Report

Workshop PLUVIAL FLOODS of EU-COM „Working Group Floods“

Berlin
4-5 Oct. 2016

German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

Version: 6th February 2017

Report

Content / structure

Abbreviations ..... **III**

Executive Summary ..... **V**

1 Introduction **1**

1.1. Background 1

1.2. Preparatory survey among the member states 1

1.3. Workshop objectives and structure 2

2 Report on Sessions **3**

2.1. Workshop opening and Introduction 3

2.2. Setting the scene 3

2.2.1. Review: The 2010 Cagliari Workshop 3

2.2.2. Recent activities regarding pluvial flood risk management of the WG F 5

2.2.3. Evaluation of pluvial flood risk management approaches in the MS 6

2.3. Theme 1: Heavy precipitation forecast and warning 8

2.3.1. Operational forecasting of flood extend in Slovenia 8

2.3.2. Current developments on heavy precipitation and flash flood forecasting, now-casting, and monitoring in EFAS 9

2.4. Theme 2: PFRA / Significance 10

2.4.1. Key findings of the questionnaire 10

2.4.2. The 1st Cycle Pluvial PFRA in Ireland 10

2.4.3. How can we determine probabilities of pluvial flood events? 11

2.4.4. Results of the break-out sessions (1) 13

2.4.5. Conclusions regarding PFRA / significance 15

2.5. Theme 3: Mapping 15

2.5.1. Key findings of the questionnaire 15

2.5.1. Surface water flood risk mapping in the UK – approaches and challenges 16

2.5.2. The Brussels approach of combined pluvial and fluvial mapping 18

2.5.3. Challenges for urban and rural mapping of pluvial flooding and mapping approaches to assist communication 19

2.5.4. Results of the break-out sessions (2) 20

2.6. Excurse: Modelling of pluvial flooding 21

3 Key findings and conclusions of the workshop **22**

APPENDICES

A. Workshop Programme

B. List of Workshop Delegates

Abbreviations

APSFR	Area of Potentially Significant Flood Risk
BMUB	German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
CCAdapt	Climate change adaptation
COM	European Commission
DTM	Digital Terrain Model
FD	Floods Directive
FF	Fluvial Flooding
FHM	Flood hazard map
FHRM	Flood hazard and risk maps
FRA	Flood Risk Assessment
FRI	Flood Risk Index
FRM	Flood risk map
FRMan	Flood risk management
FRMP	Flood Risk Management Plan
LAWA	German Working Group on water issues of the Federal States and the Federal Government
MKULNV	Ministry for Climate Protection, Environment, Agriculture, Conservation and Consumer Protection of the State of North Rhine-Westphalia
MSs	Member States
NRW	North Rhine-Westphalia
PF	Pluvial Flooding
PFHM	Pluvial Flood Hazard Map
PFRA	Preliminary Flood Risk Assessment
PFRM	Pluvial Flood Risk Map
WG F	EU-COM Working Group on Floods
WS	Workshop

Report data:

Workshop Organising Committee:	Clemens Neuhold (AT), Babro Näslund-Landenmark (SE), Mathieu Morel (FR), Christina Elms (UK), Luka Stravs (SI), Katharina Schwarz (DE)
Scientific support / editing:	INFRASTRUKTUR & UMWELT Professor Böhm und Partner (IU), Darmstadt und Potsdam (Germany)
Date:	15.12.2016
Drafting team:	Dr. Peter Heiland, Christian Gering (IU); Katharina Schwarz (BMUB); Input of: Corinna Baumgarten, Cindy Mathan (Umweltbundesamt DE), Darren Lambroso (HR Wallingford, GB), Harald Jendrike (Saxony, Germany)

Executive Summary

During the workshop several approaches on how to deal with pluvial flood risk taken by some EU member states or in some regions of EU member states for the 1st FD-cycle were introduced to the participants. The existing approaches that apply under the framework of the Floods Directive within the member states reflect different methods and philosophies depending on individual risk situations, data, capacities and legal framework. One remaining key question (throughout the workshop) is the proper definition of pluvial flooding and the specifications in opposite to other types of flood.

A questionnaire based survey in EU MSs before the workshop delivered a proper overview on experiences, good practise examples, bottlenecks and open questions regarding the 1st and 2nd FD cycle.[1] Results of the survey were presented as start-up for each thematic session. After the presentation of results and findings of the 2010 Cagliari workshop and the approaches on pluvial flood risk management in the 1st FD-cycle different examples on heavy rain forecasting strategies and methods were presented during the first thematic session.

The second session focused on dealing with pluvial flooding in the PFRA. A presentation from Ireland and Germany as well as the results of the questionnaire formed the basis for a deeper in detail discussion in smaller groups. Following results of the discussions were reported:

Is it possible to determine “Potential Pluvial Flood Risk Areas” in the PFRA or has pluvial flood risk more or less everywhere the same significance? What are proper significance criteria? How to deal with probabilities?

- The participant’s points of view were split whether pluvial flood risk is significant in the terms of PFRA (Art. 4/5 FD) or not. It was stated that areas of potentially significant pluvial flood risk cannot be determined reliably since pluvial flooding can happen everywhere and therefore the occurrence probability is very low. Hence, historic pluvial events are no proof for future events in the same place. At the same time pluvial flooding can cause high damage and even casualties, especially if it hits settlements or following disasters such as debris or landslides. Facing this, examples on how APSFR could be determined were presented by some member states. One important remaining question is how reliable these approaches are and which consequences might derive from this (including legal consequences if drastic events hit non-significant areas). This question was especially important for those MS, which implemented a legal framework following the identification of APSFR (and/or the according mapping)
- Return periods are an instrument for fluvial risk assessment and cannot be simply transferred to pluvial flooding.

[1] The response to the survey comprised 28 filled-in questionnaires from 22 member states.

- Some MSs stated that pluvial flood risk management should be considered outside of the fixed steps of the FD: Art. 4, 5 and 6 rather refer to fluvial flood risk areas and do not consequently reflect the needs of pluvial flood risk assessment. In this point no consensus was possible. It was agreed that a lot of measures for pluvial flood risk mitigation can be incorporated into flood risk management plans even without determining APSFR as many measures show a high synergy potential to fluvial flooding. Since pluvial flooding is a local phenomenon, there is a clear need for different approaches at different scales.
- Legal framework has to be considered: pluvial flood risk management is in local responsibility in most MS. Thus local approaches have to be in the focus of pluvial flood risk management. However the national framework and support was strongly recommended.
- The presented maps on national level were discussed in the light of the question if pluvial flood risk assessment does not call for a much more detailed level of data and modeling. Thus some MSs called for rather local than national approaches.

COM commented that some approaches of MSs have shown that pluvial flood risk has to be called significant in the light of PFRA. But at the same time COM agreed that uncertainties and missing reliability of the risk assessments are a great challenge. Consequently the FD provides a considerable flexibility for implementing best fitting solutions for the MSs – also for pluvial flooding with the PFRA and maps, if made transparent and if well documented.

The second session focused on pluvial flood hazard and risk mapping. Examples from UK and BE for different types of surfaces were presented. The main discussion results were:

Do we need different approaches for urban/rural maps on pluvial flooding? Should we have integrated maps for different types of floods? How to communicate the findings from mapping?

- The major difference is the required level of detail for all input data: for urban pluvial flood risk assessment e.g. a very detailed DTM is necessary (5 cm can decide whether a catastrophe occurs or not), as well as more detailed modelling parameters. For rural areas and for fluvial mapping the level of detail is different.
- Generally similar approaches can be used for urban and rural areas if specific assumptions are made: short and heavy rainfall is the decisive scenario for urban areas, longer duration for rural areas. Other parameters have to be adjusted to the specific situation.
- The integration of different types of flooding in one map is sometimes possible and helpful to present risk information in one place and with one communication strategy. However often the integration is not possible due to different responsibilities, different target groups or different legal consequences. E.g. in some MSs approved fluvial flood risk areas result in immediate building restrictions by water law while pluvial flood risk areas have different legal consequences.
- Communication of pluvial risk maps needs a different approach than communication of fluvial flood risk maps: regarding the uncertainties and especially focusing on activation of

individuals for precautionary measures the messages of pluvial flood risk management are slightly different.

- Publishing maps might not be sufficient. Proposals for individual actions can be combined with risk information in the communication strategies.

The 3rd session focused on modelling of pluvial floods. An approach from Spain was presented and discussed.

Germany as hosting country concluded as main workshop results that most member states agree on the need to improve pluvial flood risk management. Since the Cagliari workshop in 2010 some MSs developed approaches to deal with pluvial flood risk under the FD, other MSs are planning to do so during the 2nd cycle. It was agreed that pluvial flooding can be addressed under the FD, but not everything has to be done under the FD. Many MSs have delivered good examples for both approaches, planned or already in place. Some important questions which have also risen in Cagliari are still under discussion or even unsolved. It came out that especially for pluvial flood risk and hazard maps local approaches have to be developed to produce meaningful maps. The existing lack of historic data and the high amount of influential parameters (e.g. soil moisture, hard surface) are limiting factors in terms of accurate pluvial flood risk and hazard mapping. The insufficient accuracy of pluvial flood risk maps raises some problems especially for countries with legal obligations deriving from flood risk or hazard mapping.

1 Introduction

1.1. Background

During the last years pluvial flood events have hit many locations throughout Europe causing casualties, economic losses and damages to infrastructure. During the 1st cycle under the FD pluvial flooding as one specific type of flood was generally taken into account in flood risk management strategies of some EU member states, but the determination of the significance and the methods applied, depth and level of detail of pluvial flood risk management were quite different.

Referring to the preliminary results of the WG F Vienna Workshop "Review of the 1st cycle of implementation of the Floods Directive" (April 2016) there seem to be two key topics of highest relevance regarding pluvial flooding (PF): dealing with PF in the PFRA and mapping PF-risks from scratch. WG F decided to discuss these topics at the beginning of the 2nd FD cycle during a 2nd workshop on pluvial flooding in Oct. 2016 linked on the results of the first workshop that took place in Cagliari, IT, in 2010.

During the workshop the focus was set on PFRA and mapping aiming to discuss related questions in depth between the MSs. Forecasting as an important aspect especially in terms of reaction and preparedness should also be tackled.

The overall goal of the workshop was to share experience and learn from other MS's approaches of pluvial flood risk management at the beginning of the 2nd cycle of the FD by discussing solutions and ideas about risk reduction for pluvial flooding.

1.2. Preparatory survey among the member states

In advance of the Workshop a questionnaire based survey evaluated the state of the art in assessing, mapping and risk mitigation regarding pluvial floods and risks of heavy rain events as well as the organisation of related tasks in the member states. The evaluation also referred to the outcome of the previous workshop on this topic (Cagliari 2010). Questions with regard to pluvial flooding and heavy rain events as type of flood in PFRA and risk mapping as well as respective mitigation measures in FRMan-planning were topics of the questionnaire. The organisational, legal and financial frameworks for these tasks were also evaluated to create a better picture on the approaches in the member states. The survey focussed primarily on planning for the 2nd cycle of FD implementation, but also asked for good experiences from the 1st cycle and therefore included a review as well.

28 questionnaires from 23 member states were completed and submitted. The analysis created a very good picture on methods, approaches, results and difficulties as well as open questions. The results were presented throughout the workshop as introduction to each of the thematic sessions.[2]

1.3. Workshop objectives and structure

The objective was to create an overview and a common understanding of the needs and options for pluvial flood risk management in Europe, the state of the art in the member states as well as requirements and bottlenecks for the 2nd FD cycle. The key overall guiding questions for the workshop sessions were formulated as follows:

- How to – clearly – distinguish between different types of floods according to the Floods Directive? Is it possible?
- Is there a difference in significance comparing different types of floods (pluvial, fluvial, coastal, etc.)?
- How to distinguish between pluvial flood management and rainwater management in urban context? Which data can support PFRA for pluvial floods?
- How to assess the probability (low, medium, high)?
- Is there a difference between urban and rural pluvial flood? Is there a link?
- How to map pluvial flood? Is there a need to identify different hazard areas (production, transfer and accumulation)?
- Should there be one map per flood type or integrated maps?
- Do we need different approaches for urban/rural maps?
- How to communicate findings from pluvial flood risk mapping?

The workshop was structures by 4 thematic modules including plenary sessions with presentations from member states and break-out sessions to discuss the themes in depth. The break-out sessions were guided by individual working questions for each theme. Facilitators and rapporteurs guided the break out groups through the questions and reported back the findings and conclusions to the plenary sessions.

The agenda can be found in the annex. This report is structured in parallel to the workshop agenda.

[2] The filled in questionnaires are provided on CIRCABC – WG Floods/ 20th meeting.

2 Report on Sessions

2.1. Workshop opening and Introduction

The Workshop was opened by ANETTE VAN DILLEN (BMUB / DE), head of the federal flood protection unit in DE, and KERSTIN MENN (MKULNV / DE), representative of the hosting federal state North Rhine-Westfalia (presentation see annex).

2.2. Setting the scene

2.2.1. Review: The 2010 Cagliari Workshop

The background of the current workshop was described by MARTINA BUSSETTINI (Instituto Superiore per la Protezione e la Ricerca Ambientale, Italy), highlighting the conclusions of the 1st WG F workshop on pluvial flooding in 2010 in Cagliari, IT (presentation see annex).

She pointed out the importance of the classification of floods according to:

- the detaining capacity of the body originating the flood (pluvial, fluvial, etc.) and
- the time scale (duration) of the hydrological event (flash or large pluvial flooding, depending on the lag time between precipitation and peak discharge amounting to less or more than 10 hours respectively).

MARTINA BUSSETTINI illustrated the findings and open questions of the 2010 Cagliari workshop to the following topics:

1. Events characterisation, analysis and approaches to hazard assessment

In the Cagliari workshop the focus was set on the main aspects that affect these events, i.e. characteristics of the catchment, rain and measures. Pluvial floods resulting from intense rainfall events risk is related to not only depth but the velocity. Owing to the space-time scale of pluvial events a dense rainfall monitoring network is needed. With respect to analysis and approaches: Hazards were analysed and the PFRA was used to prioritise successive detailed analysis. The use of different tools (geomorphic, hydrodynamic) is needed. Hazard maps require numerical models. Therefore the question is, if there is a need to benchmark different models? Hazard mitigation measures must be evaluated as to their effectiveness.

2. High intensity storms and flood: monitoring, nowcasting and forecasting

With the local and sudden nature of occurrence of pluvial flood events and the limited time available for response in mind, research needs have been discussed and following open questions identified:

- What should be observed / monitored to advance pluvial flood risk management capability? What are the key variables and what is their resolution?

- Weather radars are essential for flash flood and pluvial flood monitoring/nowcasting. How can the quality of radar rainfall estimates be improved? Which is the most promising remote sensing technique?
- How can uncertainty in hydro-meteorological predictions be taken account of and how can it be communicated to end users?
- How can awareness and preparedness in the communities exposed to flash and fluvial floods be increased?

The conclusions in this field hint on PF being best managed by local authorities and people at risk. Due to the limited time available for reaction, there is a need for specific preparedness strategies.

3. Structural and non-structural measures

MARTINA BUSSETTINI presented aspects of planning and prioritisation for structural and non-structural measures and posed the question whether the terms “structural/non-structural measures” should be better abolished, because they are often complementary rather than being alternatives. She also discussed preparedness and the various measures including self-help measures and the importance of education. Another open question of the Cagliari workshop is how to identify the "right behaviour" in the case of flash and pluvial flood events.

4. Socio-economic aspects

The perception of risk was discussed. It was stated that information and education were needed to produce appropriate behaviour in floods and post-flood survey should also collect information about social understanding. Open questions included:

- How can the perception of the risk of a community in its various components be assessed?
- How does risk perception change with age?
- Should “danger” or “safety” be emphasised?

It was underlined that due to the “invisibility” of the flood sources, risk communication is crucial. Therefore all stakeholders should be involved, especially those who are unaware of the risks or indifferent towards measures of risk reduction. It needs to be examined how the interest of stakeholders could be raised. Communication should be targeted in order to maintain the memory of floods and increase the responsibility for self-protection. The best way to communicate the risk for flash and pluvial events still needs to be identified.

In the end, aspects of resilience and the correlation of the risk depending on the scale of the events were addressed. The different meanings of resilience in the EU were discussed and also stated that living with risk is a cultural question, with economic aspects also playing an important role. Accordingly, there is the necessity to define different levels of acceptable risk and to explore new approaches to define resilience measures.

Eventually MARTINA BUSSETTINI posed the question as to whether a paradigm shift was needed. Because PF are short duration localised events and random dynamic phenomena, it’s necessary to

re-think the scenarios in terms of impacts. Owing to the fact that precipitation is the main driver in pluvial flooding, causing ponding and overland flow, precipitation forecasting needs to be improved in order to better respond to the challenge posed by these events and combined measures need to be adapted to them.

She concluded her presentation, asking if the open questions were still open six years after the Cagliari workshop, expressing her expectation that the Berlin workshop would deliver a proper answer to this question.

2.2.2. Recent activities regarding pluvial flood risk management of the WG F

IOANNIS KAVVADAS (European Commission; for presentation see annex) gave an overview on PF risk management in the European Union after the 1st cycle under the FD, also referring to the WG F workshop in Cagliari and the experience with Preliminary Flood Risk Assessment (PFRA) and Flood Hazard Mapping (FHM) of Pluvial Floods so far.

Based on a definition of PF as "flooding of land directly from rainfall water falling on, or flowing over, the land" IOANNIS KAVVADAS emphasised that historically only roughly 20% of flooding happened due to PF and only 8% of potential future floods are forecast to occur due to PF. Nevertheless, looking at historic records of pluvial flooding, there has been a substantial increase of PF events recorded during the 20th and even more at the beginning of the 21st century. However it is not clear whether this increase has been documented due to better reporting of such events or due to actually more flooding events taking place.

Looking at the policy of EU member states (MSs), PF has been initially categorised by some MSs as not significant. By all other MSs except Denmark it was included in the PFRA. Pluvial flooding has eventually been assessed by 12 MSs as being significant and by 3 MSs as not significant. There is no sufficient information on the significance assessed by further 8 MSs.

About 13% of Areas of Potentially Significant Flood Risk (APSFR) have been associated to PF, which is only the third frequent type of flooding after fluvial and sea water flooding. The most common characteristic of floods in APSFR is flash flooding, "a flood that rises and falls quite rapidly with little or no advance warning, usually the result of intense rainfall over a relatively small area" (flash flood; 11%).

A specific mapping of pluvial flooding has been carried out in five MSs (AT, BE, IT, MT and UK). Further eight MSs combined pluvial flooding with other sources in the same map (EE, ES, FR, LT, NL, RO, SI and SK). In the remaining MSs there has been no explicit mention of mapping pluvial flooding.

Finally IOANNIS KAVVADAS emphasised on the diversity of approaches chosen by MSs with respect to

1. the application of different expressions of probabilities for the three different probability scenarios for pluvial flooding and

2. the inclusion of different elements in hazard maps for pluvial flooding.

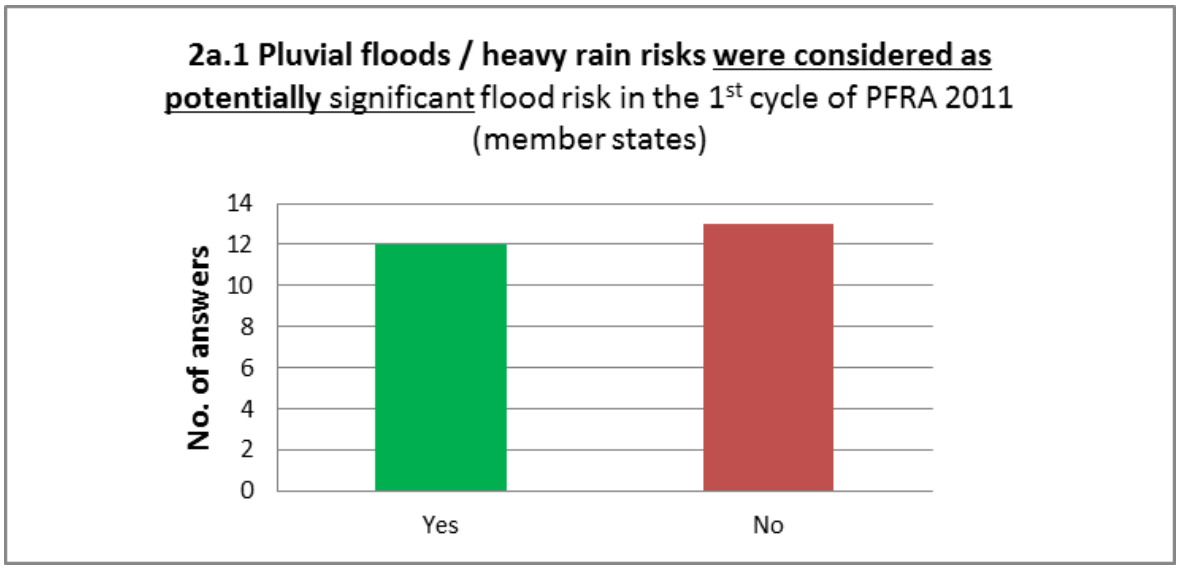
He underlined that the EU floods directive gives guidance for implementing FRMan in the member states but leaves room for the methods and specifications on how the member states implement the necessary steps. This is the general approach for all types of flood, including pluvial floods.

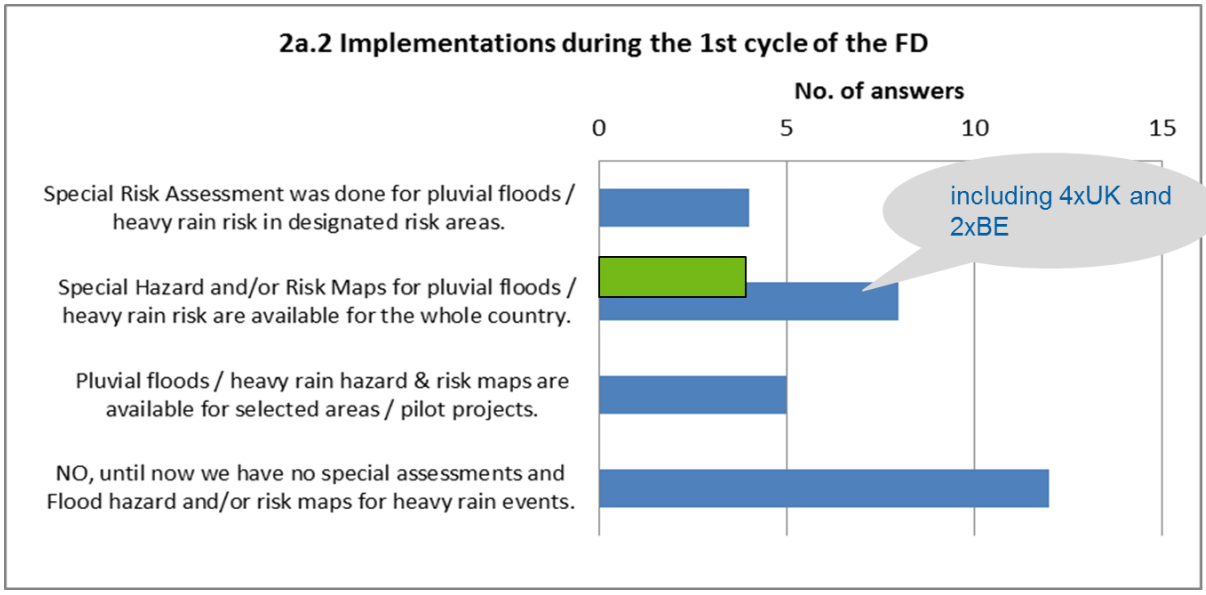
2.2.3. Evaluation of pluvial flood risk management approaches in the MS

KATHARINA SCHWARZ (BMUB) as a contrast presented recent findings from the questionnaire (presentation see annex), for which by September 2016 there had been a return of 28 questionnaires from 23 MS.

The main findings from the questionnaires were:

- 12 of 25 MSs considered pluvial flood risk as potentially significant during the 1st cycle;
- 8 MSs developed maps (for selected areas or the whole country);
- 18 out of 22 member states did not conduct a preliminary risk assessment,
  13 out of 22 member states did not develop any flood hazard and risk maps for pluvial flooding,
- but 14 member states stated the consideration of pluvial flooding in their FRMP for the first cycle.





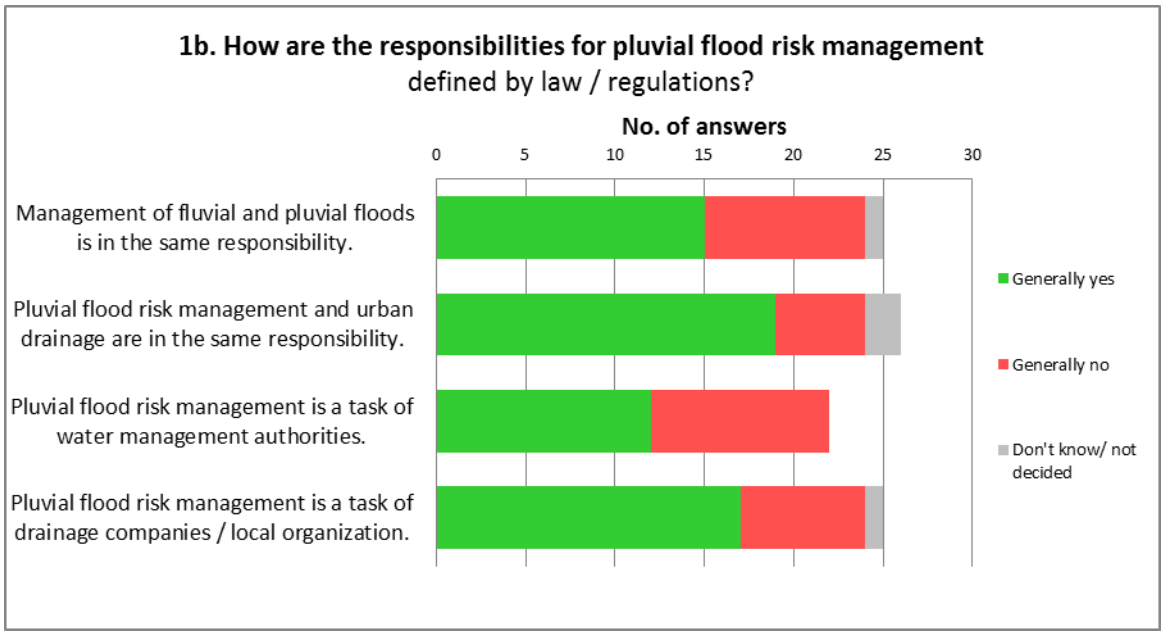
The approaches of the MSs that have implemented PF risk assessments differ regarding some individual methodological factors:

- objectives for pluvial FRMan are kept quite general in most cases (e.g. reduction and slowing the runoff in watersheds) or the MSs work with the same objectives for all types of floods.
- pluvial FRMan in the MSs often focusses on combined measures for different types of floods (e.g. awareness rising, NWRM)
- in the 1st cycle pluvial FRMan is often based on selected regional approaches as pilot projects that are upscale into FRMan plans.

Following issues have been identified as main challenges for the future of PF-risk management:

- PFRA - determination of risk areas in respect to:
  - insufficient historic data,
  - clear distinction between different types of floods needed,
  - collection and merging of data is difficult (formalised process desirable?),
  - determination of potentially significant PF risk areas (localisation: occurrence everywhere?, thresholds: how to define?; reliability of determined risk areas in regard to further restrictions etc.?).
- Mapping methods and accuracy:
  - different approach for mapping PF needed? (e.g. without return periods)
  - very detailed data necessary for proper mapping (currently not available)
  - integrated maps for different sources of floods?

- Capacity and awareness raising:
  - split responsibilities for pluvial flood risk management, with strong focus on local level
  - capacities vary strongly on the local level; the key question regarding capacities are: How to raise capabilities and interest on local level? And: How to communicate pluvial flood risk?



Résumé:
The need to deal with pluvial flood risk is stated by many member states. At the same time several complex questions have risen regarding the methodology to do so under the Floods Directive (FD). The main contentious question remains: Do the requirements of the FD suit for pluvial flood risk management? Or might other approaches be more expedient and feasible for this type of flood?

2.3. Theme 1: Heavy precipitation forecast and warning

2.3.1. Operational forecasting of flood extend in Slovenia

LUKA ŠTRAVS (Ministry of the Environment and Spatial Planning, Slovenia) presented the example "Flood Risk Management and Operational quasi2D Flood Forecasting in Slovenia" (presentation see annex). At the beginning he referred to the last WG F meeting in Vienna where the question of how to deal with precipitation forecasts had been raised as well. He pointed out that there is a different perception of PF and FF by the public and illustrated the enormous damage caused by floods in Slovenia in the past 25 years: about 2,150 million Euro of direct damage, most of it to water infrastructure. There has been an accumulation of flood events since 2005. A total of 61 APSFR has been identified in Slovenia, being the location of 90,000 working places and home to 130,000 inhabitants. About 600 m Euro would be needed for a substantial reduction of the flood risk. Flood forecasting is one of the major measures in this respect.

At present there are 177 hydrological and 123 meteorological stations in Slovenia contributing to the Hydrological Forecasting System. Its components are a hydrologic model and a hydrodynamic model (1 D, quasi D2 and 2D). The outputs are simulations and warnings as text, graphics and multimedia. There are statistically derived thresholds of 1, 3 and 6 hours of cumulative rainfall respectively and a catchment specific runoff. Maps have been produced from the 2D models, i.e. experimental setups for Ljubljanica and Savinja. Additionally there is a quasi 2D real time flood visualization pilot project for Ljubljanic River, an enhancement of an existing flash flood model with a calculation time of ca. 2 min for a 6 day simulation. Its accuracy depends strongly on meteorological and hydrological models. The model has been verified in practice during flood event of 2014.

2.3.2. Current developments on heavy precipitation and flash flood forecasting, now-casting, and monitoring in EFAS

Subsequently PETER SALAMON from the Joint Research Centre reported on current developments on heavy precipitation and flash flood forecasting, now-casting, and monitoring in the European Flood Awareness System (presentation see annex). The European Flood Awareness System (EFAS) is part of the Copernicus Emergency Management System (EMS). Its main indicator is the European Runoff Index Climatology (ERIC). High resolution numerical weather predictions (NWP) are used to build an indicator for upcoming extreme precipitation events and possible associated flash floods. It compares accumulated upstream precipitation taking into account hydrological conditions (soil moisture/runoff relation).

A case study of an extreme pluvial flood event in Simbach of 1st June 2016 showed that the timing of the event from the NWP forecast was very good but the location was not correct, it was focused on a neighbouring catchment area. This example proved how difficult it is to find the right balance between maximising possible hits and minimising the probability of false alarms from the system. In this respect flash floods pose the biggest challenge to the system.

Another example, of a pluvial flood event in Montpellier on 29th September 2014, served to illustrate the transformation of radar observation data into flood hazard anticipation. The European Radar Nowcasting - OPERA mosaics allows for a nowcasting of rainfall intensities of up to 6 hours. The European Rainfall Induced Hazard Assessment (ERICHA) is due to be fully included in EFAS in 2017.

After the presentation participants used the opportunity to ask questions about the forecasting and nowcasting systems. PETER SALAMON explained that a 20 year return period of intensity in precipitation was applied which however is not comparable to return periods for fluvial flooding. It reflects events based on experience and takes national alert levels into account. As main challenge he characterized the development of the current 1D model, which takes the local situation into account, into a 2D model and underlined the efforts to better avoid false alarms. During post processing, radar data errors (e.g. caused by hail) are being filtered as far as possible, but merging the data from different radar systems of the respective MSs is a challenge of its own. With respect to the communication of flood forecast finally it was pointed out that for expert purposes the

mapping is referring to rivers (catchment areas), but for communication with the public through the media to territories.

2.4. Theme 2: PFRA / Significance

2.4.1. Key findings of the questionnaire

KATHARINA SCHWARZ (BMUB) introduced to this topic by presenting the respective findings from the questionnaire (presentation see annex). Beside the fact that 12 out of 25 MSs considered pluvial floods/heavy rain risks as a potentially significant flood risk in the 1st cycle of PFRA in 2011 she illustrated the current status of the approaches of PFRA for pluvial flooding in the MS. As a major challenge reported in the questionnaires the MSs mentioned the availability of data of pluvial flood events and of information on consequences of these events. Guidance on how to collect and record flood event data appears to be necessary due to difficulties in collecting and merging existing data and a high level of interaction between different stakeholders is needed. So far this kind of guidance is only available in about half of the responding MS. Another critical aspect is the accuracy of information covering large proportions of the relevant territories in terms of digital elevation/surface models, land use, soil types, rainfall gauges etc.; Those MSs undertaking PFRA and identifying APSFR for pluvial flooding mostly refer to expert judgement and only to a smaller extend to modelling.

On this basis following core questions for the further discussion have been identified:

- How to deal with insufficient historic data for past pluvial flood events?
- How to clearly distinguish between different types of floods, e.g. pluvial and fluvial?
- Is there a need for a formalised process of data collection?
- How to raise the accuracy of the localisation of probable flooding events?
- How to define appropriate thresholds?
- Is a reliable determination of risk areas possible?

These questions served as guidance for the following presentations and break-out sessions.

2.4.2. The 1st Cycle Pluvial PFRA in Ireland

MARK ADAMSON (Office of Public Works, OPW; Ireland) introduced the Irish approach for pluvial PFRA (presentation see annex). He delivered a synopsis of the overall approach on risk assessment (consisting of historic and predictive flood risk assessment as well as consultation of local stakeholders), the identification of APSFRs and public consultation. Based on the definition that flood risk is a function of 1) the probability of a flood event (hazard) and 2) its consequences (degree of damage in event of a flood), MARK ADAMSON explained the model, input data, method (including a depth threshold for mapping of 50 mm) and assumptions of the national pluvial flood mapping in the Republic of Ireland. He illustrated the outcome at the example of two maps from the coastal areas of Fingal County and County Meath / the area around River Dodder in South Dublin.

As benefit of the Irish Pluvial Flood mapping he emphasised that there is a rapid, national assessment, allowing the identification of areas where more detailed assessment may be required. On the other hand there are limitations, mainly concerning the accuracy of the Digital Terrain Model (DTM; structures that may influence the flow of pluvial water are not taken into account), the lack of incorporation of fluvial drainage, as well as coastal boundary issues.

Afterwards MARK ADAMSON explained the principles of risk assessment that were applied, including risk criteria, receptors / indicators and vulnerability classification (for a receptor assigned as a function of importance and degree of impact / damage). Finally a Flood Risk Index (FRI) is being calculated for each receptor, as a product of the probability of a flood event and the vulnerability, according to the FRI matrix. On that basis, APSFR have been defined, reflecting the cumulative risk within an area / the sum of FRI within a given area. The outcome was illustrated by an example risk map of Middleton, Co. Cork.

Taking the outcome of the predictive assessment (FRI) and the consultations / information on past events into account, it has been established that in Ireland there is no significant pluvial risk outside of Dublin, with the exception of the town of Raphoe in Co. Donegal, which due to its location in a depression is endangered by overland flow into town.

The outcome of the Irish pluvial PFRA has been documented in publications that are accessible on the web site www.cfram.ie.

2.4.3. How can we determine probabilities of pluvial flood events?

MARKUS MOSER (Regional council of Stuttgart / DE, presentation see annex) outlined that the idea of PFRA is the identification of areas for which it is concluded that potential significant flood risks exist or might be considered likely to occur, based on available or readily derivable information. So PFRA is a first screening as a base for advance survey, with mapping being the next step. That said, he explained why from his point of view the method of fluvial flood risk assessment cannot simply be transferred to risk assessment of pluvial floods:

- historic data don't give any reliable hints on the probability and distribution of future pluvial flood events (they can occur nearly everywhere with similar probability),
- already small changes of structures on the surface can have a significant impact on the extent and the course of a pluvial flood event,
- taking heavy precipitation as basis for the assessment of pluvial flood hazards and risks, literally all settlement areas would have to be assigned as being under potential significant pluvial flood risk,
- based on available information, settlement areas with special vulnerability could be easily identified - but so far often small settlements have been affected by extreme PF events, which would not have been considered as especially vulnerable on this basis,
- recent events have shown that the impact of large sediments and debris on the actual damage has to be considered also in low mountain ranges much more than it is done by

hydrologic modelling. Here the available modelling methods need to be developed much further.

The statements were underlined by means of the example of the small village of Braunsbach (low damage potential, catchment area of 6 km², no classified streams or rivers) that has been heavily affected by pluvial flooding on 30th May 2016 (estimated damage in two hours 70 – 100 million Euro).

MARKUS MOSER continued that, according the floods directive, for all potentially significant risk areas for pluvial floods (if declared significant), maps would have to be generated which show for three scenarios (Art. 6 of the directive):

- the flood extent
- water depths or water level, as appropriate
- where appropriate, the flow velocity or the relevant water flow.

Showing exemplary maps of pluvial floods MARKUS MOSER illustrated that these maps are helpful for local use (readable in a scale 1:500 to 1:2,500), using local knowledge. But they are not appropriate on national or EU level. He concluded that it would not be possible to generate pluvial flood hazard maps with the same reliability like fluvial flood hazard maps. Unlike for fluvial floods it would not be possible to determine with sufficient certainty to go public with the information where it will get wet or stay dry in a heavy rain event.

This amounted to the question: What actually are the expectations of the Commission regarding mapping of pluvial flood risk in the EU?

MARKUS MOSER made the point, that it's not possible to fit pluvial flood risk mapping into the framework of the Floods Directive (FD). His interim conclusion therefore contained following assumptions:

- following the PFRA according to the FD, all settlement areas are at pluvial flood risk - so this approach is not sensible to determine APSFR for pluvial flooding,
- nevertheless there is the need to assess and map pluvial flood hazards; in order to do so, data base and rules for local mapping need to be provided (DTM, input scenarios: rain, soil moisture etc.),
- detailed pluvial flood risk maps containing risk areas (based on flow path and depression area analysis) need to be produced on local level, in respective detail, using local knowledge and must be linked to local measures to reduce pluvial flood risk,
- they are a valuable measure as part of the local risk management strategies and flood risk management plans,
- in communication with the public it has to be made clear that these maps reflect scenarios and not probabilities; therefore properties which are not considered to be under significant risk cannot be excluded from any risk and their owners need to brace themselves for the possible event of flooding and take reasonable precautions.

In the **Question & Answer section** that followed, following matters were discussed:

Return periods / classification of pluvial APSFR:
It was discussed if working with return periods as applied in fluvial PFRA (and recommended by the floods directive) would be possible and useful in the determination of pluvial APSFR. This was rejected, since according to this approach above a certain threshold (like 1,000 years return period) APSFR would have to be assigned virtually everywhere. Ireland chose to avoid this by working with a 50 mm threshold for pluvial flooding, thus cutting down the number of pluvial APSFR.

Definition of "pluvial flooding" / distinction from fluvial flooding:
In this context the definition of the term "pluvial flooding" was discussed. Basically there was consent that it concerns flooding caused by precipitation on the surface, not connected to rivers. In the discussion some participants put it the way that "pluvial flooding goes into the river, fluvial flooding comes out of the river". Other participants underlined that the source of the flooding is decisive for its classification as pluvial or fluvial. Special considerations are necessary for cases like fluvial flooding caused by pluvial flooding upstream in terrain filling with water in cases of extreme precipitation. The discussion showed that clear definitions are important but that fluvial and pluvial flooding are often interdependent as well.

Concentration of pluvial flood risk / hazard in time and space:
Finally several participants pointed out that in their countries pluvial flooding almost exclusively occurs seasonally, mainly in summer. Others hinted on pluvial flooding being a significant problem in specific, mainly urban areas. Pluvial flood risk is mainly a problem of settlements due to the vulnerability. But in some regions also agricultural vulnerabilities are called at high risk. In this respect a joint definition of significant risk thresholds cannot be defined.

2.4.4. Results of the break-out sessions (1)

After the plenary session, the workshop participants took part in three parallel break-out sessions which addressed the following questions:

Working questions 1.1:
Is it possible to determine "Potential Pluvial Flood Risk Areas" in the PFRA?
Or: Is pluvial flood risk more or less everywhere significant/not significant?

If a determination is possible:
How to set significance thresholds for pluvial flooding?
Should they be the same like for fluvial flooding?

and

Working questions (1.2).
How to work with three scenarios (high, medium, low probability) for pluvial flooding with regard to Art. 6 (3) FD?
Can we determine frequencies/return periods in one certain location or do we have other solutions?

Following conclusions can be drawn from the summary session in which all break out group results were presented and discussed in the plenum:

(1) The workshop participants were split into two different positions: one part tends to consider the determination of “Potential Pluvial Flood Risk Areas” as technically possible as examples have shown and that this could be done in the PFRA in future. The other part considered APSFR for PF even if technically possible as not reliable and questionable in regard to further use for risk mitigation, since pluvial flooding could occur practically everywhere. A majority of participants agreed that the FD steps and criteria are better applicable for fluvial floods, and that there are some challenges in applying them to pluvial floods accordingly. Therefore specific approaches for pluvial FHM and FRM are necessary and criteria should be defined by the member states, not necessarily linked to the FD, but rather taking national and regional conditions and legislation into account. Local conditions need to be considered importantly (like urban / rural areas, soil conditions and debris risk). Also the requests of end users are decisive for the specific mapping approach (urban planning, water management, agriculture etc.).

(2) The workshop participants acknowledged that the definition of probability for PF-events for certain locations out of the available parameters is at least a challenging task (or even not possible). Although effects of FF and PF on risk objects finally are often similar, there should be no thresholds to pluvial flooding events, which by nature have an “on / off” character for individual areas or objects. Therefore a reduction to two or three scenarios might be further developed: normal vs. extreme (simple drainage overflow vs. high overflow, often connected with debris or large sediments), but taking other factors into account. Another sensible approach could be the stronger consideration of the impacts and consequences of such events, including the definition of a tipping point for damages.

In the further discussion the importance of proper national legislation for PF risk assessment and respective consequences was emphasised. With respect to accuracy, the assessment of pluvial flood risks will only be able to deliver a rough estimation. But although the assignment of APSFRs might not be sensible in some cases, mapping is nevertheless needed, as local hazard maps. It was agreed: “Yes, we have to handle pluvial floods, even if we can’t always define significant and not significant risk areas.”

IOANNIS KAVVADAS reminded the participants that about half of EU member states consider PF as significant risk and that half a dozen of them have developed maps accordingly. So there is an option and a necessity to act. Special emphasis needs to be put on good communication of PF hazards and risks. The review of the FD might be a chance to a better consideration of PF. But at present the review is been characterized by many uncertainties (e.g. with respect to coastal floods).

2.4.5. Conclusions regarding PFRA / significance

KATHARINA SCHWARZ concluded the first day of the workshop by delivering a short survey of the findings of the plenary and break-out sessions.

- PF has been recognized as a relevant issue by many MS,
  - Some MSs mapped / reported in the first cycle, other MSs intend to deal with PF in the second cycle,
  - but there is a lot of uncertainty how to operationalise pluvial flood risk assessment / mapping.
- The accuracy of forecasting / nowcasting approaches needs to be improved (c.f. the example of Simbach).
- There are different approaches of how to define PF which might be further discussed.
- Subsidiarity should be applied with respect to criteria and methods, since approaches on member state or regional level better are more appropriate than on EU level, with local expert judgement being an important part of PFRA.

2.5. Theme 3: Mapping

2.5.1. Key findings of the questionnaire

Due to time constraints the key findings of the questionnaire regarding pluvial FHRM were not explicitly presented. The presentation which was actually prepared can be found in the annex. Key findings are:

Flood hazard and risk maps for pluvial flooding have been prepared by 9 out of 26 respondents in the first cycle and will be prepared by another 8 in the second cycle. If maps have been prepared during the first cycle, then integrated FHRM for pluvial and fluvial flooding have been the most frequent solution, but separate approaches are gaining ground in the second cycle. Most commonly, pluvial FHRM have been and are going to be elaborated for both urban and rural areas, and in other cases maps are prepared for selected regions, hot spots or pilot areas.

A majority of respondents (13) neither uses nor intends to use fixed return periods for pluvial flooding, nine did use them in the first cycle and two intend to do so in the second. However the challenge and problems to define return periods for PF has been commented by many MSs.

Pluvial mapping in the first cycle is (where done) was mainly based on 2D modelling, also using the analysis of historic pluvial events. Some did GIS-based hydraulic analysis, which seem to gain ground during the second cycle.

With respect to communication, the publication of pluvial FHRM on the internet is the most popular approach, followed by the presentation to local authorities and on public events. Their regular incorporation into spatial planning and land use decision making is less common.

Those respondents, who are already working with pluvial FHRM, rather tend to consider them a reliable basis for FRMan planning and spatial planning decisions. Even the possibility to determine the return period of a pluvial flood event is seen positive by a majority of those respondents who already prepared the maps.

Résumé: The main challenges are adequate pluvial mapping methods and sufficient accuracy to use the results for further planning steps. Accordingly the key questions for the workshop were:

- How to determine return periods / scenarios and related water depth?
  Is a different approach for mapping PF needed (e.g. without return periods)?
- Very detailed data, which currently is not available and whose acquisition would be very cost intensive, is necessary for proper mapping (e.g. high resolution DEM, detailed run-off data, soil data in relation to actual moisture, drainage discharge).
  What are the limits of pluvial flood risk mapping, taking the limits of data into account?
- Is it possible (and reasonable) to elaborate integrated maps for different kinds of flooding?

These questions were further discussed within the next presentations and breakout sessions.

2.5.1. Surface water flood risk mapping in the UK – approaches and challenges

CHRIS ELMS (Department for Environment, Food and Rural Affairs, DEFRA), SELENA PETERS (Environment Agency, EA; England), KIRSTEN THORBURN (Scottish Environment Protection Agency, SEPA) and LINDA MACHUGH (Northern Ireland Department for Infrastructure, DfI) provided an overview of surface water flood risk mapping in the UK (presentation see annex).

DEFRA coordinates the Flood Risk Management Plans (FRMPs), but each of the four countries is responsible for the assessment of flood risk. Each country has adapted it's approach, e.g. in England and Wales pluvial flooding was mapped nationally. CHRIS ELMS outlined the common needs including: developing understanding of pluvial flood risk; informing the FRMP and supporting decision making; raising public awareness and understanding future impacts.

<u>England and Wales</u>

SELENA PETERS (EA) explained that in England and Wales legislation defines surface water flooding as the water that has not yet entered the sewer or river. Three storm durations were looked at: 1, 3, 6 hours; for three annual frequencies: a 1 in 30, a 1 in 100 and a 1 in 1,000 chance of happening in any given year (Annual Exceedance Probability, AEP). The results were merged together to get the worst case. There is a composite DTM with a horizontal resolution of 2 m, in order to pick up small structures. Elements that weren't picked up automatically were edited manually, e.g. tunnels through rail embankments. Owing to the fact that not everything is included, e.g. flood defences, there are some limitations with the maps.

Localised modelling was included if available by local authorities. Outputs produced were in line with the FD requirements (i.e. flood extent, depth, velocity and hazard). In addition a "suitability layer" was produced that gives an indication of the confidence in the information. Any flooding

below a defined hazard threshold was removed. Preliminary FRMs were shared on-line with local authorities and they were asked if these matched their local information. Local authorities had an opportunity to change the information. The challenge of communication was addressed.

In December 2013 the maps were published on the Environment Agency's web site, showing the adverse impacts of flooding. Subsequent research carried out by the Environment Agency led to the broadening of communication channels, with Long Term Flood Risk Information replacing the maps-only approach. The new approach is based on a postcode search for flood risk information focussed on action before risk and simpler map visuals, with a slider from basic to more detailed information.

Scotland

KIRSTEN THORBURN (SEPA) said that in Scotland a strategic national pluvial flood model was carried out for the whole of the country to inform the 2011 PFRA. The national pluvial flood model was based on a DTM that was available for the whole of Scotland although it was less accurate than LIDAR-based topographic data. Buildings and roads were represented in the model. This national pluvial modelling was used to identify areas with higher pluvial flood risk where more sophisticated modelling was done based on a 2D hydraulic model and more accurate LIDAR DTM data. This more detailed modelling informed the 2013 pluvial hazard and risk mapping. KIRSTEN THORBURN summarised the data required for the modelling.

For both the national pluvial modelling and the more detailed pluvial modelling the adverse consequences of flooding were assessed, the impacts on receptors assessed (e.g. number of homes flooded and £damages caused by flooding) and climate change scenarios also taken into account. It has been found out that the number of properties at risk from pluvial flooding is very sensitive to how buildings are represented in the DTM and the method used to identify what properties are within the flood extent. Based on this data it is estimated that in Scotland pluvial flooding accounts for 23% of £annual average flood damage (river 56% and coastal 21%). The pluvial hazard and risk data was given to local authorities in order to inform about the management of pluvial flooding at a local level. The Scottish pluvial flood hazard and risk maps are available on-line.

Northern Ireland

LINDA MACHUGH (DfI) explained the methodology used in Northern Ireland. It is very similar to that employed in England and Wales. The Northern Irish surface water maps focus on flood hazard only and are available on the web as pre-formatted PDF maps showing depth information for all 3 flood scenarios (high, medium, low probability). They are accessible from a map viewer presenting an interactive map for all of NI. The information is presented for both present day and climate change scenarios. The maps are used within the planning process to trigger drainage assessments where appropriate. Statistics are produced at a national and parliamentary boundary scale to indicate the number of properties that are impacted by surface water flooding.

Questions and Answers

Questions on experiences with communication of PF risks using the presented maps or preference for other communication paths were discussed among the plenary group. In addition the discussion referred to the legal consequences of the maps in regard to the high level of uncertainty. The representatives of the UK explained that different communication approaches have been tested in the public and feedback is being gathered. There is a clear statement indicating confidence with the maps in public discussions. However there is no general difference in this observation regarding hazard maps and risk maps for all types of flooding.

In UK there is no direct legal consequence of PF risk maps, they are used to inform decision making and raise awareness, understanding the confidence in the maps is important to ensure they are used appropriately. National maps are made available on-line to raise awareness and aid communication, the maps are not appropriate for identifying single properties at risk and this is made clear in communication. The maps are also used to inform the Flood Risk Management Plans and shared with local authorities that add their local knowledge and lead on management of pluvial floods and use the information to inform decision on land use planning / new development. Individuals are directed to local authorities for detailed information.

CHRIS ELMS (DEFRA) concluded the contribution of the UK with a short glance at the current key activities in in surface water modelling and mapping (creating, using, sharing, understanding, improving and forecasting).

2.5.2. The Brussels approach of combined pluvial and fluvial mapping

MICHAËL ANTOINE (Bruxelles Environment, presentation see annex) reported how a qualitative risk assessment of pluvial flooding was carried out in Brussels without hydraulic models. He explained how punctual data about compensation paid as a result of flooding, about calls made to firemen with respect to floods and about places where there were issues with sewerage system has been mapped. Afterwards deductions based on the hydrological links between these observations and in correlation with landscape properties have been made, in order to extrapolate the flood risk zone in the whole city.

Because the national DTM with a 20 x 20 m grid was not accurate enough, LIDAR topographic data for the Brussels was procured. A soil map was used with the DTM and flooding “predisposal factors” were estimated. The “topographic wetness index” was assessed. One of the predisposal factors included alluvial soils as this indicates where there have been floods in the past.

MICHAËL ANTOINE explained how the different parameters were combined. A fuzzy logic distribution was used to convert the physical parameters to a predisposal factor for floods (e.g. 0.75 sensitivity for a specific home means that 75% of the homes that have been flooded, according to the records, were less prone to flooding than the one indicated). A flood sensitivity map was produced. The information was adjusted using knowledge from local experts. The results have been published on the web and the percentage of people exposed to risk was looked at. There is an observation tool for the municipalities to report new floodings.

Answering questions on the linkage between the maps and actions and measures MICHAËL ANTOINE explained that the flood maps have no direct legal impact, no restrictions e.g. to build in risk areas. But they are used to advise responsible persons and authorities (like developers and architects) of the areas that are at risk from flooding.

2.5.3. Challenges for urban and rural mapping of pluvial flooding and mapping approaches to assist communication

IAIN BLACKWELL (European Water Association, EWA) provided an overview of urban and rural examples for mapping and communication of pluvial flood risk management (presentation see annex). He presented the assumptions, different planning frameworks and local drivers. He explained that there were various approaches to support the assessment to reduce the uncertainties associated with pluvial flood risk.

He introduced methods such as using a rolling ball analysis to define flow paths as a preliminary (and much simpler) approach than detailed pluvial hydraulic modelling. He also highlighted a Preliminary Risk Assessment approach and the contributing factors to “high risk” locations that can be assessed from mapping combined with a walkover site visit. He presented the findings of site inspections: Rail and road embankments, critical infrastructure, vulnerable receptors along flood paths, doorway thresholds (e.g. with low thresholds for access), basement flats, contributing catchment / drainage area and steep flow paths all severely affect the flood risk. Starting from this point, he gave an overview of the Preliminary Risk Assessment and the subsequent modelling, taking the aforementioned observations into account. He further said that understanding the local features such as raised kerbs, walls etc. can make a significant difference to results and helps to give a better starting point for the quality of modelling. He then referred to the validation with real events, which actually confirmed the model, and finally presented the mapping of economic damage, explaining how this can be used for building a robust basis for investments.

IAIN BLACKWELL talked about how to use mapping creatively, e.g. by developing a Flood Map Viewer for the door to door communication with residents. This tool can be used on a Laptop or Tablet by a resident. It doesn’t require an internet connection and shows best available data in a less technical way. It encourages interaction and exploration of available data. Finally it generates discussion on topics like: risk to property, risk on route to work, what is the local authority doing to help, what options are available to manage flooding etc.

Then IAIN BLACKWELL gave examples of flood maps showing depths and velocities for different quantities of rain. He concluded that desk and site-based preliminary assessments are very effective in identifying important areas of pluvial / surface water flood risk. But it is likewise important to always ground truth pluvial flood risk. Flood information should be used critically to validate mechanisms. Because a calibration of pluvial flood maps is very unlikely, he encouraged the participants to “make the best of what you have”. Mapping and other approaches should be jointly used as communication tools. Eventually it is important to be creative about how mapping is presented, depending on the needs of the users. The extensive possibilities provided by GIS should be taken advantage of.

2.5.4. Results of the break-out sessions (2)

After the plenary session, the participants took part in three parallel break-out sessions which addressed the following four working questions:

Working questions (2.1):
Do we need different approaches for urban/rural maps on pluvial flooding?
Should integrated maps be developed for different types of floods (sewage systems/ fluvial)?

and

Working questions (2.2):
How to communicate the findings from mapping?
How can the maps support actions for pluvial flood risk reduction at the local/individual scale?

Following conclusions can be taken from the summary session in which the results from the break-out sessions were presented and discussed in the plenum:

(1) The workshop participants by their majority agreed that approaches and methods for urban and rural hazard and risk maps on pluvial flooding are not identical but build on the same basis. This is already being practiced. Even if there are similarities the urban and rural specifications have a different scope and require a different level of detail. The adequate approaches reflect different conditions and local needs, also regarding the communication and emergency response. Availability of data is nevertheless a decisive factor for processing, accuracy and result. Underlined was the importance of local expert knowledge and of the variation of the several parameters involved.

(2) There was a tendency amongst the workshop participants to doubt the practicability of combined maps for fluvial and pluvial maps, especially due to different responsibilities, differences in the information given and especially the probabilities. Similar looking information would have very different background and messages. Very important is to consider the legal framework and legal consequences of flood hazard and risk maps in the respective MSs which might lead to the requirement of very accurate mapping results. With respect to the readability of the information presented the combined maps might become too complex. Participants rather agreed to the formula “different approaches result in different maps”. For some occasions and target groups that are well informed about the background combined maps might be a solution to provide one product and not different maps and to avoid confusion among the target groups.

(3) It was pointed out that great care has to be taken to proper communication of the information. Communication of PF maps to the users of the maps is crucial, to avoid wrong interpretation and to raise attention and awareness of the recipients. Generally the way of communication of the findings from mapping, including the level of detail, depends on the audience targeted (e.g. national vs. local level, authorities vs. individuals). It was pointed out that different channels of information should be used and findings need to be well

explained, with special emphasis on the consequences and actions resulting from the findings. For example, local authorities generally require more detailed mapping to use them for planning decisions, than the general public. The targeted explanation of the meaning of the maps and of the ideas expressed by them also helps to avoid misinterpretation and misunderstandings.

(4) Looking at the ability of maps to support actions for pluvial flood risk reduction at the local or individual level, it was stated that the maps are also an important tool of emergency management, serving as a basis for community and private planning as well as for the communication between stakeholders (e.g. municipalities). Emergency management as target group of PFHRM should be considered in the mapping design and processing.

2.6. Excurse: Modelling of pluvial flooding

In the final presentation of the workshop ERNEST BLADÉ (Universitat Politècnica de Catalunya) gave an overview of the modelling of pluvial floods in Spain which is mainly focused on urban areas (presentation see annex). He explained the process via which risk is reached for both fluvial and pluvial floods. For the hydrology and hydraulics an integrated model was used for pluvial floods. Dual flow was considered e.g. sewer and surface water flow. Special attention was paid to vehicles and pedestrians. A distributed hydrological model was needed because it is hard to define the catchment areas. Tests have been carried out to assess the stability of people in the street at high velocity and low depth using flume-based laboratory experiments. The stability of vehicles was also investigated using scale models of different types of cars.

ERNEST BLADÉ presented the case study of Barcelona. Maps of hazard and risk to pedestrians were produced. The same was done for vehicles. Risk maps were elaborated for various return periods. The work had been carried out for 25 km^2 catchment in Badalona, Catalonia.

The participants used the **Question & Answer section** in order to learn more about the details and practicability of the model: It was discussed how long it would take to adapt the model to the whole of any given municipality? It depends on the availability of data. Fieldwork for data collection can be quite time consuming (e.g. mapping of inlets/grates for the sewerage system). Once the data is collected, it is a matter of a few weeks to run the model. Further the questions on precipitation data in the model were discussed and how many stations collect the data. A design hyetograph was used with a spatial distribution of 14 km that is assumed to move south-west to north-east at 10 km/hour. This is the design precipitation of are convective storm, a typical event in the area in autumn, according to actual data provided by the municipality.

The tool was a research project of the municipality of Badalona and developed with the support of the Spanish Ministry of Agriculture, Food and the Environment. The model has been applied in no further communities so far because of lacking funds.

3 Key findings and conclusions of the workshop

KATHARINA SCHWARZ (BMUB) wrapped up the workshop. It was states that most MSs want to – or already did - develop strategies to deal with pluvial flood risk. The workshop showed that in the past six years since the Cagliari workshop some MSs had found approaches to deal with pluvial flooding under the FD. But for many EU- MSs a lot of questions raised in Cagliari are obviously still challenging, e.g. finding significance criteria, develop scenarios for pluvial flooding, or the inherent uncertainty in pluvial flood risk maps. The availability of data for mapping is still an issue for many MSs, with many parameters playing a role (like meteorology, soil moisture etc.). Although PF has already been addressed in the first cycle by a number of MSs, it remains a great challenge to produce proper (reliable, useful) pluvial flood hazard and risk maps. This is an issue especially for those countries where legal consequences derive from flood hazard and risk maps.

The framework for the FRMan steps (PFRA, FHRM, FRMan planning) is derived based on a good knowledge of fluvial flood risk assessment and mapping. The interpretation of the FD and the used methods and processes in many MSs focussed in the past on fluvial flooding rather than on pluvial. Therefore in future some of the directive´s requirements need to be specifically interpreted for pluvial flooding. Most MSs stated they will consider PF but not always as significant by means of the FD and will cope with this local process outside the FD. Since pluvial flooding is a local phenomenon, there is a clear need for approaches with a strong focus on local risk management strategies.

.

APPENDICES

A. Workshop Programme
(and list of presentations)

B. List of Workshop Delegates