FloodResilienCity, Managing Adaptive REsponses to changing flood risk, Skills Integration and New Technologies.

The development of Flood Risk Management Plans at City and County Scale

Part 1: Initial Planning

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Managing Adaptive Responses to changing flood risk in the North Sea Region (MARE)

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Glossary of terms

(To be completed)

Foreword

These notes are based on the shared knowledge and experience of the partners of the Interreg IVB projects FloodResilienCity (FRC), Managing Adaptive Responses to Changing Flood Risk (MARE) and Skills Integration and New Technology (SKINT)

They are written in a way that they can be easily understood by the majority of Europeans, whose first language is not English. By products of this is that they can be easily translated and that they should also be easy to understand by non specialists. Hopefully, this should make them more relevant to those for whom flood risk management is relevant, but who are not water engineers.

The notes cover the first phase of developing flood risk management plans; that of initial planning at city or county scale. This includes

- Identification of stakeholders that should be involved in the process
- Development of parameters to identify relative risk and develop a prioritised programme for investigations
- Assessment of current vulnerability
- The choice of approach for the assessment of risk at highly vulnerable locations
- Setting priorities and scoping investigations
- Identifying the resources and capacity building required by stakeholders to carry out the investigations

Subsequent notes in this series will cover the selection and application of suitable methods for the analysis and assessment of flood hazard and flood risk, and the development of flood risk management plans

Only rarely do the activities associated with flood risk management fall within the control of a single organisation. Because of this and because of the potential diversity in the aims and objectives of the stakeholder organisations, we recognise that integration in its true sense is not possible. However, we do believe that organisations can align their activities as best as possible, and for those wishing to do this we hope that our contribution will help.

Please feel free to use any part of these notes, but a reference to FRC, MARE and SKINT would be appreciated.

The tables in Appendix 2 are based on the framework for sharing knowledge and experience being to align FRC, MARE and SKINT with a fourth Interreg project Strategic Alliance for integrated Water Management Actions (SAWA). The strand of the framework dealing with flood risk management is well advanced, but we are still working on the strands for water quality management and land use and amenity (Appendix 3). This will be completed in the new year.

If you have any comments and suggestions about these notes, please email John Blanksby at j.blanksby@sheffield.ac.uk and we shall take them on board in subsequent versions.

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1 Introduction:

1.1 Context,

The EU Flood Directive[1], requires member states to develop flood risk management plans by 22nd December 2015. Along the way member states are required to carry out preliminary flood risk assessments by 22nd December 2011, and detailed flood risk and hazard maps by 22nd December 2013.

Following these initial submissions, the assessments, maps and plans will be reviewed and updated in six yearly cycles.

Many countries have already carried out preliminary assessments and produced flood risk and hazard maps for coastal and river flooding. National and regional bodies have considerable expertise and there is little need for guidance for these organisations. However, there is a general need to align flood risk management across all types of flooding and a specific need for support for the development of flood risk management plans at sub river scale; in particular in urban areas where risks to people and properties are greatest. Here there are many different forms of flooding, which can also interact with coastal and river flooding. Some types of flooding; such as that resulting from piped urban drainage systems are well understood and again there is no need to provide guidance for these. However, there is a need for insights into the interactions between surface water flooding and urban drainage systems. EN 752, 2008[2] moves toward a more integrated view of sewer system management in the context of the wider urban drainage system and the wider water environment. Thus it is aligned with the EU Flood Directive and the Water Framework Directive aims of integrated urban drainage management. The tried and tested process of initial planning, diagnostic study and development and assessment of options is aligned with the Flood Directive requirements for the production of Preliminary Flood Risk Assessments, Flood Hazard and Risk Maps and Flood Risk Management Plans. Thus this series of documents adopts the same structure.

This particular document addresses initial planning at city or county scale, the aim of which is to prioritise the production of diagnostic studies resulting in detailed in flood risk and hazard maps. The aim is to identify the high priority problems that need to be addressed, the sources of flooding contributing to the problems, the appropriate analytical approaches and the tools for the diagnostic studies, and the competencies and capacity building requirements for those participating in the studies. All these are essential for the development of a realistic programme that can be achieved within the timescales set out by the Flood Directive.

[1] DIRECTIVE 2007/60/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL, of 23 October 2007 on the assessment and management of flood risks

[2] EN 752:2008, Drain and sewer systems outside buildings, European Committee For Standardization Management Centre: rue de Stassart, 36 B-1050 Brussels

The main need for support is in those aspects of flooding for which there is currently limited experience of formal investigation. In some countries, there has been a concerted effort to improve understanding and experience over the past decade, so rather than attempt to provide new guidance this report will draw on this work and will align procedures with those used for coastal, river and sewer flooding.

2 Scope

This document is one of a series setting out a general methodology for the production of flood risk and hazard maps and flood risk management plans across cities or counties. The complete series follows tried and tested procedures covering:

- Initial planning at city or county scale:
    - Identification of stakeholders that should be involved in the process
    - Development of parameters to identify relative risk and develop a prioritised programme for investigations
    - Assessment of current vulnerability
    - The choice of approach for the assessment of risk at highly vulnerable locations
    - Setting priorities and scoping investigations
    - Identifying the resources and capacity building required by stakeholders to carry out the investigations
- The diagnostic study to develop flood hazard and risk maps
    - Collecting historic data
    - Preparation an inventory of all relevant assets
    - Hydraulic investigation
    - Environmental investigation
    - Structural investigation of critical relevant assets
    - Summary of problems
    - Setting priorities and scoping the development of integrated solutions
    - Identifying the resources and capacity building required by stakeholders to implement the development of integrated solutions
- Developing integrated solutions to formulate a flood risk and water management plan
    - Identify hydraulic, environmental and structural options
    - Assess options
    - Produced prioritised flood risk and water management plan, including the development of an appropriate emergency response plan where necessary

The scope of this document covers initial planning at city or county scale. Diagnostic studies and the development of integrated solutions to formulate a flood risk and water management plan will be covered in sister documents.

2.1 General principles

Develop a database of locations with a known history of flooding, identifying any steps taken to reduce the flood risk.

Ensure that emergency response plans are reviewed regularly and take account of changes in flood risk through climate change and other catchment changes, such as development. Ensure that cross

boundary issues are taken into account. Vulnerable communities should be identified to ensure that emergency response is risk based

Determine in greater detail the risk of flooding to the transport network and the consequences of road and rail closures during flooding. Where practically possible ensure that key routes remain operational during a flood event. Following the identification of flood risk to these facilities, ensure alternative routes and emergency plans are developed and reviewed periodically

Determine risk of flooding to critical infrastructure, public and emergency services and buildings and access routes. Determine the potential impact of flooding, develop emergency plans and identify alternative routes to ensure that emergency services can be provided in time of flooding

Determine risk of flooding within and from land allocations identified as part of the planning process. Work in partnership to ensure that flood risk at sub river scale is taken into account during the production and implementation of development plans for any future scheme. Good practice flood risk and water management should be rigorously implemented and where possible, improvements to the urban infrastructure made to ensure that the risk of flooding is not increased locally, or elsewhere. Make sure that you don't develop in such a way that the emergency services may be overwhelmed when flooding does occur.

2.2 Drainage assets

In order of priority, produce and maintain a register of all culverts and outfalls within the administrative district and identify capacity, sediment and other debris issues. As part of the study, identify locations where culverts can be removed or improved through redevelopment.

Identify the capacity and condition of established drainage infrastructure, review the requirements of all new drainage infrastructure, including Sustainable urban drainage (SuDs),

2.3 Integrated working

Stakeholders should work together to ensure that activities are integrated to an appropriate degree. Following the initial planning a schedule of integrated activities should be produced.

2.4 Climate change and urbanisation

Identify the implications of climate change scenarios on the drainage systems. Following the preliminary assessment, produce a detailed management plan for the future maintenance of infrastructure linked to development policy to ensure that the level of flood risk does not fall below an acceptable standard in the future.

2.5 Processes to be assessed

Table 1 identifies inland and coastal water types. These can interact in different ways. One of the aims of the initial planning process is to identify which of these interact at any particular location. This will enable detailed approaches for more detailed assessment to be identified.

For those readers who are not familiar with the different types of flooding and how they may interact, Appendix 1 provides a brief introduction

Table 1: **Water types and categories**

Flood type	Flood category	sub category
Rural and urban areas	Exceedence pathways	
	Surface water and soil	Rural green space
		Green space at urban fringe
		Green space within urban area
		Developed urban surface
	Groundwater	Artificial superficial deposits(Made, Worked, In filled, Disturbed or Landscaped Ground)
		Natural superficial deposits
		Bedrock
	Drainage infrastructure	Combined sewer
		Surface water sewer
		Foul sewer
		SUDS/Source control
		Pipe drain
		Open Drain
Streams and ponds	Small Stream[2]	Open
		Piped/culverted
		Built over
	Large Stream[3]	Open
		Piped/culverted
		Built over
	Ponds	Ponds with outlets
		Ponds without outlets
Rivers and lakes	River[1]	
	Lakes	Lakes with outlets
		Lakes without outlets (oxbow)
		Salt lakes (inland seas)
Artificial water bodies	Drainage channel	
	Canal	
Coastal	Estuaries and deltas	
	Open sea	

Notes to table 1

River, stream and coastal flooding only occur in limited areas and for relatively short periods of time, in all other areas and at all other times flooding is rural and urban area flooding

1 In this context a river is a body which drains sufficient area and has sufficient time of concentration to make flood warning a viable flood risk management option, whereas flood warning is not a viable option for a stream

2 A small stream is defined as a watercourse which is considered to be too small for inclusion in flood zone mapping required by the EU Flood Directive

3 A large stream is defined as a watercourse which is considered to be sufficiently large for inclusion in flood zone mapping required by the EU Flood Directive

3 Generalised flood risk assessment methodology for initial planning at city or county scale

3.1 Rationale

The initial requirement of Lead Flood Authorities and other responsible authorities is to scope and quantify the activities required for diagnostic studies and the development of integrated options

In order to accurately scope the work to deliver the reports and flood risk maps, it will be necessary to identify the available data and methods that will be used to produce them. Hence it will be beneficial to adopt a basic approach using data that is known to be available.

It is assumed at this point that there will be no desire to acquire the high resolution digital elevation models and the costly software packages that are required to carry out detailed integrated urban drainage studies. Apart from the immediate costs of acquisition of data and software, there are other issues that preclude this; principally, the human resource required to carry out complex, cutting edge modelling and the lack of available models which have been verified and audited as fit for purpose for flood risk management studies. In this respect, the demonstration of the benefits of high resolution DEMs and various software packages are process deliverables

Hence the approach proposed in this document uses a bare minimum of newly acquired data and a minimum of human resources so as to minimise the tendency to drive cost upwards.

3.2 Data and availability

It is assumed that the following data will be available for the scoping study and the preliminary assessment

- Map background
- The results of different types of modelling to provide information on flood extents, velocity and depth for a range of flood probabilities.
- River and coastal flood zone maps (RCFZM) to define extent and depth of national river and coastal flooding
- Digital elevation model (DEM), but recognise the limitations inherent in the resolution of the data used to produce the DEM when making decisions.
- LFA and other stakeholder flood incident databases
- Key stakeholder data on location of; Schools, community centres, care homes, sheltered accommodation, vulnerable communities and communities with special needs, council depots, council offices, hospitals, medical centres, utility depots, utility offices, critical infrastructure, airports, police stations, fire stations, ambulance stations, key transport routes (railways and highways), etc. to define consequences of flooding. The main sources of these data are found in Land and Property Gazetteers developed in many countries and data held by local authority contingency planning sections
- Watercourse data including asset data for culverts, headwalls etc.
- Minor drainage system data (sewers etc) including; asset data, flood registers at a property level, Incident data (from operations databases) and model results
- Other mapping and study outputs may be relevant where available.

3.3 Check list

The following table identifies all the stages in the prioritisation and scoping of diagnostic studies to produce detailed flood risk assessments. The table is presented in the approximate order in which the activities may be carried out, but it is not intended to identify critical paths as these are dependent on local circumstances. Users may wish to convert the check list into flow and Gantt charts to help them to plan activities

Table 2: Checklist for prioritising and scoping diagnostic studies for flood risk assessment

Task	Complete
Identify stakeholder organisations	
Identify stakeholders within organisations	
Engage with stakeholders	
Proceed with participating stakeholders	
Create a ranked list of receptor vulnerability	
First pass assessment of flood vulnerability for each receptor	
Prioritisation of diagnostic flood risk assessment studies	
Identify appropriate assessment methods for each priority flood risk	
Determine scope and cost of each study	
Develop programme	

Many drainage specialist reading this document will think, so what, I know that, it's obvious. However it's important to remember that not all the people who should be involved in this process, know that. Also, given the complexities of flood risk and water management, it can be helpful to write down who does what, who should communicate with who, what people need to know, and by identifying what thy do know, identify the needs for capacity building etc.

Back in 1972, Robert F Mager[3] said "if your goals are important to achieve, it is essential that you do more than just talk about them in "Fuzzy" terminology. Broad statements of intent can only be achieved to the degree that their meaning is understood". Therefore it is beneficial to take some time to clearly establish what the task is and what the contributions from the different stakeholders are. Once the tasks are established it will then be possible to quantify what is needed to carry them out.

If you agree with that, then you can draw on what follows to help you achieve your goals

3.3.1 Identify stakeholder organisations

One of the first tasks is to identify which organisations and groups of people are, or should be involved in flood risk management. In order to do that you need a framework showing what flood risk management is about. Appendix 2 provides such a framework. It is found firmly on the five elements of flood risk management identified by the European Union[4] and adopted in the Floods Directive. However, drawing on the Four As approach developed by the Scottish Government[5] and the experiences of several European partners, it has been adapted to make it more relevant to operational organisations. The framework is illustrated in Figure 1 and the key elements are:

[3] Mager R.F., 1972, Goal Aanalysis, Fearon Publishers

[4] COMMUNICATION FROM THE COMMISSION TO THE COUNCIL, THE EUROPEAN PARLIAMENT, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS, Flood risk management, Flood prevention, protection and mitigation, COM(2004)472 final, Brussels, 12.07.2004

[5] Flooding Issues Advisory Committee Final Report (4). Scottish Government., 2007

- **Awareness**, which helps everyone involved in flood risk management to do their part
- **Analysis and assessment**, which cuts across all aspects of flood risk management
- **Alleviation**, of current problems
- **Avoidance**, of future problems
- **Assistance**, prior to, during and after flood events

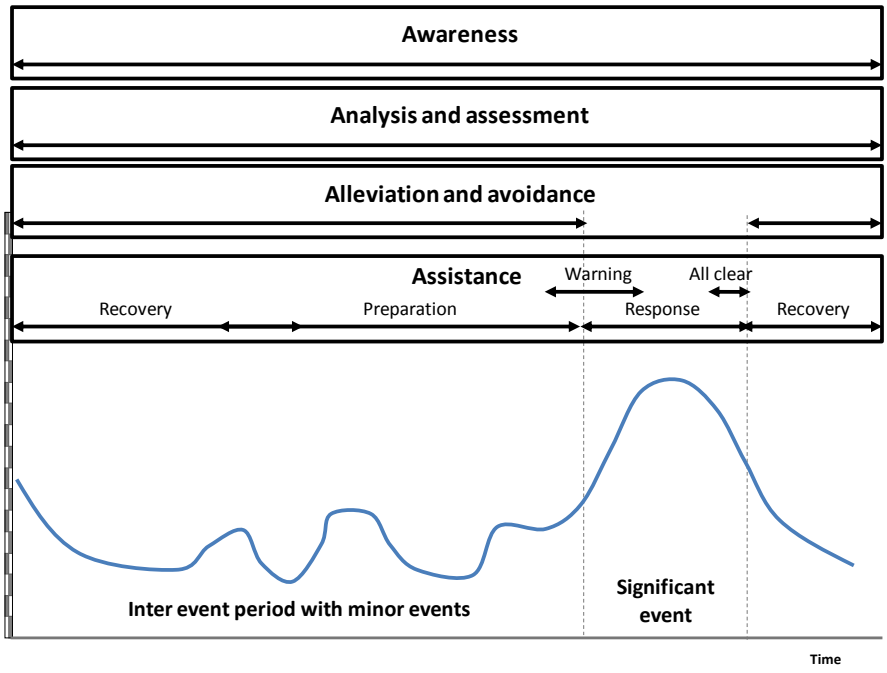

Figure 1: The flood risk management framework and the cycle of flooding

3.3.2 Identify stakeholders within organisations

Once the stakeholder organisations have been identified the framework may be used within each organisation in order to identify the departments responsible for specific aspects. At the end of the process it should be possible to identify who does what, who should communicate with each other and where gaps in responsibilities lie. This will enable the development of a communication plan and an institutional policy development plan in parallel with the plan to deliver effective flood risk management.

3.3.3 Engage with stakeholders

The previous tasks may be completed by an individual or a small group. This task sets out to involve the identified stakeholders within the process. Not all stakeholders will need to be involved in detail throughout the development of a flood risk management plan, but they should be aware of what is going on and when and how they should be able to contribute. For example, an education authority may have a view on the vulnerability of its schools and the priority that they should be given in terms of flood risk assessments. They may also be required to help in terms of temporary housing during a flood emergency. Therefore this task is about identifying when and how to contact the different stakeholders.

3.3.4 Proceed with participating stakeholders

Not all stakeholders may recognise their role or wish to contribute, but this should not prevent the development of a flood risk management plan. Once reasonable steps have been taken to engage

with and involve all relevant stakeholders, then the process should proceed with those wishing to participate. Further attempts to engage with others can be made at a later stage, when their role becomes better established.

3.3.5 Create a ranked list of receptor vulnerability

The aim here is to identify the receptors that are vulnerable to flooding should it occur. The vulnerability will depend on a number of factors, including use etc. Stakeholders will have differing view about what constitutes vulnerability, which is why they should be involved in the ranking process. The assessment process should be based on factors such as; development need, the vulnerability of people and communities, the needs of first level responders, the need to maintain and operate community facilities during and after floods and the impact of flood on different environments.

Using available sources of data and best available mapping techniques the stakeholders should agree a ranking system and then rank all known receptors prior to establishing the likelihood of flooding.

Table 3 provides an initial list of the different types of receptor and their vulnerability with respect to local communities. Stakeholders may use and adapt the list to identify who is responsible for each receptor, the roles they play and whether or not their responsibilities should be classed as duties, powers or voluntary. They may then review the vulnerability category, adding additional receptors as required.

3.3.6 First pass assessment of flood vulnerability for each receptor

This is where the real work starts. Using best available information on land use, the stakeholders responsible for modelling and mapping the different hazards and risks should produce a map showing relevant infrastructure and buildings and the community vulnerability category into which they fall.

Other layers should be produced to identify the potential for flooding from the different sources of flooding identified in Table 1. Some of these layers may already have been produced and may contain information on the probability of flooding, but those not yet produced may simply indicate that there is a potential for flooding to occur. In the case of the latter, locations of major pathways and significant ponds can be identified using digital elevation models and confirmed by site inspections where these are coincident with identified receptors.

The results of this analysis should be combined with information on known flood locations.

At this point a qualitative assessment (e.g. high, medium and low) of flood probability can be made.

3.3.7 Prioritisation of diagnostic flood risk assessment studies

The initial prioritisation is carried out by identifying the relative flood risk using the flood vulnerability and flood probability for each item of infrastructure and property using a weighted scoring system agreed by the stakeholders. Mapping of the relative risk will enable the stakeholders to identify clusters where the investigation of several receptors may be combined. Those receptors or groups of receptors with the highest score may then be selected for more detailed consideration.

Table 3: Prioritisation of receptor vulnerability

Community vulnerability category	Infrastructure and buildings	Stakeholder reference number	Responsibility type (D, P, V)
Very High	Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk, and strategic utility infrastructure, including electricity generating power stations and grid and primary substations.		
	Police stations, Ambulance stations and Fire stations and Command Centres and telecommunications installations required to be operational during flooding.		
	Emergency dispersal points.		
	Water treatment plants.		
High	Basement dwellings		
	Caravans, mobile homes and park homes intended for permanent residential use.		
	Installations requiring hazardous substances consent		
	Hospitals.		
	Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels.		
	Sites used for waste management facilities for hazardous waste		
	Sewage treatment plants		
	Gas plants		
	Flood control infrastructure.		
	Water transmission infrastructure and pumping stations.		
	Sewage transmission infrastructure and pumping stations.		
Medium	Buildings used for: dwelling houses; student halls of residence; drinking establishments; nightclubs; and hotels.		
	Non–residential uses for health services, nurseries and educational establishments.		
	Sites used for holiday or short-let caravans and camping, **subject to a specific warning and evacuation plan**.		
	Landfill		
Low	Buildings used for: shops; financial, professional and other services; restaurants and cafes; hot food takeaways; offices; general industry; storage and distribution; non–residential institutions not included in 'more vulnerable'; and assembly and leisure.		
	Land and buildings used for agriculture and forestry.		
	Waste treatment (except landfill and hazardous waste facilities).		
	Minerals working and processing (except for sand and gravel working).		
Very low	Sand and gravel workings.		
	Docks, marinas and wharves.		
	Navigation facilities.		
	MOD defense installations.		
	Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location.		
	Water-based recreation (excluding sleeping accommodation).		
	Lifeguard and coastguard stations.		
	Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms.		
	Essential ancillary sleeping or residential accommodation for staff required by users in this category, subject to a specific warning and evacuation plan.		

3.3.8 Identify appropriate assessment methods for each priority flood risk

There are many different approaches and techniques for assessment. Once the contributions of the different sources of flooding have been identified for each high priority receptor or receptor group, appropriate assessment methods should be identified. The tools available vary from country to country and detailed guidance on specific tools can be found nationally. General guidance on assessment is provided in the sister document on diagnostic studies

3.3.9 Determine scope and cost of each study

Once the assessment methods have been identified, the resources and costs can be determined. These may include in house or bought in resources, data enhancements and surveys, capacity building etc Stakeholders will have to identify their own contributions and how a more integrated approach may affect the way that they currently work. The aim is to get maximum benefit for the communities that they serve.

3.3.10 Develop programme

A realistic integrated programme of work to assess flood risk in the identified locations should be developed. Stakeholders may wish to consider that the programme and resources applied should reflect the most effective way of establishing risk and attributing responsibility and not the balance of responsibility.

Appendix 1: A brief introduction to flood types

A1.1 Flood Zones and the European Flood Directive

The Flood Directive identifies three different flood scenarios (probability zones); high, medium and low, for which flood risk and hazard maps should be produced.

High probability flooding is defined as being more frequent than once in 100 years
Medium probability flooding is less frequent than this, but still lies within the extreme flood.
Low probability flooding occurs outside medium probability zone

These are illustrated in Figure A1.1 which shows high probability zones for river and coastal flooding in red, medium probability in yellow and low probability in green

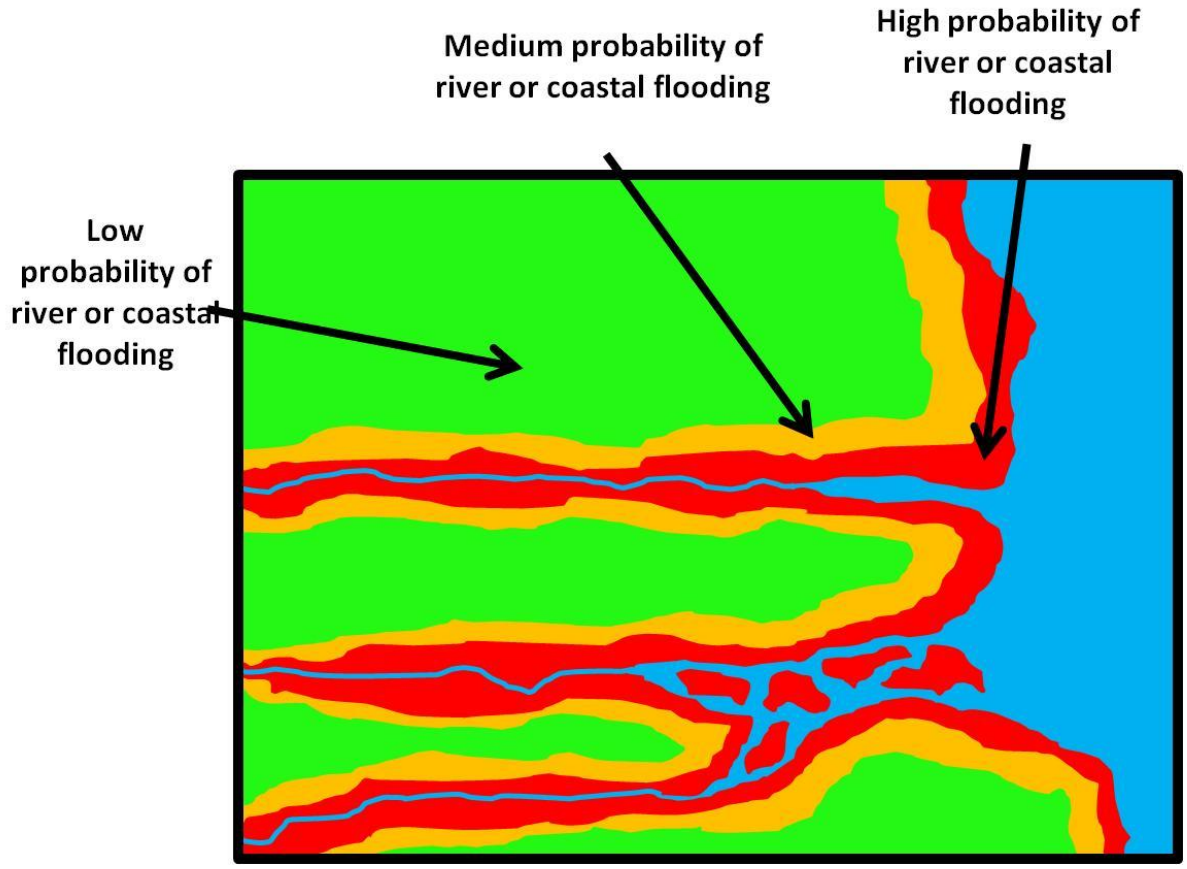

Figure A1.1: Illustration of flood probability zones

Other than the definition of the boundary between high and medium probability flooding, there are no specific definitions of probability within the Directive, so member states have made their own interpretations.

Readers should check the definitions in place within their own countries, but the following are not untypical.

Very high frequency flooding could be considered to occur more frequently than once in 20 or once in 30 years. This equates to what might be termed as the functional flood plain

High frequency coastal flooding could be considered to occur more frequently than once in 200 years. This is because sea water may be considered to be more damaging than fresh water

The boundary between medium and low probability flooding could be considered to be the 1 in 1,000 year probability event.

A1.2 Identifying flood types

Figure A1.2 identifies three different types of flooding:

Coastal (including estuaries and deltas)
Rivers
Other sources

Flood risk management of coastal areas and rivers, including the production of flood risk and hazard maps are generally the responsibility of national and regional bodies. Responsibility for the management of other sources is likely to be devolved down to local bodies.

The figure identifies the extents of the different types of flooding and the high, medium and low probability zones for rivers and coasts shown in red, yellow and green respectively. It's important to remember that most of the time, the high and medium zones are not subject to river or coastal flooding. BUT they may be subject to flooding from other sources. This is a special case and when assessing flood risk or designing drainage systems in these areas the interactions between the different types of flooding should be considered. This is where different types of modelling need to be coupled or even integrated. More detailed information on the different types of flooding follow.

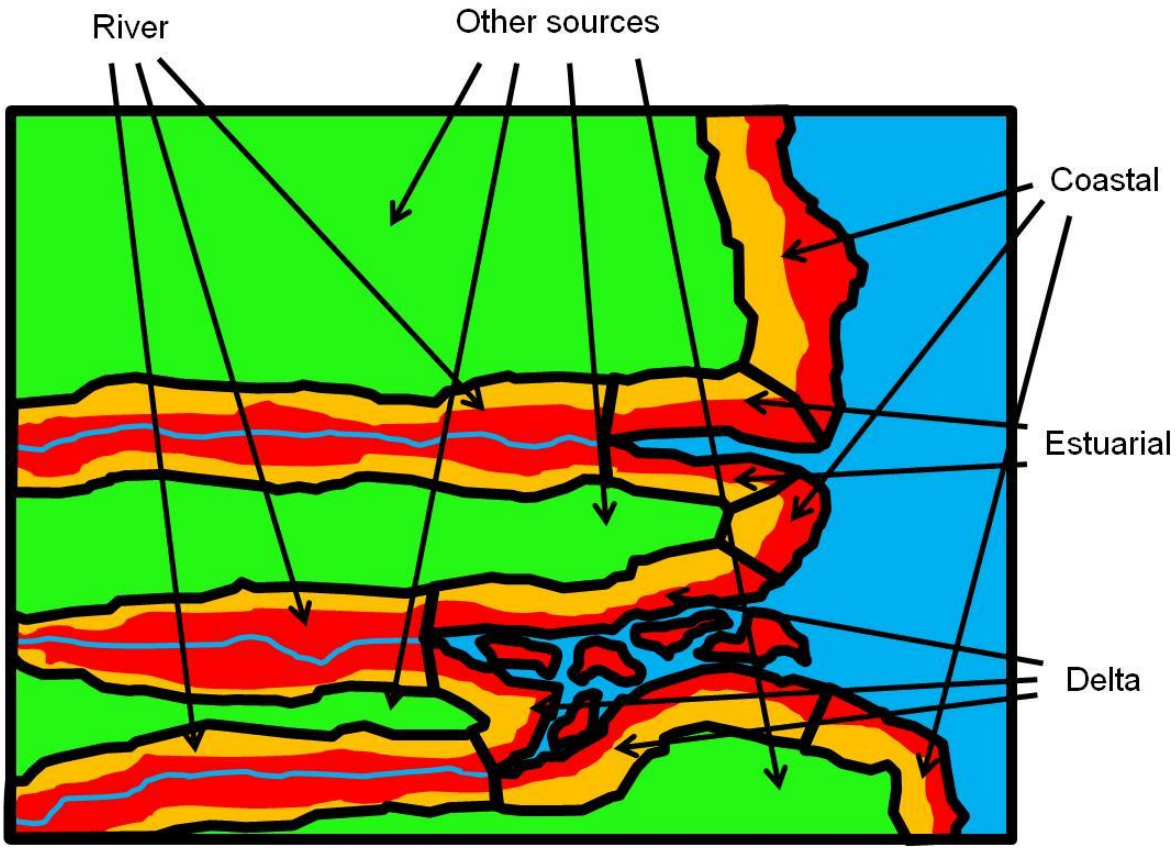

Figure A1.2: Types of flooding

A1.2.1 Rivers

River flooding occurs along large watercourses which have large catchment areas and slow response times. This means that flood warning systems based on weather forecasts and river flow gauging systems can be sufficiently accurate to make them an effective measure for flood risk management.

River flooding occurs in areas which have a high or medium probability of flooding as defined in Article 6 of the Flood Directive. River flooding may occur in natural or modified river channels as illustrated below.

It is common for flood probability maps to identify the flood extents based on an undefended channel, and this is illustrated in the following section (Figure A1.3).

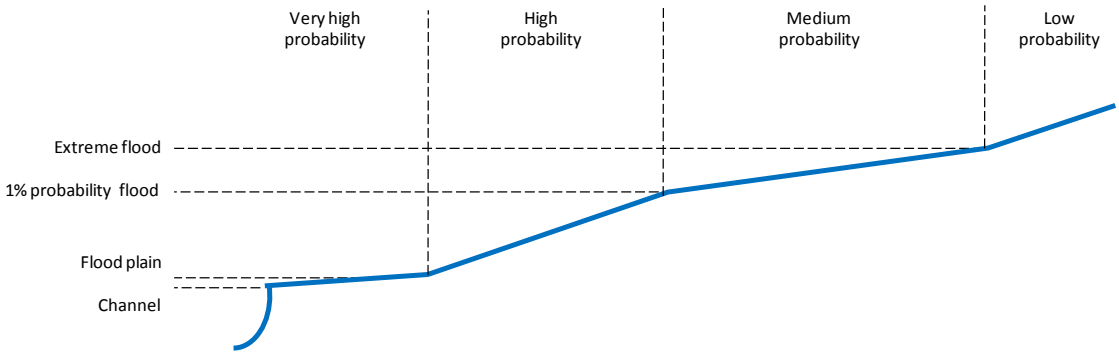

Figure A1.3: Typical section of bank and flood zones

However, most urban rivers are modified in one way or another and the areas protected by flood defences may be shown on flood probability maps.

Flood defences may be located at any position and at any elevation, but typically would be located at edge of channel, edge of flood plain or edge of 1% flood as illustrated in Figure A1.4. Elevations might typically be the level of the 1% flood or extreme flood with an addition for freeboard

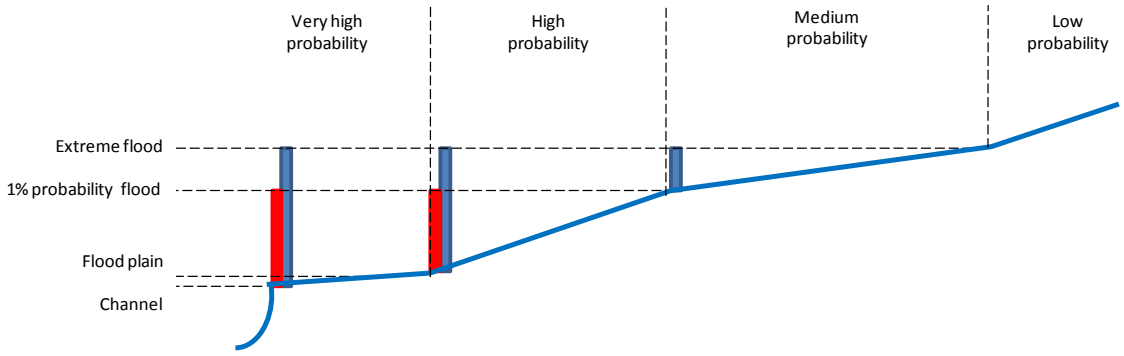

Figure A1.4: Typical locations and elevations of flood defence

By channelling a river and filling the land behind it, high probability flooding can be reduced or eliminated, but the loss of cross sectional area may increase the level of the medium and low probability floods when they occur. This is illustrated in Figure A1.5.

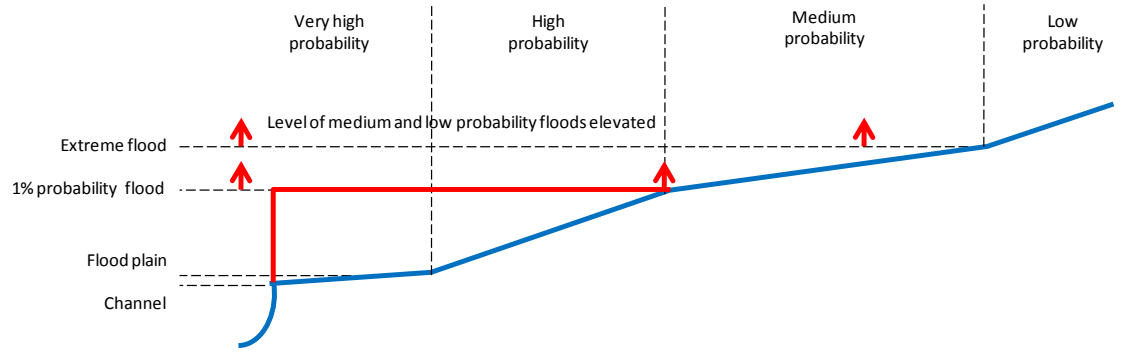

Figure A1.5: Effect of elevating bank profiles

Alternatively a well positioned, moderate flood defence coupled with a widening of the flood plain can significantly reduce flood risk in the medium probability zone as shown in Figure A1.6.

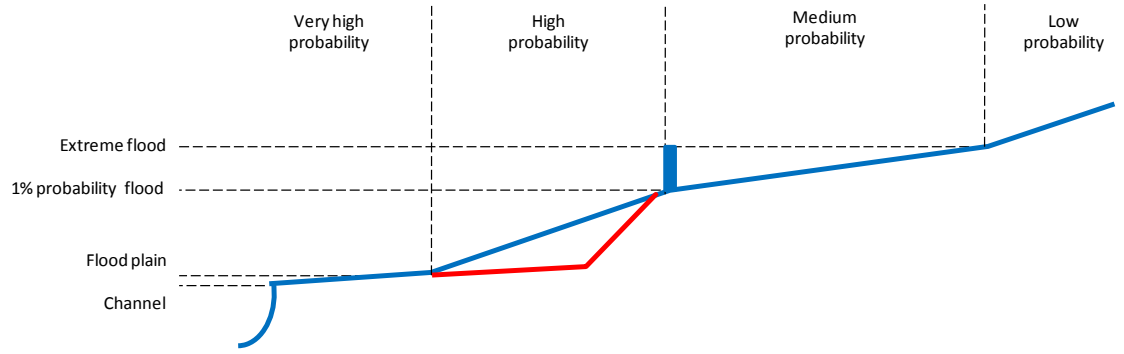

Figure A1.6: Effect of increasing flood plain width

Users may also use this selection technique to search for information on the potential effects of flood risk management measures that they wish to consider.

A1.2.2 Artificial watercourses

A1.2.2.1 Drainage channels

These are in effect man made rivers and may included storm drains and dykes. Flood zones and the effects of flood defences may those of rivers, but in large flat areas may also have the characteristics of Deltas (see section 1.2.6).

A1.2.2.2 Canals

These are navigable waterways and unlike rivers may be located in elevated locations on valley sides. Because of the needs of navigation, flows into and out of canals are controlled to reduce velocities to minimal levels and under normal operation flows remain within the channel. However, during extreme events runoff from adjacent land may increase flows and depths within canals causing overflows to operate, flooding of the banks and surrounding areas when it is constructed in cutting or overtopping the embankment when it is elevated.

A1.2.3 Lakes

Lakes and ponds are associated with rivers and streams respectively system. Their response times are different to those of rivers and water levels may be controlled at the outlets. In a large lake, it is possible that the discharge from a single event which caused flooding in the upstream rivers has little effect on the level in the lake. But long term rainfall can slowly cause levels to increase until flooding of the surrounding land occurs. In this case flooding may take a long time to abate. However, the zoning of flooding and the effects of flood defences are similar to those of rivers.

Some lakes do not have outlets and depending on the size of these may even be classed as inland seas. This is a very special case and is not considered further in this note.

A1.2.4 Coastal flooding

Coastal flooding is caused by raised sea levels resulting from a combination of astronomical and meteorological conditions. Spring tides, can combine with surges driven by low atmospheric pressure and wind to result in extreme high water levels and large waves. Behind this temperature increases associated with climate change will result in:

- land based ice masses melting and running into the sea and increasing the volume of sea water
- expansion of seas water

These will combine to increase the general sea level over the years

Figure A1.7 illustrates coastal flood probability zones

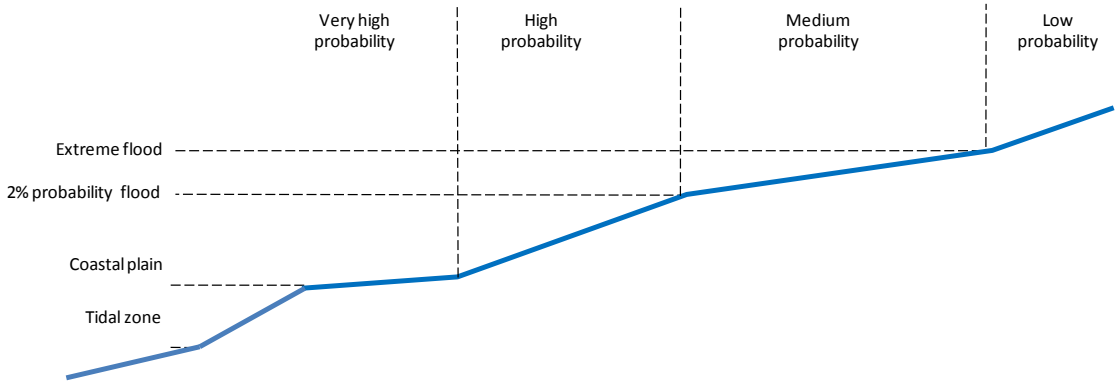

Figure A1.7: Typical section of natural coast line and flood zones

Although the construction of promenades and coastal defences does not affect sea level, they can affect the dynamic effects of wave motion and the way that drainage in the protected areas performs. This is illustrated in Figures A1.8 and A1.9.

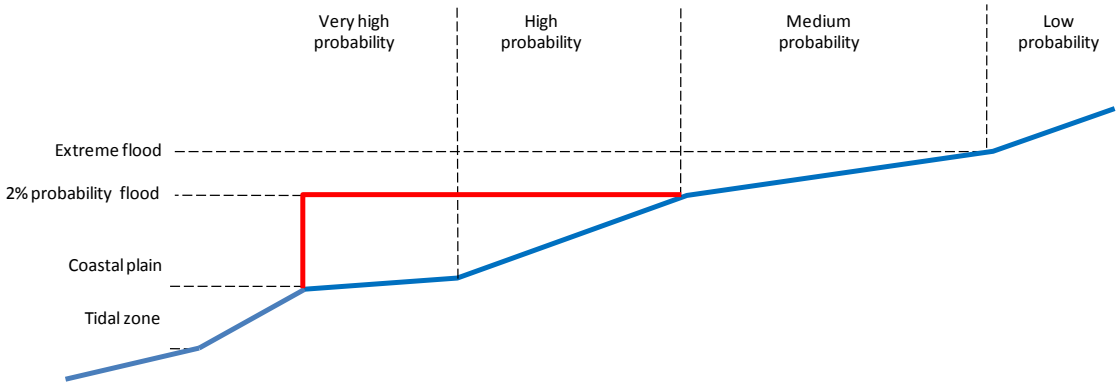

Figure A1.8: Typical section through a promenade

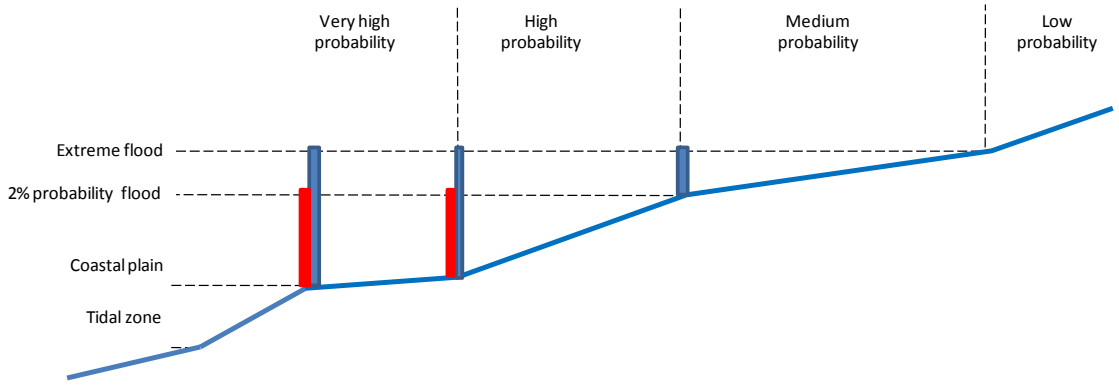

Figure A1.9: Typical locations and elevations for coastal defences

A1.2.5 Estuarial flooding

Estuarial flooding is caused by a combination of river and coastal effects which varies between the upstream limits of coastal effects and the downstream limit of river effects. The narrowing of estuaries can exacerbate surge effects.

A1.2.6 Delta flooding

In deltas large areas of low lying land are bounded by river channels and the sea. In these areas, land falls naturally within the flood plain (Figure A1.10) and may, because of a combination of land reclamation activity and siltation of river channels, lie below the normal river level. As with Estuaries the balance between river and coastal effects will vary from the upstream to downstream reaches, but it is important to recognise that there are very specific requirements of flood risk management in deltas.

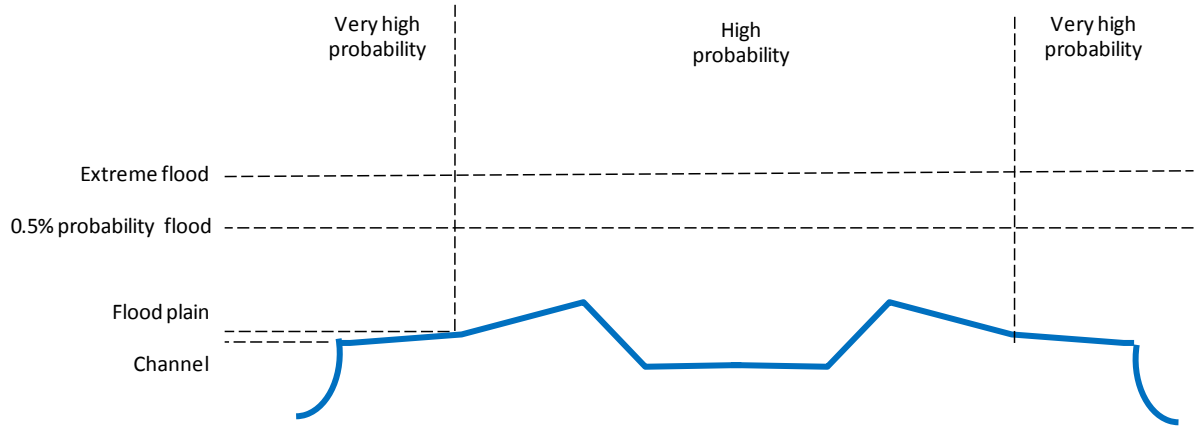

Figure A1.10: Typical flood zones on a delta island

The location of flood defences diminishes in importance as the river impacts reduce downstream. Nevertheless sufficient width has to be provided for the impact of surges (Figure A1.11).

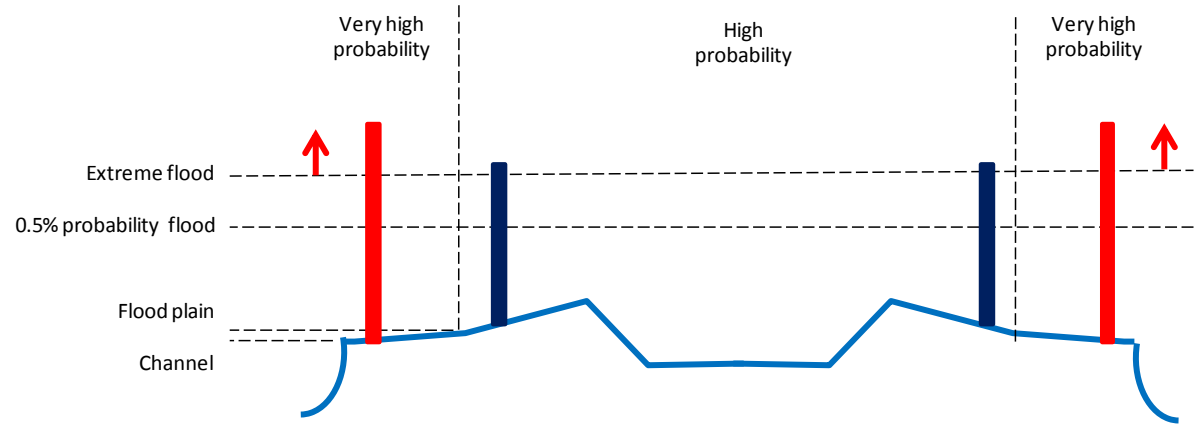

Figure A1.11: Impact of defence location on height of extreme flood where river impacts predominate

A1.2.7 Flooding from other sources

A1.2.7.1 Introduction

Flooding from other sources include:

Flash flooding from streams which are rapidly responding and are too small for effective flood warning

Rural and urban area flooding

1. Surface water and soil,
2. Ground water
3. Minor drainage systems (sewers, SUDS and land drainage)
4. Exceedence pathways

These sources of flooding interact in complex ways and are relevant to all areas of land. However, in areas with a high or medium probability of river, coastal, estuarial or delta flooding, there are special requirements for flood management and drainage systems lying behind flood defences, from which water cannot drain when river or sea levels are elevated and .

The following illustration (Figure A1.12) shows an urban area with its drainage system which for the sake of simplicity it is not affected by river or coastal flooding. Typical of most urban areas it is surrounded by urban green space which drains into or is affected by urban runoff and there are pockets of urban green space such as parks and playing fields within the developed urban area. The area is drained by a combination of sewers and small watercourses, but in some areas the process of urbanisation has in effect destroyed the natural drainage system

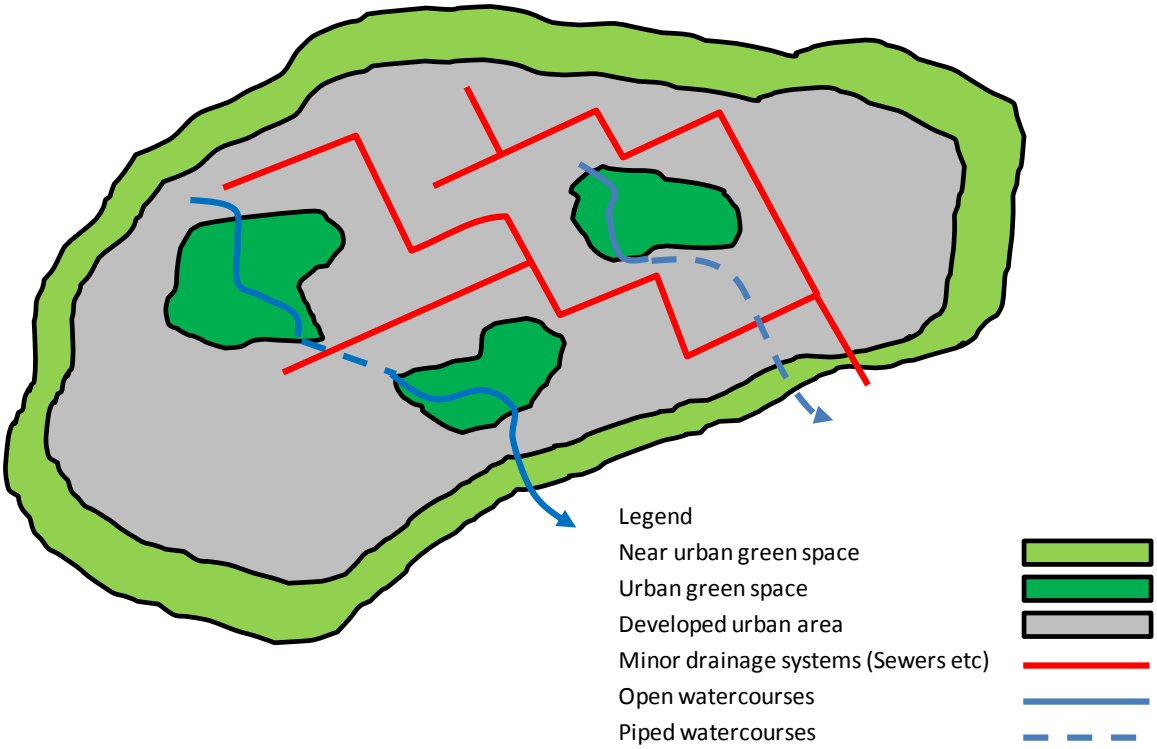

Figure A1.12

A1.2.7.2 Surface water and soil

Flooding from surface water and soil includes runoff from:

- Undrained impervious areas
- Drained impervious areas when the design capacity of the drainage system is exceeded
- Pervious areas when intense rainfall exceeds the rate at which the water can soak into the ground
- Pervious areas when the ground is fully saturated by prolonged rainfall

Runoff from one area of land can flow onto an adjacent area causing overloading of that area and so on.

Figure A1.13 shows runoff migrating through our urban area passing from the near urban green space area into the developed urban area; from the developed urban area into the urban green space and vice – versa and finally, from the developed urban area into the downstream near urban green space. The illustration also shows rural areas, but these may be considered to be buffered from the urban areas by near urban green space.

This simple illustration tells us that in order to manage the complexities of urban drainage; we have to understand the complexities of the hydrology of near urban and urban green space as well as that of developed urban areas and how that affects runoff.

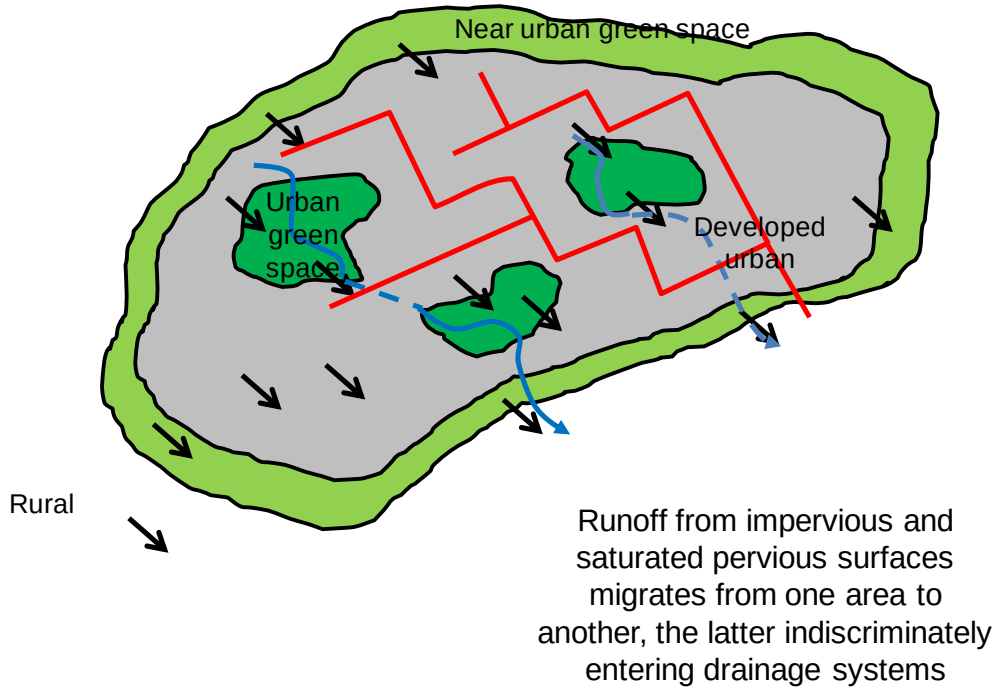

Figure A1.13: Illustration of flooding from land

A1.2.7.3 Flooding from groundwater

Flooding from groundwater can arise from:

- Artificial and natural superficial deposits,
- Bedrock

In both cases water moves from the ground to the land surface when the downward migration of water into the ground is stopped by an impervious layer, or a layer which has inadequate permeability to convey the water percolating into the ground. This typically manifests itself as high groundwater levels in flat land or river valleys, or as spring lines on hillsides after periods of prolonged wet weather (Figure A1.14)

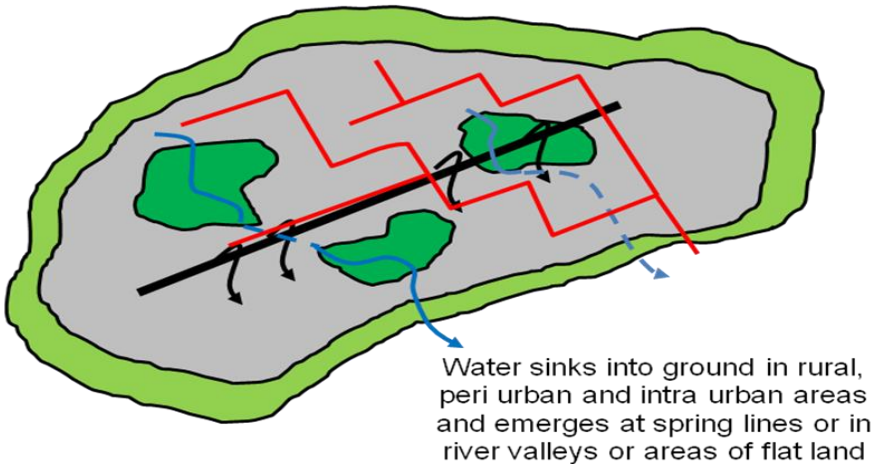

Figure A1.14: Illustration of flooding from ground water

A1.2.7.4 Flooding from drainage infrastructure

Drainage infrastructure includes:

- Land drainage
- Sewers
- SUDS

Expectations of the capacity of minor drainage systems vary, but it is inevitable that the capacity of these systems will be exceeded as it is not practicable to provide capacity for all events. Factors which affect the choice of capacity for a minor drainage system include the degree of urbanisation and the proximity of watercourses, which affect the amount of water that will flow over the surface and the distance that it has to travel and thus affect the risk of flooding of properties. The impacts of climate change and urbanisation over the serviceable life of drainage assets are likely to exacerbate inadequacies in capacity towards the end of their life. The difficulty lies in the uncertainty of the predictions of climate change and urbanisation and the cost of constructing additional capacity that might not be needed. Figure A1.15, gives illustrations of how capacity might be exceeded due to inadequate provision for runoff from green space and increasing demand because of climate change and urbanisation. In addition, poor operation and maintenance may result in capacity being reduced.

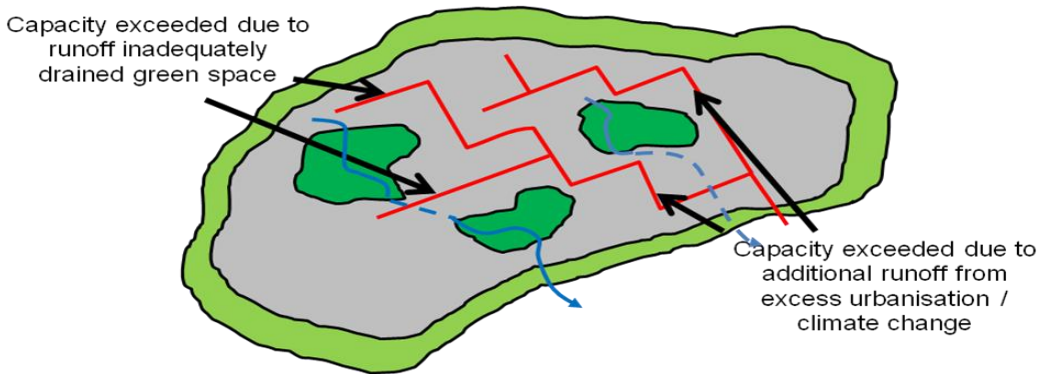

Figure A1.15: Illustration of flooding from minor drainage systems

A1.1.7.5 Flooding from streams

Flooding from streams occurs for the same reasons as flooding from rivers, but because of their size the impacts of modifications in urban areas are likely to be greater including the construction of long lengths of culverts. Because of this, the Figure A1.16 is added to those in Section 4.1

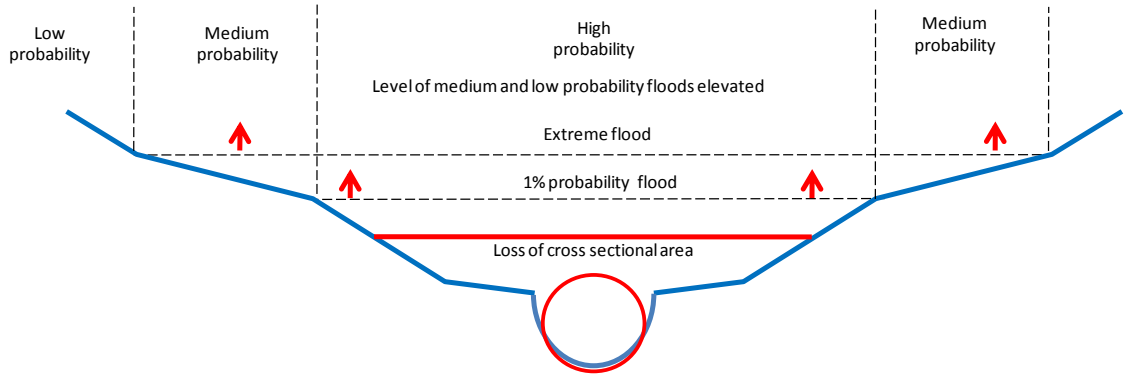

Figure A1.16: Effect of culverting

The impact of culverting is compounded by sedimentation and blockage of the culvert which reduces the capacity of the culvert and by the reduction of connectivity between the land surface and the culvert which can cause the surface to flood before the culvert runs full.

Blockage of culverts and their inlets reduces capacity and can generate secondary pathways. This is shown in Figure A1.17.

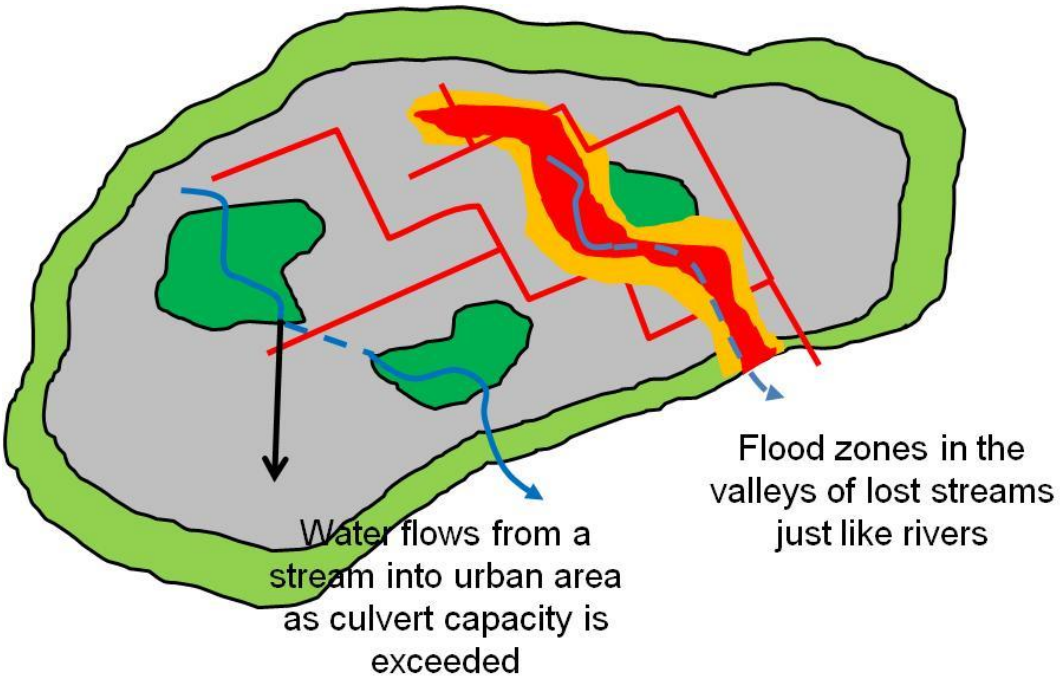

Figure A1.17: Illustrations of flooding from streams

A1.2.7.6 Flooding from exceedence pathways

When flooding from surface water, soil, groundwater, streams and minor systems occur, the flows enter exceedence pathways. These pathways may be natural and built. If the pathways contain the water without causing damage or unacceptable disruption, then this is acceptable. However, if unacceptable damage or disruption is caused then this is classed as flooding.

Appendix 2: Identify stakeholders and their roles

Tables A1, A2, A3, A4 and A5, check lists for the different topic groups relevant to flood risk management. The stakeholders responsible for each cell within the table should be identified together with an assessment of whether the stakeholder is acting because of legislative duties, legislative powers, or voluntarily. Each cell may be completed by entering a unique number for each stakeholder followed by a letter as follows:

D for a duty set down in statute
P for a power set down in statute
V for a voluntary action

Therefore cells may be completed 1P, 4V etc.

If no one takes action within a particular cell then it may be left blank, or if the cell is not relevant, e.g. coastal waters within an inland city, then they may be shaded out.

Those wishing to align flood risk management with other aspects of water quality and land use and biodiversity management should refer to Appendix 3 for additional check lists to enhance the stakeholder analysis process.

Table A2.1: Stakeholder involvement in flood analysis and assessment

This table may be used to identify who does what modelling etc

		Exceedence pathways	Surface water and soil				Groundwater			Drainage infrastructure				Small Streams and ponds	Large Streams and ponds	Rivers and lakes	Artificial water bodies		Estuaries and deltas	Open sea
			Rural green space	Green space at urban fringe	Green space within urban area	Developed urban surface	Artificial superficial deposits(Made, Worked, In filled, Disturbed or Landscaped Ground)	Natural superficial deposits	Bedrock	Sewers	SUDS/Source control	Pipe drain	Open Drain				Drainage channels	Canals		
Data collection and management	Rainfall																			
	Flow and depth																			
Modelling	Rainfall																			
	Probability and consequences (risk)																			
	Modelling joint probabilities																			
Economic damage assessment																				
Mapping	Hazard, probability and risk																			
	Mapping joint probabilities																			
Flood forecasting																				

Table A2.2: Stakeholder involvement in raising flood awareness This table may be used twice: • To identify the awareness raising that stakeholders believe they should be providing • To identify the awareness raising that they are doing By taking one from the other the need to develop awareness raising material can be identified. Gaps will identify where material should be provided from external sources.		Exceedence pathways	Surface water and soil				Groundwater			Drainage infrastructure				Small Streams and ponds	Large Streams and ponds	Rivers and lakes	Artificial water bodies		Estuaries and deltas	Open sea
			Rural green space	Green space at urban fringe	Green space within urban area	Developed urban surface	Artificial superficial deposits(Made, Worked, In filled, Disturbed or Landscaped Ground)	Natural superficial deposits	Bedrock	Sewers	SUDS/Source control	Pipe drain	Open Drain				Drainage channels	Canals		
Customising awareness raising material for decision makers, professional advisors and public	Flood mechanisms and their interactions																			
	Flood risk																			
	Flood risk management																			
	Impact of climate change																			
	Impact of demographic change																			
	Local flood history																			
	Resilient construction																			
	Resistant construction																			
	Sustainable Drainage Systems (SUDS)																			
	Controlled surface conveyance																			
	Watercourse restoration																			
	Traditional flood defense measures																			
	Adapted Land Use																			
	Residual risk																			
	Insurance																			
	Decision support tools																			
	Communication																			
	Education and guidance																			

Table A2.3: Stakeholder involvement in flood alleviation and avoidance

This table may be used to identify the stakeholders involved in developing and implementing appropriate measures for alleviating current flood risk and avoiding future risk. Many, but not all flood risk management measures are applicable to alleviation and avoidance so makes sense to merge the two. These stakeholders should work closely with those identified in Table A2.4 to manage flood risk

		Exceedence pathways	Surface water and soil				Groundwater			Drainage infrastructure				Small Streams and ponds	Large Streams and ponds	Rivers and lakes	Artificial water bodies		Estuaries and deltas	Open sea
			Rural green space	Green space at urban fringe	Green space within urban area	Developed urban surface	Artificial superficial deposits(Made, Worked, In filled, Disturbed or Landscaped Ground)	Natural superficial deposits	Bedrock	Sewers	SUDS/Source control	Pipe drain	Open Drain				Drainage channels	Canals		
Resilient and resistant infrastructure																				
Resilient and resistant buildings (Flood adaptive architecture)																				
Strategy and master planning	Regulation																			
	Guidance																			
Development control	Regulation																			
	Guidance																			
Building control	Regulation																			
	Guidance																			
Zoning ordinances and maps																				
Water sensitive urban design																				
Surface water management																				
Surface water maintenance																				
Developing and assessing options																				
Appropriate use of adaptive and non adaptive responses																				
Flood minimisation by flow management																				
Insurance																				
Reserve funds																				
FRM programme development																				
FRM programme implementation																				

Table A2.4: Stakeholder involvement in assistance

This table may be used to identify the stakeholders involved in assisting communities to prepare for, manage and recover from flood events. These stakeholders should work closely with those identified in Table 2.3 to manage flood alleviation and avoidance. Because the stakeholders in this table assist communities with all types of emergency and are very busy, all stakeholders in the water and land management sector are advised to adopt a common framework to ease communication and improve the effectiveness of collaborative working.

		Exceedence pathways	Surface water and soil				Groundwater			Drainage infrastructure				Small Streams and ponds	Large Streams and ponds	Rivers and lakes	Artificial water bodies		Estuaries and deltas	Open sea
			Rural green space	Green space at urban fringe	Green space within urban area	Developed urban surface	Artificial superficial deposits(Made, Worked, In filled, Disturbed or Landscaped Ground)	Natural superficial deposits	Bedrock	Sewers	SUDS/Source control	Pipe drain	Open Drain				Drainage channels	Canals		
Preparing for floods																				
Flood warnings	Email																			
	SMSOn-line																			
	Door knocking																			
Responding to emergencies	Temporary flood protection																			
	Emergency operations																			
The “All clear” process																				
Helping recovery																				

Table A5: Stakeholder involvement in integration, strategy and capacity Flood risk management is only one aspect of land and water management. It operates alongside water quality management, water supply and drought management, land use and biodiversity management. The civil contingency planning and emergency response sector also work across all these different aspects of urban life. Consequently there are perceived benefits in developing a common framework and language to ease communication and enhance effectiveness. It is expected that each cell in this table will be relevant to several stakeholders. Once identified these stakeholders can work together to develop appropriate approaches.		Exceedence pathways	Surface water and soil				Groundwater			Drainage infrastructure				Small Streams and ponds	Large Streams and ponds	Rivers and lakes	Artificial water bodies		Estuaries and deltas	Open sea
			Rural green space	Green space at urban fringe	Green space within urban area	Developed urban surface	Artificial superficial deposits(Made, Worked, In filled, Disturbed or Landscaped Ground)	Natural superficial deposits	Bedrock	Sewers	SUDS/Source control	Pipe drain	Open Drain				Drainage channels	Canals		
Regulation, procedures and institutional arrangements																				
Embedding water into the culture and conscience of the city.																				
Developing a coherent vision (consensus) for land and water management																				
Communication	Within organisations																			
	Between organisations																			
	With communities and citizens																			
	Communications systems																			
Integration of all aspects of land and water management																				
Integrating flood avoidance, alleviation and assistance	Integration of spatial and emergency planning																			
	Balancing structural and non structural responses by assessment of impact on assistance																			
Capacity building	Assessment of needs																			
	Processes and tools																			
	Training material																			
Innovation	Assessment of needs																			
	Identification of measures																			

Appendix 3: Stakeholder involvement in water quality, land use and biodiversity management

(To be completed)