

## **07 – OPW RESPONSE TO THE WINTER 2015/2016 FLOODING IN IRELAND**

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### **Abstract**

During the winter of 2015/2016 Ireland experienced exceptional and widespread flooding. All Met Éireann synoptic weather stations reported rainfall amounts that were well above their Long Term Average (LTA) for December and most reported double or triple their normal rainfall for the month. Some of the largest flood events occurred between 6<sup>th</sup> and 13<sup>th</sup> December, predominantly in the West and North-west of the country. In other areas, the largest events occurred between 29<sup>th</sup> December and 6<sup>th</sup> January. The OPW have prepared a report on their overall response to the floods of winter 2015/2016. The report briefly describes the meteorological situation that led to the flood emergency and the resulting hydrological situation at a reference network of river gauges throughout the country. The locations where flooding impacted most are discussed, together with the important work carried out by the OPW during the floods. This paper summarises the main content of the report.

### **1. INTRODUCTION AND BACKGROUND**

The Office of Public Works (OPW) is the lead agency for flood risk management in Ireland, and whilst the OPW does not have a formal role in responding to flood emergencies under the Major Emergency Management Framework, it does provide assistance to the flood response effort when and where possible. The purpose of this paper is to outline the activities of the OPW in support of the overall response to the widespread floods of winter 2015/2016, and to describe the associated hydrological situation.

### **2. METEOROLOGICAL SITUATION OF WINTER 2015/2016**

During the winter of 2015/2016, Ireland experienced exceptional and widespread flooding. All Met Éireann synoptic weather stations reported rainfall amounts that were well above their Long Term Average (LTA) for December and most reported double or triple their normal rainfall for the month. Wettest conditions were in county Cork where nearly all stations reported over 300% of LTA. Other counties with more than 240% of LTA in December included: Carlow, Westmeath, Mayo, Cavan, Dublin, Wexford, Galway and Roscommon (*source: Met Éireann*).

Six storms also affected Ireland in November and December: Abigail on 12 November, Barney on 17 November, Clodagh on 29 November, Desmond on 4/5 December, Eva on 23 December and Frank on 29/30 December. The most significant of these for flooding were Abigail, Desmond and Frank.

## 2. HYDROMETRIC SITUATION OF WINTER 2015/2016

Some of the largest flood events occurred between 6 and 13 December, mainly in the West and North-west of the country. In other areas, the largest events occurred between 29 December and 5 January. Many OPW surface water gauging stations in Ireland registered their highest levels on record during these periods. The floods of winter 2015/2016 were believed by many to be the worst on record. To assess this further, a reference network of 75 water level gauges in Ireland was examined to see where flood levels exceeded their highest on record. The constituent gauging stations in the reference network were chosen because of the quality of data at those sites, and also because of the uniform spatial distribution of the gauges. The first flood events of the winter 2015/2016 period were witnessed in the North-West on 15 November 2015 and the last flood peaks occurred on 5 January 2016 along the middle and lower Shannon. As a result, the country was in a state of sustained flood emergency for almost two months.

### 2.1 Highest Recorded Levels on the Reference Network

The following tables illustrate the water levels to Ordnance Datum (mOD) recorded at the 75 gauging stations around the country. In total, 37 of these stations (representing half of the stations) in the network registered their highest flood on record during the winter of 2015/2016. These large events were not confined to one area, but were spread uniformly across the country. The locations where the highest floods on record occurred are shown in Table 2.1.

*Table 2.1 OPW Gauges that Recorded their Highest Water Level on Record*

Station No.	Station Name	River	County	Date	Peak Level [mOD]*
39001	New Mills	Swilly	Donegal	15/11/2015	23.08
35028	New Bridge	Bonet	Leitrim	15/11/2015	53.24
23012	Ballymullen	Lee	Kerry	05/12/2015	6.72
34007	Ballycarroon	Deel (Crossmolina)	Mayo	05/12/2015	26.53
22016	Old Weir Bridge	Long Range	Kerry	05/12/2015	25.16
35002	Billa Bridge	Owenbeg	Sligo	05/12/2015	49.76

01041	Sandy Mills	Deele	Donegal	05/12/2015	10.44
35005	Ballysadare	Ballysadare	Sligo	06/12/2015	24.85
26001	Ballinamore	Shiven	Galway	06/12/2015	50.74
35071	Lareen	Lough Melvin	Leitrim	06/12/2015	30.49
29007	Craughwell	Dunkellin	Galway	06/12/2015	22.46
22035	Laune Bridge	Laune	Kerry	06/12/2015	22.75
30005	Foxhill	Robe	Mayo	07/12/2015	31.94
34001	Rahans	Moy	Mayo	07/12/2015	5.45
30007	Ballygaddy	Clare	Galway	07/12/2015	35.26
35001	Ballynacarrow	Owenmore	Sligo	07/12/2015	57.03
34083	Corryosla	Lough Conn	Mayo	10/12/2015	14.10
25001	Annacotty	Mulkear	Limerick	12/12/2015	14.30
22009	White Bridge	Deenagh (Laune)	Kerry	29/12/2015	24.39
18055	Mallow Railway Br.	Munster Blackwater	Cork	30/12/2015	50.14
18107	Fermoy Bridge d/s	Munster Blackwater	Cork	30/12/2015	26.63
15002	John's Bridge	Nore	Kilkenny	30/12/2015	46.32
16011	Clonmel	Suir	Tipperary	30/12/2015	20.92
15006	Brownsbarn	Nore	Kilkenny	30/12/2015	11.21
16062	Carrick-on-Suir	Suir estuary	Tipperary	30/12/2015	6.21
14001	Carlow	Barrow	Carlow	30/12/2015	49.30
14029	Graiguenamanagh u/s	Barrow	Carlow	30/12/2015	14.49
26021	Ballymahon	Inny	Longford	30/12/2015	47.36
18002	Ballyduff	Munster Blackwater	Waterford	31/12/2015	13.97
30084	Cong Pier	Lough Corrib	Mayo	31/12/2015	9.97
07001	Tremblestown	Tremblestown	Meath	31/12/2015	60.49
25006	Ferbane	Brosna	Offaly	02/01/2016	45.41
25056	Meelick Weir U/S	Shannon	Offaly	04/01/2016	36.21
25017	Banagher	Shannon	Offaly	05/01/2016	37.64
26027	Athlone	Shannon	Westmeath	05/01/2016	39.12
26028	Shannonbridge	Shannon	Offaly	05/01/2016	38.77
26088	Hodson's Bay	Lough Ree	Roscommon	05/01/2016	39.77

## 2.2 Second Highest Recorded Levels on the Reference Network

At 23 stations from the reference network (a third of those examined) the second highest flood on record was observed during winter 2015/2016. As was the case with the highest levels on record, these were spread uniformly across the country. The locations where these second highest floods on record occurred are shown in Table 2.2.

**Table 2.2:** OPW Gauges that Recorded their Second Highest Water Level on Record

Station No.	Station Name	River	County	Date	Peak Level Recorded [mOD]*
27001	Inch Bridge	Claureen	Clare	05/12/2015	14.07
38001	Clonconwal	Owenea	Donegal	05/12/2015	29.52
03058	Cappog Bridge	Blackwater	Monaghan	05/12/2015	61.04
26007	Bellagill	Suck	Roscommon	07/12/2015	43.19

29004	Clarinbridge	Clarinbridge	Galway	08/12/2015	6.87
26108	Boyle Abbey Bridge	Boyle (Shannon)	Roscommon	10/12/2015	52.93
26074	Blackrock Lock	Lough Allen	Leitrim	10/12/2015	50.59
25309	Clonsingle Bridge	Annagh	Tipperary	12/12/2015	37.84
25004	New Bridge	Bilboa	Limerick	12/12/2015	51.80
25308	Waterpark Bridge	Newport	Limerick	12/12/2015	36.61
27066	Ennis Bridge	Fergus estuary	Clare	12/12/2015	6.25
25012	Groody Bridge	Groody	Limerick	13/12/2015	9.00
27002	Ballycorey	Fergus	Clare	13/12/2015	9.53
26324	Carrick-on-Shannon	Shannon	Leitrim	13/12/2015	45.02
18003	Killavullen	Munster Blackwater	Cork	30/12/2015	41.69
20001	Bandon	Bandon	Cork	30/12/2015	17.43
20002	Curranure	Bandon	Cork	30/12/2015	9.83
12002	Enniscorthy	Slaney	Wexford	30/12/2015	7.21
07010	Liscartan	Blackwater (Kells)	Meath	31/12/2015	41.09
36010	Butler's Bridge	Annalee (Erne)	Cavan	31/12/2015	53.80
14018	Royal Oak	Barrow	Carlow	31/12/2015	36.84
36019	Belturbet	Erne	Cavan	02/01/2016	49.51
14019	Levistown	Barrow	Kildare	03/01/2016	53.64

\*Levels rounded to 2-decimal places

### 2.3 Third Highest Recorded Levels on the Reference Network

At 12 stations from the reference network (a sixth of those examined) the third highest flood on record was observed during winter 2015/2016. The locations where these second highest floods on record occurred are shown in Table 2.3.

**Table 2.3: OPW Gauges that Recorded their Third Highest Water Level on Record**

Station No.	Station Name	River	County	Date	Peak Level Recorded [mOD]
01043	Ballybofey	Finn	Donegal	15/11/2015	21.75
01042	Dreenan	Finn	Donegal	05/12/2015	19.01
22006	Flesk Bridge	Flesk (Laune)	Kerry	05/12/2015	27.24
03055	Glaslough	Mountain Water	Monaghan	05/12/2015	39.00
28001	Ennistymon	Inagh	Clare	06/12/2015	22.24
35011	Dromahair	Bonet	Leitrim	06/12/2015	25.13
26008	Johnston's Bridge	Rinn (Shannon)	Leitrim	07/12/2015	42.74
30004	Corrofin	Clare	Galway	08/12/2015	29.49
12001	Scarawalsh	Slaney	Wexford	30/12/2015	12.06
07009	Navan Weir	Boyne	Meath	30/12/2015	35.77
16009	Cahir Park	Suir	Tipperary	31/12/2015	40.30
07005	Trim	Boyne	Meath	31/12/2015	56.08

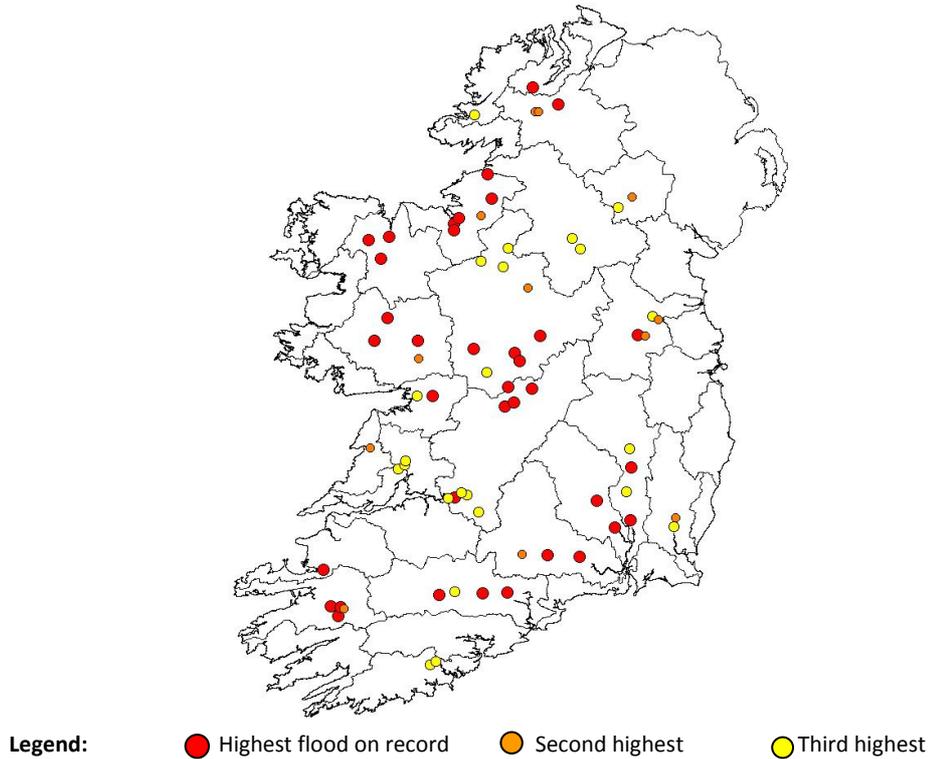
\*Levels rounded to 2-decimal places

In summary, of the OPW reference network of gauging stations, 72 of the 75 stations experienced either their highest, second highest or third highest levels on record. As it

currently stands, November 2009 remains the highest flood levels at only 13 gauging stations. This confirms that the floods of winter 2015/2016 are ahead of those of November 2009 in terms of flood severity and duration.

#### 2.4 Spatial Distribution of Flood Peaks in Winter 2015/2016

The floods of winter 2015/2016 were widespread with very few counties experiencing no flood events, as can be seen in Figure 2.1.

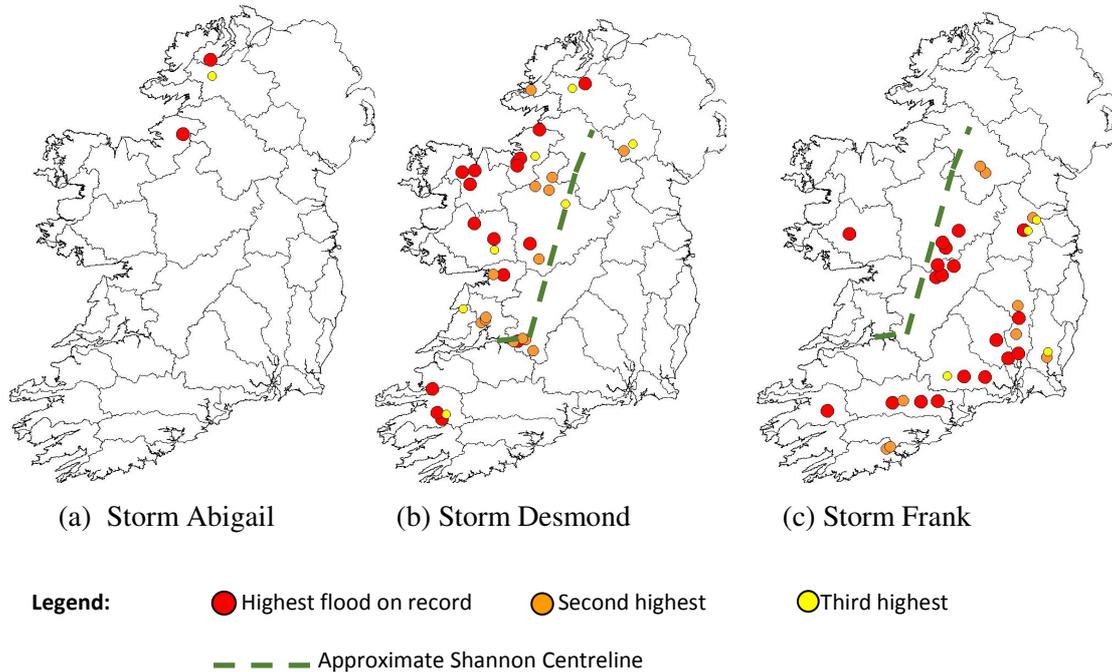


*Figure 2.1 Spatial distribution of the winter 2015/2016 flood events*

#### 2.5 Flood Peaks Following Storms Abigail, Desmond and Frank

The information presented in Figure 2.1 was further examined to see what areas were affected by each of the winter storms, Abigail (12 November 2015), Desmond (4/5 December 2015) and Frank (29/30 December 2015). When the spatial distribution of the highest flood events following each storm is examined (see Figure 2.2), a clear pattern emerges. Storm Abigail was concentrated on the north-west counties, especially in Donegal and Sligo, and that was where the resulting flood peaks were experienced. Storm Desmond contributed to flooding primarily to west of the Shannon, while Storm Frank contributed to flooding east and south-east of the Shannon and along the Shannon. A number of major flood events were experienced in the south-east of the country with the Nore, Suir, Barrow, and Slaney catchments worst affected. The Shannon reached its highest recorded levels at Hodson's Bay,

Athlone, Shannonbridge, and Banagher on 5 January 2016, and at Meelick Weir on the previous day.



*Figure 2.2 Flood events in the aftermath of Storms Abigail, Desmond and Frank*

## 2.6 Locations Flooded

During winter 2015/2016, numerous locations throughout the country experienced flooding. These locations include those listed in Table 2.4 together with the dates on which flooding was first reported. Some towns were affected by flooding on two occasions. Bandon, Co. Cork was one such location. It flooded on 5 December 2015, and was again flooded on 3 January 2016. Other locations experienced sustained flooding which started in early December and persisted into early January. Athlone, Shannonbridge, Portumna, Castleconnell, Montpelier, Springfield and Annacotty are examples of where the flood levels remained high through December 2015 and into January 2016. It is estimated that approximately 550 houses were flooded during winter 2015/2016 (*source: DECLG*). Without the co-ordinated and effective response effort, a great many more homes and businesses would have flooded.

**Table 2.4** *Flooded Locations with Date of Initial Reports of Flooding*

<b>Location of Flooding</b>	<b>County</b>	<b>Date of Initial Reports of Flooding</b>
Bandon	Cork	05/12/2015 and 30/12/2015
Athlone	Westmeath	05/12/2015
Crossmolina	Mayo	05/12/2015
Castlefinn	Donegal	05/12/2015
Ballybofey	Donegal	05/12/2015
Ballinasloe	Galway	05/12/2015 and 05/01/2016
Claregalway	Galway	05/12/2015
Portumna	Galway	05/12/2015
Ennis	Clare	05/12/2015
Feakle	Clare	05/12/2015
Killarney	Kerry	05/12/2015
Athleague	Roscommon	06/12/2015
Craughwell	Galway	06/12/2015
Galway City	Galway	06/12/2015 and 02/01/2016
Foxford	Mayo	07/12/2015
Monaghan	Monaghan	07/12/2015
Montpelier	Limerick	09/12/2015 and 05/01/2016
Castleconnell	Limerick	09/12/2015
Annacotty	Limerick	13/12/2015
Corbally	Limerick	13/12/2015
Shannonbridge	Offaly	15/12/2015
Carrick-on-Shannon	Leitrim	16/12/2015
Springfield	Clare	28/12/2015
Dundalk	Louth	28/12/2015
Graiguenamanagh	Kilkenny	29/12/2015
Thomastown	Kilkenny	29/12/2015
Inistioge	Kilkenny	29/12/2015
Clonmel	Tipperary	29/12/2015
Fermoy	Cork	30/12/2015
Mallow	Cork	30/12/2015
Enniscorthy	Wexford	30/12/2015
Cavan	Cavan	28/12/2015

### **3. FORECASTING AND ONGOING MONITORING OF THE FLOOD SITUATION**

#### **3.1 Flood Notifications from the European Flood Awareness System (EFAS)**

Following the devastating floods in Europe in 2002 the European Commission (EC) began the development of a European Flood Awareness System (EFAS) for improving and increasing preparedness for fluvial floods across Europe. EFAS provides complementary, added value information to national hydrological services, however it is not considered to be a replacement for a national flood forecasting service. For further information on EFAS refer to the following url: <https://www.efas.eu/about-efas.html>. In 2010, the OPW became the EFAS Partner for Ireland.

From 3 December 2015 to 6 January 2016, a total of 19 Flood Notifications for Ireland were issued from EFAS. These comprised three EFAS Formal Flood Notifications, seven Informal

Flood Notifications and nine Flash Flood Notifications and details of these notifications are provided in Table 3.1.

A Formal Flood Notification is issued by the EFAS team when the following criteria are satisfied:

- There is a high probability of exceeding the 5-year return period flood threshold
- The forecast is for greater than 2 days ahead
- The river catchment has a minimum upstream area of more than 2,000 km<sup>2</sup>, and
- The forecast is persistent

An Informal Flood Notification is issued by the EFAS team when the probability of exceeding the 5-year return period flood threshold is forecast in a river basin but the forecast event does not satisfy the rules of a Formal Flood Notification (e.g. regarding lead time, size of river basin, or location of event). An Informal Flood Notification can also be issued if EFAS forecasts are not conclusive but one of the multiple forecasts indicates a risk of severe flooding. A Flash Flood Notification is issued by the EFAS team when the probability of exceeding a 20-year return period (magnitude of the surface runoff index) is forecasted to be greater than 35% and the forecast start of the event is less than 72 hours.

**Table 3.1:** EFAS Flood Notifications issued for Ireland winter 2015/2016

<b>Formal Flood Notifications</b>	
<b>Date Issued</b>	<b>Basin/River Catchment</b>
03/12/2015	Clare and Moy
03/12/2015	Shannon
29/12/2015	Erne
<b>Informal Flood Notifications</b>	
<b>Date Issued</b>	<b>Basin/River Catchment</b>
04/12/2015	Erne
26/12/2015	Suir & Barrow
27/12/2015	Munster Blackwater
27/12/2015	Slaney
28/12/2015	Clare
28/12/2015	Moy
29/12/2015	Liffey
<b>Flash Flood Notifications</b>	
<b>Date Issued</b>	<b>Region(s)</b>
03/12/2015	Border, West
11/12/2015	West
12/12/2015	Mid-West, South-East
12/12/2015	South-West
27/12/2015	Mid-West, South-East, South-West
28/12/2015	South-East, South-West, West
29/12/2015	Border, Mid-East
01/01/2016	South-East
06/01/2016	Border

### 3.2 Dissemination of EFAS Flood Notifications

EFAS Flood Notifications for Ireland are issued by the EFAS Dissemination Centre in the Netherlands, which is operated by the Dutch Ministry of Infrastructure and the Environment (Rijkswaterstaat). The EFAS Flood Notifications are sent by email to partner organisations in respective member states where flooding is forecast. In Ireland the organisations who receive EFAS Flood Notifications directly are the OPW and Met Éireann and both organisations have been provided with passcodes by the EFAS team to allow them to directly access and view ongoing EFAS forecasts. When EFAS Formal Flood Notifications are received by the OPW, they are promptly disseminated (via automatic email re-direct) to the Local Authorities, ESB, National Directorate for Fire and Emergency Management and other relevant stakeholders. During the floods of winter 2015/2016 the OPW carefully monitored EFAS forecasts on an almost daily basis and provided regular update reports of these forecasts to the Local Authorities and other relevant stakeholders.

### **3.3 Waterlevel.ie**

The OPW Hydrometric Section provides access to real time water level information for all the main river catchments through the <http://waterlevel.ie> web portal. Data is drawn from OPW hydrometric monitoring stations at c.390 river, lake and tidal locations nationwide. Water level data is recorded at 15 minute intervals and updated in real time for the majority of these stations. During the severe floods of winter 2015/2016, the web portal proved critical for the monitoring of water levels and for aiding the response to, and management of, these severe floods. The web portal was widely used by the OPW, Local Authorities, Waterways Ireland, ESB, EPA, the public and the media as a source of information on the severity of flooding nationwide. In the period from 3 December 2015 to 4 January 2016 there were 106,086 visits recorded on this portal and an average of 23,206 visits per week. In comparison, the average number of weekly visits recorded during December 2014 and November 2015 were 1,953 and 3,232, respectively. The OPW Hydrometric Section also provided access to archive hydrometric data via the [www.opw.ie/hydro-data](http://www.opw.ie/hydro-data) web portal. This portal has recently been upgraded and is now integrated with the OPW hydrometric archive to enable near real time update of water level and river flow data. This portal provides standard data types such as station meta-data, mapping, instantaneous data, sub-daily data series, summary statistics, and annual maxima series.

## **4. OPW PARTICIPATION IN THE NATIONAL COORDINATION GROUP**

#### **4.1 Convening the National Coordination Group**

The first EFAS Formal Flood Notification was issued on 3 December 2015. This was promptly disseminated to the National Directorate for Fire and Emergency Management (NDFEM), and following this, a meeting of a sub-group of the National Coordination Group (NCG) took place to discuss the situation. This meeting was attended by OPW staff amongst others, and based on the then EFAS and meteorological forecasts, it was decided to convene further meetings with all NCG members commencing on 7 December 2015. During the period of the flood emergency, updates on an almost daily basis were provided by the OPW to the NCG. At these meetings, an OPW representative (from Hydrology and Coastal Section) briefed the group on the current and ongoing flood forecast situation based on EFAS forecasts. These briefings also included details of the EFAS flash flood forecasts, which provided some useful short range flood forecasting capability. The OPW briefings to the NCG also included updates of water levels across the OPW hydrometric gauge network (via *waterlevel.ie* website) which indicated whether water levels were either rising or falling and their respective rates of rise or fall. The briefings from the OPW were also used in official press releases and statements issued by the NCG. The OPW representative also provided regular (almost daily) verbal updates to the media during the press conferences that immediately followed NCG meetings.

#### **4.2 Communication with Government and the Public**

The OPW Engineering Services staff undertook a substantial amount of work and effort in briefing the Taoiseach and Ministers and keeping the government fully informed of ongoing developments and actions being taken generally, on a whole-of-government basis regarding flood risk management (e.g. Two Memos for the Government were submitted on 5 and 26 January), and also in briefing and dealing with elected national and local representatives as well as the public intensively throughout the flood emergency situation. The OPW also briefed and communicated extensively with the various media throughout this period.

### **5. FLOOD EVENT MAPPING**

#### **5.1 Copernicus Emergency Mapping Service**

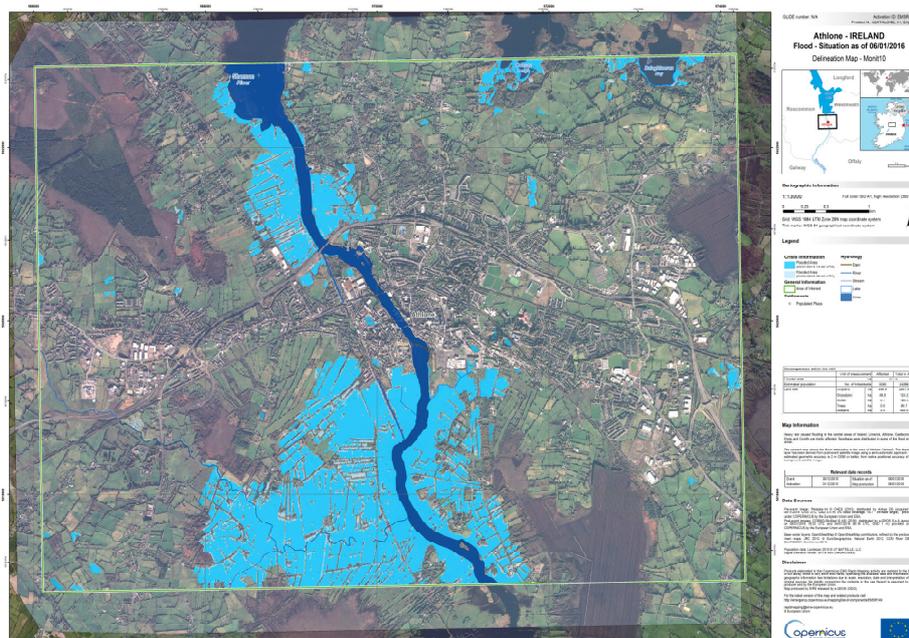
The Copernicus Emergency Management Service (Copernicus EMS) is part of the European Union's earth observation programme. The service provides those involved in the management of natural disasters, man-made emergency situations, and humanitarian crises with timely and accurate geo-spatial information derived from satellite remote sensing and completed by available in situ or open data sources. The service started operations in April

2012 and is implemented by the European Commission DG Joint Research Centre (JRC). For further service details refer to: *emergency.copernicus.eu*.

The rapid mapping component of this service, Copernicus EMS - Rapid Mapping, was activated during the floods of winter 2015/2016 by the National Directorate for Fire and Emergency Management. This service activation was assisted by the OPW who identified target areas for the generation of rapid flood event delineation maps together with the timing of some of the activations. There were two main activations requested of the service. The first (*EMSR:149 Flood in Ireland*) was on 8 December 2015 and initially focused on Carrick-on-Shannon, Athlone and Limerick but was subsequently extended to also include: Ballinasloe, Belturbet, Castleconnell, Claremorris, Corofin, Ennis, Enniscorthy, Gort, Portumna and Roscommon. The outputs from this service comprised 107 flood delineation maps, all of which may be accessed on the Copernicus EMS web portal using the following url: <http://emergency.copernicus.eu/mapping/list-of-components/EMSR149>. There was also a second activation (*EMSR:154 Flood in Roscommon*) on 5 February 2016. An example of one such rapid flood delineation map supplied by the Copernicus EMS - Rapid Mapping service is shown in Figure 5.1.

## **5.2 Use of Copernicus EMS – Rapid Mapping**

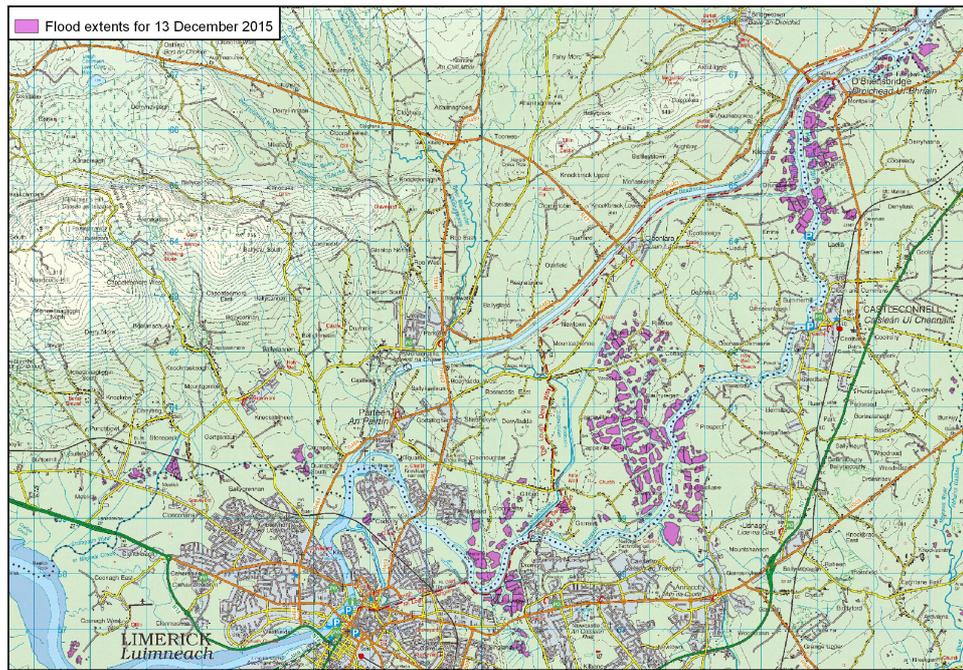
The Copernicus EMS flood delineation maps were closely monitored by the OPW during the flood emergency and proved very useful for indicating the scale of the evolving flood extents and whether the flood extents were increasing or decreasing. This information was used by the OPW during the NCG briefings. In the context of the Catchment Flood Risk Assessment and Management (CFRAM) Programme, the OPW and its engineering consultants are also reviewing these Copernicus EMS flood delineation maps as they may assist with validation of the CFRAM predictive flood maps and/or inform the associated Flood Risk Management Plans (FRMPs) that are to be published later this year.



**Figure 5.1:** Flood delineation map of Athlone on 6 January 2016 (Source: Copernicus EMS - Rapid Mapping Service, with flooded areas shown in blue)

### 5.3 Sentinel-1 Flood Event Mapping

Following the flood emergency, the OPW, in conjunction with consultants, investigated a range of remote sensing methods for deriving recent flood event maps throughout Ireland. The optimum method selected was to use data from the Copernicus Sentinel-1 satellite that was launched by the European Space Agency (ESA) in April 2014. This satellite carries an advanced Synthetic Aperture Radar (SAR) instrument which is ideal for sensing flooded areas during day-and-night and in all-weather conditions. Despite its relatively short operating period, Sentinel-1 represents the most comprehensive source of SAR data for Ireland. The Sentinel-1 data, which is freely available, offers an important new capability to observe and monitor flooding events in Ireland (and globally) at a range of spatial scales (local, regional and national) which has not previously been feasible. A number of the Copernicus Sentinel-1 datasets were selected by the OPW on five dates over one month, from 6 December 2015 to 6 January 2016, to produce indicative extent maps of the flood events which occurred at these times. A sample of one of these indicative flood event maps is shown in Figure 5.2. This work is being used to assess the application of the Sentinel-1 data for the derivation of flood event mapping and thereby post flood event monitoring and recording applications.



**Figure 5.2:** Flood event map of Limerick on 13 December 2015 (Source: OPW, derived from Sentinel-1 Satellite Data, with flooded areas shown in purple)

## 6. OPW AERIAL PHOTOGRAPHY

### 6.1 OPW Aerial Photographic Survey with the Air Corps

In early December 2015, the OPW requested assistance from the Air Corps to acquire aerial photography of the flooding around the country. The locations that were captured in these aerial photographic surveys are shown in Table 6.1.

**Table 6.1:** OPW Aerial Photographic Survey Locations, Numbers and Dates

Locations	No. of Photographs	Date of Survey
Along the Clare River	247	7-Dec-15
Headford, Claregalway, Clarinbridge, Kilcolgan, Craughwell, Shannonbridge, Ballinasloe, Ballyforan, Headford	399	8-Dec-15
South Galway	70	9-Dec-15
Athlone, Dromod, Carrick on Shannon, Boyle, Shannonbridge, Banagher	964	10-Dec-15
Shannon Harbour, Banagher, Shannon East bank to Lough Derg, Lough Derg West bank, Castleconnell and Castletroy	827	11-Dec-15
Athlone, Lanesboro, Ballymahon, Shannonbridge, Banagher, Shannon East bank to and including Limerick	896	16-Dec-15
Gort Area and Lower River Brosna	605	5-Jan-16
Athlone, Clara, Ferbane, Shannon Harbour, Banagher, Portumna, Scarriff, Gort, Ardrahan, Craughwell and Ballinasloe (rural area)	888	5-Jan-16

The first flight was undertaken on 7 December which coincided approximately with the time of peak flooding in the upper Shannon Catchment. OPW staff accompanied the Air Corps on a number of flights in the weeks that followed, and recorded over 4,800 aerial photographs of flooded areas. The OPW has geo-referenced this aerial photography and has submitted much of it to the Copernicus team to assist them with the validation of the rapid mapping that was issued under the activations referenced in Section 5.1. This validation exercise should help to further improve the Copernicus EMS - Rapid Mapping service during future such emergency situations.

## **6.2 OPW Drone Aerial Photography Survey**

The Annagh embankments, part of the river Inny Arterial Drainage Scheme, are located on the shores of Lough Ree on the border between Westmeath and Longford. These embankments were erected to assist in improving agricultural productivity. Water is pumped from the area behind the embankments. The embankments also protect the access route to a number of houses. In early December 2015, a breach occurred on a section of these embankments which resulted in the area normally protected by this section of embankment being flooded. The OPW commissioned a drone survey on 16 December to record aerial photography of the areas that were flooded as a result of this breach. A sample of this aerial photography is shown in Figure 6.1.



*Figure 6.1: Aerial Photography Recorded by Drone Survey on 16 December 2015 (Source: OPW)*

## **7 OPW REGIONAL AND LOCAL ACTIVITIES**

### **7.1 Activities Undertaken by OPW Regional Staff**

The OPW is responsible for the maintenance of arterial drainage schemes completed under the Arterial Drainage Acts 1945 and 1995. From early December, both in the context of its statutory maintenance responsibilities and in support of the primary response agencies, the following work was carried out by the OPW regional offices:

- Repair of a breach in an OPW embankment at Annagh, Co. Longford.
- Erection of demountable defences.
- Repair of storm damage to a sea defence.
- Deployment and maintenance of pumps, tractors and excavators.
- Provision and placing of sandbags around houses (individual and groups).
- Removal of debris from bridges and cleaning of grids.

Where such work was outside of OPW scheme locations it was carried out at the behest of the relevant local authority (LA), who have the lead role in flood emergency response, and the OPW resources and equipment was made available to the LAs on a first come first served basis. During this emergency work, a number of seasonal staff were employed to augment the OPW resources on the ground. Regional updates were also provided in support of the OPW briefings to the NCG.

OPW regional staff were available on a full time basis to liaise, and deal with requests from elected representatives referred via the Office of the Minister of State. Both the President and the Minister of State were accompanied to a number of locations that flooded. For preliminary investigation purposes staff also visited a number of flooded areas (other than the locations listed in Table 7.1).

OPW regional staff provided data and expertise to Cork County Council to assist decision making on the flood warning system in Mallow. Assistance was also provided to a team in Fermoy dealing with the mobilisation and erection of flood barriers, as this was the first time these defences were deployed to this particular level. Though the Arterial Drainage schemes were not primarily designed to provide flood relief to property it is noteworthy that there was a very low incidence of property flooding in those catchments where these schemes are being maintained by the OPW.

During the floods of winter 2015/2016 the OPW worked in co-operation with the local authorities and other primary response agencies to provide support where possible. Arising from these events the OPW regional offices and depots deployed resources, both staff and equipment, at the following locations:

**Table 7.1:** Locations where OPW provided staff and equipment in winter 2015/2016

Athlone, Co. Westmeath	Claregalway, Co. Galway	Leban, Co. Galway
Ballina, Co. Mayo	Cloghaunaninchy, Co. Clare	Listowel, Co. Kerry
Ballinasloe, Co. Galway	Craughwell, Co. Galway	Lixnaw, Co. Kerry
Ballinastague, Co. Galway	Crossmolina, Co. Mayo	Meelick, Co. Clare
Ballyfree, Co. Sligo	Ennis, Co. Clare	Rathbraughan, Co. Sligo
Caherglassaun, Co. Galway	Fermoy, Co. Cork	Roo, Co. Galway
Caherlea - Lisheenavalla, Co. Galway	Foxford, Co. Mayo	Sixmilebridge, Co. Clare
Cahermore, Co. Galway	Gort, Co. Galway	Skehanagh, Co. Galway
Carnmore Cashla, Co. Galway	Grannagh, Co. Galway	Tuam – Gardenfield, Co. Galway
Carraroe, Co. Sligo	Kiltartan, Co. Galway	

It should also be noted that the Hydrometric Section of the OPW undertook a large amount of work in response to the floods of winter 2015/2016:

The constantly monitored hydrometric data dissemination web portals <http://waterlevel.ie> (real-time water level data) and [www.opw.ie/hydro-data](http://www.opw.ie/hydro-data) (near real-time and archive hydrometric data, water level and flow) for continuity of data provision service and to detect instances of monitoring station malfunction.

During the flood emergency, they ensured that the OPW hydrometric network (c.390 surface water stations and 63 rainfall stations) was maintained as far as possible, providing seven-day cover to ensure continuous and uninterrupted supply of hydrometric data to the [www.waterlevel.ie](http://www.waterlevel.ie) web portal and Flood Early Warning Systems (FEWS) for Clonmel, Mallow and Fermoy, and the Local Authority flood alert system for Bandon. Attended to monitoring station malfunctions as they arose implementing temporary or alternative monitoring arrangements where required.

Undertook flow measurement activities at monitoring stations nationwide during flood conditions to further define and establish the stage-discharge relationship or rating. This was done at numerous locations, in particular at Cahermore (near Kinvarra) to assist Galway County Council in the assessment of the effectiveness of locally driven temporary flood relief measures, and at Claregalway to assess the effectiveness of OPW flood relief measures. They also provided hydrometric information in response to data requests and enquiries from internal and external sources and reported on the severity of the events.

### **7.3 National Flood Forecasting and Warning Service**

During the floods of winter 2015/2016, the OPW prepared a memorandum for government which included information on a proposed National Flood Forecasting and Warning Service (NFFWS). On 5 January 2016, the government decided to establish a National Flood Forecasting and Warning Service. This decision has provided the opportunity to proceed with a first stage of implementation of the service that will involve the following elements:

- Establishment of a National Flood Forecasting Service as a new operational unit within Met Éireann, and
- Establishment of an independent Oversight Unit within the Office of Public Works (OPW).

Given the complexities involved in establishing, designing, developing and testing this new service, it is anticipated that the first stage of the service will take 4-5 years before it is fully operational. In the interim existing flood forecasting systems and arrangements will continue to be maintained.

## CONCLUSIONS

The most important conclusion to be drawn from the flood events of winter 2015/2016 is that they were the worst on record. Out of the 75 gauging stations in the reference network, 37 gauges registered their highest flood levels since records began. In contrast, the flood levels of 2009 remain the highest on record in only 13 of these gauges. The geographical spread of the highest flood levels is also greater, with only three counties not reporting any widespread flooding.

In the many areas that did not possess a dedicated flood forecasting and warning capability, the only means of receiving forecasts was through EFAS. While EFAS has proven useful as a high level flood forecasting tool, it is only suitable for larger catchments (over 2,000 km<sup>2</sup>), and it is clear that a National Flood Forecasting Service is required to provide more accurate and site specific flood forecasts. In response to the government decision of the 5 January 2016, the government has set up a steering group to guide the development of the National Flood Forecasting and Warning Service.

Since the floods of winter 2015/2016, and based on lessons learned from that time, the OPW has sought to improve how information from EFAS can be accessed by Local Authorities in a more efficient manner. In this regard, the OPW has secured agreement from the EFAS team to provide direct access to the EFAS portal for all Local Authorities in Ireland. In April 2016, the OPW provided feedback to the EFAS team regarding the accuracy of EFAS forecasts during winter 2015/2016 in terms of their timing, magnitude and location so that future such forecasts might be improved.

At the meetings of the NCG, the OPW's [waterlevel.ie](http://waterlevel.ie) website was used to convey the existing flood situation, and information as to whether flood levels were rising or falling, and this was communicated to the media at the NCG media briefings.

The [waterlevel.ie](http://waterlevel.ie) website provides realtime water level information from almost 450 OPW gauges, and is freely available to the public. The OPW hydrometric section have reported that during the winter 2015/2016 floods there were very few data requests received from the public compared to 2009 when [waterlevel.ie](http://waterlevel.ie) was not in operation. This meant that hydrometric staff were freed up to gather useful information and spot gaugings at a number of river locations instead of dealing with data requests. As a result, a number rating curves at gauging stations have been improved which will lead to more accurate stream flow estimation at higher flows.

The winter of 2015/2016 was the first widespread activation of the Copernicus EMS in Ireland. The outputs from the Copernicus EMS are being used for a number of post event activities. The maps are being used to assess the extent of flood damage to land and properties in the aftermath of the flooding, and are clearly a valuable resource for Irish government departments. It is also being used in the CFRAM Programme to validate much of the predictive flood mapping that has been produced for the selected study areas. Furthermore, the outputs from the EMS are also being used as the main source of information for research in some of the third level Irish institutions. Seeing as the winter of 2015 was the first activation of the Copernicus EMS for Ireland, it is now clear that there may be further uses of the Copernicus EMS for flood related studies and research, in Ireland and that Ireland as a partner should encourage the further development of the service.

On a number of dates between 5 December 2015 and 5 January 2016 the OPW accompanied the Irish Air Corps on fly overs of some of the flooded areas around the country. The Aerial Photography captured in December 2015 and January 2016 proved useful in validating flood maps and satellite imagery taken during the floods. There were almost 6,000 images of the flooding captured in the west and along the Shannon during this time. The images that were captured by the OPW during the winter of 2015/2016 have been passed to the Copernicus Emergency Mapping Service to assist them in validating the outputs of their mapping. However, it is noted that this imagery was not georeferenced, and it is recommended that a clear system be put in place for that rapid capture of accurately georeferenced imagery for flood events.