Guidance on surface water flood mapping for Lead Local Flood Authorities

Report version 2.0

21 December 2012

We are the Environment Agency. We protect and improve the environment and make it **a better place** for people and wildlife.

We operate at the place where environmental change has its greatest impact on people's lives. We reduce the risks to people and properties from flooding; make sure there is enough water for people and wildlife; protect and improve air, land and water quality and apply the environmental standards within which industry can operate.

Acting to reduce climate change and helping people and wildlife adapt to its consequences are at the heart of all that we do.

We cannot do this alone. We work closely with a wide range of partners including government, business, local authorities, other agencies, civil society groups and the communities we serve.

Published by:

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Executive summary

This document is for flood risk management authorities including Lead Local Flood Authorities (LLFAs) and Internal Drainage Boards and any person involved in developing surface water flood mapping on their behalf.

The updated Flood Map for Surface Water will combine local detailed mapping with national mapping to form a single source of surface water flood mapping for England and Wales. The Environment Agency is required to publish hazard maps for Flood Risk Areas to fulfil the requirements of the Flood Risk Regulations 2009 (the Regulations) by December 2013.

The document outlines the differences between the updated national scale surface water mapping and previous national scale surface water mapping. It describes how LLFAs can check if their mapping is compatible to be included in the updated Flood Map for Surface Water. It also explains the steps to create the updated Flood Map for Surface Water.

This document is not a specification for surface water flood mapping, but does set out some guidelines for producing surface water flood mapping locally, that is compatible with the updated Flood Map for Surface Water.

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1 Introduction

1.1 National Surface Water Flood Mapping

The Environment Agency has a strategic overview (England) and oversight (Wales) of flooding from all sources, including surface water. Managing risks from surface water is the responsibility of LLFAs across England and Wales.

As part of this strategic role, the Environment Agency has shared two surface water flood maps to support local flood risk management.

- Areas Susceptible to Surface Water Flooding maps (shared in 2008)
- Flood Map for Surface Water (shared in 2010)

The Environment Agency has produced new national scale surface water flood mapping for England and Wales. It improves on the existing surface water maps in many ways, including using more local information from LLFAs and Water Companies and using better data and modelling techniques (see section 2 and Appendix A for more information)

1.2 Flood Risk Regulations

The Flood Risk Regulations (the Regulations) implement the requirements of the European Floods Directive which aims to provide a consistent approach to managing flood risk across Europe. The approach is based on a 6 year cycle of planning which includes the publication of:

- Preliminary Flood Risk Assessments (PFRAs) by 22 December 2011
- Flood hazard and risk maps by 22 December 2013
- Flood risk management plans by 22 December 2015

The next stage in the process for LLFAs within designated Flood Risk Areas is to produce **flood hazard** for flooding from local sources.

The national scale surface water flood mapping meets the requirements of the Regulations for flood hazard maps.

LLFAs can use the national scale mapping where they do not have appropriate (local) mapping for their Flood Risk Areas. (See Appendix B for more information about compatibility of local mapping.)

This means LLFAs do not need to update or create any new surface water flood mapping to comply with the Regulations.

LLFAs are responsible for confirming to the Environment Agency which maps to use (either our national map or your local maps) by **22 June 2013**; the Environment Agency is responsible for publishing maps for Flood Risk Areas by **22 December 2013**.

1.3 What if LLFAs don't have a Flood Risk Area?

Not all LLFAs are in a Flood Risk Area, but this guidance is relevant to all LLFAs, whether they already have local mapping or are considering carrying out mapping in the near future.

All LLFAs can use the national scale surface water mapping to support local flood risk management activities including developing and updating their local flood risk strategies.

Isolated areas of high surface water flood risk may not be included in a Flood Risk Area but may still be significant on a local scale.

1.4 Will the mapping take into account other sources of local flood risk?

This national scale surface water flood mapping does not map all forms of local flood risk (it will not include flooding from groundwater and ordinary watercourses). As part of Preliminary Flood Risk Assessments, flooding from surface water was identified as the primary source of potentially significant flooding. Ordinary watercourses and groundwater were not identified, in the majority of Flood Risk Areas, as posing such a significant risk.

The national scale surface water flood mapping **does not include the presence or effect of ordinary watercourses** or drainage channels explicitly in the model.

However, the slope of the land is one of the main factors in identifying where flooding may occur. The national scale mapping shows flooding where water collects or flows. Often, this coincides with the location of ordinary watercourses and drainage channels.

2 Updating the Flood Map for Surface Water

The updated Flood Map for Surface Water will draw together national scale mapping and appropriate local mapping from LLFAs. We believe the updated Flood Map for Surface Water will be the best single source of information on surface water flooding for England and Wales.

LLFAs will have access to tools to continue to update the Flood Map for Surface Water with local information in the future.

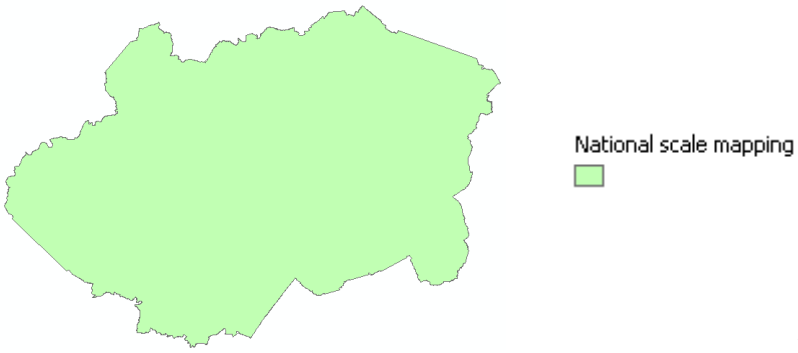
2.1 Why are we creating an updated Flood Map for Surface Water?

We are updating the map for a number of reasons:

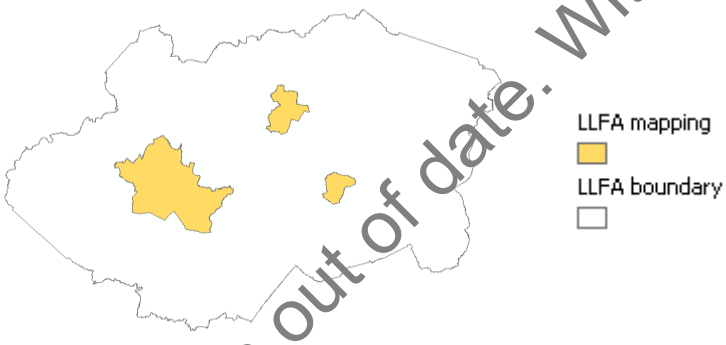
- To help LLFAs, our customers, Environment Agency and Government understand surface water flood risk consistently across all England and Wales and in particular, benefit:
  - LLFAs, to allow them to focus on managing (rather than mapping) surface water flood risk;
  - the Environment Agency, to inform our strategic overview (in England) and oversight (in Wales) and to provide evidence for future funding decisions;
  - our customers, to give them easier access to surface water flood risk maps.
- Government would like to see updated and improved surface water flood mapping published for England and Wales. They are funding the update to the national scale mapping.
- To draw together surface water flood information into a single map, and to make it easier to share with our customers. (Until now, surface water flood mapping was not available from a single organisation or place.)
- To use new data and modelling techniques to produce a more accurate picture of flood risk than previous national scale mapping (see section 2.3 and Appendix A for more information on the improvements).
- To meet the requirements of the Regulations for flood hazard and risk mapping in the most efficient and cost effective way and to reduce the burden on LLFAs.

2.2 Creating a single map

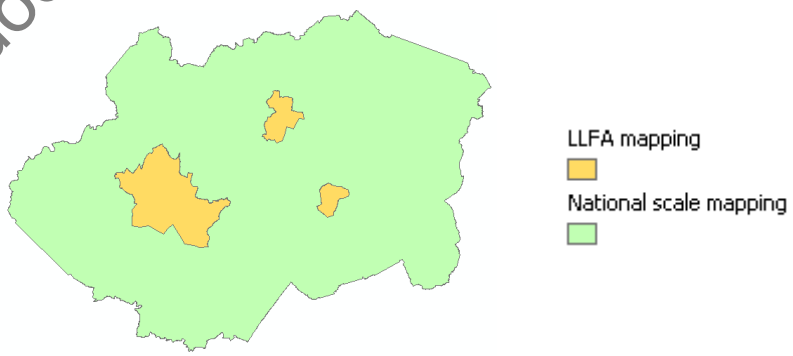
National scale mapping is available for whole LLFA area.



LLFAs identify compatible and more representative mapping for areas within their boundary.



National scale and local mapping are drawn together to form a single map - the updated **Flood Map for Surface Water** - where LLFA mapping replaces national scale mapping for a defined spatial area.



2.3 Why will this map be better?

The updated Flood Map for Surface Water will improve upon the Flood Map for Surface Water (2010), and the Areas Susceptible to Surface Water Flooding maps (2009) as it will:

- incorporate improvements in modelling techniques, understanding and data;
- combine appropriate local mapping from LLFAs with national mapping to provide an improved and consistent picture of surface water flood risk;
- provide velocity and depth information for a range of flood probabilities.

Although the updated national scale surface water flood mapping will be an improvement, there will still be a number of assumptions in the model:

- we have digital terrain information for over 90% of urban areas in England and Wales at 2m resolution or finer, yet there are still some areas with coarser resolution data (5m) where the flood maps will be less detailed;
- we have better technology, data, and modelling techniques, yet the model cannot represent every detail of the urban landscape and very local mechanisms of flooding;
- drainage capacity is the biggest factor in uncertainty in the modelling; we have to make assumptions where no drainage data is available and therefore the outputs of the model may be less accurate.

Refer to Appendix A for further information on improvements in the modelling.

2.4 What is flood hazard mapping?

The term 'hazard' has been described in previous research as a combination of the effects of water depth, velocity and debris. This guidance uses the term to mean 'hazard' as described in the Regulations, which defines flood hazard maps as showing:

- the likely **extent** of flooding;
- **depth** of flooding;
- the **direction** and **speed** of flow;
- the **probability** of the floods occurring.

To meet the requirements of the Regulations, we will assess a flooding scenario as a result of rainfall with the following chance of occurring in any given year (annual probability in brackets):

- **1 in 30** (3.3%)
- **1 in 100** (1%)
- **1 in 1000** (0.1%)

Existing national scale mapping and most local mapping do not provide all of this information.

3 What happens next?

The national surface water mapping project is underway. We will need help from LLFAs at several points between December 2012 and June 2013. The timeline below sets out the main tasks for LLFAs and the Environment Agency through to December 2013.

Timing	Activity	Who?
June - July 2012	LLFAs supplied local information to input to the national scale surface water flood model. Guidance published on surface water mapping for LLFAs to support decisions about carrying out new mapping.	LLFA
December 2012	LLFAs with Flood Risk Areas are able to start reviewing the maps on the review website. Updated guidance on surface water flood mapping for LLFAs is published, including a guide on how to check if local mapping is compatible. Guidance available for LLFAs on how to use the review website.	Environment Agency / LLFA
February 2013	Guidance available for LLFAs on how to review mapping and determine new 'locally agreed surface water information'. Once guidance is available, LLFAs with Flood Risk Areas able to provide feedback on the national scale mapping.	Environment Agency / LLFA
End February 2013	LLFAs without Flood Risk Areas able to start to review national scale mapping using local information.	LLFA
By end March 2013	Tell us if you think your local surface water mapping better represents flood risk in your area, but it does not meet all the criteria for being compatible.	LLFA
February - 22 June 2013	LLFAs check if their mapping is compatible and consider which mapping is most representative for their area. LLFAs identify their new 'locally agreed surface water information' and provide their mapping to the Environment Agency **by 22 June**.	LLFA
By December 2013	Publish updated Flood Map for Surface Water for Flood Risk Areas to meet the requirements of the Flood Risk Regulations. The national scale model will be cut to allow each LLFA to hold a set of model input data for their area.	Environment Agency / LLFAs
January 2014 onwards	LLFAs continue to gather information and carry out mapping studies where needed. LLFAs use a new web-based tool (provided by the	LLFAs

	Environment Agency) to keep Flood Map for Surface Water up to date with local mapping as it is produced.	

4 Using mapping from LLFAs

From December onwards, LLFAs can start to check if their models and maps meet the minimum standards for inclusion in the updated Flood Map for Surface Water. Further guidance on what to check can be found in Appendix B.

4.1 Compatibility

Many LLFAs have created their own surface water flood maps using a range of methods and data; consequently, there are different maps showing flood risk. It is important that local and national scale mapping is sufficiently consistent and compatible so information can be brought together into a single map.

The Flood Map for Surface Water will enable LLFAs, the Environment Agency, our partners and customers to **interpret surface water flood risk in a consistent way across England and Wales.**

If you have local mapping that you would like to incorporate into the Flood Map for Surface Water you will need to consider:

- how your models were created and what they represent;
- what outputs, particularly maps, you have;
- whether there are any missing data layers or differences that need to be filled.

We would like the mapping to be compatible. There are some **minimum standards** which local data should meet for it to be included in the updated Flood Map for Surface Water. The national scale mapping will match or exceed all of the minimum standards set out in Appendix B.

It is likely that some LLFAs will have most of this information, but not all parts. There may be some flexibility in the data we can include in the updated Flood Map for Surface Water, particularly for LLFAs outside Flood Risk Areas. There is less flexibility for LLFAs inside Flood Risk Areas as data must meet the requirements of the Regulations.. If you think your mapping better represents flood risk in your area, but you are missing some data to make it compatible, please contact us as early as possible, or by the end of March 2013 at the latest at updating.fmfsw@environment-agency.gov.uk

In summary, modelling and mapping should:

- include a flooding scenario as a result of rainfall with **1 in 30, 1 in 100 and 1 in 1000** chance of occurring (in any year);
- include flood **extent, depth and velocity** data;
- take into account the deflection **effect of buildings**;
- take into account **sub-surface drainage**;
- use a **model grid size** no larger than **5m**.

4.2 Further recommendations

Appendix B sets out more detailed information about **minimum standards** for modelling and mapping, as well as some further recommendations for good practice in surface water flood mapping. A separate guidance document about **digital formats for your maps** will be available by February 2013.

5 Reviewing surface water flood maps

December 2012 / February 2013 to June 2013, LLFAs review the national scale mapping alongside local mapping to determine new 'locally agreed surface water information'. Further guidance can be found in separate document about how to review the maps (available by February 2013).

5.1 Reviewing the maps

If you have local mapping, first you need to determine whether it is compatible with the national mapping, and, as part of the review process consider whether it is still the most representative mapping for your area.

We will ask all LLFAs to use local information to review the national scale mapping and to determine how confident they are in the maps.

As part of this review process we will ask you to:

- use **local recorded flood data** to identify areas that are known to flood, and to highlight unexpected patterns of flooding;
- identify how **confident** you are in the national mapping;
- where you have compatible local mapping, compare it with the national mapping to determine which mapping is **more representative** for your area (to determine locally agreed surface water information).

Please refer to the separate document about **how to review the maps** (available by February 2013).

5.2 Confirming new 'locally agreed surface water information'

February to June 2013, having reviewed the mapping, LLFAs confirm their new 'locally agreed surface water information' and provide any appropriate local mapping for inclusion in the updated Flood Map for Surface Water by 22 June 2013. Further guidance can be found in a separate guidance document how to review the maps (available by February 2013).

The Flood Map for Surface Water (2010) and the AStSWF maps (2008) do not meet the requirements of the Regulations and are not compatible with the new national scale mapping. Consequently, these datasets cannot be used as 'locally agreed surface water information'.

For your locally agreed surface water information you can use either:

- national scale mapping, or

- compatible local mapping, or
- a mix of these datasets for defined locations within your LLFA area.

Your local mapping will replace the national scale mapping within a defined location. A defined location could be a:

- drainage area within an urban area;
- urban area (such as a town or city);
- Flood Risk Area;
- LLFA area.

Please refer to detailed instructions on how to determine 'locally agreed surface water information' set out in a separate document about **how to review the maps** (available by February 2013).

6 Creating Flood Map for Surface Water

February to June 2013, having reviewed the mapping, LLFAs confirm their new 'locally agreed surface water information' and provide any appropriate local mapping for inclusion in the updated Flood Map for Surface Water by 22 June 2013. Further guidance can be found in a separate document on digital formats for your maps (available by February 2013).

6.1 Providing local mapping to Environment Agency

LLFAs must confirm their new 'locally agreed surface water information' and provide any **compatible local mapping** to us by **22 June 2013**. When submitting local mapping we will ask LLFAs to provide model outputs in digital format including:

- GIS file (ESRI or MapInfo) showing the **area that each local model covers**;
- GIS files (ESRI or MapInfo) of **model output data**;
- **metadata** for each local model.

LLFAs must be confident that they have the right to pass data to the Environment Agency for wider sharing for flood risk management purposes (for example, publishing through the internet)

Further information about appropriate format of your digital mapping can be found in a separate guidance document about **digital formats for your maps** (available by February 2013).

6.2 Creating the Flood Map for Surface Water

Once LLFAs have confirmed new locally agreed surface water information and provided any compatible local mapping, we can draw the data together to form the **Flood Map for Surface Water**. Local mapping will directly replace the national mapping for a defined location; there will be no blending or merging at the boundaries between different sources of mapping.

We have agreed with the Local Government Association (LGA) and Defra that we will work with them to publish surface water flood mapping in a way that is acceptable to LLFAs and Government.

The Flood Map for Surface Water will be available to flood risk management partners via our DataShare website.

7 What happens after December 2013?

7.1 Maintenance of Flood Map for Surface Water

The Flood Map for Surface Water will be **updated on a regular basis** with compatible local mapping. We are developing a new web-based tool where LLFAs will be able to store and share their mapping and identify whether it is suitable for inclusion in **future updates** of the Flood Map for Surface Water.

The web-based data sharing tool – Map Edit – is still under development. Further information will be provided about how LLFAs can use this tool during 2013.

7.2 Providing models to LLFAs for future use

We will provide the model created for the national scale mapping to LLFAs so you will be able to refine the data and maps in your areas.

The national scale surface water flood model will be cut to allow each LLFA in England and Wales to hold a self-contained set of model input data for their area.

The model input data will be provided in widely supported, non-proprietary formats . This means that LLFAs can use any commonly available 2D hydraulic modelling software packages to run the models and are not restricted to the software used in the national scale project.

LLFAs (or their contractors) will be able to run their part of the national scale model and include more local information in the future. The models will be available to LLFAs during 2013.

7.3 Future mapping studies

We recognise there are many reasons that you may need to carry out surface water flood mapping for example:

- to better understand mechanisms and risk of flooding in complex drainage areas;
- to better understand the scale and spatial distribution of investment in flood risk management and to inform Local Flood Risk Management Strategies;
- to support specific planning and development of local drainage schemes and to better assess the options in areas that are known to flood;
- to support emergency and spatial planning;
- to raise public awareness of flood risk, so they can take actions.

If you are in the middle of a mapping study or about to carry out new mapping we recommend you use this guidance to make sure any **new mapping is compatible**. Use the information in Appendix B and a separate document about **digital formats for your maps** (available by February 2013) to check if your modelling and mapping is compatible with the national scale mapping.

7.4 What to continue to do

We encourage you to continue to gather local information on surface water flooding (past and present) to help you review and validate surface water mapping and to improve your understanding of local surface water flood risk in your area. You will need to keep records of past floods for reporting when we start the second cycle of the Flood Risk Regulations in 2016. We recommend you continue to:

- **record local flood data** for example, photographs, reports, measurements, newspaper articles, anecdotal data from residents, and use it to compare with the most recent surface water flood mapping;
- **compile useful information** on surface water flood risk, for example:
- **identify drainage system capacity**, in particular urban drainage rates;
- **assess how areas respond to rainfall**, such as how quickly an area responds to intense or prolonged rainfall.

Collecting information about flooding, as well as data about the local drainage network can provide a strong **evidence base** to support local flood risk management.

Having an evidence base can help LLFAs to shape their flood risk management strategies**, support any applications for additional funding** and will also help the government allocate funding where the need is greatest across England and Wales.

7.5 Further guidance

Further detailed information is available in the Appendices here:

- Appendix A - Improvements in new mapping
- Appendix B - How to check if your modelling and mapping are compatible
- Appendix C - Sources of surface water flood modelling guidance

And in separate guidance documents:

- **Guidance on digital formats for your maps** (available February 2013)
- **How to review the maps** (available February 2013)
- **How to use the review website** (available in the document library on the review website)
- **Your questions answered** (available in the document library on the review website)

8 Appendix A

8.1 How does the new mapping compare?

Model parameter	Model values		
	National scale SW flood mapping (2013)	**FMfSW (2010)**	**ASTSWF (2009)**
Digital terrain model	Environment Agency LIDAR data 2m or finer in 90% of urban areas, 5m NextMap SAR in other areas	2010 Composite (Environment Agency LIDAR, PGA2 LIDAR and SAR)	Infoterra bare earth LIDAR and GeoPerspectives
Model grid size	2m	5m	5m
Representation of buildings	Represented in the DTM using OS MasterMap Buildings layer (building footprints raised by 0.3m in DTM)	Represented in the DTM using 2009 OS MasterMap Buildings layer (building footprints raised by 5m in DTM)	Not represented
Reduction to rainfall to represent sewers	12mm/hour (or local data where provided by LLFA)	12mm/hour	0mm/hour (no sewer drainage)
Reduction to rainfall to represent infiltration	Spatially varying according to land cover defined by OS MasterMap data	Urban 70% Rural 39%	100%
Storm duration(s)	1, 3 and 6 hours (or local data where provided by LLFA) (50% summer storm profile)	1.1 hours (50% summer storm profile)	6.5 hours (50% summer storm profile)
Manning's n (surface roughness)	Defined by OS MasterMap Feature Codes for land cover	0.1 rural 0.03 urban	0.1
Flooding as a result of rainfall (chance of occurring in any year)	1 in 30 1 in 100 1 in 1000	1 in 30 1 in 200	1 in 200
Model software and equations	2D model software Solves shallow water equations	2D software Does not solve full shallow water equations	2D software Does not solve full shallow water equation

8.2 Improvements in new mapping

The table below outlines the improvements in modelling techniques and data that will make the updated national scale surface water flood mapping a more representative map of surface water flood risk.

Area of improvement	Improvements in new mapping
Digital terrain model	Environment Agency's LIDAR/NEXTMap composite DTM which includes high resolution (2m or finer) LIDAR for **all urban areas greater than 3km²** in England and Wales. Small topographic features and flow paths can be represented in the model.
Model grid size	The flood modelling will be undertaken on a **2m resolution** grid for all England and Wales. Our confidence in this data will also depend on other inputs to the model such as the Digital Terrain Model.
Representation of buildings and other topographic controls on flow	OS MasterMap data has been used to **represent buildings in the digital terrain model**. The method allows flood water to flow into the building footprint once the water depth exceeds 300mm. The road network is known to preferentially collect and route water. Road surfaces as defined in OS MasterMap will be lowered by 125mm (height of a standard kerb) to better delineate these flow routes.
Reduction to rainfall to represent sewers	Drainage capacity is the source of greatest uncertainty in the modelling. Information from LLFAs on drainage capacity, infiltration/runoff rates has been incorporated into the model where it is available. Where local information is not available, the modelling has used a **default drainage rate of 12mm/hr** to reflect the 'national average' capacity of urban drainage systems.
Reduction to rainfall to represent infiltration	Land use has a strong influence on the way water on the surface behaves. OS MasterMap data on land cover, and data on soil type and land permeability is used to represent the **spatial variation in runoff and infiltration rates**.
Storm duration(s)	The duration and intensity of a rainfall storm that causes the most flooding varies widely between areas as it is strongly linked to the topography. Information from LLFAs about rainfall storms that have the greatest effect in an area has been incorporated into the model where available. Where local information is not available, storm durations of **1 hour, 3 hours, and 6 hours** using the 50% summer rainfall profile.
Surface roughness (Manning's 'n')	OS MasterMap data has been used to define spatially vary surface roughness according to land cover type.
Flooding as a result of rainfall probability	The model produced outputs for flooding outcomes as a result of three rainfall probabilities - **1 in 30, 1 in 100 and 1 in 1000** chance of occurring in any year.
Model software and equations	The modelling software uses more detailed mathematical equations (full shallow water equations) permitting production of more accurate velocity information.

9 Appendix B

How to check if your mapping is compatible

It is important that the Flood Map for Surface Water is sufficiently consistent so the Environment Agency, LLFAs, our partners and customers can **interpret the risk across England and Wales in the same way**.

This is not a detailed modelling specification. We have taken the principles behind the updated Flood Map for Surface Water, and identified elements of the modelling or model input or output data which have a **significant influence** on the resulting flood maps or on the way that they will be interpreted.

We would like the mapping to be compatible. There are some **minimum standards** which local data should meet for it to be included in the updated Flood Map for Surface Water. The national scale mapping will match or exceed all of the minimum standards set out in Appendix B.

It is likely that some LLFAs will have most of this information but not all parts. There may be some flexibility in the data we can include in the updated Flood Map for Surface Water, particularly for LLFAs outside Flood Risk Areas. There is less flexibility for LLFAs inside Flood Risk Areas as data must meet the requirements of the Regulations. If you think your mapping better represents flood risk in your area, but you are missing some data to make it fully compatible, please contact us as early as possible, or by the end of March 2013 at the latest at updating.fmfsw@environment-agency.gov.uk

There are also **recommended standards** which offer 'good practice' approaches to surface water modelling at this scale but do not need to be met for data to be included in the Flood Map for Surface Water.

Appendix C provides references to other guidance containing more detailed technical modelling specifications.

In summary, modelling and mapping should:

- include a flooding scenario as a result of rainfall with **1 in 30, 1 in 100 and 1 in 1000** chance of occurring (in any year);
- include flood **extent, depth and velocity** data;
- take into account the deflection **effect of buildings**;
- take into account **sub-surface drainage**;
- use a **model grid size** no larger than **5m**.

Further detail about these points is given in the tables below.

9.1 Input data

Digital Terrain Model	
Minimum standard	Use terrain data that best represents the landscape, with a maximum **grid size of 5m**, with a vertical accuracy (root mean square error) of no more than +/- 150mm for LIDAR data, and +/- 1.0m where LIDAR data is not available. *(Note that the updated Flood Map for Surface Water uses a grid size of 1m or 2m in many areas, which includes more detail about the ground surface than a grid size of 5m.)* LIDAR can be obtained from the Environment Agency (www.geomatics-group.co.uk) or Infoterra under the Pan Government Agreement 2 as part of the Environment Agency composite LIDAR dataset. *See also* **Model Grid.** *In some software, the DTM is edited to create the model grid. In other software, the DTM and model grid are separate.*
Recommended	In areas you consider to be **urban in nature**, use terrain data that best represents the landscape with a grid size **no greater than 2m**, with a vertical accuracy (root mean square error) of no more than +/- 150mm for LIDAR data. In areas you consider to be **rural in nature**, use terrain data that best represents the landscape with a grid size **no greater than 5m**, with a vertical accuracy (root mean square error) of no more than +/- 150mm for LIDAR data, and +/- 1.0m where LIDAR data is not available.

Probability of flooding and rainfall duration	
Minimum	Use the standard Flood Estimation Handbook (FEH) and depth duration frequency (DDF) techniques to derive rainfall depth. Use the DDF curves to calculate a total rainfall depth for rainfall of given duration and probability. **Flood Risk Areas** To meet the requirements of the Regulations, model a flooding scenario as a result of rainfall with the following chance of occurring in any year: • **1 in 30 (3.3%)** • **1 in 100 (1%)** • **1 in 1000 (0.1%)** Rainfall with a 1 in 1000 chance of occurring in any year is an extreme event and there is inevitably more uncertainty estimating scenarios of this magnitude. **Outside Flood Risk Areas** Although we expect the minimum standard for **probability of flooding** to be the same outside Flood Risk Areas, we are investigating the potential to allow more flexibility (to be confirmed in February 2013). If

	you think your mapping better represents flood risk in your area, but you are missing some data to make it compatible, please contact us as early as possible at updating.fmfsw@environment-agency.gov.uk to check if your data is compatible. **Rainfall duration** The critical rainfall storm duration (the duration of rainfall with the greatest flooding outcome) will vary depending on the physical properties of the whole surface water drainage system. Use rainfall durations which are representative of the area being modelled. Where more than one duration is modelled, combine these to produce a map of the worst case flooding outcome for each model cell, from the rainfall durations modelled, for each given rainfall probability
Recommended	Use local rain gauge data from stations with long records to derive better rainfall probabilities and depths using local Flood Estimation Handbook (FEH) analysis. Run the model for a range of rainfall durations that are most appropriate for your area, generally within a range from 0.5 hours to 12 hours depending on rainfall response times, for each rainfall probability. Combine these to produce a map of the worst case flooding outcome for each model cell, from the rainfall durations modelled, for each given rainfall probability.

9.2 Flood modelling

Modelling software and techniques	
Minimum	Use software that uses shallow water equations to produce reliable depth and velocity data. See Defra/Environment Agency Research & Development report 'Benchmarking of 2D Hydraulic Modelling Packages' for further information on suitable modelling software. An update to this report is underway and will be available in 2013.
Recommended	See Defra/Environment Agency Research & Development report 'Benchmarking of 2D Hydraulic Modelling Packages' for further information on modelling software. An update to this report is underway and will be available in 2013.

Model grid	
Minimum	Model outputs in a regular (square) grid of results containing attributes such as water depth (rather than flood level) and velocity data with a maximum **grid size of 5m**. The national scale mapping will use a **grid size of 2m** for all England and Wales. N.B. Some modelling software uses a triangulated irregular network (TIN) rather than a regular (square) grid. LLFAs can provide data in TIN

	format, but the data will be re-sampled to allow inclusion of the data in the Flood Map for Surface Water. For a TIN, use an appropriate equivalent resolution to a recommendations for a regular grid, with an element or triangle size of no greater than 25m^2. In some software, the DTM is edited to create the model grid. In other software, the DTM and model grid are separate. Consider removing/reinforcing hydraulically significant topographic features within the model grid or DTM. Ensure large features such as railway embankments, significant bridges, motorway junctions, and other similar structures do not artificially block the movement of water across the floodplain.
Recommended	For future modelling, consider using a model grid resolution **no greater than 2m** (or equivalent TIN) to show details of the urban environment. Models with grid sizes greater than 5m are less detailed than the existing national scale surface water flood mapping, and are unlikely to capture the details of the urban landscape. However, some local LLFA modelling may have a coarser model grid size (5m for example), but may include more local detail in some aspects of the modelling, such as sub-surface drainage. Significant urban flow paths (for example, gaps between buildings) may be better represented using a finer grid. Grid size can have an impact on the following factors; consider the balance between these factors when selecting an appropriate model grid size: • computing capacity and model run time; • usability of outputs (for example, manageable file size); • the size of the study area and the level of detail you wish to represent. Use a dataset such as Ordnance Survey MasterMap Topography data to produce maps of building footprints, road layout and impervious areas. Use these maps as the basis for positively reinforcing important topographic controls on flow in the model topography as part of the model grid, and defining spatial variation in runoff, infiltration rates and hydraulic roughness. Consider removing/reinforcing hydraulically significant features in the model topography as part of the model grid. At a local scale you may consider reinforcing features such as roads, kerbs, and walls that could affect movement of water across the floodplain, as well as representing flow paths/passage of water through smaller structures.

Representation of urban landscape	
Minimum	Models include a representation of the effect of buildings on flooding, considering the deflection effect of buildings particularly on fast, shallow flows. Buildings are represented in the model by incorporating them into the

	model topography as part of the model grid.
Recommended	There are a range of methods to represent buildings and other elements of the urban landscape in a model; refer to Appendix C for links to other guidance to determine the most appropriate method for your study. At a strategic level it is acceptable to use uniform surface roughness values for areas defined as 'urban' and 'rural' (or paved and unpaved) for assessing surface water flood risk. Studies at a local (or detailed) level should consider assessing roughness values in more detail to represent local effects of variable land use.

Drainage allowance	
Minimum	Models include a representation of the effect of the sub-surface drainage system. An allowance for the drainage system can be included in the model implicitly by reducing the rainfall hyetographs to represent the loss of water from the surface due to the effect of sewers, or explicitly by modelling the sub-surface drainage system in detail (e.g. using a pipe network model. There are a range of methods to use to allow for drainage; refer to Appendix C for links to other guidance to determine the most appropriate method for your study.
Recommended	There are a range of methods to use to allow for drainage and selecting an appropriate storm durations; refer to Appendix C for links to other guidance to determine the most appropriate method for your study. Sub-surface drainage can be included in the model implicitly by reducing the rainfall hyetographs to represent the loss of water from the surface due to the effect of sewers, or explicitly by modelling the sub-surface drainage system in detail (e.g. using a pipe network model) for example. In the national scale modelling, the rainfall hyetographs are reduced to represent the loss of water due to the effect of sewers. For modelling on a local scale, use local information about drainage rates, where available. Using different assumptions about sub-surface drainage may produce quite different patterns of flooding. Making assumptions about sub-surface drainage is one of the greatest areas of uncertainty in modelling surface water flood risk. We recommend incorporating local information about the drainage rates where available, as well as understanding the limitations of the method you are using to account for sub-surface drainage.

9.3 Outputs from the modelling

Water depth and velocity

Minimum	Regular (square) grid with a maximum size of **5m** for each flooding scenario. **Maximum water depth** (in metres) and **maximum water velocity** (in metres per second) attributed with a model output value on a cell-by-cell basis so that the data can be divided into categories. LLFA model outputs will be categorised into new depth and velocity bands for the updated Flood Map for Surface Water. In order to be categorised into new bands, LLFA data will need to contain model output values on a cell-by-cell basis. It may not be possible to use LLFA data that is already divided into bands if it does not include model output values on a cell-by-cell basis. N.B. Some modelling software uses a triangulated irregular network (TIN) rather than a regular (square) grid. LLFAs will be able to provide data in TIN format, but the data will need to be re-sampled to allow inclusion of the data in the Flood Map for Surface Water.
Recommended	Regular (square) grid with a maximum size of **2m** for each flooding scenario. **Maximum water depth** (in metres) and **maximum water velocity** (in metres per second) attributed on a cell-by-cell basis so that the data can be divided into categories. The national scale mapping will be mapped at a 2m resolution. LLFA mapping will be re-sampled to match the national scale mapping. The re-sampled LLFA maps may look different to the original LLFA mapped outputs. It is important that flood risk managers focus on the areas of most significant flood risk. Some modelling methods (direct rainfall methods) input rainfall to every cell of the model, this means everywhere in the model could be perceived as 'flooded' to a very shallow depth. Flood risk maps can be **filtered to remove insignificant areas of flooding.** The national scale mapping uses a direct rainfall method and will filtered to exclude **very small areas** of isolated flooding, and flooding with a **very low hazard** to people. Methods that do not use direct rainfall may not need to be filtered. Maps created by different modelling methods (and using different assumptions) may look quite different or show quite different patterns of flooding. We anticipate that the published maps will include information about the source of the mapping and the methods used to create it.

Direction of flow data

Minimum	A minimum compatible standard will be required. Detail to be confirmed based on early testing of pilot areas and discussions with representative LLFAs. Further information will be available in February 2012.
Recommended	Detail to be confirmed, as above. Likely to recommend capturing flow direction at the time of maximum hazard rating, or time of maximum velocity. See 'hazard rating' table for more information on where to find further information on hazard ratings.

Hazard rating	
Minimum	Hazard ratings are not required to meet the requirements of the Regulations.
Recommended	Detail to be confirmed, as above. Likely to recommend capturing flow Although not required to meet the requirements of the Regulations, hazard ratings are useful for other purposes such as emergency planning. Recommend following advice set out in (Defra/Environment Agency R&D project FD2321) (see Appendix C for more detail on this publication).

Intellectual property	
Minimum	LLFAs must be confident that they have the right to pass data to the Environment Agency for publication and for flood risk management purposes (for example, publishing through the internet).
Recommended	• LLFAs retain a copy of the model input and output files so that the models can be re-used in the future. • LLFAs know what data has been used to create the model and generate the outputs (these are likely to be available in technical reports that accompany the modelling. • LLFAs understand any licence restrictions of data used in model creation or development of outputs.

Confidence in data	
Minimum	A minimum compatible standard will be required. Detail to be confirmed based on early testing of pilot areas and discussions with representative LLFAs. Further information will be available in December 2012.
Recommended	Use historic information and local knowledge of surface water flood risk to validate the models where possible. Use known measurements, photographs, newspaper reports, and anecdotal data where available to validate the modelled outputs. Use local information to better understand the confidence in the modelled outputs. Identify any patterns where the modelled outputs are representative and where the model may not perform so well.

9.4 How much further work is needed?

The time, cost and effort involved updating your models will be dependent on the number and type of modelling factors and parameters that need to be changed to match the minimum standards above. It may be possible to make your modelling compatible and compliant, for minimal time, cost and effort if there are only a small number of changes to make. See the table below for more information. The overall score is based on a modeller's assessment of the maximum time, effort, and cost (1=minimal; 5=significant).

Factor	Score	What do you need to be aware of?
Suitability of software	5	Changing modelling software can mean that the model needs to be re-built.
Probability of flood occurring in any year	2	Run the existing model with additional flood probabilities.
Model grid size and DTM	3	Incorporate most representative available digital terrain data. Re-create part of 2D model, re-define the model grid size or resample the model outputs to meet the grid size specification.
Representation of buildings and surface roughness	3	Make changes to the method used to represent buildings and surface roughness in the model by updating the model input data updated, and run the models again.
Storm duration / Infiltration / Drainage capacity	3	Make changes to the modelling parameters and run the models again to incorporate the changes.
Depth and velocity	2	Re-run 2D model to produce depth and velocity outputs for additional flood probabilities.
Direction of flow data	2	Processing raw model outputs using a method still under development.
Processing digital outputs	1	Processing the raw model outputs to produce the final maps. For example, this includes filtering the data to remove very small areas of flooding that can be artefacts of the modelling process. Further criteria to be confirmed.

10 Appendix C

Sources of surface water flood modelling guidance

All of the guidance below is useful when considering how to carry out surface water flood modelling. Some of the guidance refers to modelling methods that are more basic than the techniques we used to produce the Flood Map for Surface Water in 2010.

- **What is the Flood Map for Surface Water - Guidance for Local Resilience Forums, Regional Resilience Teams, Local Planning Authorities and Lead Local Flood Authorities** (Environment Agency, November 2010) available from the Environment Agency Datashare website http://www.geostore.com/environment-agency/ when downloading the Flood Map for Surface Water, or from a local Environment Agency office.

- **Computational modelling to assess flood and coastal risk - Operational Instruction 379_05** (Environment Agency, Oct 2010) available from a local Environment Agency office.

- **Benchmarking of 2D Hydraulic Modelling Packages** (Joint Defra/Environment Agency Research and Development report, Project SC080035, June 2010) available from http://publications.environment-agency.gov.uk/PDF/SCHO0510BSNQ-E-E.pdf

- **Surface Water Management Plan Technical Guidance** (Defra, March 2010) available from http://www.defra.gov.uk/publications/files/pb13546-swmp-guidance-100319.pdf

- **Annexes to Surface Water Management Plan technical Guidance (**Defra, March 2010) available from http://www.defra.gov.uk/publications/files/pb13546-swmp-guidance-annex-100319.pdf

- **Integrated Urban Drainage Modelling Guide** (WaPUG/CIWEM, 2009) available from http://www.ciwem.org/media/44495/WaPUG_IUD_Modelling_Guide_Draft_Rev1_v28_(June_09)_v01-001.pdf

- **Risks to people phase II (Defra/Environment Agency R&D project FD2321) (**Defra/Environment Agency, 2005) available from http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=FJPProjectView&Location=None&ProjectID=12016&FromSearch=Y&FieldOfStudy=12&SearchBy=3&SearchText=FD2321&ShowDocuments=1&SortString=ProjectCode&SortOrder=Asc&Paging=10&FJP=1

- **Data Standard - GIS Data Types Version 1.9** (Environment Agency, July 2005) available from a local Environment Agency office.

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