Comhairle Contae Fhine Gall
Fingal County Council

Fingal East Meath Flood Risk Assessment & Management Study

(FEM FRAMS)

Flood Risk Management Plan

July 2014

fingal.ie

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List of abbreviations

AAD	Annual Average Damages
AEP	Annual Exceedence Probability
AOD	Above Ordnance Datum
APSR	Areas of Potential Significant Risk
APMR	Area of Potential Moderate Risk
AU	Analysis Unit
BCR	Benefit Cost Ratio
CFRAMS	Catchment Flood Risk Assessment and Management Study
FRMP	Flood Risk Management Plan
CMRC	Coastal and Marine Resources Centre
DAFF	Department of Agriculture, Fisheries and Food
DEHLG	Department of Environment, Heritage and Local Government
DTM	Digital Terrain Model
EPA	Environmental Protection Agency
ERBD	Eastern River Basin District
ERFB	Eastern Regional Fisheries Board
EU	European Union
FRM	Flood Risk Management
HEFS	High End Future Scenario
HPW	High Priority Watercourse
IRR	Individual Risk Receptor
Km	Kilometres
km^2	Square kilometres
LiDAR	Light Detection and Ranging
m	metres
m^3	Cubic metres
MCA	Multi Criteria Analysis
MDSF	Modelling Decision Support Framework

mm	millimetres
MPW	Medium Priority Watercourse
MRFS	Mid Range Future Scenario
OPW	Office of Public Works
PVD	Present Value Damages
SAC	Special Area of Conservation
SEA	Strategic Environmental Assessment
SPA	Special Protection Area
WFD	Water Framework Directive
WTP	Water Treatment Plant
WWTW	Waste Water Treatment Works
Yr	Year
+ve	Positive
-ve	Negative

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- Fingal County Council (FCC)
- Forestry Services
- Geological Survey of Ireland
- Health Service Executive (HSE)
- Marcon Computation International Ltd
- Meath County Council (MCC)
- Met Éireann
- National Parks and Wildlife Services (NPWS)
- National University of Ireland, Galway
- National University of Ireland, Maynooth
- Office of Public Works (OPW)
- Teagasc
- University College Dublin (UCD)

Executive Summary

Introduction

Flood risk in Ireland has historically been addressed through the use of structural or engineered solutions. In 2004 the Irish Government adopted a new policy that shifted the emphasis towards a catchment based context for managing flood risk, with more proactive risk assessment and management, and increased use of non-structural and flood impact mitigation measures.

Flood Risk Assessment and Management (FRAM) studies and their product - Flood Risk Management Plans (FRMPs) - are at the core of this new national policy for flood risk management and the strategy for its implementation. This policy is in line with international best practice and meets the requirements of the EU Floods Directive.

In 2008, Fingal County Council (FCC), Meath County Council (MCC) and the Office of Public Works (OPW) commenced work on a Flood Risk Assessment and Management Study (FRAM Study) for the Fingal and East Meath area, as a means of addressing existing flood risk in the study area and the potential for significant increases in this risk in the future.

The Fingal East Meath Flood Risk Assessment Management Study (FEM FRAMS) was one of four pilot CFRAM studies for the new Flood Risk Assessment and Management Programme. The CFRAM studies are the core of the delivery of the new Flood Policy adopted by the Irish Government in 2004, shifting the emphasis in addressing flood risk towards '*a catchment-based, pro-active approach for identifying and managing existing, and potential future, flood risk'*.

The principal output from FEM FRAMS is a Flood Risk Management Plan (FRMP). This has been prepared by Halcrow Barry in consultation with Fingal County Council, Meath County Council and the OPW.

An in-house Project Management Team consisting of representatives from the OPW, FCC and MCC managed the work of the Consultant on the Study. A Project Steering Group, which included representatives from the OPW, FCC, MCC, the Environmental Protection Agency, the Department of Agriculture, Fisheries and Food (DAFF, which, later on, became part of the OPW) was responsible for overseeing and directing the study, and reviewing key outputs and deliverables.

The main stated objectives for FEM FRAMS are to:

- assess flood risk, through the identification of flood hazard areas and the associated impacts of flooding;
- build the strategic information base necessary for making informed decisions in relation to managing flood risk and provide appropriate data to inform future spatial planning and development;
- identify viable structural and non-structural measures and options for managing the flood risks for localised high-risk areas and within the study area as a whole; and

- prepare a strategic flood risk management plan for the Fingal East Meath area, namely, the Fingal East Meath Flood Risk Management Plan (FEM FRMP) and associated Strategic Environmental Assessment (SEA) that sets out the measures and policies that should be pursued by the Local Authorities and the OPW to achieve the most cost-effective and sustainable management of flood risk within the Fingal and East Meath study area.

This document is the draft FEM FRMP (or the draft Plan) for the Fingal East Meath study area; it is a non-technical document for consultation, and it summarises what has been done and elaborates on the findings and recommendations of the Study. This document is supported by separate bound volumes of flood maps and the SEA. There is also an extensive library of reports on all the components of the FEM FRAMS that detail the studies undertaken and the results, and which are available on the study website, www.fingaleastmeathframs.ie.

The involvement of external parties has been essential in the development of the FEM FRMP and associated SEA. Throughout the FEM FRAM Study, it was important to both meet statutory requirements for consultation with relevant parties; and to ensure that the knowledge, experience and views of stakeholders and the general public of both Fingal and Meath counties were taken into account throughout the development of the FEM FRMP.

The next and final stage of the consultation process is the publication of and consultation on this draft FEM FRMP and accompanying SEA Environmental Report (ER). The draft FEM FRMP and SEA ER have been made available on the project website www.fingaleastmeathframs.ie and in hard copy at the Fingal Council and Meath County Council Offices throughout the study area. Comments on the draft FEM FRMP and SEA ER are invited until 31 January 2012. Following a review of comments received, the draft FEM FRMP will be amended, finalised and published, together with a post-adoption SEA Statement, documenting how the comments received have been addressed.

The Fingal East Meath Study Area

The Fingal East Meath study area consists of approximately 772km^2 in plan area, located mostly in Hydrometric Area 08 and a small area in southern part located in Hydrometric Area 09. The topography of the study area is characterized by low undulating land intersected by several small and medium sized watercourses. The study area comprises a group of 23 rivers and streams, three estuaries and the Fingal and Meath coastline (see Table below and Figure overleaf). The Fingal East Meath study area is bounded by the River Boyne & Mornington River catchment areas to the north and west, the Tolka and Santry River catchments to the south, and by the Irish Sea to the east. All watercourses in the study area flow to the Irish Sea either directly or via the three estuaries (Baldoyle, Broadmeadow and Rogerstown).

Rivers, streams and estuaries included in the FEM FRAM study

River name		
Mayne River	Baleally Stream	Balbriggan North Stream
Sluice River	Bride's Stream	Delvin River
Gaybrook Stream	Jone's Stream	Mosney Stream*
Ward River	Rush West Stream	River Nanny
Broadmeadow River	Rush Town Stream	Brookside's Stream
Lissenhall Stream	St Catherine's Stream	**Estuaries**
Turvey River	Rush Road Stream	Baldoyle Estuary
Ballyboghil River	Mill Stream	Broadmeadow Estuary
Corduff River	Bracken River (including Matt Stream)	Rogerstown Estuary

** The Mosney Stream is also known as the Bradden Stream*

The principal urban areas in the study area include Portmarnock, Swords, Balbriggan, Ashbourne, Dunshaughlin, Malahide, Rush, Skerries and Duleek. Important infrastructure includes the M1 motorway, Dublin Airport, Gormanstown Military camp and Fairyhouse racecourse.

Fingal-East Meath study area (Refer to Figure 1 at the back of the report for more detail)

Study approach

The methodology adopted for the FEM FRAMS has been thorough and to a level of detail appropriate for the development of a Flood Risk Management Plan. It has included the collection of survey data, and the assembly and analysis of meteorological, hydrometric and tidal data, which have been used to develop a suite of hydraulic computer models. Computer models have been developed for all 23 rivers and their tributaries in the study area including the three estuaries, coastal model for the study area coastline and a pluvial (surface water) flood model. Flood maps are one of the main outputs of the study and are the way in which the model results are communicated to each of the end users. The key types of mapping developed have been:

- Flood extent maps – show the estimated area inundated by a flood event of a given AEP. These maps also show levels of confidence in the flood extents, plus water levels, flows and defended areas;

- Flood zone maps – show flood zones A, B and C representing high, moderate or low risk areas in accordance with the Guidelines on the Planning System and Flood Risk Management;
- Flood depth maps – show the estimated flood depths for areas inundated by a particular flood event using graduated colours;
- Flood velocity maps - show the speed of the flood water for areas inundated by a particular flood event using graduated colours; and
- Flood hazard maps – show the harm or danger which may be experienced by people from a flood event of a given annual exceedance probability, calculated as a function of depth and velocity of flood waters.

The flood extents are non-instantaneous extents, but rather a representation of all areas likely to be inundated at some point during the flood event. The flood maps allow us to identify locations within the Fingal East Meath study area at risk of flooding; we have then considered the impacts of flooding under five risk categories:

- Human health – the number of residential properties located within the flood extent ;
- Environment – the number of pollution sources (discharge licences, landfill sites) or nature conservation sites (SAC, SPA, NHA) within the flood extent;
- Cultural heritage – the number of monuments, protected structures etc. within the flood extent;
- Critical infrastructure – the number of transport routes (e.g. road and rail) and utility assets (e.g. waste water and water treatment plants, power stations) within the flood extent; and
- Economy - estimate of the potential economic damages where the floodwater gets above the threshold level of a building.

The SEA process has assessed the impacts of flooding on the environment, in terms of the loss, damage or benefit to the environment. Environmental constraints and opportunities relating to flood risk management within the Fingal and East Meath study area have been fully considered throughout the development of the FEM FRMP. This integrated approach has sought to ensure that environmental considerations are embedded within decision-making and that the environmental impacts of the recommendations of the FEM FRMP are minimised.

Where flood risks are significant, the study has identified a range of potential flood risk management options to manage these risks, including structural options (e.g. flood walls and embankments) and non-structural options (e.g. flood forecasting and warning systems and public awareness). The options were developed for Analysis Units (AUs), which are large sub-catchments or areas of tidal influence, and also for Areas of Potential Significant Risk (APSRs), which are smaller scale urban areas with the potential for flood risk. Individual Risk Receptors (IRRs), which are individual assets such as transport and utilities infrastructure identified as being at significant risk, have also been assessed.

A three stage process has assessed flood risk management options against defined flood risk management objectives.

- Stage 1 considers a long list of measures which was screened for each AU and APSR to filter out any measures which were not applicable and to provide a short list of measures for each assessment unit;
- Stage 2 involves development of potential flood risk management options for each AU and APSR; and
- Stage 3 involves a detailed assessment of options using multi criteria analysis to determine the preferred option(s) for each AU and APSR, to be included as part of the Fingal East Meath FRMP.

A total of 16 objectives were developed for the Fingal East Meath study area under four different categories: technical, economic, social and environmental. The option assessment process starts with preliminary evaluation of a long list of measures for each AU and APSR to filter out any that are not applicable. It culminates in a detailed multi criteria analysis (MCA) to determine the preferred option(s) for each AU and APSR. The process has been developed and used to ensure that the assessment of flood risk management options is evidence-based, transparent, and inclusive of stakeholder and public views.

The result of the MCA is a list of options whose scores range from negative to positive, with a score of zero implying a neutral impact. A review of the scores points the way towards the major components of the FEM FRMP, with negatively scored options being discarded and positively scored options being considered further.

The flood risk management plan

The FEM FRMP does not aim to provide solutions to all of the flooding problems that exist in the study area; that would be neither feasible nor sustainable. It identifies viable structural and non-structural options for managing the flood risks within the study area as a whole and for localised high-risk areas.

The FEM FRMP components have been derived from the MCA output and comprise options with positive overall MCA scores and that are cost-beneficial. In summary, it includes:

- Two options (i) Proactive maintenance and (ii) targeted public awareness campaign and individual property flood protection are proposed for the study area as a whole. Both options are recommended equally and can be implemented independently of each other;
- Fluvial flood forecasting and warning systems (FFWS) are recommended for some of the rivers (Nanny, Broadmeadow and Mayne Rivers), as the other rivers have too short a time to peak and therefore a FFWS would be ineffective. Tidal flood forecasting and warning system are proposed for the coastal areas and this should be integrated with the fluvial FFWS and the existing FCC/MCC telemetry systems;
- No other AU level options have been carried forward to the preferred options;
- At APSR level the proposals are generally for the construction of flood embankments/walls, improvements in channel conveyance through river widening and/or culvert replacement, installation of demountable defences have been proposed for Malahide, and replacement/rehabilitation of flap valves;
- The option with the highest MCA score (505) is the preferred option for protecting over 80 properties in Skerries from flooding by the Mill Stream. The preferred option

is to replace undersized culverts under the railway embankment as well as increasing the capacity of the channel downstream. This option also has a positive benefit cost ratio (1.25).

- The preferred option to protect at risk properties in Malahide town centre incorporates the use of demountable flood defences to prevent tidal flooding of a significant number of properties. While costs of incorporating a tidal flood forecasting system in the option have been considered (giving a BCR of 1.2) significantly greater benefit can be achieved if this option is linked with the Coastal AU tidal flood forecasting and warning option (BCR of 6.2); and
- It is noted that the BCR for some options significantly increase if combined with other viable options, these include;
    - targeted public awareness campaign and individual property flood protection combined with flood forecasting and warning systems;
    - flood forecasting and warning systems combined with individual property flood protection; and
    - Construction of demountable defences in Malahide combined with flood forecasting and warning systems.
- At IRR level, the proposals are generally for the construction of localised flood defences.

An indicative programme for implementation of the FRMP is set out, with timescales suggested according loosely with EU Directive cycles, namely:

- High priority = first phase: Plan implementation to 2015;
- Medium priority = second phase: 2016 to 2022; and
- Low priority = third phase: 2023 onwards.

These timescales, particularly after 2016, may change due to economic conditions in the country and also where flood risk management fits in national priorities.

In summary, development of options beyond the FRAMS stage will be based on MCA scores, with consideration also being given to those that have been demonstrated to be most cost-beneficial and those that have a lower cost.

Phasing of the Fingal East Meath FRMP

Phase I A (2011-13)	**Phase I B (2014-15)**	**Phase II (2016-21)**	**Phase III (2022 onwards)**	**Who***
NON STRUCTURAL OPTIONS				
Undertake Strategic Review of FFWS	Implement findings of Strategic Review of FFWS			**OPW**
Assess scope and develop fluvial and integrated fluvial - tidal FFWS	Implement and test fluvial and integrated fluvial - tidal FFWS	Provide technical support, including technical reviews of system performance		**OPW**, FCC & MCC
		Operate FFWS (transfer to National Flood Forecasting Centre, if established)		**FCC, MCC, OPW**
Agree responsibility for proactive maintenance. Confirm locations of culverts to be maintained.	Implement proactive maintenance option. Review and update list of culverts that block.			**FCC, MCC & OPW**
Develop public awareness and preparedness campaign and review flood event response plans. Provide information on individual property flood proofing	Implement public awareness and preparedness campaign. Maintain, review and update flood event response plans. Provide information on individual property flood proofing			**FCC, MCC** & OPW
Reinstall existing and install additional hydrometric monitoring equipment		Operate additional hydrometric monitoring equipment		**OPW,** FCC
Coordinate, operate and maintain existing hydrometric network				**OPW,** FCC, MCC
Continue to implement the Planning System and Flood Risk Management Guidelines				**FCC & MCC**
EXISTING FLOOD DEFENCES				

Phase I A (2011-13)	Phase I B (2014-15)	Phase II (2016-21)	Phase III (2022 onwards)	Who*
Determine defence asset monitoring and maintenance programme	Proactive maintenance of existing defence assets including Duleek, Ratoath, Ashbourne, Swords, Balbriggan and coastal flap valves			**OPW, FCC & MCC**
STRUCTURAL MEASURES – OPW MINOR WORKS PROGRAMME < €0.5M				
MALAHIDE TOWN CENTRE (PORTMARNOCK & MALAHIDE AREAS APSR)				
Implement scheme for Malahide	Maintain scheme			**OPW,** FCC
ROWLESTOWN EAST (ROWLESTOWN EAST APSR)				
Implement scheme for Rowlestown East	Maintain scheme			**FCC**, OPW
ASPEN (SWORDS) (SWORDS AREA APSR)				
Implement scheme for Aspen (Swords)	Maintain scheme			**FCC**, OPW
STRUCTURAL MEASURES – OPW FLOOD RELIEF SCHEMES > €0.5M				
SKERRIES (SKERRIES AREA APSR)				
Detailed design, planning & procurement of scheme for Skerries		Implement scheme for Skerries	Maintain scheme for Skerries	**OPW**, FCC
BALGRIFFIN (ST MARGARET'S, DUBLIN AIRPORT, BELCAMP & BALGRIFFIN AREA APSR)				
Implement scheme for Balgriffin	Maintain scheme			**OPW,** FCC
LAYTOWN (LAYTOWN, BETTYSTOWN & COASTAL AREA APSR)				
Detailed design, planning & procurement of scheme for Laytown		Implement scheme for Laytown	Maintain scheme for Laytown	**MCC**, OPW
STRAND ROAD, PORTMARNOCK (PORTMARNOCK & MALAHIDE AREAS APSR)				

Phase I A (2011-13)	Phase I B (2014-15)	Phase II (2016-21)	Phase III (2022 onwards)	Who*
Detailed design, planning & procurement of scheme for Portmarnock		Implement scheme for Portmarnock	Maintain scheme for Portmarnock	**FCC**, OPW
OTHER WORK				
RUSH (RUSH AREA APSR)				
Further work to determine if positive BCR can be determined. Implement scheme for Rush	Maintain scheme for Rush			**OPW**, FCC
RATOATH (RATOATH APSR)				
Further work to determine if positive BCR can be determined	Detailed design, planning & procurement of scheme for Ratoath		Maintain scheme for Ratoath	**OPW**, MCC
DULEEK (DULEEK APSR)				
		Consider whether additional standard of protection should be provided at Duleek		**OPW**
INDIVIDUAL RISK RECEPTORS				
Operators to pursue detailed risk assessment and management measures				

Note: Bodies highlighted in bold text under the 'who' column are those responsible for leading the action

1. Introduction and background

1.1. Background

Flooding is a natural process that can happen at any time in a wide variety of locations, and its causes, extent and impacts are varied and complex. There is a consequent risk when people and human assets, property, infrastructure, agricultural land, heritage, etc., are present in the area that floods.

Flood risk in Ireland has historically been addressed largely through a reactive approach and the use of structural or engineered solutions. In line with internationally changing perspectives, the Irish Government adopted a new policy in 2004[1] that shifted the emphasis in flood risk towards:

- a catchment context for managing risk;
- more proactive risk assessment and management, with a view to avoiding or minimising future increases in risk; and
- increased use of non-structural and flood impact mitigation measures.

Notwithstanding this shift, engineered solutions to manage existing risks are likely to continue to form a key component of any flood risk management strategy.

Flood Risk Assessment and Management Studies (FRAMSs) and their product - Flood Risk Management Plans (FRMPs) - are at the core of this new national policy for flood risk management and the strategy for its implementation. These studies have been developed to meet the requirements of the EU Floods Directive[2] on the assessment and management of flood risks. The Directive requires Member States to first carry out a preliminary flood assessment by 2011 to identify the river basins and associated coastal areas at risk of flooding, need to draw up flood risk maps by 2013 and establish flood risk management plans focused on prevention, protection and preparedness by 2015.,

Underlying this policy shift is the acceptance of flooding as a natural phenomenon and the realisation that we must learn to live with and adapt to flood events. An integrated, holistic and catchment-based approach to flood risk management is the way forward, something that is consistent with and complements the Water Framework Directive[3] (WFD).

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[1] Report of the Flood Policy Review Group, OPW, 2004

[2] EU Council Directive 2007/60/EC on the assessment and management of flood risks

[3] EU Water Framework Directive (2000/60/EC)

1.2. Aims and Scope

In line with Government policy, the Fingal East Meath Flood Risk Assessment and Management Study (FEM FRAMS) was initiated, its objectives being to:

- Identify and map the existing and potential future flood hazard and risk areas within the study area;
- Build the strategic information base necessary for making informed decisions in relation to managing flood risk in the study area;
- Identify viable structural and non-structural measures and options for managing the flood risks for localised high-risk areas and within the study area as a whole; and
- Prepare a Flood Risk Management Plan (FRMP) for the study area, and associated Strategic Environmental Assessment (SEA), that sets out the measures and policies, including guidance on appropriate future development, that should be pursued by the Local Authorities and the OPW to achieve the most cost-effective and sustainable management of flood risk within the study area.

The outputs from the study shall be in compliance with the EU Floods Directive and Water Framework Directive.

Figure 1-1 sets out the project activities undertaken since 2008 to meet these objectives.

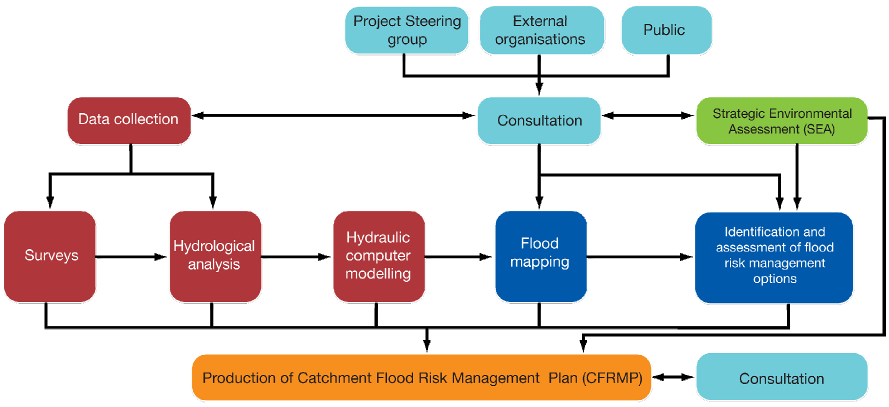


Figure 1-1 Flow chart setting out the project activities

The flood hazards and risks to be addressed include both those that currently exist and those that might potentially (foreseeably) arise in the future. The flood risk management measures, options and management plan will address both existing and potential future hazards and risks.

While the FEM FRAM Study considers flood risk on a catchment-wide basis, it has focused on areas where the flood risk was understood to be, or might become, significant (the Areas of Potentially Significant Risk, or 'APSRs'). These areas were identified by the Fingal County Council, Meath County Council and the OPW based on historic records of flooding and the local knowledge of the council and OPW staff.

This Flood Risk Management Plan includes prioritised actions and works (structural and non-structural) including indicative costs and benefits, to manage the flood risk in the study area in the long-term, and makes recommendations in relation to appropriate development planning.

The project is intended to develop a *strategic* flood risk management plan, and is *not* intended to develop *detailed* designs for individual flood risk management measures.

This document is the draft Fingal East Meath Flood Risk Management Plan (FEM FRMP, or the Plan) that has been developed as a component of the Fingal East Meath Flood Risk Assessment and Management Study. It is a non-technical document for consultation, and it summarises what has been done and elaborates on the findings and recommendations for actions to be included in the Plan. There is an extensive library of reports on the components of the FEM FRAMS that detail the studies undertaken and the results, and which are available on the study website, www.fingaleastmeathframs.ie.

As discussed in section 2.5, the draft FEM FRMP has been made available on the project website www.fingaleastmeathframs.ie and in hard copy at various Fingal and Meath County Council offices throughout the study area. Comments on this draft FRMP are invited and following a review of the comments received, the draft FEM FRMP will be amended, finalised and published, together with an SEA Post Adoption Statement.

The FEM FRAMS and the FEM FRMP have been prepared by Halcrow Barry on behalf of Fingal County Council, Meath County Council and the OPW. The FEM FRMP, including the areas of focus (the APSRs), will be reviewed on a six-yearly cycle, as is required by the EU Floods Directive.

1.3. Flood risk management policies

1.3.1. National flood risk management policy

For the FEM FRMP to be valid, it should respond to Government policy on flood risk management, which in turn should be consistent with EU policy, for example the Water Framework Directive (WFD) and the Floods Directive. Government policy is based on the Report of the Flood Policy Review Group, OPW, 2004, and is summarised below:

- Seek to minimise the national level of exposure to flood damages through the identification and management of existing, and particularly potential future, flood risks in an integrated, proactive and river basin based manner.

The policy pursues a two-pronged approach to flood management with a greater level of importance attributed to non-structural flood relief measures supported, where necessary, by traditional structural flood relief measures.

The OPW is the lead agency in delivering this policy, and has responsibility for advising Government on flood risk matters and for coordinating the activities of all organisations with responsibilities for flood risk management. As lead agency, the OPW has been designated as the Competent Authority with respect to implementation of the Floods Directive.

The OPW also has powers and responsibilities in relation to the implementation and maintenance of arterial drainage and flood relief schemes and of other flood risk management measures for flood risks arising from sources such as rivers, lakes, estuaries and the sea.

1.3.2. Flood risk management and planning

While the measures that the OPW has powers to implement can address existing risk, it is essential to manage flood risk long-term and that communities develop in a sustainable manner in which potential future increases in flood risk are avoided or minimised.

Development in flood-prone areas can create flood risk by building houses and other properties in areas where they may be flooded, or worsen the risk to properties up or downstream. Development in areas outside of the floodplain can also increase flood risk to existing development downstream through increased runoff rates and volumes.

The Guidelines on the Planning System and Flood Risk Management[4], published under Section 28 of the Planning Act, set out a transparent and robust framework to ensure the full consideration of flooding and flood risk in both planning and development management, to ensure that these risks are not created or risks to existing property and people are not made worse. The Guidelines set out Government Policy on appropriate planning and development with respect to flood risk and should be followed by all planning authorities, taking careful account of the FEM FRMP.

In general the potential future land-use changes in the study area will be based, in the short to medium term, on the published statutory and non-statutory spatial planning documents produced by Government and the planning authorities within the study area. Table 1-1 contains a list of the spatial planning documents that are relevant to flood risk management within the study area. Future iterations of policies within these planning documents will need to take account the flood maps prepared by the FEM FRAMS and the flood risk management actions recommended in the FEM FRMP.

The FEM FRMP presents an opportunity to identify areas at risk of flooding so as to avoid inappropriate development in the floodplains, and to inform decisions and risk assessment where development is considered necessary or appropriate in areas of flood risk. In addition, there are likely to be planning issues that could present opportunities for partnerships and integrated schemes. The recommended actions in this Plan take account of appropriate development controls as set out at national, regional and local levels. The existing and future flood maps produced as part of the study reflect the current level of development in the study area. The extent of flooding indicated on the maps may be subject to change where planning permission has been granted using the criteria set out in the Guidelines. Any planning application made for a site located within a floodplain must submit a site specific flood risk assessment to the Local Authority. Should permission be granted, the mapping output detailing any flood relief works constructed will be included in the next review of the Plan.

[4] Guidelines on The Planning System and Flood Risk Management, Department of Environment, Heritage & Local Government and the Office of Public Works, November 2009

Table 1-1 Relevant spatial planning and development plans

Scale	Documents
National	• National Development Plan: 2007-2013 *Transforming Ireland – A Better Quality of Life for All* • National Spatial Strategy: 2002-2020
Regional and local	• Regional Planning Guidelines for the Greater Dublin Area (RPG): 2010-2022 (Dublin Regional Authority and Mid East Regional Authority, 15th June 2010)
	• Fingal Development Plan: 2005-2011 • Fingal Development Plan: 2011 – 2017 • County Meath Development Plan: 2007 - 2013
	• Local Area Plans (LAPs) (Fingal County Council, 2007) - Dublin Airport LAP, June 2006 - Balbriggan SE LAP, Ballyboghil LAP, Donabate LAP, Garristown LAP, Portmarnock LAP, Rush Kenure LAP, Streamstown LAP, Balbriggan North LAP, Balbriggan Stephenstown LAP, Kinsealy LAP, Lusk LAP, Old town LAP, Rolestown LAP, Rush Skerries Road LAP
	• Dunshaughlin Electoral Area Development Plan (Meath County Council, 2009): - Ashbourne LAP, Ashbourne LAP, Ratoath LAP

1.3.3. Flood risk and the Water Framework Directive

The Draft River Basin District Management Plan for the Eastern River Basin District (ERBD) was published in December 2008. According to the website www.erbd.ie, the final ERBD Management Plan was published in July 2010, following six months of public consultation on the draft Plan, and following the review of all submissions received. The ERBD Management Plan has been prepared to meet the requirements of the EU Water Framework Directive (2000/60/EC). It sets out a series of objectives and measures for the river, lake, estuarine, coastal and groundwater water bodies of the ERBD, of which the FEM study area forms a part. This plan will be subject to a six-yearly review cycle.

The ERBD Plan is relevant to the FEM FRMP and its SEA as it sets specific standards for the maintenance and improvement of the ecology (including the supporting habitat) and chemical water quality of the water bodies in the FEM study area within a defined timescale, the main target date being 2015. These requirements present both constraints and opportunities for flood risk management as the actions recommended within the FEM FRMP must, as a minimum, not prevent the achievement of the required standards within the prescribed timescale.

1.4. Interface with other studies

Reference has been made throughout this study with other projects which relate to this study area or to this type of study. A full list of references is included at the back of this report. In particular reference was made to the following key studies:

- **Dublin Coastal Flooding Protection Project (DCFPP).** This project was undertaken by Royal Haskoning for Dublin City Council and Fingal County Council and the final report was published in April 2005. The project covers the Dublin City coastal area from the Martello Tower in Sandymount to north of Portmarnock. The DCFPP Report included information on existing defence assets, tide levels, drawings showing the extent of the February 2002 tidal flood event, predictive flood hazard maps for the 0.5% AEP tidal event and proposed flood protection works. The results of this study were considered in the FEM FRAMS Hydraulics Report and the results of the defence asset survey were incorporated into the FEM FRAMS Defence Asset Database (DAD).

- **Irish Coastal Protection Strategy Study (ICPSS) Phase III.** This project was undertaken by RPS consulting for DAFF (now incorporated into the OPW). The Draft Final Technical Report was published in August 2008. The ICPSS covered the coastline between Dalkey and Omeath. The ICPSS used numerical modelling of combined storm surges and tide levels to obtain extreme water levels along the coastline. The application of extreme value analysis and joint probability analysis to both historic recorded tide gauge data and data generated by the numerical model allowed an estimation of the extreme water levels of defined exceedance probability to be established along the coastline.

- **Greater Dublin Strategic Drainage Study**. This project was undertaken by RPS consulting for Dublin City Council. The Report was published in March 2005 and includes information about the study area, hydrological analysis, joint probability analysis, recommendations for flood proofing and so forth. This study also informed our assessment of strategic sustainable urban drainage systems (SuDS).

- **Mornington District Surface Water and Flood Protection Scheme**. The Preliminary Report was published in January 2004 by Kirk McClure Morton for Meath County Council and OPW. The Mornington River is located to the north of the FEM study area and the river discharges into the Boyne River. The proposed flood defence works are currently under construction and hence this river has not been included in the FEM FRAM study area. Information in relation to tide and flood levels and joint probability analysis was sourced from this study.

2. Involvement of external parties

2.1. Overview

The involvement of external parties has been essential in the development of the FEM FRMP and associated SEA. Throughout the FEM FRAM Study, it was important to both meet statutory requirements[5] for consultation with relevant parties as well as to ensure that the knowledge, experience and views of stakeholders and the general public were taken into account throughout the development of the FRMP.

Further details of all consultation events undertaken throughout the study are provided in the SEA Environmental Report (March 2011).

2.2. Provision of information

The dissemination of information relating to the FEM FRAM Study to stakeholders and to the general public and receiving feedback was undertaken throughout the study period, through the following measures:

- The creation and maintenance of a project website www.fingaleastmeathframs.ie;
- The provision of a dedicated email address fem-frams@fingalcoco.ie to receive feedback;
- The publication of the newsletters on the project website, making the hard copies available at local council offices and public libraries in the study area, emailing copies to persons that had registered on the project website; and
- The publication of all final reports and flood extent maps on the project website.

In addition to the above, opportunities to consult with members of the public also arose during channel survey works and technical visits around the study area by the project team, and these have generally been informative and useful.

2.3. Stakeholder consultation

From the beginning of the study in 2008, a range of statutory, non-statutory and local organisations were identified as stakeholders and were invited to get involved in the development and future implementation of the FEM FRMP and associated SEA. These stakeholders included:

- Planning, Transport and Water Services personnel from FCC and MCC;
- Area Engineers from the OPW;

[5] Both the SEA Directives and the Floods Directive set statutory consultation requirements

- Environmental bodies;
- Government departments and agencies;
- Non-governmental organisations; and
- Local business and industry representatives.

The complete list of the stakeholders involved in the FEM FRAMS is included in Appendix A.

Opportunities provided to interested stakeholders to participate in the development of the FRMP and its SEA included:

- An introductory letter and questionnaire issued to all potential interested parties seeking data and their views on the key issues within the FEM study area;
- Three stakeholder workshops held in February 2009, June 2010 and November 2010 to discuss progress and to seek feedback on the developing outputs of the study;
- Invitations to comment on project outputs such as the Environmental Scoping Report published for formal consultation in June 2009;
- Two mapping workshops held in December 2009 and March 2010 to discuss the 10% and 1% AEP flood outlines with the local area engineers from the Local Authorities and the OPW;
- FCC, MCC and the OPW issued a questionnaire to stakeholders in November 2010 to ask for stakeholder's information, views and concerns on the issues of local importance in the study area i.e. the local weightings score (refer to Section 7.4.4);
- Presentations were made to Fingal County Council and Meath County Council council meetings and to the Strategic Policy Committees (SPCs), to the FCC and MCC Planning Departments; and
- Presentations were made at the National Hydrology Conferences in both 2009 and 2010.

All feedback and comments received from these consultation and engagement activities have contributed to the development and outcomes of the FEM FRMP and its SEA.

2.4. Public consultation

A series of four public information and consultation days were held in November 2010 in key locations around the study area as follows:

- 22nd November 2010 at Fingal County Hall, Swords;
- 23rd November 2010 at Ashbourne Library;
- 24th November 2010 at Balbriggan Library; and
- 25th November 2010 at Duleek Library.

Public information day in Fingal County Hall, Swords. November 2010.

The objectives of the November 2010 public consultation process was to ensure the general public were made aware of the study and had sufficient opportunity to express their views and comments on the draft outputs (i.e. the draft flood maps); and to discuss the FRM options under consideration. The draft flood extent maps were also made available for comment on the project website. The information obtained from these events has informed the finalisation of the flood maps for the study area and the development of the FRMP and its SEA ER.

Further details of all consultation events undertaken throughout the FEM FRAM study area are provided in the SEA Environmental Report (ER).

2.5. Final consultation stage

The next and final stage of the consultation process is the publication of and consultation on this draft FRMP and accompanying SEA ER, which are being held in November 2011 at the following four key locations around the study area:

- Fingal County Hall, Swords, Co. Dublin on Tuesday, 8th November 2011;
- Ashbourne Library, 1 - 2 Killegland Square Upper, Killegland Street, Ashbourne, Co. Meath on Wednesday, 9th November 2011;
- Rush Library, Chapel Green, Fingal, Co. Dublin on Thursday, 10th November 2011; and
- Duleek Civic Offices, Main Street, Duleek, Co. Meath on Friday, 11th November 2011.

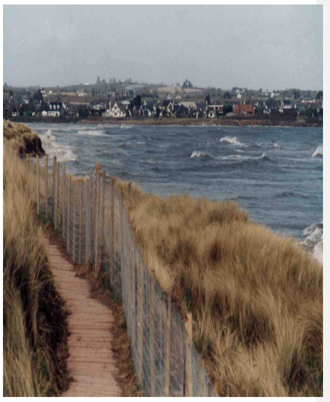
The draft FRMP and SEA ER have been made available on the project website www.fingaleastmeathframs.ie and in hard copy at the four locations mentioned above.

Comments on this draft FRMP are invited until 31 January 2012. Following a review of the comments received, the draft FEM FRMP will be amended, finalised and published, together with an SEA Post Adoption Statement, documenting how the comments received have been addressed.

All comments, feedback and observations should be submitted by email to fem-frams@fingalcoco.ie or in writing to: Denise Treacy, FEM FRAM Study Project Manager, Water Services Department, Fingal County Council, Grove Road, Blanchardstown, Dublin 15.

3. River and catchment description

3.1. Overview of the study area



The Fingal East Meath study area comprises a group of 23 rivers and streams, three estuaries and the Fingal and Meath coastline. The study area is approximately 772km^2 in plan area (Figure 3-1). The study area is bounded by the River Boyne & Mornington River catchment areas to the north and west, the Tolka and Santry River catchments to the south, and by the Irish Sea to the east. All watercourses in the study area flow to the Irish Sea either directly or via the three estuaries (Baldoyle, Broadmeadow and Rogerstown).

The principal urban areas in the study area include Portmarnock, Swords, Balbriggan, Ashbourne, Dunshaughlin, Malahide, Rush, Skerries and Duleek. Important infrastructure includes the M1 motorway, Dublin Airport, Gormanstown Military camp and Fairyhouse racecourse.

The Fingal East Meath study involves modelling 23 rivers and streams in the study area and three estuaries as detailed in (Table 3-1) below. Modelling of surface water (pluvial) flooding and coastal flooding was also undertaken.

Coastal and urban areas in the catchment

Table 3-1 Rivers, streams and estuaries included in the FEM FRAM study

River name (abbreviation)		
Mayne River (MAY)	Baleally Stream (BAY)	Balbriggan North Stream (BNS)
Sluice River (SLU)	Bride's Stream (BRI)	Delvin River (DEL)
Gaybrook Stream (GAY)	Jone's Stream (JON)	Mosney Stream* (MOS)
Ward River (WAR)	Rush West Stream (RWS)	Nanny River (NAN)
Broadmeadow River (BRO)	Rush Town Stream (RUT)	Brookside's Stream (BSS)
Lissenhall Stream (LIS)	St Catherine's Stream (CAT)	**Estuaries**
Turvey River (TUR)	Rush Road Stream (RUR)	Baldoyle Estuary
Ballyboghil River (BAL)	Mill Stream (MIL)	Broadmeadow Estuary
Corduff River (COR)	Bracken River (BRA) (including Matt Stream)	Rogerstown Estuary

** The Mosney Stream is also known as the Bradden Stream*

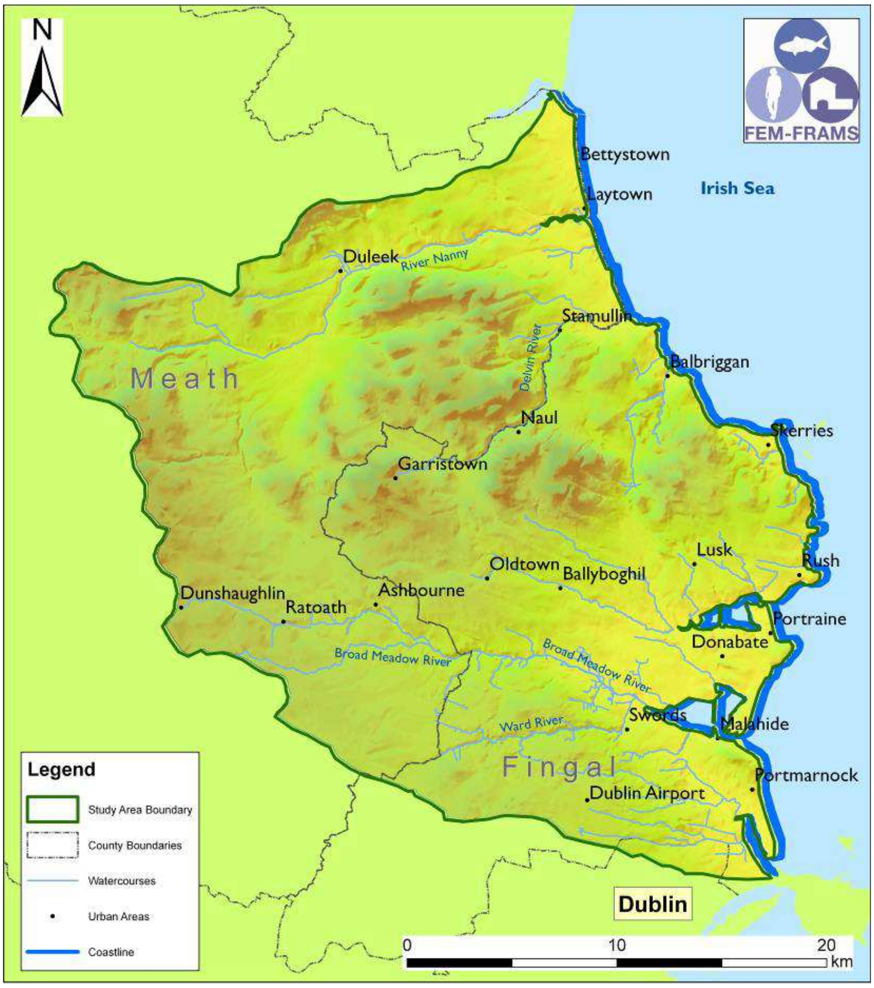


Figure 3-1 Watercourses and urban areas within the Fingal East Meath study area (Refer to Figure 1 at the back of the report for more detail)

There are a number of *Natura 2000* sites designated under the EU Birds Directive[6] and Habitats Directive[7] within the study area. These include the Boyne Coast and Estuary candidate Special Area of Conservation (cSAC), Boyne Estuary Special Protection Area (SPA), River Nanny Estuary and Shore SPA, Skerries Islands SPA, Rogerstown Estuary cSAC and SPA, Broadmeadow Estuary/Swords SPA, Malahide Estuary cSAC, Baldoyle Bay cSAC and SPA and Ireland's Eye cSAC and SPA.

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[6] Council Directive 79/409/EEC on the conservation of wild birds (the 'Birds Directive').
[7] Council Directive 92/43/EEC on the Conservation of Natural Habitats and Wild Fauna and Flora (the 'Habitats Directive')

3.2. Topography, geology and soil and drainage

Nanny River Estuary

Broadmeadow Estuary, January 2009

Topography has a direct impact on flood risk through its influence on catchment response to rainfall. Steeper slopes tend to cause a faster speed of flow, both below and over the ground surface. Topography also influences the extent of flooding as in flat areas floodwaters spread over larger areas of land than in narrow valleys. The topography of the study area is relatively flat. The highest ground is in the centre of the study area around Garristown (elevation 168 m OD). The lowest points are along the coastline and estuaries.

The impact of geology on flood risk is determined by the permeability of rocks and overlying soils. If the permeability is high then a greater proportion of rainfall will infiltrate into the ground. This reduces the amount of surface run-off that reaches rivers and reduces peak flows by delaying the transport of water from the catchment into the watercourses.

Underlying the study are sedimentary limestones and sandstones of Lower to Middle Carboniferous age interbedded with calcareous shales. These are overlain by a variety of rocks and soft alluvial deposits and glacially deposited tills including boulder clay, kames and eskers, most of which have been deposited by melting glaciers. There are many geological fault lines within the study area, where slippage could occur.

Figure 3-2 shows the types of sub-soil within the study area derived from the surface geology. These sub-soils are predominantly overlain by shaly limestone, basalt and granite from a cover of deep poorly drained minerals e.g. under the River Nanny Estuary. There are peaty sub-soils in some areas.

There are a lot of drainage ditches and small streams in the study area. This is generally indicative of a flat catchment where drainage needs to be improved to prevent ponding.

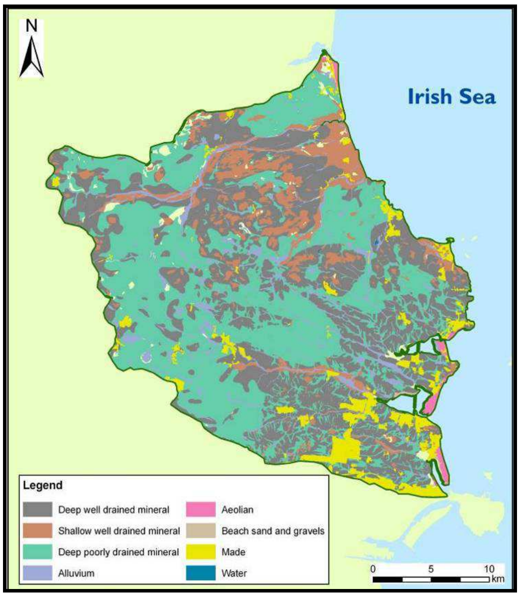


Figure 3-2 Surface geology (sub-soils) within the study area (Source: EPA)

3.3. Land use and land management

Land use and land management practice has an effect on catchment responses to rainfall. Vegetation, for example, can change the amounts of rainfall and snowmelt reaching the main channels by intercepting and storing precipitation. Vegetation can influence the hydrological cycle through shading, which slows down the rate of melting in snow, and through processes such as transpiration (uptake of water and its evaporation to the atmosphere from leaf surfaces) in plants. The type of vegetation will influence the amount of water intercepted in these ways; in summer, broadleaved trees will have greater interception and transpiration potential than conifers, but conifers will provide more shading in winter. Grassland has much less potential for interception and transpiration, although it does have an important role in soil conservation. These patterns of interception and transpiration in different plant groups are influenced by time of year and by land management practices. Thus, land use and land management can influence flood risk by affecting the amount and rate of rainfall reaching the river channel. It also affects its sensitivity to flooding.

Urban land uses typically have hard surfaces which drain quickly causing rapid run-off into drains and sewers. Urban areas are also very sensitive to flooding with small amounts of flooding potentially causing significant damages and risks to people. Rural land has a run-off rate dependent on the particular use to which it is put to and the land management practices that are used. These land uses and management practices include agricultural uses, land drainage, vegetation type and cover, soil management etc.

3.3.1. Land types and land management

Land cover within the study area, based on data from 2000, is shown on Figure 3-3. Agriculture, predominantly pasture with some mixed farmland, including market gardening/horticulture in the eastern parts of the study area, is the dominant land use within the study area covering approximately 91.6% of the land area. No specific information is available regarding the quality of this land for agricultural use.

Areas covered by built development such as urban centres, including residential areas, commercial centres and industrial areas, and transport infrastructure occupy approximately 7.5% of the study area; with the remaining area covered by forest and semi-natural habitat (0.6%), water bodies (0.1%) and wetland (0.2%).

Figure 3-3 Land use within the study area (Source: EPA Corine land cover database 2006)

Agricultural land use

In future years pasture is likely to remain the dominant land use; although the pattern of use may become more or less intensive. Other changes that are likely to occur include increased development and urbanisation, which may reduce the proportion of land in agricultural use.

Urban and rural vistas in the study area

3.4. Hydrology and tides

Hydrology is concerned with the occurrence and movement of water in the environment. For assessing fluvial flood risk, we are particularly interested in the effects of surface water hydrology, which looks at the relationship between rainfall on the land surface and runoff into water bodies (streams, rivers and lakes).

3.4.1. Hydrological cycle

The hydrological cycle is shown in Figure 3-4. Water vapour in the atmosphere condenses and may give rise to precipitation. Not all of this precipitation reaches the ground due to interception by vegetation cover and may be evaporated back into the atmosphere. Any precipitation that reaches the ground surface may flow over the surface into streams and lakes, from where it will either flow over the surface to the oceans, evaporate back into the atmosphere or will move by seepage towards groundwater. Precipitation reaching the ground may also infiltrate through the ground surface to join existing soil moisture. This may be removed by either evaporation from soil and vegetation cover, by through-flow towards stream channels or by downward percolation to the underlying groundwater where it may be held for weeks or months or even longer.

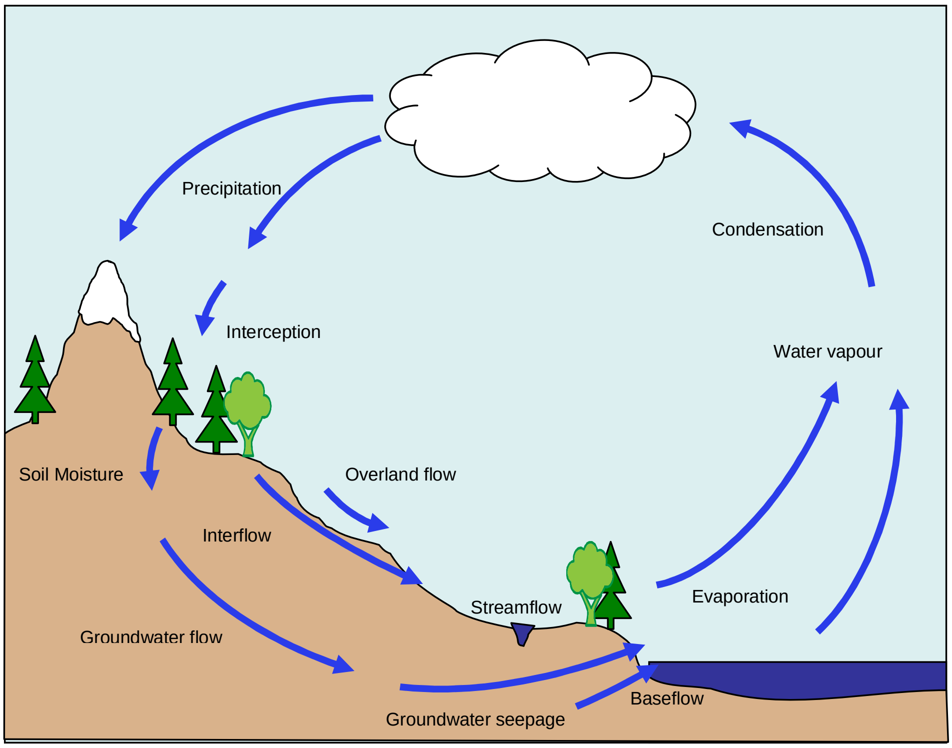


Figure 3-4 The hydrological cycle

3.4.2. Rainfall and hydrometric data

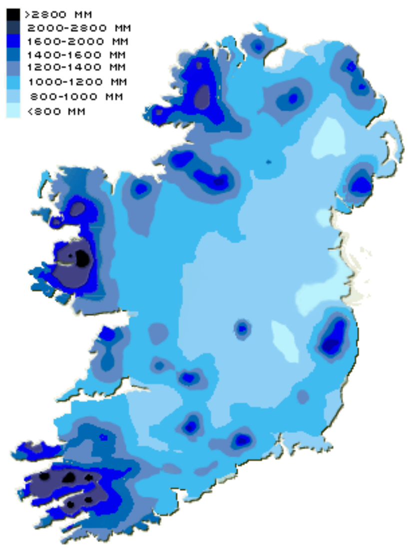


Figure 3-5 Mean annual rainfall (mm) from 1961 – 1990 (Source www.meteireann.ie)

The climate of the Fingal East Meath study area is generally temperate and experiences low to modest annual precipitation dependent on topography. Figure 3-5 shows the study area along the east of Ireland, experiences a lower mean annual rainfall when compared to most regions in Ireland.

Annual precipitation within the FEM study area is estimated to be somewhere between 800 and 1000mm per year.

The best method of assessing the frequency and size of a flood is through historical records of river levels and flows. The OPW, EPA and Met Éireann operate a number of water level, flow and rainfall gauges in the study area, which have been used in this study. This is discussed in more detail in Section 4.

3.4.3. Groundwater

Groundwater is water located in the soils and rocks beneath the ground surface. Groundwater is fed or recharged mainly from precipitation which soaks into the soil. In the soil some of the water will be taken up by plants and some will infiltrate to become groundwater. The upper level of this groundwater is known as the water table. Groundwater will flow from where it has infiltrated to a point of discharge. This is usually a spring, a river or the sea. Groundwater provides a vital role supporting wetlands, streams and rivers as much of the flow of a river will be made up of discharging groundwater.

The geological make-up of the subsurface will impact on the movement of the groundwater. Permeability is a measure of how fast water will flow through connected openings in soil or rock. Low permeability refers to soil or rock that restricts the movement of water through it. Permeable layers (such as sands and gravels) contain fine holes that allow water to flow. Permeable formations that contain groundwater are known as aquifers.

Information on the groundwater bodies and hydrogeology were gathered from the Databases of the Geological Survey of Ireland (GSI) and the data produced as part of the Water Framework Directive and Eastern River Basin Management Plan (ERBD). The bedrock underlying the study is predominantly carboniferous limestone. There are a number of different aquifer types in the study area including unconsolidated gravels / sands / silts and bedrock aquifers. These groundwater bodies vary from Karsitic (Skerries south urban and Bettystown), productive fissured bedrock in (Lusk Bog of the Ring, Lusk East and Lusk West) and poorly productive bedrock (all other areas). Further detail is contained in the Groundwater technical note in the Hydraulics Report.

3.4.4. Tides and surge

Tides are the rising and falling of the earth's ocean surface and are caused by the gravitational forces of the moon and sun on the earth's oceans. The rising and falling of the ocean surface changes the depth of marine and estuarine water bodies and produces oscillating currents known as tidal streams. The oscillation of these tidal streams occurs in Ireland on a twice-daily basis in response to the semi-diurnal tidal cycle. The tidal cycle is also influenced by other factors such meteorological conditions e.g. wind and barometric pressure, which can raise or lower the normal or astronomical sea levels. During periods of low barometric pressure, usually associated with deep depressions, a phenomenon called storm surge occurs, whereby normal sea levels are artificially raised.

Predictive coastal flood outlines and associated water levels and predictive points for various annual exceedence probabilities (AEPs) for various locations along the coastline were provided by DAFF.

3.4.5. Catchment response

The response of a catchment to rainfall is controlled by a wide range of catchment characteristics including urbanisation, vegetation, soils, geology and topography. Rainfall occurring in the catchment will first contact any vegetation where it will be temporarily stored and some rainfall will be lost through evaporation and transpiration. Water reaching the soil will either infiltrate into the soil or run-off across the soil surface into a stream or channel. The rate at which water infiltrates into the soil is controlled by a number of factors including soil type, surface slope and the wetness of the soil. Dry, level, permeable surfaces generally result in more water entering the soil and less running off.

Water entering the soil can flow laterally within the soil layer until it reaches streams or rivers or it can percolate downwards into the underlying rock layers. Groundwater (as it is known once it enters the rock layer) can then flow through the rock layers and resurface at springs or enter rivers and streams.

Run-off reaches river channels much more rapidly than water which infiltrates the underlying soil. The time it takes run-off to reach streams and rivers is influenced by surface slope, how close the watercourse is, and if there are any drains or infrastructure to collect the water. Drainage systems tend to drain surface water to watercourses more quickly, hence increasing the catchment response. Water reaching rivers by sub-surface and groundwater flow takes a lot longer but can still make significant contribution to flood flows, especially in long duration rainfall events where rain occurs over days or weeks.

River flows are made up of a combination of run-off, sub surface flow, and spring flow from the subcatchments which drain into a particular river. This combined flow will pose a flood risk if it exceeds the capacity of the channel.

The 23 rivers modelled in the Fingal East Meath study area generally show minor or localised flooding for the 1% AEP. Fluvial flooding only affects some urban areas including Duleek (which is protected for the 1% AEP), Ratoath, Rowlestown, Balbriggan, Skerries, Swords (Aspen) and Ballyboghil. Flooding is much more significant in this study area in tidal/estuary areas.

4. Hydrological analysis overview

4.1. Overview

Hydrological analysis is the determination of flows in rivers based on the type and characteristics of the catchment and the analysis of available rainfall and water level data. The hydrological analysis forms the basis for subsequent hydraulic modelling and flood risk mapping stages of the FEM FRAM study.

The overall hydrological analysis of the study area was undertaken in two stages, namely, preliminary hydrological analysis and detailed hydrological analysis. The preliminary hydrological analysis involved the collection and analysis of the available data (hydrometric, historic flood, rainfall, soil and geology, land-use, tidal datasets etc), and the results are included in the Preliminary Hydrology Report (February, 2009).

The detailed hydrological analysis involved the review of the rating at the gauging stations and refined the hydrological analysis of the preliminary hydrological study using revised flow data at the gauges. The study applied the Flood Studies Report (FSR), Flood Estimation Handbook (FEH) and Irish Flood Studies Update (FSU) methodologies to enable the determination of design hydrological inputs (flow and water level) for the current scenario as well as for the future scenarios which may arise due to future climate changes likely to influence flood risk. The results of the detailed hydrological analysis are presented in the Hydrology Report (April 2010). Thus the two reports (Preliminary Hydrology Report and Hydrology Report) detail the overall hydrological analysis undertaken for the FEM FRAMS.

4.2. Key Points

The following key points are noted:

- The EPA has split Ireland into 40 different hydrometric areas based on river catchments. The Fingal East Meath study area is in Irish Hydrometric Area 08 and some of Hydrometric Area 09;
- Daily rainfall data from ten meteorological stations in the study area and four stations in the neighbouring catchments . These have been operational for a variety of years varying from 9 to 67 years. The rainfall data was reviewed to determine the relationship between the depth of rainfall and the duration of the rainfall event (called depth duration frequency curves).
- Hydrometric data from 12 gauges in the study area and further 12 in neighbouring catchments was available. A detailed rating review was undertaken for nine hydrometric stations in the study area (Figure 4-1) which provided information on the flow in the rivers for the various design flood events. This information was also compared to historic information on flooding such as photographs/ surveys of actual flood events.

Station 08008 Broadmeadow

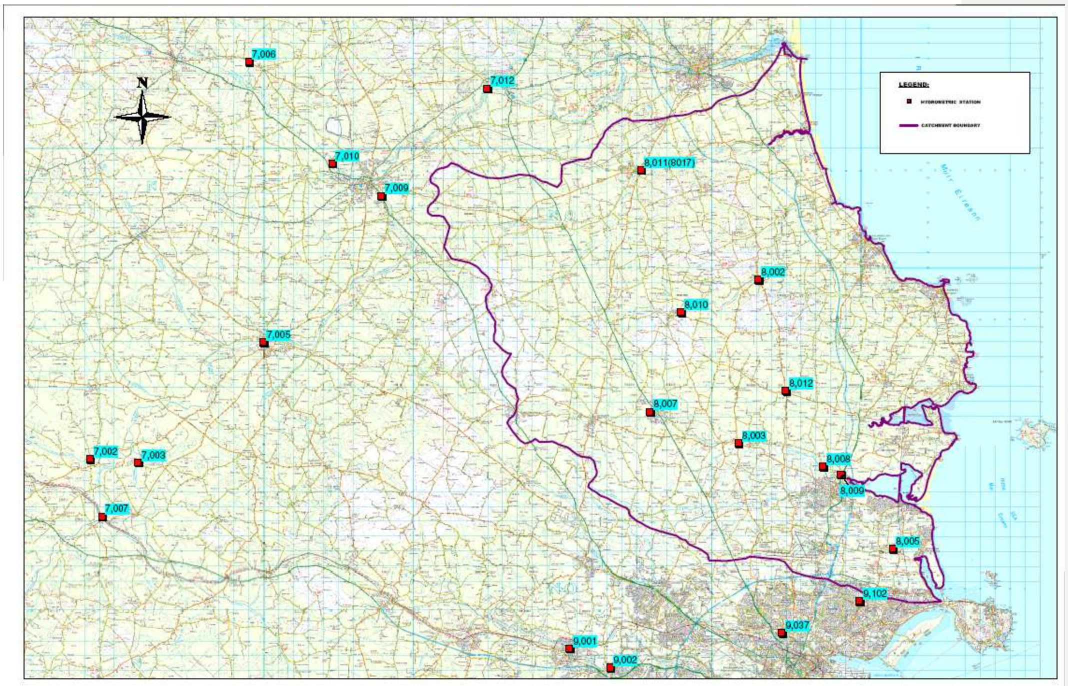


Figure 4-1 Hydrometric stations in and around the study area

- The rivers were divided into smaller sub-catchments (refer to Figure 4-2 and the flows in the rivers were estimated based on the characteristics of the catchments e.g. catchment area, slope of the river, degree of urbanisation (using the FSSR 16 and Institute of Hydrology Report No. 124 Unit Hydrograph (UH) methods).

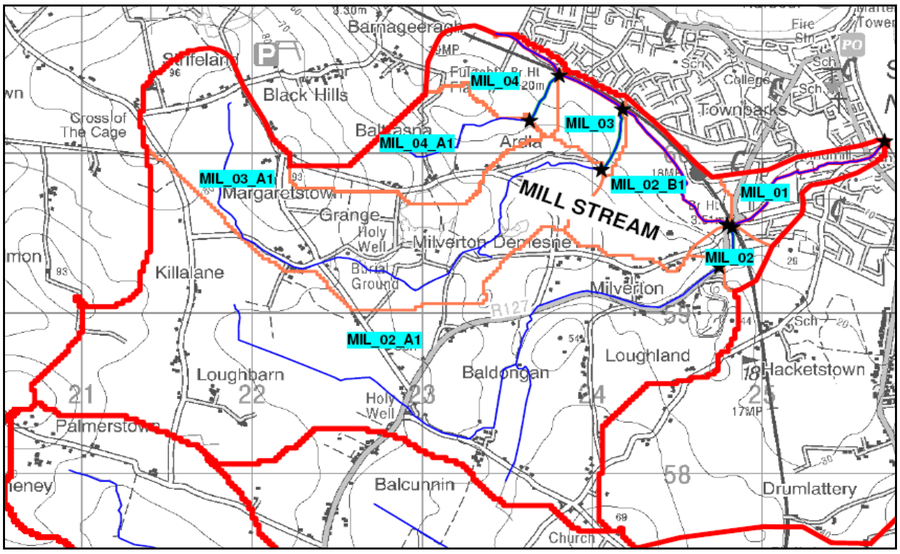


Figure 4-2 Sample sub-catchment boundaries

- The results of the estimation of the flows using the calculation method were compared with the statistical analysis at the gauging stations and a scaling factor was determined. This scaling factor was then applied to each sub-catchment to determine the flows.
- The main factors for future flood risks were considered to be climate change and increasing urbanisation. Table 5-4 (following) summarises the recommended projections for climate change and urbanisation for two future scenarios, namely, the mid range future scenario (MRFS) and the high end future scenario (HEFS) for the Fingal East Meath study area.
- The rivers in the study area discharge to the Irish Sea or one of the three estuaries and water levels in the rivers are affected by tide levels. The joint probability of a fluvial and tidal flood event occurring at the same time was investigated and the recommended joint probability combination is detailed in Table 4-1 below.

Table 4-1 Joint probability of fluvial and tidal events

Design event	Boundary return period	
	Fluvial boundary	Sea level boundary
2 year	2	2
5 year	5	2
5 year	2	5
10 year	10	2
10 year	2	10
25 year	25	2
25 year	2	25
50 year	50	2
50 year	2	50
100 year	100	5
100 year	5	100
200 year	200	10
200 year	10	200
1000 year	1000	50
1000 year	50	1000

The results of the hydrological analysis were then used in the hydraulic modelling of the various rivers and tributaries in the study area.

5. Flood hazard assessment

5.1. Introduction

This Section of the Plan summarises the historic flood hazard in the Fingal East Meath study area. It describes how we have used the computer modelling to help us identify and map current flood hazard, and then summarises the future scenarios that have been developed for use when assessing and mapping future flood hazards. There is also a summary of the groundwater and pluvial hazard assessments.

5.2. Historic flood hazard

Historically there have been a number of areas prone to fluvial and/or tidal flooding within the FEM study area. The main source of information on historic floods is the OPW National Flood Hazard Mapping website www.floodmaps.ie which provides an abundance of historic flood information throughout Ireland. A record of at least 141 historic flood events in the study area since the 1940's was made available by the OPW in GIS (MapInfo) layer. The relevant reports on these historical flooding events were downloaded directly from the website. Historic flood reports, including those on the recent flooding in summer 2008, were also received from FCC, MCC and from a number of organisations, websites and individuals. Information on the August/September 2008 flooding in the study area was collected by Halcrow Barry during the defence asset field survey.

Flooding at North Street, Swords, Nov 2002

Tidal flooding at Laytown, Feb 2002

The most 'significant' flooding events in the study area are listed in Table 5-1.

Table 5-1 Significant recent fluvial and tidal flood events within the study area

Flood Event Date	Main Flood Mechanism	Rivers/Coast Affected	Areas Affected:
1924*	Tidal	Coastal	Coastal area of Fingal and Meath counties
December 1954	Fluvial	Nanny River	Washed away Drogheda Bridge
November 1982	Fluvial	Ward River, Broadmeadow River, Mill Stream	Swords, Malahide, Skerries
August 1986	Fluvial	Broadmeadow River, Ward River, Mill Stream, Nanny River	Swords, Skerries, Balbriggan, Duleek
June and October 1993	Fluvial	Mayne River, Nanny River	Balgriffen, Duleek
February 2002	Tidal	Ward River, Mayne River, Turvey River, Sluice River	Swords, Portmarnock, Maynetown, Skerries, Portrane, Bettystown, Malahide, Rush
October/November 2002	Fluvial	Ward River, Sluice River, Mill Stream, Ballyboghill River	Portmarnock, Swords, Malahide, Skerries, Ballyboghil, Donabate, Portrane, Rush, Balbriggan
November 2000/ November 2004	Fluvial/tidal	Sluice River, Brooks Stream, Mayne River	Bettystown, Rush, Skerries
August 2008	Pluvial/fluvial	Sluice River, Hazelbrook Stream, Gaybrook Stream near Swords, Corduff Stream	Lusk, Ashbourne, Malahide, Swords, Kinsaley Village

**The Dublin Coastal Flooding Protection Project Final Report (2005) has reported this extreme tidal even in 1924 whereas the Mornington District Surface Water & Flood Protection Scheme Final Preliminary Report (2004) has reported this anecdotal event in 1922.*

The major flood events in the last 23 years were the August 1986 (Hurricane Charlie), November 2000 and November 2002, which all resulted in considerable flood damage in the study area. The highest recorded tidal levels in Dublin Bay occurred in February 2002, resulting in tidal damage to properties along the Fingal and Meath coast.

Apart from both fluvial and tidal flood hazards, a further problem occurs from pluvial flooding in areas where surface water cannot escape due to high river or tide levels. Pluvial flooding is exacerbated by restricted pipe sizes, under-capacity bridges and culverts and debris causing blockages. This is relatively widespread across the study area as demonstrated by the pluvial assessment maps and examples include the August 2008 flooding at Lusk, Ashbourne, Malahide, Swords, Kinsaley village etc.

5.3. Current flood hazard

Flooding can come from a number of sources; this FRMP considers the effects of flooding from rivers and tides, groundwater and pluvial flooding. An assessment has also been made of the effect of blockage of structures and defence failures on fluvial flooding.

5.3.1. Sources of flooding

River flooding is caused by the channel system being unable to convey the quantity of rainfall draining into it from the surrounding catchment; this quantity is a function of catchment response (see Section 3.4.5), which is influenced by factors such as land use and urbanisation (see Section 3.3). During extreme events natural rivers occupy not only their channel but also their floodplain. A flood occurs when the conveyance capacity of the channel is overwhelmed. Channel capacity is influenced by the channel size, shape, slope and roughness as well the height of the banks or defences on either side of it, the restrictions posed by bridges and other structures, and the operation of pumps, gates and weirs. The duration of a fluvial flood is dependant on the intensity and duration of the rainfall event. Runoff from sustained rainfall events tends to result in longer duration flood events. Runoff from intense thunderstorms results in short duration flash floods.

Tidal flooding is the inundation of low lying floodplains by the tides. Tidal flooding may be caused by a number of mechanisms including seasonal high tides such as those driven by the spring neap tide cycle, storm surges caused by low pressure weather systems which forces the water level to rise higher than the normal sea level, and storm driven wave action (though wave action is not explicitly assessed in this study). Extreme conditions leading to tidal flooding are most commonly a result of a combination of two or more of these mechanisms. The duration of tidal flooding is limited by the cycle of the tides where drainage is available.

5.3.2. Flood probability, modelling and extents

Flood extents are influenced by the floodplain's topography and the volume of water in it. The volume of water in the floodplain is influenced by the magnitude of the flood event and the flooding mechanisms that are taking place.

Different magnitudes of flooding have different probabilities of occurring. Probability of flooding is defined by annual exceedance probability (AEP). This is the likelihood of a particular magnitude flood occurring or being exceeded in any given year. Thus, a 1% AEP event describes a flood event which has a 1% (or 1 in 100) chance of occurring or being exceeded in any given year. Flood events with a lower probability of occurrence result in more extreme flooding. For example, a 1% AEP flood event will result in more flooding than a 50% AEP event. It should be noted that the likelihood of a flood event occurring in the future, whatever its probability, is independent of the time since the last flood of similar magnitude. In order to understand the flood generation process, and hence assess flood hazard, we must identify issues and processes specific to the catchment. Computer modelling can be used to replicate natural processes and help understand the extent and nature of fluvial and tidal flooding issues.

To assess existing and future flood hazard we have developed twenty computer models which represent the river and estuarine systems. The models, lengths of high priority watercourse (HPW) and medium priority watercourse (MPW) and areas of potential significant risk (APSRs) are shown in Table 5-2.

Table 5-2 River models, HPW/MPW lengths & APSRs

Model	River model Name	Length (km)		APSRs
		HPW	MPW	
1	Broadmeadow and Ward Rivers	57.6	35.1	Dunshaughlin area, Ratoath area, Ashbourne area, Swords area, Owens Bridge area, Killeek area and Coolatrath area.
2	River Nanny	12.5	35.9	Kentstown area, Duleek area, Julianstown area and Laytown, Bettystown and Coastal area.
3	Lissenhall Stream	4.4	-	None
4	Turvey River	5.4	-	Donabate area
5	Rush Road Stream	-	2.2	Rush area
6	Mosney Stream	1.4	3.3	None
7	Delvin River	11.7	15.5	Garristown area, Naul area, Stamullin area and Gormanston area
8	Brookside Stream	3.0	-	Laytown, Bettystown and Coastal area
9	Ballyboghil and Corduff Rivers	8.8	16.3	Ballyboghil area and Oldtown area
10	Balbriggan North Stream	3.1	-	Balbriggan area
11	Bracken River	10.5	3.6	Balbriggan area and Rowans Little area
12	Mill Stream	3.2	1.0	Skerries area
13	Gaybrook Stream	5.7	-	Swords area and Malahide & Portmarnock area
14	Mayne River	11.3	11.3	Dublin airport, Belcamp & Balgriffin area,
15	Sluice River	16.7	5.1	Portmarnock and Malahide area, Kinsaley Lane area, Ballymacartle area and Dublin airport, Belcamp & Balgriffin area.
16	St Catherine's Stream	1.2	1.2	Rush area
17	Baleally Stream	2.0	2.8	Lusk area
18	Bride's Stream and Jone's Stream	1.9	6.0	Lusk area and Rush area
19	Rush Town Stream	2.1	0.6	Rush area
20	Rush West Stream	1.9	0.6	Rush area

The river models are built using detailed river channel and ground level information, plus estimated river flows and tidal levels (i.e. the hydrological analysis described in Section 4). The model calculates where the water would flow based on the ground levels and in doing so simulates the movement of floodwater within the catchment.

Figure 5-1 Map showing the extent of the HPW and MPW watercourses

Coastal modelling to simulate flooding from the sea has also been undertaken for the Fingal East Meath study area coastline. The OPW provided digital terrain model (DTM) survey data of the coastline. The survey data was augmented with the topographic survey of the coastal defence assets.

The extreme sea levels were obtained from DAFF's Strategic Coastal Flood Risk and Erosion Study. The OPW provided historic tide data at Dublin Port and at Port Oriel, Clogherhead. This information was used to determine the design event tide levels for the range of AEPs.

The modelling has considered the coastal defences (including high ground and coastal dunes) in place to protect the coastline.

The flood extents from the coastal model have been merged with flood extents of the river models to produce flood extents for the coasts, estuaries and tidally dominated reaches of the rivers.

Both the fluvial and the coastal models provide flood extents as well as flood depths and velocities. Floodwater depth and velocity are important as they have a direct effect on potential for loss of life and damage to property, infrastructure and the environment.

The depth of flood waters in the floodplains is affected by a number of factors including the scale of the flood event, the width and shape of the floodplain, the floodplain land use, and the presence of structures. Deeper flood waters will accumulate on the floodplain where the speed of flow is reduced or restricted due the roughness of the ground surface and the presence of structures. Depressions or 'bowls' in the floodplain will cause deep pools of floodwaters to build up.

The velocity of flood flow in the rivers is controlled by the gradient of the channel, the size, shape and roughness of the channel and the river valley, the restrictions posed by bridges and other structures, and the operation of pumps, gates and weirs.

The models have been used to assess the impact of flooding for the current situation as well as for future scenarios (see Section 5.4). A range of annual exceedance probability floods have been modelled for each scenario, varying from 50% to 0.1% AEP in any given year. The modelling considers the joint probability of fluvial events and tidal events occurring at the same time (refer to Table 4-1 for details).

Using this flood hazard information we can estimate the number of properties prone to flooding which can be used to measure the social impact of flooding, what the economic damage to property might be and how the environment is affected (for example, impacts on designated sites).

5.3.3. Flood mapping

Flood maps are one of the main outputs of the study and are the way in which the model results are communicated to the end users. The flood maps represent all areas that are likely to be inundated at some point during a flood event. The key types of mapping developed have been:

- Flood extent maps – show the estimated area inundated by a flood event of a given AEP. These maps also show levels of confidence in the flood extents, plus water levels, flows and defended areas;
- Flood zone maps – show flood zones A, B and C representing high, moderate or low risk areas in accordance with the Guidelines on the Planning System and Flood Risk Management;
- Flood depth maps – show the estimated flood depths for areas inundated by a particular flood event using graduated colours;
- Flood velocity maps - show the speed of the flood water for areas inundated by a particular flood event using graduated colours; and

- Flood hazard maps – show the harm or danger which may be experienced by people from a flood event of a given annual exceedance probability, calculated as a function of depth and velocity of flood waters.

Flood maps provide valuable information regarding flooding within the study area for both technical and non technical users. The maps have been used to identify areas that are prone to significant flooding and to inform the development of flood risk management options. These flood maps can also be used to:

- Raise awareness of flood hazard to property and life;
- Aid flood event response planning and action; and
- Inform spatial planning and development management within the floodplain and support the implementation of the Guidelines on the Planning System and Flood Risk Management.

A separately bound volume of draft flood extent, depth, velocity and hazard maps, representing the current flood hazard, accompanies this draft FRMP and the flood extent maps are available publicly through the FEM FRAMS website, www.fingaleastmeathframs.ie, and local authority offices.

5.3.4. Description of current fluvial/tidal flood hazard

Areas of potential significant risk (APSRs) are existing urban areas that have been identified by the client as being at potential risk of flooding. They are also urban areas where the client considers that there is potential for significant development. A description of the current flood hazard for each APSR within the study area, based on the flood extent maps prepared for the study, is presented in Table 5-3 below.

Table 5-3 Current fluvial/tidal flood hazard for APSRs in the study area

APSR	Description of fluvial/tidal flood hazard
Donacarney and Donacarney Little area	This area is not affected by fluvial or tidal flooding.
Duleek area	The Duleek area is exposed to fluvial flooding. The existing defence embankments and walls offer protection to the majority of properties up to 1% AEP event. Flooding occurs in the western part of the Millrace Estate for the 2% AEP event and at localised areas along the Paramadden tributary as a result of flood waters overtopping the bank upstream of the defences near Main Street. There is significant flooding for the 0.5% AEP event or greater, principally at the Millrace Estate, Colgan Street and Abbeylands, due to overtopping of the flood defences. The R152 road between Duleek and Drogheda overtops for a 0.1% AEP fluvial design event on the left bank (looking downstream) and for a 4% AEP fluvial design event or greater on the right bank (looking downstream).

APSR	Description of fluvial/tidal flood hazard
Kentstown (R150/R153 crossing) area	The Kentstown area is exposed to fluvial flooding and the R153 road bridge overtops for the 2% AEP fluvial design event or greater. Fluvial flooding for the 10%, 1% and 0.1% AEP flood events affects agricultural lands on the left and right banks of the River Nanny.
Garristown area	This area is not affected by fluvial or tidal flooding.
Naul area	There is a limited extent of fluvial flooding from the Delvin River in the Naul area APSR. Fluvial flooding for the 1% AEP flood event affects a small area of agricultural lands on the left and right banks of the River Delvin
Area to the southeast of N2/Hurley crossing	This area is not affected by fluvial or tidal flooding.
Stamullin area	The Stamullin area is exposed to fluvial flooding. Fluvial flooding for the 1% AEP flood event mainly affects farmland on the left and right banks of the channel south of Main Street. A recreational area in the Mountain View/Elvana Housing Estates is also at risk of flooding..
Rowans Little area	The Rowans Little area is exposed to fluvial flooding with a large area of agricultural land flooded. Upstream of Decoy Bridge, between Hynespark and the M1 motorway, the left and right bank floodplains of the Bracken River floods for the 10% AEP fluvial design event or greater. Downstream of the APSR, the Bog of the Ring area floods for all fluvial design events.
Oldtown area	There is a limited extent of fluvial flooding for the 1% AEP flood event which mainly affects agricultural lands along the Ballyboghil River.
Ballyboghil area	This area is exposed to fluvial flooding. Flooding occurs both upstream and downstream of Ballyboghil at Ballyboghil Bridge/R108 and the R129 which runs parallel to the river. Flooding at Ballyboghil starts for the 4% AEP fluvial event. Some properties on right bank upstream of Ballyboghil Bridge and on Riverside Street are at risk as a result of this flooding.
Turvey Bridge area to the west of Donabate	This area is exposed to both tidal and fluvial flooding. Flood flows from the Ballyboghil River spilling into the Turvey River upstream of the M1 increases the flooding risk along the Turvey River. For extreme fluvial events, this additional flow can peak at twice the flow in the Turvey River upper catchment. The Staffordstown

APSR	Description of fluvial/tidal flood hazard
	Industrial Estate along with the N1/R132 floods for fluvial events of 4% AEP or greater. Further downstream, agricultural land is affected.
Donabate area	This area is exposed to both fluvial and tidal flooding. Within Newbridge Demesne, there is a sizeable area of natural floodplain which floods for the 20% AEP fluvial event or greater and for the 2% AEP tidal event or greater. The Turvey River has a flapped outfall that acts as a defence against tidal events by preventing storm surges propagating up the Turvey River. Hydraulic modelling results indicate that this flapped outfall provides protection to a significant area of agricultural land in the Newbridge Demesne for higher order return period events.
Lusk area	This area is not affected by fluvial or tidal flooding.
Dunshaughlin area	This area is exposed to fluvial flooding. Fluvial flooding for the 1% AEP flood event mainly affects agricultural lands to the north east of the town.
Ratoath area	This area is exposed to fluvial flooding. Fluvial flooding for the 1% AEP flood event mainly affects agricultural lands and a small number of properties on the eastern side of Ratoath in the Moulden Bridge Area. Defences in the Somerville Estate in Ratoath provide protection up to the 1% AEP event. This area, however, is liable to flood for a 0.1% AEP event.
Ashbourne area	This area is exposed to fluvial flooding. Fluvial flooding for the 1% AEP flood event mainly affects zoned recreational and future new residential communities areas in the Ballybin townland to the west of Ashbourne. To the east of Ashbourne this flood event affects agricultural lands on both banks of the Broadmeadow River. Localised flooding of some houses occurs on the Broadmeadow tributary at Brookville.
Rowlestown East area	This area is exposed to fluvial flooding. Fluvial flooding for the 1% AEP flood event mainly affects agricultural lands and a small number of residential properties.
Owens Bridge area	This area is exposed to fluvial flooding. Fluvial flooding for the 1% AEP flood event mainly affects agricultural lands and a warehousing area.
N2 - Coolatrath Bridge area	This area is exposed to fluvial flooding. Fluvial flooding for the 1% AEP flood event mainly affects agricultural lands.

APSR	Description of fluvial/tidal flood hazard
Killeek area	This area is not affected by fluvial or tidal flooding.
St Margarets, Dublin Airport, Belcamp and Balgriffin areas	This area is exposed to fluvial flooding. Fluvial flooding for the 1% AEP flood event mainly affects pockets of agricultural land in the area and small section of Swords Road in the Toberbunny area and the R132 at Turnapin. At Balgriffin, a significant number of properties are at risk of flooding from a tributary of the Mayne River. The tributary starts to flood upstream of Balgriffin Road (R123) for a 2% AEP fluvial event. This flooding spills over the R123 and flows into the housing development located downstream of the R123.
Kinsaley Lane area	This area is exposed to fluvial flooding. Fluvial flooding for the 1% AEP flood event mainly affects agricultural lands along the right bank of the Sluice River at Chapel Road. 2 properties at Kinsaley lane is also flooded.
Ballymacartle area	This area is exposed to fluvial flooding. Fluvial flooding for the 1% AEP flood event mainly affects agricultural lands north of the Sluice River and local property.
Portmarnock and Malahide areas	Portmarnock is affected by both fluvial and tidal flooding. The most significant flood risk is at Strand Road where a large number of properties are at risk of flooding from both the Sluice River and the Baldoyle Estuary. Out of bank flooding downstream of Portmarnock Bridge starts at the 10% AEP tidal event. This flooding crosses Strand Road and inundates properties at Hazel Grove and St. Anne's Square. The Sluice River has a flapped outfall at Portmarnock Bridge that acts as a defence against tidal events. Hydraulic modelling results show that the flapped outfall provides protection to a significant area of land upstream of Strand Road including the Beechwood golf course and lands near the racecourse. Malahide is at risk from tidal flooding only from the Broadmeadow Estuary. Flooding in Malahide town centre has it source from two main locations: overtopping of the coastline within the town centre and spilling of floodwater under the railway underpass from the coast road west of the railway embankment. This flooding results in a large number of properties in Malahide town centre and along the coast road being at risk of flooding.
Swords area	This area is exposed to both tidal and fluvial flooding. The flood maps indicate that the most significant flooding in Swords is in the area of Balheary Road where flood flows from both the Ward River and Broadmeadow River interact in the vicinity of the confluence

APSR	Description of fluvial/tidal flood hazard
	between the two rivers. The water levels at this location are also influenced by the tide levels in the Broadmeadow estuary. Flooding at this location starts at the 20% AEP fluvial event and affects a number of properties at this location. Further upstream along the Ward River, Bridge St. road is partially overtopped and some properties along Main Street are affected on the right bank floodplain upstream from the bridge (4% AEP fluvial event). Elsewhere in the Swords area APSR, a tributary of the Gaybrook Stream, west of the M1 motorway, causes fluvial flooding of the southern part of the Airside Retail Park. This flooding is due to several surcharged culverts and starts for the 4% AEP event. Further downstream along the Gaybrook Stream, a number of properties are flooded at Aspen Drive as a result of out of bank flood flows.
Portrane area	There is limited flooding in Portrane as a result of tidal flooding propagating up the Rogerstown Estuary. The 0.5% AEP tidal event affects marshlands and residential gardens in the Marsh Lane area.
Rush area	This area is exposed to both tidal and fluvial flooding. The majority of flooding occurs at the downstream extent of the Rush West Stream, to the west of Rush town around Channel Road. Flood maps indicate that a large urban area is at risk of flooding from a combination of both fluvial and tidal flooding. Surcharging of a culvert on the Rush West Stream at channel road starts for a 4% AEP fluvial design event and results in flooding along Channel Road. Tidal flooding at Shore Road starts for the 0.5% AEP tidal design event extending inland to affects properties in Rush town Elsewhere in Rush, fluvial and tidal flooding along the Rush Town Stream results in a caravan park and recreational area being inundated at six cross lane, off the Skerries Road.
Skerries area	Flooding in Skerries is primarily as a result of the poor capacity of existing culverts along the Mill Stream, particularly the culverts under the railway at the junction of Dublin Road and Miller's Lane. The capacity of these culverts is insufficient to convey large fluvial flows and results in flood waters ponding on land to the west of the railway embankment and surcharging of the culverts. This surcharging results in spilling of flood waters along the R127, Millar Lane and Sherlock Park. Flooding begins for the 4% AEP fluvial event at Miller's Lane with a significant number of properties along Miller's Lane and Sherlock Park flooded for the 1% AEP event. At the downstream extent of the Mill Stream, out of bank flooding

APSR	Description of fluvial/tidal flood hazard
	results in flood risk to a number of properties at Holmpatrick Road. These properties are at risk from both fluvial and tidal flooding. Tidal flooding also affects a number of properties along South Strand Road and Harbour Road.
Balbriggan area	This area is exposed to both tidal and fluvial flooding. Along the Bracken River, properties are at risk of flooding for the 4% AEP fluvial design event or greater principally around Bridge Street and along Quay Street. Bridge Street is overtopped for a 0.5% AEP fluvial design event or greater and for a 0.1% AEP tidal event. The car parks next to the harbour (between Mill Street and Quay Street) flood for a 4% AEP fluvial design events or greater and for a 0.2% AEP tidal event or greater. Further north, a large number of properties are at risk from fluvial flooding from the Balbriggan North Stream for the 0.1% AEP event at Drogheda Street.
Gormanston and Gormanston Demesne area	These areas are exposed to both tidal and fluvial flooding which mainly affects a small area of agricultural land along the left and right banks of the Delvin River.
Military Aerodrome (south to Irishtown)	This area is not affected by fluvial or tidal flooding.
Julianstown area	This area is exposed to both tidal and fluvial flooding which mainly affects a small area of agricultural land along the left and right banks of the Nanny River.
Laytown, Bettystown and Coastal area	This APSR is exposed to both tidal and fluvial flooding. At Laytown area APSR, inundation of land results from combined fluvial and tidal flooding along the Nanny River. The flooding is mainly confined to a small area of agricultural land with a small number of properties at risk at the mouth of the Nanny River. Further north, fluvial flooding along the Brookside Stream mainly affects the lands south of the Bettystown Court Hotel. A small number of residential properties are prone to flooding. A large area of agricultural land is also flooded.
Baldoyle area APSR	Baldoyle is affected by both fluvial and tidal flooding. There is a large area of agricultural land at risk from out of bank flooding from the Mayne River. The Mayne River has a flapped outfall that acts as a defence against tidal events. The flood maps indicate that tidal flooding at

APSR	Description of fluvial/tidal flood hazard
	Maynestown and Stapolin is reduced with the flapped outfall. The fluvial flood extent map indicates that the flapped outfall has no affect on the fluvial flood extents.

It should be noted that the flood extent maps show that there is also some flooding outside of these APSRs. This is mainly rural / agricultural land but some isolated properties are also affected.

5.4. Future flood hazard

In the previous section, we looked at the areas currently prone to flooding. In this section we look to the future and try to show how flood hazard may change in the future. This will help us set the right policies, strategies and actions to meet the needs of flood risk management for the next 100 years.

5.4.1. Introduction

The future management of flood risk in the FEM FRAM study area needs to be considered as part of the wider socio-economic future. How our society and economy develops will be a major driver in our future management of flood risk. Effective and sustainable management can only be achieved through the development and implementation of a range of flood risk management activities that are flexible and adaptable to change in light of the inherent uncertainties.

Flood hazard is influenced by a range of factors such as climate change, changes in land use (particularly further urban development within the floodplain, but potentially also development elsewhere within the study area), and changes in land management practices. This section considers possible changes in the FEM FRAM study area for three generic factors:

- Urban development both within the study area and river corridor. An increase in urban areas is likely to lead to increased surface water run-off and a more rapid rise in peak flows as the area of impermeable surface increases;
- Land use/management. Any change in land management practices (e.g. an agricultural intensification, afforestation) can lead to changes in surface water flows and field run-off; and
- Climate change. Milder wetter winters and increases in intensive rainfall events could increase flows in rivers on a more frequent basis, increase demands on our urban drainage networks, and lead to increased occurrence of blockage to structures. Sea level rise could mean that higher tides are experienced; this rise, coupled with stormier winters, means the impact of climate change at the coast could be severe.

The potential impact of flooding over the next 100 years has been explored through modelling and mapping future flood hazard.

Whilst it is not possible to understand in detail what will occur in 100 years time, we can project general trends to determine the scale of change that would affect flood hazard in the study area. FEM FRAMS will be reviewed every 6 years and will be updated to reflect changing conditions in the study area.

5.4.2. Drivers

There are a number of drivers that can influence future flood hazard, the main ones identified in the FEM study area being climate change and urban growth. These drivers have been extensively investigated and river flows and sea levels determined for two future flood risk management scenarios, a Mid Range Future Scenario (MRFS) and a High End Future Scenario (HEFS). It must be stressed that there is uncertainty in what will actually happen; the MRFS / HEFS are just possible future scenarios selected to represent the foreseen probable range of futures.

The mid range future scenario considers the more likely estimates of changes to the drivers by 2100, whereas, to allow for future adaptability of flood defence measures, the high end future scenario has been included to represent more extreme changes in the respective drivers by 2100. It is worth noting that these future estimates will not necessarily impact cumulatively.

Table 5-4 summarises the recommended projections for climate change and urbanisation for the two future scenarios for FEM FRAMS.

Table 5-4 Relevant combinations of drivers to provide boundaries for future flood risk

Driver	Scenario	
	MRFS	HEFS
Climate change - rainfall	+ 20%	+30%
Climate change - net sea level rise	+35cm	+100cm
Land use change – urbanisation	100% increase in urban area	400% increase in urban area

The MRFS has been used to map the extent of future flood hazards. Both the MRFS and HEFS have been used when considering the design level of flood mitigation options in the FEM study area (see Section 7).

5.4.3. Description of future flood hazard

The hydraulic computer models have been used to model the effects of the MRFS and flood extent maps have been prepared for the 50% to 0.1% AEP flood events. A separately bound volume of draft flood extent maps, representing the future flood hazard for the MRFS, accompanies this draft FRMP and they are available publicly through the local authority offices.

A description of the future flood hazard for each urban area within the study area, based on the MRFS flood extent maps, is presented in Table 5-5. Future flood hazard maps were not produced for the HEFS.

Table 5-5: Future fluvial/tidal flood hazard for APSRs in the study area

ASPR	Description of fluvial/tidal flood hazard
Donacarney and Donacarney Little area	This area is not affected by fluvial or tidal flooding.
Duleek area	For the MRFS, there is a significant increase in flood risk in Duleek with the majority of the defended area of Duleek town (current scenario) flooding for the 1% AEP MRFS fluvial flood event.
Kentstown (R150/R153 crossing) area	There is marginal increase in flooding of agricultural lands on the left and right banks of the Nanny River
Garristown area	The MRFS maps indicate that there is no significant increase in flooding in this area.
Naul area	There is marginal increase in flooding of agricultural lands on the left and right banks of the River Delvin.
Area to the southeast of N2/Hurley crossing	The MRFS maps indicate that there is no significant increase in flooding in this area.
Stamullin area	There are marginal increases in MRFS fluvial flood extents in this area. The areas affected are mainly agricultural lands on both banks of the Delvin River.
Rowans Little area	There is marginal increase in flooding of agricultural lands west and east of the Rowans Little grade separated junction on the M1.
Oldtown area	There is a marginal increase in fluvial flooding affecting agricultural lands on the left bank of the Ballyboghil River.
Ballyboghil area	There is an increase in fluvial flooding affecting agricultural lands and residential areas south of Oldtown Road.
Turvey Bridge area to the west of Donabate	The MRFS maps indicate that there is no significant increase in flooding in this area.
Donabate area	The MRFS maps indicate that there is no significant increase in tidal flooding in this area.
Lusk area	The MRFS maps indicate that there is no significant increase in flooding in this area.
Dunshaughlin area	There is a marginal increase in fluvial flooding affecting agricultural lands on the right bank of the Broadmeadow River.

ASPR	Description of fluvial/tidal flood hazard
Ratoath area	There is marginal increase in flooding on the banks of the Broadmeadow River.
Ashbourne area	There is a marginal increase in fluvial flooding affecting the Brookville and Deerpark housing estates and agricultural lands.
Rowlestown East area	There is a marginal increase in fluvial flooding affecting agricultural lands on the left and right banks of the Broadmeadow River. This increase in flood risk affects a small number of residential properties in Rowlestown for the MRFS.
Owens Bridge area	The MRFS maps indicate that there is a marginal increase in fluvial flooding in this area.
N2 - Coolatrath Bridge area	The MRFS maps indicate that there is a marginal increase in fluvial flooding in this area.
Killeek area	The MRFS maps indicate that there are no significant increases in fluvial or tidal flooding in this area.
St Margarets, Dublin Airport, Belcamp and Balgriffin areas	The MRFS maps shows a marginal increase in fluvial flooding affecting agricultural land in the area and small section of Swords Road in the Toberbunny area. There is also an increase in flood risk to properties at Balgriffin.
Kinsaley Lane area	The MRFS maps show that there is a marginal increase in fluvial flooding affecting agricultural lands in the area.
Ballymacartle area	The MRFS maps show that there is a marginal increase in fluvial flooding affecting agricultural lands in the area.
Portmarnock and Malahide areas	In Portmarnock there is an increase in both the fluvial and tidal flooding along the Sluice River. The majority of the defended area for the current scenario is flooded for the MRFS. The MRFS tidal maps also indicate a significant increase in flooding in Malahide town centre and along the coast road.
Swords area	The MRFS maps show an increase in both the fluvial and tidal flooding along the Broadmeadow and Ward Rivers. The most significant increase in flood risk is to the north of Swords at the junction of the Ward and Broadmeadow Rivers. The increase in mean sea levels associated with the MRFS also impacts on the flooding at this location. There is a marginal increase in fluvial flooding from the Ward River affecting the river banks and Balheary

ASPR	Description of fluvial/tidal flood hazard
	road areas. Along the Gaybrook Stream, there is a marginal increase in flooding at both the Airside Retail Park and Aspen.
Portrane area	There is a marginal increase in tidal flooding affecting Burrow Road.
Rush area	The MRFS maps indicate that there is an increase in both the fluvial and tidal flood extents in Rush Town for the MRFS. The most significant increase in flood extents is to the west of Rush Town along the Rush West Stream.
Skerries area	The MRFS flood maps indicate that there is a significant increase in both fluvial and tidal flood extents in Skerries. Along the Mill Stream, there is a large increase in flood extents towards the downstream extent of the river at and around Holmpatrick Road. Along South Strand Road, there is a large increase in the tidal flood extents.
Balbriggan area	There is a significant increase in fluvial flooding in Balbriggan for the MRFS along the Balbriggan North Stream which affects a large number of properties at Drogheda Street. Along the Bracken Stream, the increase in flooding is less significant and mainly affects the areas around Bridge Street and along Quay Street.
Gormanston and Gormanston Demesne area	There is a negligible increase in MRFS fluvial and tidal flooding for this area.
Military Aerodrome (south to Irishtown)	This area is not affected by fluvial or tidal flooding.
Julianstown area	There is a negligible increase in MRFS fluvial and tidal flooding for this area.
Laytown, Bettystown and Coastal area	Along the Nanny River, there is a marginal increase in fluvial and tidal flood extents at the mouth of the Nanny River. Further north along the Brookside Stream, there is a more significant increase in fluvial flooding to lands south of the Bettystown Court Hotel with additional properties at risk of flooding.
Baldoyle area APSR	The MRFS maps show an increase in both the fluvial and tidal flooding in the Mayne River floodplain. The increase in flood risk mainly affects agricultural land.

5.5. Defence failures

Defences are generally defined as structures that restrain/contain the rivers or the tides. They can include walls, earth embankments, sand dunes, and non return (flap) valves. As part of the FEM FRAM Study, it was required to investigate flood risk and flood hazard due to the sudden failure of existing defences. Additional model runs were carried out to determine the impact of failure of defences at a number of locations along the watercourses and along the coastline. The results of this analysis are described in detail in the Hydraulics Report.

5.6. Blockage of structures

Debris and vegetation can easily cause a blockage to culverts and bridges and this is particularly prevalent during a flood event. Once the structure becomes blocked then the water level has to rise until it finds another flood route or it overtops the structure. As part of the FEM FRAM Study, it was required to investigate flood risk and flood hazard due to the blockage of structures. As with the defence failures, additional model runs were carried out to determine the impact of the blockage of structures at a number of locations along the watercourses. The results of this analysis are described in detail in the Hydraulics Report.

5.7. Groundwater flood hazard

The main objective of the groundwater flood hazard analysis was to undertake a desk study review of the available data on groundwater to produce a meaningful assessment of the groundwater flood risk in the FEM FRAM study area; to investigate the necessity for groundwater monitoring in the study area, and if required, to recommend groundwater monitoring locations. The study also investigates the mechanisms by which groundwater flooding can occur in the study area and their remedial measures.

Significant groundwater flooding in Ireland is associated with Karst landscapes and turloughs. However, this setting does not occur in the FEM study area. The hydrogeological setting of this study area together with all the available information indicates that there is no significant groundwater flooding in the study area.

There is a risk of groundwater flooding of poorly constructed basements and recommendations have been included in the groundwater technical note in relation to basement design and construction.

5.7.1. Future groundwater flood hazard

With the lack of existing evidence for groundwater flooding it is difficult to determine whether there is a significant future risk related to groundwater rise.

Based on present evidence, even if flood defence structures are built to a higher level of defence than presently exists, it is considered unlikely that emergent groundwater flooding will become a significant problem during periods of high tidal level - there remains a limiting rate at which groundwater may move and emerge. Short term exposure to high tide levels (e.g. the 3 hours around high tide) appears to be insufficient to raise groundwater pressures such that groundwater emerges at the surface. The low permeability of the made ground directly below the surface appear to further limit any such emergence (although groundwater is potentially more likely to emerge where this layer is punctured).

However, it is less clear how this situation would change if there was a significant rise in average sea levels (i.e. as a result of climate change). Under such a scenario, groundwater will be exposed to higher tidal levels for longer periods and ground below average sea levels may become susceptible to water logging. There is however insufficient information available to determine what level of sea level rise would lead to water logging/ flooding or to determine the susceptibility of different areas through the study area.

A recommendation for future work includes the development of a basement register which notes the location of the basement, size, floor level, purpose, record of flooding and the type of flooding.

Details on the groundwater flood hazard are presented in the Technical Note in Appendix E of Hydraulics Report.

5.8. Pluvial flood hazard

A pluvial flood risk assessment was undertaken as part of the FEM FRAM study. Pluvial flooding occurs following heavy, intense rainfall, when the surface-water cannot drain to the river because of high water levels. As a result, drains can become surcharged leading to the risk of localised flooding of streets and property, and there is also the risk of manhole covers being lifted and displaced by pressure build up in the drains, which in turn leads to a health and safety risk.

The main objective of the pluvial analysis was to assess the potential locations where pluvial floodwaters and surface runoff might accumulate within APSRs during extreme rainfall events and/or blockage or saturation of the stormwater drainage systems and assess the potential degree (extent and depth) of flooding that could occur. Thus, the assessment has not required consideration of the capacity or arrangement of the urban stormwater drainage systems

The results of the pluvial model analysis compared well with the historic records of pluvial flood locations for all the APSRs in the study area (refer to Appendix E of Hydraulics Report) . The results also showed that a few of the APSRs are at risk of flooding from only pluvial sources (e.g., Donabate area), whereas other areas are at risk of flooding from either fluvial, coastal, pluvial or a combination of all three types of flood sources. A consultation workshop with FCC, MCC and the OPW was held on 9th March 2010 which reviewed the draft pluvial flood maps. The workshop provided valuable feedback confirming that the pluvial flood maps were representative of local knowledge of flooding in the area.

Many surface-water drainage outfalls are fitted with flap-valves to prevent flow from the rivers backing up the drains, and it is these that also stop the drains discharging when river levels are high. It is important that all drainage outfalls and culverts are fitted with flap-valves and that these are maintained in good working order. If the risk of pluvial flooding is to be reduced, the basic options would be:

- Pumping installations to pump from the drains, over the top of any defences and into the river; and
- Increased storage capacity and control in the drainage system such that it can cope with the volume of surface water drainage until water levels in the receptor subside.

5.8.1. Future pluvial flood hazard

It is likely that pluvial flood hazard will increase in the future. This is as a result of increasing urbanisation and climate change including 'monster storms' where very significant amounts of rainfall falls in a very short period of time.

A number of recommendations were included in the pluvial assessment technical note including further investigation and modelling of the existing stormwater / combined systems and routing the flow along the river network and drainage channels.

Compliance with the planning guidance and inclusion of source control and sustainable drainage systems (SuDS) will be a necessary requirement. An assessment of sustainable urban drainage systems (SuDS) is also included in a Technical Note in the Hydraulics Report (February 2011), Appendix E.

6. Flood risk assessment

6.1. Introduction

The previous Section described sources, probability and extent of flooding. The flood maps produced following a detailed hydrological analysis and hydraulic modelling allow the identification of locations within the Fingal East Meath study area prone to flooding. This Section describes the impacts of flooding; which have been considered under the following five risk categories:

- Human health;
- Environment;
- Cultural heritage;
- Critical infrastructure;
- Economy.

In identifying locations within the FEM study area at risk of flooding, the focus has been on assessing the flood risk for the 0.1% AEP (1 in 1,000 chance) fluvial and tidal events.

6.2. Flood risk receptor maps

Flood risk maps have been prepared for both the current scenario and MRFS, with separate maps for fluvial and tidal flooding. A sample map is shown in Figure 6-1. A full set of risk maps are available in the offices of the Local Authority.

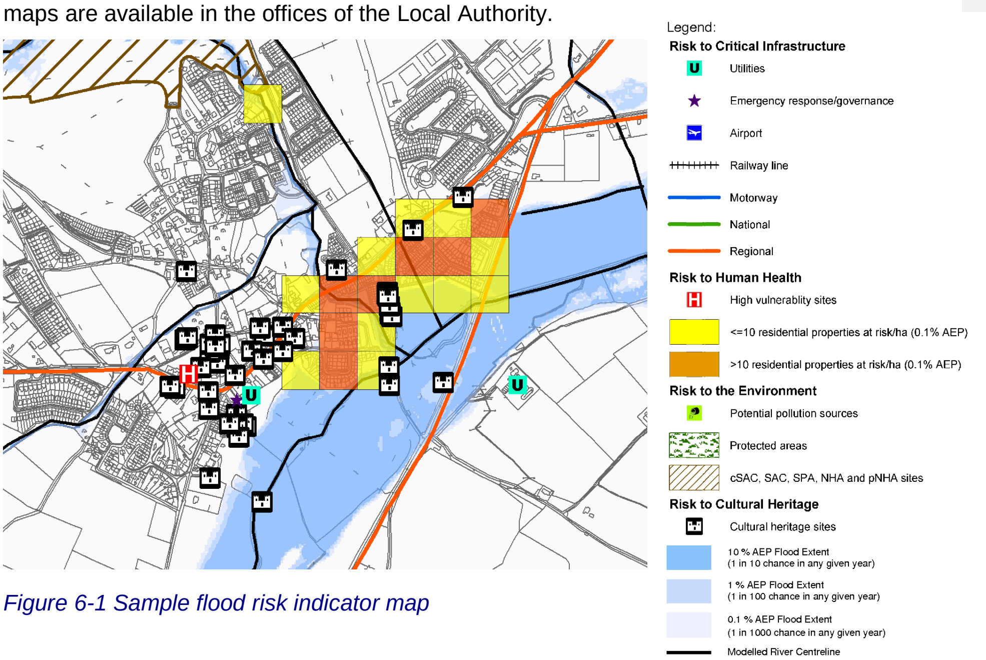


Figure 6-1 Sample flood risk indicator map

6.3. Risk to human health

The risk to human health has been measured through the number of residential properties located within the flood extent. This was represented on the flood risk maps in the form of the density of residential properties at risk of flooding per hectare for the 0.1% AEP event. Although not all properties located within the flood extent will suffer economic flood risk, i.e. in some cases only driveways and gardens will be flooded; the flood hazard will result in a degree of risk to human health through stress and anxiety. Table 6-1 shows the number of residential properties at risk for the current scenario and MRFS for the 0.1% AEP event, for each of the APSR in the study area.

Table 6-1 Number of properties flooded for the 0.1% AEP

APSR	Current		MRFS	
	Fluvial	*Tidal*	*Fluvial*	*Tidal*
Donacarney and Donacarney Little area	0	0	0	0
Duleek area	191	0	198	0
Kentstown (R150/R153 crossing) area	0	0	0	0
Garristown area	0	0	0	0
Naul area	0	0	0	0
Area to the southeast of N2/Hurley crossing	0	0	0	0
Stamullin area	0	0	0	0
Rowans Little area	0	0	0	0
Oldtown area	1	0	1	0
Ballyboghil area	6	0	7	0
Turvey Bridge area to the west of Donabate	0	0	0	0
Donabate area	0	0	0	0
Lusk area	0	0	13	0
Dunshaughlin area	0	0	0	0
Ratoath area	25	0	52	0
Ashbourne area	51	0	59	0
Rowlestown East area	5	0	5	0
Owens Bridge area	2	0	2	0
N2 - Coolatrath Bridge area	1	0	2	0
KilFingal East Meathk area	0	0	0	0
St Margarets, Dublin Airport, Belcamp and Balgriffin areas	28	0	34	0
Kinsaley Lane area	2	0	3	0
Ballymacartle area	0	0	0	0
Portmarnock and Malahide areas	27	94	69	209
Swords area	58	4	69	11
Portrane area	0	0	0	0
Rush area	22	30	36	53
Skerries area	107	56	169	177
Balbriggan area	43	0	84	4
Gormanston and Gormanston Demesne area	0	0	0	0
Military Aerodrome (south to Irishtown)	0	0	0	0
Julianstown area	1	0	1	0
Laytown, Bettystown and Coastal area	4	12	4	60
Baldoyle area APSR	0	12	0	155

The most significant number of at risk residential properties for the current scenario is mainly to urban areas along the Meath and Fingal coastline including Malahide, Portmarnock, Swords, Skerries, Rush and Balbriggan which are at risk from either tidal flooding or a combination of fluvial and tidal flooding. Away from the coast there are a large number of residential properties at risk from fluvial flooding in Ashbourne, Ratoath and Duleek. The majority of the risk in the remainder of the study area is confined to the APSRs; however there are both isolated and clusters of rural residential properties at risk of flooding.

For the MRFS scenario, the increase in mean sea levels along the coast results in a potentially large number of additional residential properties being at risk from tidal flooding. Away from the coast, an increase in river flows, associated with the MRFS, results in a large increase in flood risk in Ratoath and Balbriggan.

6.4. Risk to the environment

Flooding is a natural process and whilst some of the environmental features within the study area, such as wetland habitats and the species they support, depend on periodic inundation, river and tidal flooding can also have a detrimental impact on the environment of the study area, especially when the flooding is of high magnitude.

Through the SEA process, the environmental features located within both fluvial and tidal flood extents mapped for the FEM study area have been identified and their sensitivity to changes in the existing flooding regime considered. This has enabled those features that could be positively or negatively affected by both predicted future changes in the flooding regime and/or the implementation of flood risk management options recommended in the FEM FRMP to be identified and assessed.

The environmental features considered relevant to the FEM FRMP include:

- The **water environment itself**, including:
    - The quality and quantity of water essential to provide drinking water, habitat for flora and fauna and support fisheries; and the risk of pollution from potential sources such as waste water treatment plants and landfills;
    - The physical condition of the river channels and estuaries including their morphology and physical processes, which are essential to provide suitable habitat for flora and fauna and maintain water quality.
- The **natural environment**, including species of flora and fauna and their supporting habitats within the water bodies and land within the mapped flood extents of the study area, that are reliant on the maintenance of specific environmental conditions.
    - Some aquatic and wetland habitats, and associated species, rely on periodic flooding, although frequent flooding followed by periods of dry conditions is unlikely to be beneficial to habitats and species that require prolonged wet conditions. Other habitats and associated species are highly sensitive to flooding which can cause adverse changes in species composition as a result of changes to drainage conditions, increased nutrient availability, reduced oxygen in the soil, erosion and increased mobility of toxic metals.
    - The study area contains several designated sites of international nature conservation importance and of national nature conservation importance (proposed Natural Heritage Areas) and a wider biodiversity of aquatic and wetland species of flora and fauna. These are described in the SEA ER and

AA Report.

- The **built environment**, including sites and structures protected for their **cultural heritage** value for which flooding has the potential to cause physical damage such as the erosion of and damage to archaeological earthworks, buried sites and standing buildings/structures as a result of repeated floodwater inundation as detailed in Table 6-3 below. Flooding can also cause damage to the integrity of protected structures, their construction materials, interior and exterior decoration and significant interior features. The study area contains over 150 sites and structures, including bridges, buildings, standing stones, *fulachta fiadh*, ring forts and water-powered mills, within the mapped flood extents, as well as numerous Architectural Conservation Areas (ACAs) and areas of archaeological potential;

- The **use and value** of the water environment and the surrounding land for recreation and tourism, including riverside access for angling, water-based sports and amenities located within the mapped flood extents; and

- The **surrounding land use and landscape** of the study area; which includes areas of high quality agricultural land and landscapes designated for their scenic value within the mapped flood extents.

Many of these environmental features require the maintenance of specific environmental conditions, including the management of flows, water levels and channel conditions, in order to meet both national and international legal requirements. These have been taken into account throughout the development of the FEM FRMP through the SEA process and further details are provided in the SEA Environmental Report.

The risk to the environment was represented on the flood risk maps using the indicators shown in Table 6-2 below. The table shows the number of each environmental indicator at risk for the 0.1% AEP event for the current scenario and MRFS for the full study area.

Table 6-2 Total number of environmental indicators at risk for the 0.1% AEP event

Indicator	Current		MRFS	
	Fluvial	*Tidal*	*Fluvial*	*Tidal*
IPPC sites	0	0	0	0
EPA landfill waste sites	0	0	0	0
Section 4 discharges*	4	3	5	3
Section 16 discharges*	1	1	2	2
Beaches**	0	14	0	14
SAC, SPA, NHA, pNHA***	20	17	20	17

**The baseline GIS data for the Section 4 and Section 16 discharges provides details of the spatial location of the discharge points along the watercourses rather than the location of the licensed facility. The assessment of risk is therefore based on the level of flood risk to the discharge points. As these are located along the watercourses, the flood maps and hence flood risk assessment indicates that these discharge points are at risk for every AEP event.*

***All of the beaches within the study area are at risk of tidal flooding. While beaches are somewhat naturally resilient to flooding, there is some potential for flood damages, i.e. erosion, to occur.*

****SACs, SPAs, NHAs and pNHAs include both land based and water based habitats and species. The assessment of flood risk has identified all sites located within the mapped flood extents, but has not distinguished between parts of these sites that might be at risk of flooding (e.g. terrestrial habitats) and the parts that comprise water bodies and hence are not at risk.*

6.5. Cultural heritage

An assessment of flood risk to sites/features of cultural heritage value contained within the study area was undertaken as part of the flood risk assessment. Table 6-3 shows the number of cultural heritage indicators at risk for the 0.1% AEP event for the current scenario and MRFS for the study area.

Table 6-3 Number of cultural heritage sites at risk for the 0.1% AEP event

Indicator	Current		MRFS	
	Fluvial	Tidal	Fluvial	Tidal
Record of Monuments and Places (RMP sites)	40	4	44	9
Record of Protected Structures (RPS sites)	39	20	50	27
National Sites and Monuments database (SMR sites)	33	7	36	11

6.6. Risk to critical infrastructure

Both nationally and regionally available infrastructure datasets have been used to determine the length, area or number of infrastructure assets that are located within flood risk areas. The infrastructure assets include transport routes (e.g. road and rail) and utility assets (e.g. waste water and water treatment plants, power stations). The depth of flooding and flood hazard affect the degree of disruption and damage to infrastructure assets and these factors have also been taken into account when assessing the flood risk to critical infrastructure.

Table 6-4 below indicates the length of transport routes and the number of utility assets that are at risk for the 0.1% AEP event for the current scenario and MRFS for the full study area.

Table 6-4 Number or length (km) of critical infrastructure at risk for the 0.1% AEP event

Indicator	Current		MRFS	
	Fluvial	Tidal	Fluvial	Tidal
Utilities	3	1	3	1
WTP	0	0	0	0
WWTP	5	0	5	0
Airports	0	0	0	0

Indicator	Current		MRFS	
	Fluvial	Tidal	Fluvial	Tidal
Fire stations	1	0	1	0
Garda stations	0	0	1	0
Government buildings	0	0	0	0
Hospitals	0	1	1	1
Rail	0	0	0	0
Roads – Motorway (km)	1.6*	0*	1.8*	0*
Roads – National primary (km)	1.4*	0*	1.5*	0*
Roads – Regional (km)	8.5*	2.3*	11.1*	8*

** Indicates values in length (km)*

6.7. Economic flood risk

6.7.1. Economic risk maps

Economic risk maps provide a graphical representation of the outputs from the economic risk assessment process. The level of economic damage is represented by a graduated colour scale which shows the annual average damages per hectare up to the 0.1% AEP event. A sample map is shown in Figure 6-2 and the full set is available at the Local Authority's offices.

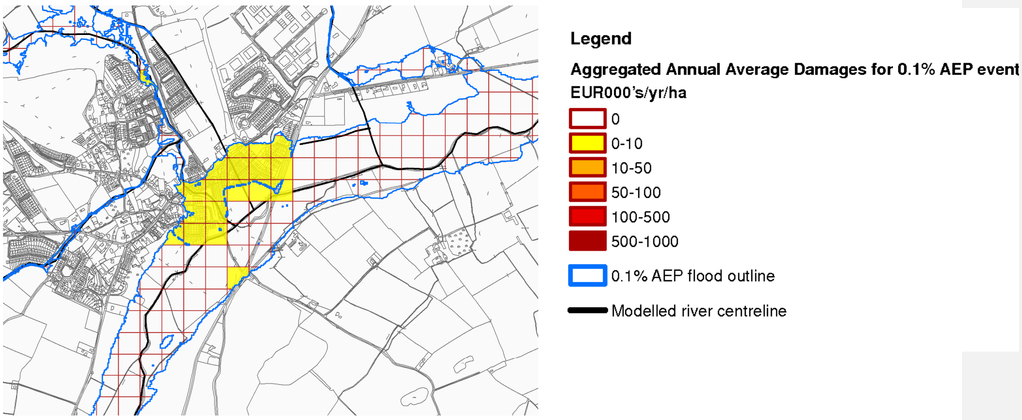


Figure 6-2 Sample economic risk map

6.7.2. Economic damage to properties

One way of assessing the different levels of flood risk across the FEM study area is to estimate the potential economic damages resulting from flooding. Economic damages occur where floodwater gets above the threshold level of a building, for example, an entrance door to a building. Some properties located within the flood extent may not incur economic damage as their threshold level may be above the flood level (i.e. flood water does not enter the property). Chapter 5 of the Preliminary Options Report (December 2010) provides details on the assessment of flood risk (economic).

Table 6-5 provides details of the economic damages to properties in the study area for the 0.1% AEP flood events for individual APSRs. Only APSRs that have economic damage are listed in this table and the 16 APSRs which do not accrue economic damage are listed in Table 6-6. Figure 6-3 provides a graphical representation of the economic damages to properties in the study area for the 0.1% AEP flood event.

Table 6-5 Economic damages for properties at risk in the APSRs for the 0.1% AEP

ASPR	Economic damages
Duleek area	€ 2,997,975
Oldtown area	€ 2,402
Ballyboghil area	€ 247,223
Ratoath area	€ 1,112,156
Ashbourne area	€ 196,456
Rowlestown East area	€ 390,295
Owens Bridge area	€ 182,682
N2 - Coolatrath Bridge area	€ 1,071
St Margarets, Dublin Airport, Belcamp and Balgriffin areas	€ 1,273,138
Kinsaley Lane area	€ 14,794
Portmarnock and Malahide areas	€ 4,886,485
Swords area	€ 2,042,493
Rush area	€ 1,392,791
Skerries area	€ 3,040,783
Balbriggan area	€ 620,436
Julianstown area	€ 11,067
Laytown, Bettystown and Coastal area	€ 1,989,468
Baldoyle area APSR	€ 51,011
Total APSR	**€ 20,452,732**

Table 6-6 APSRs that do not accrue economic damage for the 0.1% AEP

ASPR that do not accrue economic damage for the 0.1% AEP
Donacarney and Donacarney Little area
Kentstown (R150/R153 crossing) area
Garristown area
Naul area
Area to the southeast of N2/Hurley crossing
Stamullin area
Rowans Little area
Turvey Bridge area to the west of Donabate
Donabate area
Lusk area
Dunshaughlin area
Killeek area
Ballymacartle area
Portrane area
Gormanston and Gormanston Demesne area
Military Aerodrome (south to Irishtown)

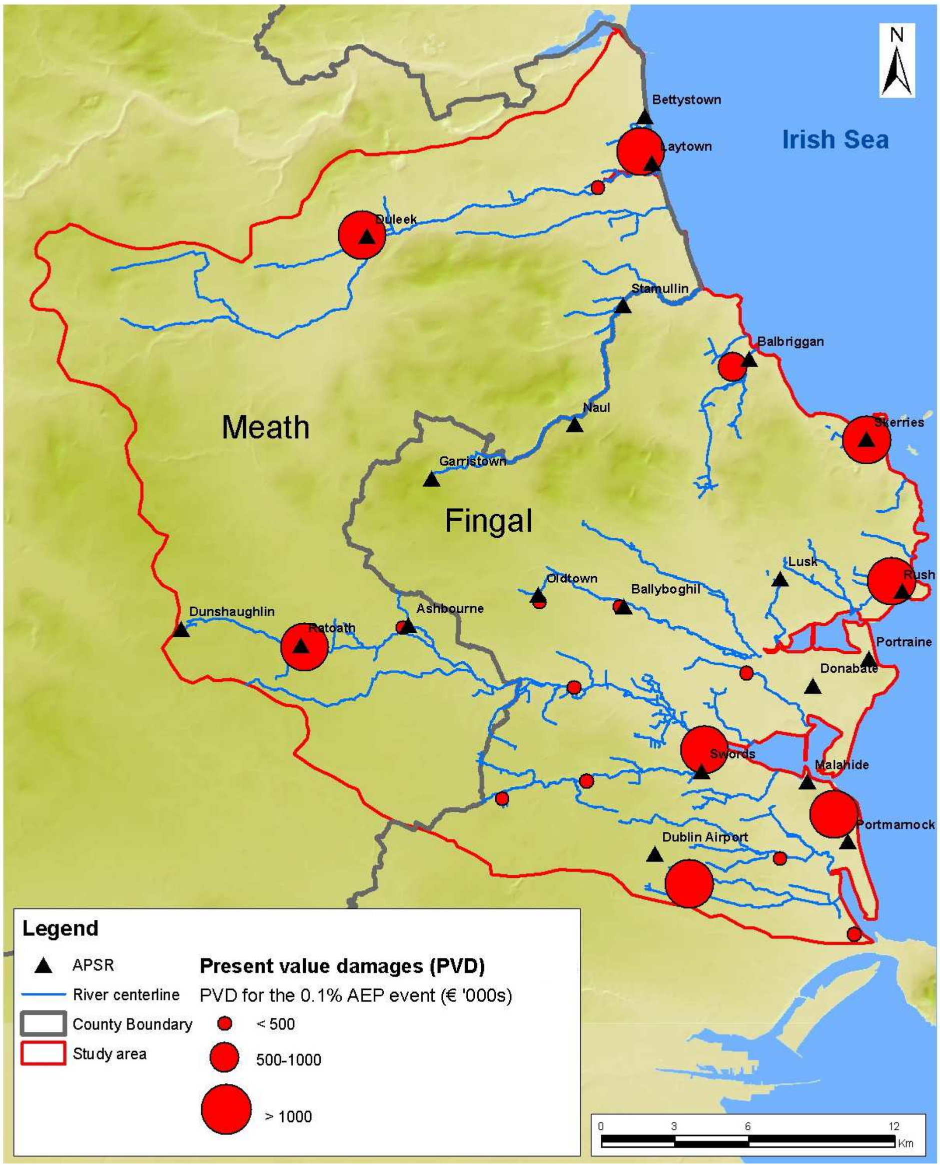


Figure 6-3 Graphical representation of economic risk areas in the study area (current scenario 0.1% AEP)

The results of the economic risk assessment indicate that the most significant economic risk is located along the coast. Portmarnock and Malahide areas APSR has the highest economic risk with properties exposed to tidal flood risk from the Broadmeadow estuary in Malahide and from fluvial and tidal flooding from the Sluice River and Sluice River estuary at Strand Road (Portmarnock).

A review of the economic risk data indicates that the majority of properties in the study area don't accrue economic damages for the more frequent AEP events. Most of the economic risk occurs for flood events greater than the 4% AEP event. Table 6-5 demonstrates that there are some APSRs where there is no economic damage. However, there are 14 APSRs where economic damage does occur and measures and options are therefore required for these areas.

The assessment of economic damages up to the 1% AEP event is used to determine the economic viability of flood risk management options. A benefit cost ratio (BCR) is determined for each option. The BCR is the economic benefit which a flood risk management option provides when compared to the costs of the implementation of the option.

6.8. Existing flood risk management

A number of flood risk management activities currently exist in the Fingal East Meath study area that limit the amount of flood risk in both urban and rural areas. These management activities include:

- Existing defence structures;
- Preparation of a flood risk assessment for new developments in flood risk areas, and
- Sustainable Drainage Systems (SuDS) (both FCC and MCC are responsible for overseeing compliance with the GDSDS SuDS policy document as a function of the Development Management process).

Two types of defence structures were identified for the FEM FRAMS. These are:

- Formal defences (e.g. the flood defence embankments and walls in Duleek which were constructed as part of a flood alleviation scheme for Duleek or flap valves on tidal outfalls) and;
- Informal effective defences (e.g. embankments at the Somerville housing development in Ratoath or other walls).

Table 6-7 lists the defence locations within the study area. These have been inspected and included in the defence asset database. Further details on these defences are included in the Hydraulics Report.

Table 6-7 Defence structure locations

Waterbody & location	Defence Type	Defence classification
Broadmeadow at Ratoath	Raised embankment	Informal effective
Broadmeadow tributary at Ashbourne	Garden/property walls along the tributary	Informal effective
Turvey River at Broadmeadow estuary	Sluice gate tidal defence.	Formal
Nanny and Paramadden	Earth embankment and concrete walls	Formal

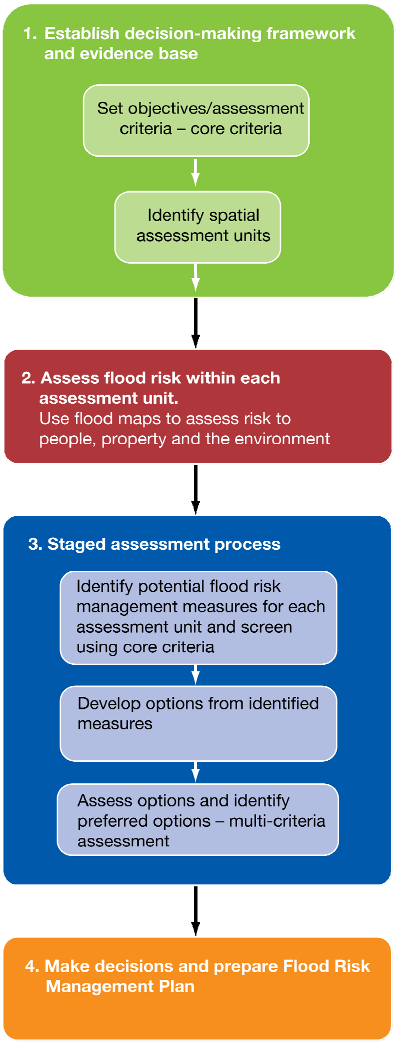
Waterbody & location	Defence Type	Defence classification
Rivers at Duleek	along the left bank of the Nanny River and both banks of its tributary, the Paramadden	
Bracken River in Balbriggan	Some protection provided by garden/property walls along the downstream reach (approx. 300m) (i) RB u/s R132 bridge (ii) & (iii) LB & RB d/s R132 bridge	Informal effective
Mill Stream in Skerries u/s of Holmpatrick Road & along Millers Lane.	Walls	Informal effective
Mayne River at Baldoyle estuary	Sluice gate tidal defence	Formal
Sluice River at Baldoyle estuary	Sluice gate tidal defence	Formal
Coastal	Combination of defences along the coast including natural sand dunes, quay walls and walls	Formal and informal effective

As required under the Planning System and Flood Risk Management Guidelines, November 2009, flood risk assessments are required for new developments where the site is believed to be at risk of flooding. This requirement has been implemented in both Fingal and Meath County Council.

Fingal and Meath County Councils require developers to include proposals for SuDS in their developments to limit the surface water run-off after construction to pre-construction "Greenfield" levels. Both councils adopt the best practice guidance on the design of SuDS contained in the Greater Dublin Strategic Drainage Study (2005). Further details on SuDS are included in the Hydraulics Report.

7. Flood risk management options

7.1. Introduction



The key output of the CFRAM Studies is a set of preferred options to manage flood risk in the study area, which are then developed into a flood risk management strategy and plan.

The flood maps identify locations within the study area at risk from economic, social and environmental flood risk. Where the risks are significant, this study identifies a range of potential options to reduce these risks. An option assessment process has been developed, as illustrated in Figure 7-1, and used to ensure that the assessment of flood risk management options is evidence-based, transparent, and inclusive of stakeholder and public views. The methodology is a nationally agreed approach to the development of flood risk management options which is transferable to other FRAMS in Ireland.

The key steps in the optioneering process, as follows:

1. Establish the decision making framework and evidence base;
2. Assess flood risk within each assessment unit;
3. Staged assessment process;
    - Stage 1 - Preliminary screening of flood risk management measures;
    - Stage 2 - Development of potential options from short listed measures;
    - Stage 3 - Appraisal of potential options using multi-criteria assessment.
4. Make decisions and prepare the Flood Risk Management Plan.

Figure 7-1 Flow chart of the option development process

The design standard for consideration of options is either the 1% AEP (fluvial) or 0.5% AEP (tidal). If there is clear benefit to deviating from this standard, then this option will be considered (i.e. providing protection up to a lower (e.g. 2% AEP) or higher standard (e.g. 0.1% AEP). Options are only considered to protect existing property and assets at risk of flooding and are not considered for undeveloped zoned land.

The options assessment process is described in detail in the Preliminary Options Report (December 2010) and the draft Final Report and a brief summary is provided in this section of the plan.

7.2. Establish the decision making framework and evidence base

7.2.1. Flood risk management objectives

The use of flood risk management objectives was integral to the option assessment process. The purpose of the FRM objectives is to provide a basis by which the flood risk management measures and options can be assessed. The sixteen objectives have been developed by the OPW and are generic in nature. The minimum and aspirational targets associated with each objective are designed to be study specific and have been agreed with the steering group and stakeholders (including all relevant SEA-related objectives identified within the Environmental Scoping Report (2009)) and cover four core criteria.

Table 7-1 FRM objectives

Core criteria	Objectives
Technical	Operationally robust
	Health and Safety
	Sustainability of FRM options
Economic	Economic risk
	Risk to transport infrastructure
	Risk to utility infrastructure
	Risk to agricultural land
Social	Risk to human health and life
	Risk to community
	Risk to social amenities
Environmental	Requirements of the Water Framework Directive
	Requirements of the Habitats Directive
	Risks from pollution
	Flora and fauna

Core criteria	Objectives
	Fisheries
	Landscape character
	Cultural heritage

Associated with each of the objectives are sub-objectives, indicators, minimum targets and aspirational targets. This information was used to assess options of the staged assessment process, i.e. multi criteria assessment (MCA), with options scored on how well they perform in meeting the minimum and aspirational targets. The full list of objectives used as part of the option development process can be found in Appendix B.

7.2.2. Identify spatial assessment units

The study area was split into four assessment units which allowed for measure and options to target the right areas. The assessment units are defined at four spatial scales as shown in Figure 7-2:

- Catchment scale: in this case the FEM FRAM study area;
- Analysis Unit (AU) scale: these are large sub-catchments or areas of tidal influence;
- Areas of Potential Significant Risk (APSRs): these are urban areas (existing or zoned for future development) with the potential for flood risk; and
- Individual Risk Receptors (IRRs): these are essential infrastructure assets or environmental sites with significant pollution potential identified as being at significant risk of flooding.

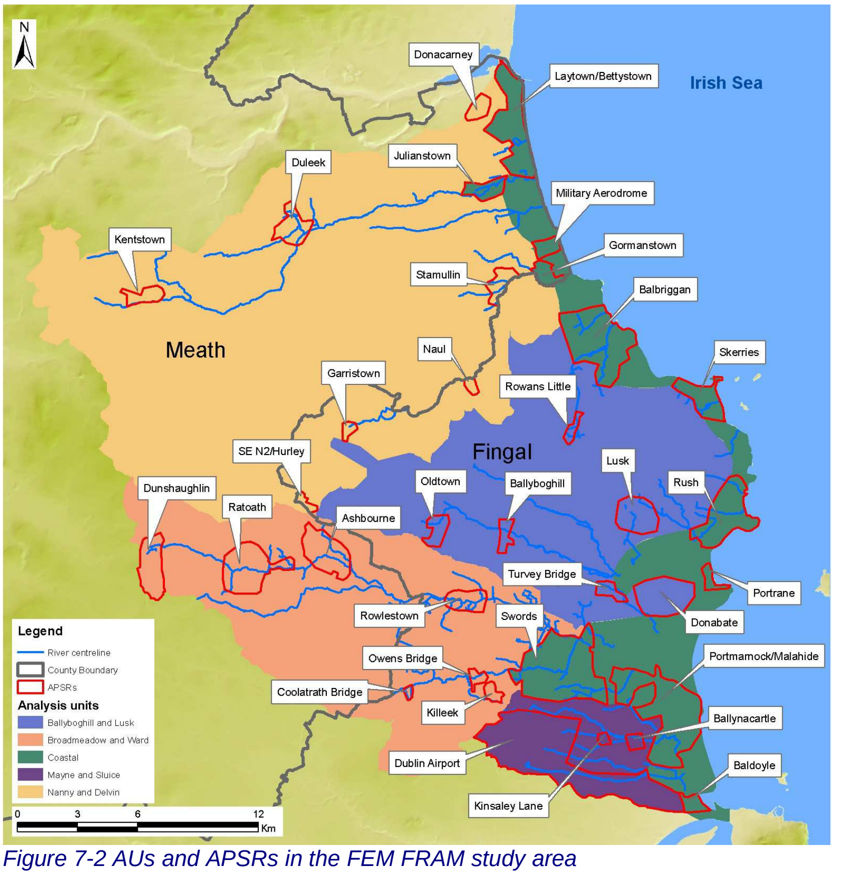


Figure 7-2 AUs and APSRs in the FEM FRAM study area

7.3. Assess flood risk within each assessment unit

The work carried out to date has resulted in the development of hydraulic models of the rivers which were then used to provide the data for the flood hazard maps. As described in Sections 5 and 6, these maps identify the locations within the FEM study area that are at risk from economic, social and environmental flood risk. Where these risks are significant the study then identifies a range of potential options to reduce these risks.

7.4. Staged assessment process

7.4.1. List of potential measures

A list of potential flood risk management measures, both structural and non-structural was developed for the study area. These potential measures are listed in Table 7-2.

Table 7-2 List of potential measures

Long list of measures
Baseline – Do nothing (assuming any current maintenance and management regime continues)

Long list of measures	
Do minimum	
1	Reduce existing activities
2	Proactive maintenance
Non-structural / minor & localised modifications	
3	Develop a flood forecasting system
4	Targeted public awareness and education campaign
5	Individual property protection/flood proofing
6	Sediment Management
7	Land Management
Structural measures	
8	Sustainable Urban Drainage Systems (SUDS)
9	Rehabilitation, improvement of existing defences
10	Improvement in channel conveyance
11	Provision of permanent flood walls/ embankments
12	Provision of demountable flood defences
13	Use of overland floodways (e.g. allowing flooding of roads in a controlled manner)
14	Flow diversion (full diversion / bypass channel, flood relief channel, etc.)
15	Flood storage reservoirs
16	Beach Recharge/sand dunes
17	Groynes
18	Breakwater
19	Managed realignment
20	Tidal barrier/Tidal barrage
21	Relocation of at risk assets (roads, properties, etc)

7.4.2. Stage 1 – identification of flood risk management measures

The first stage of the assessment process is discussed in detail in the Preliminary Options Report (December 2010). Stage 1 involved an initial screening of the list of potential measures for each assessment unit to filter out any measures which were not suitable. The remaining measures were then evaluated against the core objectives (technical, economic, social, environmental), to provide a short list of measures for each assessment unit. The stage 1 assessment identified a number of viable flood risk management measures for the AUs, APSRs, localised areas and the IRRs which were then considered further.

A summary of the results for stage 1 for each assessment unit is included in Appendix B of the Draft Final Report.

7.4.3. Stage 2 – development of potential options

Stage 2 and Stage 3 of the options assessment process is discussed in detail in the Draft Final Report. The short list of measures for each assessment unit was reviewed and developed into potential flood risk management options. The options are made up of either a single, or a combination of, measures carried forward from stage 1.

A summary of the results for stage 2 is included in Appendix C of the Draft Final Report.

7.4.4. Stage 3 – assessment of potential options

The stage 3 assessment of potential options used a detailed multi criteria analysis (MCA) process to score the performance of each option in managing flood risk relative to the baseline flood risk data for each of the sixteen flood risk management objectives. Each objective was weighted to reflect its importance and/or sensitivity, and ensure that those objectives most relevant to the location under consideration were given priority in the decision-making process.

- **Global weightings** were developed by the OPW and are fixed nationally. This weighting recognises the key drivers behind FRM options and gives higher weightings to risk to human health and life and economic return on options.
- **Local weightings** take into account local conditions and concerns. They vary for each assessment unit depending on the level of applicability of that objective to that unit. The OPW and FCC arranged for a local weightings questionnaire to be issued to key stakeholders in the study area so that their information and concerns could be taken into account in the local weighting score.

7.4.5. Scoring of options

The performance of each option, relative to defined baseline conditions (the present day situation) was scored for each of the 16 FRM objectives (Table 7-1 FRM). Following scoring, for each objective, a weighted score (weighted score = global weighting x local weighting x option performance score) was then calculated for each option as shown in Table 7-3. A total MCA score was then calculated for each objective as the sum of the weighted scores across the 16 objectives for each option. This MCA score reflected the performance of the option in terms of the study's objectives. All FRM options with a positive MCA score were carried forward to the final stage of the process – the identification of the preferred options.

Table 7-3 Scoring of options

Objectives	Global Weighting (GW)	Local Weighting (LW)	Option performance (relative to baseline, where 0 = no change)	
			Score (S)*	Weighted Score (WS)
Technical	5	0 – 5	-999 to + 5	WS = (GW x LW) x S
Economic	5 – 25	0 – 5	-999 to + 5	WS = (GW x LW) x S
Social	5 – 30	0 – 5	-999 to + 5	WS = (GW x LW) x S
Environmental	5 – 15	0 – 5	-999 to + 5	WS = (GW x LW) x S
				MCA score = Total WS (all objectives)

7.5. Preferred options

The preferred options for the study area, analysis units and APSRs are presented in Table 7-4. This table also includes the MCA score, the benefit cost ratio and the estimated cost of the option.

Only options for the individual AUs, APSRs and the study area as a whole, which have positive MCA scores from the detailed option evaluation process, are included in the FRMP. The options incorporate the feedback from the public consultation process and from the stakeholder workshops.

*Table 7-4 Options with a positive MCA from the detailed options evaluation (potential options in **bold** are those proposed to be taken forward to development of cohesive options)*

Assessment Unit	Potential options	MCA Score	BCR
Study Area as a whole	**1. Proactive maintenance** **2. Targeted public awareness and preparedness campaign and individual property flood proofing**	**345** **125**	**0.9** **0.85 (3 with FFWS)**
Nanny and Delvin AU	**1. Flood forecasting and warning system (Nanny River)**	**225**	**1.2 (4.9 with IPFP)**
Duleek (Duleek APSR)	**1. Raising existing defence embankment to a higher standard of protection (to protect up to 0.1% AEP)**	**375**	**1.1**
Broadmeadow & Ward AU	**1. Flood forecasting and warning system (Broadmeadow River)**	**225**	**0.8, (3.2 with IPFR)**
Ratoath (Ratoath APSR)	**1. Improving channel conveyance by replacing a bridge on the Broadmeadow River at the R125 Ratoath Road and replacing a culvert on a tributary of the Broadmeadow River**	**385**	**0.9, (0.9 at 0.1% AEP)**
Rowlestown East (Rowlestown East APSR)	**1. Construction of flood defence embankments along left bank of Broadmeadow River tributary upstream of R125**	**225**	**2.2**
Mayne & Sluice AU	**1. Develop a fluvial FFWS for the Mayne River only**	**225**	**0.4 (1.6 with IPFP)**
Balgriffin (St Margaret's, Dublin Airport, Belcamp & Balgriffin area APSR)	1. Improve channel conveyance by replacing existing culverts together with construction of flood defence embankments & walls upstream of R123 and along left bank of Mayne River and tributary **2. Improve channel capacity by removing an existing unused bridge together with construction of flood defence embankments & walls upstream of R123 and along left bank of Mayne River and tributary**	340 **340**	1.2 **1.3**
Coastal AU	**1. Fluvial & tidal flood forecasting and warning system**	**225**	**2.1 (7.3 with IPFP)**
Strand Road, Portmarnock (Portmarnock & Malahide areas APSR)	**1. Rehabilitating and raising existing coastal defences at Strand Road (including rehabilitation walls and flapped outfall) and construction of flood defence embankment** 2. Rehabilitating flapped outfall on Sluice River and construction of flood defence	**95**	**1.0**

Assessment Unit	Potential options	MCA Score	BCR
	embankments and walls to protect at risk properties at Strand Road	-25	2.7
Malahide town centre (Portmarnock & Malahide areas APSR)	**1. Construction of demountable flood defences at underpass along with embankments to protect at risk properties in Malahide town centre** 2. Construction of demountable flood defences along coast road with embankments to protect at risk properties in Malahide town centre	**350** 350	**1.2 (6.2 with FFWS)** 0.6 (0.9 with FFWS)
Aspen (Swords) (Swords area APSR)	**1. Improve channel conveyance by widening and deepening of the Gaybrook Stream to reduce fluvial flood risk to properties at Aspen near Kinsaley**	**195**	**3.6**
Rush (Rush area APSR)	**1 Construction of secondary culvert along Channel Road to protect properties at risk from fluvial flooding along the Rush West stream.**	**430**	**0.7 (0.9 at 0.1% AEP)**
Skerries (Skerries area APSR)	**1. Improve channel conveyance by replacing culverts under roads and railway with larger capacity culverts and widening channel through park to reduce fluvial flood risk to properties at Millar Lane and Sherlock Park** 2. Construction of storage reservoir to the west of railway embankment to provide flood storage upstream of Skerries Area APSR to reduce fluvial flood risk to properties along Miller Lane and Sherlock Park	**505** 325	**1.3** 2.7
Laytown (Laytown, Bettystown & coastal area APSR)	**1. Construction of flood defence embankments to protect properties at risk along the coast and from the Nanny River**	**140**	**1.2**

7.6. Cohesive options

7.6.1. Introduction

Potential options for the individual AUs, APSRs and the study area as a whole, which have positive MCA scores from the detailed option evaluation process, are listed in Table 7-4.

The options listed in Table 7-4, along with feedback from public consultation and stakeholder involvement, point the way towards the major components of the FEM FRMP, but they required further consideration in terms of consistency, mutuality, dependency etc to produce cohesive options that will effectively manage the flood risk in the study area now and in the future.

Table 7-4 shows that in the majority of locations there is only one viable option. Where there is more than one option, the option with the higher MCA score has been selected as the preferred option. Where two options have equal MCA scores, the option with higher MCA/cost score is selected as the preferred option (in **bold**). The two options for the study area are both shown as preferred options as they are complimentary options rather than alternative options, as discussed below.

When developing cohesive options, consideration is given to both spatial and temporal cohesion. This is required to take account of potential impacts of options in different locations and at different spatial scales (e.g. catchment scale and analysis unit scale) on each other, as well as the timeline for implementation of different options or the potential dependency of one option on another being implemented (e.g. an option incorporating demountable defences may be dependent on a separate option at a different spatial scale being implemented).

As can be seen in Table 7-4 the majority of options that have come through the options assessment process with a positive MCA score are independent of each other. However, there are a number of options, particularly at catchment scale and analysis unit scale, which are mutually beneficial or dependent. This is further discussed in Section 9.2.

7.7. Assessment of potential options for IRRs

An individual risk receptor is an individual asset of particular economic or social value that has been identified as being prone to flooding and hence represents a significant risk in its own right, such as transport and utilities infrastructure, which may require specific consideration during the development of the flood risk management options.

The full three stage option assessment process was not used to determine an MCA score for an Individual Risk Receptor (IRR). IRRs tend to be isolated structures and in most cases can be protected by local defences such as a flood embankment or wall

Table 9-2 summarises the preferred options for the IRR and Figure 9-4 shows the locations of the IRRs in the study area.

The preferred options for flood management at the individual risk receptors are subject to discussion with the owners, usually the local authorities but also the National Roads Authority in the case of the M1 Dublin to Belfast motorway which floods at Staffordstown. The purpose of these discussions will be to agree an appropriate course of action and the responsibility for the implementation of the action.

7.8. Flood risk areas not included in the preferred options

Due to the complex nature of the flood risk in the study area, that is flood risk arising from many small watercourses, risk to very small clusters of properties and a combination of fluvial and tidal risk in many areas, lengthy discussions were held to determine the best way forward for the detailed assessment of options and identifying preferred options for the plan. The two main points of discussion were:

- Position of FRM options for localised urban areas outside of APSRs; and
- Viability of considering individual properties for relocation out of the floodplain.

Following the discussions it was agreed to only consider specific structural options for properties within APSRs. It was also agreed not to include options for relocating existing properties out of the floodplain in the stage 3 assessment. Instead information on clusters of properties and individual properties at significant risk of flooding but outside of APSRs would be provided to the Local Authorities and OPW. Owners of these properties would be advised, by the Local Authority or OPW, of the flood risk and have the option to pursue FRM options being implemented under the OPW Minor Works Programme. Potential options that have been identified for clusters of properties at risk of flooding outside of APSRs are included in Appendix H of the draft Final Report.

8. Environmental considerations

8.1. Introduction

The FEM FRMP is subject to a Strategic Environmental Assessment (SEA) to meet the requirements of the transposing Irish Regulations[8]. This draft version of the FEM FRMP is accompanied by an SEA Environmental Report (ER), which documents the SEA process and outcomes. The SEA ER identifies, evaluates and describes the likely significant effects on the environment of implementing the draft FEM FRMP, and recommends how identified adverse effects can be mitigated, communicated and monitored. Key recommendations of the SEA process are summarised in Section 9.6.2.

The overall aim of the SEA Directive is to '*provide a high level of protection of the environment and to contribute to the integration of environmental considerations into the preparation and adoption of plans and programmes with a view to promoting sustainable development*.'

To achieve this, environmental constraints and opportunities relating to flood risk management within the Fingal and East Meath study area (see Section 6.4) have been considered throughout the development of the FEM FRMP. This integrated approach has sought to ensure that environmental considerations are embedded within decision-making and that the environmental impacts of the recommendations of the FEM FRMP are minimised.

In addition, the SEA has included specific consideration of the impacts of the FEM FRMP on the sites of European nature conservation importance (*Natura 2000* sites) within the study area (Figure 7-1), as required under the EU Habitats Directive[9] and the transposing Irish regulations[10]. The results of this assessment (referred to as an 'appropriate assessment') are integrated within the SEA process, and are documented separately in the SEA ER. Key recommendations of the 'appropriate assessment' are summarised in Section 9.6.2.

The SEA process has also provided a framework for consultation with stakeholders and the general public throughout the development of the FEM FRMP, as described in Section 2.

Following consultation on the draft FEM FRMP, the publication of the final FRMP, which will be amended to take into account comments received on the draft FRMP, will be accompanied

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[8] The European Communities (Environmental Assessment of Certain Plans and Programmes) Regulations 2004 (Statutory Instrument Number 435 of 2004) (the SEA Regulations)

[9] EU Council Directive 92/43/EEC on the Conservation of Natural Habitats and Wild Fauna and Flora (the 'Habitats Directive')

[10] The European Union (Natural Habitats) Regulations, SI 94/1997, as amended. Note that these regulations are being updated and the *Draft European Communities (Birds and Natural Habitats) Regulations 2010* were subject to consultation in 2010.

by a SEA Statement documenting the impacts of the changes to the final FRMP and its overall environmental effects.

8.2. Environmental constraints and opportunities in the study area

Broadmeadow estuary

The Fingal and East Meath study area contains a wealth of features of biodiversity, cultural, social, archaeological and landscape value; and its watercourses, estuaries and coastal waters provide a range of environmental services, including drinking water, fisheries, habitat for flora and fauna, industry and amenity.

Many of the environmental features within the study area are afforded protection under international/national legislation and/or local planning policy. The environmental features located within the floodplains of the study area and at risk from flooding or affected by proposed flood risk management options have been specifically considered during the preparation of the FEM FRMP. These include:

- Habitats and species of nature conservation and biodiversity value located within and outside EU-designated *Natura 2000* sites (i.e. Special Protection Areas (SPA) and Special Areas of Conservation (SAC)); and nationally important Natural Heritage Areas (NHAs);
- Archaeological sites and features listed on the national Sites and Monuments Records and the Meath and Fingal Records of Monuments and Places; and structures of architectural significance listed on the Meath and Fingal Records of Protected Structures and within Architectural Conservation Areas (see Figure 8-1);
- Fisheries within the rivers, estuaries and coastal waters, including designated Shellfish Waters;
- Areas of significant landscape character and scenic value designated under the Meath and Fingal Development Plans; and
- Requirements for the protection and improvement of water quality and the ecological status of water bodies under the EU Water Framework Directive, Bathing Waters Directive and national legislation.

Nanny estuary

The development of the FEM FRMP has incorporated relevant environmental issues, constraints and opportunities within the plan-making process – taking into account the sensitivity and value of relevant environmental features identified through the SEA process as identified in Section 6.4.

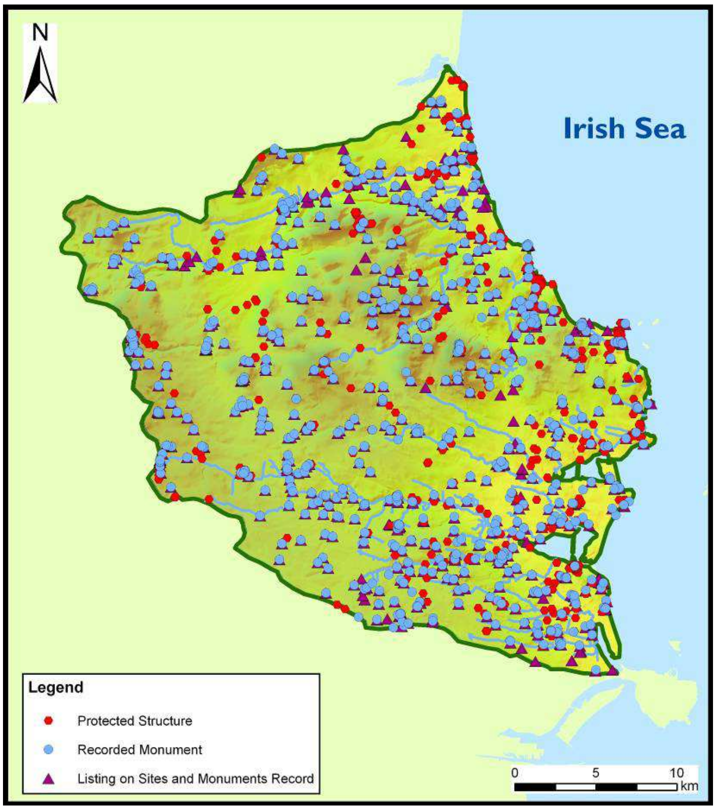


Figure 8-1 – Features of archaeological and architectural heritage importance within the study area (Source: Fingal and Meath County Councils)

8.3. Strategic Environmental Assessment

The approach to the SEA of the FEM FRMP has drawn from Irish[11] and international best practice guidance. The SEA is a multi-staged process as shown on Figure 8-2, feeding into plan development at key stages as described in Section 6.4.

[11] *Development of Strategic Environmental Assessment (SEA) Methodologies for Plans and Programmes in Ireland – Synthesis Report* (Environmental Protection Agency (EPA), 2003) and associated Final Report; *Implementation of SEA Directive (2001/42/EC): Assessment of the Effects of Certain Plans and Programmes on the Environment. Guidelines for Regional Authorities and Planning Authorities* (Department of Environment, Heritage and Local Government, 2004); *Strategic Environmental Assessment – SEA Pack* (EPA, 2008); *Consultation Draft of the GISEA Manual* (EPA, 2009)

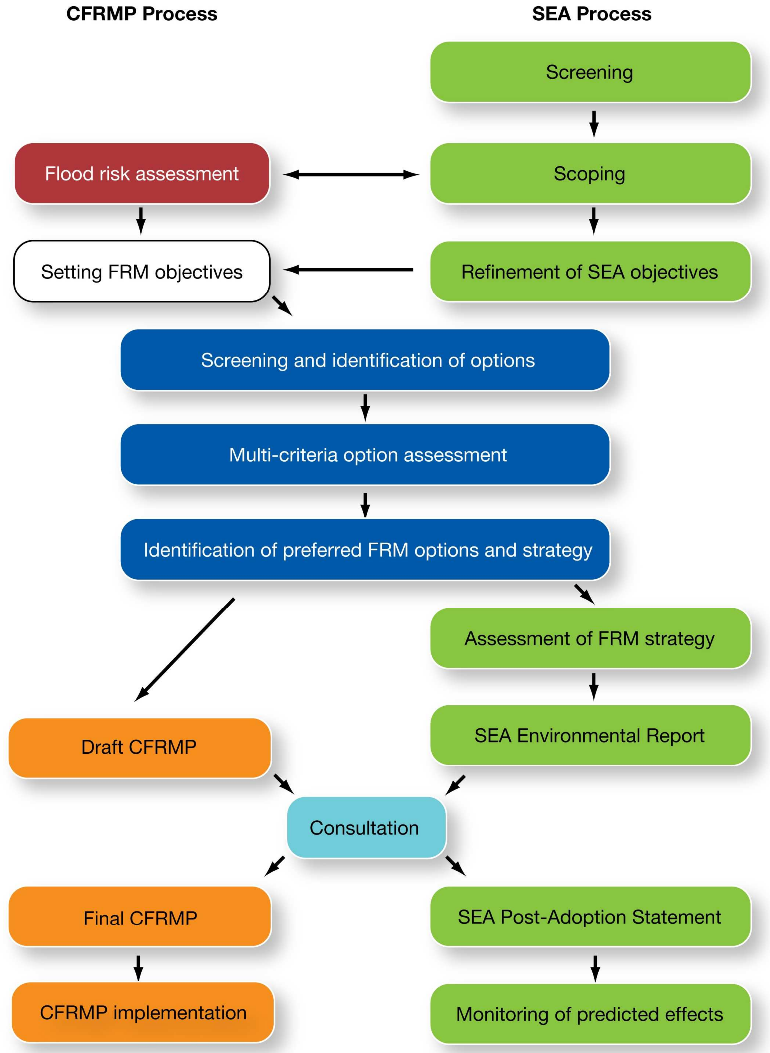


Figure 8-2 Key stages of the SEA process

A key stage of the SEA process was the publication of an Environmental Scoping Report in 2009, when comments were sought from stakeholders and the general public during a three month consultation period. This report documented the scoping process and presented its key output – a set of environmental objectives for the study area – which reflected the key environmental issues within the study area relating to flood risk management (see Appendix B). Following consultation, these objectives were incorporated within the overall flood risk management objectives for the study and together with their associated sub-objectives, indicators and targets, formed part of the multi-criteria option assessment process described in Section 7.4. These SEA objectives are shown in Table 8-1.

Table 8-1 The SEA objectives for the FEM FRMP

SEA topic	SEA objective	FRM objective category
Population and human health	Minimise risk to human health and life	Social
	Minimise risk to community	
	Minimise risk to, or enhance, social amenity	
Material assets	Minimise risk to transport infrastructure	Economic
	Minimise risk to utility infrastructure	
Soil/Land use	Manage risk to agricultural land	
Biodiversity, fauna and flora	Avoid damage to, and where possible enhance, the flora and fauna of the study area	Environmental
Fisheries	Avoid damage to, and where possible enhance, fisheries within the study area	
Landscape	Protect, and where possible enhance, landscape character and visual amenity within the study area	
Cultural heritage	Avoid damage to or loss of features of cultural heritage importance, their setting and heritage value within the study area	
Water	Minimise risk of environmental pollution	
	Support the objectives of the WFD	

These objectives were then used to determine the environmental effects of the preferred flood risk management options recommended within the draft FEM FRMP, as described within the SEA ER. Where adverse environmental effects were predicted, appropriate mitigation requirements and a monitoring framework are also identified.

Specific details of the environmental assessment of each of the preferred options recommended within this draft FRMP are presented in the SEA ER. Details of the environmental performance of these preferred options relative to the available alternative flood risk management options are also described in the SEA ER.

8.4. Habitats Directive Appropriate Assessment

An 'appropriate assessment' of the impacts of the draft FEM FRMP on sites of European nature conservation importance (*Natura 2000* sites) has also been undertaken. This specific assessment considers whether the recommendations of the draft FEM FRMP are likely to have an effect on the ecological integrity of 14 *Natura 2000* sites within and adjacent to the study area as shown on Figure 8-3. The results of the appropriate assessment, including both an initial screening stage and a subsequent, more detailed, assessment are reported in the SEA ER.

Figure 8-3 Internationally designated nature conservation sites within the study area (Source: Department of Environment, Heritage and Local Government (DEHLG); National Parks and Wildlife Service (NPWS))

9. Flood risk management strategy

9.1. Introduction to the Strategy

The final objective of the Fingal East Meath FRAMS is to prepare a strategic Flood Risk Management Plan (FRMP), and associated Strategic Environmental Assessment (SEA), that sets out the measures and policies that should be pursued by Fingal County Council (FCC), Meath County Council (MCC) and the Office of Public Works (OPW) to achieve the most cost-effective and sustainable management of flood risk within the Fingal East Meath study area in the short, medium and long-term.

This is the draft FRMP for consultation, and the SEA ER is an accompanying report.

This Plan summarises the component parts of the study, which are reported in detail in separate technical reports, and this Section develops the findings into the FRMP. Viable structural and non-structural measures and options for managing the flood risks have been identified through the option assessment process. This is described in the Section 7 and the viable options are listed in Table 7-4.

The FRMP does not prescribe solutions to all of the flooding problems that exist in the study area; that would be neither feasible nor sustainable. The purpose of the FRMP is to

- Identifies the measures and flood risk management options that have been shown to be viable in flood risk management terms by the analyses undertaken;
- Set the prioritisation/phasing in terms of development of these options;
- Indicates the further studies and work needed to move forward to implementation of the options; and
- Identifies the requirements for future monitoring and review of the FRMP.

In addition, the FRMP discusses the role of ‘partners’ in the implementation of the Plan, and also the relevance of wider catchment issues, such as land use, land management and urbanisation.

With an understanding of flood risk and its quantification, the strategy for flood risk management seeks to mitigate the impacts of flooding on people’s lives, economic activity and the environment, where it is feasible (technically, economically, socially and environmentally) and sustainable to do so. Inevitably, this approach will not remove all flood risk and, indeed, it would be wrong to do so because that would be ignoring natural processes and is unsustainable.

A flood risk management strategy necessarily incorporates both non-structural and structural measures, all partners/stakeholders, and deals with both present day and potential future flood risk. The findings and recommendations for the Fingal East Meath study area will have to be considered in a national context and assigned an order of priority at that level, subject to time-scale and budget considerations.

Structural measures and flood alleviation schemes receive most public attention when a FRMP is published, and public perception is often that as non-structural measures do not prevent flooding, they are of less value. Flood alleviation schemes are visible and they give the security of protection to the design standard but they can be expensive and, usually, require on-going operation and maintenance. As shown in Figure 9-1, any such scheme will require a pre-construction period for detailed study, investigation and design, which could be quantified in years for major schemes such as flood defences for a large town or city.

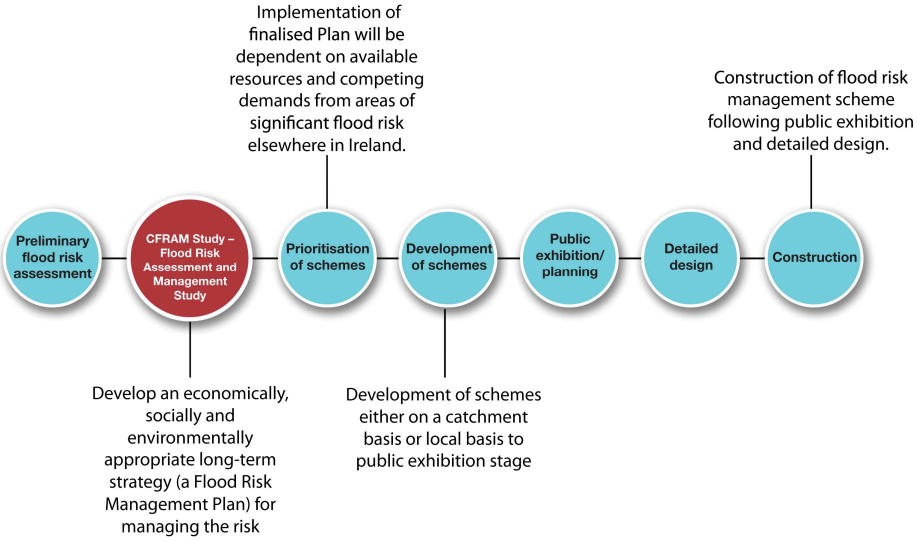


Figure 9-1 Flow chart showing the process through to construction for a scheme

Non-structural measures such as public awareness and flood forecasting, however, are a most important, if not essential, part of the strategy, which can usually be implemented in the short to medium-term at relatively low cost and independent of prioritisation at a national level. They can have benefits in the short, medium and long-term, and, importantly, do much to increase the awareness of the public to flood risk. Collectively, non-structural measures reduce the risk of flooding and there are intangible social benefits through increasing awareness of flood risk and better advising the public on how to take damage reduction action in the event of a flood.

Structural measures to be pursued generally follow the results from the option assessment and multi-criteria analysis (MCA) process, and are assigned prioritisation in the Fingal East Meath study area on this basis. An indication of the overall duration for implementation of the FRMP is given in Section 9.8, along with an indicative programme. The programme is subject to consideration of the Fingal East Meath study area within the national context, and to budget availability, which will be an important determining factor, especially in the short-term while severe recessionary pressures remain.

As a pilot study for catchment-level flood risk assessment and management in Ireland, it is important to incorporate monitoring, review and evaluation of the components into this Plan. This should be established at an early stage in the programme such that the findings can be fed through to other similar studies elsewhere in the country.

9.2. Components of the Fingal East Meath FRMP

The discussions in Section 6 and Section 9.1 above lead to a list of options to be pursued, or components of the FRMP, as indicated in Table 9-1. Figure 9-2 shows the locations of these proposed options. Some explanation of the content of Table 9-1 is as follows:

- Two options (i) Proactive maintenance and (ii) targeted public awareness campaign and individual property flood protection are proposed for the study area as a whole. Both options are recommended equally and can be implemented independently of each other;
- Fluvial flood forecasting and warning systems (FFWS) are recommended for some of the rivers (Nanny, Broadmeadow and Mayne Rivers), as the other rivers have too short a time to peak and therefore a FFWS would be ineffective. Tidal flood forecasting and warning system are proposed for the coastal areas and this should be integrated with the fluvial FFWS and the existing FCC/MCC telemetry systems;
- No other AU level options have been carried forward to the preferred options;
- At APSR level the proposals are generally for the construction of flood embankments/walls, improvements in channel conveyance through river widening and/or culvert replacement, installation of demountable defences have been proposed for Malahide, and replacement/rehabilitation of flap valves;
- The option to raise the existing flood defences to the 0.1% AEP standard in Duleek has positive MCA and BCR scores. While the standard of protection is the 1% AEP this study has identified a high level of residual risk in Duleek when looking at the 0.1% AEP. Based on this it is considered that there may be some economic benefit in giving increased protection to Duleek. The option for increasing protection to properties in Duleek shall not be considered for implementation in the short term but shall be monitored and reviewed in the next cycle of the CFRAM process in 2015. The responsibility for this shall be with the OPW;
- The preferred option to protect at risk properties in Malahide town centre incorporates the use of demountable flood defences to prevent tidal flooding of a significant number of properties. While costs of incorporating a tidal flood forecasting system in the option have been considered (giving a BCR of 1.2) significantly greater benefit can be achieved if this option is linked with the Coastal AU tidal flood forecasting and warning option (BCR of 6.2); and
- It is noted that the BCR for some options significantly increase if combined with other viable options, these include;
  - targeted public awareness campaign and individual property flood protection combined with flood forecasting and warning systems;
  - flood forecasting and warning systems combined with individual property flood protection; and
  - Construction of demountable defences in Malahide combined with flood forecasting and warning systems.

Table 9-1 Components of the FRMP

Assessment unit	Preferred options	MCA Score	BCR	Cost €million	Comments
Study Area as a whole	• Proactive maintenance • Targeted public awareness and preparedness campaign and individual property flood proofing	345 125	0.88 0.85 (2.96 with FFWS)	1.7 4.1	Both of these options ranked equally as they are completely independent and both be implemented.
Nanny and Delvin AU	• Flood forecasting and warning system (Nanny River)	225	1.24 (4.94 with IPFP)	0.5	System to be compatible with the FCC/MCC telemetry system.
Duleek (Duleek APSR)	• Raising existing defence embankment to a higher standard of protection (to protect up to 0.1% AEP)	375	1.07	2.8	Recommended option included in the Plan but for potential longer term implementation.
Broadmeadow & Ward AU	• Flood forecasting and warning system (Broadmeadow River)	225	0.81 (3.22 with IPFR)	0.5	System to be compatible with the FCC/MCC telemetry system.
Ratoath (Ratoath APSR)	• Improving channel conveyance by replacing a bridge on the Broadmeadow River at the R125 Ratoath Road and replacing a culvert on a tributary of the Broadmeadow River	385	0.9 (0.94 at 0.1% AEP)	1.1	Further work to determine if positive BCR can be achieved.
Rowlestown East (Rowlestown East APSR)	• Construction of flood defence embankments along left bank of Broadmeadow River tributary upstream of R125	225	2.23	0.2	
Mayne & Sluice AU	• Develop a fluvial FFWS for the Mayne River only	225	0.41 (1.64 with IPFP)	0.5	System to be compatible with the FCC/MCC telemetry system.
Balgriffin (St Margaret's, Dublin Airport, Belcamp & Balgriffin area APSR)	• Improve channel conveyance by removing old bridge structure combined with construction of flood defence embankments & walls upstream of R123 and along left bank of Mayne River and tributary	340	1.27	0.8	
Coastal AU	• Fluvial & tidal flood forecasting and warning system	225	2.08 (7.29	1.8	System to be compatible with the

Assessment unit	Preferred options	MCA Score	BCR	Cost €million	Comments
			with IPFP)		FCC/MCC telemetry system.
Strand Road, Portmarnock (Portmarnock & Malahide areas APSR)	• Rehabilitating and raising existing coastal defences at Strand Road (including rehabilitation walls and flapped outfall) and construction of flood defence embankment	95	1.0	1.6	
Malahide town centre (Portmarnock & Malahide areas APSR)	• Construction of demountable flood defences at underpass along with embankments to protect at risk properties in Malahide town centre	350	1.2 (6.2 with FFWS)	0.4	Traffic management required when demoutable defences in place.
Aspen (Swords) (Swords area APSR)	• Improve channel conveyance by widening and deepening of the Gaybrook Stream to reduce fluvial flood risk to properties at Aspen near Kinsaley	195	3.57	0.1	
Rush (Rush area APSR)	• Construction of secondary culvert along Channel Road to protect properties at risk from fluvial flooding along the Rush West stream.	430	0.74 (0.88 at 0.1% AEP)	0.6	Further work to determine if positive BCR can be achieved.
Skerries (Skerries area APSR)	• Improve channel conveyance by replacing culverts under roads and railway with larger capacity culverts and widening channel through park to reduce fluvial flood risk to properties at Millar Lane and Sherlock Park	505	1.25	1.5	Consultation with Irish Rail required during the detailed design phase of this measure.
Laytown (Laytown, Bettystown & coastal area APSR)	• Construction of flood defence embankments to protect properties at risk along the coast and from the Nanny River	140	1.21	1.4	Detail design stage to look at access to the car park. Costing included provision for drainage works behind the new embankments.
Individual Risk Receptors – Refer to Table 9-2 for options					

Figure 9-2 shows the locations of these preferred options.

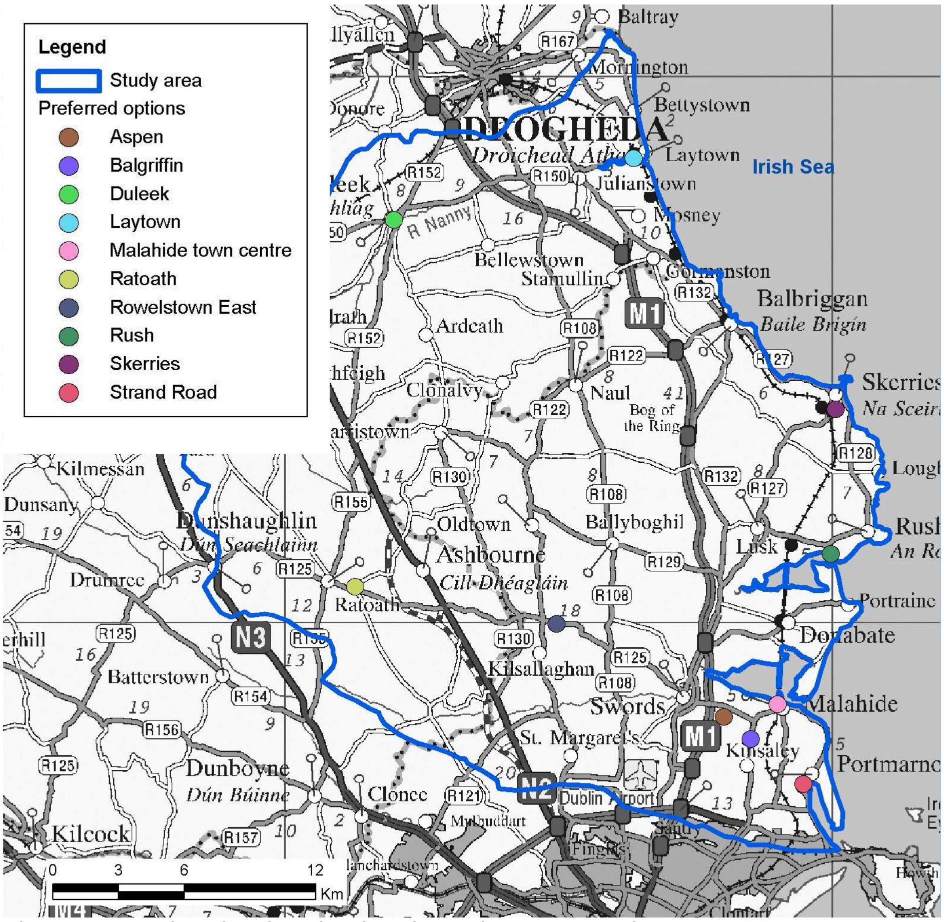


Figure 9-2 Location of preferred options for study area, AU and APSRs

Option description sheets for the options to be pursued are provided in Appendix D. These give qualitative and quantitative information on the proposals and have been prepared for each component of the FRMP.

9.3. Non-structural measures

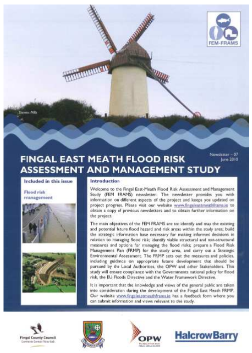
9.3.1. Proactive maintenance

This option involves the development (Meath County Council (MCC)) and enhancement (Fingal County Council (FCC)) of a proactive maintenance regime targeting potential culvert blockage locations along the watercourses in the study area. FCC currently carries out maintenance at approximately 20 locations at risk of flooding in Fingal. This involves the cleaning of screens on a two to three week basis, with the frequency increased when heavy rain is forecast. A limited maintenance regime is carried out by MCC. This option would involve including additional culverts as part of the FCC proactive maintenance regime and setting out a proactive maintenance regime for culverts in MCC. Proactive maintenance would involve the removal of debris (vegetation, silt, rubbish) at the entrance and exit of culverts on a regular basis (i.e. monthly) and in advance of, and subsequent to, a flood event.

This option would also involve the monitoring of culverts prone to blockages during a flood event. FCC currently uses weather forecast information to identify when a flood is likely. There is an opportunity to link this option to the FFWS identified for the following analysis units (Broadmeadow and Ward, Nanny and Delvin, Mayne and Sluice and Coastal).

It should be noted that the ownership and viability of this option is currently under discussion at national level as it places additional duties on Local Authorities that may not have the resources or the legal ability to implement this option. A list of potential culvert locations that should be targeted for maintenance is included in Appendix E. This list should be regularly reviewed and updated.

9.3.2. Public awareness and education



The study has identified flood risk throughout the Fingal East Meath study area and the results are presented in the flood extent maps that are currently available for consultation on the project website, www.fingaleastmeathframs.ie, and in the local authority offices.

A widespread public awareness campaign will be necessary to inform the public of the level of flood risk in their area, what is planned to be done about it, what self-help measures they can take and where they can find information. When implemented, information on flood forecasting and warning systems, and how the public can benefit from them, will be broadcast. A particular source of information is the 'Plan-Prepare-Protect' website operated by OPW, www.flooding.ie. In addition to this website, more targeted local awareness and education campaigns (e.g. on the ground using local flood maps) will be required at this stage.

The public awareness campaign will make use of various media, such as public meetings; notices in public buildings, newspapers and on the radio and television, and websites. For this to be effective, adequate technical knowledge and support will be necessary to implement the campaign and respond to queries.

The public awareness and education campaign has already commenced with the establishment of the project website, the publication of the newsletters and with the four public exhibition days held in November 2010.

It is noted that Fingal County Council Major Emergency Plan 2011 has been prepared on an "all hazards" basis and it forms part of a coordinated response to any major emergency within the Fingal administrative area. It was prepared in consultation with the other Principle Responding Agencies in the region (An Garda Síochana and the Health Service Executive) and sets out arrangements for a regional response to any incident which would involve co operation with the neighbouring local authorities. It is recommended that the flood risk data from the FEM FRAM study be incorporated into the FCC Major Emergency Plan.

9.3.3. Individual property flood protection

Individual property flood protection will be required to fully realise the potential benefits of flood forecasting and warning systems, especially for isolated properties in areas that will not be defended through implementation of the FRMP proposals. This option may also be attractive to some property owners in APSRs where defence scheme implementation is a lower priority and unlikely before 2015.

There are a multitude of proprietary products on the market, with some information available on the OPW's website www.flooding.ie. Products can provide flood resistance, such as those that seal door openings (flood gates & floor barriers), air vent blocks and the installation of non return valves on service pipes. Other individual property protection measures include those that increase the resilience of a property if flooded, such as the replacement of wooden flooring with concrete, raising of electrical wiring and sockets to above flood level, replacing carpets with waterproof floor covering, etc.

The level of protection afforded by individual property flood protection is dependant on a number of factors including the uptake, advance warning of flood risk (i.e. FFWS) and depth of flooding. The viability of this measure is reduced when the flood depth is greater than 0.6m.

Adequate technical knowledge and support will be necessary to implement these measures and respond to queries from the public. The issue of funding for individual property protection remains to be resolved, and at present is the responsibility of the property owner, but may, subject to ongoing consideration of the issue, be through government funding or partial grants.

Currently, the installation of individual property flood protection is the responsibility of the owner/homeowner. The OPW is in the process of assessing co-funding mechanisms to support the uptake of individual property protection by property owners, and will progress a scheme if it is found to be viable.

9.3.4. Flood forecasting and warning systems

Flood forecasting and warning systems involves the use of mathematical computer models to predict flood water levels based on actual meteorological data and tools to disseminate flood hazard data to people at risk. A FFWS option has been found as the preferred option for the Nanny River (Nanny Delvin AU), Broadmeadow River (Broadmeadow Ward AU), Mayne River (Mayne Sluice AU) and the Coastal AU. Details on the viability of various flood forecasting options are presented on the Technical Note on Flood Forecasting and Warning System in Appendix E of the Preliminary Options Report.

The benefit of a flood forecasting and warning system can be greatly increased if it is linked to options at the study area scale such as a public awareness campaign and individual property flood protection. In addition, the implementation of a FFWS system could benefit options at APSR scale, for example the preferred option for Malahide Town Centre incorporates the use of demountable defences which require advance flood warning to allow the demountable defences to be installed and hence be effective.

A flood forecasting and warning system is a very effective method of identifying weather events that may cause flood hazard and damage to property. In particular, it is a very useful tool for emergency planning.

It is noted that FCC currently uses weather forecast information to identify when a flood is likely.

The OPW has begun the process of undertaking a strategic review of options for flood forecasting and warning systems (FFWS) in Ireland with a view to:

- Examining the potential benefits that FFWS could achieve in Ireland,
- Identifying and assessing the options for the delivery of such a service, including the associated resource requirements, and
- Developing an appropriate and sustainable strategy (including consideration for the potential impacts of climate change) for FFWS in Ireland.

The review would (inter alia) define:

- Roles and responsibilities of the relevant authorities and stakeholders,
- Procedures and infrastructure required for communications,
- Responsibility for resourcing (human and financial) of the development, installation, maintenance and operation of the system(s) and infrastructure.

The review is being undertaken by consultants, with the OPW funding and project managing the review. The review is being guided by a steering group comprising relevant stakeholders. It is currently anticipated that the review will be completed in early 2011.

9.3.5. Other non-structural/minor & localised modifications

There are other non-structural/minor and localised modifications not included in the option assessment process that are important components of a flood risk management strategy. Inter-alia, these include:

i. Hydro-meteorological data collection network

One of the main difficulties when undertaking the hydrological analysis for the study area has been the unavailability of recent hydrometric data in the river catchments. Only two out of the 12 hydrometric stations for which hydrometric data was available were in operation, whereas all other stations were closed during the period 1995-2001. The closed hydrometric stations therefore did not record useful information on the recent significant flooding incidents in the study area, which would have provided valuable information for the calibration of the hydraulic models. Although the EPA has installed data loggers at two stations in November/December 2009, other gauges are still closed.

Therefore, in addition to continuing the current operation of four stations (one each on the Nanny, Broadmeadow, Delvin and Garristown), the hydrological study included the following priority list of gauging stations for reinstallation in the study area:

- Immediate re-installation of the gauge on the Ballyboghil River (Station 08012);
- Re-installation of another three gauges on the Sluice (Station 08005), the Ward (Station 08009) and the Broadmeadow (Station 08007) rivers as a first priority;
- Re-installation of a further four stations on the Mayne (Station 08006), the Broadmeadow (Station 08003), the Ward (Station 08004) and the Mill Stream (Station 08014) as a second priority.

According to EPA register, FCC is responsible for the installation of seven stations and MCC one station.

Future review and study may identify additional improvements for consideration. In addition to the above, the existing hydro-meteorological data collection network should also be maintained.

A further improved and expanded network would also be a requirement for effective flood forecasting and as part of any upgrades to the hydrological network for improving information on river flows and levels, consideration should be given to the needs of a flood forecasting system when deciding on the gauges to be installed.

ii. Spatial planning and development management

Inappropriate development in floodplains, or development that can increase runoff rates and volumes, can create flood risk to the properties being built or increase the risk to other areas. The Planning System and Flood Risk Management Guidelines (November 2009) should be implemented in full by the planning authorities to ensure that flood risks are not created or made worse.

The flood maps produced through the Fingal East Meath FRAM Study set out flood-prone areas, and indicate the flood levels and flows, within many parts of the study area. Planning authorities and developers should make use of these maps to assist with the Flood Risk Assessment (FRA) required in the preparation of development, local area and other plans, and in the preparation and assessment of planning applications.

Planning authorities also should have particular regard to proposed flood risk management options set out in the Plan, to ensure that the implementation of the proposed options is not prevented or impeded.

Planning authorities should consult with the OPW in relation to the maps and how they might be used, and for general support and advice in relation to flood risk and the implementation of the Guidelines, when preparing development or local areas plans.

The 2006 census indicated that Fingal County is one of the fastest growing counties in Ireland and has an overall population of 239,992. This is a county-wide increase of over 43,579 (22.2%) from 2002. According to the census of 2006, Meath County has a total population of 162,831; this equates to a county-wide increase of 28,826 (21.5%) between 2002 and 2006. The Regional Planning Guidelines similarly indicate significant population growths in both counties. The impact of this population increase will be an increased demand for more housing, employment and community infrastructure. The largest urban settlements in the study area and their associated infrastructure are shown on Figure 9-3.

Figure 9-3 Urban settlements and transport network

iii. The wider aspects of land use management in the study area

Agriculture, predominantly pasture with some mixed farmland, including market gardening/horticulture in the eastern parts of the study area, is the dominant land use within the study area covering approximately 91.6% of the land area. Areas covered by built development such as urban centres, including residential areas, commercial centres and industrial areas, and transport infrastructure occupy approximately 7.5% of the study area; with the remaining area covered by forest and semi-natural habitat (0.6%), water bodies (0.1%) and wetland (0.2%).

In future years pasture is likely to remain the dominant land use; although the pattern of use may become more or less intensive. Other changes that are likely to occur include increased development and urbanisation, which may reduce the proportion of land in agricultural use. The guidance on spatial planning and management, referred to in ii. above, should be followed by planning authorities, to prevent inappropriate development. Attention to planned development extending the urban boundaries will be especially important to prevent loss of floodplain storage and conveyance.

iv. Other

Other non-structural measures not included in the option assessment process that are important components of a flood risk management strategy include:

- Technical training for planners
- Determine Defence Asset Monitoring and Maintenance Programme
- Regular programme of inspection, removal of debris from channels etc

v. Institutional strengthening

Fingal County Council, Meath County Council and the OPW will be key players in the development and implementation of the non-structural measures. The OPW has much of the specialised technical knowledge at present but it will be important to increase the technical resource capacity in the local authorities to support the successful implementation of the national programme of catchment flood risk assessment and management studies. The strengthening of the technical flood risk management capacity within the local authorities can also support the development of local flood relief works, as well as the effective implementation of the Guidelines on the Planning System and Flood Risk Management.

vi. OPW flood relief and arterial drainage schemes

The OPW has implemented a flood relief scheme in Duleek consisting of earth embankments, flood walls and flap valves on surface water outfalls. This protects properties to the south of Duleek along the Nanny River and its tributary – the Parmadden. The OPW have the statutory responsibility to regularly inspect and maintain this scheme.

In addition, the OPW also have responsibility for a number of arterial drainage schemes including dredging of the Broadmeadow Estuary and channel maintenance of parts of the Broadmeadow, Ward, Nanny and Hurley Rivers. The primary focus of arterial drainage schemes are not for flood relief but for land improvement. The OPW also have the statutory responsibility to regularly inspect and maintain these arterial drainage schemes. A review of these activities should be undertaken to ensure that these activities are contributing to minimising flood risk.

9.4. Structural Measures

Structural measures form the preferred options to be pursued for the APSRs in the Fingal East Meath study area where the flood risk is greatest. Details of the preferred options to be pursued are given in the option description sheets included as Appendix D.

The flood defences proposed are relatively straightforward and include the following;

- New flood walls or embankments with the precise type of defence to be determined by space availability, defence height and visual impact. Demountable defences and improvement of channel conveyance generally resulted in a lower MCA score than an option based solely on permanent defences, nevertheless, these will be investigated in more detail as components of a scheme at the next stage of development in order to optimise the solution;
- Improvement in channel conveyance through river widening and removal or replacement of culverts, bridges or pipes;
- Rehabilitation of flap valves/flap gates and associated outlet structures and walls particularly in tidal areas; and
- Demountable defences may be necessary where defences cross roads and/or accesses e.g. in Malahide town centre. Demountable defences do have to be stored and installed when flooding is expected and this operational constraint inclines towards using them only where necessary. It is essential that it is clearly understood who is responsible for the installation of these demountable defences.

For any structural works, operation and maintenance procedures should be prepared and budget provision made. The cost estimates include for this and it will be important to continue the effective functioning of any structure and prolong its design life. Flood walls need little attention other than periodic inspection and repair as necessary. Embankments are susceptible to settlement and crest degradation where they are accessible to people, animals or vehicles, or where shrubs and trees are allowed to grow. Embankments therefore need more frequent inspection and rectification of any defects. Where defences incorporate gates or other mechanical components, regular inspection and maintenance will be provided. Any demountable defences need storage and resourced procedures for their installation in the event of a flood, and this will be included as necessary.

For any structural works, environmental management plans should be established for each specific project, as required, arising out of the implementation of the plan, to take account of and assess the potential impacts on water quality, biodiversity, landscape character, natural and cultural heritage, infrastructure and habitat during construction, maintenance and operation of the proposed flood mitigation scheme.

9.4.1. Existing Defences

The Study has identified a number of existing defence assets at various locations along the rivers in urban areas and along the coastline Proactive maintenance of these defences, and other Council-owned, identified flood defences, including road embankments protecting properties, should be undertaken where relevant. A mechanism for undertaking any proactive maintenance of existing defences will need to be agreed by the responsible authorities in the study area (FCC, MCC & OPW).

9.5. Individual risk receptors

An individual risk receptor is an individual asset of particular economic or social value that has been identified as being prone to flooding and hence represents a significant risk in its own right, such as transport and utilities infrastructure, which may require specific consideration during the development of the flood risk management options.

Flood risk management of the individual risk receptors is subject to discussion with their owners usually the local authorities, but Iarnród Éireann in the case of the Dublin to Belfast railway; and the National Roads Authority in relation to the M1 motorway should also be consulted to agree an appropriate course of action and responsibility for it.

Table 9-2 summarises the preferred option for the individual risk receptors and Figure 9-4 shows the locations of these IRR.

Table 9-2 Preferred options for IRRs

Risk receptor	Location	Likely FRM option
Utility asset at Stamullin	Stamullin area APSR	Construction of localised flood defence embankments or IPFP
WWTW at Ballyboghil	Ballyboghil area APSR	Construction of localised flood defence embankments
M1 at Staffordstown	Ballyboghil & Lusk AU	Construction of localised flood defence embankments
Wastewater pumping station in Ashbourne	Ashbourne area APSR	Construction of localised flood defence embankments
WWTWs at Toberburr	Owens Bridge area APSR	Construction of localised flood defence embankments
N32 at Clonshaugh	St Margaret's, Dublin Airport, Belcamp & Balgriffin areas APSR	Construction of localised flood defence embankments
WWTWs at Julianstown	Julianstown area APSR	Construction of localised flood defence embankments

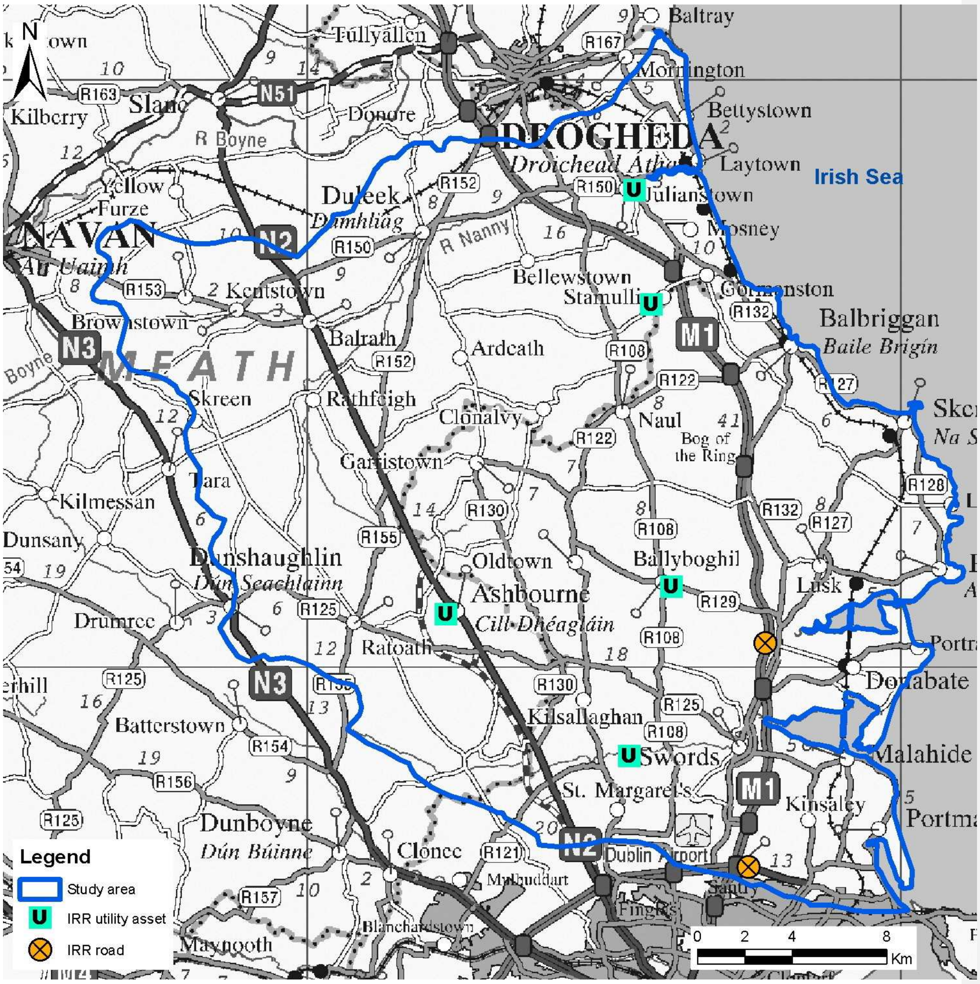


Figure 9-4 Location of IRRs in the study area

9.6. Assessment of the Plan components

9.6.1. Overview

The focus of this SEA was on the principal components of the draft FEM FRMP – the preferred flood risk management options, comprising both structural and non-structural measures, recommended for implementation across the FEM study area at four scales: the whole study area, Analysis Units, Areas of Potentially Significant Risk and individual risk receptors.

Through the SEA process, multi-criteria option assessment was applied to ensure comprehensive and transparent assessment of the proposals. However, this process was not applied to; (a) wider strategic and policy recommendations such as improvement to the flood forecasting monitoring network and the application of guidelines on spatial planning and flood risk using the flood maps prepared by the study; or (b) the measures proposed to address flood risk to identified "Individual Risk Receptors" (i.e. critical infrastructure). However, these were considered in broad terms within the SEA.

The integration of the SEA within the development of the draft FEM FRMP has ensured that:

- Effective and comprehensive stakeholder and public consultation was undertaken throughout the FEM FRAMS to inform the plan development process and the SEA.
- Key environmental issues, constraints and opportunities within the FEM study area relating to flood risk management were identified at an early stage of the plan development process, enabling:
  - Environmentally unacceptable flood risk management measures to be screened out from further consideration at an early stage; and
  - The development of flood risk management options to avoid potential environmental impacts where possible.
- The preferred options selected following the multi-criteria option assessment process were generally those that scored well in terms of the SEA objectives and those for which likely impacts of the preferred flood risk management options could potentially be minimised.
- The predicted effects of the draft FEM FRMP are clearly identified and recommendations are made to address these during the implementation of the FRMP, when the development and implementation of the preferred flood risk management options will be informed by these conclusions and recommendations.

9.6.2. Key recommendations of the SEA process

The SEA has identified that the proposed flood risk management options could give rise to a number of significant permanent positive environmental effects. No significant negative effects have been identified. Additionally, some significant and minor (both temporary and permanent) negative environmental effects could arise that could not be avoided through the selection of alternative options. However, for all these negative effects, mitigation measures are proposed to be taken forward to the next stage of option development in order to avoid (e.g. through appropriate design) or reduce the predicted effects.

Table 9-3 summarises the significant effects identified for the proposed flood risk management schemes that form the basis of the draft FRMP. Table 9-3 also identifies the permanent effects considered to be potentially significant, prior to the consideration of potential mitigation measures, for which it is assumed that mitigation could reduce their significance to minor. None of the remaining components of the flood risk management strategy (i.e. proposals at a study area and AU scales) are predicted to give rise to significant negative or positive effects, although a number of minor negative and positive effects are also identified. These conclusions are consistent with those of the Appropriate Assessment process as described in Section 9.6.3.

Table 9-3 Summary of the residual effects of the FEM FRMP components and the associated mitigation recommendations)

APSR - Location	Identified significant residual effects		Mitigation recommendations
***Duleek area –** raising existing defence embankment (to be considered in longer term)*	✓✓	Significant positive effects as a result of the reduction in flood risk to four residential properties and transport infrastructure (a 50m stretch of regional road)	None required
	X	Minor negative effects as a result of permanent changes in landscape and visual amenity in a medium sensitivity landscape setting *(significance reduced from moderate assuming that proposed mitigation measures are effective)*	Appropriate design to minimise visual intrusion
***Ratoath area –** replacing a bridge and culvert (at two separate locations) to improve channel conveyance*	✓✓	Significant positive effects as a result of the reduction in flood risk to nine residential properties, transport infrastructure (i.e. 90m of regional road) and 2ha of agricultural land	None required
***Rowlestown East area –** constructing new flood embankments*	✓✓	Significant positive effects as a result of the reduction in flood risk to two residential properties and transport infrastructure (i.e. 80m of regional road)	None required
	X	Minor negative effects as a result of permanent changes in landscape and visual amenity in a medium sensitivity landscape setting *(significance reduced from moderate assuming that proposed mitigation measures are effective)*	Appropriate design to minimise visual intrusion
***Balgriffin –** removing old bridge structure to improve conveyance and constructing new flood embankments and walls*	✓✓	Significant positive effects as a result of the reduction in flood risk to 19 residential and two non-residential properties (i.e. positive community effects) and transport infrastructure (i.e. up to 600m of regional road)	None required
	X	Minor negative effects on designated habitats and bird species resulting from a potential change in the pattern of freshwater input received by Baldoyle Bay pNHA/cSAC/SPA 1.5km downstream*(significance reduced from moderate assuming that proposed*	Optimise scheme design to reduce changes in water flows/levels

APSR - Location	Identified significant residual effects		Mitigation recommendations
		mitigation measures are effective)	
Strand Road, Portmarnock – *rehabilitating and raising existing coastal defences and constructing new embankment*	✓✓	Significant positive effects as a result of the reduction in flood risk to 17 residential properties and one non-residential property (i.e. positive community effects) and transport infrastructure (i.e. up to 650m of regional road)	None required
	X	Minor negative effects as a result of potential damage to intertidal saltmarsh habitat and disturbance to designated bird species within Baldoyle Bay cSAC/SPA/pNHA; and reduction in saline inputs to transitional features of the Sluice River Marsh pNHA *(significance reduced from moderate assuming that proposed mitigation measures are effective)*	Appropriate design to avoid damage to the saltmarsh zone or, if necessary, create replacement habitat. Avoid sensitive periods for birds and reduce noise by appropriate construction methods. Ensure occasional saline incursions into Sluice River Marsh to maintain transitional habitats and species
	X	Minor negative effects as a result of permanent changes in landscape and visual amenity within an area designated as an 'Important View' *(significance reduced from moderate assuming that proposed mitigation measures are effective)*	Appropriate design to minimise visual intrusion
Malahide town centre – *constructing new embankments and demountable defences*	✓✓	Significant positive effects as a result of the reduction in flood risk to up to 22 residential and 15 non-residential properties (i.e. positive community effects) and transport infrastructure (i.e. up to 350m of regional road)	None required
Aspen, Swords area – *channel widening to improve conveyance*	✓✓	Significant positive effects as a result of the reduction in flood risk to 9 residential properties and transport infrastructure (i.e. short stretch of local roads)	None required

APSR - Location		Identified significant residual effects	Mitigation recommendations
Rush area – *channel widening to improve conveyance*	✓✓	Significant positive effects as a result of the reduction in flood risk to 25 residential properties and transport infrastructure (i.e. up to 600m of local roads	None required
Skerries area – *enlarging culverts and widening channel to improve conveyance*	✓✓	Significant positive effects as a result of the reduction in flood risk to 49 residential properties; transport infrastructure (i.e. >1.5km of local roads); up to 4ha of agricultural land; and one cultural heritage site	None required
Laytown area *– constructing new embankments*	✓✓	Significant positive effects as a result of the reduction in flood risk to 10 residential properties and transport infrastructure (i.e. up to 0.45km of regional road)	None required
	X	Minor negative effects due to potential disturbance to birds designated as part of the River Nanny Estuary and Shore SPA and permanent loss of habitat which support these birds *(significance reduced from moderate assuming that proposed mitigation measures are effective)*	Appropriate design to set back defence from intertidal, or create replacement habitat. Plan to avoid sensitive months for birds. Apply best practice construction measures to minimise disturbance
	X	Minor negative effects on landscape character and visual amenity in a highly sensitive setting *(significance reduced from moderate assuming that proposed mitigation measures are effective)*	Appropriate design to minimise visual intrusion

9.6.3. Key recommendations of the AA process

An assessment of the impacts of the FEM FRMP on the *Natura 2000* or European Sites within the FEM study area, as required under the European Union (EU) Habitats Directive (*Council Directive 92/43/EEC on the Conservation of Natural Habitats and Wild Fauna and*

Flora) and the transposing Irish regulations (*The European Union (Natural Habitats) Regulations, SI 94/1997, as amended*), has been undertaken. These European Sites comprise Special Areas of Conservation (SAC) and Special Protection Areas (SPA) (including candidate or proposed sites), designated respectively under the EU Habitats Directive and the EU Birds Directive (*Council Directive 79/409/EEC on the Conservation of Wild Birds*)[12]. This assessment has been undertaken in accordance with relevant legislation and the Department of Environment, Heritage and Local Government (DEHLG) *Guidance on Appropriate Assessment for Planning Authorities* (DEHLG, 2009) and has been fully integrated with the SEA process and the preparation of the FRMP.

The (stage 1) screening assessment identified that the proposed draft Fingal East Meath FRMP has the potential to have significant effects, on seven of the European Sites considered: Boyne Estuary SPA, River Nanny Estuary and Shore SPA, Rogerstown Estuary SPA, Rogerstown Estuary cSAC, Broadmeadow Estuary/Swords SPA, Baldoyle Bay cSAC and Baldoyle Bay SPA. The (Stage 2) Appropriate Assessment considered the likely effects of the implementation of the preferred options for the APSRs identified in the draft Fingal East Meath FRMP, alone and in-combination, on the integrity of the seven European Sites listed. None of the preferred options for the study area and AUs were identified as having potential for a significant effect. This concluded that the preferred options for the APSRs are not likely to adversely affect the integrity of any European Site provided the following mitigation measures are applied:

- **River Nanny Estuary and Shore SPA and Boyne Estuary SPA** – the timing of the proposed works on the River Nanny Estuary take place between April and August to avoid the main bird migration and wintering period; the reduction of noise by using appropriate construction methods; and the setting back of the flood defences and road, or the creation of new intertidal habitat to mitigate for habitat likely to be lost through coastal squeeze;
- **Rogerstown Estuary SPA and cSAC** – the timing of the proposed works take place between April and August to avoid the main bird migration and wintering period, and measures are implemented to minimise construction noise; scour protection to be installed at the outlet of the culvert;
- **Broadmeadow/Swords Estuary SPA** – the timing of the proposed works take place between April and August to avoid the main bird migration and wintering period, and measures are implemented to minimise construction noise; and
- **Baldoyle Bay cSAC and SPA** – minimising the footprint of the proposed works at the detailed design and construction phases of the scheme, to avoid or minimise effects on the intertidal zone of the estuary; appropriate timing of the proposed works; the reduction of noise by using, appropriate construction methods; minimising the use of construction materials that may have a contaminating effect on the

[12] This has now been replaced by *Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the Conservation of Wild Birds (codified version).*

estuary; and the creation of new intertidal habitat to replace any habitat that may be lost through coastal squeeze.

However, the assessment highlighted that subsequent site-specific assessments should be undertaken at the project stage to confirm that these elements of the FRMP will have no adverse effect on the integrity of these European Sites and that mitigation measures are appropriate.

9.7. Pluvial flooding

As detailed in section 5.8 a pluvial flood risk assessment was carried out and a Technical Note is included in the Hydraulics Report.

A number of recommendations were included in the pluvial assessment technical note including further investigation and modelling of the existing stormwater / combined systems and routing the flow along the river network and drainage channels.

9.8. Prioritisation and Implementation of the FRM Plan

9.8.1. Prioritisation

The process for identifying potential flood risk management options and their evaluation through the MCA process was thorough and detailed for this level of catchment study. It was designed and tested taking account of technical, economic, social and environmental criteria to give confidence in the output. Logically, the preferred options with the highest overall MCA score should be the most attractive options. These therefore provided the basis for prioritisation.

There are sixteen preferred options in Table 9-1. The MCA scores range from 95 to 505. The highest score was for the Skerries APSR option to '*improve channel conveyance by replacing culverts under roads and railway with larger capacity culverts and widening channel through park to reduce fluvial flood risk to properties at Millar Lane and Sherlock Park'*.

However, cost also plays a part in final decision-making, especially in times of severe budgetary pressures. The total estimated cost of the implementation of all sixteen options is €19.6m. The most expensive option is €4.1m for the public awareness campaign and individual property flood protection which would benefit the whole study area.

The benefit cost ratio (BCR) is the economic benefit of the option compared to the implementation costs. For projects to be economically viable, the BCR ratio must be greater than 1.

Minor schemes, those with estimated costs less than €500,000, could proceed under the OPWs minor works programme.

It will be 2015 before all CFRAMS within the State are complete and only then will it be possible to do a full national prioritisation of all potential works. Notwithstanding this, it is reasonable for viable works, including structural schemes, to be initiated in advance of this with a view to progression to full scheme development.

An indicative programme for implementation of the FRMP is set out, with timescales suggested according loosely with EU Directive cycles, namely:

- High priority = first phase: Plan implementation to 2015;
- Medium priority = second phase: 2016 to 2022; and
- Low priority = third phase: 2023 onwards.

These timescales, particularly after 2016, may change due to economic conditions in the country and also where flood risk management fits in national priorities.

In summary, development of options beyond the FRAMS stage will be based on MCA scores, with priority being given to the lower cost options as well as those that have been demonstrated to be most cost-beneficial.

9.8.2. Proposed implementation

The proposed phasing for implementation of the Flood Risk Management Plan for the Fingal East Meath study area is given in Table 9-3.

Budget availability will be the key factor influencing the implementation of the Plan. Nevertheless, a range of structural works can be funded and implemented in the short-term, such as those to be progressed under the OPW's minor works programme (Malahide Town Centre, Rowlestown East and Aspen).

The development and implementation of non-structural measures can and should also be progressed in the first phase of the Plan implementation. These costs are €1.7m for the proactive maintenance and €4.1m for the public awareness campaign and individual property flood protection. As noted earlier, proactive maintenance and public awareness campaign are primarily the responsibility of the local authorities who may not have the funding for this work. It is also noted that the responsibility for individual property flood protection is likely to remain the responsibility of the individual homeowners.

The detailed design and procurement for the more expensive structural options in this study area such as for Skerries, Laytown and Portmarnock should also be progressed in the first phase of the Plan implementation. Given that the costs for these options are between €1.4m and €1.6m, i.e. relatively small, it is possible that these could be funded by the OPW in advance of the National programme.

The benefit cost ratio (BCR) for two of the options (Rush and Ratoath) is less than 1 and further work would be required to determine if the BCR could be improved. These options should only proceed to implementation if the BCR is greater then 1.

In addition to budget, human resource capacity will be a factor in deciding the rate at which the Fingal East Meath FRMP can be implemented. Institutional strengthening will be needed.

Options for flood risk management at the individual risk receptors have been identified. The next step will be to initiate discussions with the owners/operators of the risk receptors to agree the response to flood risk in terms of what to do and responsibility for doing it. These discussions are to be undertaken in the first phase, although action on flood risk management works is unlikely before the second phase of the Plan.

9.8.3. Other localised works

The Fingal East Meath FRMP focuses and proposes solutions to the areas within the study area that have been found to be at significant flood risk. It is however recognised that local flooding problems do exist that have not been addressed within this Plan. Such problems can be addressed at a local level, such as through the OPW funded minor works programme, and the fact that such areas are not addressed within the Plan does not preclude action in parallel to the implementation of the Plan. Local actions taken should however consider in full the hazard and risk information available and should not impact on the implementation of the Plan. They should also take account of the environmental issues and objectives identified in the Fingal East Meath FRAM SEA.

Table 9-3 Phasing of the Fingal East Meath FRMP

Comment [MCD1]: To be updated as per exec summary

*Bodies highlighted in bold text under the 'who' column are those responsible for leading the action

Phase I A (2011-13)	Phase I B (2014-15)	Phase II (2016-21)	Phase III (2022 onwards)	Who*
NON STRUCTURAL OPTIONS				
Undertake Strategic Review of FFWS	Implement findings of Strategic Review of FFWS			**OPW**
Assess scope and develop fluvial and integrated fluvial - tidal FFWS	Implement and test fluvial and integrated fluvial - tidal FFWS	Provide technical support, including technical reviews of system performance		**OPW**, FCC & MCC
		Operate FFWS (transfer to National Flood Forecasting Centre, if established)		**FCC, MCC**
Agree responsibility for proactive maintenance. Confirm locations of culverts to be maintained.	Implement proactive maintenance option. Review and update list of culverts that block.			**FCC, MCC & OPW**
Develop public awareness and preparedness campaign and review flood event response plans. Provide information on individual property flood proofing	Implement public awareness and preparedness campaign. Maintain, review and update flood event response plans. Provide information on individual property flood proofing			**FCC, MCC** & OPW
Reinstall existing and install additional hydrometric monitoring equipment		Operate additional hydrometric monitoring equipment		**OPW,** FCC
Coordinate, operate and maintain existing hydrometric network				**OPW,** EPA
Continue to implement the Planning System and Flood Risk Management Guidelines				**FCC & MCC**

Phase I A (2011-13)	Phase I B (2014-15)	Phase II (2016-21)	Phase III (2022 onwards)	Who*
EXISTING FLOOD DEFENCES				
Determine defence asset monitoring and maintenance programme	Proactive maintenance of existing defence assets including Duleek, Ratoath, Ashbourne, Swords, Balbriggan and coastal flap valves			**OPW, FCC & MCC**
STRUCTURAL MEASURES – OPW MINOR WORKS PROGRAMME < €0.5M				
MALAHIDE TOWN CENTRE (PORTMARNOCK & MALAHIDE AREAS APSR)				
Implement scheme for Malahide	Maintain scheme			**FCC**, OPW
ROWLESTOWN EAST (ROWLESTOWN EAST APSR)				
Implement scheme for Rowlestown East	Maintain scheme			**FCC**, OPW
ASPEN (SWORDS) (SWORDS AREA APSR)				
Implement scheme for Aspen (Swords)	Maintain scheme			**FCC**, OPW
STRUCTURAL MEASURES – OPW FLOOD RELIEF SCHEMES > €0.5M				
SKERRIES (SKERRIES AREA APSR)				
Detailed design, planning & procurement of scheme for Skerries		Implement scheme for Skerries	Maintain scheme for Skerries	**OPW**, FCC
BALGRIFFIN (ST MARGARET'S, DUBLIN AIRPORT, BELCAMP & BALGRIFFIN AREA APSR)				
Implement scheme for Balgriffin	Maintain scheme			**OPW,** FCC
LAYTOWN (LAYTOWN, BETTYSTOWN & COASTAL AREA APSR)				
Detailed design, planning & procurement of scheme for Laytown		Implement scheme for Laytown	Maintain scheme for Laytown	**MCC**, OPW

Phase I A (2011-13)	Phase I B (2014-15)	Phase II (2016-21)	Phase III (2022 onwards)	Who*
STRAND ROAD, PORTMARNOCK (PORTMARNOCK & MALAHIDE AREAS APSR)				
Detailed design, planning & procurement of scheme for Portmarnock		Implement scheme for Portmarnock	Maintain scheme for Portmarnock	**FCC**, OPW
OTHER WORK				
RUSH (RUSH AREA APSR)				
Further work to determine if positive BCR can be determined. Implement scheme for Rush	Maintain scheme for Rush			**OPW**, FCC
RATOATH (RATOATH APSR)				
Further work to determine if positive BCR can be determined	Detailed design, planning & procurement of scheme for Ratoath	Maintain scheme for Ratoath		**OPW**, MCC
DULEEK (DULEEK APSR)				
		Consider whether additional standard of protection should be provided at Duleek		**OPW**
INDIVIDUAL RISK RECEPTORS				
Operators to pursue detailed risk assessment and management measures				

Note: *Bodies highlighted in bold text under the 'who' column are those responsible for leading the action

9.9. Monitoring, review and evaluation

The FRMP will be reviewed on a six-yearly cycle as part of the Easter River Basin District CFRAM Study. For the review to be effective, systems will be set up to provide data with which to assess performance in relation to the original Plan content and the information on which it is based. What is required for the review includes:

- Continued collection and analysis of hydro-meteorological data for improved flood flow and frequency analysis; similarly for tide level data;
- In the event of a flood, either fluvial or tidal, recording the event with photographs, peak water levels, duration, effectiveness of existing defences and/or measures implemented under the Plan, including flood forecasting;
- Monitoring of compliance with the planning guidance in relation to flood risk, including use of the flood maps in spatial planning and development management;
- Monitoring of land use change and management to establish if it is significant in terms of flood risk and needs to be taken account of in the FRMP;
- Monitoring institutional capacity, both technical and quantity, in relation to the FRMP programme and standards, and initiate strengthening as necessary; and
- Reviewing the development of FRMP components, in particular their costs, and updating the cost database;

Review and monitoring will be an on-going exercise and lessons learnt will be taken account of in the national CFRAMS/FRMP programme. Lessons learnt will be acted on once they are confirmed and not held back until a six-yearly review.

Appendix A List of Stakeholders

Appendix B List of Objectives, indicators and targets

Appendix C Weighting of objectives and scoring of flood risk management options

Appendix D Option description sheets

Appendix E List of culverts for proactive maintenance by the Local Authorities

Appendix F List of Reports prepared for this project