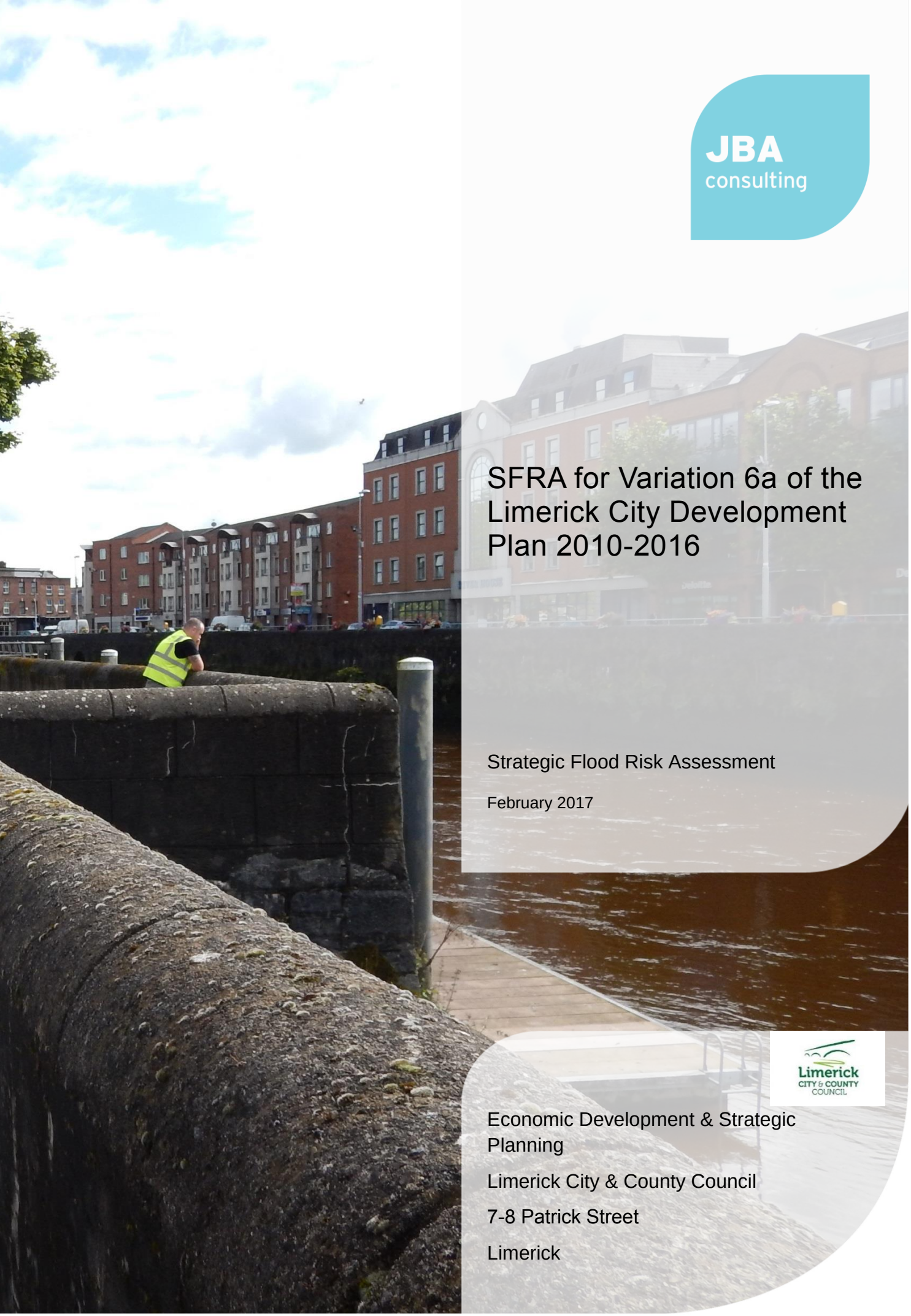

SFRA for Variation 6a of the Limerick City Development Plan 2010-2016

Strategic Flood Risk Assessment

February 2017

Economic Development & Strategic Planning

Limerick City & County Council

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Contract

This report describes work commissioned by HRA, on behalf of Limerick City & County Council, by an email dated 22 February 2016. Ross Bryant and David Casey of JBA Consulting carried out this work.

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Purpose

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Abbreviations

1D ..... One Dimensional (modelling)
2D ..... Two Dimensional (modelling)
AEP ..... Annual Exceedance Probability
AFA ..... Area for Further Assessment
CFRAM ..... Catchment Flood Risk Assessment and Management
DoEHLG..... Department of the Environment, Heritage and Local Government
DTM ..... Digital Terrain Model
EPA..... Environmental Protection Agency
FRA..... Flood Risk Assessment
FRMP..... Flood Risk Management Plan
FRR..... Flood Risk Review
HEFS ..... High End Future Scenario
HPW..... High Priority Watercourse
LA..... Local Authority
MRFS..... Medium Range Future Scenario
OPW ..... Office of Public Works
OS..... Ordnance Survey
PFRA ..... Preliminary Flood Risk Assessment
SAC..... Special Area of Conservation, protected under the EU Habitats Directive
SEA..... Strategic Environmental Assessment

1 Study Background

JBA Consulting was appointed by Limerick City & County Council to carry out the Strategic Flood Risk Assessment (SFRA) for the proposed Variation 6a of the Limerick City Development Plan 2010-2016.

This report details the SFRA for this area and has been prepared in accordance with the requirements of the DoEHLG and OPW Planning Guidelines, The Planning System and Flood Risk Management; these guidelines were issued under the Planning and Development Act 2000, and recognise the significance of proper planning to manage flood risk.

1.1 Scope of Study

Under the "Planning System and Flood Risk Management" guidelines, the purpose for the FRA is detailed as being "to provide a broad (wide area) 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".

It is important that the Development Plan fulfils the requirements of the document “The Planning System and Flood Risk Management Guidelines for Planning Authorities” (OPW/DoEHLG, 2009) which states that flood risk management should be integrated into spatial planning policies at all levels to enhance certainty and clarity in the overall planning process.

In order to ensure that flood risk is integrated into the Development Plan, the main requirements of this document are to:

- Produce Flood Mapping,
- Prepare a Stage 2 - Flood Risk Assessment of proposed regeneration areas in particular in relation to location and type of zoning and land-use proposals,
- Prepare a Flood Risk Management Plan in compliance with OPW/DoEHLG – “The Planning System and Flood Risk Management –Guidelines for Planning Authorities (OPW/DoEHLG, 2009)” and Circular PL02/2014 (August 2014),
- Advise on zonings/land use-proposals, assess and report on any submissions received as part of both the preparation and the public consultation stage of the plan, as they relate to flood risk.

The proposed Variation 6a, will ensure that certain objectives of the Limerick Regeneration Framework Implementation Plan (LRFIP) will be fully incorporated within the Limerick City Development Plan 2010-2016. The Limerick Regeneration was set up during June 2007 to address social issues within Limerick City. Four areas were selected which included Moyross, St Mary's Park/Kings Island, Southill and sections of Ballinacurra Weston.

As part of the regeneration plan there will be modifications of the current zoning within the Limerick City Development Plan in order to successfully implement the objectives of the LRFIP. The current and proposed zonal changes will be assessed for flood risk as part of the SFRA process.

1.2 Report Structure

This study considers the development strategy that will form part of the Limerick City Development Plan. The context of flood risk in Limerick is considered with specific reference to the primary flood sources, tidal and fluvial flooding, as well as secondary sources such as, pluvial, groundwater, sewer and artificial reservoirs.

A two stage assessment of flood risk was undertaken, as recommended in 'The Planning System and Flood Risk Management' guidelines, for the area that lies within the development plan boundary. The first stage is to identify flood risk and is based primarily on the findings of the Shannon Catchment Flood Risk Assessment and Management Study (Shannon CFRAM). Historical records and recent events demonstrate that Limerick City has a history of flooding in certain areas. The second stage and the main purpose of this SFRA report is to appraise the adequacy of existing information, to prepare an indicative flood zone map, based on available data, and to highlight potential development areas that require more detailed assessment on a site specific level.

Section 2 of this report provides an introduction to the study area and Section 3 discusses the concepts of flooding, Flood Zones and flood risk as they are incorporated into the Planning System and Flood Risk Management.

In Section 4 the available data related to flooding is summarised and appraised and outlines the sources of flooding to be considered, based on the review of available data.

Following this, Section 5 provides guidance and suggested approaches to managing flood risk to development; the contents of this section will be of particular use in informing the policies and objectives within the development plan.

In Section 6 the proposed zonings are reviewed, with specific responses to flood risk in relation to Moyross, St Mary's Park/Kings Island, Southill and sections of Ballinacurra Weston.

Finally, triggers for the ongoing monitoring and future review of the SFRA are detailed in Section 7.

2 Limerick Study Area

2.1 Introduction

The plan area comprises four areas of the Limerick City designated A-D located within the Shannon catchment, namely;

A. Moyross,

B. St Mary's Park/Kings Island,

C. Southill, and

D. Sections of Ballinacurra Weston.

2.2 Watercourses

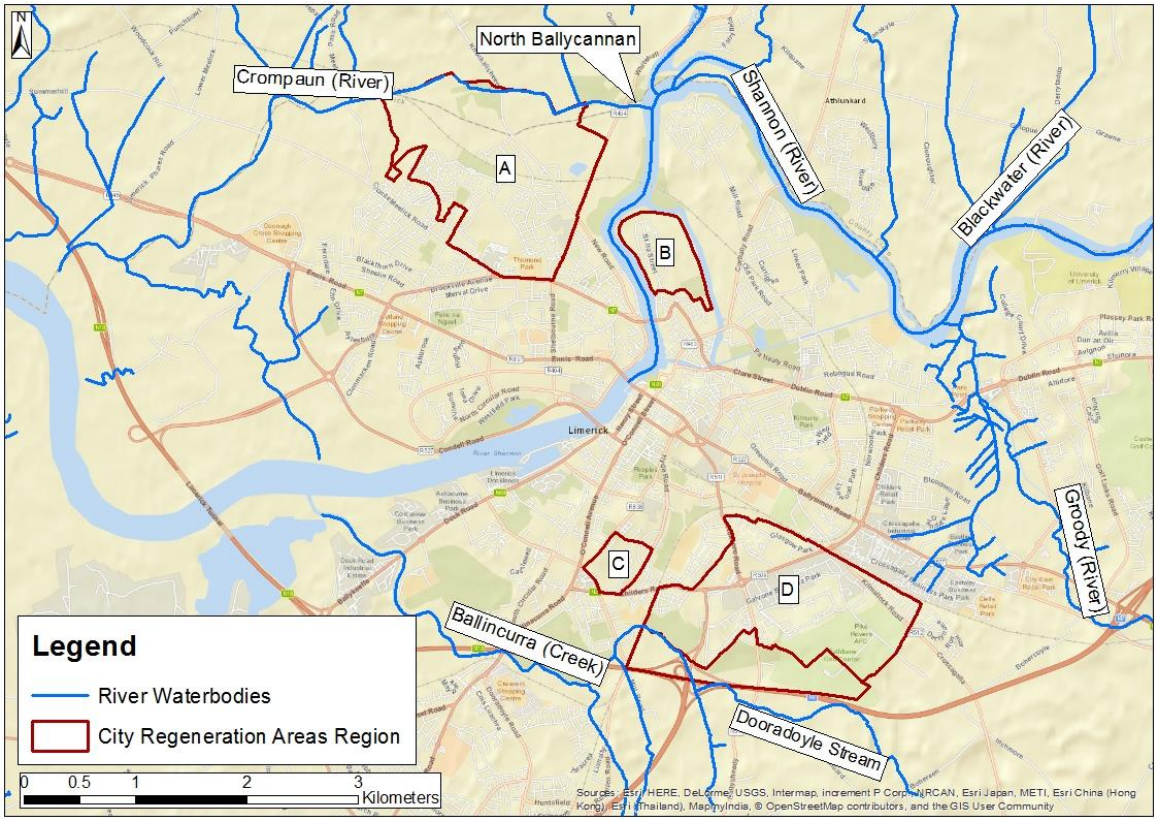
The River Shannon covers an area of 16,865km^2 and has a river length of 386km. The river rises at the Cuilicagh Mountains in County Fermanagh. It subsequently flows through the counties of Cavan, Leitrim, Offaly, Clair, Tipperary, Limerick and Kerry.

The river contains a large number of waterbodies which provide attenuation as the river flows through the catchment.

Within the confines of Limerick City, the Shannon is classified as an estuarial waterbody and is therefore under tidal influence.

Other waterbodies of note in the city are the North Ballycannan, Ballinacurra Creek, Mulkear and Groody rivers. See Figure 2-1 for the hydrological environment.

Figure 2-1 Hydrological Environment



2.3 Environment

The Lower River Shannon has been designated as a Special Area of Conservation (SAC) site-002165 and three proposed Natural Heritage Areas which are designated Inner Shannon Estuary South (000435), Knockalisheen Marsh (002001) and Fergus Estuary and Inner Shannon (002048).

Under Article 6(3) of the EU Habitats Directive, an “appropriate assessment” (AA) is required where any plan or project, either alone or ‘in combination’ with other plans or projects, could have an adverse effect on the integrity of a Natura 2000 site.

The management of flood risk within such areas must have regard to potential negative impacts to this environment. Further information is provided in the full Strategic Environmental Assessment (SEA) and AA for the CDP.

2.4 Planning Policy

2.4.1 Limerick City Development Plan

The current plan covers the period 2010-2016. The plan sets out compliance with national spatial strategy and the West Regional Planning Guidelines, including; "policies for the protection of areas at risk from flooding."

The flood management policies of Limerick City Council, as laid out in the development plan include:

- It is the policy of Limerick City Council to continue to work towards reducing flooding within the City and ensure that all new development proposals comply fully with the requirements of ‘The Planning System & Flood Risk Management Guidelines for Planning Authorities’, 2009, and any additional guidance introduced during the lifetime of the Development Plan.
- Avoid the risk of flooding by not permitting development in flood risk areas, particularly floodplains, unless where it is fully justified that there are wider sustainability grounds for appropriate development and unless the flood risk can be managed to an acceptable level without increasing flood risk elsewhere and where possible, reducing flood risk overall.
- Adopt a sequential approach to flood risk management based on (1) avoidance, (2) reduction and only then (3) mitigation of flood risk as the overall framework for assessing the location of new development.
- Incorporate flood risk assessment into the Development Management process and planning appeals.
- Cater for future developments through public and private driven initiatives where capacity permits.
- In association with the Office of Public Works, develop a Flood Risk Map of the City in accordance with Section 14.6 of the requirements of the EU Floods Directive (Directive 2007/60/EC).
- Provide a detailed study and modelling exercise of the catchments, Risk Assessment of whether the proposed development is likely to be affected by flooding (including for climate change), whether it will increase flood risk elsewhere and of the measures proposed to deal with these effects and risks in accordance with ‘The Planning System and Flood Risk Management Guidelines for Planning Authorities’, 2009.
- Satisfy the planning authority that any flood risk arising from the proposal will be successfully managed with the minimum environmental effect to ensure that the site can be developed and occupied safely.
- Comply with Limerick City Council planning authority requirements on finished floor levels.
- It is the policy of Limerick City Council to ensure that development should not itself be subject to an inappropriate risk of flooding nor should it cause or exacerbate such a risk at other locations.
- Development that is sensitive to the effects of flooding will generally not be permitted in flood prone or marginal areas. (Preventing such development, where flooding would result in significant hardship, financial losses or costs, will avoid increasing the existing level of risk and will protect the proposed new development from the human (stress and ill-health, for example) and financial costs of flood events. It will also eliminate or reduce expenditure on flood protection measures and compensation.
- Appropriately designed development, which is sensitive to the effects of flooding, may be permissible in flood plains provided it does not reduce the flood plain area or otherwise restrict flow across floodplains. (Examples of such development might include park areas, sports pitches, certain types of industry, warehousing, etc. designed to be flood resistant and/or insensitive. Such development should only be permitted provided it incorporates adequate measures to cope with the ever-existent flood risk, e.g. adequate drainage

systems, safety measures, emergency response facilities and/or warning and response systems and where it is considered that flooding would not result in significant hardship/financial loss or cost.)

- Development must so far as is reasonably practicable incorporate the maximum provision to reduce the rate and quantity of runoff e.g.:
    - Hard surface areas (car parks, etc.), should be constructed in permeable or semipermeable materials.
    - On-site storm water ponds to store and/or attenuate additional runoff from the development should be provided.
    - Soak-aways or french drains should be provided to increase infiltration and minimise additional runoff
- Such sustainable design/construction measures are desirable in most areas and essential in floodplains, areas liable to flooding, and areas where the conveyance capacity of watercourses is marginal. In all of these cases development that reduces the rate of absorption or increases the rate of runoff increases the risk of flooding of lands and properties downstream.
- For developments adjacent to watercourses of a significant conveyance capacity any structures (including hard landscaping) must be set back from the edge of the watercourse to allow access for channel clearing/maintenance. (A setback of 5m-10m is required depending on the width of the watercourse).
- Development consisting of construction of embankments, wide bridge piers, or similar structures will not normally be permitted in or across flood plains or river channels. (Such structures restrict/obstruct flow and increase the risk of flooding to property and land upstream. If it is considered necessary, in exceptional cases, to permit such structures, they should be designed to minimise and/or compensate for any potential negative effects).

All new development must be designed and constructed to meet the following minimum flood design standards:

- For Urban areas or where developments (existing, proposed or anticipated) are involved - the 100 year flood;
- For Rural areas or where further developments (existing, proposed or anticipated) are not involved - the 25 year flood;
- Along the Coast and Estuaries - the 200 year tide level;
- Where streams, open drains or other watercourses are being culverted - the minimum permissible culvert diameter is 900mm. (Access should be provided for maintenance as appropriate.)

The requirement for a suitably detailed FRA for all development has been reviewed as part of this SFRA, and specific standards and guidance are included in this document.

3 The Planning System and Flood Risk Management

3.1 Introduction

Prior to discussing the management of flood risk, it is helpful to understand what is meant by the term. It is also important to define the components of flood risk in order to apply the principles of the Planning System and Flood Risk Management in a consistent manner.

The Planning System and Flood Risk Management: Guidelines for Planning Authorities, published in November 2009, describe flooding as a natural process that can occur at any time and in a wide variety of locations. Flooding can often be beneficial, and many habitats rely on periodic inundation. However, when flooding interacts with human development, it can threaten people, their property and the environment.

This Section will firstly outline the definitions of flood risk and the Flood Zones used as a planning tool; a discussion of the principles of the planning guidelines and the management of flood risk in the planning system will follow.

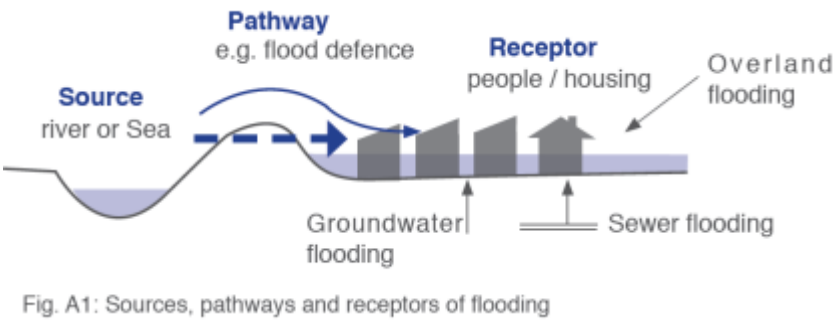
3.2 Definition of Flood Risk

Flood risk is generally accepted to be a combination of the likelihood (or probability) of flooding and the potential consequences arising. Flood risk can be expressed in terms of the following relationship:

Flood Risk = Probability of Flooding x Consequences of Flooding

The assessment of flood risk requires an understanding of the sources, the flow path of floodwater and the people and property that can be affected. The *source - pathway - receptor* model, shown below in Figure 3-1, illustrates this and is a widely used environmental model to assess and inform the management of risk.

Figure 3-1 Source Pathway Receptor Model



Source: Figure A1 The Planning System and Flood Risk Management Guidelines Technical Appendices

Principal sources of flooding are rainfall or higher than normal sea levels while the most common pathways are rivers, drains, sewers, overland flow and river and coastal floodplains and their defence assets. Receptors can include people, their property and the environment. All three elements must be present for flood risk to arise. Mitigation measures, such as defences or flood resilient construction, have little or no effect on sources of flooding but they can block or impede pathways or remove receptors.

The planning process is primarily concerned with the location of receptors, taking appropriate account of potential sources and pathways that might put those receptors at risk.

3.2.1 Likelihood of Flooding

Likelihood or probability of flooding or a particular flood event is classified by its annual exceedance probability (AEP) or return period (in years). A 1% AEP flood indicates the flood event that will occur or be exceeded on average once every 100 years and has a 1 in 100 chance of occurring in any given year.

Return period is often misunderstood to be the period between large flood events rather than an average recurrence interval. Annual exceedance probability is the inverse of return period as shown in Table 3-1.

Table 3-1 Probability of Flooding

Return Period (Years)	Annual Exceedance Probability (%)
2	50
100	1
200	0.5
1000	0.1

Considered over the lifetime of development, an apparently low-frequency or rare flood has a significant probability of occurring. For example:

- A 1% flood has a 22% (1 in 5) chance of occurring at least once in a 25-year period - the period of a typical residential mortgage;
- And a 53% (1 in 2) chance of occurring in a 75-year period - a typical human lifetime.

3.2.2 Consequences of Flooding

Consequences of flooding depend on the hazards caused by flooding (depth of water, speed of flow, rate of onset, duration, wave-action effects, water quality) and the vulnerability of receptors (type of development, nature, e.g. age-structure, of the population, presence and reliability of mitigation measures etc.).

The 'Planning System and Flood Risk Management' provides three vulnerability categories, based on the type of development, which are detailed in Table 3.1 of the Guidelines, and are summarised as:

- **Highly vulnerable**, including residential properties, essential infrastructure and emergency service facilities;
- **Less vulnerable**, such as retail and commercial and local transport infrastructure;
- **Water compatible**, including open space, outdoor recreation and associated essential infrastructure, such as changing rooms.

3.3 Definition of Flood Zones

In the 'Planning System and Flood Risk Management', Flood Zones are used to indicate the likelihood of a flood occurring. These Zones indicate a high, moderate or low risk of flooding from fluvial or tidal sources and are defined below in Table 3-2.

It is important to note that the definition of the Flood Zones is based on an **undefended scenario** and does not take into account the presence of flood protection structures such as flood walls or embankments. This is to allow for the fact that there is a residual risk of flooding behind the defences due to overtopping or breach and that there may be no guarantee that the defences will be maintained in perpetuity.

It is also important to note that the Flood Zones indicate flooding from fluvial and tidal sources and do not take other sources, such as groundwater or pluvial, into account, so an assessment of risk arising from such sources should also be made.

Table 3-2 Definition of Flood Zones

Zone	Description
Zone A High probability of flooding.	This zone defines areas with the highest risk of flooding from rivers (i.e. more than 1% probability or more than 1 in 100) and the coast (i.e. more than 0.5% probability or more than 1 in 200).
Zone B Moderate probability of flooding.	This zone defines areas with a moderate risk of flooding from rivers (i.e. 0.1% to 1% probability or between 1 in 100 and 1 in 1000) and the coast (i.e. 0.1% to 0.5% probability or between 1 in 200 and 1 in 1000).
Zone C Low probability of flooding.	This zone defines areas with a low risk of flooding from rivers and the coast (i.e. less than 0.1% probability or less than 1 in 1000).

3.4 Objectives and Principles of the Planning Guidelines

The 'Planning System and Flood Risk Management' describes good flood risk practice in planning and development management. Planning authorities are directed to have regard to the guidelines in the preparation of Development Plans and Local Area Plans, and for development control purposes.

The objective of the 'Planning System and Flood Risk Management' is to integrate flood risk management into the planning process, thereby assisting in the delivery of sustainable development. For this to be achieved, flood risk must be assessed as early as possible in the planning process. Paragraph 1.6 of the Guidelines states that the core objectives are to:

- "*avoid inappropriate development in areas at risk of flooding;*
- *avoid new developments increasing flood risk elsewhere, including that which may arise from surface run-off;*
- *ensure effective management of residual risks for development permitted in floodplains;*
- *avoid unnecessary restriction of national, regional or local economic and social growth;*
- *improve the understanding of flood risk among relevant stakeholders; and*
- *ensure that the requirements of EU and national law in relation to the natural environment and nature conservation are complied with at all stages of flood risk management".*

The guidelines aim to facilitate '*the transparent consideration of flood risk at all levels of the planning process, ensuring a consistency of approach throughout the country.*' SFRAs therefore become a key evidence base in meeting these objectives.

The 'Planning System and Flood Risk Management' works on a number of key principles, including:

- Adopting a staged and hierarchical approach to the assessment of flood risk;
- Adopting a sequential approach to the management of flood risk, based on the frequency of flooding (identified through Flood Zones) and the vulnerability of the proposed land use.

3.5 The Sequential Approach and Justification Test

Each stage of the FRA process aims to adopt a sequential approach to management of flood risk in the planning process.

Where possible, development in areas identified as being at flood risk should be avoided; this may necessitate de-zoning lands within the plan boundary. If de-zoning is not possible, then rezoning from a higher vulnerability land use, such as residential, to a less vulnerable use, such as open space may be required.

Figure 3-2 Sequential Approach Principles in Flood Risk Management

Source: The Planning System and Flood Risk Management (Figure 3.1)

Where rezoning is not possible, exceptions to the development restrictions are provided for through the Justification Test. Many towns and cities have central areas that are affected by flood risk and have been targeted for growth. To allow the sustainable and compact development of these urban centres, development in areas of flood risk may be considered necessary. For development in such areas to be allowed, the Justification Test must be passed.

The Justification Test has been designed to rigorously asses the appropriateness, or otherwise, of such developments. The test is comprised of two processes; the Plan-making Justification Test, and the Development Management Justification Test. The latter is used at the planning application stage where it is intended to develop land that is at moderate or high risk of flooding for uses or development vulnerable to flooding that would generally be considered inappropriate for that land.

Table 3-3 shows which types of development, based on vulnerability to flood risk, are appropriate land uses for each of the Flood Zones. The aim of the SFRA is to guide development zonings to those which are 'appropriate' and thereby avoid the need to apply the Justification Test.

Table 3-3 Matrix of Vulnerability versus Flood Zone

	Flood Zone A	Flood Zone B	Flood Zone C
Highly vulnerable development (Including essential infrastructure)	Justification Test	Justification Test	Appropriate
Less vulnerable development	Justification Test	Appropriate	Appropriate
Water-compatible development	Appropriate	Appropriate	Appropriate

Source: Table 3.2 of The Planning System and Flood Risk Management

3.6 Scales and Stages of Flood Risk Assessment

Within the hierarchy of regional, strategic and site-specific flood-risk assessments, a tiered approach ensures that the level of information is appropriate to the scale and nature of the flood-risk issues and the location and type of development proposed, avoiding expensive flood modelling and development of mitigation measures where it is not necessary. The stages and scales of flood risk assessment comprise:

- **Regional Flood Risk Appraisal (RFRA)** – a broad overview of flood risk issues across a region to influence spatial allocations for growth in housing and employment as well as to identify where flood risk management measures may be required at a regional level to support the proposed growth. This should be based on readily derivable information and undertaken to inform the Regional Planning Guidelines.
- **Strategic Flood Risk Assessment (SFRA)** – an assessment of all types of flood risk informing land use planning decisions. This will enable the Planning Authority to allocate appropriate sites for development, whilst identifying opportunities for reducing flood risk. This SFRA will revisit and develop the flood risk identification undertaken in the RFRA, and give consideration to a range of potential sources of flooding. An initial flood risk assessment, based on the identification of Flood Zones, will also be carried out for those areas which will be zoned for development. Where the initial flood risk assessment highlights the potential for a significant level of flood risk, or there is conflict with the proposed vulnerability of development, then a site specific FRA will be recommended, which will necessitate a detailed flood risk assessment.
- **Site Specific Flood Risk Assessment (FRA)** – site or project specific flood risk assessment to consider all types of flood risk associated with the site and propose appropriate site management and mitigation measures to reduce flood risk to and from the site to an acceptable level. If the previous tiers of study have been undertaken to appropriate levels of detail, it is highly likely that the site specific FRA will require detailed channel and site survey, and hydraulic modelling.

4 Data Collection

4.1 Overview

There are a number of sources of flood data available for the Limerick area. The following table lists the core datasets used to compile the flood map for the Limerick City Development Plan 2010-2016 and gives an assessment of the data quality and the confidence in its accuracy.

Table 4-1 Flood Data Used to Compile Flood Zone Mapping

Description	Coverage	Robustness	Comment on usefulness
Shannon CFRAM Flood Mapping	Covers the Rivers Shannon, Abbey, Mulkear, Goody, Ballinacurra Creek Upper Ballycannan etc.	High AFA status.	Detailed 1D/2D CFRAM HPW model and is useful.
Limerick City Development Plan 2010-2016 Flood Mapping (JBA Mapping)	Covers the Rivers Shannon, Abbey, Mulkear, Goody, Ballinacurra Creek Upper Ballycannan etc.	Moderate	CFRAM mapping supersedes all development plan flood mapping. Has been used for sensibility checking only.
OPW PFRA flood extent maps, as verified by CFRAM FRR	Covers all watercourses.	Moderate	CFRAM mapping supersedes all PFRA mapping. Has been used for sensibility checking only.
Historical Flood Records	Spot coverage of whole Development Plan	Moderate	Highly useful oversight of historic flooding issues provided by Local Authority.

The Flood Zone mapping represents a combination of the above flood sources. The Shannon CFRAM mapping, has formed the core source of the final Flood Zones for all watercourses as they have all been subject to detailed analysis under this project. There has also been a thorough review of historic flood records. The result is Flood Zone mapping that presents the best available data for the study area.

4.2 National PFRA Study Fluvial Flood Outlines

The Preliminary Flood Risk Assessment (PFRA) is a national screening exercise that was undertaken by the OPW to identify areas at potential flood risk. The PFRA was a requirement of the EU Floods Directive and the publication of this work informed the more detailed assessment that is being undertaken as part of the Catchment Flood Risk Assessment and Management (CFRAM) studies. The PFRA study considered flooding from a number of sources; fluvial, tidal, pluvial and groundwater and resulted in production of a suite of broadscale flood maps.

For the preparation of the PFRA fluvial flood maps, flood flow estimates were calculated at nodes every 500m along the entire river network. (The river network is the EPA 'blue-line' network, which, for the most part, matches the rivers mapped at the 1:50,000 scale Discovery Series OS mapping). This flow estimation was based on the OPW Flood Studies Update research programme. An assumption was made that the in-channel flow equates to the mean annual flood and so the out of bank flow for a particular AEP event was determined by deducting the mean annual flood from the flood flow estimate for that probability event.

Using a 5m national digital terrain model (DTM) a cross section was determined at 100m spacing's. The Manning's equation, a hydraulic equation for normal flow, was used to calculate a flood level which was then extrapolated across the DTM to determine the flood extent. This exercise was completed by the OPW for all river catchments greater than 1km^2.

This methodology did not take into account defences, channel structures or channel works. Potential sources of error in the mapping include local errors in the DTM or changes to the watercourse flow route due to an error in mapping or new development. Throughout Limerick City the PFRA mapping covers the River Shannon (although this has been superseded by CFRAM data) and all main tributaries in the area.

4.3 National CFRAM Programme

Following on from the PFRA study, the OPW commenced appointment of consultants to carry out a more detailed flood risk assessment for key flood risk areas. This work is being undertaken under the national CFRAM programme across seven river basin districts in Ireland. The CFRAM programme commenced with three pilot studies covering the River Lee, Fingal East Meath area and the River Dodder. A further seven studies are currently underway in the Shannon, East, South-East, South-West, West, North-West and Neagh-Bann regions.

Limerick City falls within the Shannon CFRAM Study area. During the initial Flood Risk Review (FRR) stage of the Shannon CFRAM Limerick City was selected as an Area for Further Assessment (AFA). This was based on the historical flood record and PFRA flood outlines for the area.

Following Limerick City's designation as an AFA it was subject to the full analysis under the Shannon CFRAM. This included a detailed 1D-2D hydraulic model, the model represents the Limerick City AFA and encompasses the River Shannon upstream and downstream of its extent, plus associated tributaries. The tributaries included in the model that flow through or adjacent to the regeneration areas are the Mulkear River, Goody (River), Upper Ballycannan and Ballinacurra (Creek). The CFRAM mapping represents a significant improvement compared to the accuracy provided by the PFRA mapping.

Following completion of the CFRAM flood mapping the OPW have released the Preliminary Options Report and the Draft Flood Risk Management Plan covering the Limerick AFA. These reports set out the available flood protection measures most suitable for the Limerick City AFA. Detailed cost benefit analysis was undertaken to identify viable solutions. The proposed measures aim to provide protection against fluvial flooding to the 1% AEP design event and to 0.5% AEP design event for tidal flooding. Existing flood defence walls and embankments including the maintenance of will be incorporated into the flood risk management plan. Refer to Section 4.5.2 for proposed measures covering the regeneration areas.

A Public Consultation on the preliminary options for flood risk management within the Limerick City AFA was held between the dates of the 15th July-23rd September 2016.

4.4 Limerick City Development Plan 2010-2016 Flood Mapping (JBA Consulting)

JBA developed software, known as JFLOW® to undertake multi-scale two dimensional hydraulic fluvial and tidal flood modelling. The fluvial flood mapping process involved two stages, hydrology and hydraulic modelling. JBA Consulting developed in-house software tools to interpolate catchment descriptors from a number of environmental datasets and produced an automated method for calculating design flows. The method used to calculate flows was based on the Flood Estimate Handbook (FEH) Statistical Method and is in line with the methods of the Flood Studies Update (FSU). Index flows were generated at 300m intervals along the entire river network. Annual Maximum flow data from the OPW Hydrodata website were used to adjust the index flows by allocating 'donor' gauges, whereby local gauges are used to compare and adjust index flows for a given catchment. Pooled data was used to generate growth curves and determine flood flows for different return periods.

JFLOW®, a two dimensional hydraulic modelling software, was used to simulate overland flooding. Cross sections were generated at each inflow point to define the extent of the area over which to route the flow. Flow was routed over a digital terrain model and this was the OSi national 10m height model with updated height data. This process was completed for all river catchments greater 3km^2 in Limerick City

JFLOW® results were subject to several iterations of manual checking and model re-runs. However, the accuracy of the flood mapping is directly correlated to the DTM and individual flow structures such as bridges, culverts, weirs and sluices are not explicitly modelled.

As suggested above, the final flood maps were adopted as part of the SFRA were predominantly obtained from the Shannon CFRAM flood maps. The CFRAM mapping uses the most detailed and

up to date hydrology, tidal and topographical models and is based on more detailed hydraulic modelling methods.

4.5 Limerick Flood Relief Schemes

4.5.1 Existing Flood Relief Schemes

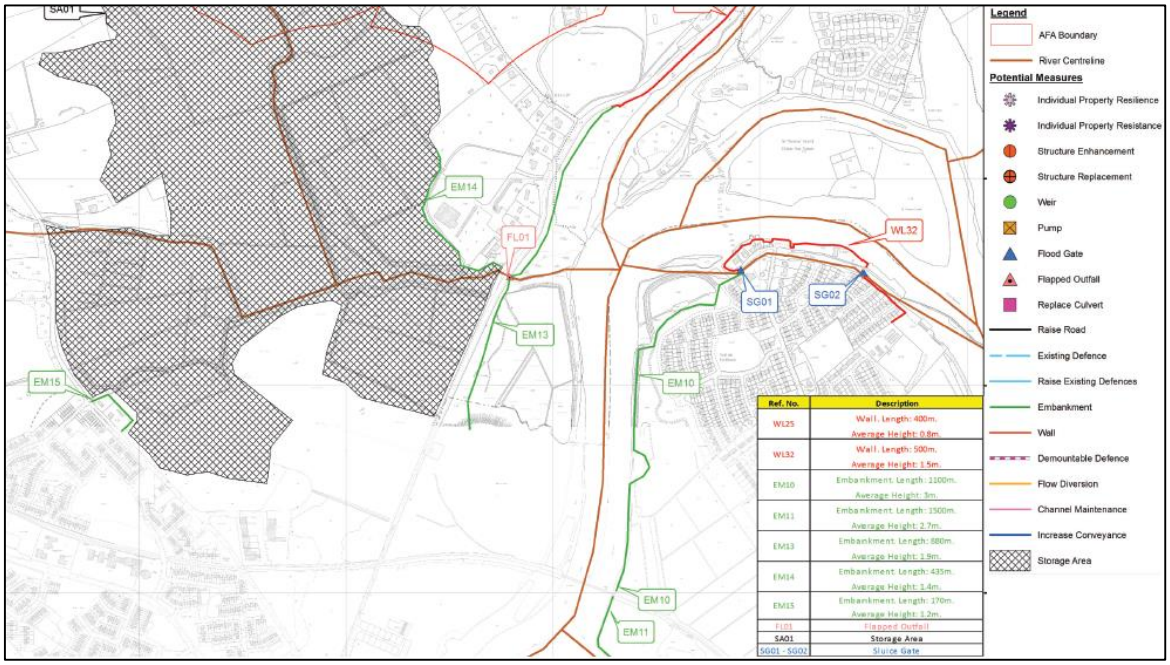
A number of flood relief schemes have been constructed within Limerick City with the existing schemes comprising mainly of defences walls and embankments to protect against 1% AEP flood events using the design criteria at the time of construction. i.e. the designed 1% AEP flood event as part of these flood defence schemes may differ than the current CFRAM 1% AEP flood event. A list of the existing flood defence schemes are listed as follows:

- Sir Harry's Mall Flood Relief Scheme - Constructed in the mid-2000's designed to protect 134 No. properties along the Abbey River.
- Clancy Strand Flood Relief Scheme - Constructed during the mid-2000's comprising defence walls and demountable barriers. The scheme was designed to protect against a 1% AEP flood event for 100 No. properties along the River Shannon.
- Howleys Quay Flood Relief Scheme- Constructed during 2012 which comprises defences walls and demountable barriers designed to protected against the then 1% AEP flood event.

4.5.2 Proposed Flood Defence Schemes

As part of the Shannon CFRAM programme as discussed in Section 4.3 various flood defence measures have been proposed and investigated throughout the Limerick AFA. Regarding the Moyross regeneration area, measures have been proposed to protect the area from tidal/fluvial flooding, refer to Figure 4-1. The measures include the development of embankment walls, flapped outfalls/sluice gates and storage areas which will provide protection up to the 1%/0.5% AEP design standard. It should be noted that there is no timetable provided or any guarantee that the proposed works will be undertaken.

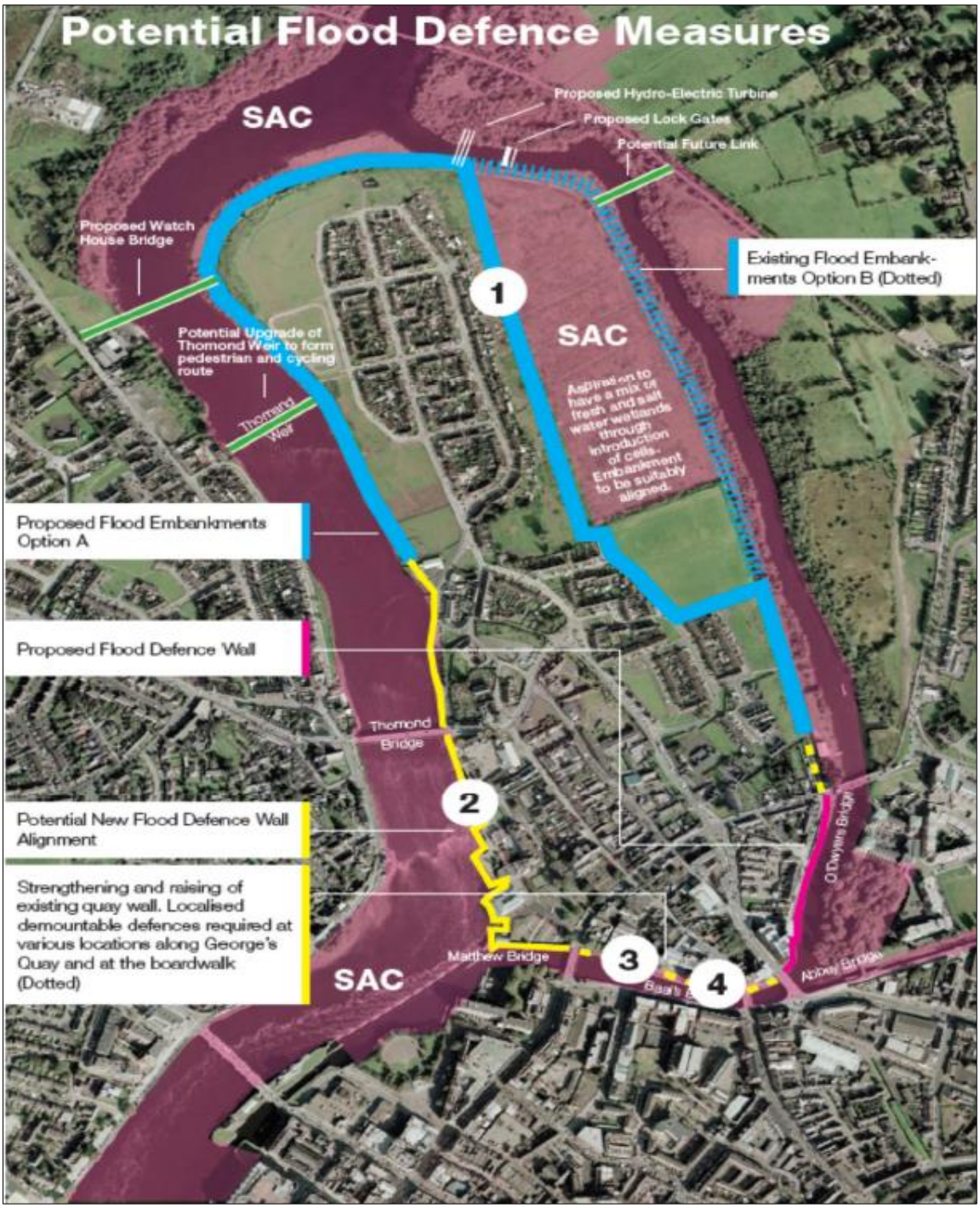
Figure 4-1 Proposed Moyross Flood Defence Measures



(Source: Shannon CFRAM Draft Flood Risk Management Plan Unit of Management 25/26)

A flood relief scheme is proposed for Kings Island, the Kings Island Flood Relief Scheme following extensive flooding during February 2014. The scheme is currently at the design stage with construction expected being during 2018 and completed by 2019. The scheme will include flood defence embankments and walls which will afford protection against the 0.5% AEP (200 year) return flood event. This will protect against flooding from the River Shannon and Abbey River including tidal events. The defence scheme will be undertaken over two phases and the proposed layout is shown in Figure 4-2.

Figure 4-2 Proposed King's Island Flood Defence Scheme



As previously stated the flood relief scheme will be undertaken under two phases. Phase 1, (labelled as 2,3 & 4 in Figure 4-2) is progressing under the construction state. Phase 2 (labelled as 1 in Figure 4-2) is currently undergoing the design & planning stage. It should be noted that Phase 2 of the flood defence scheme has not achieved approval from An Bord Pleanála, therefore the final design may differ from the current proposals.

4.6 Historic Flood Review

Records of past flooding are useful for looking at the sources, seasonality, frequency and intensity of flooding. Historical records are mostly anecdotal and incomplete, but are useful for providing background information.

4.6.1 OPW Floodmaps.ie

The OPW hosts a National Flood Hazard Mapping website that makes available information on areas potentially at risk from flooding. This website provides information on historical flood events across the country and formed the basis of the Regional Flood Risk Appraisal.

Information is provided in the form of reports and newspaper articles which generally relate to rare and extreme events. Since the establishment of the hazard mapping website, more records are available which identify more frequent and often recurring events. These tend to include memos and meeting records from local authority area engineers, often relating to road flooding.

4.6.2 Summary of Historic Flood Risk

The pertinent flood risk history obtained from the OPW floodmaps.ie sources are displayed in Figure 4-3 and summarised in and Table 4-2 below.

Figure 4-3 OPW Floodmaps.ie

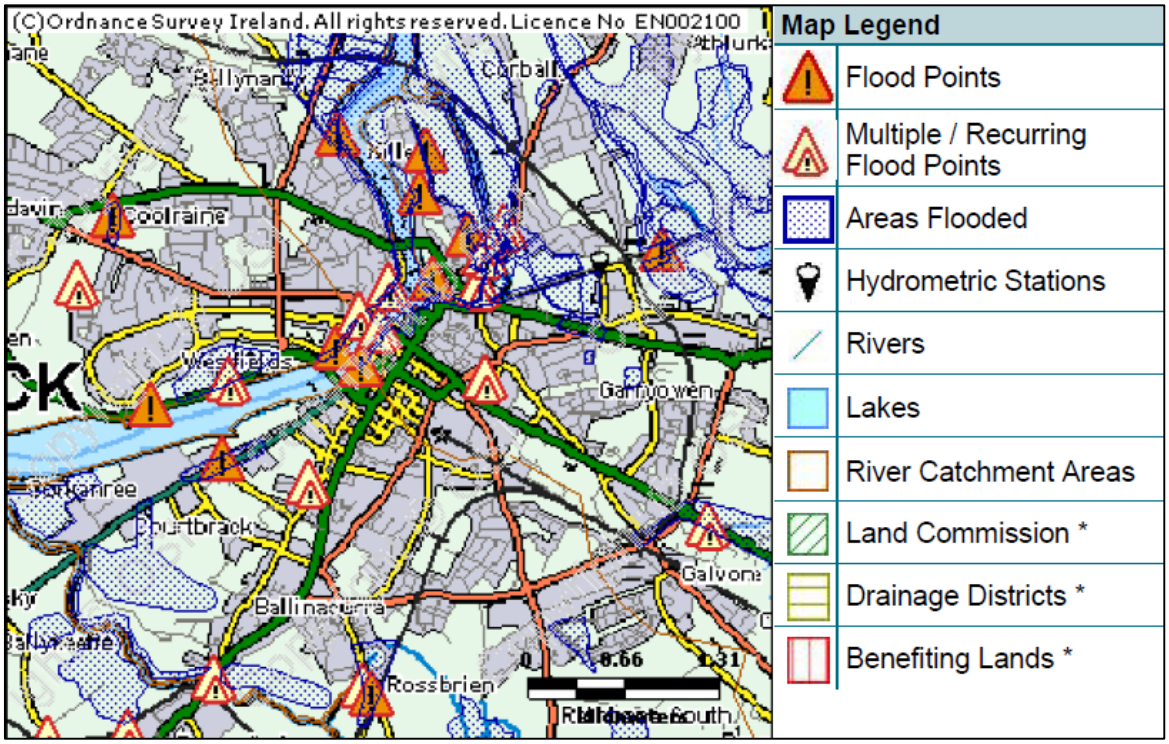


Table 4-2 Historic Flood Information-Floodmaps.ie

Date of Flood	Description
February 2014	High tide (4.51mOD at Limerick Dock) resulted in overtopping of the embankments along Condell Road and King's Island. Flooding was recorded in St Mary's Park, Kings Island. Approximately 191 No. properties were flooded.
January 2014	High tide resulted in breach (infiltration of defence wall) of flood embankments. No recorded flooding of residential or commercial properties.
February 2002	Flooding caused by the combination of heavy rainfall, westerly winds and a spring tide. Numerous areas were flooded within Limerick City including St Mary's Park.
October 2001	Photographic evidence of flooding of roadway along Limerick City quays
February 2001	Flooding of c.25 properties in the Athlunkard St area of Limerick City.
December 1999	Heavy rainfall during December 1999 resulted in severe flooding along the Shannon catchment with rainfall levels ranging from 100-250% higher than average. Water level recorded downstream of Parteen Weir were the fourth highest on record up to this flood event. Flooding occurred in Limerick City over the Christmas period.
February 1997	Serious flooding across Limerick City resulting from a combination of westerly winds and high tides. The flood event resulted in the inundation of <105 properties.
January 1995	Tidal flooding resulted in some flooding of Limerick City. The highest tide level of 4.2mOD was recorded at the harbour. Flooding was mainly confined to roadways and low-lying lands.
May 1994	Photographic evidence of flooding of roadway in Corbally & Kings Island area of Limerick.
January 1994	Photographic evidence of flooding of roadway in Clancy strand area of Limerick. Floodwaters appear to seep through defence wall.
February 1990	Flooding along the River Shannon.
December 1954	Flooding along the River Shannon at the end of 1954 and early 1955 resulted in flooding of c25,000 agricultural lands.

4.7 Sources of Flooding

A review of the historical event data and predictive flood information has highlighted a number of sources of potential flood risk to the town. These are discussed in the following sections. There are two main sources of flooding within the Limerick AFA which are fluvial and tidal flooding.

4.7.1 Fluvial Flooding

The main source of pluvial flooding within Limerick City is from the River Shannon with a lower risk of flooding present from its tributaries along the Ballinacurra Creek, Mulkear River and the Ballycannan River. River flows through the River Shannon are controlled by the Parteen Weir located upstream of Limerick City. An estimated 747 No. residential properties are considered to be at risk from a 1% flood event, as stated in the Preliminary Options Report for Limerick City.

4.7.2 Tidal Flooding

Tidal flooding is the dominant source of flooding along the River Shannon through Limerick City and Kings Island. Significant tidal flooding having been recorded since 1961. The mechanism behind the tidal flooding is the occurrence of high tide and a surge due to low atmospheric pressure and westerly winds along the Shannon Estuary. The tidal surge has an impact on the River Shannon and its tributaries up to its confluence with the Mulkear River.

4.7.3 Residual Risk

The existing flood defence works along the River Shannon are designed to a fluvial 1% AEP (100 year) standard of protection. As with any built defences there is a residual risk associated with failure of these defences due to overtopping or breach, or failure to erect sections of the defences.

With climate change, the frequency, pattern and severity of flooding are expected to change and become more damaging. Climate change and increased river flows will impact on the level of protection of the scheme in future years. Further discussion on the types of residual risk is provided below.

4.7.3.1 Residual Risk due to Overtopping

Overtopping of flood defences will occur during flood events greater than the design level of the defences. A number of flood defences in Limerick have been designed to a 1% and 0.5% AEP level of protection which will include a level of freeboard. During any event greater than the design level AEP overtopping will occur. This can cause more limited inundation of the floodplain than if defences had not been built, but the impact will depend on the duration, severity and volume of floodwater. However, and more critically, overtopping can destabilise a flood defence, cause erosion and make it more susceptible to breach or fail.

Overtopping may become more likely in future years due to the impacts of climate change.

4.7.3.2 Residual Risk due to Breach or Structural Failure

Breach or structural failure of flood defences is hard to predict and is largely related to the structural condition and type of flood defence. 'Hard' flood defences such as solid concrete walls are less likely to breach than 'soft' defence such as earth embankments.

Breach will usually result in sudden flooding with little or no warning and presents a significant hazard and danger to life. There is likely to be deeper flooding in the event of a breach than due to overtopping. The volume and impact of flooding will depend on a number of factors including:

- Size and number of breaches;
- The time that the breach develops; a breach that develops early will allow more floodwater through, however a breach that develops near the peak of the event will be more hazardous;
- How long the breach remains open, leaving those in the floodplain vulnerable to secondary flood peaks on a watercourse.

4.7.3.3 Residual Risk due to Operational Failure

If a defence system includes temporary or demountable sections, such as in Limerick City, it may fail due to forecasting errors, access or technical difficulties with the demountable system itself. The lead in time is short and this residual risk should not be underestimated.

There is also a risk that surface water pumping from behind the defences suffers failure, this pumping occurs on both the western and eastern sides of the river.

4.7.3.4 Scales of Residual Risk

In the event of defence overtopping or breach on relatively narrow flood plains inundation levels across the floodplain are likely to be the same, or very nearly the same, as levels in the river channel. In the area immediately behind the defences, known as the 'rapid inundation zone' flood depths and velocities will be highest, particularly in the time immediately following the onset of overtopping or breach. There may be little time for warning or reacting to the failure of the defence. In the area of floodplain furthest from the river, water levels will rise more gradually and reach lower depths and velocities. Being nearest to higher and dry land, evacuation opportunities from this area are also greatest.

Where an area is protected by a demountable defence, either fully or in part, the residual risks are greater than where land is behind a fixed defence. It is therefore important that risks, and the impact of defence failure, is considered in relation to the whole flood cell, rather than the land immediately behind one section of defence. This is particularly relevant in areas where flood relief scheme relies on a combination of fixed and demountable defences.

The scale of residual risk is difficult to predict and requires detailed modelling to estimate the flood extents from a range of different scenarios, defended and undefended. As part of Shannon CFRAM,

defended and un-defended flood extents are available and the undefended flood extents have been used to create Flood Zone A.

Understanding the residual risks is critical to application of the Flooding Guidelines in these defended areas. Even though the area is defended, it is important to be able to guide more vulnerable development to the lower residual risk areas, and to assess how the urban form of the development maybe impacted by these risks. As part of the CFRAM programme breach analysis on the flood defences was undertaken within the Limerick City AFA. Defence failure flood maps were produced to show areas at risk from potential failure, including flood extent and depth maps. King's Island is the only regeneration area with existing flood defences offering a SOP to 10% AEP and was modelled under the breach analysis. The resulting flood maps show extensive inundation of existing greenspace area and some inundation of residential properties. It should be noted that protection will be provided up to the 0.5% AEP design standard under the Kings Island Flood Relief Scheme, however consideration will ned to be given to the residual risk of potential overtopping/failure.

In areas without detailed breach modelling, the following assumptions have been made in order to assess the residual risk:

- Worst case scenario would be flood extent equal to that of an undefended scenario for a particular return period;
- Flood depths in this narrow floodplain can be accurately assumed to be similar to the predicted flood levels from the Shannon CFRAM modelling;
- Flow velocities and hence hazard will be greatest immediately adjacent to the flood defences.

Development in areas benefiting from defences must consider long-term flood risk management policies and plans. On a site specific level, emergency response plan should be prepared taking into account the overall plan for the area and the implications for adding further demands on the blue light services.

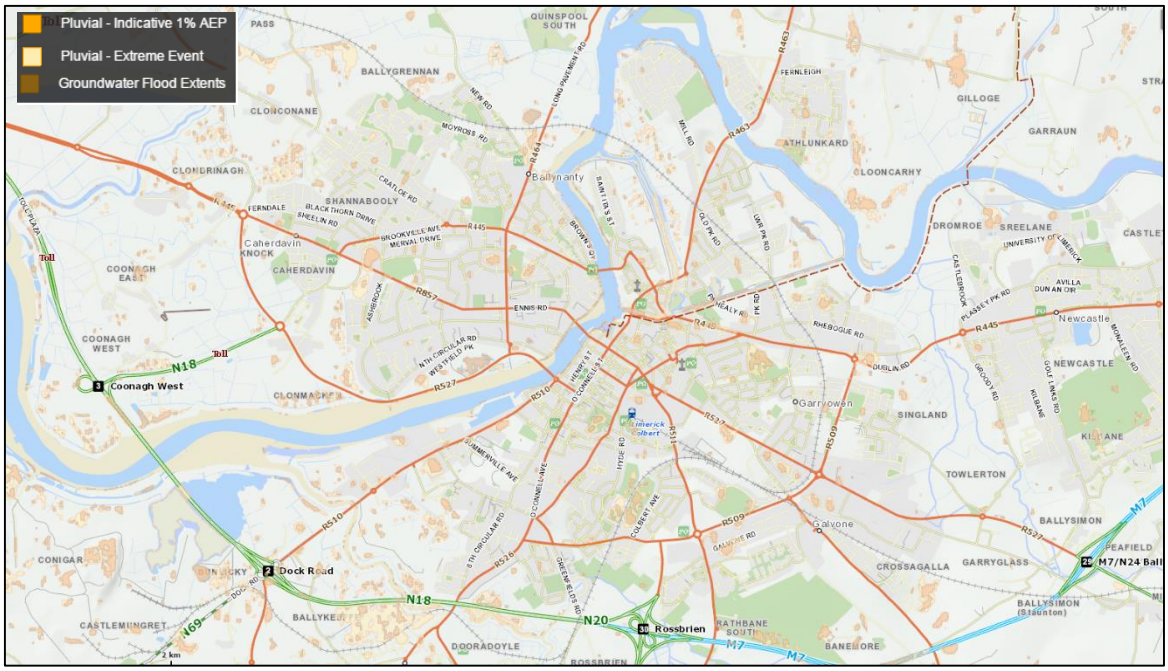
The management of fluvial flood risk through the development of appropriate policies and objectives is discussed Section 5. A full review of locations where development is impacted by flood risk is included in Section 6.

4.7.4 Surface Water / Pluvial Flooding

Flooding of land from surface water runoff is usually caused by intense rainfall that may only last a few hours. Areas at risk from fluvial flooding will almost certainly be at risk from surface water flooding. The indicative pluvial map from myplan.ie shows the OPW PFRA study in Figure 4-4. It has been used to identify development areas at particular risk of surface water and pluvial flooding.

The OPW historic records indicate that backing up of the surface water system has caused localised flooding in Limerick City. Although surface water could have been a contributing factor within some of these flood events, poorly planned developments or inadequately designed surface water drainage systems can increase the risk of surface water flooding and exacerbate the extent of fluvial flooding. New development or redevelopment of existing sites adhering to the policies on the management of surface water will ensure the risk will be adequately managed. This is explained further in Section 5.

Figure 4-4 PFRA Indicative Pluvial Flood Map



(Source:Myplan.ie)

4.7.5 Groundwater Flooding

Groundwater flooding is caused by the emergence of water originating from the subsurface, and is particularly common in karst landscapes. This source of flooding can persist over a number of weeks and poses a significant but localised issue that has attracted an increasing amount of public concern in recent years. In most cases groundwater flooding cannot be easily managed or lasting solutions engineered.

The draft PFRA groundwater flood maps, which entailed an evidence-based approach and considered the hydro-geological environment, such as the presence of turloughs, did not show any significant risk in the development plan area. Based on the PFRA study the risk of groundwater flooding is not considered significant enough to warrant further investigation in this SFRA.

4.7.6 Climate Change

The Planning System and Flood Risk Management guidelines recommends that a precautionary approach to climate change is adopted due to the level of uncertainty involved in the potential effects.

Specific advice on the expected impacts of climate change and the allowances to be provided for future flood risk management in Ireland is given in the OPW guidance. Two climate change scenarios are considered. These are the Mid-Range Future Scenario (MRFS) and the High-End Future Scenario (HEFS). The MRFS is intended to represent a "likely" future scenario based on the wide range of future predictions available. The HEFS represents a more "extreme" future scenario at the upper boundaries of future projections. Based on these two scenarios the OPW recommended allowances for climate change are given in Table 4-3 below.

Table 4-3 Allowances for Future Scenarios (100 Year Time Horizon)

Criteria	MRFS	HEFS
Extreme Rainfall Depths	+20%	+30%
Flood Flows	+20%	+30%
Mean Sea Level Rise	+500mm	+1000mm
Land Movement	-0.5mm / year*	-0.5mm / year*
Urbanisation	No General Allowance - Review on Case by Case Basis	No General Allowance - Review on Case by Case Basis

Forestation	-1/6 Tp**	-1/3 Tp** +10% SPR***
Notes: * Applicable to the southern part of the country only (Dublin - Galway and south of this) ** Reduce the time to peak (Tp) accordingly; this allows for potential accelerated runoff that may arise as a result of drainage of afforested land *** Add 10% to the Standard Percentage Runoff (SPR) rate; this allows for increased runoff rates that may arise following felling of forestry		

4.7.7 Climate Change and Flood Risk Assessment

The Flood Zones are determined based on readily available information and their purpose is to be used as a tool to avoid inappropriate development in areas of flood risk. Where development is proposed within an area of potential flood risk (Flood Zone A or B), a flood risk assessment of appropriate scale will be required and this assessment must take into account climate change and associated impacts. Under the National CFRAM programme, the detailed modelling and assessment stage of each study will include for climate change effects, but has not yet been delivered.

Climate change may result in increased flood extents and therefore caution should be taken when zoning lands in transitional areas. **As recommended in the Planning System and Flood Risk Management Guidelines; Flood Zone B, which represents the 0.1% AEP extent, can be taken as an indication of the extent of the 1% AEP flood event with climate change.** In steep valleys an increase in water level will relate to a very small increase in extent, however in flatter low-lying basins a small increase in water level can result in a significant increase in flood extent.

In the design of flood alleviation measures, climate change should be taken into account and design levels of structures, such as flood walls or embankments, must be sufficient to cope with the effects of climate change over the lifetime of the structure or where circumstances permit, be capable of adaptation. Further consideration to the potential future impacts of climate change will be given for specific areas within Section 6.

5 Approach to Flood Risk Management

The Planning Guidelines recommend a sequential approach to spatial planning, promoting avoidance rather than justification and subsequent mitigation of risk. The implementation of the Planning Guidelines on a settlement basis is achieved through the application of the policies and objectives contained within Section 12 Part II 'Flooding' of the Limerick City Development Plan 2010-2016. These have been outlined in Section 2.4.1.

The use and application of the policies and guidelines at the Development Plan level constitutes the formal plan for flood risk management for Limerick City.

5.1 The Strategic Approach

A strategic approach to the management of flood risk is important in Limerick City as there is a significant area of the core town centre area located within Flood Zone A/B most notably at Kings Island. Whilst there are existing FRS in place protecting local areas within Limerick City with further FRS planned and undergoing development as part of the Draft Flood Risk Management Plans, the protection afforded by the scheme relies on the placement of demountable defences and the defences can fail or overtop. The residual risk therefore remains significant and FRAs for development within the designated regeneration areas must take this into account when providing mitigation and design advice.

A summary of flood risks associated with each of the zoning objectives has been provided in Table 5-1, below. It should be noted that this table is intended as a guide only and should be read in conjunction with the detailed assessment of risks provided in Section 6. However, when applications are being considered it is important to remember that not all uses will be appropriate on flood risk grounds, hence the need to work through the Justification Test for Development Management on a site by site basis and with reference to Section 6. For example, the community zoning objective could include a highly vulnerable crèche, less vulnerable shops and water compatible car parking / sports facilities but they would not be equally permissible on the ground floor within Flood Zone A or B.

Table 5-1 Zoning objective vulnerability

Zoning Objective	Indicative Primary Vulnerability	Flood Risk Commentary
Residential	High vulnerability	Justification Test needs to be passed to allow zoning in Flood Zone A and B. For alterations to existing development see Section 5.2
Agriculture	High or less vulnerable or water compatible	Justification Test needs to be passed to allow highly vulnerable development (Farmhouses) in Flood Zone A and B and for less vulnerable development in Flood Zone B. Water compatible uses are appropriate.
Community and Educational Uses	High or less vulnerable or water compatible	Justification Test needs to be passed to allow highly vulnerable development Flood Zone A and B and for less vulnerable development in Flood Zone B.
Neighbourhood Centres	High and less vulnerable	Justification Test needs to be passed to allow highly vulnerable development Flood Zone A and B and for less vulnerable development in Flood Zone B.
City Centre Area	Less vulnerable, with some highly vulnerable	Justification Test needs to be passed to allow highly vulnerable development Flood Zone A and B and for less vulnerable development in Flood Zone B.
Mixed Use	Less vulnerable	Justification Test needs to be passed to allow zoning in Flood Zone B.
Sports Grounds	Water compatible or less vulnerable	Justification Test needs to be passed to allow zoning in Flood Zone B.
Public Open Space	Water compatible or less vulnerable	Water compatible uses are appropriate. Justification needs to be passed to allow less vulnerable development in Flood Zone B.

5.2 Application of the Plan Making Justification Test

Having reviewed the proposed zoning objectives within the settlement it is clear that there is relatively little overlap between zoned undeveloped lands and potential conflict with flood risk. Where there are overlaps then specific measures can be put in place to define and avoid risk and the Justification Test has not been applied, this is discussed in Section 5.2.1.

Appropriate measures for assessing and managing risks to existing high and low vulnerability development in Flood Zones A, B and C at Development Management (Planning Application) stage is discussed in Section 5.4 onwards.

5.2.1 Development on Greenfield Land

The majority of undeveloped land that is within Flood Zone A or B is zoned for water compatible uses, such as Public Open Space and, or to facilitate future flood risk management infrastructure. This is an appropriate zoning and should continue.

Risk specific uses and detailed FRA are discussed in Section 6 for each specific area. Measures focus on the more detailed assessment of risk from the contributing watercourses and the avoidance of highly vulnerable development within the redefined Flood Zone A specifically in relation to Moyross and Kings Island.

Other proposals for new development on greenfield land within Flood Zone A or B would not pass the Justification Test and land is zoned accordingly with a water compatible or less vulnerable use.

5.2.2 Existing, Developed, Zoned Areas at Risk of Flooding

There are significant areas of the existing city centre and southwest along the Dock Road and Kings Island located behind existing flood defences that is at potential residual risk of flooding (within Flood Zone A/B) and in this case zoning cannot be significantly amended, but measures can be put in place to manage risk.

Section 5.4 onwards provides general guidance on how to manage development and Section 6 provides a detailed review of risk to specific areas of the settlement.

5.3 Flood Management Action Plans

There are various levels of flood management plans produced by a number of public bodies and these include the overall strategy for the river catchment, the emergency response plan of the local authority and the flood risk management plan at a site specific level.

A Draft Flood Risk Management Plan has been prepared for Limerick City which was informed by the detailed assessment undertaken during the Shannon CFRAM Study. The plans cover the proposed regeneration areas of Moyross, Kings Island, Ballinacurra Weston and Southill. Formulation of the management plan is particularly important in Limerick City because of the presence of the flood defences. The management plan must consider residual risk and an effective emergency response should the defences fail due to overtopping or breach.

Emergency Response Plan - it is recommended that the Local Authority draft an Emergency Plan that deals with severe weather scenarios, including flooding, and the document should incorporate a ‘Flood Plan’. It is essential that the flood plan is reviewed to ensure the operation and evacuation procedures associated with the demountable defences are included, along with the specific roles and responsibilities of those issuing alerts, erecting the defences and carrying out any related duties.

Site Specific FRMP - this will be specific to the development and associated activities, most likely it will be required for more significant town centre sites that are located behind the defences and are at residual risk of flooding. A site specific FRMP, which may include an emergency plan, will be required for any development proposal that is granted approval in an area of flood risk.

5.4 Development Management and Flood Risk

In order to guide both applicants and relevant council staff through the process of planning for and mitigating flood risk, the key features of a range of development scenarios have been identified (relating the flood zone, development vulnerability and presence or absence of defences). For each scenario, a number of considerations relating to the suitability of the development are summarised below.

It should be noted that this section of the SFRA begins from the point that all land zoned for development has passed the Justification Test for Development Plans, and therefore passes Part 1 of the Justification Test for Development Management. In addition to the general recommendations in the following sections, Section 6 should be reviewed for specific recommendations for individual areas of the Development Plan.

As stated in Section 6, in order to determine the appropriate design standards for a development it may be necessary to undertake a site specific flood risk assessment. This may be a qualitative appraisal of risks, including drainage design. Further details of each of these scenarios, including considerations for the flood risk assessment are provided in the following sections.

5.5 Requirements for a Flood Risk Assessment

It is recommended that an assessment of flood risk is required in support of any planning application where flood risk may be an issue and this may include sites in Flood Zone C where a small watercourse or field drain exists nearby. The level of detail will vary depending on the risks identified and the proposed land use. As a minimum, all proposed development, including that in Flood Zone C, must consider the impact of surface water flood risks on drainage design. In addition, flood risk from sources other than fluvial and tidal should be reviewed.

For sites within Flood Zone A or B, a site specific "Stage 2 - Initial FRA" will be required, and may need to be developed into a "Stage 3 - Detailed FRA". The extents of Flood Zone A and B are delineated through this SFRA. However, future studies may refine the extents (either to reduce or enlarge them) so a comprehensive review of available data should be undertaken once a FRA has been triggered.

Within the FRA the impacts of climate change and residual risk (including culvert/structure blockage) should be considered and remodelled where necessary, using an appropriate level of detail, in the design of finished floor levels. Further information on the required content of the FRA is provided in the Planning System and Flood Risk Management Guidelines.

Any proposal that is considered acceptable in principle shall demonstrate the use of the sequential approach in terms of the site layout and design and, in satisfying the Justification Test (where required), the proposal will demonstrate that appropriate mitigation and management measures are put in place.

5.5.1 Development Proposals in Flood Zone A or B

Commentary on the procedure for developing lands within Flood Zone A or B within Limerick City are closely linked the location of the potential development within a defended or undefended area of the city. Additional consideration is then given to the scale of the development, be it renovation, minor infill or more significant new development.

Generally, the approach to deal with flood protection would involve raising the ground floor levels above the level of extreme flood levels. If this leads to floor levels being much higher than adjacent streets it could create a hostile streetscape for pedestrians. This would cause problems for infill development sites if floor levels were required to be significantly higher than those of neighbouring properties. In this regard, it has been recognised that some flexibility could be allowed when within defended areas or where the development is considered minor. In these cases, the detailed design of the development should reflect the vulnerability of the site in terms of internal layout, materials, fixtures and fittings and internal layout. For high risk areas, less vulnerable uses are encouraged at ground floor levels. The site specific FRA will inform appropriate uses and detailed design and layout.

It should be noted that for residential buildings within Flood Zone A or B, bedroom accommodation is more appropriate at upper floor levels.

For commercial operations, business continuity must be considered, and steps taken to ensure operability during and recovery after a flood event for both residential and commercial developments. Emergency access must be considered as in many cases flood resilience will not be easily achieved in the existing built environment.

5.5.1.1 Undefended Areas

It is not appropriate for new, highly vulnerable development to be located in Flood Zones A or B, particularly where there are no flood defences, and such proposals will not pass the Justification Test. Instead, a less vulnerable use should be considered.

In general, the application of the sequential approach under this SFRA has ensured that there is only a small amount of land zoned for vulnerable use and the development is caveated by further analysis and avoidance (see Section 6), therefore ensuring the continued application of the sequential approach and appropriate site specific FRA.

5.5.1.2 Defended Areas

In areas of renovation and/or regeneration within defended areas of Limerick City it is not necessarily desirable to exclude highly and less vulnerable development altogether. By definition, it can pass the Justification Test, however, extremely careful consideration must be given to the position and design of any development. Minor/small scale infill housing, extensions or changes of use is discussed in Section 5.5.1.3 and, subject to site specific flood risk assessment, can generally be considered appropriate and resilience/resistance will be employed.

In cases where larger scale new development is proposed within the town centre area a "Stage 3 - Detailed FRA" and management plan is required to accompany the Planning Application. For this type of development, The FRA should improve on the detail provided by the Shannon CFRAM and investigate the impacts of defence failure/breach. It should therefore include an examination of hazard, velocity and time of inundation, and should propose suitable management and mitigation measures. Of prime importance is the requirement to manage risk to the development site and not to increase flood risk elsewhere. It may be necessary to raise the FFLs above significant flood levels and the design should give due consideration to safe evacuation routes and access for emergency services during a flood event, further advice on design levels and assessment is provided in Section 5.6.3 below.

Within the FRA the impacts of climate change and residual risk (including culvert/structure blockage) should be modelled and used to inform the design and FFLs.

5.5.1.3 Note on Minor Developments

Section 5.28 of the Planning Guidelines on Flood Risk Management identifies certain types of development as being 'minor works' and therefore exempt from the Justification Test. Such development relates to works associated with existing developments, such as extensions, renovations and rebuilding of the existing development, small scale infill and changes of use.

Despite the ‘Sequential Approach’ and ‘Justification Test’ not applying, as they relate to existing buildings, an assessment of the risks of flooding should accompany such applications. This must demonstrate that the development would not increase flood risks, by introducing significant numbers of additional people into the flood plain and/or putting additional pressure on emergency services or existing flood management infrastructure. The development must not have adverse impacts or impede access to a watercourse, floodplain or flood protection and management facilities. Where possible, the design of built elements in these applications should demonstrate principles of flood resilient design (See ‘The Planning System and Flood Risk Management Guidelines for Planning Authorities Technical Appendices, 2009', Section 4 - Designing for Residual Flood Risk).

The requirement for providing compensatory storage for minor developments has been reviewed and can generally be relaxed, even where finished floor levels have been raised. This is because the development concerns land which has previously been developed and would already have limited capacity to mitigate flooding. However, a commentary to this effect must be substantiated in the site specific FRA.

5.5.2 Development proposals in Flood Zone C

Where a site is within Flood Zone C, but adjoining or in close proximity to Flood Zone A or B there could be a risk of flooding associated with factors such as future scenarios (climate change) or in the event of failure of a defence, blocking of a bridge or culvert. Risk from sources other than fluvial and coastal must also be addressed for all development in Flood Zone C. As a minimum in such a scenario, a flood risk assessment should be undertaken which will screen out possible indirect sources of flood risk and where they cannot be screened out it should present mitigation measures. The most likely mitigation measure will involve setting finished floor levels to a height that is above the 1 in 100 year fluvial flood level, with an allowance for climate change and freeboard, or to ensure a step up from road level to prevent surface water ingress. Design elements such as channel maintenance or trash screens may also be required. Evacuation routes in the event of inundation of surrounding land should also be detailed.

The impacts of climate change should be considered for all proposed developments. Details of the approach to incorporating climate change impacts into the assessment and design are provided in Sections 4.7 and 5.8.

5.6 Flood Mitigation Measures at Site Design

For any development proposal within Flood Zone A or B that is considered acceptable in principle, it must be demonstrated that appropriate mitigation measures can be put in place and that residual risks (failure or overtopping of the flood defences in Limerick City) can be managed to acceptable levels. The approach will vary depending on whether the development is located within a defended or un-defended area of Limerick City.

Various mitigation measures are outlined below and further detail on flood resilience and flood resistance are included in the Technical Appendices of the Planning Guidelines, The Planning System and Flood Risk Management.

5.6.1 Raised Defences

Installation of raised defences such as embankments and demountable defences has been the traditional response to flood risk in Limerick City is already subject to schemes that protect sections of the city centre to a 1% AEP (at the time of construction) standard of protection. A review of flood risk and management measures has recently been completed under the OPW Shannon CFRAM.

A number of defence structures as discussed in Section 4.5.2 are proposed for Limerick City. These will include earthen embankments, walls, demountable defences and the raising of existing roadways. The proposed measures are contained in the Preliminary Options and Flood Risk Management Plans developed as part of the CFRAM programme. The proposed measures at the time of writing (Sept. 2016) are an indication of the available and most suitable options to protect against flooding. There is no guarantee that the proposed flood defences will be undertaken.

The King's Island flood relief scheme is being undertaken separately with Phase 1 currently under construction. Phase 2, which will provide protection to King's Island (regeneration Area B) is currently going through the planning/design stage of development and has not achieved approval from An Bord Pleanála.

5.6.2 Site Layout and Design

To address flood risk in the design of new development, a risk based approach should be adopted to locate more vulnerable land use to higher ground while water compatible development i.e. car parking, recreational space can be located in higher flood risk areas. This should be the preferred approach for sites located within core development areas and subject to redevelopment.

The site layout should identify and protect land required for current and future flood risk management. Waterside areas or areas along known flow routes can be used for recreation, amenity and environmental purposes to allow preservation of flow routes and flood storage, while at the same time providing valuable social and environmental benefits.

5.6.3 Ground levels, floor levels and building use

Modifying ground levels to raise land above the design flood level is a very effective way of reducing flood risk to the particular site in question. However, in most areas of fluvial flood risk, conveyance or flood storage would be reduced having an adverse effect on flood risk elsewhere. Therefore, there is a general requirement that compensatory storage is provided on a level for level basis where raising ground levels is proposed in un-defended areas.

This requirement can be relaxed in areas behind defences, where the flood storage has already been lost and assessed through the design of the flood relief scheme.

For undefended areas:

- The particular zoning must have been justified through this SFRA based on the existing (unmodified) ground levels.
- The FRA should establish the function provided by the floodplain. Where conveyance is a prime function then a hydraulic model will be required to show the impact of its alteration.
- Compensatory storage should be provided on a level for level basis to balance the total area that will be lost through infilling where the floodplain provides static storage.

- The provision of the compensatory storage should be in close proximity to the area that storage is being lost from (i.e. within the same flood cell).
- The land proposed to provide the compensatory storage area must be within the ownership / control of the developer.
- The land being given over to storage must be land which does not flood in the 1% AEP event (i.e. Flood Zone B or C).
- The compensatory storage area should be constructed before land is raised to facilitate development.

In some sites it is possible that ground levels can be re-landscaped to provide a sufficiently large development footprint. However, it is likely that in other potential development locations there is insufficient land available to fully compensate for the loss of floodplain. In such cases it will be necessary to reconsider the layout or reduce the scale of development, or propose an alternative and less vulnerable type of development. In other cases, it is possible that the lack of availability of suitable areas of compensatory storage mean the target site cannot be developed and should remain open space.

For defended areas:

- Raising finished floor levels within a development is an effective way of avoiding damage to the interior of buildings (i.e. furniture and fittings) in times of flood. Raising of FFLs is recommended for consideration on new development of highly vulnerable uses. Appropriate FFL should be typically directed by at least 300mm freeboard above the breach level at the 1% AEP plus climate change and this level should be ascertained by detailed hydraulic modelling under a site specific FRA or as provided by the Shannon CFRAM.
- The overall impact on the risk to surrounding property (if significant ground raising is employed) should still be defined by a detailed FRA that represents a breach scenario for the design event under pre and post-development scenarios. Any significant increase in residual risk to surrounding properties will not be appropriate and alternative mitigation solutions should be investigated.
- Alternatively, it may not be suitable to raise FFLs significantly and assigning a water compatible use (i.e. garage, car parking, landscaping) or less vulnerable use to the ground floor level, along with suitable flood resilient construction, is an effective way of raising vulnerable living space above design flood levels. It can however have an impact on the streetscape. Safe access and egress is a critical consideration in allocating ground floor uses.
- Depending on the scale of residual risk, resilience and resistance measures may be an appropriate response but this will mostly apply to less vulnerable development.

5.7 Drainage impact assessment

It is recommended that all proposed development, whether in Flood Zone A, B or C, must consider the impact of surface water flood risks on drainage design. Consideration must be given to the surface water policies set out in the Limerick City Development Plan 2010-2016 which details the requirements for discharge capacity and Sustainable Urban Drainage System (SuDS). Generally, discharges will be limited to a maximum of 4l/sec/ha however areas of restricted capacity a discharge rate of 2l/sec/ha will apply. Refer to Part II Water Services of the Limerick City Development Plan 2010-2016 for complete list of requirements. The surface water/fluvial risk should be in the form of a section within the flood risk assessment (for sites in Flood Zone A or B) or part of a surface water management plan.

Areas vulnerable to ponding are indicated on the OPW's PFRA mapping reproduced in Figure 4-4. Particular attention should be given to development in low-lying areas which may act as natural ponds for collection of runoff.

The drainage design should ensure no increase in flood risk to the site, or the downstream catchment. Where possible, and particularly in areas of new development, floor levels should at a minimum be 300mm above adjacent roads and hard standing areas to reduce the consequences of any localised flooding. Where this is not possible, an alternative design appropriate to the location may be prepared.

In addition, for larger sites (i.e. multiple dwellings or commercial units) master planning should ensure that existing flow routes are maintained, through the use of green infrastructure.

5.8 Incorporating Climate Change into Development Design

The Flood Zones are determined based on readily available information and their purpose is to be used as a tool to avoid inappropriate development in areas of flood risk. Where development is proposed within an area of potential flood risk (Flood Zone A or B), a flood risk assessment of appropriate scale will be required and this assessment must take into account climate change and associated impacts.

Consideration of climate change is particularly important where flood alleviation measures are proposed as the design standard of the proposal may reduce significantly in future years due to increased rainfall and river flows. As recommended by the planning guidelines, a precautionary approach should be adopted.

Climate change may result in increased flood extents and therefore caution should be taken when zoning lands in transitional areas. In general, Flood Zone B, which represents the 0.1% AEP extent, can be taken as an indication of the extent of the 1% AEP flood event with climate change. In steep valleys (such as the smaller tributary streams) an increase in water level will relate to a very small increase in extent, however in flatter low-lying basins a small increase in water level can result in a significant increase in flood extent.

For most development, including residential, nursing homes, shops and offices, the medium-range future scenario (20% increase in flows or 0.5m increase in tidal level) is an appropriate consideration. This should be applied in all areas that are at risk of flooding (i.e. within Flood Zone A and B) and should be considered for sites which are in Flood Zone C but are adjacent to Flood Zone A or B. This is because land which is currently not at risk may become vulnerable to flooding when climate change is taken into account.

Where the risk associated with inundation of a development is low and the design life of the development is short (typically less than 30 years) the allowance provided for climate change may be less than the 20% or 0.5m. However, the reasoning and impacts of such an approach should be provided in the site specific FRA. An example of this might be commercial use in City Centre lands or manufacturing uses potentially at risk of flooding from the River Shannon.

Conversely, there may be development which requires a higher level response to climate change. This could include major facilities which are extremely difficult to relocate, such as hospitals, Seveso sites or waste water treatment plants, and those which represent a high-economic and long term investment within the scale of development of the specific settlement. In such situations it would be reasonable to expect the high-end future scenario (30% increase in flow or 1m in tidal level) to be used as the design standard.

Further consideration to the potential future impacts of climate change will be given for each settlement within Section 6.

6 Settlement Review

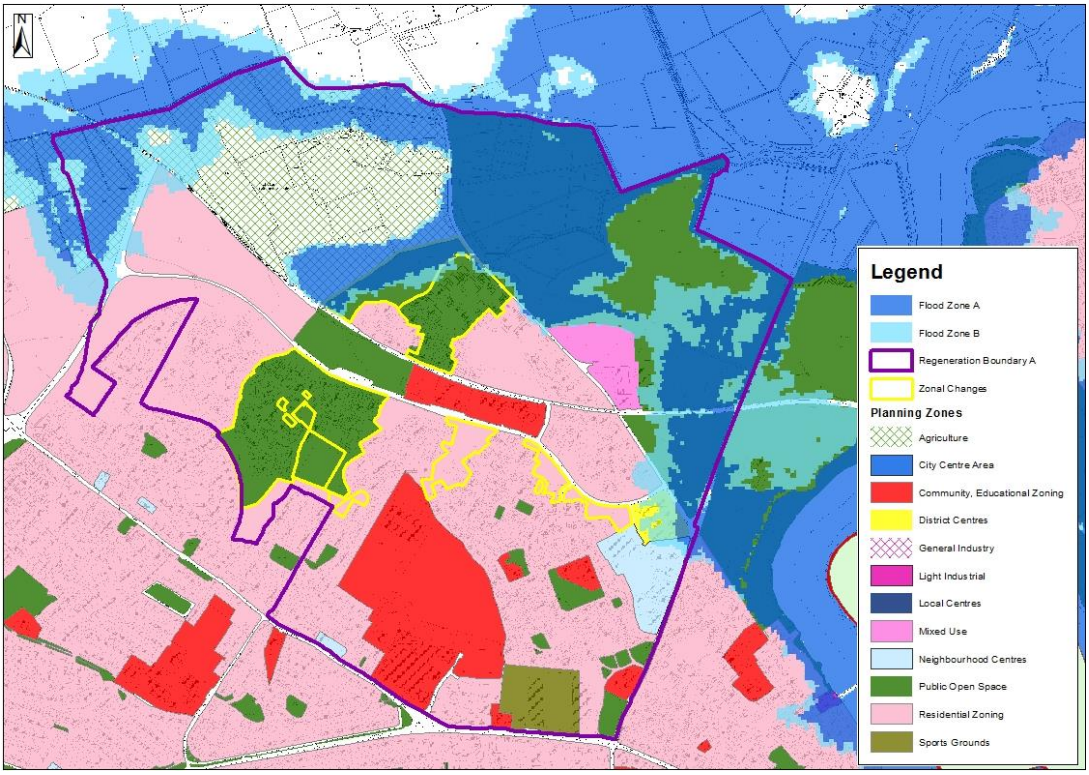
In the following sections, a review of flood risk to key sites has been provided, along with recommendations for the development of these sites. Reference is made to general management measures that are discussed in more detail under Section 5 of this report.

For each site consideration of flood risk will be required at the development management stage of the planning process. This ranges from an assessment of surface water drainage for sites within Flood Zone C, to more considered FRAs for sites in Flood Zone A and B. The construction of any significant new re-development behind the flood defences in Limerick City will necessitate that a detailed flood risk assessment will be required to define residual flood risk and lead mitigation design, but in other areas it is generally possible to understand risks through an initial FRA without incurring the cost and time input required for a detailed FRA.

In all cases, the advice on flood mitigation for site design contained in Section 5 should be followed, along with any site specific recommendations detailed in the following sections.

6.1 Regeneration Area A

Area A



Flood Zone Data	OPW CFRAM mapping.
Flood Risk Overview	Potential flood risk from River Shannon to some existing residential lands and greenfield residential lands
Sensitivity to Climate Change	Moderate/High
Historical Flooding	Lands were inundated within Area A during the February 1990 and December 1954 flood events.
Zoning Changes	Residential to Public Open Space Public Open Space to Residential Agriculture to Public Open Space Sports Grounds to Public Open Space and Residential
Flood Zone Conflict	Currently, the Bays site forms a key objective of LRFIP and is zoned as 'Mixed Use'. The site has significant undeveloped lands within Flood Zone A/B. All development lands currently within the Flood Zone A/B will

	be re-zoned as open space as part of Variation 6a. Other lands with existing development are at risk (residential & district centre).
CFRAM Draft Management Plan	Proposed flood defence wall/embankments to protect from River Shannon pluvial/tidal flooding and flood storage, flapped outfall for the Upper Ballycannon River. Note: proposed measures are at a preliminary stage therefore there is no guarantee that works will be undertaken.

Comment:

Some existing Community & Educational zoned lands are at risk from tidal Flood Zone A/B as highlighted above. This relates to the Bays section of Moyross and a significant proportion of the site is currently undeveloped. As part of the Variation 6a, development lands at the Bays site that currently encroach onto Flood Zone A/B will be re-zoned as open space. The remaining areas are within Flood Zone A and any proposed development will be subject to an FRA in accordance with the procedures outlined in Section 5.

Under the CFRAM programme flood relief measures have been proposed that could provide flood protection to areas within Regeneration A. Details of the proposed scheme is discussed in Section 4.5 which includes embankments and provisions for flood storage as part of the flood defences. It should be noted that the measures are only proposed, with no guarantee that the measures will proceed.

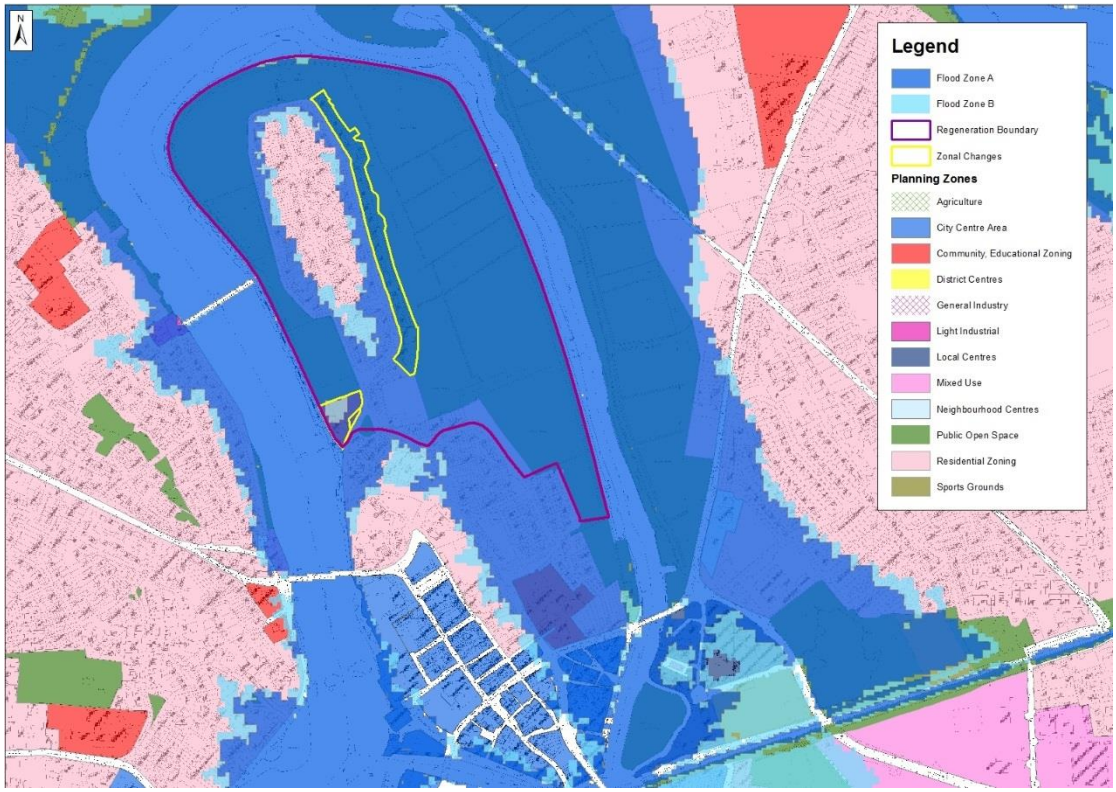
The majority of undeveloped lands within Flood Zone A/B are appropriately zoned as amenity and open space.

For areas with existing developments at potential risk of flooding, the management of risk can take the form of warning and preparedness under a proposed Flood Management Action Plan, as discussed in Section 5.3.

Future applications for development will require an FRA including consideration of surface water provisions at development management stage - in accordance with the requirements stated under Section 5 of this SFRA.

6.2 Regeneration Area B

Area B



Flood Zone Data	OPW CFRAM mapping
Flood Risk Overview	Potential flood risk from River Shannon to existing residential lands.
Sensitivity to Climate Change	High
Historical Flooding	February 2014, February 2002, December 1999, February 1990, December 1954
Proposed Zonal Changes	Residential to Open Public Space Open Public Space to Community and Educational
Flood Zone Conflict	Existing Residential Areas reside in Flood Zones A/B Proposed Community & Educational zone resides in Flood Zone A/B The Key strategic sites within Nicolas Street, including the development of a National Social Innovation hub and Bridge Street are within Flood Zone A/B although will be protected by the King's Island flood relief scheme. Key strategy of the LRFIP to extend the St. Mary's Park Community Centre which is within current Flood Zone A/B although will be protected by King's Island flood relief scheme.
Proposed Defences	Flood defence embankment/wall to protect against 0.2% AEP tidal design event.

Comment:

A substantial number of existing residential properties are at risk of tidal flooding from the River Shannon in addition to a number of non-residential properties. There is significant flood history related to King's Island.

Special consideration is provided for designated regeneration areas within the Flood Risk Management guidelines and the circular PL 2/2014. It states that areas highlighted for regeneration within Flood Zone A/B should consider relocation as part of the assessment. This

applies to St Mary's Park/King's Island and has been fully considered. To provide a structural response to flood risk management the King's Island Scheme is underway and is being designed to provide the required standard of protection for St Mary's Park and the entirety of King's Island, further details presented in Section 4.5.2. As of September 2016, work has begun on Phase I of the defences with Phase II under detailed design. The proposed works will offer protection up to the 0.5% AEP tidal event. The Justification test for Development Plans has subsequently been applied and passed, this is provided within Appendix II of the SEA and provides further detail on the consideration of relocation and other key strategic planning points. It is noted that the total number of residents within St Mary's Park has reduced as part of the regeneration; some residents have been relocated and some have been temporarily re-housed pending the replacement of housing.

The section of residential property along the eastern side of St Munchin's Street is proposed to be rezoned from residential to public open space. This section of parkland must be available to incorporate a flood defence embankment under the proposed flood defence scheme, see Figure 4-2. Furthermore, residential properties to be demolished (and not replaced) should be rezoned as public open space.

In the lands proposed for Community and Educational (previously public open space), it is proposed to provide an extended multi-use community centre. It is necessary to provide a 25m wayleave from the riverbank to accommodate potential embankments/flood risk management measures. Residual risk may be high. Therefore, any proposed developments in this area are required to be assessed during a site specific FRA. Refer to section 5 for the specific requirements to be contained and assessed in the site specific FRA's.

All future applications for re-development within this area will require an FRA, including consideration of residual risk and surface water/pluvial risk at the development management stage - in accordance with the requirements stated under Section 5 of this SFRA. Residual risk relates to the potential impacts of defence overtopping or breach following completion of the flood relief scheme. These impacts must be estimated and managed by site design measures specified under the site specific FRA at development management stage.

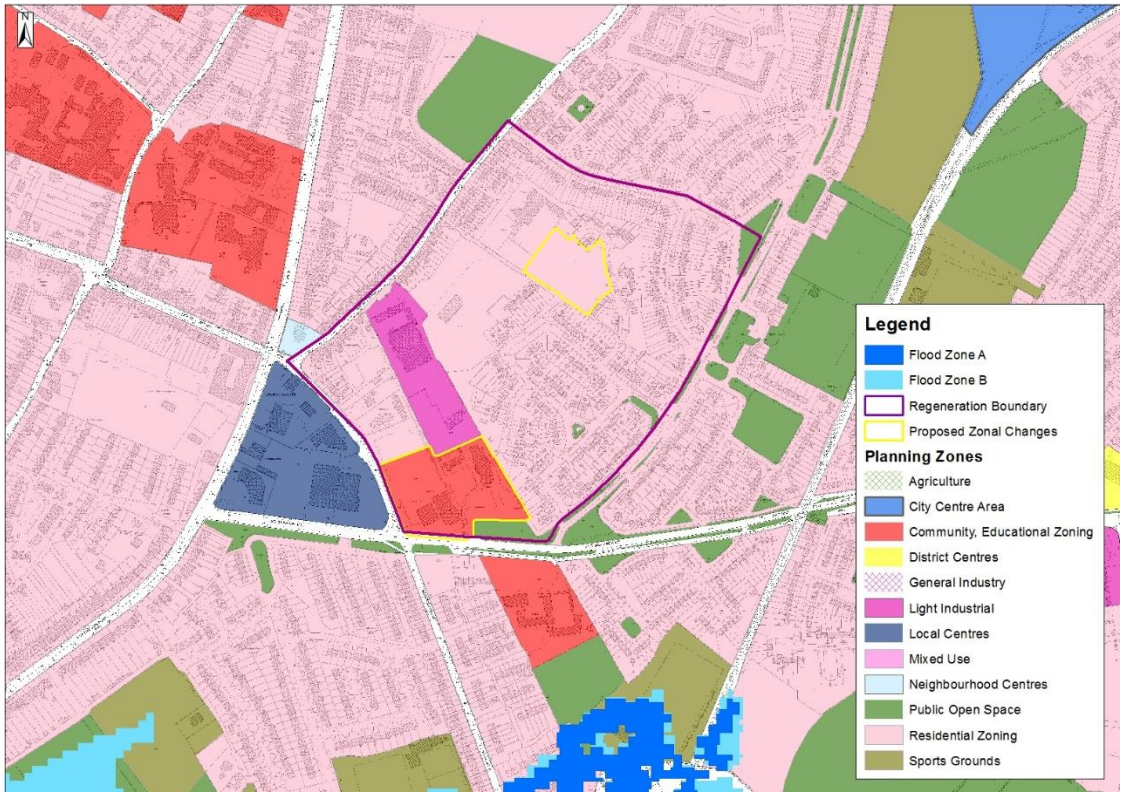
St Marys/King's Island is subject to a flood relief scheme as discussed in Section 4.5.2 which will be undertaken over two phases. Phase 1 of the scheme is currently within the construction phase. Phase 2 is at the design stage and yet to go through planning. Upon completion of the flood relief scheme Kings Island will be afforded protection up to a 0.5% AEP tidal flood extent.

In the interim, prior to the completion of the Kings Island flood relief scheme any proposed development should consider the existing (undefended) flood risk to the proposed site. Mitigation and management measures should be considered in accordance to Section 5 of the SFRA.

For areas of existing development at potential risk of flooding the management of risk, particularly prior to the completion of the King's Island Scheme, should include warning and preparedness under a proposed Flood Management Action Plan, as discussed in Section 5.3.

6.3 Regeneration Area C

Area C



Flood Zone Data	OPW CFRAM mapping,
Flood Risk Overview	No flood risk from Ballinacurra Creek to lands located within Regeneration Area C.
Sensitivity to Climate Change	Low/Moderate
Historical Flooding	No historic flooding encountered
Proposed Zonal Changes	Public Open Space to Residential Residential to Education, Community and Cultural
Flood Zone Conflict	None
Proposed Flood Defences	None

Comment:

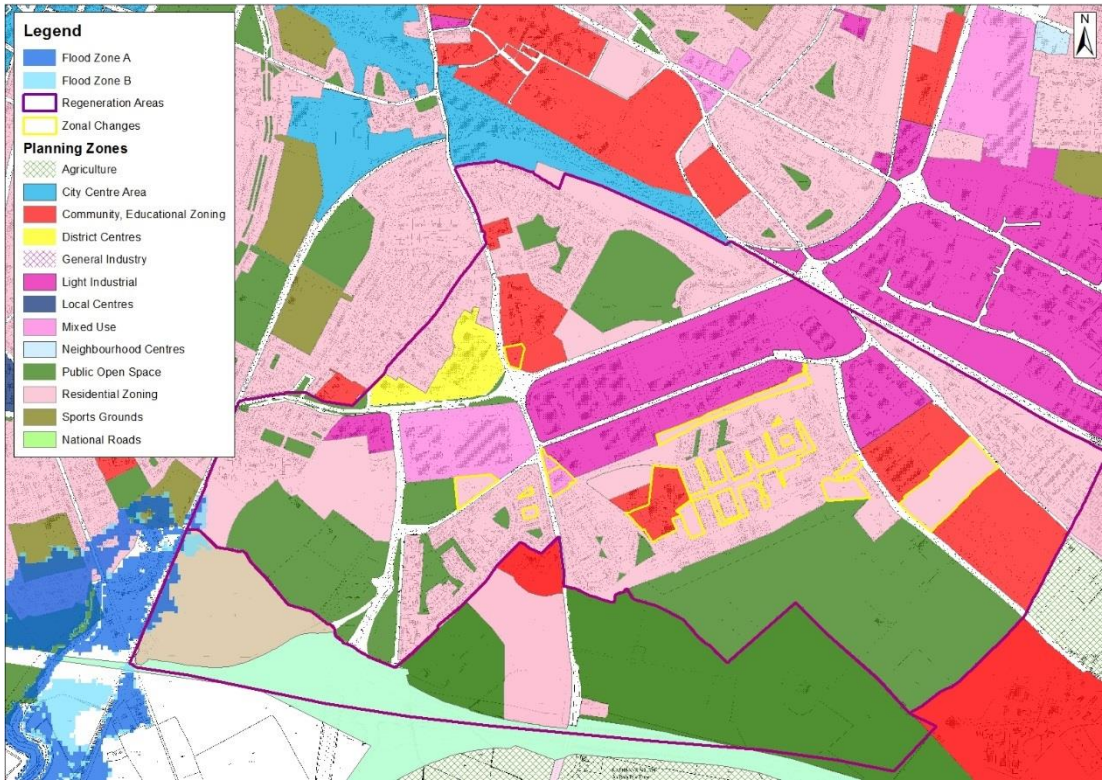
No lands within the regeneration zone are identified to be at risk of flooding from the Ballinacurra Creek as shown in the CFRAM flood mapping.

Regarding pluvial and groundwater flooding there are no areas at risk by the OPW PFRA flood maps within the regeneration Zone C, nor were any instances of historic flooding recorded on floodmaps.ie.

Future applications for re-development on any residential sites will require an FRA at development management stage the key issue to be dealt with will be the drainage impact assessment - in accordance with the requirements stated under Section 5 of this SFRA.

6.4 Regeneration Area D

Area D



Flood Zone Data	OPW CFRAM mapping
Flood Risk Overview	Potential flood risk from Ballinacurra Creek to residential zoned lands
Sensitivity to Climate Change	Low/Moderate
Historical Flooding	Fluvial flooding recorded during December 1999
Proposed Zonal Changes	Education, Community and Cultural to Residential Public Open Space to Residential Public Open Space to Education, Community and Cultural Light Industrial to Residential Light Industrial to Mixed Use Residential to Education, Community and Cultural Residential to Mixed Use
Flood Zone Conflict	Encroachment to some Residential and Industrial Zoned Lands
Proposed Flood Defences	None

Comment:

Residential zoned lands conflict with Flood Zone A/B in minor areas along the Ballinacurra Creek. The CFRAM mapping does not indicate flood risk to existing residential properties or in the designated regeneration zones. It is noted that the current extents of the CFRAM mapping for the Ballinacurra Creek terminates near the western boundary of the regeneration area. Therefore, flood maps for the upstream section of The Ballinacurra Stream and Dooradoyle Stream were obtained from the Limerick City Development Plan 2010-2016 (see Section 4.4). The Limerick City Development Plan 2010-2016 flood map indicates flooding along the southern section of the regeneration area which originates from the Dooradoyle Stream (refer to Figure 2-1 for location of the watercourse).

It is noted in this area, that the Limerick City Development Plan 2010-2016 flood maps are based on low resolution DTM data which may not accurately depict the actual flow pathways or

fully represent the motorway network. Following a site visit, it was noted that the motorway intercepts the natural flow pathways from the Dooradoyle Stream. The motorway is predominantly higher than lands to the south which will prevent floodwaters inundating the regeneration area north of the motorway. Any floodwaters that inundate the motorway will be captured by the engineered stormwater system and ultimately conveyed westward towards the Ballincurra Creek. Therefore, the current Limerick City Development Plan flood outlines have been removed north of the motorway, however during the next variation of the Limerick City Development Plan or SFRA, a full study is necessary to identify the existing flood extents in the area.

Considering the above, the majority of undeveloped lands within Flood Zone A/B are appropriately zoned as amenity and open space. Applications for re-development on any residential sites on or adjacent to Flood Zone A/B will require an FRA at development management stage - in accordance with the requirements stated under Section 5 of this SFRA. This will provide detailed and revised flood mapping that will ensure that any potential flood risk is adequately assessed and flow pathways (if any) across the motorway are comprehensively identified. The sequential approach should be undertaken, including the Justification Test if necessary.

7 SFRA Review and Monitoring

An update to the SFRA will be triggered following review of the Limerick City Development Plan.

There are a number of key outputs from possible future studies and datasets, which should be incorporated into any update of the SFRA as availability allows. Not all future sources of information should trigger an immediate full update of the SFRA; however, new information should be collected and kept alongside the SFRA until it is updated.

Limerick City was subject to a detailed flood risk mapping and management study under the CFRAM programme. The flood maps produced as part of the CFRAM programme have been release during 2016 and were incorporated within the SFRA. As part of the CFRAM programme the flood maps will be updated on a six yearly basis. Any modifications to the Flood Maps following the review process should be incorporated into the subsequent revision of the Limerick City Development Plan.

Overall, detailed site specific FRAs may be submitted to support planning applications. Whilst these reports will not trigger a review of the Flood Zone maps or SFRA, they should be retained and reviewed as part of the next cycle of the Development Plan.

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