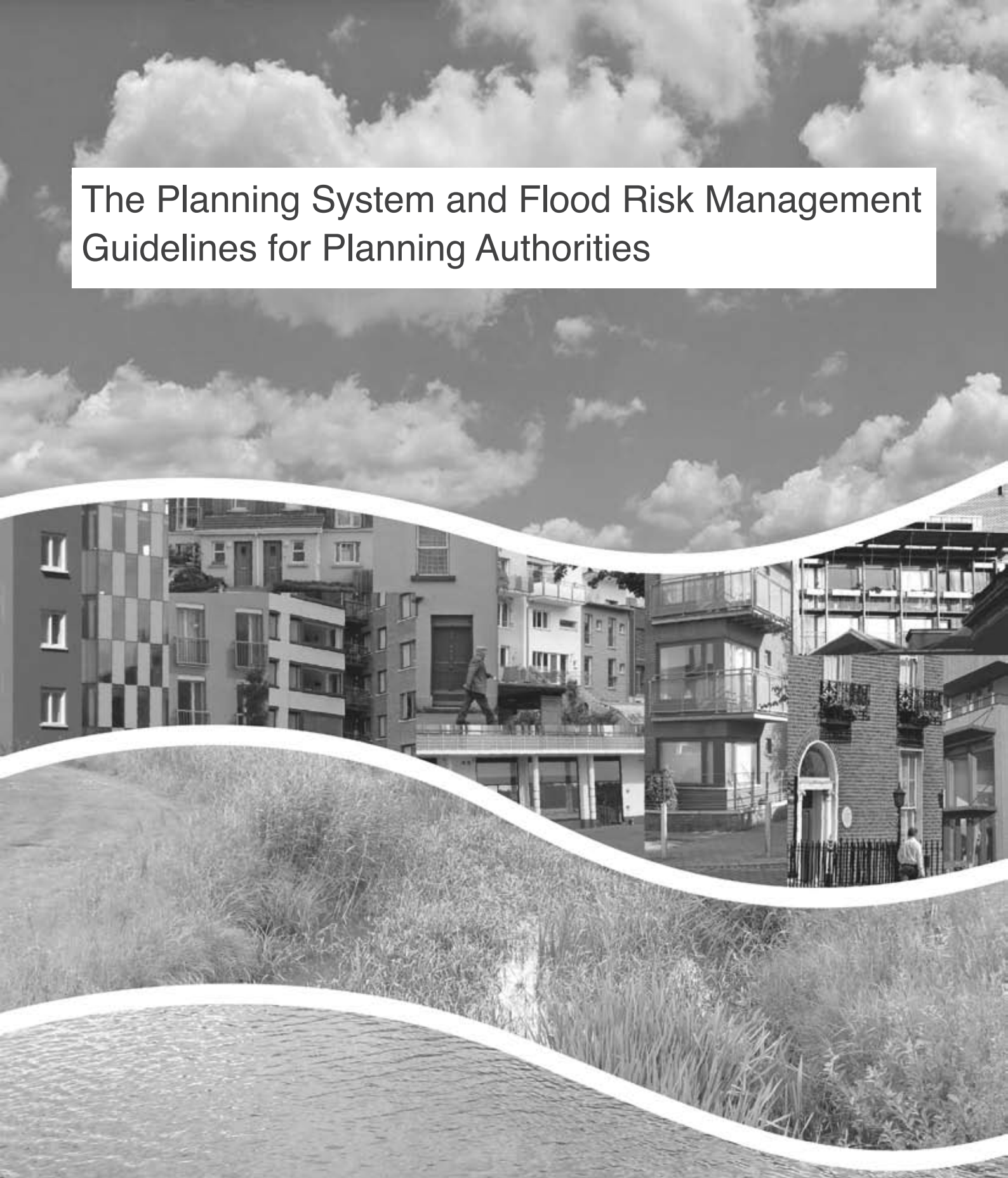
The Planning System and Flood Risk Management Guidelines for Planning Authorities



Technical Appendices

November 2009

Comhshaol, Oidhreacht agus Rialtas Áitiúil
Environment, Heritage and Local Government

OPW
The Office of Public Works
Oifig na nOibreacha Poiblí

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1.0 Flood risk assessment

1.1 Overview

Flood risk assessments (FRAs) aim to identify, quantify and communicate to decision-makers and other stakeholders the risk of flooding to land, property and people. The purpose is to provide sufficient information to determine whether particular actions (such as zoning of land for development, approving applications for proposed development, the construction of a flood protection scheme or the installation of a flood warning scheme) are appropriate.

A flood risk assessment (FRA) can be undertaken either over a large area or for a particular site to:

:: Identify whether and the degree to which flood risk is an issue;

:: Identify flood zones (if not already available);

:: Inform decisions in relation to zoning and planning applications; and

:: Develop appropriate flood risk mitigation and management measures for development sited in flood risk areas.

Flood risk assessments can be undertaken at a range of scales relevant to the planning process (see 1.4 below). The key scales of FRA are:

:: Regional (for regional planning guidelines);

:: Strategic (for city or county development plans or local area plans); and

:: Site Specific (for master plans and individual site planning applications).

FRAs are typically undertaken over a number of stages (see section 1.5), with the need for progression to a more detailed stage dependent on the outcomes of the former stage until the level of detail of the FRA is appropriate to support the planning matter, be it a zoning proposal or a decision on an individual planning application, or it has been demonstrated that flooding is not a relevant issue for the area or site.

This Appendix seeks to explain the terminology and the methodology of flood risk assessment so that decision-makers can plan, scope and consider such assessments in an informed manner. It makes appropriate reference to further guidance and sources of information.

The Appendix sets out the key principles of the assessment of flood risk, and how these are applied at the different spatial scales within the hierarchy of the planning system. Flood risk assessments will differ in scale, detail and breadth of flood risk issue considered. In this Appendix the inputs are considered for each stage of assessment but the outputs are described for each scale of assessment (see sections 1.5 and 1.6). Both sections should be read in tandem so that the scale and stage attributes of a flood risk assessment can be brought together in defining what needs to be done. The OPW will provide template specifications for the differing scales of flood risk assessment available via the OPW website.

1.2 General principles of flood risk assessment

Flood risk assessments should (be):

:: Proportionate to the risk scale, nature and location of the development;

:: Undertaken by competent people, such as a suitably qualified hydrologist, flood risk management professional or specialist water engineer;

:: Undertaken as early as possible in the particular planning process;

:: Supported by appropriate data and information, including historical information on previous events, but focusing more on predictive assessment of less frequent or more extreme events, taking the likely impacts of climate change into account;

:: Clearly state the risk to people and development and how that will be managed over the lifetime of the development;

:: Focused on addressing the impact of a change in land use or development on flood risk elsewhere, ensuring that any such change or development must not add to and should, where practicable, reduce flood risk;

:: Consider the vulnerability of those that could occupy the development, including arrangements for safe access and egress; and

:: Consider the modification to flood risk that infrastructure such as raised defences, flow channels, flood-storage areas and other artificial features provide, together with the consequences of their failure.

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1.3 Source-Pathway-Receptor Model

The assessment of flood risk requires a thorough understanding of the sources of flood water (e.g. high sea levels, intense or prolonged rainfall leading to run-off and increased flow in rivers and sewers), the people and assets affected by flooding (known as the receptors) and the pathways by which the flood water reaches those receptors (e.g. river channels, river and coastal floodplains, drains, sewers and overland flow).

The Source-Pathway-Receptor (S-P-R) Model has become widely used to assess and inform the management of environmental risks. This is illustrated in Fig. A1.

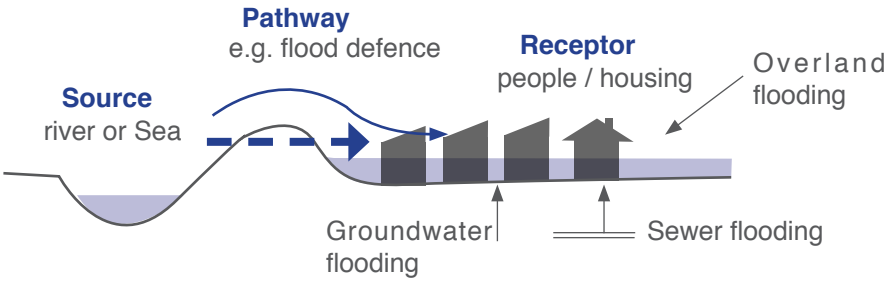


Fig. A1: Sources, pathways and receptors of flooding

Flood risk assessments require identification and assessment of all three components:

:: The probability and magnitude of the source(s) (e.g. high river levels, sea levels and wave heights);

:: The performance and response of pathways and barriers to pathways such as floodplain areas and flood defence systems; and

:: The consequences to receptors such as people, properties and the environment.

The ultimate aim of a flood risk assessment is to combine these components and map or describe the risks on a spatial scale, so that the consequences can then be analysed. FRAs need to consider the situation both as it is now and also how it might change in the future. Such consideration should include changes in climate (which impact largely on sources), the construction of flood protection or drainage schemes within the locality by others, the deterioration of existing and proposed defences, the operational performance of screens and pumps over time both locally and provided by development (which all modify the pathways) and the introduction, through development, of receptors into areas at risk of flooding.

In a complex defended tidal area, where flood gates may be operated all elements of the S-P-R model should be examined to identify the high risk elements in order to focus the analysis. An example of such an analysis is given in Table A1, but does depend on the local context, such as the current level of flood risk management measures and the flood depths that could result in an extreme event.

Source	Pathway	Receptor	Likelihood	Consequence	Risk
Tidal	Overtop breach	People, property	Very remote to remote	Very high/high	High
Fluvial	Overbank	People, property	Possible	Medium	High
Surface water	Blockage overflow	People, property	Likely	Low	Medium
Ground water	Raising water level	People, property	Possible	Low	Low
Human/ mechanical error	Gates remain open	People, property	Likely (for small gates)	Medium/high	High

Table A1: Example components to be considered in identification and assessment of flood risk

1.4 Scales used for flood risk assessment

FRAs are required at different scales by different organisations for many different purposes. A hierarchy of assessments is necessary to ensure a proportionate response to the needs of organisations by avoiding the need for detailed and costly assessments prior to making strategic decisions. This hierarchy is summarised in Table A2.

Regional Flood Risk Appraisal (RFRA) is a high-level broad-brush appraisal of flood risk across an entire regional authority area, based on existing readily available information and will normally identify areas of flood risk and the potential for conflict with areas of identified future growth. The RFRA will thus feed into high-level strategic RPG policies, particularly relating to the need for a more detailed assessment of flood risk when preparing development plans and local area plans at a local level and highlight the need for co-operation across planning authority boundaries in some areas.

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The Strategic Flood Risk Assessment (SFRA) at county or city level is a more detailed assessment which is initially based on existing information but may require the gathering of new information and hydraulic model output for the area concerned, as described in Fig. A2.

FRA	Code	Purpose	Responsibility
Regional Flood Risk Appraisal	RFRA	RFRAs provide a broad overview of the source and significance of all types of flood risk across a region and also highlighting areas where further more detailed study will be required. At this level, they are an appraisal and not an assessment.	Regional authorities in consultation with the OPW, river basin management bodies and LAs. CFRAM Study outputs, when available, will be an important and prime input to the appraisal.
Strategic Flood Risk Assessment for development plan and LAP	SFRA	To provide a broad (area-wide) assessment of all types of flood risk to inform strategic land-use planning decisions. SFRAs enable the LA to undertake the sequential approach, including the Justification Test, allocate appropriate sites for development and identify how flood risk can be reduced as part of the development plan process. The level of detail required will differ for county and city development plans.	LAs in consultation with the OPW, and emergency services. The Flood risk management plan arising from the CFRAM programme will heavily inform the SFRA. In its absence local authorities may need to commission extensive flood risk assessments, albeit at a strategic level. OPW will provide advice on the specifications that should be applied.
Site-specific Flood Risk Assessment	Site FRA	To assess all types of flood risk for a new development. FRAs identify the sources of flood risk, the effects of climate change on this, the impact of the development, the effectiveness of flood mitigation and management measures and the residual risks that remain after those measures are put in place. Must be carried out in all areas where flood risk have been identified but level of detail will differ if SFRA at development plan level has been carried out.	Those proposing the development in consultation with the LA and emergency planners.

Table A2: Hierarchy of flood risk assessment

A county development plan will not normally have to produce a flood risk map for all watercourses or coastal frontage. Detailed assessments may be identified in county wide flood risk assessment or in the Regional Flood Risk Appraisal but should be undertaken where zoning of land is being considered within the development plan. Presenting flood risk information at this broad county scale can be done using flood risk indicators. These compile a range of information sources on flood risk, such as historic incidents, floodplain or flood zone extents as a proportion of urban area, sensitivity to climate change impacts, area defended by barriers or storage reservoirs. In order to map these indicators consistently they should be attributed to the communities and/or settlements at risk. This can be presented in kilometre square tiles, a technique currently being used in the EU Floods Directive Preliminary Flood Risk Assessment (PFRA). Caution should however be taken in using indicators of flood risk based on existing conditions (such as that portrayed by the PFRA). While such information is useful to identify where further FRA may required for towns already at risk, it is important to consider the sustainability of expansion of all communities, including those currently at low risk. The latter consideration will require access to flood zone information or its provision within a SFRA. The OPW will be available to advise on how to map flood risk at a county scale. A diagrammatic presentation of the spatial resolution appropriate to county and city SFRAs is shown in Fig. 4.1.

Where flooding is not a major issue and where development pressures are low, a less detailed approach may be required. The level of detail required will be apparent through the staged approach to planning and executing flood risk assessment. This approach is recommended to allow flexibility in the level of assessment required from one local authority area to another.

SFRAs will provide more detailed information on the spatial distribution of flood risk within extensive areas of high flood risk where development is to be considered, and also where it will be necessary to apply the Justification Test. City development plans are therefore expected to have produced SFRAs, as identified in the scoping stage of the SEA and within the RFRA. The SFRA will then be used within the SEA process to assess the suitability of, and options for, land use scenarios.

SFRAs may need to undertake a detailed flood risk assessment albeit in outline to demonstrate that a planned development could pass the flood risk management elements of the Justification Test. Key to this will be ensuring that the impacts of a mitigated development site do not cause any externalities.

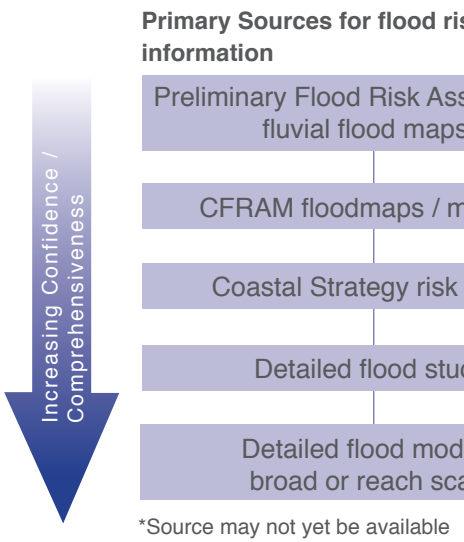


Fig. A2: Sources of flood data

A detailed site-specific Flood Risk Assessment of development proposals or localised plans needs to consider the nature of flood hazard, taking account of the presence of any flood risk management measures such as flood protection schemes and how development will reduce the flood risk to acceptable levels. These detailed assessments, either in outline for the SFRA or full for a development application will need to describe with sufficient certainty that the core flood risk elements of the Justification Test are passed, namely that residual risks can be successfully managed and there are no unacceptable impacts on adjacent lands. The following indicators are typically used in the assessment of flood risk and are appropriate at both Strategic and Site FRA scales:

:: Flood probability;

:: Flood depth;

:: Flood velocity;

:: Rate of onset of flooding.

1.5 Stages in the assessment of flood risk

As outlined in chapter 3 of the Guidelines the stages of assessment are:

:: *Stage 1 Flood risk identification* – to identify whether there may be any flooding or surface water management issues related to a plan area or proposed development site that may warrant further investigation;

:: *Stage 2 Initial flood risk assessment* – to confirm sources of flooding that may affect a plan area or proposed development site, to appraise the adequacy of existing information and to determine what surveys and modelling approach is appropriate to match the spatial resolution required and complexity of the flood risk issues. The extent of the risk of flooding should be assessed which may involve preparing indicative flood zone maps. Where existing river or coastal models exist, these should be used broadly to assess the extent of the risk of flooding and potential impact of a development on flooding elsewhere and of the scope of possible mitigation measures; and

:: *Stage 3 Detailed risk assessment* – to assess flood risk issues in sufficient detail and to provide a quantitative appraisal of potential flood risk to a proposed or existing development, of its potential impact on flood risk elsewhere and of the effectiveness of any proposed mitigation measures. This will typically involve use of an existing or construction of a hydraulic model of the river or coastal cell across an wide enough area to appreciate the catchment wide impacts and hydrological processes involved.

Shapes FRA

Influences FRA

	Flood risk identification	Initial flood risk assessment	Detailed flood risk assessment
Regional Flood Risk Appraisal	✓	U	U
Strategic Flood Risk assessment – County-wide	✓	P	U
Strategic Flood Risk Assessment – City or town within a county plan	✓	✓	P
Site-specific flood risk assessment	✓	✓	✓

P = Probably needed to meet the requirements of the Justification Test

U = Unlikely to be needed

✓ = Required to be undertaken

Table A3: Flood risk assessment stages required per scale of study undertaken

Stage 1 - Flood risk identification

Identification is the process for deciding whether a plan or project requires a flood risk assessment and is essentially a desk-based exercise based on existing information. In order to establish whether a flood risk issue exists or may exist in the future, a range of sources should be consulted. The prime source will ultimately be the flood zone maps produced by the OPW, but where these have not been prepared or are not on watercourses that will be covered by a CFRAM study then the planning body or developer will need to refer to alternative sources of information. However, these only identify some of the more obvious sources of flood risk. Flooding from other sources such as surface water systems or adjoining hillsides are difficult to map, but need to be carefully considered.

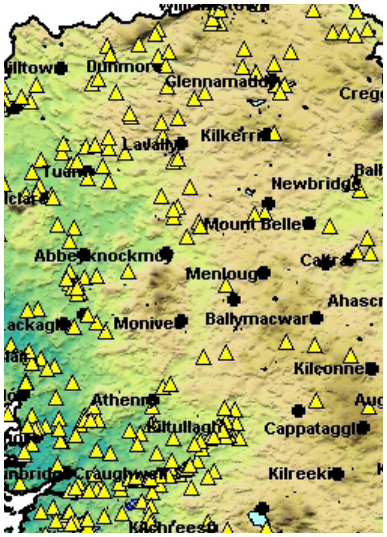


Fig. A3: Recorded historic flood events for County Galway

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Table A4 provides an indication of where those undertaking an assessment should start:

Information source	Scale of assessment			
	RFRA	SFRA - COUNTY	SFRA - CITY	Site FRA
OPW Preliminary Flood Risk Assessment indicative fluvial flood maps;	✓	✓	✓	✓
National Coastal Protection Strategy Study flood and coastal erosion risk maps;	✓	✓	✓	✓
Predictive and historic flood maps, and Benefiting Lands Maps, such as those at http://www.floodmaps.ie;	✓	✓	✓	✓
Predictive flood maps produced under the CFRAM Studies;	✓	✓	✓	✓
River Basin Management Plans and reports;	✓	✓	✓	✓
Indicative assessment of existing flood risk under Preliminary Flood Risk Assessment;	✓	✓	✓	✓
Previous Strategic Flood Risk Assessments;	✓	✓	✓	
Expert advice from OPW who may be able to provide reports containing the results of detailed modelling and flood-mapping studies, including critical drainage areas, and information on historic flood events, including flooding from all sources;	✓	✓	✓	n/a
Consultation with Local Authorities who may be able to provide knowledge on historic flood events and local studies etc.	✓	✓	✓	✓
Topographical maps, in particular digital elevation models produced by aerial survey or ground survey techniques;	S	✓	✓	✓
Information on flood defence condition and performance;	n/a	S	✓	✓

Alluvial deposit maps of the Geological Survey of Ireland (which would allow the potential for the implementation of source control and infiltration techniques, groundwater and overland flood risk to be assessed). These maps, while not providing full coverage, can indicate areas that have flooded in the past (the source of the alluvium) and may be particularly useful at the early stages of the FRA process where no other information is available;	P	P	P	n/a
'Liable to flood' markings on the old '6 Inch' maps;	n/a	P	P	n/a
Local libraries and newspaper reports;	n/a	✓	✓	✓
Interviews with local people, local history/ natural history societies etc;	n/a	n/a	S	✓
Walkover survey to assess potential sources of flooding, likely routes for flood waters and the site's key features, including flood defences, and their condition; and	n/a	n/a	S	✓
National, regional and local spatial plans, such as the National Spatial Strategy, regional planning guidelines, development plans and local area plans provide key information on existing and potential future receptors.	✓	✓	✓	✓

P = Possible source of information but not primary or essential, especially if better information exists from more detailed studies.

S = Selective source depending on scale of issues and could be delayed until initial flood risk assessment stage.

✓ = Primary source. This will be readily available information once CFRAMS have been completed, but in order to examine all development allocations within a plan further research from secondary sources will be required.

n/a = Not appropriate or not applicable.

Table A4: Information sources appropriate for the identification of flood risk

If the planning authority considers that there is a potential flood risk issue, it should move to Stage 2. If the planning authority is satisfied that there is no potential flood risk identified within areas planned for growth from an assessment of all the sources listed above and bearing in mind the precautionary approach, the FRA will not be required and the process can end at Stage 1 and the avoidance principle of the sequential approach has been met. It would be prudent in such circumstance for the planning authority to keep a record on the public file of this decision and reasons for deciding that an FRA is not required.

However in the majority of circumstances, the process will move onto Stage 2 for either particular towns or cities which will be assessed by the SFRA, or where development is planned in an area of flood risk and a detailed site assessment is required.

Stage 2 – Initial flood risk assessment

The purpose of the initial FRA is to ensure that all relevant flood risk issues are assessed in relation to the decisions to be made and potential conflicts between flood risk and development are addressed to the appropriate level of detail. An initial FRA will assess the adequacy of existing information and identify what further studies may be needed fully to address flooding issues. As part of an initial assessment, information on the location, standard and condition of existing flood defences should be obtained from those who operate and maintain these assets. Detailed analysis within the FRA will depend on the nature and severity of flood risk, vulnerability and pathways in the area behind the flood defences. An initial FRA at the city/county level needs to be sufficiently detailed to allow the application of the sequential approach within the flood risk zone. At site-specific level flood zones should be estimated (subject to a detailed FRA if needed). An initial FRA needs to be sufficiently detailed to allow the determination of the potential residual risks behind any existing infrastructure so that the complexity of a hydraulic model, if needed, can be scoped fully. It should be noted that decisions can be made on limited data so long as a precautionary approach is taken.

Whether the initial FRA is taking place at development plan level or site-specific level, it is important to identify the necessary level of detail and most appropriate assessment techniques based on the quality and robustness of the available datasets. It is anticipated that planning authorities will need to commission a flood risk assessment as early as possible within the development planning process as part of the SEA and a robust initial assessment is essential to determine whether more detailed assessment is needed in areas of significant conflict between flood risk and development. Table A5 illustrates the elements of an initial flood risk assessment and how it differs for different scale.

The initial assessment may determine that sufficient quantitative information is already available, appropriate to the scale and nature of the changed land use or development proposed, for the necessary decision to be made. If not, then the FRA will need to carry out such information generation and gathering as part of a detailed assessment. It should also be noted that flood risk assessments for local area plans are informed and scoped within the appropriate development plan, so that when the LAP starts its SFRA it should use this initial FRA stage to confirm the previous findings.

Elements of initial assessment	Type of flood risk assessment:		
	SFRA for county plan	SFRA for city development plan or LAP	FRA for site
An examination of all sources of flooding that may affect a plan area	C Z	✓ C	✓
An appraisal of the availability and adequacy of existing information	✓	✓ C	✓
Produce flood zone map where not available	U	✓ (But not all areas)	S
Determine what technical studies are appropriate	✓ Z	✓ C	✓
Describe what residual risks will be assessed	✓ Z	✓ C	✓
Potential impact of development on flooding elsewhere	✓ Z	✓ C	✓
Scope of possible mitigation measures and what compensation works may be required and what land may be needed	U	✓ C	✓
Set out requirements for subsequent stages of FRA	✓	✓ C	n/a

✓ = Expected activity

U = Unlikely initial assessment will undertake this element

Z = detail will differ in County Plan where zoning is being considered

C = Confirmation of details provided in county wide SFRA or RFRA

S = FRA's main purpose is not to challenge the flood zone map, but concentrate on the flood risk issues. Where no SFRA has been produced flood zones should be produced in accordance with OPW specifications.

n/a = Not applicable

Table A5: Elements of initial flood risk assessment (SFRA and FRA)

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Stage 3 - Detailed flood risk assessment

Where Stages One and Two indicate that a proposed development or area of possible zoning may be subject to a significant flood risk, a detailed flood risk assessment must be carried out.

Assessment of flood risk and any subsequent mitigation measures principally relies on estimation of flow, level, and the performance of the development at an appropriate degree of accuracy that will deliver "fit-for-purpose" information for decision-making.

The detailed flood risk assessment will normally involve some form of mathematical modelling of river systems that embrace the source-pathway-receptor concept. However, as is known from experience, modelling is dependent on the accuracy of the inputs and the particular model being used. Poor data and use of inappropriate techniques can undermine the confidence of the decision maker. It is also important that an assessment of flood risk should consider both the actual and the residual risks.

Actual flood risk is the risk posed to an area, whether it is behind defences or undefended, at the time of the study. This should be expressed in terms of the probability of flooding occurring, taking into account the limiting factors, both natural and manmade, preventing water from reaching the development.

Residual risks are the risks remaining after all risk avoidance, substitution and mitigation measures have been taken. Examples of residual flood risk include:

:: The failure of flood management infrastructure such as a breach of a raised flood defence, blockage of a surface water channel or drainage system, failure of a flap valve, overtopping of an upstream storage area, or failure of a pumped drainage system; and

:: A severe flood event that exceeds a flood design standard such as, but not limited to, a flood that overtops a raised flood defence.

Assessment of flood defence breaching should generally be undertaken on the basis of a design event of the appropriate design standard (such as 1% AEP[1] for river flooding and 0.5% AEP for flooding from the sea), including an allowance for climate change[2]. Assessment of overtopping of flood defences should generally be undertaken on the basis of the 0.1% AEP event, including an allowance for climate change.

[1] AEP – Annual Exceedance Probability

[2] See http://www.opw.ie

A successful FRA is characterised by:

:: Assessing existing flood risk in terms of the likelihood of flooding and resultant consequences; and

:: Assessing the potential, post-development risks having regard to the design of mitigation and compensation measures.

This assessment should be carried out in an iterative process as set out in Fig. 4.1 of the Guidelines.

1.5.1 Flooding from other sources, identification and assessment

Flooding from sources other than the coast and rivers, such as overland flow can be more complex than river and coastal flooding but it is essential that they be considered and, if necessary, addressed. For example, the widespread flooding of August 2008 included many instances of overland flow in areas not historically known to flood. Therefore, where flooding from other sources arises as an important flood risk issue, it generally will require a level of investigation and analysis more typical of Stage Three of flood risk assessment as mentioned earlier. A range of interactive mapping (GIS), topographical analysis and overland routing techniques can be used to assess and map flood risk from other sources as part of detailed assessment to provide an indication of overland flow routes and areas prone to surface water flooding that are not identified by flood zone mapping. The initial assessment should be used to focus on assessment of storm events that exceed the available capacity of surface water systems and of flash floods, since these will be the ones that have been recorded in the past.

Surface water flood risk mapping generally requires a 3 dimensional representation of the area of interest, in the form of a Digital Terrain Model (DTM), and a rainfall hyetograph for a storm of fixed magnitude and duration. The water depths are then applied and the storm water is free to flow over the area. This provides a prediction of those areas where water will collect, or 'pond', and the location and magnitude of flow routes to leading to these areas. The output shown above is then thematically mapped by depth, removing predicted flood depths below a threshold. An example map of rainfall data is included as Fig. A4.

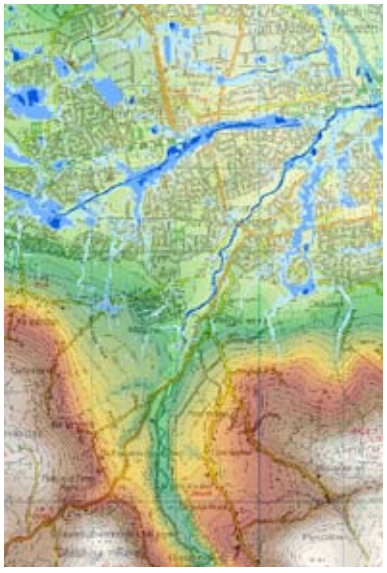


Fig. A4: Example of rapid surface water run off mapping

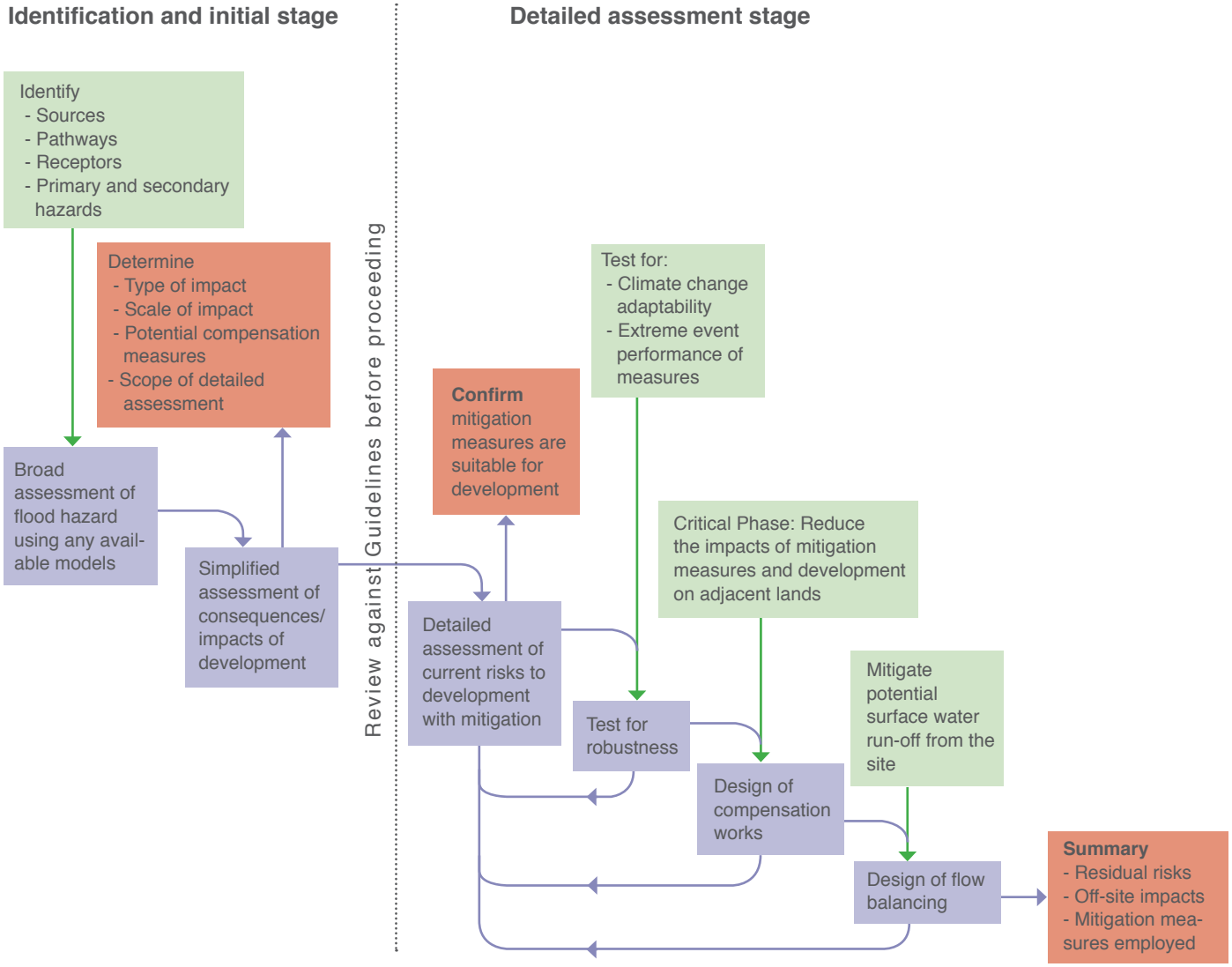


Fig. A5: Approach to flood risk assessments

1.6 Flood risk assessment - recommended outputs

Every FRA will be designed and influenced by previous work, data availability, programme, the spatial scale and complexity of the flood risks and scale and location of planned development. It is therefore difficult to be prescriptive about the specific outputs of FRAs. However, this section describes general outputs expected from the three main levels of FRA which have followed the staged approach.

Regional Flood Risk Appraisal

Such appraisals should identify:

:: Summary plans/figures and statement showing the broad spatial distribution of flood risk and any potential conflicts with growth/ development areas;

:: Supplementary description of any areas of a region where addressing flood risk is especially important – e.g. central urban areas in Gateways or areas of development pressure, with a view to highlighting these as priority locations for further assessment of flood risk, and / or the need for coordinated action at development plan level;

:: Suggested policies for sustainable flood risk management for incorporation into the regional planning guidelines (RPGs); and

:: Guidance on the preparation of City and County level SFRAs and the management of surface water run-off within new development, highlighting significant flood risk issues, potential infrastructure investment requirements and the need for co-operation between planning authorities and identifying any need for more detailed assessment.

Strategic Flood Risk Assessments - city/county level

Such assessments should:

:: Identify principal rivers, and flood zones as recommended in chapter 2 of these Guidelines, and across the local authority area, as well as key development areas in relation to the above;

:: The potential impacts of climate change should be assessed to demonstrate the sensitivity of an area to increased flows or sea levels. Where mathematical models are not available climate change flood extents can be assessed by using the Flood Zone B outline as a surrogate for Flood Zone A with allowance for the possible impacts of climate change;

:: Identify the location of any flood risk management infrastructure and the areas protected by it and the coverage of flood-warning systems;

:: Consider, where additional development in Flood Zone A and B is planned within or adjacent to an existing community at risk, the implications of flood risk on critical infrastructure and services across a wider community-based area and how emergency planning needs of existing and new development will be managed;

:: Identify areas of natural floodplain, which could merit protection to maintain their flood risk management function as well as for reasons of amenity and biodiversity;

- :: Assess the current condition of flood-defence infrastructure and of likely future policy with regard to its maintenance and upgrade;
- :: Assess the probability and consequences of overtopping or failure of flood risk management infrastructure, including an appropriate allowance for climate change[3];
- :: Assess, in broad terms, the potential impact of additional development on flood risk elsewhere and how any loss of floodplain could be compensated for;
- :: Assess the risks to the proposed development and its occupants using a range of extreme flood or tidal events;
- :: Identify areas where site-specific FRA will be required for new development or redevelopment;
- :: Identify drainage catchments where surface water or pluvial flooding could be exacerbated by new development and develop strategies for its management in areas of significant change;
- :: Provide guidance on the likely applicability of different Sustainable Drainage Systems (SuDS) techniques for managing surface water run-off at key development sites as determined by surface water and drainage strategies development within the SFRA;
- :: Identify where integrated and area based provision of SuDS and green infrastructure are appropriate in order to avoid reliance on individual site by site solutions; and,
- :: Provide guidance on appropriate development management criteria for zones and sites (please see Appendix B for further information).

[3] See http://www.opw.ie

In general, the SFRA should aim to provide clear guidance on appropriate risk management measures for adoption on sites within flood zones to minimise the extent to which individual developers need to undertake separate studies of the same problem.

For those lands being considered for zoning for development, the SFRA should indicate:

- :: Whether the proposed development is likely to be affected by current or future flooding from any source;
- :: Whether the proposed development will increase flood risk elsewhere;
- :: Whether there are appropriate measures to deal with these effects and risks; and
- :: Whether the risks can be reduced to an acceptable level to enable the passing of the Justification test if this is appropriate.

In some instances, where improvements to existing flood defences may be required to manage residual flood risks, the SFRA should include an appraisal of the extent of any works required to provide or raise the flood defence to an appropriate standard.

Strategic Flood Risk Assessment at city/county development plan level should also address any impacts from the cumulative loss of floodplain through land raising or development that may arise in the context of implementing the objectives of the relevant development plan (e.g. prioritising the development of the centre of urban settlements in line with the Justification Test) using established methodologies for compensation works referred to in Appendix B.

For further information regarding the compensation requirements for loss of floodplain see Appendix B.

Loss of flood storage or blockage of flow paths within existing defended areas on the floodplain can exacerbate flooding to other properties within the defences in the event that such defences are overtopped and also needs to be addressed in the analysis described above.

The SFRA should therefore assess the effects of cumulative loss of floodplain and/or loss of flood storage or blockage of flow paths within existing defended areas including the requirement for any compensatory works and set out a framework for the implementation of such works at a strategic level.

Site-specific Flood Risk Assessments

The key outputs from a site-specific FRA are:

Plans

:: A location plan that includes geographical features, street names and identifies the catchment, watercourses or other bodies of water in the vicinity;

:: A plan of the site showing the existing site and development proposals;

:: Identification of any structures, which may influence local hydraulics. This will include bridges, pipes/ducts crossing the watercourse, culverts, screens, embankments, walls, outfalls and condition of channel;

A

Surveys

:: Site levels related to Ordnance Datum, both existing and proposed;

:: Appropriate cross-section(s) of the site showing finished floor levels or road levels, or other relevant levels relative to the source of flooding; and

:: Anticipated water levels and associated probabilities.

Assessments

:: Consideration of the flood zone in which the site falls and demonstration that development is appropriate given the flood zone and the vulnerability criteria set out in this Guidance;

:: Flood alleviation measures already in place, their state of maintenance and their performance;

:: Information about all potential sources of flooding that may affect the site – from rivers and the sea, streams, surface water run-off, sewers, groundwater, reservoirs, canals and other artificial sources or any combination of these;

:: The impact of flooding including;

- The likely rate at which flooding might occur (i.e. rapid onset or slow rise of flood water);
- The speed of flow of flood water;
- The order in which various parts of the location or site might flood;
- The likely duration of flood events; and
- The economic, social and environmental consequences of flooding on occupancy of the site;

:: Information on extent and depth of previous flood events or on flood predictions;

:: An assessment of how safe access and egress can be provided for routine and emergency access under both frequent and extreme flood conditions;

:: An assessment of how the layout and form of development will reduce or minimise flood risk;

:: Proposals for surface-water management according to sustainable drainage principles and any strategy developed in the SFRA for the area, with the aim of not increasing, and where practicable, reducing the rate of run-off from the site as a result of the development; and

:: The likely impact of any displaced flood water on third parties caused by alterations to ground levels, reducing floodplain attenuation, impeding flood flow routes or raising flood embankments and the means of providing compensation for this loss of floodplain, where necessary. Details on how to approach the provision of floodplain compensation is provided in Appendix B section 3.3.

In addition to the requirements listed above, when completing a site-based FRA as part of meeting the requirements of the Justification Test, an assessment will be required of on- and off-site opportunities for reducing flood risk overall (e.g. flood storage). This will include an appraisal of wider flood risk management measures to which the development can contribute.

1.6.1 Drainage

An assessment of how surface water run-off will be managed should be addressed in most FRAs. Drainage is a material consideration at the planning stage of a development and due consideration must be given to the impact of the proposed development on the catchment area. This includes an assessment of potential for both flood risk and pollution. Surface water run-off may need to be assessed in all flood zones. The FRA should demonstrate that the surface-water drainage system takes account of SuDS principles, in accordance with the design guidance referenced below. Where SuDS solutions are not possible the FRA should identify the principles behind the chosen approach and demonstrate that the method that gives the best environmental protection available at the site has been adopted.

The scope of the drainage aspects of the FRA will depend on the type and scale of the development and the sensitivity of the area. The basic requirements for the drainage aspects of FRA are as listed below:

:: An examination of the current and historical drainage patterns;

:: A concept drawing of the development proposal;

:: A brief summary of how the drainage design provides SuDS techniques or complies with any drainage strategy for the area identified in the SFRA;

:: Summary of SuDS to be incorporated;

:: The soil classification for the site;

:: Evidence of subsoil porosity tests including where possible at the location of any intended infiltration device;

:: Calculations showing the pre- and post-development peak run-off flow rate for the critical rainfall event; and

:: Accompanying wastewater drainage proposals.

A

Guidance on design standards for smaller drainage systems have traditionally been drawn from the An Foras Forbartha publication 'Recommendations for Site Development Works for Housing Areas', which was republished by DEHLG in 1998. This document is currently under review by the DEHLG with the aim of making it more sustainable in respect of surface water drainage which would involve urging local authorities to adopt the Sustainable Drainage Systems (SuDS) approach. This document is available for download at the following link:

:: http://www.environ.ie/en/Publications/DevelopmentandHousing/Housing/F ileDownLoad,2451,en.pdf

Subsequent to the above, a number of local authorities have also developed guidance documents to assist applicants in the preparation of their drainage design, including the drainage impact assessment. The most comprehensive of these local authority guidance documents is the 'Greater Dublin Strategic Drainage Study: New Development Policy':

:: http://www.dublincity.ie/WATERWASTEENVIRONMENT/WASTEWATER/ DRAINAGE/GREATERDUBLINSTRATEGICDRAINAGESTUDY/Pages/New DevelopmentPolicy.aspx

This is a comprehensive document and is complemented by the Greater Dublin Regional Code of Practice for Drainage Works:

:: http://www.dublincity.ie/WATERWASTEENVIRONMENT/WASTEWATER/P ages/GDSDSCodeofPractice.aspx

An additional document on interpretation of this guidance is given in the document "Irish SuDS: guidance on applying the GDSDS surface water drainage criteria" to be found at

:: http://www.irishsuds.com/guidance_ criteria.htm

These are considered key reference material for those undertaking drainage impact assessments. Until more comprehensive national design standards for SuDS are put in place, the three documents above should be studied closely and applied as far as practicable in addressing SuDS considerations in the context of drainage aspects of a detailed flood risk assessment.

1.7 Further guidance on flood risk assessments

Standards and methodologies for FRAs, and detailed specifications of work for undertaking a range of FRAs for use in Ireland (i.e., for each stage of FRA at different scales), are available from the OPW (http://www.opw.ie).

Comprehensive guidance is also available from research in the UK through the following:

:: Practice Guide that accompanies the equivalent planning guidance (PPS25);

:: http://www.communities.gov.uk/ planningandbuilding/ planning/plan ningpolicyguidance/ planningpolicystatements/ planningpolicystatement s/pps25/);

:: CIRIA Report C624 “Development and flood risk - guidance for the construction industry” (http://www.ciria.org.uk/acatalog/C624.html); and

:: Defra/Environment Agency Guidance on flood-risk assessment (FD2320) and on flood risks to people (FD2321), http://www.defra.gov.uk/environ/fcd/research/default.htm.

B

Appendix B: Addressing Flood Risk Management in Design of Development

1 Introduction

The purpose of this appendix is to provide information on how new development in flood risk areas should be planned, designed and constructed to reduce and manage flood risk and be adaptable to changes in climate.

2 Key design considerations

Addressing flood risk in the design of new development should be based on a set of broad considerations that ensure the response to flood risk is balanced within a range of proper planning and sustainable development considerations. Innovation, creativity and high quality approaches will be essential in meeting the design challenges.

2.1 Core principles

The core principles in planning and designing for flood risk are:

:: Locating development away from areas at risk of flooding, where possible;

:: Substituting more vulnerable land uses with less vulnerable ones, where the principle of development within flood risk areas has been established; and

:: Identifying and protecting land required for current and future flood risk management, such as conveyance routes, flood storage areas and flood protection schemes etc. where the principle of development within flood risk areas has been established.

2.2 Aspects of planning and design

Careful consideration of planning and design is one of the primary means of avoiding the impacts of a flood on a specific site. Key aspects of good site layout and design include:

:: Understanding the nature and extent of flood risk;

:: Achieving an appropriate range and mix of land uses;

:: Creating and/or extending a robust and permeable urban structure; and

:: Creating and/or extending a landscape structure and drainage.

3 Application of design considerations

The following hypothetical case examples illustrate the application of the core principles and key aspects of site layout and design. The examples assume that a sequential approach has been adopted and that the Justification Test has been passed.

The figure below indicates Flood Zone A has the highest probability of flooding. Zone B has a moderate risk of flooding and Zone C (which covers all remaining areas) has a low risk of flooding.

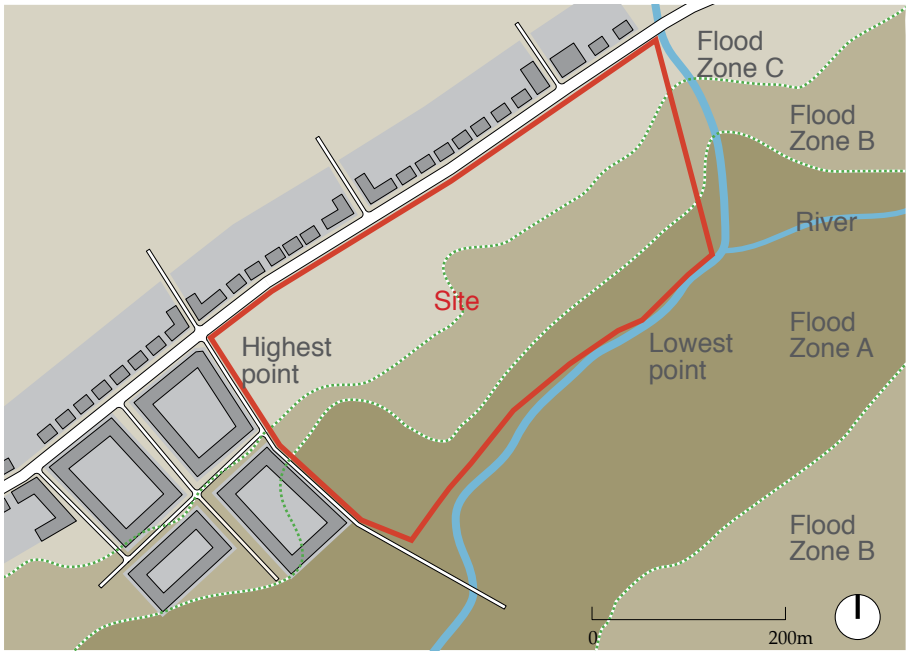


Fig. B1: Flood zone mapping

3.1 Choosing land uses

Once the spatial extent of flood risk is understood, land use type and location will be informed by the following considerations:

:: The most vulnerable land uses should be located in areas of lower flood risk;

:: Less vulnerable land uses (e.g. parks, gardens and open spaces for natural habitats, etc.) should be located in areas of higher flood risk;

:: There should be a degree of flexibility in the location of land uses to reflect existing or future sustainable urban structure; and

:: Less vulnerable uses should be provided at ground floor level in areas of greater flood risk where a sustainable mix of uses is sought.

Fig. B2 below illustrates how the application of these principles onto the flood risk map described in section 3.1 offers a way to match flood risk with appropriate land uses.

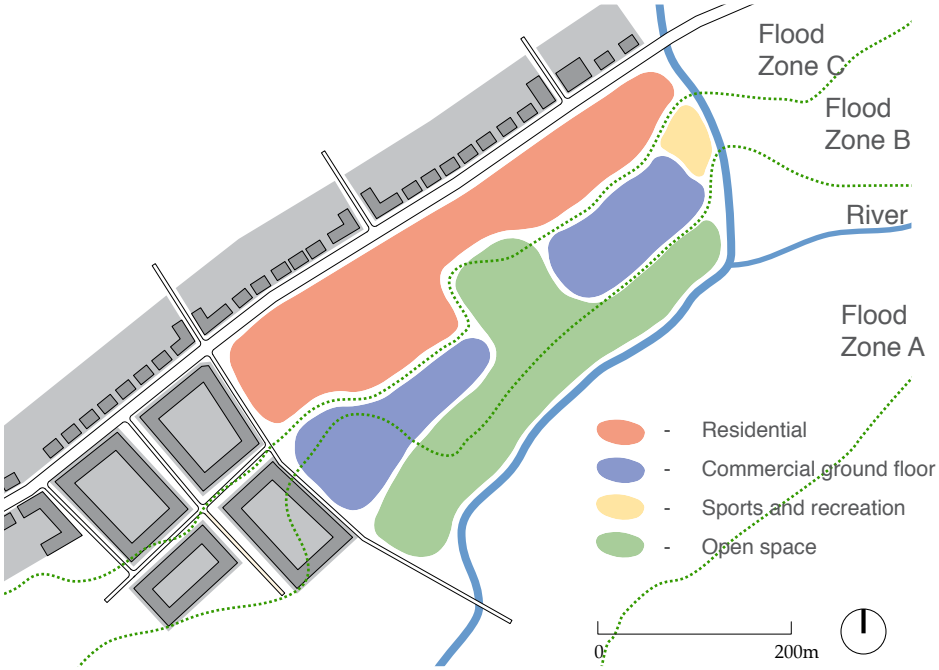


Fig. B2: Land use

3.2 Creating a Sustainable Urban Structure

Creating a sustainable urban structure is achieved by:

:: Understanding of, and working with, existing topography;

:: Creating a permeable and legible structure, which provides clear and direct routes from high risk areas to safer, low risk areas;

:: Designing for the safe movement of people into and out of the area, especially near where floodwater might be flowing, and considering the location of safe overland flow routes (see section 3.4 of this appendix);

:: Avoiding cul-de-sacs in medium and high risk areas to limit the pooling of floodwater or the creation of a layout where people would have to move through an area of flood hazard in order to reach safety; and

:: Providing secondary defences in areas of low risk such as demountable barriers and altered land/ floor levels.

Fig. B3 builds on the land use concept to illustrate how flood risk considerations can influence urban design, access and circulation.



Fig. B3: Integrating flood risk into urban structure

In the example shown here, residential uses are accommodated above ground-floor level and a flood warning system is incorporated in areas of medium risk. In areas of high risk, safe refuges at higher levels, resilient utility supplies, early warning systems, emergency response plans and renewable power supplies are provided.



Detention pond as part of a wider flood management system, Hammarby Sjöstad, Stockholm

3.3 Landscape and drainage

Landscape planning and drainage of new development must be closely integrated to play an effective role in flood-reduction. The key elements are:

:: Creating a permeable network and hierarchy of green spaces to provide for direct access to areas of lower flood risk;

:: Planting and shaping the land surrounding individual buildings and groups of buildings to encourage drainage away from property;

:: The use of “higher-risk”, low-lying ground in waterside areas for recreation, amenity and environmental purposes;

:: Modest land-raising of areas at high risk of flooding accompanied by compensatory provision of flood storage in existing risk areas having regard to other natural and built heritage issues;

:: Re-contouring the edge of the floodplain;

:: Use of earth bunds to provide local flood defence;

:: Avoiding structures in the floodplain; and

:: The use of Sustainable Drainage Systems (SuDS) to manage surface water run-off. This can be an effective means of reducing the impact of floodwater by reflecting natural drainage processes and removing pollutants from urban run-off at source.

Fig. B4 illustrates the principle of land-raising with compensatory floodwater storage to facilitate an extension to the existing urban fabric.

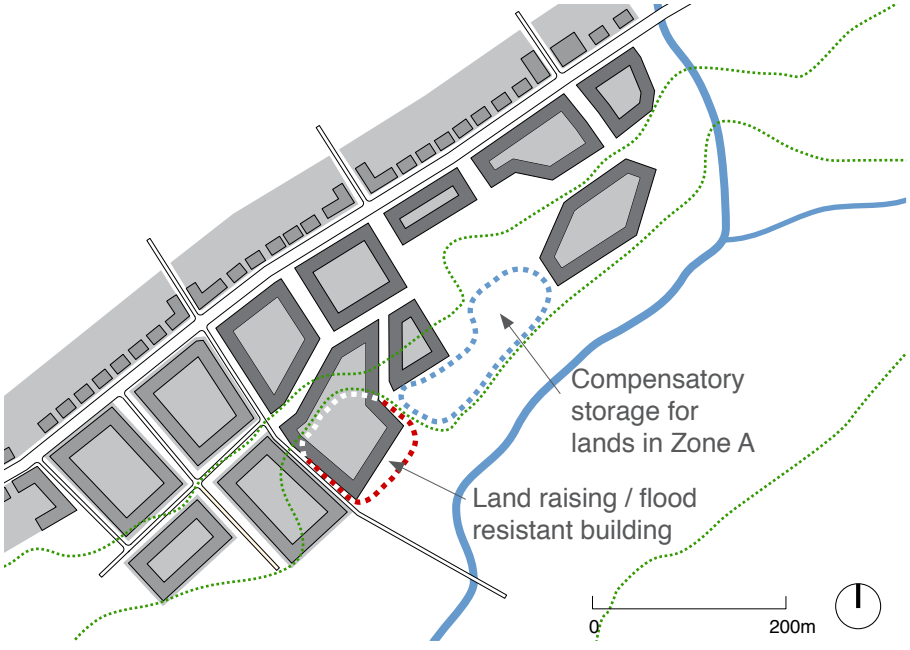


Fig. B4: Landscape planning and flood risk

3.3.1 Compensation

Compensation works are divided into direct and indirect. These terms come from UK Construction Industry Research and Information Association (CIRIA) report C624 "Development and flood risk – guidance for the construction industry (2004)".

Direct or 'level for level'[1] methods, as they are also known, re-grade land and provide a direct replacement for the lost storage volume.

Indirect methods rely on water entering a defined storage area which then releases it at a slower rate, similar to a surface water attenuation scheme. The storage area can be remote from the floodplain and can contribute to an enhancement of the floodplain. Indirect schemes are complicated to design and construct and may require a more intensive maintenance regime, which must be continued indefinitely. As a default, level for level compensation should be considered, and where a Strategic Flood Risk Assessment (or site-specific FRA in its absence) suggests that a relaxation is possible, compensation can be provided by these indirect methods.

The compensatory volume must be at the same level (within reasonable working limits) as the lost storage. Level for level compensation should be a default position in fluvial flooding areas which will ensure incremental loss of floodplain is managed throughout the catchment. Where an SFRA has identified that the impact of development on downstream areas at flood risk is negligible for this and other potential development then compensation requirements could be relaxed.

[1]Level for level compensation provides the same surface area at the same elevation before and after development. This should be assessed using increments or slices of approximately 0.1m. For a site fully bounded within Flood Zone A, compensation can only be provided from outside the site and as a result could be a significant barrier to development in areas at flood risk, and should be assessed as part of the Justification Test. Ideally, new areas of floodplain are provided from outside of Flood Zone A & B as compensation.

For further information regarding the requirements of a Strategic Flood Risk Assessment see Appendix A.



Vegetated swale, Freiburg

In general, level for level compensation should only be applied in areas where flood water is stored. Floodwater is stored in most natural and defended floodplains which are inundated in the 1% AEP event. It is important to ensure flood flow routes should be protected, whatever the cause of flooding. In some circumstances, this is more critical than providing level for level compensation. There may sometimes be benefits in altering routes or increasing flood flow capacity. However, it should only be carried out after careful assessment of the downstream impacts. This assessment must be included in the detailed site specific FRA.

The basic requirements for compensatory flood plain storage are as follows:

:: A volume of flood plain equal to that lost to the proposed development should be created;

:: The equal volume should apply at all levels between the lowest point on the site and the design flood level. Normally this is calculated by comparing volumes taken by the development and the volume offered by the compensatory storage for a number of horizontal slices through the range defined above;

:: The thickness of a slice should be typically 0.1 metres. In the case of large flat sites or very steep sites this may be varied to 0.2 or even 0.05 metres in order to have about 10 slices to compare; and

:: Compensatory storage should be provided equal to or exceeding that lost as a result of development for each of these slices.

3.4 Site layout

The broader framework planning of the case example site highlights the importance of getting the context right before engaging with more detailed site layout issues. Important design issues to consider at the more detailed site layout stage include:

:: Size, shape and qualities of the landscape and planting; and

:: The incorporation of Sustainable Drainage Systems (SuDS) measures into the design.

More detailed issues of building design and construction are described in section 4 of this appendix.

Fig. B5 below illustrates the application of the principles in a SuDS planning and management context.

The main aspects of the hypothetical scheme illustrated in Fig. B5 would include:

:: The identification of a focal space as part of green open space network;

:: Ease of access to higher land in the event of a flood;

:: Clear water conveyancing routes free of barriers such as walls or buildings;

:: Choice of durable flood resistant plant species;

:: Signing of floodplain areas to indicate the shared use of the land and to identify safe access routes; and

:: Siting of street furniture and fittings in conjunction with other measures to reduce debris reaching the watercourse in times of flood.



Fig. B5: Detailed site layout planning







Features of a sustainable drainage system. Top to bottom: Water butt, vegetated swale and green roof (Green roof source: Sargfabrik, Vienna)

The design and implementation of SuDS covers a whole range of sustainable approaches to surface water drainage management including:

:: Source control measures, including rainwater recycling and drainage;

:: Infiltration devices to allow water to soak into the ground, which include individual soak-away and communal facilities;

:: Filter strips and swales, which are vegetated features that hold and drain water downhill to mimick natural drainage patterns;

:: Filter drains and porous pavements to allow rainwater and run-off to infiltrate into permeable material below ground and provide storage if needed;

:: Permeable paving for parking areas including front gardens (see UK Guidance on the Permeable Surfacing of Front Gardens http://www.communities.gov.uk/publications/planningandbuilding/pavingfrontgardens; see also in these Guidelines chapter 2 paragraphs 2.37-2.39 on SuDS);

:: Basins and ponds to hold excess water after rain and allow controlled discharge that avoids flooding; and

:: Green Roofs.

A broad overview of the philosophy behind SuDS and techniques that are appropriate under different circumstances is provided in the CIRIA publication C697: “The SuDS Manual”. CIRIA publication C609: “SuDS – Hydraulic, Structural and Water Quality Advice”, provides further detailed information, and is available to download at http://www.ciria.org/. Additional guidance SuDS can be found at: http://www.irishsuds.com.

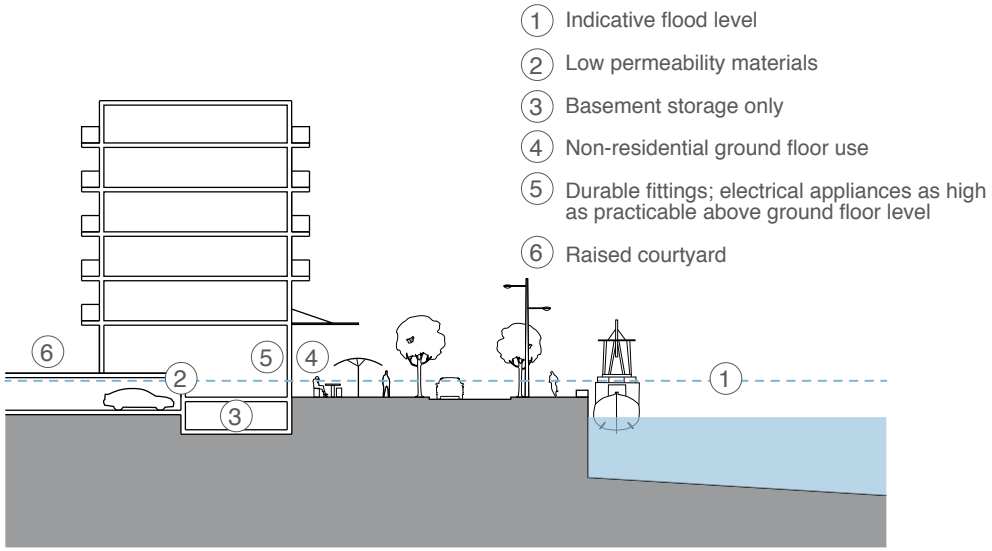
4 Designing For Residual Flood Risk

4.1 Residual Risk

Flood defences may be exceeded by a flood (or rainstorm in the case of SuDS) that is greater than that which they were designed to resist. Such defences may not be maintained to the standard of installation intended or they may be damaged by some other means. Consequently, there may be residual risks to development behind defences.

Design responses to this are illustrated by the following hypothetical case example (Fig. B6) which is set in the context of an existing (‘brownfield’) urban infill site at a town centre, waterfront location. In this case, the site spans Flood Areas A, B and C. As an overall planning and urban design objective, it was important to provide new permeability and street connections and to

ensure a continuity of building frontage based on the robust and traditional, perimeter block pattern. In addition, there was an opportunity to provide new urban blocks while providing a new north-south street, providing direct street access from areas at higher risk of flooding to areas at lower risk of flooding. The traditional, continuous perimeter block can also provide improved flood resistance when combined with active measures such as, demountable door barriers, vent covers and stoppers (see section 4.5 of this appendix).



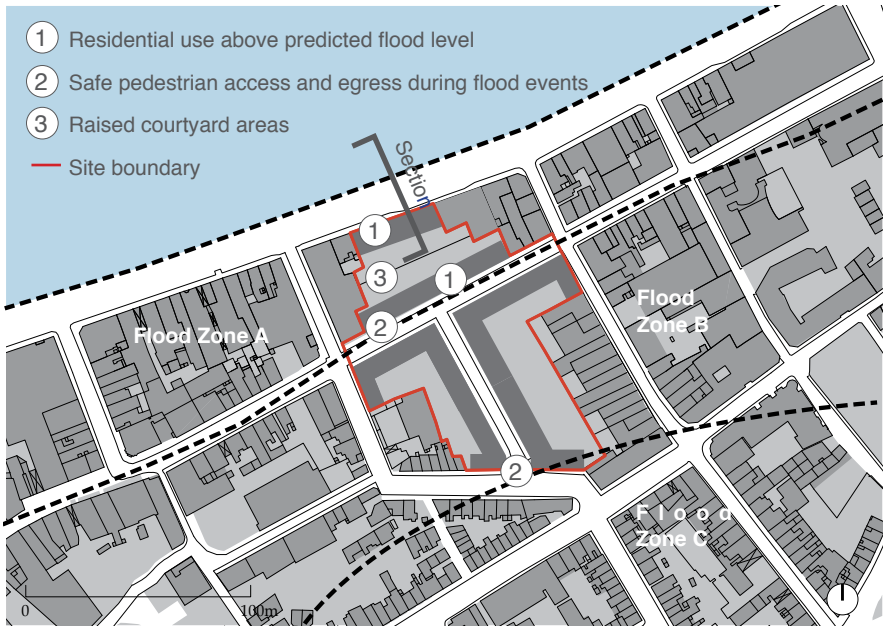


Fig. B6: Responding to residual risk

B

4.2 Exceedance

All developments in flood risk areas should be tested for exceedance of flood management measures. This can involve:

:: Identifying and protecting routes of floodwater through a development; and

:: Designing new buildings in flood risk areas to reduce the consequences of flooding and facilitate recovery from its effects.

This may be achieved through careful "flood-considerate design" in accordance with the Building Regulations.



Raised threshold to protect basement car park

4.3 Floor Levels

Raising threshold and floor levels above expected flood levels can also be used to reduce the risk of flooding to a building. This is typically achieved by raising floor heights within the building structure using a suspended floor arrangement or raised internal concrete platforms.

These approaches are most commonly adopted in developments that may be subject to limited flood depths and where adjustments could help reduce potential flood losses. When designing an extension or modification to an existing building, an appropriate flood risk reduction measure may also be needed to ensure the threshold levels into the building are above the design flood level. However, care must also be taken to ensure access for all is provided in compliance with Part M of the Building Regulations. Where threshold levels cannot be raised to the street for streetscape, conservation or other reasons, a mixing of uses vertically in buildings may be appropriate with less vulnerable uses located at ground floor level, along with other measures for dealing with residual flood risk.

4.4 Internal Layout

Internal layout and the careful design of internal space can be an effective measure to reduce the impact of flooding. For example, living accommodation, essential services, storage space for provisions and equipment should be designed to be located above the predicted flood level. In addition, siting of living accommodation (particularly sleeping areas) above flood level, may be an appropriate design option in areas at risk of flooding.

With the exception of single storey extensions to existing properties, new single storey accommodation may not be appropriate where predicted flood levels are above design floor levels. In all cases, the requirements for safe access, refuge and evacuation should always be incorporated into the design of development.

4.5 Flood-Resistant Construction

Flood-resistant construction incorporates design measures aimed at preventing water from entering a building and can mitigate the damage floodwater causes to buildings.

Conventional forms of building construction are not inherently resistant to sustained hydrostatic pressure. Flood resistant construction necessitates a specialist technical input to the design and specification of the external building envelope. Preferably, measures to resist hydrostatic pressure (commonly referred to as “tanking”) should be incorporated on the outside of the building fabric.

The main entry points for floodwater into buildings are doors and windows (including gaps in sealant around frames), vents, air-bricks and gaps around conduits or pipes passing through external building fabric. Floodwater may also arise through sanitary appliances as a result of backflow through the drainage system.

There are a range of proprietary flood protection devices available on the market that are designed specifically to resist the passage of floodwater. These include removable barriers designed to fit openings, vent covers and stoppers designed to fit WC pans. The efficacy of such devices relies on their being deployed before a flood event occurs. It should also be borne in mind that devices such as vent covers, if left in place by occupants as a precautionary measure, may compromise safe ventilation of the building in accordance with Building Regulations.



Examples of demountable flood barriers

Consequently, they should not be relied upon to mitigate flood risk, and should be limited to infill development within existing urban areas that are at risk of flooding. Where flood risk mitigation measures are required following flood risk assessment and application of the Justification Test, permanent flood-mitigation measures should always be used.

4.6 Flood-Resilient Construction

Design for flood resilient construction accepts that floodwater will enter buildings and provides for this in the design and specification of internal building services and finishes. These measures limit damage caused by floodwater and allow relatively quick recovery.

This can be achieved by using wall and floor materials such as ceramic tiling that can be cleaned and dried relatively easily, provided that the substrate materials (e.g. blockwork) are also resilient. Electrics, appliances and kitchen fittings may also be raised above floor level, and one-way valves may be incorporated into drainage pipes.

However, these measures on their own are not suitable for areas with potential for a combined risk of quickly rising water levels and/or where speed of flow is likely to be high and dangerous to the stability of buildings and the safety of people.



4.7 Emergency Response Planning

In addition to considering physical design issues, planning and assessing new development must take account of the need for effective emergency response planning for flood events in areas of new development. This is normally the responsibility of the developer.

Key elements are:

:: Provision of flood warnings, evacuation plans and ensuring public awareness of flood risks to people where they live and work;

:: Coordination of responses and discussion with relevant emergency services i.e. Local Authorities, Fire & Rescue, Civil Defence and An Garda Siochána through the SFRA; and

:: Awareness of risks and evacuation procedures and the need for family flood plans.

4.8 Access and Egress During Flood Events

In general, flood escape routes should be kept to publicly accessible land, as safeguarding escape routes located within private property may be problematic. Such routes should have signage and other flood awareness measures in place, to inform local communities what to do in case of flooding. The location of the most suitable access routes may be derived from the flood risk assessment. This information should be provided in a welcome pack to new occupants.

4.9 Further Information

Further and more detailed guidance and advice can be found at http://www.flooding.ie and in the Building Regulations.

"Improving the Flood Performance of New Buildings" published by the Department of Communities and Local Government in the UK is a valuable resource. In addition, a full technical report prepared for the Association of British Insurers and the Building Research Establishment on Flood Resilient Homes can be downloaded from the ABI website (http://www.abi.org). The British Standards Institute (BSI) has introduced a "Kitemark" Certification Scheme for flood-resilient products, and CIRIA has published a number of documents detailing flood-protection products for the home. These can be downloaded from the CIRIA website (http://www.ciria.org).

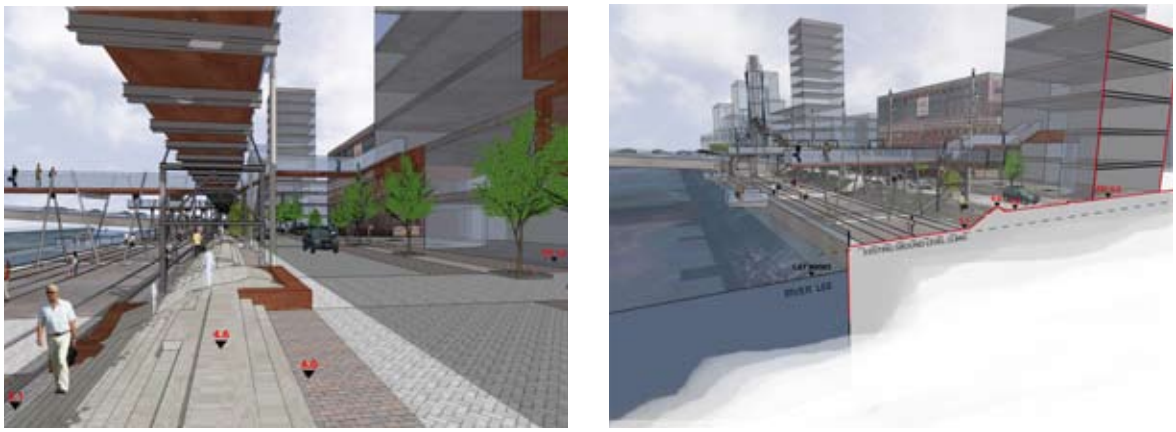


Fig. B7: Development proposal in an area at risk of flooding. (Source: Cork City Council).

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