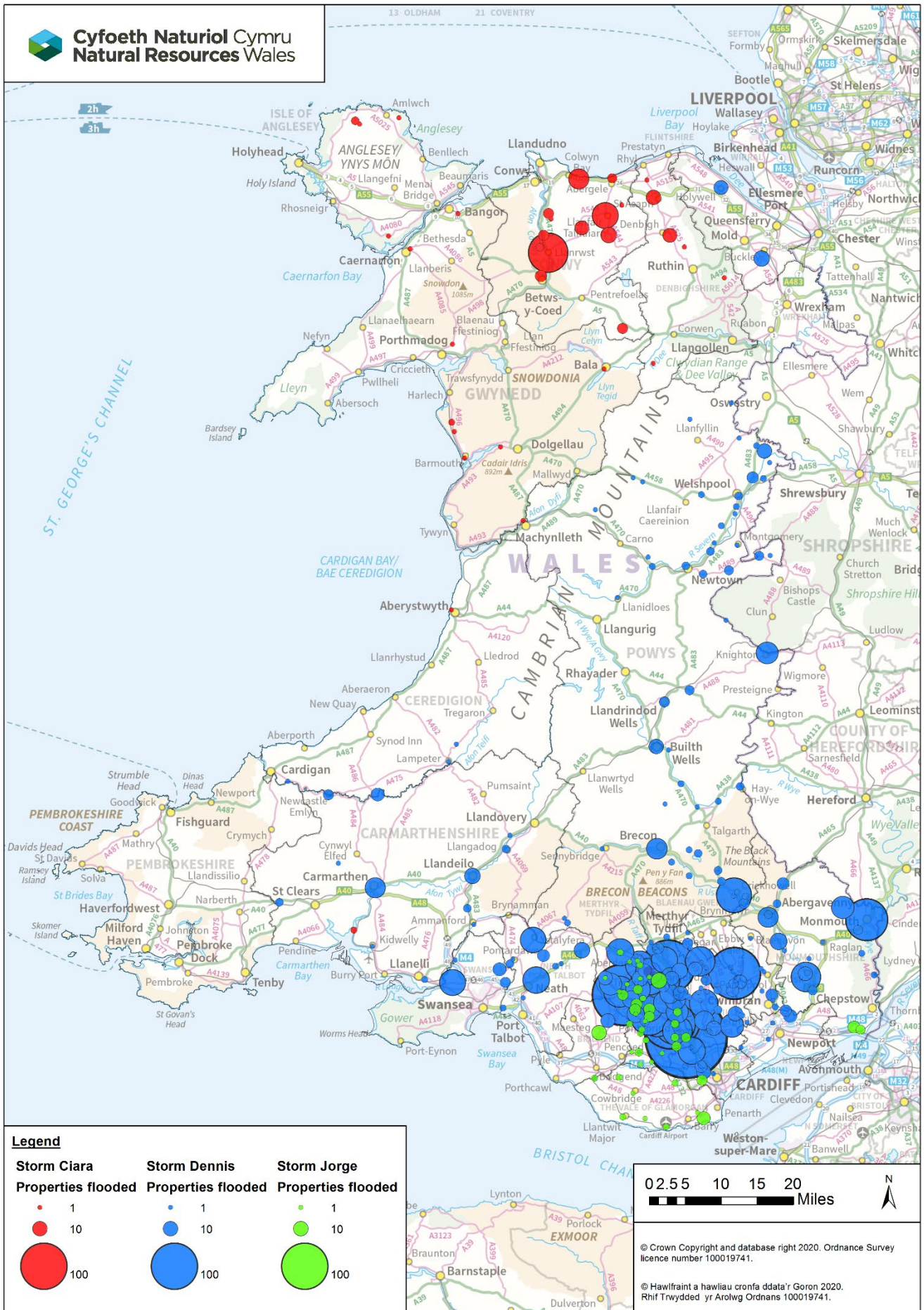


Figure 22 – Properties flooded during February 2020

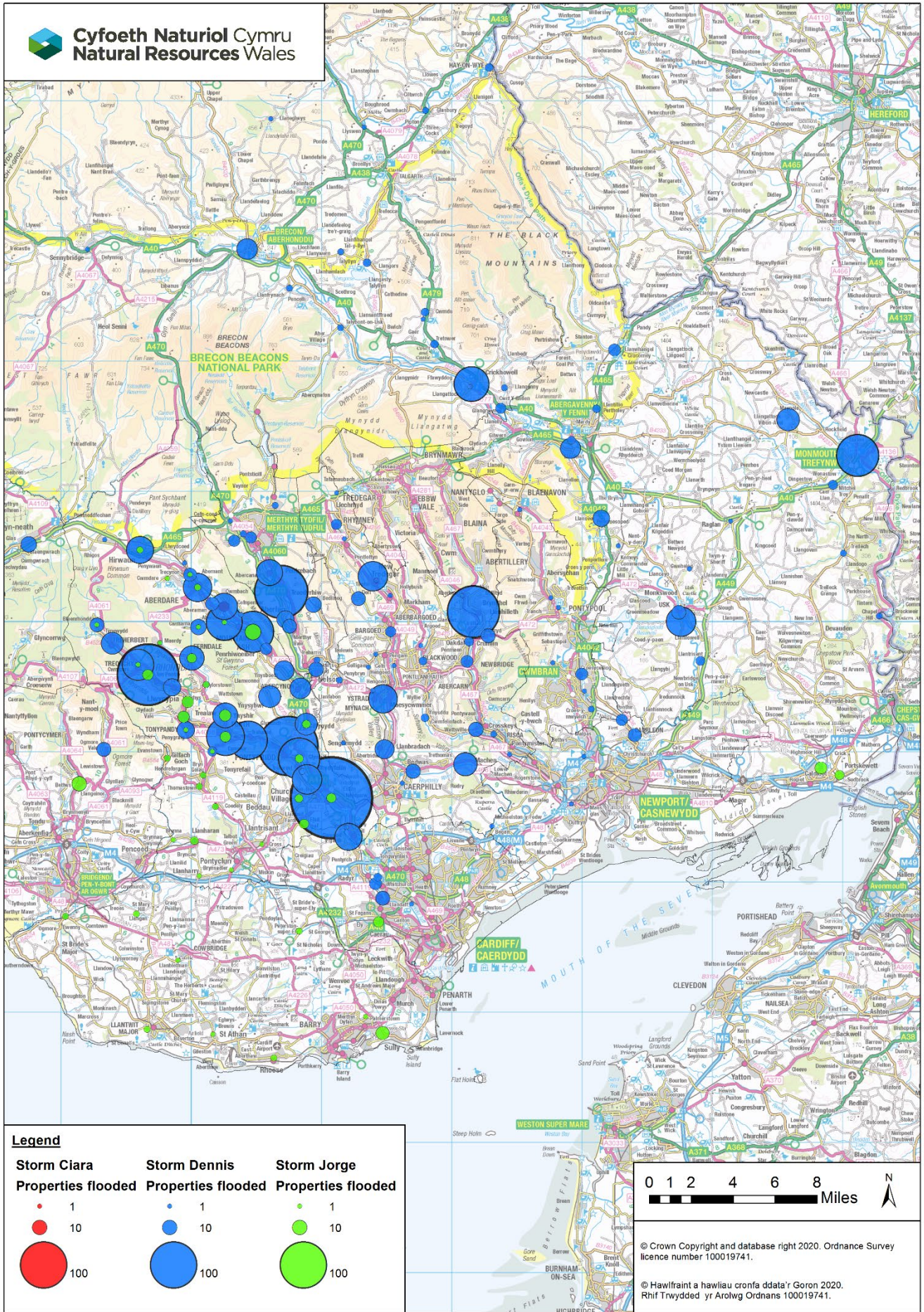


Figure 23 – Properties flooded during February 2020 in South Wales

Areas protected

Whilst NRW defences overtopped in a number of locations or properties behind them flooded from other flood sources, importantly they did not fail, which would have resulted in even more widespread flooding. Our defences are built to provide industry-standard levels of protection, typically to hold back water levels in a 1% chance event. Given that defences were overtopped in places, however, calls into question whether this standard of protection is sufficient for the future. It could be concluded that defences should be built higher, but this often has the effect of pushing water further downstream to the next community. If this is done down a whole river, then the defences at the lower end will need to be significantly higher than they are now. This raises concerns over feasibility and acceptability, as well as the potentially greater risk to people and communities if those defences structurally fail.

Also, with the increasing frequency of extreme weather events, a defence that was built with a 1 in 100 standard of protection 10 years ago will provide a lower level of protection today. This reflects the fact that river levels associated with particular likelihoods of flooding are also changing. It is a moveable feast, depending on the rate of climate change. Our designs take into account the UK climate change predictions published periodically by the Met Office Hadley Centre Climate Programme, but the pace of climate change and the uncertainty around it make this challenging. As the height of defences is increased, there is an additional cost and impact on the local environment. Also, to maintain structural stability, higher defences need wider bases, but there may not be available space sufficient for this construction. Maintenance costs also increase and this raises further questions for consideration.

Despite the inevitable focus on areas that flooded, significant numbers of properties benefitted from flood defences during the February 2020 events. Overall in Wales, it is estimated that over 73,000 properties benefit from a 1:100 standard of protection provided by NRW owned and maintained flood defences⁴.

During Storm Ciara, it is estimated that the river levels in St Asaph on the River Elwy were higher than in November 2012 when significant flooding was experienced. On the whole, the newly constructed NRW flood alleviation scheme, built to protect 293 homes and 121 businesses in the city, performed well and prevented a repeat of the events of 2012. The impacts of flooding in Llanrwst on the River Conwy could also have been much worse without the successful deployment of NRW demountable defences, which prevented flooding from the River Conwy.

Given the record high river levels experienced during February 2020, peak flows during Storm Dennis in particular were larger than the events which hit Wales in 1998 and 1979. However, in terms of impact, the events of February 2020 were lower than those experienced in 1979 which brought widespread devastation across many communities in Mid and South Wales - flooding 3,000 properties in Cardiff alone. This level of property flooding experienced was not the case in February 2020, despite higher river levels in some cases, which reflects the significant investment into flood alleviation schemes and flood warning services in the decades since.

⁴ 1 in 100 standard of protection would be expected to protect the defended area behind the defence from all floods up to and including the 1 in 100 (1% chance in any one year of an event of this scale happening) flood event.

Using estimates of the hydrological scale of flooding experienced in February 2020, the available information on the performance of NRW flood defences, and the latest flood risk modelling data, analysis has been undertaken to understand the number of properties that benefitted from NRW defences during Storm Dennis. This analysis is built on a number of assumptions but demonstrates the potential severity of the event without these defences in place.

Across the rivers in South Wales that were impacted by Storm Dennis an estimated 19,000 properties benefitted from NRW flood defences. Notably, the analysis shows over 10,000 properties in Cardiff were likely to have flooded without the presence of NRW defences. Significant numbers also benefitted in the catchments of the Rivers Ebbw, Sirhowy and Afan.

Using estimates from the Association of British Insurers, which place an average household claim at £32,000³, and based on an approximate 17,000 households benefitting from flood protection during Storm Dennis, the flood damage avoided to household property alone is estimated at over £550 million. This demonstrates the significant value of the investment made in flood defences.

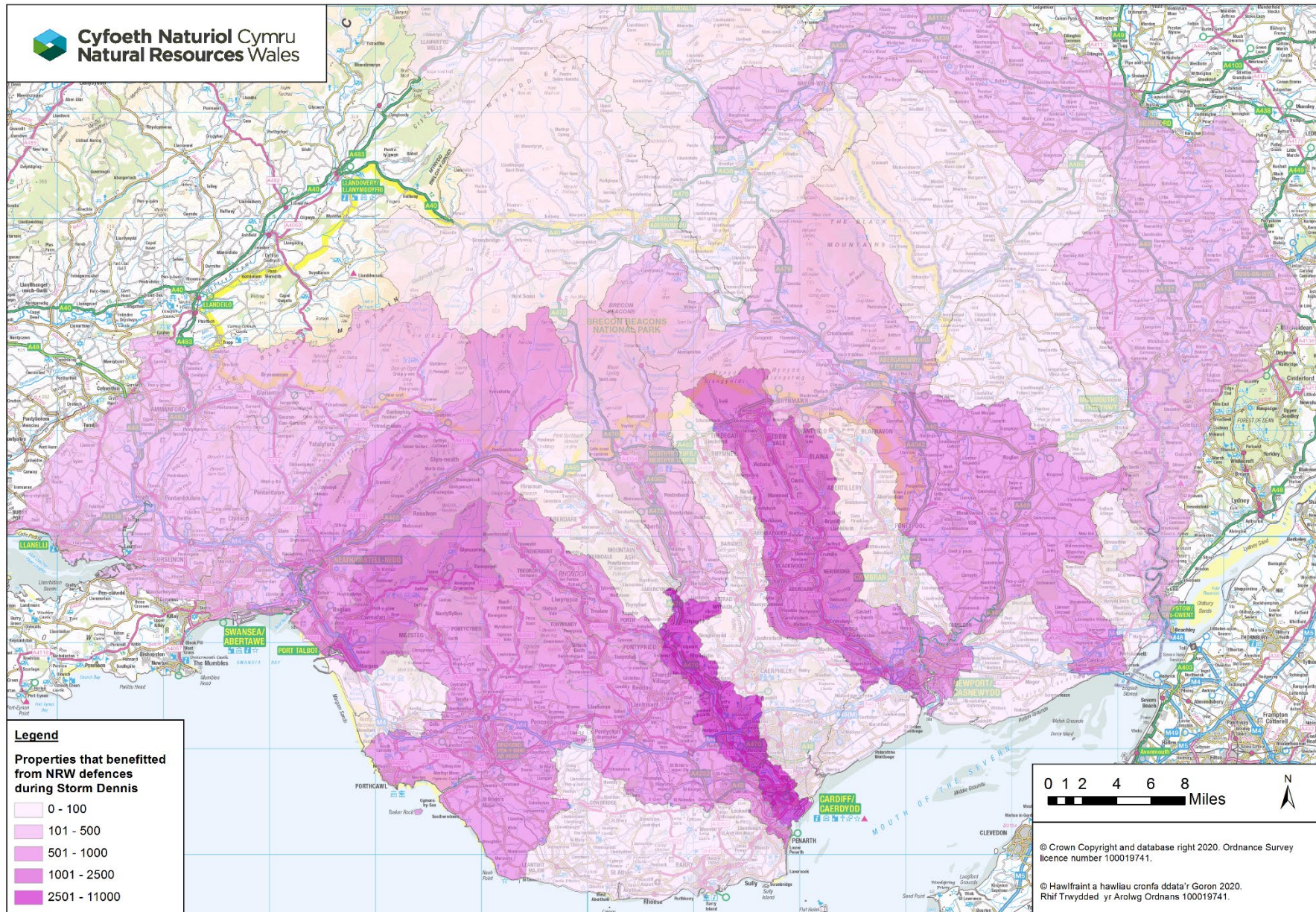


Figure 24 – Properties that benefitted from NRW defences during Storm Dennis

Next steps and conclusions

The flooding events experienced across large parts of Wales in February 2020 were devastating for many communities, and in many cases, it will take months, if not years, to recover. It is an unwelcome reminder of the power of nature, and evidence from climate scientists suggests that we will see more extreme weather events in the future.

NRW is taking the events of February 2020, and the impact it has had on individuals and communities, extremely seriously. Flooding is traumatic and has long-term effects on people and communities, both physically and mentally.

NRW is progressing flood investigation work at a local scale, seeking to better understand and determine what happened and why. We will review what further work is possible to reduce the risk of the impacts of the February 2020 floods happening again.

Local Authorities in Wales, where relevant, will produce Section 19 reports under the Flood and Water Management Act (2010)⁵. This legislation requires Local Authorities to investigate the causes of flooding in their authorities. NRW is working with Local Authorities to make these as effective as possible. These reports will conclude local investigations into flooding that occurred and will potentially determine further action for the relevant Risk Management Authorities.

After every significant flood incident, NRW carries out recovery and review work to ensure that our organisation is not only ready to respond to the next event when it occurs, but that we learn lessons and continue to improve our service. Following the events of February 2020, NRW has been undertaking substantial recovery works. This includes 2,241 inspections of flood defences which have resulted in 77 planned repairs to those impacted by the floods.

NRW is also undertaking a thorough performance review of its systems, procedures, tools and ways of working to identify potential areas for improvements. This will heavily focus on the operation of the Flood Warning Service, our operational response, and our work immediately after the events such as recovery work. It will also cover the performance of our communications and ICT services. We know there are areas where our services were stretched, and where there were weaknesses and errors in systems. We need to learn from these and understand what we can do to lessen the chances of this happening again.

The rainfall distribution highlighted by this report also demonstrates the highly specific areas which received extreme amounts of rainfall in different storm events, reinforcing that this can happen in any community. The geography of Wales means that a significantly different set of communities would have been impacted if the rainfall had fallen, say, ten miles in a different direction.

These are some of the challenges that Wales faces. NRW, alongside other Risk Management Authorities and professional partners, will continue to invest in people, technology, infrastructure, systems and processes to undertake flood risk management.

⁵ Flood and Water Management Act 2010, c.29. Available at: <http://www.legislation.gov.uk/ukpga/2010/29/section/19> (Accessed: 12 June 2020).

However, the impact of climate change is something that will require all of us to think collectively about our response and the need for adaptation in order to cope with the challenges of the future.