RPS

SOUTH EASTERN CFRAM
CATCHMENT FLOOD RISK ASSESSMENT AND MANAGEMENT STUDY

South Eastern CFRAM Study

UoM15 Preliminary Options Report

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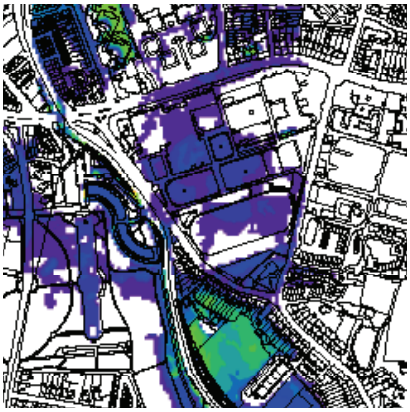

OPW
The Office of Public Works
Oifig na nOibreacha Poiblí

South Eastern CFRAM Study
UoM15
Preliminary Options Report

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TABLE OF CONTENTS

ABBREVIATIONS ..... **IV**
1 INTRODUCTION **1-1**
1.1 General information on the South Eastern CFRAM Study 1-1
1.2 Flood sources 1-3
1.2.1 Fluvial Flooding 1-3
1.2.2 Coastal Flooding 1-3
1.3 South Eastern CFRAM Study Activities 1-3
1.3.1 Preliminary Flood Risk Assessment 1-5
1.3.2 Data collection 1-5
1.3.3 Flood Risk Review 1-5
1.3.4 Surveys 1-5
1.3.5 Hydrological Analysis 1-5
1.3.6 Hydraulic Analysis 1-6
1.3.7 Flood Risk Assessment 1-6
1.3.8 Development of Flood Risk Management Options 1-6
1.3.9 Environmental Assessment 1-6
1.3.10 Communications Activities 1-7
1.3.11 Preparation of Flood Risk Management Plan 1-7
1.4 Purpose of the Preliminary Options Report 1-7
1.5 Introduction to the optioneering process 1-8
2 DATA COLLECTION **2-1**
2.1 Background mapping 2-1
2.2 Receptors 2-1
2.3 Flood Hazard 2-2
2.4 Survey data 2-3
2.5 Economic Assessment 2-3
3 SPATIAL SCALES OF ASSESSMENT **3-1**
3.1 Unit of Management SSA 3-1
3.2 Sub-Catchment SSA 3-2
3.3 AFA SSA 3-2
3.4 Spatial Scales of Assessment for UoM15 3-2
4 FLOOD RISK ASSESSMENT **4-1**
4.1 Flood Risk Maps 4-4
4.2 Flood Cells 4-6
5 DAMAGE ASSESSMENT **5-1**
5.1 Damage assessment guidelines 5-1
5.2 Recording Damage Assessment data 5-2
5.3 Categorisation of properties 5-2
5.4 Property Floor Level 5-5
5.5 Flood depth of properties 5-5
5.6 Flood Damage to properties 5-6
5.7 Intangible Damages, Utility and emergency costs 5-8
5.8 Annual Average Damage and present value damage 5-9
5.9 Coastal Flooding 5-11
5.10 Defended Flood Damages 5-11
5.11 Benefit 5-11
5.12 Capping Benefit 5-12
5.13 Damage Assessment review 5-13
6 FLOOD RISK MANAGEMENT METHODS **6-1**
6.1 Standard of protection 6-1
6.1.1 Residual Risk 6-1
6.2 List of FRM methods 6-2
6.3 Baseline Condition 6-3
6.3.1 Drainage Districts (Local Authorities) 6-3
6.3.2 Arterial Drainage (OPW) 6-4
7 ASSESSMENT OF FRM METHODS **7-1**

7.1 SCREENING FRM METHODS 7-2
7.1.1 Shortlisting FRM Methods 7-2
7.1.2 Technical Screening 7-2
7.1.3 Do Nothing 7-2
7.1.4 Additional Maintenance 7-3
7.1.5 Do Minimum 7-3
7.1.6 Sustainable Planning and Development Management 7-3
7.1.7 Land Use Management 7-4
7.1.8 Storage 7-5
7.1.9 Improvement of Channel Conveyance 7-6
7.1.10 Hard Defences 7-7
7.1.11 Relocation of Properties 7-7
7.1.12 Diversion of flow 7-7
7.1.13 Flood Warning/Forecasting 7-8
7.1.14 Public Awareness Campaign 7-9
7.1.15 Individual Property Protection 7-9
7.1.16 Other Works 7-9
7.1.17 Economic Screening 7-10
7.1.18 Environmental and Social Screening 7-11
7.2 DEVELOPING POTENTIAL FRM OPTIONS 7-12
7.2.1 Identifying possible FRM options 7-12
7.2.2 Option effectiveness 7-12
7.2.3 Benefit Cost Analysis 7-12
7.3 ASSESSMENT OF POTENTIAL FRM OPTIONS (MCA PROCESS) 7-13
7.3.1 Criteria and Objectives 7-14
7.3.2 Scoring Options 7-16
7.3.3 Weighting objectives 7-17
7.4 PREFERRED FRM OPTIONS 7-17
7.4.1 No potential options 7-18
7.5 FUTURE CHANGE ASSESSMENT ALONGSIDE OPTION DEVELOPMENT 7-18
8 OPTIONEERING OF UOM15 SPATIAL SCALE OF ASSESSMENTS 8-1
8.1 UOM15 ..... 8.1-1
8.2 BALLYHALE AFA 8.2-1
8.3 BALLYRAGGET AFA 8.3-1
8.4 BALLYROAN AFA 8.4-1
8.5 CALLAN AFA 8.5-1
8.6 FRESHFORD AFA 8.6-1
8.7 INISHTIOGE AFA 8.7-1
8.8 KILKENNY (NORE) AFA 8.8-1
8.9 KILKENNY (BREAGAGH) AFA 8.9-1
8.10 MOUNTRATH AFA 8.10-1
8.11 RATHDOWNEY AFA 8.11-1
8.12 THOMASTOWN AFA 8.12-1
9 SUMMARY OF FRM OPTIONS 9-1
10 REFERENCES 10-1

APPENDICES

Appendix A – Ballyhale AFA additional information

Appendix B – Callan AFA additional information

Appendix C – Freshford AFA additional information

Appendix D – Inistioge AFA additional information

Appendix E – Mountrath AFA additional information

Appendix F – Rathdowney AFA additional information

Appendix G – Thomastown AFA additional information

Appendix H – Kilkenny (Breagagh) AFA additional information

LIST OF FIGURES

Figure 1.1 - South Eastern CFRAM Study Area 1-2
Figure 1.2 – South Eastern CFRAM Study activities 1-4
Figure 1.3 - UoM15 AFA Locations and Extents 1-8
Figure 1.4 - Optioneering process 1-10
Figure 3.1 – UoM15 SSAs 3-3
Figure 4.1 - Extract from cultural heritage risk map 4-4
Figure 4.2 – Extract from economic activity map 4-5
Figure 4.3 - Extract from economic risk density maps 4-5
Figure 5.1 - MCM's depth damage data for detached houses 5-1
Figure 5.2 - Example shapefile with attribute table showing damage assessment data 5-2
Figure 5.3 - The MCM's depth damage data for a detached house 5-7
Figure 5.4 - Example damage curve 5-10
Figure 7.1 - Assessment of FRM methods flow chart 7-1

LIST OF TABLES

Table 2.1 - Background Mapping data 2-1
Table 2.2 - Receptor data 2-1
Table 2.3 - Flood Hazard data 2-2
Table 2.4 - Survey data 2-3
Table 2.5 - Economic Assessment data 2-3
Table 3.1 – List of SSAs in UoM15 3-2
Table 4.1 - Flood risk receptor groups 4-1
Table 5.1 - MCM property types 5-3
Table 5.2 - Categorisation of properties data 5-4
Table 5.3 - Property threshold data 5-5
Table 5.4 - Flood depth of properties data 5-6
Table 5.5 - Converting pound sterling to euro using the PPP 2010 values from OECD website 5-7
Table 5.6 - Conversion rates to current year prices using CPI from CSO Ireland website 5-7
Table 5.7 - Flood damage to properties data 5-8
Table 5.8 - Intangible damages and emergency cost data 5-9
Table 5.9 - AAD and PvD data 5-11
Table 5.10 - Capping damages data 5-12
Table 5.11 - Capping damages data 5-13
Table 7.1: Summary of FRM Applicability to SSA 7-10
Table 7.2 - Additional costs to FRM options 7-11
Table 7.3 - Criteria and Objectives of the MCA 7-15
Table 9.1 – Summary of Preliminary Options Identified at AFA SSA within UoM15 9-2

ABBREVIATIONS

AEP	Annual Exceedance Probability
AFA	Area for Further Assessment
BCR	Benefit Cost Ratio
CFRAM	Catchment Flood Risk Assessment and Management
CPI	Consumer Price Index
DD	Drainage District
DEHLG	Department of Environment, Community and Local Government (previously known as the Department of Environment, Heritage and Local Government)
FCERM	Flood or Coastal Erosion Risk Management
FFL	Finished Floor Level
FHRC	Flood Hazard and Research Centre
FRA	Flood Risk Assessment
FRM	Flood Risk Management
FRMP	Flood Risk Management Plan
UoM	Hydrometric Area
HEFS	High end future scenario
IRR	Individual Risk Receptor
MCM	Multi Coloured Manual
MPW	Medium Priority Watercourse
MRFS	Mid-range future scenario
OPW	Office of Public Works
PFRA	Preliminary Flood Risk Assessment
pvD	present value Damage
RBD	River Basin District
RMP	Record of Monuments and Places
SAC	Special Area of Conservation
SMR	Sites and Monuments Record
SI	Statutory Instrument
SoP	Standard of Protection
SPA	Special Protection Area
SSA	Spatial Scale of Assessment
UoM	Unit of Management

1 INTRODUCTION

The Office of Public Works (OPW) commissioned RPS to undertake the South Eastern Catchment-based Flood Risk Assessment and Management Study (South Eastern CFRAM Study) in July 2011. The South Eastern CFRAM Study was the third River Basin District (RBD) level CFRAM study to be commissioned in Ireland under the EC Directive on the Assessment and Management of Flood Risks 2007, the EU Floods Directive, (Reference 1) as implemented in Ireland by SI 122 of 2010 European Communities (Assessment and Management of Flood Risks) Regulations 2010 (Reference 2). The South Eastern CFRAM Study will culminate in 2016 with the development of Flood Risk Management Plans (FRMPs) which will include Flood Risk Management Measures designed to deal with identified flood risk.

Unit of Management 15 (UoM15) is located within the South Eastern CFRAM study area (Figure 1.1). The UoM15 Preliminary Options report details the generic methodology for the flood risk assessment and development of flood risk management options to be carried out for all areas being studied in the South Eastern CFRAM Study, also providing the specific findings for the Areas for Further Assessment (AFAs) found in UoM15. The preferred Flood Risk Management Options identified in this report, and the subsequent Flood Risk Management Plan, are recommended to be developed and progressed by more detailed subsequent studies.

1.1 GENERAL INFORMATION ON THE SOUTH EASTERN CFRAM STUDY

As shown in Figure 1.1, the South Eastern CFRAM Study Area covers approximately 12,857 km^2 and includes six Units of Management; UoM11 (Owenavorragh), UoM12 (Slaney and Wexford Harbour), UoM13 (Ballyteigue-Bannow), UoM14 (Barrow), UoM15 (Nore) and UoM17 (Colligan-Mahon). UoM16 (Suir) is covered by the Suir pilot CFRAM Study and covers an area of approximately 3,542 km^2.

There is historical evidence of a high level of flood risk within certain areas of the South Eastern CFRAM Study area with significant coastal and fluvial flooding events having occurred in the past. A detailed account of historical flooding can be found in the South Eastern CFRAM Study inception reports in which can be downloaded from the South Eastern CFRAM Study website at **www.southeastcframstudy.ie**.

The objectives of the South Eastern CFRAM Study are to:

- Identify and map the existing and potential future flood hazard within the Study Area.
- Assess and map the existing and potential future flood risk within the Study Area.
- Identify viable structural and non-structural options and measures for the effective and sustainable management of flood risk within the Study Area.
- Prepare a set of Flood Risk Management Plans (FRMPs) for the Study Area, and associated Strategic Environmental and, as necessary, Habitats Directive (Appropriate) Assessment, that set out the policies, strategies, measures and actions that should be pursued by the relevant bodies, including OPW, Local Authorities and other stakeholders, to achieve the most cost effective and sustainable management of existing and potential future flood risk within the

Study Area, taking account of environmental plans, objectives and legislative requirements and other statutory plans and requirements.

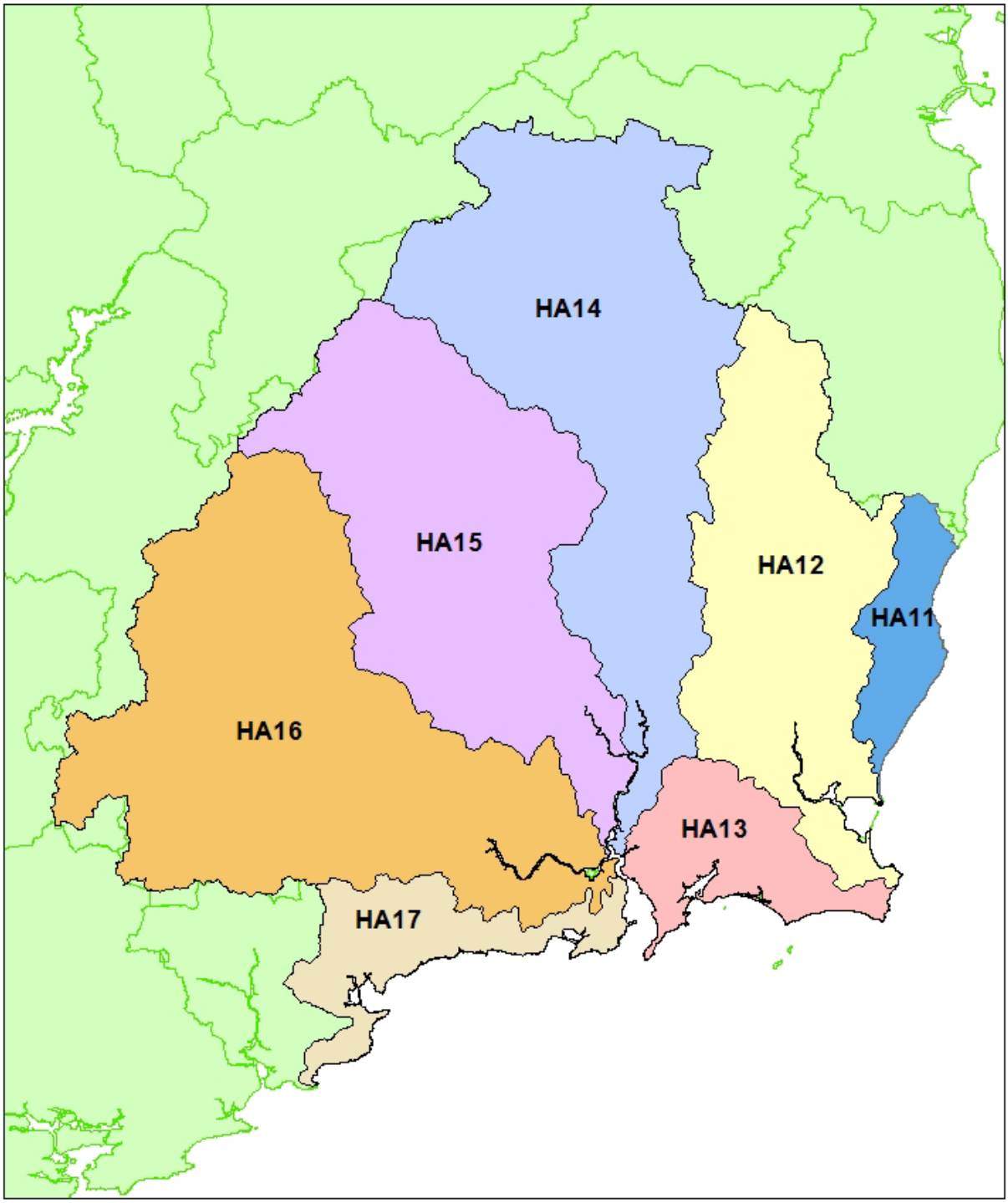


Figure 1.1 - South Eastern CFRAM Study Area

*UoM 16 Flood Risk Management Options have been developed under the Suir pilot CFRAM Study.

1.2 FLOOD SOURCES

Two flood sources are considered under CFRAM analysis; fluvial and coastal.

1.2.1 Fluvial Flooding

Fluvial flooding occurs when rivers and streams break their banks and water flows out onto the adjacent low-lying areas (the natural floodplains). This can arise where the runoff from heavy rain exceeds the natural capacity of the river channel, and can be exacerbated where a channel is blocked or constrained or, in estuarine areas, where high tide levels impede the flow of the river out into the sea. While there is a lot of uncertainty on the impacts of climate change on rainfall patterns, there is a clear potential that fluvial flood risk could increase into the future.

1.2.2 Coastal Flooding

Coastal flooding occurs when sea levels along the coast or in estuaries exceed neighbouring land levels, or overcome coastal defences where these exist. This flooding mechanism is known as tidal inundation or coastal mechanism 1.

Coastal flooding also occurs when waves overtop the coastline or coastal defences. This flooding mechanism is known as wave overtopping or coastal mechanism 2.

Mean sea levels are rising as a result of climate change, and consequentially flood risk from the sea is expected to increase over the coming decades.

1.3 SOUTH EASTERN CFRAM STUDY ACTIVITIES

To achieve the study objectives the South Eastern CFRAM Study has carried out a range of activities. Each activity, while focusing on a specific task, is connected to and informs the other activities. Figure 1.2 summarises the activities involved in the study and how they relate to each other.

The main outputs and reports associated with the study activities are listed in Table 1.1. An explanation of each activity's output(s) are summarised in sections 1.3.1 to 1.3.11.

Table 1.1 - Outputs of study activities

Activity	Output
Preliminary Flood Risk Assessment	National fluvial flood maps Identification of Areas for Further Assessment
Data Collection	-
Flood Risk Review	Confirmation of Areas for Further Assessment
Surveys	Survey data for all watercourses identified for assessment
Hydrological Analysis	Estimation of flows for all watercourses for all flood events Hydrology report
Hydraulic Analysis	Flood hazard maps Hydraulics report
Flood Risk Assessment	Flood risk maps Preliminary options report
Development of Flood Risk Management Options	Identification of flood risk management measures and options Preliminary options report
Environmental Assessment (including Strategic Environmental Assessment (SEA) & Appropriate Assessment (AA))	SEA Screening Statement, SEA Scoping Report, SEA Environmental Report, SEA Statement AA Screening Statement, Natura Impact Statement
Communications Activities	Influence on draft maps, options and FRMPs Communications synthesis reports
Preparation of Flood Risk Management Plan	Flood Risk Management Plan

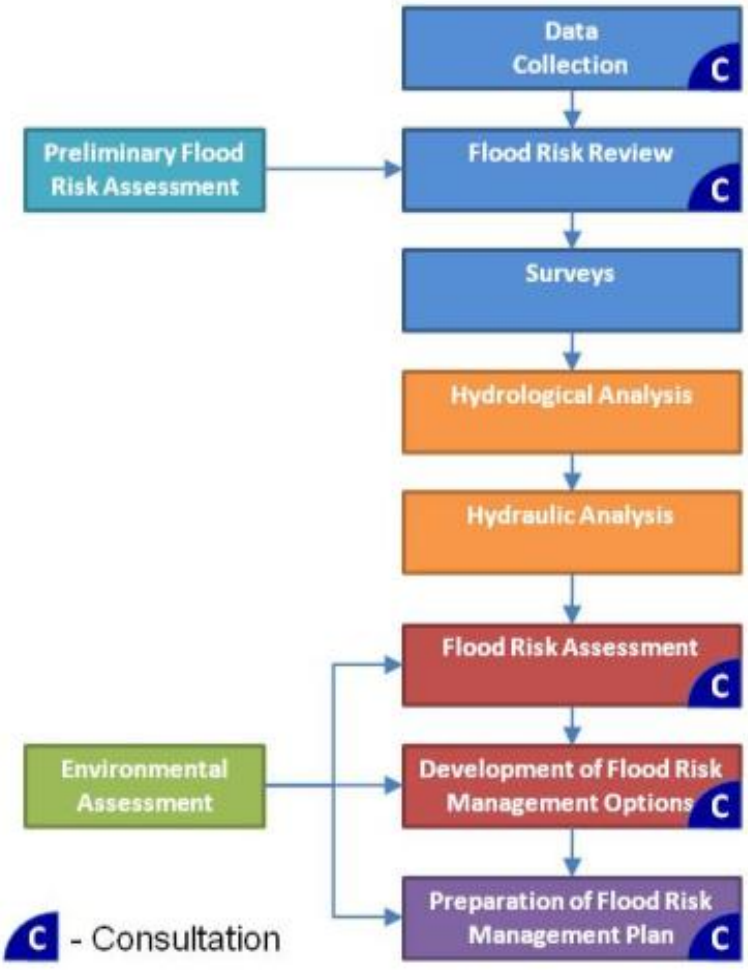


Figure 1.2 – South Eastern CFRAM Study activities

1.3.1 Preliminary Flood Risk Assessment

In 2011 the OPW completed a Preliminary Flood Risk Assessment (PFRA) in accordance with the EU Floods Directive. The objective of the PFRA is to identify areas where the risks associated with flooding might be significant. The PFRA provides maps showing areas deemed to be at risk. The PFRA identified Areas for Further Assessment (AFAs) which were then taken forward in the CFRAM programme. The documentation associated with the PFRA including the flood maps can be accessed through the national CFRAM website **www.CFRAM.ie/pfra**.

1.3.2 Data collection

An initial data collection exercise was carried out to capture the relevant information to meet the objectives of the project. This main proportion of this activity was carried out at the start of the project but this activity is also ongoing as new information is made available and new data requirements are identified. Details of the initial data collection process can be found in the South Eastern CFRAM Study inception reports which can be accessed through the South Eastern CFRAM Study website **www.eastcframstudy.ie**.

1.3.3 Flood Risk Review

The Flood Risk Review (FRR) was completed in October 2011 for the South Eastern CFRAM Study. RPS was required to review the output of the preliminary flood risk assessment and all other information and knowledge readily available during the initial stages of the South Eastern CFRAM Study. The data was assessed and identified AFAs where potential significant flood risk exists or might be considered likely to exist including areas other than those identified through the PFRA. Areas where significant flood risk does not exist and no further assessment was required were also identified as part of the FRR. The findings of the FRR can be found in the Flood Risk Review Report and maps which can be accessed through the South Eastern CFRAM Study website **www.southeastcframstudy.ie**.

1.3.4 Surveys

Before progressing to the hydrological and hydraulic analysis activities the topographical data for each watercourse and associated floodplains identified for assessment was required. This activity started in 2011 and was completed in May 2013. The outputs of the survey were LiDAR information of floodplains, river channel cross sections and geometrical data for structures located in the river channel or influencing the hydraulic nature of the river.

1.3.5 Hydrological Analysis

The hydrological analysis encompasses all aspects of flood hydrology including review of historic flood events within the AFAs, flood frequency analysis and design flow estimation. The review of historic flood events and initial flood frequency analysis (to determine the statistical frequency / severity of historic flood events within the AFAs) was completed for the South Eastern study area in June 2012 and is contained within the Inception Reports. The second stage of the hydrological analysis focused on design flow estimation such that design flows for various risk scenarios could be defined and used as inputs for hydraulic modelling. The approach to design flow estimation relies heavily on defining the index flood, equivalent to the statistical median from a series of annual peak flood flows (equivalent to

a 50% chance of occurring in any given year). The design flow estimation includes a more detailed flood frequency analysis to define appropriate flood growth behaviour for each catchment / sub-catchment in order to define design events based on scaling of the index flood flow. The hydrological analysis also includes consideration of the factors which will affect future changes in flows such as catchment changes and climate change. The hydrological analysis stage overlapped with the hydraulic analysis as design flow estimates were tested and refined through the models against observed data. Details of the hydrological analysis can be found in South Eastern CFRAM Study UoM15 Hydrology Report.

1.3.6 Hydraulic Analysis

Dynamic hydraulic models have been developed for all the areas of assessment. These models simulated how each watercourse will react to various sizes of floods and the interaction with the surrounding floodplain. The output of this analysis is a Hydraulics Report in addition to a series of flood extent, zone, depth, velocity and risk-to-life maps known collectively as flood hazard maps which are generated based on the model results. Details of the hydraulic analysis can be found in the South Eastern CFRAM Study UoM15 Hydraulics Report.

1.3.7 Flood Risk Assessment

The Flood Risk Assessment (FRA) is detailed in this report and its main output is to achieve one of the CFRAM study objectives; assess and map the existing and potential future flood risk within the Study Area. The FRA focuses on the receptors at risk from flooding that are categorised as either social (including risk to people), environmental, cultural heritage or economic receptors.

1.3.8 Development of Flood Risk Management Options

The development of Flood Risk Management (FRM) Options is detailed in this report and its main output is to achieve one of the CFRAM study objectives; identify viable structural and non-structural options and measures for the effective and sustainable management of flood risk within the Study Area. The output of this activity is to present FRM options for the receptors identified during the FRA. This is achieved through a screening process and analysis of the options in order to identify which are the most appropriate in relation to the flood risk management objectives established by national level consultation for the CFRAM programme.

1.3.9 Environmental Assessment

Strategic Environmental Assessment (SEA) is a process to evaluate, at the earliest appropriate stage, the environmental effects of a plan or programme before it is adopted. It also gives the public and other interested parties an opportunity to comment and to be kept informed of decisions and how they were made. The outputs of the process include an SEA Screening Statement notifying the decision to carry out SEA, an SEA Scoping Report outlining the environmental issues considered by the SEA, an SEA Environmental Report outlining the assessment of the potential effects of the measures in the Flood Risk Management Plans on aspects of the environment, and an SEA Statement detailing how the SEA process influenced the development of the Flood Risk Management Plans. Details of the SEA process can be found in the South Eastern CFRAM Study Scoping and supporting environmental reports.

Appropriate Assessment (AA) is a process which ascertains if there are internationally important sites whose integrity could be significantly adversely affected by the implementation of a plan or project. Special Protection Areas (SPAs) and Special Areas of Conservation (SACs) together form the Natura 2000 network of protected areas. Outputs of the process include an AA Screening Statement notifying the decision to carry out AA and a Natura Impact Statement outlining the assessment of the potential effects on Natura 2000 sites of the measures contained in the Flood Risk Management Plans. Details of the AA process can be found in the South Eastern CFRAM Study Screening Statement and supporting assessments.

1.3.10 Communications Activities

Communications activities include elected member briefings, public consultation days, stakeholder workshops, website consultations and consultation with progress group members and other key stakeholders. Stakeholder input influenced the technical review of flood maps, flood risk management options and Flood Risk Management Plans.

1.3.11 Preparation of Flood Risk Management Plan

This is the last activity of the South Eastern CFRAM Study and will follow the Preliminary Options Report. The draft plan will detail the work carried out during the entire study including the outcomes of the PFRA, flood hazard assessment, flood risk assessment, FRM objectives, environmental considerations, FRM options, programme or work and plan monitoring and review. The plan will be finalised taking into consideration the stakeholder consultation feedback on the draft plan.

1.4 PURPOSE OF THE PRELIMINARY OPTIONS REPORT

The main objectives of the preliminary options report are to detail the activities associated with Flood Risk Assessment and the development of Flood Risk Management Options and to present the outcomes of each within UoM15 (Figure 1.3).

The report details the process carried out as part of the FRA and option development in sections 2 - 7.

Sections 8 – 9 of this report detail the decision making process in identifying the most appropriate and feasible FRM options and present details of the options to be taken forward to consultation for UoM15.

Figure 1.3 - UoM15 AFA Locations and Extents

1.5 INTRODUCTION TO THE OPTIONEERING PROCESS

Optioneering is a process where the flood risk to an area is identified and quantified which informs the choice of which the most appropriate FRM options are. This is carried out through a series of activities summarised in Figure 1.4.

The activities shown in the blue boxes aim to identify and assess the flood risk. The starting point in this process is to identify the spatial scale of assessment (SSA). The following SSAs are defined:

- Unit of Management SSA - refers to a hydrometric area. There are six Units of Management within the South Eastern CFRAM study area. This report covers UoM15;
- Sub-Catchment SSA - refers to the catchment of the principle river on which multiple AFAs sit;
- AFA SSA - refers to the individual AFA being considered only;
- IRR SSA - refers to Individual Risk receptor outside of an AFA boundary. There are no such IRR identified in the South Eastern CFRAM Study area.

Identifying the SSA informs the FRM method screening process by assuring that only methods appropriate to the spatial scale are considered. FRM methods are considered to be any action that will manage flood risk in some capacity.

The next step in the optioneering process is review of the flood hazard maps output from hydraulic modelling. The flood hazard maps are used to assess the flood risk and produce flood risk maps. The flood risk receptors are assessed in order to ascertain where flood risk management will be required and to what extent. These activities are detailed in Section 4.

On quantifying the flood risk the FRM methods are screened to rule out unacceptable methods. The remaining methods are then developed further and combined to make potential FRM options. This process is described further in Section 7 and illustrated in the orange boxes.

The FRM options are assessed against a set of criteria and objectives and scored in order to identify the preferred options (maroon box). These options are then presented for consultation with the OPW, progress group and steering group (consisting of local authorities and key stakeholders) and the preferred options identified are taken forward to public consultation, thereby allowing the public and stakeholders the opportunity to influence the options (purple box).

Comments from the public consultation are then considered and if appropriate used in updating preferred options which in turn becomes the FRM Measure to be presented in the draft Flood Risk Management Plan (draft FRMP). Environmental assessment (SEA and AA) feeds into the screening of the FRM methods, the development of potential FRM options, the Multi Criteria Analysis (see section 7.3) and consultation activities (green box).

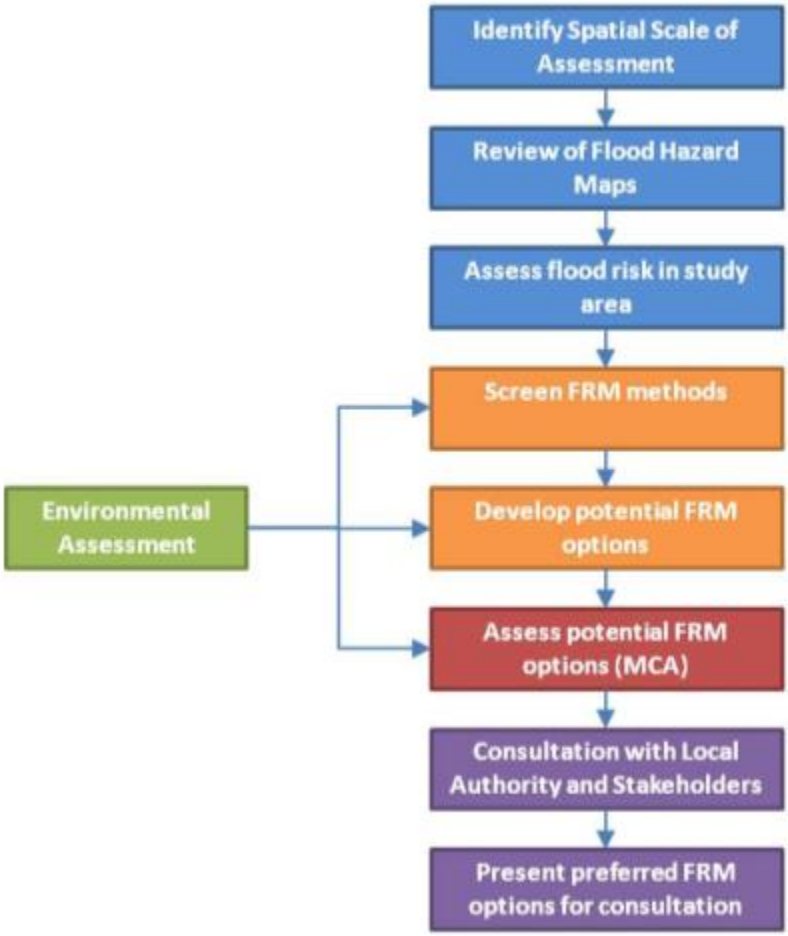


Figure 1.4 - Optioneering process

2 DATA COLLECTION

This section details the data used in the optioneering process. The data was received primarily from the OPW or produced by RPS through the hydraulic analysis within South Eastern CFRAM Study activities. Supplementary data was also received from Local Authorities and stakeholders. The data was received in various formats including GIS, AutoCAD, MS Excel and MS Word. The following sections list the data used for the various activities in the optioneering process.

2.1 BACKGROUND MAPPING

Mapping was used throughout to aid the various tasks. This included assessing the flood risk in the area being studied and identifying the receptors at risk. The maps were used to locate and inform the alignment of proposed FRM options and to reference the options being displayed in the various maps produced. Table 2.1 summarises the mapping that was used.

Table 2.1 - Background Mapping data

Data	Use
OSi 210,000 scale raster map	Various tasks
OSi 50,000 scale raster map	Various tasks
OSi 10,000 scale Digi-City map	Various tasks
OSi 6 inch scale map	Historical review
OSi Ortho Photography	Various tasks
OSi 5,000, scale vector map	Various tasks
OSi 2,500, scale vector map	Various tasks
OSi 1,000, scale vector map	Various tasks
Google maps	Identification of receptors and location of FRM measures
Bing maps	Identification of receptors and location of FRM measures

2.2 RECEPTORS

The following data was used to identify and assess the social, environmental, cultural heritage and economic receptors at flood risk within the area being studied.

Table 2.2 - Receptor data

Data	Use
Primary Schools, Post Primary Schools, Third Level	Flood Risk Assessment
Fire Stations	Flood Risk Assessment
Garda Stations	Flood Risk Assessment

Data	Use
Civil Defence	Flood Risk Assessment
OPW buildings	Flood Risk Assessment
Nursing Homes, Hospitals, Health Centres	Flood Risk Assessment
Geo-Directory (Oct 2010)	Flood Risk Assessment and Damage Assessment
Utility Infrastructure Assets	Flood Risk Assessment
Road	Flood Risk Assessment
Rail	Flood Risk Assessment
Ports	Flood Risk Assessment
Airports	Flood Risk Assessment
Architectural Heritage	Flood Risk Assessment
National Monuments	Flood Risk Assessment
National Heritage Area	Flood Risk Assessment
Proposed National Heritage Area	Flood Risk Assessment
Special Area of Conservation	Flood Risk Assessment
Special Protected Area	Flood Risk Assessment
Pollution Sources	Flood Risk Assessment
Development and Local Area Plans	Assessment of FRM methods
Historical Flood Data	Flood Risk Assessment
OPW Channels	Assessment of FRM methods
OPW Embankments	Assessment of FRM methods
OPW Benefiting Land	Assessment of FRM methods
River Centrelines	Various tasks
Lakes	Various tasks

2.3 FLOOD HAZARD

The output of the hydraulic analysis provides details on the flood extent, depth, velocity, risk to life and flood zones. This was used to inform the flood risk assessment, the screening of FRM methods and in developing and assessing potential FRM options. The following datasets were used.

Table 2.3 - Flood Hazard data

Data	Use
Flood extent raster (50%, 20%, 10%, 5%, 2%, 1%, 0.5%, 0.1% AEP present day flood events)	Establish flood extent and depth for Flood Risk Assessment and developing FRM options
HEFS (10%, 1%, 0.1% AEP flood events)	Developing FRM options
MRFS (50%, 20%, 10%, 5%, 2%, 1%, 0.5%, 0.1% AEP flood events)	Developing FRM options

2.4 SURVEY DATA

Surveys were carried out by CCS for the South Eastern CFRAM Study. This consisted of surveying river cross sections, and specified structures such as culverts, bridges and weirs. Existing defences were surveyed, their geometric data recorded and a visual condition assessment carried out. LiDAR surveys were flown for all relevant areas within the area being studied providing detail of the topography of the flood plain.

Table 2.4 - Survey data

Data	Use
Channel and Structure survey	Flood Risk Assessment and developing FRM options
Defence asset condition survey	Flood Risk Assessment and developing FRM options
Property survey	Flood Risk Assessment
Floodplain survey	Various tasks

2.5 ECONOMIC ASSESSMENT

The following data was used during the economic assessment. This involved assigning damage to receptors during different flood events and providing costs to FRM options.

Table 2.5 - Economic Assessment data

Data	Use
Cost Database	Costing FRM options
Depth Damage Database	Damage Assessment
Consumer Price Index data	Damage Assessment and costing FRM options
Market value of house data	Damage assessment
Purchasing Power Parity	Damage Assessment and costing FRM options
OSi Building polygons	Damage assessment

3 SPATIAL SCALES OF ASSESSMENT

UoM15 contains 10 Areas for Further Assessment (AFAs). These AFAs are situated along, or in proximity to, the River Nore and its tributaries the Coles River, Erkina River, Nuenna River and Kings River. Ballyroan and Ballyragget AFAs within UoM15 do not have flood risk in the 0.1% AEP design fluvial event and therefore optioneering has not been undertaken for these areas. Kilkenny (Nore) AFA has also not been optioneered as it already has an effective FRM scheme in place. The remaining 8 AFAs within UoM15 all have some degree of flood risk and therefore risk assessment coupled with optioneering has been undertaken for all these areas.

Through the optioneering process preliminary FRM solution(s) for each AFA will be proposed for UoM15. This could theoretically consist of FRM options within each of the at risk AFAs or one overarching FRM option within UoM15 which benefits all the AFAs. To help assess the solution, Spatial Scales of Assessment (SSA) have been identified. The flood risk within each SSA has been evaluated and optioneered to identify potential FRM measures.

When considering which FRM methods to assess it is accepted that certain methods will be more appropriate at larger spatial scales and others at smaller spatial scales. It is important therefore to define what spatial scale is being assessed at the beginning of the screening process. This is to avoid a situation where the full impact of a FRM method is missed due to the spatial scale of assessment (SSA) being too small, or the FRM method being considered is ineffective as the SSA is too large. OPW have defined SSAs which are described in the following sections.

3.1 UNIT OF MANAGEMENT SSA

The Unit of Management (UoM) SSA refers to a full hydrometric area. For the South Eastern CFRAM UoM15 (Nore) is one of six UoMs

At this scale, methods that could provide benefits to multiple, often all, AFAs within the Unit of Management and other areas should be considered, along with the spatial and temporal coherence of methods being considered at smaller SSAs.

FRM methods and options that might typically be applicable at this scale might include (but are not necessarily limited to):

- Policy requirements;
- Flood forecasting and warning systems;
- Land Use Management, where applicable;
- Methods implemented under other legislation;
- Methods which offer potential benefit to multiple UoMs/Sub-catchments and/or AFAs such as tidal barrages;
- Requirements for additional monitoring (rain and river level / flow gauges)
- Public awareness and education campaigns.

3.2 SUB-CATCHMENT SSA

The sub-catchment SSA refers to the catchment of the principal river on which multiple AFAs sit, including areas upstream and areas downstream to the river's discharge into another, larger river or into the sea.

At this scale, methods that could provide benefits to multiple AFAs within the sub-catchment and other areas should be considered, such as storage or conveyance improvement, along with the spatial and temporal coherence of methods being considered at smaller SSAs.

3.3 AFA SSA

The AFA SSA refers to an individual AFA; such areas would include towns, villages, areas where significant development is anticipated and other areas or structures for which the risk that could arise from flooding is understood to be significant. At this scale, methods benefitting only the particular AFA in question are considered, even if the implementation of a given method includes works or activities outside of the AFA, i.e., elsewhere in the sub-catchment or UoM. Examples of where this might apply would be storage options upstream of the AFA, or flood forecasting and warning systems, that provide benefits to no other AFAs than the AFA under consideration.

3.4 SPATIAL SCALES OF ASSESSMENT FOR UOM15

A review was carried out for UoM15 to identify the SSAs which would require optioneering. This was based on the flood risk to each AFA. Only AFAs with a present day flood risk were considered when identifying Sub Catchment SSAs. . The principal flood mechanism was also considered to ensure that any FRM Methods being assessed would have the potential to benefit all the AFAs within the Sub Catchment identified. UoM and Sub Catchment SSAs were delineated using the hydrological catchment boundaries. Table 3.1 and Figure 3.1 detail the SSAs for UoM15.

Table 3.1 – List of SSAs in UoM15

SSA	Name	AFAs within SSA		
UoM	UoM 15	All		
AFA	Ballyhale			
AFA	Ballyragget (Inc Borris)			
AFA	Ballyroan			
AFA	Callan			
AFA	Freshford			
AFA	Inistioge			
AFA	Kilkenny (Nore)			
AFA	Kilkenny (Breagagh)			
AFA	Mountrath			
AFA	Rathdowney			
AFA	Thomastown			

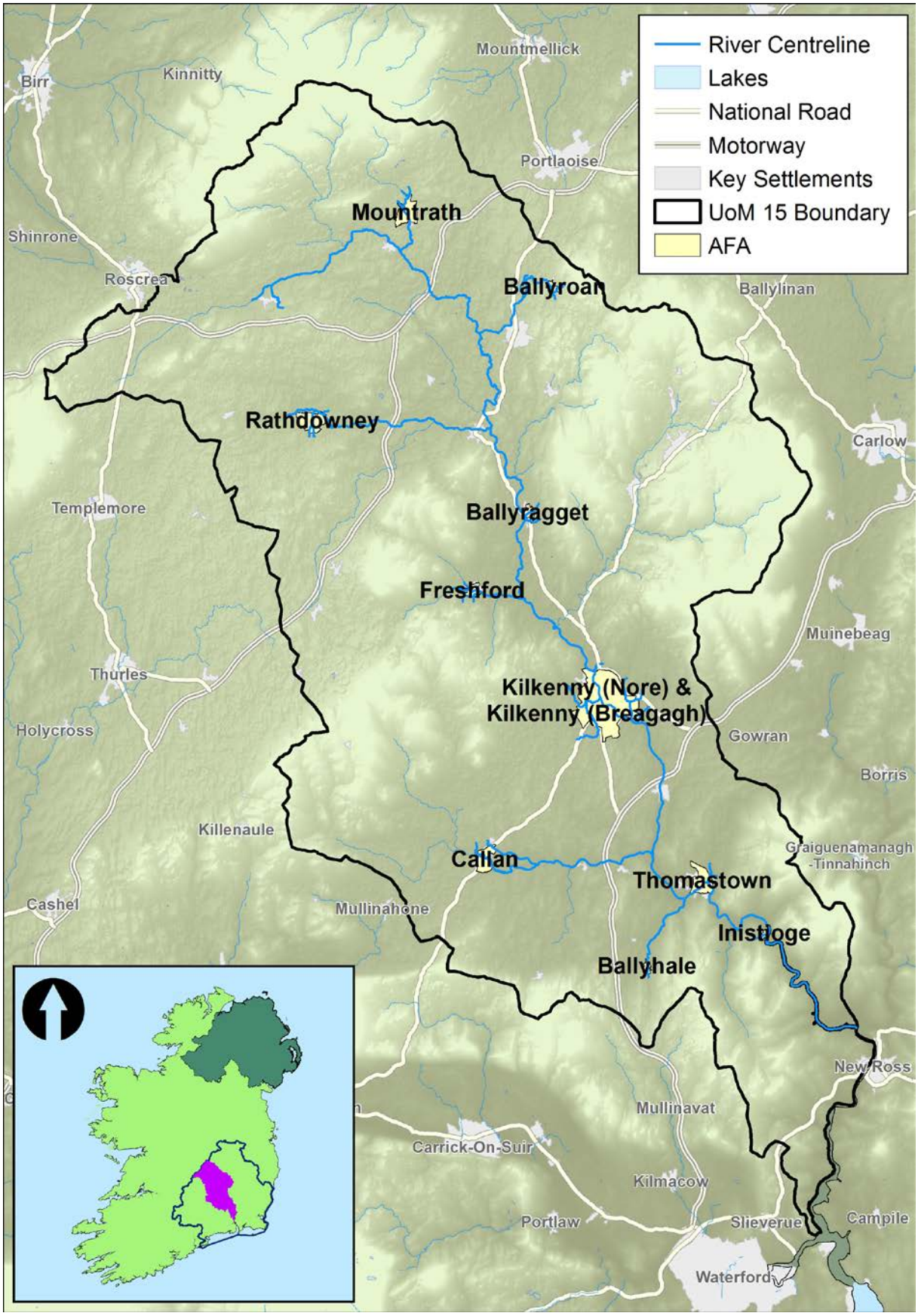


Figure 3.1 – UoM15 SSAs

4 FLOOD RISK ASSESSMENT

The aim of the Flood Risk Assessment is to assess and map the potential adverse consequences (risk) associated with flooding in the area being studied. The assessment identifies how flooding occurs, i.e. its flooding mechanism, and the consequence of the flooding to the receptors affected. This process helps to identify the applicability of an FRM method for each SSA being considered.

The level of flood risk is assessed using four receptor groups as described in Table 4.1. The risk to a receptor can be affected by its location within the flood extent or the proportion of the receptor within the flood extent, the depth to which it floods, the velocity of the water adjacent to the receptor and the receptors' vulnerability to flooding.

Table 4.1 - Flood risk receptor groups

Flood Risk Receptor Group	Receptor Dataset	Indicator
Social	Residential Properties	Location and number of residential properties
	Residential Homes (children, disabled, elderly)	Location, type and number
	Prisons, Schools (primary, post-primary, third level education), fire stations, garda stations, civil defence, ambulance stations, hospitals, health centres, OPW buildings, government buildings, local authority buildings.	Location, type and number
	Social amenity sites	
Economic	Residential and Commercial Properties	Location, type, number, depth-damage data
	ESB power stations, ESB HV substations, Board Gais assets, Eircom assets, Water supply, Data centres	Location, type and number
	Road networks, Rail networks & Stations, Ports and Harbours	Location. type. number and length
Environment	Special Area of Conservation, Special Protected Area, Groundwater Abstraction for Drinking Water, Pollution Sources, Recreational water including bathing water	Location, extent and nature
Cultural Heritage	Architectural Heritage, National Monuments, National Heritage Area, Proposed National Heritage Area, Sites and Monument Records, Record of Monuments and Places	Location, type and number

The flood risk to the four receptor groups in each of the AFAs within UoM15 is summarised in Table 4.2.

Table 4.2 Flood Risk Analysis UoM15

Type of Risk	Flood Risk for Design AEP (1% Fluvial & 0.5% Coastal) Event										
	Ballyhale AFA	Ballyragget AFA	Ballyroan AFA	Callan AFA	Freshford AFA	Inistioge AFA	Kilkenny (Nore) AFA	Kilkenny (Breagagh) AFA	Mountrath AFA	Rathdowney AFA	Thomastown AFA
Current Scenario (Present Day)											
Event Damage (€)	4,707,129	0	0	5,078,626	13,549,914	3,239,665 Fluvial 270,894 Coastal 1	1,355,989	396,770	2,253,144	12,873,671	15,317,088
No. Residential Properties at Risk	19	0	0	18	55	22 Fluvial 4 Coastal1	14	36	33	17	48
No. Business Properties at Risk	6	0	0	20	38	8 Fluvial 0 Coastal1	6	1	7	27	87
No. Utilities at Risk	0	0	0	0	1	0 Fluvial 0 Coastal1	1	1	0	0	1
No. Major Transport Assets at Risk	4	0	2	1	16	6 Fluvial 4 Coastal1	17	11	13	7	13
No. Highly Vulnerable Properties at Risk	1	0	0	0	0	0 Fluvial 0 Coastal1	0	0	1	0	1
No. of Social Infrastructure Assets at Risk	0	0	4	8	6	4 Fluvial 9 Coastal1	56	8	9	2	24
No. Environmental Assets at Risk	2	4	2	4	2	3 Fluvial 3 Coastal1	7	3	4	1	6
No. Potential Pollution Sources at Risk	0	0	0	0	0	0 Fluvial 0 Coastal1	0	0	0	1	0
Type of Risk	**Flood Risk for Design AEP (1% Fluvial & 0.5% Coastal) Event**										
	Ballyhale AFA	**Ballyragget AFA**	**Ballyroan AFA**	**Callan AFA**	**Freshford AFA**	**Inistioge AFA**	**Kilkenny (Nore) AFA**	**Kilkenny (Breagagh) AFA**	**Mountrath AFA**	**Rathdowney AFA**	**Thomastown AFA**
Mid-Range Scenario (Future)											
Event Damage (€)	6,417,449	1,024,070	9,538	13,258,375	21,735,484	6,106,592 Fluvial 415,856 Coastal1	38,873,693	2,078,002	5,322,534	16,198,724	25,347,157
No. Residential Properties at Risk	21	1	2	42	115	32 Fluvial 7 Coastal1	121	59	53	31	58
No. Business Properties at Risk	7	3	0	47	43	14 Fluvial 0 Coastal1	125	4	15	28	102

No. Utilities at Risk	0	0	0	0	1	0 Fluvial 0 Coastal1	3	2	0	0	1
No. Major Transport Assets at Risk	6	0	2	8	19	11 Fluvial 4 Coastal1	24	15	13	9	13
No. Highly Vulnerable Properties at Risk	1	0	1	0	0	1 Fluvial 0 Coastal1	0	0	1	0	1
No. of Social Infrastructure Assets at Risk	1	0	4	11	6	4 Fluvial 9 Coastal	125	8	9	3	25
No. Environmental Assets at Risk	2	4	2	4	2	3 Fluvial 3 Coastal1	7	3	4	1	6
No. Potential Pollution Sources at Risk	0	0	0	0	0	0 Fluvial 0 Coastal1	1	0	0	1	0
Type of Risk	**Flood Risk for Design AEP (1% Fluvial & 0.5% Coastal) Event**										
	Ballyhale AFA	**Ballyragget AFA**	**Ballyroan AFA**	**Callan AFA**	**Freshford AFA**	**Inistioge AFA**	**Kilkenny (Nore) AFA**	**Kilkenny (Breagagh) AFA**	**Mountrath AFA**	**Rathdowney AFA**	**Thomastown AFA**
High-Range Scenario (Future)											
Event Damage (€)	6,744,679	1,603,996	17,679	15,969,842	26,506,244	10,411,195 Fluvial 812,971 Coastal1	94,229,585	3,526,960	9,073,443	19,227,357	32,034,003
No. Residential Properties at Risk	22	2	2	48	130	39 Fluvial 8 Coastal1	222	78	57	34	68
No. Business Properties at Risk	8	3	0	61	48	15 Fluvial 1 Coastal1	227	6	20	31	114
No. Utilities at Risk	0	0	0	0	1	0 Fluvial 0 Coastal1	3	2	0	0	1
No. Major Transport Assets at Risk	6	0	2	10	22	11 Fluvial 5 Coastal1	30	22	13	9	14
No. Highly Vulnerable Properties at Risk	1	0	2	0	0	1 Fluvial 0 Coastal1	3	0	1	0	1
No. of Social Infrastructure Assets at Risk	1	0	4	12	6	6 Fluvial 9 Coastal1	201	9	9	3	26
No. Environmental Assets at Risk	2	4	2	4	2	3 Fluvial 3 Coastal1	7	3	4	1	6
No. Potential Pollution Sources at Risk	0	0	0	0	0	0 Fluvial 0 Coastal1	1	0	0	1	0

4.1 FLOOD RISK MAPS

The clearest way to present the flood risk within an area being studied is through flood risk maps. These maps detail the source of the risk and the receptors at risk. The following flood risk maps were produced:

- Social Risk map
- Environmental Risk map
- Cultural Heritage Risk map
- Economic Risk map
- Economic Activity map
- Economic Risk Density map
- Number of Inhabitants map

The social, environmental, cultural heritage and economic risk maps display the various receptors within each AFA. Their proximity to the flood extents and therefore the level of risk can be ascertained by these maps. Figure 4.1 presents an example of a cultural heritage risk map in Portlaoise.

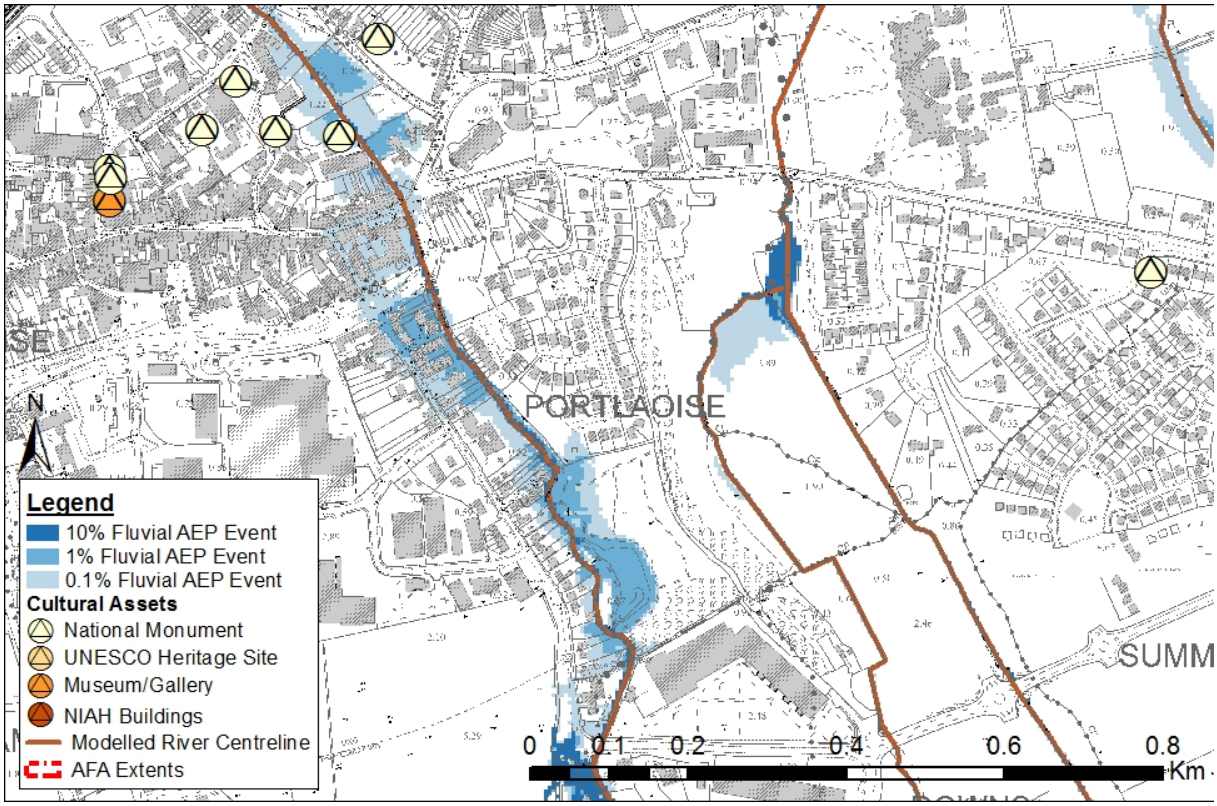


Figure 4.1 - Extract from cultural heritage risk map

The economic activity maps present the nation's economic activity in four categories; property (residential properties), infrastructure (transport and utilities), rural land use and economic (commercial properties). Where an economic activity is at risk in any AFA it is highlighted on the map. Figure 4.2 presents an example of an economic activity map.

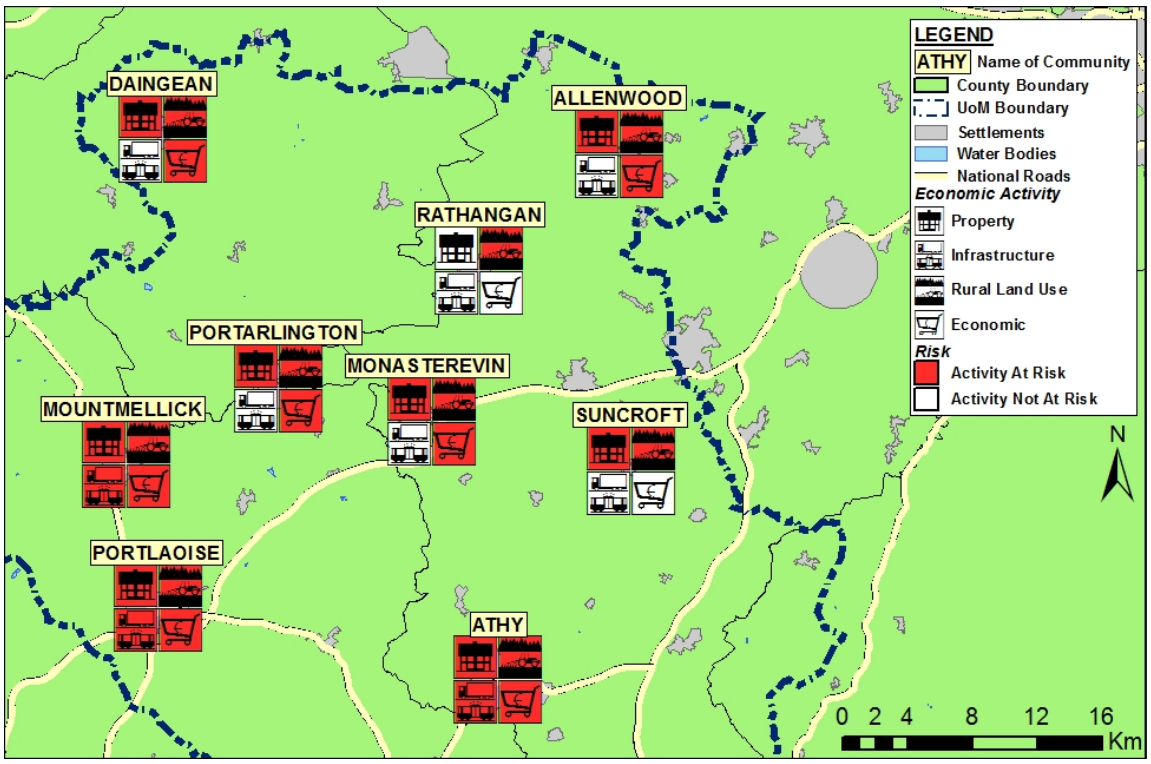


Figure 4.2 – Extract from economic activity map

The economic risk density maps and number of inhabitants maps present their data in the form of grid squares, 100m x 100m. Depending on the annual average damage (AAD) or the number of inhabitants within each grid square the square is assigned a colour format. An example of an Economic Risk Density map is shown in Figure 4.3. The flood risk within the UoM15 AFAs is summarised within Section 8.

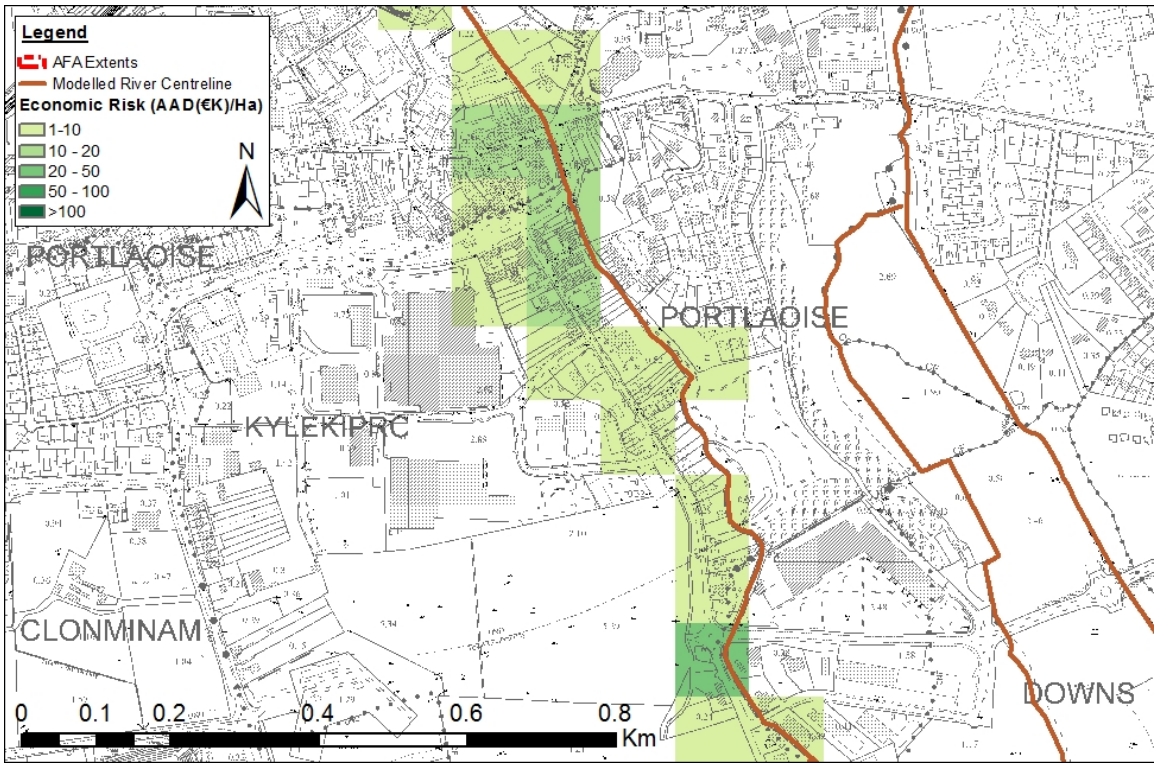


Figure 4.3 - Extract from economic risk density maps

4.2 FLOOD CELLS

It is recognised that the preferred method in one part of the AFA may not be the preferred method in another part. This may be due to location specific factors such as the flood source, the flooding mechanism or the receptors being affected including the potential benefit available from protecting them. Therefore before FRM methods are screened for their suitability within any given AFA a review was carried out, considering the above factors, to identify sub-areas of the AFA, referred to as “flood cells”.

A further assessment of these flood cells was carried out to ascertain how a change within a flood cell would likely impact on another flood cell. Where flood cells were deemed likely to affect other AFAs or where the flood cell contains the majority of the AFA risk they were considered complex. Where flood cells were discrete areas with relatively little risk they were considered local.

Where flood cells were interdependent the FRM methods considered in these flood cells were screened together so as to ensure that no adverse effect was imposed on any given flood cell. All other flood cells were screened independently.

When all flood cells for an AFA have been screened the suitable FRM methods are taken forward to develop FRM options for the AFA as a whole. Section 8, which details the screening process for each AFA, includes the findings of the flood cell review within UoM15.

In identifying flood cells it is recognised that the complex cells contain the majority of the risk and the methods that are proposed will have the biggest impact to the town or area in question. For this reason it is important that all suitable methods in complex cells are considered and developed into potential options for analysis. Local flood cells represent discrete areas of flooding remote from the main flood risk area within the town of area in question and have a relatively low risk. There are often numerous local cells scattered around an AFA and it is preferable to identify, and discretely select, the most suitable method/s to address the flood risk before developing the options. Otherwise a large number of potential options will be identified which will represent only minor variations of the same option dealing with the main risk area. A qualitative review of suitable methods has therefore been carried out for local cells where the technical, economic, social and environmental implications are considered based on professional judgement. These considerations are similar to the objectives set out in the multi criteria analysis (MCA) details of which are given in section 7.3.

5 DAMAGE ASSESSMENT

As part of the economic risk assessment a monetary damage is assigned to certain receptors at risk. This damage represents the costs to the nation if the flood events being considered were to occur. The following receptors are assigned a monetary damage value:

- Residential properties
- Commercial properties
- Utility infrastructure

The total damage to an area being studied is used to quantify the economic risk and provide the amount of potential benefit that would accrue if a FRM measure is put in place which would prevent the damage from occurring.

5.1 DAMAGE ASSESSMENT GUIDELINES

The damage assessment methodology for the CFRAM study follows the guidance in "The Benefits of Flood and Coastal Defence: A Manual of Assessment Techniques" (Flood Hazard Research Centre, Middlesex University, UK, 2005). This document is often referred to as the Multi Coloured Manual (MCM).

The MCM results from research carried out by Middlesex University Flood Hazard Research Centre and provides data and techniques for assessing the benefits of flood risk management in the form of flood alleviation. The MCM has focused on the benefits that arise from protecting residential property, commercial property, and road disruption amongst other areas as experience has shown that these sectors constitute the vast majority of the potential benefits of capital investment.

Based on this research the MCM provides depth damage data for both residential and commercial properties. For certain depths of flood water a damage has been assigned to a property type. This damage is a combination of the likely items within the building and the building structure itself. The damage to each property is dependent on the property type, as such the MCM has categorised both the residential and commercial properties. An example of depth damage data is shown in Figure 5.1.

	DETACHED LAND USE CODE 11				*2010 PRICES*			FLOOD DURATION MORE THAN 12 HOURS						
	DEPTH ABOVE UPPER SURFACE OF GROUND FLOOR													
Components of damage	-0.3	0	0.05	0.1	0.2	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3
1 Paths and paved areas	0	54.32	58.38	73.32	162.24	360.86	413.33	455.09	503.6	604.25	695.98	824.35	859.62	902.05	949.92
2 Gardens/fences/sheds	0	0	102.7	202.5	705.95	1308.73	2248.7	2948.95	3755.38	5856.54	6811.11	8088.28	9415.97	10109.3	10487.34
3 External main building	935.51	1223.52	1430.1	1763.94	2321.56	2647	3129	3808.85	4520.47	5913.69	8082.01	9828.87	12058.9	15251.18	19279.72
4 Plasterwork	176.84	487.74	1124.95	1712.61	2592.26	3917.47	4739.55	5016.94	5913.36	7178.64	8142.19	9363.46	9918.23	10305.43	10860.2
5 Floors	0	1756.48	6399.48	7457.37	8453.96	9270.39	9344.44	9418.48	9455.5	9603.59	9751.68	9899.77	9899.77	9899.77	9899.77
6 Joinery	0	357.66	1572.85	4443.87	6055.64	7510.61	7534.94	7853.8	7951.63	8025.14	8220.27	11396.54	11396.54	11396.54	11396.54
7 Internal decorations	209.19	241.8	374.99	1716.8	2753.95	2833.64	2931.01	3104.93	3234.52	3348.56	3462.6	3480.28	3480.28	3480.28	3480.28
8 Plumbing and electrical	0	0	962.99	1726.05	2669.08	4106.08	4395.48	4395.48	4395.48	4395.48	4395.48	4395.48	4395.48	4395.48	4395.48
Building Fabric Damage	**1321.54**	**4121.52**	**12026.44**	**19096.46**	**25714.63**	**31954.78**	**34736.44**	**37002.52**	**39729.95**	**44925.9**	**49561.33**	**57277.02**	**61424.8**	**65740.04**	**70749.25**
1 Domestic appliances	0	0	2.76	194.14	903.63	1657.79	1798.06	1906.38	1907.06	1907.74	1910.12	1911.61	1911.61	1911.61	1911.61
2 Heating equipment	0	0	35.91	68.21	118.1	161.3	697.84	955.69	1149.08	1149.08	1149.08	1149.08	1149.08	1149.08	1149.08
3 Audio/video	0	0	163.71	479.77	686.43	959.78	1287.64	1682.48	1718.91	1718.91	1718.91	1718.91	1718.91	1718.91	1718.91
4 Furniture	0	0	194.6	334.79	2140.23	2175.78	2207.94	2251.35	2335.43	2361.77	2361.77	2361.77	2361.77	2361.77	2361.77
5 Personal effects	0	0	57.37	143.14	281.24	430.58	642.4	785.56	859.81	974.85	1058.12	1058.12	1058.12	1058.12	1058.12
6 Floor coverings/curtains	0	0	1360.09	1432.05	1432.05	1474.94	1654.79	1667.42	1688.06	1702.99	1702.99	1702.99	1702.99	1702.99	1702.99
7 Garden/DIY/leisure	0	0	32.38	96.52	126.4	203.42	233.81	266.64	269.59	277.21	278.09	278.09	278.09	278.09	278.09
8 Domestic clean-up	0	0	4820.2	4820.2	5915.8	5915.8	6884.9	6884.9	6884.9	6884.9	8666.9	8666.9	8666.9	8666.9	8666.9
Household Inventory Damag	**0**	**0**	**6667.02**	**7568.82**	**11603.87**	**12979.4**	**15407.39**	**16400.42**	**16812.85**	**16977.46**	**18845.97**	**18847.46**	**18847.46**	**18847.46**	**18847.46**
Total Damage	**1321.54**	**4121.52**	**18693.46**	**26665.28**	**37318.5**	**44934.18**	**50143.83**	**53402.95**	**56542.8**	**61903.35**	**68407.3**	**76124.49**	**80272.26**	**84587.5**	**89596.71**
Total Damage/Square Metre	17.07	52.5	247.12	353.18	495.36	597.03	666.9	711.58	751.92	821.18	908.61	1013.84	1068.33	1123.67	1188.23

Figure 5.1 - MCM's depth damage data for detached houses

For properties identified at risk from coastal flooding an additional 10% was added onto the damage figure attributed to building fabric, which is made of up several components as shown in Figure 5.1. This percentage was set by the OPW to account for increased repair costs related to property inundation from seawater.

5.2 RECORDING DAMAGE ASSESSMENT DATA

The damage assessment is carried out in order to quantify the economic risk to the area being studied. This requires details to be recorded such as background data, interim calculations and final damage results. As such RPS have created geo-referenced shapefiles, known as economic risk shapefiles, with the relevant data recorded in the attribute tables, an example is shown in Figure 5.2.

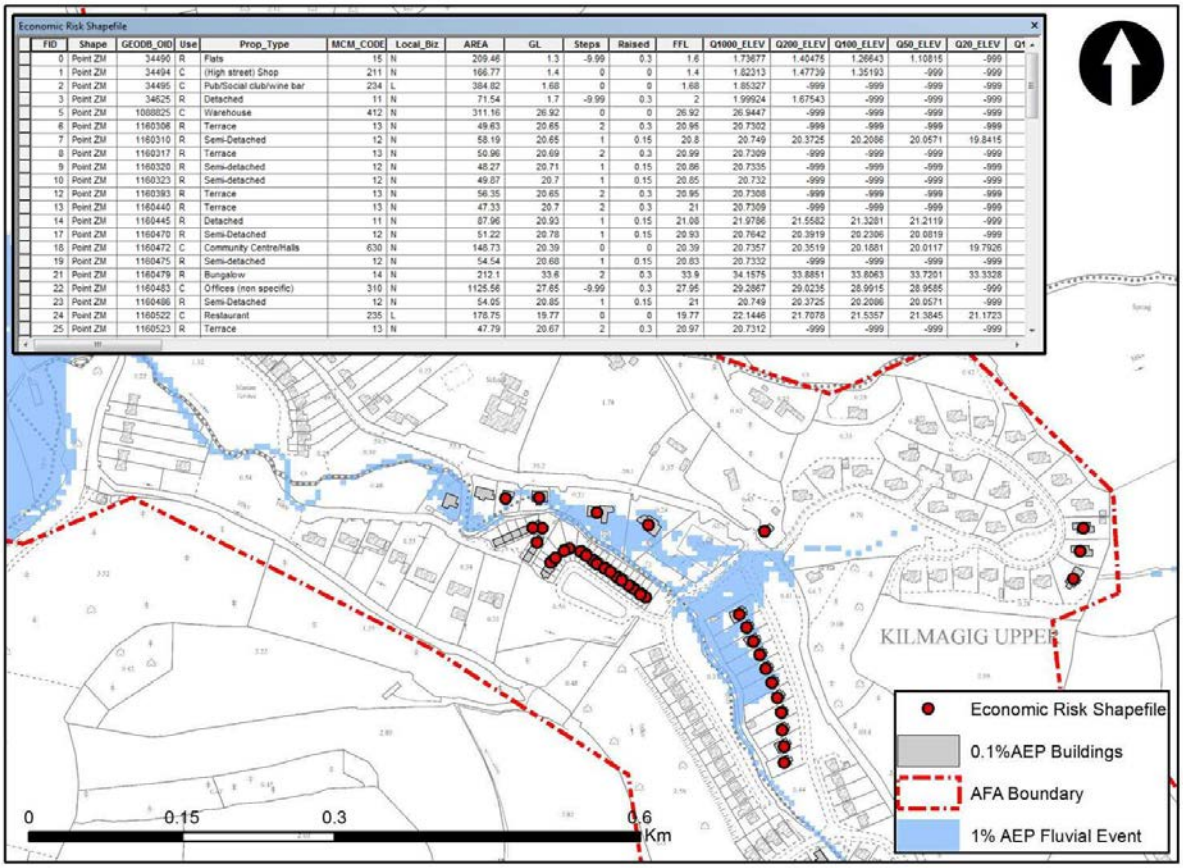


Figure 5.2 - Example shapefile with attribute table showing damage assessment data

The damage data for residential properties and commercial properties has been grouped into a single point file for each area being studied. The following sections detail the key steps in the damage assessment and the data that is recorded during various processes within the shapefile attribute tables.

5.3 CATEGORISATION OF PROPERTIES

Properties were categorised according to MCM guidelines. A complete list of the property types and MCM codes utilised is included in Table 5.1. The MCM assigns a code to each property type to aid the

damage calculations where a number can more readily be used in calculations rather than a description in text format.

Table 5.1 - MCM property types

Property Type	MCM code	Property Type	MCM code
Detached House	11	**Leisure**	51
Semi Detached House	12	Hotel	511
Terrace House	13	Boarding House	512
Bungalow	14	Caravan Mobile	513
Flat	15	Caravan Static	514
Shop/Store	21	Self-catering Unit	515
(High Street) Shop	211	Hostel (including prisons)	516
Superstore/Hypermarket	213	Bingo hall	517
Retail Warehouse	214	Theatre/Cinema	518
Showroom	215	Beach Hut	519
Kiosk	216	**Sport**	52
Outdoor market	217	Sports Grounds and Playing Fields	521
Indoor Market	218	Golf Courses	522
Vehicle Services	22	Sports and Leisure centres	523
Vehicle Repair Garage	221	Amusement Arcade/Park	524
Petrol Filling Station	222	Football Ground and Stadia	525
Car Showroom	223	Mooring/Wharf/Marina	526
Plant Hire	224	Swimming Pool	527
Retail Services	23	**Public Building**	6
Hairdressing Salon	231	School/College/University/Nursery	610
Betting Shop	232	Surgery/Health Centre	620
Laundrette	233	Residential Home	625
Pub/Social club/wine bar	234	Community Centres/Halls	630
Restaurant	235	Library	640
Café/Food Court	236	Fire/Ambulance station	650
Post Office	237	Police Station	651
Garden Centre	238	Hospital	660
Office	3	Museum	670
Offices (non-specific)	310	Law court	680
Computer Centres (Hi-Tech)	311	Church	690
Bank	320	**Industry**	8
Distribution/Logistics	4	Workshop	810
Warehouse (including store)	410	Factory/Works/Mill	820
Land Used for Storage	420	Extractive/heavy Industry	830
Road Haulage	430	Sewage treatment works	840
Warehouse (electrical goods)	411	Laboratory	850
Warehouse (ambient goods)	412	**Miscellaneous**	9
Warehouse (frozen goods)	413	Car Park	910
		Public Convenience	920
		Cemetery/Crematorium	930

Property Type	MCM code	Property Type	MCM code
		Bus Station	940
		Dock Hereditament	950
		Electricity Hereditament	960

For each area being studied all properties found within the 0.1% AEP flood extent were categorised. This was carried out using data gained from site visits, surveys, OSi mapping, An post geo-directory and online mapping. The OSi building polygon layer was used initially to locate all the properties and provide their floor area.. GIS software was used to select all properties whose outlines intersected flood extents. This selection was tailored depending on the hydraulic model used to produce the flood extents. For rectangular mesh models, the buildings were represented by 5m grid squares orientated on the north-south axis. These building grid squares were selected where they intersected with the various flood extents. The selected building grid squares were then used to overlay and select the OSi buildings. Hydraulic models utilising a flexible mesh represented the building using the OSi building footprint. The OSi building polygons were therefore used to select the properties that intersected the various flood extents. Further details of which hydraulic model type was used in each AFA are available in the South Eastern CFRAM Study, UoM15 Hydraulics Report.

Sheds and garages have no depth damage data in the MCM guidelines and therefore required removal from the properties to be assessed. Using the An post geo-directory spatial dataset it was possible to identify those properties without any information. These properties were checked to ensure they were garages or sheds before removal, or where information did not exist for buildings that were to be included RPS manually filled in the missing data required.

All remaining buildings were then categorised, with information collected under the headings in Table 5.2.

Table 5.2 - Categorisation of properties data

Data type	Attribute name	Data details
Property ID	GEODB_OID	An Post geo-directory database ID
Property Use and Basement Present	Use	"R" for residential “RB” for residential with basement "C" for commercial "CB" for commercial with basement “CC” for commercial cellar
MCM code	MCM_CODE	As per MCM guidelines
Local Business	Local_Biz	“L” for local business “N” for not local business
Building Floor Area	AREA	Area (m^2), calculated using the OSi building polygon in ArcGIS

5.4 PROPERTY FLOOR LEVEL

The damage assigned to a property relates to the depth of water above the finished floor level. In the absence of surveyed floor levels for every property at risk, online mapping and site visits were utilised to collect data which could be used to provide a more accurate estimate of property floor levels. This included the number of steps into each property and whether basements were present.

The property ground levels were extracted from LiDAR datasets for each building, where the minimum level on the building footprint was acquired. This provided a conservative level on which to add the height of the steps. The LiDAR survey carried out captured the ground level to an accuracy of 0.2m.

As a general rule most properties are constructed with the floor level raised 300mm above the adjacent ground level, with two steps at entrances. For this reason each step was assigned a 150mm height, and where an entrance was not visible it was assumed to have the standard 300mm rise. This was assumed for the South Eastern CFRAM Study and is consistent with the assumptions made in the MCM. For the purposes of this study a conservative approach was assumed where a basement was found, where the threshold level was dropped 2.5m below ground level.

These details were attributed to each property and the finished flood level calculated accordingly. Table 5.3 shows the details recorded in the damage assessment shapefile.

Table 5.3 - Property threshold data

Data type	Attribute name	Data details
Ground Level	GL	LiDAR data extracted at each property, measured in mOD
How many steps into property	Steps	Number of steps into property entrance. Where details of property entry are unknown “-999” value recorded.
Is ground floor raised	RAISED	Calculated from “Steps” column. Each step to be 0.15m, on basis of 0.3 standard entry to a property. Where “-999” value recorded the 0.3m standard entry is assumed.
Finished Floor Level	FFL	Ground level plus raised value. For properties with basements FFL is calculated to be ground level minus 2.5m.

5.5 FLOOD DEPTH OF PROPERTIES

To estimate the damage to a property the depth that it floods was required. This will vary depending on the size of the flood event. As part of the South Eastern CFRAM Study the depths to which the properties flood during the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP flood events were calculated. The depth of flooding is calculated by finding the difference between the flood water elevation and the FFL.

To achieve this, the maximum flood depth at each property was required. It is recognised that as flood water passes around a structure such as a building the water will build up against the upstream face and be forced around the structure. This creates an uneven distribution of water levels around the

structure. This was simulated in the hydraulic analysis where buildings were placed in the floodplain forcing the modelled flood to flow around them. To maintain a conservative approach the maximum flood level adjacent to the building was extracted and recorded in the attribute table of the economic risk shapefile. This process was achieved by carrying out analysis in ArcGIS and was carried out for each property and for each flood event. As the water was deflected around buildings and not through them no flood elevation data was located within the building footprint. The flood elevation rasters were therefore buffered through an interpolation tool within GIS placing flood elevation data inside buildings. This also ensured that buildings close to the margins of the floodplain were included in the analysis where appropriate. The maximum flood elevation was then extracted from the raster and assigned to the relevant building. Table 5.4 shows the details recorded within the economic risk shapefile attribute tables.

Table 5.4 - Flood depth of properties data

Data type	Attribute name	Data details
Flood level for all flood events	Q1000_ELEV, Q200_ELEV, Q100_ELEV, Q50_ELEV, Q20_ELEV, Q10_ELEV, Q5_ELEV, Q2_ELEV.	The maximum flood level adjacent to the building (mOD)
Flood depth for all flood events	Q1000_Dp, Q200_Dp, Q100_Dp, Q50_Dp, Q20_Dp, Q10_Dp, Q5_Dp, Q2_Dp.	Difference between the flood level and FFL

5.6 FLOOD DAMAGE TO PROPERTIES

Once the depths of flooding are known the damage can be calculated using the MCM depth damage data. This is known as principal direct damage in that the flooding directly damages assets, it does not account for indirect damages such as heating costs to dry out the house, etc. For each property type a typical damage based on historical data has been assigned to a depth of flooding, an example of which is shown in Figure 5.3.

DETACHED
LAND USE CODE 11 *2010 PRICES* FLOOD DURATION MORE THAN 12 HOURS

Components of damage	DEPTH ABOVE UPPER SURFACE OF GROUND FLOOR -0.3	0	0.05	0.1	0.2	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3
1 Paths and paved areas	0	54.32	58.38	73.32	162.24	360.86	413.33	455.09	503.6	604.25	695.98	824.35	859.62	902.05	949.92
2 Gardens/fences/sheds	0	0	102.7	202.5	705.95	1308.73	2248.7	2948.95	3755.38	5856.54	6811.11	8088.28	9415.97	10109.3	10487.34
3 External main building	935.51	1223.52	1430.1	1763.94	2321.56	2647	3129	3808.85	4520.47	5913.69	8082.01	9828.87	12058.9	15251.18	19279.72
4 Plasterwork	176.84	487.74	1124.95	1712.61	2592.26	3917.47	4739.55	5016.94	5913.36	7178.64	8142.19	9363.46	9918.23	10305.43	10860.2
5 Floors	0	1756.48	6399.48	7457.37	8453.96	9270.39	9344.44	9418.48	9455.5	9603.59	9751.68	9899.77	9899.77	9899.77	9899.77
6 Joinery	0	357.66	1572.85	4443.87	6055.64	7510.61	7534.94	7853.8	7951.63	8025.14	8220.27	11396.54	11396.54	11396.54	11396.54
7 Internal decorations	209.19	241.8	374.99	1716.8	2753.95	2833.64	2931.01	3104.93	3234.52	3348.56	3462.6	3480.28	3480.28	3480.28	3480.28
8 Plumbing and electrical	0	0	962.99	1726.05	2669.08	4106.08	4395.48	4395.48	4395.48	4395.48	4395.48	4395.48	4395.48	4395.48	4395.48
Building Fabric Damage	**1321.54**	**4121.52**	**12026.44**	**19096.46**	**25714.63**	**31954.78**	**34736.44**	**37002.52**	**39729.95**	**44925.9**	**49561.33**	**57277.02**	**61424.8**	**65740.04**	**70749.25**
1 Domestic appliances	0	0	2.76	194.14	903.63	1657.79	1798.06	1906.38	1907.06	1907.74	1910.12	1911.61	1911.61	1911.61	1911.61
2 Heating equipment	0	0	35.91	68.21	118.1	161.3	697.84	955.69	1149.08	1149.08	1149.08	1149.08	1149.08	1149.08	1149.08
3 Audio/video	0	0	163.71	479.77	686.43	959.78	1287.64	1682.48	1718.91	1718.91	1718.91	1718.91	1718.91	1718.91	1718.91
4 Furniture	0	0	194.6	334.79	2140.23	2175.78	2207.94	2251.35	2335.43	2361.77	2361.77	2361.77	2361.77	2361.77	2361.77
5 Personal effects	0	0	57.37	143.14	281.24	430.58	642.4	785.56	859.81	974.85	1058.12	1058.12	1058.12	1058.12	1058.12
6 Floor coverings/curtains	0	0	1360.09	1432.05	1432.05	1474.94	1654.79	1667.42	1688.06	1702.99	1702.99	1702.99	1702.99	1702.99	1702.99
7 Garden/DIY/leisure	0	0	32.38	96.52	126.4	203.42	233.81	266.64	269.59	277.21	278.09	278.09	278.09	278.09	278.09
8 Domestic clean-up	0	0	4820.2	4820.2	5915.8	5915.8	6884.9	6884.9	6884.9	6884.9	8666.9	8666.9	8666.9	8666.9	8666.9
Household Inventory Damag	**0**	**0**	**6667.02**	**7568.82**	**11603.87**	**12979.4**	**15407.39**	**16400.42**	**16812.85**	**16977.46**	**18845.97**	**18847.46**	**18847.46**	**18847.46**	**18847.46**
Total Damage	**1321.54**	**4121.52**	**18693.46**	**26665.28**	**37318.5**	**44934.18**	**50143.83**	**53402.95**	**56542.8**	**61903.35**	**68407.3**	**76124.49**	**80272.26**	**84587.5**	**89596.71**
Total Damage/Square Metre	17.07	52.5	247.12	353.18	495.36	597.03	666.9	711.58	751.92	821.18	908.61	1013.84	1068.33	1123.67	1188.23

Figure 5.3 - The MCM's depth damage data for a detached house

Depth of flooding and therefore damage is measured relative to the FFL of the property in question. Damages start at a threshold value of -0.3m for residential properties and at 0m for non-residential, as provided in the MCM. In accordance with OPW guidance for residential properties the property type was considered for calculating damages, but not the property age, social class or size. Contrary to this the property type and size (floor area) have been considered for calculating non-residential property damages, where the floor area was derived from the OSi building polygon layer.

A GIS tool has been developed which provides the direct damage in each flood event for each building in pound sterling 2010 as provided in the MCM. These direct damage figures were then updated from 2010 pound sterling prices to 2013 euro rates applicable to Ireland, using the OECD's purchasing power parities (PPP) records and CSO Ireland's consumer price index (CPI). The overall adjustment factor used in the South Eastern CFRAM Study was 1.344, the conversion rates are shown in Tables 5.5 and 5.6.

Table 5.5 - Converting pound sterling to euro using the PPP 2010 values from OECD website

	PPP
US - UK	0.667
US - Ire	0.853
UK - Ire	**1.279**

Table 5.6 - Conversion rates to current year prices using CPI from CSO Ireland website

	CPI
2006	100
2010	101.2
Apr-13	106.4
2010 - 2013	1.051

The following details of the information and calculations described above were recorded within the economic risk shapefile attribute tables:

Table 5.7 - Flood damage to properties data

Data type	Attribute name	Data details
Direct damage per meter square	Q1000_M2Dm, Q200_M2Dm, Q100_M2Dm, Q50_M2Dm, Q20_M2Dm, Q10_M2Dm, Q5_M2Dm, Q2_M2Dm.	Damage per meter square to each property according to the depth of flooding from each flood event as per MCM data. Values in pound sterling updated to 2010 costs and for non-residential properties only.
Direct Damage to property over full floor area	1000_Dm£10, Q200_Dm£10, Q100_Dm£10, Q50_Dm£10, Q20_Dm£10, Q10_Dm£10, Q5_Dm£10. Q2_Dm£10	For residential properties calculations are based on property type and flood depth. For non-residential properties calculations are based on property type, flood depth and floor area.
Principal Direct Damage conversion to euro and 2013 prices	1000_PDD, Q200_PDD, Q100_PDD, Q50_PDD, Q20_PDD, Q10_PDD, Q5_PDD, Q2_PDD.	Conversion rate (1.344) applied to damage to property over full floor area.

5.7 INTANGIBLE DAMAGES, UTILITY AND EMERGENCY COSTS

Apart from the material damages to the building structure and the goods inside the property, it is recognised that there are monetary damages associated with clean-up costs, temporary accommodation, stress, etc. To account for this, it is OPW policy to assign intangible damages to all residential properties equal to the direct damages. No intangible damages are assigned to commercial properties as these costs do not apply at the same level with the exception of small family run businesses. To achieve this, a survey was carried out identifying these small businesses and an intangible damage equal to the direct damage assigned to those properties as well.

An economic damage relating to infrastructure utility assets will be incurred in flood events. Examples of these may include electrical sub-stations and telecommunications assets. A percentage of 20% of the principal direct damage has been applied to account for these damages, which have been set based on the analysis of damages from historical flooding in the UK.

A cost will be associated with emergency services dealing with the flood events. Following the MCM guidance, the OPW have set the emergency costs at 8.1% of the principal direct damages which has been adopted in this study. The following details were recorded within the economic risk shapefile attribute tables:

Table 5.8 - Intangible damages and emergency cost data

Data type	Attribute name	Data details
Intangible Damage	Q1000_IntD, Q200_IntD, Q100_IntD, Q50_IntD, Q20_IntD, Q10_IntD, Q5_IntD, Q2_IntD.	Set equal to the present direct damage of residential properties and small family run businesses.
Utility costs	1000_Util, Q200_Util, Q100_Util, Q50_Util, Q20_Util, Q10_Util, Q5_Util, Q2_Util.	Equal to 20% of the present direct damage for all properties.
Emergency costs	1000_Emerg, Q200_Emerg, Q100_Emerg, Q50_Emerg, Q20_Emerg, Q10_Emerg, Q5_Emerg, Q2_Emerg.	Equal to 8.1% of the present direct damage for all properties.
Event damage	1000_EvDam, Q200_EvDam, Q100_EvDam, Q50_EvDam, Q20_EvDam, Q10_EvDam, Q5_EvDam, Q2_EvDam.	Summed damage of any one event. This is the total of the present value damage, utility damage, emergency costs and intangible damage.
Event damage for MCA	1000_EvMCA, Q200_EvMCA, Q100_EvMCA, Q50_EvMCA, Q20_EvMCA, Q10_EvMCA, Q5_EvMCA, Q2_EvMCA.	Sum of the present value damage and emergency costs. The multi-criteria analysis requires economic damages which only account for these contributors.

5.8 ANNUAL AVERAGE DAMAGE AND PRESENT VALUE DAMAGE

Thus far in the process, damages have been assigned to each property for each flood event. In order to gain an appreciation of the economic risk the overall damage needs to be calculated. This is represented by assessing the likelihood of each of these flood events occurring in any given year and applying this as a percentage to the damage, this is known as the Annual Average Damage (AAD). This can then be taken over the lifetime of the project which has been set at 50 years and discounted back to present day costs, this is known as present value damage (PvD).

Calculating the AAD can best be described by considering the graph shown in Figure 5.4. The points shown represent the flood events where the damage has been calculated. Their position on the graph

is dictated by the damage caused and by the frequency of the flood event occurring in any given year. These points are joined together to create a damage curve. This curve represents all the other flood events that could occur in between the flood events shown, for example the damage that would occur in a 33%AEP event can be estimated by the damage curve that is drawn from the 50%AEP event to the 20%AEP event.

The area under the curve is therefore a function of the damage and the frequency and gives the AAD. It can be seen then that for many areas being considered the majority of the damage occurs from the smaller, more frequent flood events rather than the larger flood events that appear at first glance to contribute most to the flood damage. Because the AAD is calculated by the area under the damage curve the more flood events included in the assessment the more accurate the AAD figure will be. A minimum of three events are required to create a curve but the less events there are the more likely the AAD will be overestimated. It is also essential to identify the threshold event. This is the event where damage starts to occur. Failure to do this will cut the damage curve short and reduce the area under the graph. The events that were considered for this study were the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP flood events.

Figure 5.4 - Example damage curve

Once the AAD is found the present value damage is calculated. The present value damage calculation sums the AAD that is expected to occur for each of the 50 years being considered in this study. However in order for the damage value in each year to be comparable with each other they are discounted to represent the equivalent present damage value. Discounting damage values in the future is based on the principle that generally people prefer to receive goods or services now rather than later. This is known as time preference. The cost therefore of providing a flood management option will also be discounted to present day values. It is therefore best practice to discount the AAD figure for any given year by the distance in years it is away from the present day. The OPW has set this discount rate at 4% and this figure has been used in this study. Over the 50 years being considered this amounted to factoring the AAD by 21.482. A separate AAD figure was calculated

specifically for use in the multi-criteria analyses process, which only included principal direct damage and emergency services costs.

The following details were recorded within the economic risk shapefile attribute tables:

Table 5.9 - AAD and PvD data

Data type	Attribute name	Data details
Annual Average Damage	AAD	The equation to calculate the AAD is as follows: (([Q2_EvDam]+[Q5_EvDam])/2*(0.5-0.2)+([Q5_EvDam]+[Q10_EvDam])/2*(0.2-0.1)+([Q10_EvDam]+[Q20_EvDam])/2*(0.1-0.05)+([Q20_EvDam]+[Q50_EvDam])/2*(0.05-0.02)+([Q50_EvDam]+[Q100_EvDam])/2*(0.02-0.01)+([Q100_EvDam]+[Q200_EvDam])/2*(0.01-0.005)+([Q200_EvDam]+[1000_EvDam])/2*(0.005-0.001))
Present value damage	PvD	The AAD factored by 21.482
Annual Average Damage*	AAD_MCA	The equation to calculate the AAD is as follows: (([Q2_EvMCA]+[Q5_EvMCA])/2*(0.5-0.2)+([Q5_EvMCA]+[Q10_EvMCA])/2*(0.2-0.1)+([Q10_EvMCA]+[Q20_EvMCA])/2*(0.1-0.05)+([Q20_EvMCA]+[Q50_EvMCA])/2*(0.05-0.02)+([Q50_EvMCA]+[Q100_EvMCA])/2*(0.02-0.01)+([Q100_EvMCA]+[Q200_EvMCA])/2*(0.01-0.005)+([Q200_EvMCA]+[1000_EvMCA])/2*(0.005-0.001))

*As the MCA requires only AAD the present value damage (PvD) was not required to be calculated.

5.9 COASTAL FLOODING

Where properties were identified to be at risk of coastal flooding, an additional 10% was added onto the building fabric damage. RPS created a GIS tool mirroring that for the fluvial damages which accounted for the additional building fabric damage. Where properties were at risk from coastal mechanisms 1 and/or 2, this tool was used for damage calculations.

5.10 DEFENDED FLOOD DAMAGES

In the defended scenario a copy of the economic risk shapefiles were made, where properties were protected up to the 1% fluvial or 0.5% coastal AEP. Any properties with extracted flood depths up to the standard of protection were removed and the damages calculations rerun to provide a defended AAD and PvD. An assumption was made that when defences were overtopped any damage in events that exceed the standard of protection would be the same as when no defence was in place.

5.11 BENEFIT

The economic benefit derived from a flood alleviation measure is the difference in present value damages before and after the measure is put in place. A separate shapefile was created in which the benefit was found. AAD and PvD figures from the current scenario and the defended scenario were extracted and the difference calculated, which provided the defended uncapped present value benefit and the defended annual average damage.

Table 5.10 - Capping damages data

Data type	Attribute name	Data details
Present Value Economic benefit of providing required standard of protection	PvB_DEF	Difference between PvD for the current and defended scenarios. This value is uncapped.
Annual average benefit of providing required standard of protection	AAD_DEF	The AAD factored by 21.482

5.12 CAPPING BENEFIT

It is recognised that for certain properties the overall damage associated with it can far exceed the market value of the property. This can be due to either the depth to which it floods or the frequency with which it floods or more likely a combination of both. Where such a situation occurs it is necessary to cap the damages at the market value. The market value was calculated at a regional level with the market value data sourced from the Central Statistics Office.

Residential properties affected have been assigned a market value of €257,462 which is the national average market value of second hand properties in Ireland taken during the last quarter of 2013. The capping value was set at twice this value to account for the market value and the intangible costs, giving a final national capping value of €514,924. For non-residential properties the capping value was set according to the Multi Coloured Manual guidelines. This used the rateable value for various commercial property types, and was factored by the floor area to account for the property size. Due to the variable methods which Local Authorities calculate the rates of commercial properties this method, which is based on UK rate data, was found to produce inconsistent results and could not be used. Therefore an equivalent region in the UK, the south west of England, was considered and the rates for commercial property types used. The rateable values were sourced from the UK government website, **GOV.uk**. These values were converted from pound sterling to euros.

Damage to commercial properties was reviewed to ascertain the proportion any individual commercial property has on the overall damage. For properties contributing 1% of the total damage or more a detailed assessment was carried out. This involved confirming the amount of floor area that would flood and the FFL assumed.

The approach taken in this study is to cap the benefit as opposed to any damage contribution earlier in the process. The following details were recorded within the benefit shapefile attribute tables:

Table 5.11 - Capping damages data

Data type	Attribute name	Data details
Capping value of each property	CAP_CODE	For residential properties the value is given as twice the national market value of €257,462, derived from CSO. Residential MCM codes were related to property types with rate values in South West England, as were found to correlate well with Irish rate values.
Capping value of each property	CapVal	Residential CapVal was set as twice the rateable value. Commercial property values were based on 10 * Area* Rateable value per metre.
Capped present value benefit	PvB_DEF_C	Any benefit greater than the CapVal calculated was capped at the CapVal. Any benefit less than the CapVal was let equal the original present value benefit.

5.13 DAMAGE ASSESSMENT REVIEW

A review of the damage assessment was carried out to quality check the data being used. This was carried out by reviewing the properties that contribute over 1% of the capped PvD. The review consists of checking the property type and the finished floor level including split levels, the footprint areas and the depth damage being applied.

6 FLOOD RISK MANAGEMENT METHODS

There are various ways to manage the flood risk within any area being studied. These methods can be grouped into four types of method.

- Permit methods - accept that flooding will occur. Methods include doing a minimal amount of additional maintenance.
- Prevent methods - avoid future flood risk. Methods include planning and development control.
- Protect methods - reduce the likelihood of flooding. Methods include flood walls, flow diversion and storage.
- Prepare methods - reduce the impact of flooding. Methods include individual property protection, flood forecasting and public awareness campaigns.

The CFRAM study has set an objective to identify viable structural and non-structural options and measures for the effective and sustainable management of flood risk within the area being studied. With this being said it is an aspiration of the study to provide the highest standard of flood risk management that is cost beneficial. This would, in general, entail providing 'protect' methods over 'prepare' methods and avoiding 'permit' methods where possible. Prevent methods, which consider future flood risk, should always be included.

6.1 STANDARD OF PROTECTION

The standard of flood risk management is also dependant on the design standard being applied i.e. the maximum level of protection that the FRM methods provide. The preferred design standard for this study is the 1% AEP event for fluvial flood risk and the 0.5% AEP event for coastal flood risk or the appropriate combination for areas of joint fluvial-coastal influence. The FRM method achieving the design standard must also have provision for adaptability to the mid-range future scenario (MRFS) flood risk (refer to section 7.5).

Where there is a clear technical, economic, social or environmental case as to why the preferred standards would not be appropriate or acceptable, or where the adoption of alternative standards would provide significant additional benefit in relation to costs and impacts, this is also considered.

6.1.1 Residual Risk

No FRM measure can totally eliminate the flood risk to an area, as a flood event greater than the design standard can occur, this is referred to as residual risk. In calculating residual damage it is assumed that for any design standard less than the 0.1% AEP flood event, residual damage will occur. In most cases the design standard will be to the 1% AEP event and there will therefore be residual damage for the 0.5% and 0.1% AEP flood events. For the purposes of this study it is assumed that for FRM methods that contain the flow within the river channel, such as flood walls, the residual damage for flood events greater that the design standard will be the same as the present day current damages.

For FRM methods that reduce the flow, such as upstream storage, the benefitprovided during flood events greater than the design standard event was calculated.

6.2 LIST OF FRM METHODS

Table 6.1 lists the FRM methods being considered in the South Eastern CFRAM Study. This list is not exhaustive and additional FRM methods may become apparent which are specific to an area being studied. Where this is the case the additional FRM methods will be added to the long list of methods to be screened under the title “other works”.

Table 6.1 FRM Methods

FRM Method	Method type	Description
Do Nothing	Permit	Stopping the current maintenance regime
Additional Maintenance	Permit	Continue and augment existing flood risk management practices, such as maintenance and inspection, based on review of the existing regime.
Do Minimum	Permit	Clearance of channels and locating isolated/single issue which can be easily addressed in order to reduce the flood risk
Planning and Development Control	Prevent	Zoning of land for flood risk appropriate development, prevention of inappropriate incremental development, review of existing Local Authority policies in relation to planning and development and of inter-jurisdictional co-operation within the catchment.
Building Regulations	Prevent	Regulation relating to floor levels, flood proofing, flood resilience, sustainable drainage systems, prevention of reconstruction, or redevelopment in flood risk areas.
Catchment Wide SuDS	Prevent	Managing runoff rates to watercourses from new development. Ensuring that required features and infrastructure is included in development plans to maintain the existing greenfield runoff rate.
Land Use Management	Protect	Changing how the land is used in order to store or slow surface water runoff and slow in channel and out of bank flow along the river in order to store flood water in suitable locations. This may consist of the creation of wetlands, restoring river meanders, increasing the amount of boulders and vegetation in channel, perpendicular hedges or ditches in the floodplain, tree rows and planting in floodplain to either slow flow or direct flow, planting along banks parallel to flow, fencing off livestock from riparian strip, changing agricultural practices to decrease soil compaction and increase water infiltration.
Strategic Development Management	Prevent	Management of necessary floodplain development (proactive integration of structural measures into development designs and zoning, regulation on developer-funded communal retention, drainage and/or protection systems.
Storage	Protect	Large scale dam and reservoir, offline washlands (embanked areas of floodplain to store water during larger flood events.
Improvement of Channel Conveyance	Protect	Deepening of channel bed, widening of channel, realigning long section profile, removal of constraints, lining or smoothing channel.
Hard Defences	Protect	Reinforced concrete walls, earth embankments, demountable barriers.

FRM Method	Method type	Description
Relocation of Properties	Protect	Abandoning flood risk area and properties within and providing alternative properties in suitable area.
Culverting	Protect	Routing the watercourse underground through culvert to prevent out of bank flooding along a specific stretch.
Diversion of Flow	Protect	Removing flow from the watercourse via a diversion and discharging to a suitable river or coastline or reintroducing the flow further downstream. This may consist of a culvert or an open channel.
Flood Warning/Forecasting	Prepare	Installation of flood forecasting and warning system and development of emergency flood response procedures.
Public Awareness Campaign	Prepare	Informing public who live, work or use a flood risk area on risks of flooding and how to prepare for flooding.
Individual Property Protection	Prepare	Flood protection and resilience measures such as flood gates, vent covers, use of flood resilient materials, raising electrical power points, etc
Other Works	-	Other specific methods not listed above.

6.3 BASELINE CONDITION

The existing regime is considered the baseline condition which incorporates activities such as monitoring, inspection and clearance. This represents the current scenario which all other scenarios, created by the implementation of other FRM methods, are compared to. This is realised by the reduction in receptors at risk, as described in Section 4, and the reduction in monetary damage (see Section 5) also known as benefit.

The review of the existing maintenance regime considers all activities currently carried out which may play a part in the management of flood risk. The level and frequency of maintenance is considered, along with inspection, and any other specific activity (for example the operation of locks, barrages, sluice gates and valves). There may be many organisations / stakeholders involved in maintaining the existing regime within a unit of management. Apart from ad-hoc maintenance undertaken by local authorities, which is discussed in relation to each AFA in Section 8, the activities discussed in the following sections may significantly contribute to maintaining the existing regime across multiple AFAs within UoM15.

6.3.1 Drainage Districts (Local Authorities)

There are eleven Drainage Districts located within UoM15:

- Boleybeg DD,
- Borris in Ossory DD,
- Gully DD,
- Erkina DD,
- Goul River DD
- Gully DD,
- Kilbride DD,
- Kilmaganny DD,

- Loughans DD,
- Rathdowney DD,
- Sugartown & Kilfane DD.

Drainage Districts represent areas where the Local Authorities have responsibilities to maintain watercourse channels and therefore contribute to maintaining the existing regime. In relation to the Drainage Districts located within UoM15 only the Rathdowney and Mountrath models contain watercourses located within Drainage Districts although even within these models the activities within Drainage Districts are not considered to significantly contribute to the maintenance of the existing regime affecting the AFAs. However the activities of Drainage Districts do contribute to the maintenance of the existing regime in other parts of UoM15.

6.3.2 Arterial Drainage (OPW)

The Kilkenny City Flood Relief Scheme was initiated in 1995 and was constructed from 2001 to 2005 under the 1945 Arterial Drainage Act. The OPW continues to have statutory responsibility for inspection and maintenance of the Scheme, which includes the Nore and Breagagh through much of The Kilkenny Flood Alleviation Scheme, which comprises flood defence walls, embankments, and channel conveyance improvements, provides protection against a 100 -Year flood (1% Annual Exceedance Probability) for 200 properties.

7 ASSESSMENT OF FRM METHODS

In order to ensure a consistent approach across the South Eastern CFRAM study area, a process to assess the FRM methods for each SSA has been standardised as summarised in the flow chart in Figure 7.1.

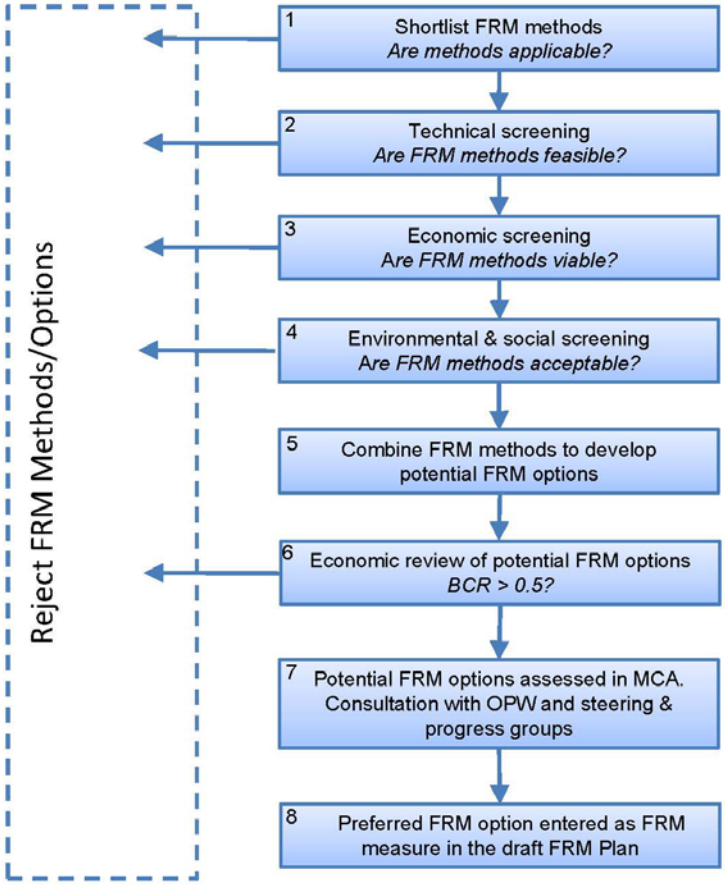


Figure 7.1 - Assessment of FRM methods flow chart

The flow chart summarises in boxes 1 to 4 how the screening of FRM methods was carried out. Boxes 5 and 6 describe how the FRM methods that came through the screening were developed into potential FRM options and box 7 shows how the potential FRM options were assessed to identify the preferred FRM options. This process was carried out in consultation with the OPW and the steering group and progress groups of the South Eastern CFRAM Study.

The preferred FRM option/s will be taken forward to public consultation and, if required, updated to reflect the comments and issues raised before presenting the final FRM measure in the FRM Plan as shown in box 8. Section 8 provides a record of the assessments and decisions made when this process was applied to the South Eastern CFRAM Study SSAs.

7.1 SCREENING FRM METHODS

The aim of the screening process was to ensure the widest possible range of FRM methods were considered in the assessment process while the rejection of any methods was robust and with clear and transparent reasoning. The following section details how the screening process achieves this.

7.1.1 Shortlisting FRM Methods

A long list of FRM methods (Table 6.1) has been developed by OPW and RPS and includes FRM methods which accept that flooding occurs (permit methods), reduce the likelihood of flooding (protect methods), reduce the impact of flooding (prepare methods) and avoid future flood risk (prevent methods).

This long list was reviewed for each SSA in terms of applicability. Methods which were not applicable to the specific SSA were rejected and a shortlist of FRM methods created to be considered further. An example of this is considering flood forecasting at an AFA SSA. If the flood forecasting were to benefit multiple AFAs, the full benefit of the FRM method would not be captured at an AFA scale of assessment and should therefore be considered at UoM scale.

7.1.2 Technical Screening

Although an FRM method may be applicable, it may not be feasible from a technical point of view. This may be due to the method providing no reduction in flood risk. An example of this is where a high level of maintenance and operation is currently being carried out on a watercourse and to implement the "do minimum" method, (a reduction on maintenance and operation) would result in increased flood risk with little cost savings. Where such methods were identified they were rejected at this stage and not considered any further in the process.

Other methods may have little impact in reducing the flood risk. This was ascertained through hydraulic modelling and reviewing the effect of the method or through reviewing the flooding mechanisms, for example a channel conveyance method will have little impact if the flood mechanism is the back water effect from the coast or a different river.

The technical screening also identifies methods which would be excessively complex to implement. This may be due to restrictions on construction methods or obstacles such as bridges and underground services. These methods may be effective in reducing the flood risk but due to their complex nature they do not merit further consideration until all other more straightforward methods have been exhausted.

The following sections detail how each of the FRM methods have been technically screened.

7.1.3 Do Nothing

This method was considered at AFA scale, in situations where the existing regime involves operation/ maintenance which might be stopped without increasing flood risk. This could apply either to the operation/maintenance of an existing flood defence/watercourse in an area where the flood risk has

been reduced sufficiently due to other works, or where receptors have become flood resilient or moved out of the flood plain.

7.1.4 Additional Maintenance

This method was considered at AFA scale, the aim of the technical review was to identify where additional maintenance works (in comparison to the current level of maintenance) would be effective. A review was carried out to assess the likelihood of the maintenance issues, such as vegetation, debris and culverts susceptible to blockages causing an increased flood risk. Where this is identified targeted maintenance methods have been proposed.

Where dense vegetation and debris was deemed to be influencing water levels during flood events the technical feasibility of this method was assessed by considering the hydraulic model sensitivity. The friction values used in the model were adjusted in order to represent the reduction in channel roughness associated with vegetation removal. Where a noticeable reduction in water levels was observed this method was considered technically feasible, where the reduction in water levels was negligible the method was considered technically unfeasible. Where this was identified as feasible targeted maintenance methods have been proposed.

Where potential culvert blockage was deemed to be influencing water levels during flood events, trash screens were considered and where this method was found effective it was considered technically feasible and targeted maintenance methods have been proposed.

7.1.5 Do Minimum

This method was considered at AFA scale, the aim of the technical review was to identify localised areas where, due to a restriction or pinch point, the flood risk is increased and where minimal construction works would remove the restriction. These activities would be considered relatively straightforward, discrete and low cost.

7.1.6 Sustainable Planning and Development Management

This method was considered at UoM scale as it is a policy level measure to prevent significant increased risk for, or due to, new development.

In November 2009, the Guidelines on the Planning System and Flood Risk Management, jointly developed by DECLG and the OPW, were published under Section 28 of the Planning Acts. These Guidelines provide a systematic and transparent framework for the consideration of flood risk in the planning and development management processes, whereby:

- A sequential approach should be adopted to planning and development based on avoidance, reduction and mitigation of flood risk.
- A flood risk assessment should be undertaken that should inform the process of decision-making within the planning and development management processes at an early stage.
- Development should be avoided in floodplains unless there are demonstrable, wider sustainability and proper planning objectives that justify appropriate development and where the

flood risk to such development can be reduced and managed to an acceptable level without increasing flood risk elsewhere (as set out through the Justification test).

The proper application of the Guidelines by the planning authorities is essential to avoid inappropriate development in flood prone areas, and hence avoid unnecessary increases in flood risk into the future. The flood mapping provided as part of the FRMP will facilitate the application of the Guidelines.

In flood-prone areas where development can be justified (i.e. re-development, infill development or new development that has passed the Justification Test), the planning authorities can manage the risk by setting suitable objectives or conditions, such as minimum floor levels or flood resistant or resilient building methods.

The following methods are encompassed within the Sustainable Planning and Development Management method and were considered at UoM scale as they are policy level measures to prevent significant increased risk for, or due to, new development:

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management.

7.1.7 Land Use Management

Floods can be attenuated (i.e. the flood slowed down, the peak flow reduced and the flood volume spread over a longer period of time) by interventions along the river and throughout the catchment, e.g. increasing channel and floodplain roughness (introducing impediments to flow in the river, or on floodplains, such as by increasing riparian vegetation or planting hedgerows) or by restoring meanders. Such methods are often referred to as Land Use Management (LUM), Natural Water Retention Measures (NWRM) or Natural Flood Management (NFM). This method has been shown to reduce flood flows with the greatest influence on smaller, more frequent floods. However this reduction in flow has been difficult to quantify and further research is required on this matter. In addition to reducing flood risk such measures can have significant benefits for environmental enhancement, such as contributing to the objectives of the Water Framework Directive or increasing biodiversity.

Whilst these methods require piloting in an Irish context to determine their practicality, it is considered appropriate to assess their application to areas with a relatively limited degree of flooding which might be addressed by marginal hydrological modification, and where current land use suggests that such methods have potential to be implemented and are therefore technically feasible, economically viable, environmentally beneficial and socially acceptable. The plan-level assessment did not consider land owner buy-in.

A national screening was carried out whereby the land's potential for rainfall runoff reduction was quantified. This screening was carried out to ascertain the potential effectiveness of natural flood management measures in a catchment. The factors that were considered were:

- Land cover – Key land use and practices were identified which give rise to the greatest hydrological impacts.
- Soil – Soils were identified and their vulnerability to soil structural degradation assessed.
- Slope – Shallow to steep slopes were identified and scored on their sensitivity to runoff.
- Rainfall – The standard annualised average rainfall was identified to find areas experiencing greater or lesser runoff.

These four factors were combined to create a sensitivity classification from 1 to 4. A classification of 1 identified areas where NFM measures would have little impact in reducing the runoff and a classification of 4 identified areas where NFM measures would have a significant impact in reducing the runoff. The screening was carried out for UoM15 and a raster dataset of 20m grid squares with each grid square having its own classification developed. This was converted to a GIS shapefile to facilitate its potential use and interaction with other receptor datasets. This output was used as an initial screening tool in order to identify AFAs with a potential for Land Use Management.

The aim of the technical review was to identify suitable pilot areas to implement natural flood management through management of land use practices upstream of flood risk areas. . This method was considered at UoM and sub-catchment scale initially to assess potentially suitable areas, and refined at AFA scale to determine where the measure would be suitable to pilot either standalone or in combination with other measures. At AFA scale a review of the area in question was carried out and an assessment made on its suitability for a pilot study. The following factors were considered:

- The size of the catchment. Smaller catchment will be more easily monitored and will have less landowners and stakeholders to liaise with.
- Land cover. This was considered using the Corine land use dataset and an assessment made its ability to reduce runoff should the land use be changed. Bog areas were considered to have little ability to reduce the runoff as rewetting drained bogs would have limited hydrologically benefit and undrained bogs would already attenuate runoff. Urban areas were also considered difficult to retrospectively change in order to reduce runoff as the space to do so is generally limited. Agricultural and forested land, including scrubland, was considered to offer relatively better scope for runoff reduction as there may be space to apply measures.
- Catchment slope. A general assumption was made that steep catchments have a good potential in reducing the runoff and slowing the flood down. Flat catchments have little potential to do this.

7.1.8 Storage

The aim of the technical review was to identify areas of land suitable to store flood water in order to attenuate river flows and reduce the existing flood risk. This method was considered at both Sub-catchment and AFA scales.

At AFA scale the effect of storage was assessed by a hydraulic analysis. The general approach was to estimate the volume of water required to be stored, identify suitable storage areas and to hydraulically model the effects of storage during the design flood event. Estimating the volume of

water required to be stored involved reviewing the simulated hydrographs produced from the existing hydraulic models. By comparing a high frequency flood event where there is no or little risk to the low frequency design flood event an estimation of the volume can be made over the duration of the flood. While this does not account for lag times caused by a storage dam it provides an initial estimate. Following this suitable storage areas were identified using LiDAR survey data that provided the required storage volume. These areas were then screened for suitability, areas found unsuitable due to receptors within or in proximity to them were removed. Where storage areas were identified and found suitable the effects of placing the storage areas in the watercourse network were modelled.

At Sub-catchment scale an estimate of the hydrological affects was undertaken where it was not possible to model the effects of storage areas outside the hydraulic model extents. Initial flood flows were estimated in part by accounting for the river's catchment characteristics. By estimating the change to these characteristics resulting from the inclusion of storage areas, post-storage flood flows were estimated. The catchment characteristic that changed as a result of increased storage areas was FARL (Flood Attenuation by Reservoirs and Lakes). Depending on the percentage of the catchment changed to flood storage areas, the FARL value changed accordingly. This in turn changed the estimated flood flow which was used to estimate the reduction in flood risk.

7.1.9 Improvement of Channel Conveyance

The aim of the technical review was to identify reaches of watercourse suitable for improved conveyance and to estimate how effective the improvement will be in reducing the flood risk. This method was considered at both Sub-catchment and AFA scales.

Conveyance can be improved because there are existing restrictions to flow, such as undersized culverts. Or conveyance can be improved through altering the existing channel's characteristics such as width, depth and slope.

The general principle applied when attempting to improve conveyance was to remove restrictions, and increase channel capacity either through changing width, depth and/or slope. However, there a certain scenarios where this would not be possible such as where an existing structure limits the width or depth that the channel can be changed by, or where the flooding originates from downstream and backs up the watercourse making any conveyance improvement techniques ineffective.

The risk areas and flooding mechanisms were identified and the suitability of channel conveyance assessed. The effects of removing restrictions to the 1%AEP flow were modelled such as upgrading culverts or removing weirs. An estimation of how the channel could be changed to convey the 1%AEP flow was carried out where the channel was found to have insufficient capacity. This was estimated using the Manning's equation which allows for width, depth and slope to be changed and the resulting flow capacity calculated. A review of the channel long section was undertaken to establish what length of the channel would need to be upgraded to ensure the required conveyance extended past the risk area. For steep watercourses this length would be relatively short, whereas flat watercourses would require a relatively long reach to be upgraded.

7.1.10 Hard Defences

The aim of the technical review was to identify where, what type and to what extent hard defences would be required to provide the required standard of protection. This method was considered mainly at AFA scale, however where the presence of a tidal barrage form of defence would benefit several UoMs/Sub-catchment/AFAs (generally at the downstream extent of a UoM for example Waterford Estuary) a UoM scale assessment was undertaken.

The assessment was carried out by reviewing the existing flood extent and delineating where hard defences would be required. As a general rule hard defences were kept as far from the watercourses as possible to ensure the maximum amount of floodplain would be retained. On establishing the position of hard defences a hydraulic model was run to assess it affects and to establish the flood water level against the defences. This was sometimes an iterative process as the presence of hard defences would push the flood water upstream or downstream causing flooding elsewhere. In these cases additional hard defences would be added and the model run again and again until the required SoP was achieved.

In some cases the model showed that the hard defences needed to provide the required standard of protection would be excessively high making it unfeasible. Where such situation occurred hard defences were technically screened out.

7.1.11 Relocation of Properties

The aim of the technical review was to identify suitable properties for relocation, which in effect means abandoning the flood prone asset and finding a similar facility in a non-flood prone area. This localised method was considered at AFA scale.

While there are many circumstances where relocation of properties was technically possible this review considered the following as unsuitable:

- Where the properties were interspersed amongst other properties. This occurred when overland flow affected some properties but not others as it progressed. Due to the uncertainty of the model and the effect of local structures such as garden walls this method was considered technically unfeasible.
- Where the property was placed in a strategic position and cannot be removed without removing a vital service.

7.1.12 Diversion of flow

The aim of the technical review was to identify suitable locations where flow could be diverted from a watercourse causing flood risk and to identify suitable discharge locations. This may be to another river, a coastline or a point further downstream on the same river. High level review determined that there were no suitable UoM or Sub-catchment scale diversion routes, and this method was considered at AFA scale.

The review estimated the size of the diversion needed in order to convey sufficient flow such that flood risk was removed or reduced along the watercourse in question. For each AFA, locations for flow

diversions were identified. These locations would be located upstream of where flood risk occurs and free from structures that might impede the diversion. If suitable locations were found to be available a diversion route was identified. This relied on the topography of the surrounding land to provide a path which falls from the diversion inlet to its outlet and on there being no barriers located across the potential diversion route such as properties.

If a diversion location was identified an estimation of how much flow it would have to convey was made. This was carried out by an analysis of the existing hydraulic model for the AFA in question. The in-channel flow was compared with the peak flow during the flood event at the risk area being considered and how much flow would need to be diverted calculated. This would depend of the location of the flow diversion to the risk area and how much lateral in-flow would take place in between these two locations. Following this a diversion channel size was calculated using the Manning's equation.

7.1.13 Flood Warning/Forecasting

The aim of the technical review was to identify catchments which would afford suitable warning time to receptor owners or emergency response teams to allow them to prepare for an oncoming flood by defending the property from flooding or moving contents out of flood risk areas. This method was considered at UoM scale initially to assess the rainfall and flow monitoring requirements, as it is considered that there are potential operational and infrastructural benefits at UoM scale. Where relevant the assessment was refined at sub-catchment and AFA scale to determine where the measure would be suitable either standalone (to support resilience) or in combination with other measures, such as individual property protection.

Flood warning and forecasting can be driven by different mechanisms. River gauges which monitor flow provide the most accurate estimate of a flood event but are more restricted in the warning time available depending on the river's catchment characteristics. Rain gauges may also be used as the basis for the warning system or in conjunction with a hydrological model. Rainfall based systems are generally less accurate as a prediction needs to be made between rainfall and river flow however a longer warning time can be provided. This type of forecasting lends itself to a large area where multiple catchments and rivers would benefit.

When this method was considered at AFA level, in most cases it was found that small catchments would require a minimal amount of gauging infrastructure to be implemented. Generally a river gauge was required at the risk area and at the forecasting area along with some rainfall gauges in the upper catchment. It was assumed that a correlation between the rainfall gauges and the river gauge at the forecasting location would provide the decision making time in order to issue a warning. The warning time available was based on the travel time of the flood event from the river gauge at the forecasting location to the risk area. This was estimated by calculating the flood wave travel time within the hydraulic model and applying an average speed to the distance between the river gauges. A minimum warning time of 2 hours was set to allow people to react to the flood events, otherwise the flood warning and forecasting method was considered technically unfeasible.

For larger areas, more rainfall gauges would be required in order to accurately represent the catchment. A minimum density of 1 gauge per 100km^2 would be required as per the World Meteorological Organization guidelines, however this rate would be increased depending on the distribution of smaller catchments within the main catchment and when the catchment itself is relatively small. River gauges would also be required throughout the catchment to provide river flow/water level data at identified risk areas and at locations upstream which would provide the required warning time. River gauges would also be added at strategic locations along the watercourses and at significant tributaries depending on the distribution of flows. The warning time would be estimated in a similar method to the small catchments where only one AFA is located using the hydraulic models results to calculate this time.

7.1.14 Public Awareness Campaign

This method was considered at UoM scale and is based on the risk in any given area and what other methods are being proposed. This method aims to make the public aware of the current flood risk their property and surrounding area is in and how residents might take necessary precautions to reduce the risk and damage to themselves and their property. This information would be tailored to the level of risk, whether the areas have an FRM option and what level of protection the option will provide. This information might be relatively generic where protect methods are being proposed however where permit and prepare methods are being proposed this information might be tailored so that the public are equipped to make their property more flood resilient, such as changing floor and wall materials to be flood resilient, or how to monitor the available flood forecasting information.

7.1.15 Individual Property Protection

This method was considered at AFA level, aiming to protect individual properties by the provision of flood gates and other items which prevent the ingress of flood waters into a property. This method is considered to have limited effectiveness as there could still be flood damage to the building structure and surrounding land and it relies on human intervention to put the defence in place every time a flood occurs. For this reason 20% of the damage was assumed to be avoided over the life time of the scheme. Where the flood depth to a property is greater than 0.6m this method was considered technically infeasible as the risk of structural damage to the property is high.

7.1.16 Other Works

These methods were considered at AFA level, and would be specific to the area being assessed or the flooding that occurs. One example is where pumping would be required to make an option technically feasible, for example assisting fluvial drainage against tidal controls.

The methods considered applicable to each SSA are summarised in Table 7.1.

Table 7.1: Summary of FRM Applicability to SSA

Method	UoM	AFA
Do Nothing	×	✓
Additional Maintenance	×	✓
Do Minimum	×	✓
Planning and Development Control	✓	×
Building Regulations	✓	×
Catchment Wide SuDs	✓	×
Land Use Management	✓	✓
Strategic Development Management	✓	×
Storage	×	✓
Improvement of Channel Conveyance	×	✓
Hard Defences	×	✓
Relocation of Properties	×	✓
Diversion of Flow	×	✓
Flood Warning/Forecasting	✓	✓
Public Awareness Campaign	✓	×
Individual Property Protection	×	✓
Other Works	×	✓

7.1.17 Economic Screening

The economic screening ensured that only methods likely to be cost beneficial progressed to the more detailed assessment. This was carried out by calculating the benefit available in the SSA and comparing that to the cost of implementing the method (the benefit available was quantified through the damage assessment as described in Section 5). As mentioned in Section 4.2 the screening was applied within flood cells when considering AFAs. Whilst discrete areas within the AFA have discrete flood risk and therefore potential benefit, the cost of a method being considered in a flood cell was compared with the benefit to the whole AFA. This is because the cost benefit ratio is taken for the whole AFA and even though a method may not be cost beneficial at any given flood cell there could be enough benefit elsewhere in the AFA to carry that method through the process. Therefore the economic screening considered the total AFA benefit.

7.1.17.1 Construction costs

The cost of constructing FRM methods was calculated using the OPW unit cost dataset. This data was based on previous schemes using real costs and was presented as rates to be applied to the FRM methods depending on the quantities involved.

As such the first stage in this process was to quantify the FRM methods. This information included wall lengths and heights, lengths of culvert, volume of excavation, etc. This was carried out by hydraulic modelling and using the GIS software ESRI ArcMap. The location and extent of FRM methods were delineated in GIS using OSi mapping with consideration of the flood risk receptors. Once the quantities were calculated, the unit construction rates could be applied to estimate the construction cost.

Additional costs were added to the construction costs to account for other work items outside of construction and to account for unknown factors that may add to the total cost of the scheme. Costs for preliminary items were added based on a percentage of the construction cost. These items would generally apply to the whole scheme, not just an individual asset within the scheme. This would include items like temporary fencing, haul roads, site cabins, road sweeping, etc. The preliminaries can range from 32% - 6% of the construction costs where cheaper construction costs have a larger percentage for preliminaries and expensive construction costs have a smaller percentage for preliminaries. In addition to this the other items were also included and are presented in Table 7.2.

A maintenance cost was estimated over the life span of the scheme, which has been set at 50 years. These costs were estimated from the OPW unit cost database as yearly costs and discounted over the 50 years.

Once the construction costs, preliminaries, other item costs and maintenance were calculated an optimism bias was added to give the total cost of the FRM method. The optimism bias accounts for unknowns, factors that could occur which if they did would add to the cost of the scheme. These factors include, for example, design complexity, ground conditions, services, public relations. A summary of FRM method costs are presented in Table 7.2.The FRM method costs for potential options are summarised in Section 8 for each AFA.

Table 7.2 - Additional costs to FRM options

Item	% of construction cost
Preliminaries	32 - 6
Detailed design (design fees)	13
Allowance for archaeological and/or environmental monitoring/exploration	10-15
Cost of land acquisition/compensation	10-15
Allowance for art	€0 - €2.55m = up to €25,500 €2.55m - €6.3m = €38,000 €6.3m - €12.7m = €51,000 >€12.7m = €64,000
Maintenance	-
Optimism Bias	70 - 10

7.1.18 Environmental and Social Screening

It is important to ensure that methods being brought through the assessment process will not have significant detrimental environmental or social/cultural impacts.

AFAs were screened for proximity to European Sites and World Heritage Sites and the potential hydraulic linkages to these sites from FRM methods. At screening stage areas sensitive to development were avoided if possible. Methods that were technically and economically feasible were visualised and reviewed from an environmental and social perspective to determine if there was any early positional improvement that could be undertaken to minimise potential negative impacts. The assessment assumed unmitigated methods but that the construction of the options will be undertaken

by competent contractors in accordance with current best working practice and construction works will be undertaken outside of seasons that may have environmental sensitivities. For some SSAs the environmental feedback resulted in the development of refined FRM options based on existing technically and socially feasible options.

Mitigation noted through the screening, and subsequent more detailed environmental and social MCA process, are ideally brought through into the SEA Environmental Report, AA Stage 2 and adopted / committed to in the FRMP.

7.2 DEVELOPING POTENTIAL FRM OPTIONS

All FRM methods that were found suitable in the screening process detailed in Section 7.1 were developed into options. Options consist of a single or multiple methods which manage the flood risk to the entire SSA. This was carried out by identifying all possible combinations of FRM methods, assessing their effectiveness and undertaking a benefit cost analysis.

7.2.1 Identifying possible FRM options

When a number of FRM methods were found suitable for an SSA they were assessed both as standalone methods and in combination with other methods. There were certain circumstances where methods could not be combined such as where one method is not complemented by another, for example relocation of properties is not suitable to consider with another method which manages the risk in the same area. Once all suitable combinations were identified the resulting potential options were proposed.

7.2.2 Option effectiveness

A quantitative assessment of how effective the options could be was carried out by hydraulic simulation. This assessment considered how different methods would interact with each other. For example where a storage method and a hard defence method were combined the reduction in the hard defence length and height was calculated due to the attenuation from the storage. Details of each option are presented in Section 8.

7.2.3 Benefit Cost Analysis

The cost of each option was calculated by combining the construction and maintenance costs of the FRM methods making up the option and then applying a cost for preliminaries, other items and optimism bias as detailed in section 7.1.17. Using the benefit, as detailed in section 5, a benefit cost ratio (BCR) was calculated. Options with a BCR or 0.5 or greater were considered potential options and continued in the assessment. The BCR threshold of 0.5 was set to allow options which are apparently not cost beneficial to progress with a view that if they are considered during a detailed study the options costs may be reduced as uncertainties in relation to site specific conditions are ruled out or mitigated.

The primary FRM methods which are progressed through the technical, environmental, social and economic screening were combined to create potential FRM options. Most methods, while providing significant reductions in flood risk, will not manage the flood risk entirely by themselves. Methods were therefore required to be combined into options so that they would manage the flood risk and achieve the objectives set by the study.

In most cases the FRM options were required to provide a design standard of the 1% AEP flood event although this could vary depending on the requirements of the SSA. All suitable combinations of FRM methods were considered as potential FRM options, however, only options that could provide the required design standard were progressed further.

7.3 ASSESSMENT OF POTENTIAL FRM OPTIONS (MCA PROCESS)

The development of options stage identified potential FRM options. From these options an assessment was required to identify preferred option(s). This was carried out with a multi criteria analysis (MCA).

Historically the assessment of FRM options has been primarily based on economic costs and benefits, with an EIA undertaken to minimise negative impacts on the environment, and public consultation undertaken to ensure social acceptability. The National Flood Policy Review (OPW, 2004) set a broader range of objectives for flood risk management in Ireland that was subsequently reinforced by the EU 'Floods' Directive [2006/60/EC].

The MCA framework was developed to broaden the range of potential impacts associated with flooding and the implementation of FRM options considered in the development and selection of FRM options and strategies, and their subsequent prioritisation. It was based on the numeric, but non-monetarised, assessment of options against a range of objectives. Indicators were used to assign scores for each objective on the basis of the degree to which the option being appraised goes beyond a specified basic requirement for that objective towards meeting a specified aspirational target for that objective. Weightings were applied globally (nationally) for each objective, with local weightings applied to reflect the local importance of that objective in the context of the respective SSA, and these weightings were applied to the scores derived as described above.

The sums of the weighted scores, set against the total costs of their achievement, represented the preference for a given option (using all criteria) or the net benefits of an option (using only the economic, social and environmental criteria). These total scores can be used to inform the decision on preferred option(s) selection for a given location and the prioritisation of potential schemes between locations.

The following section describes the MCA process in more detail.

7.3.1 Criteria and Objectives

Each option was assessed against four criteria; Social, Economic, Environmental and Technical. Scoring against these criteria helps to achieve the CFRAM Study objective of achieving the most cost effective and sustainable management of existing and potential future flood risk within the area being studied. A set of objectives, associated with each criteria, are an expansion on the requirements of the National Flood Policy Review and the EU Floods Directive. The degree to which an option achieves each objective is an indication of the success of the option in managing the flood risk, the more the option achieves across all the objectives, the greater preference it will be given.

Generally each objective focused on a flood risk receptor type and how the flood risk was to be reduced with the exception of the technical objectives which focused on how the options would be constructed and operated during their lifetime. In some cases the flood risk receptor type was wide reaching and sub-objectives were required to focus on a specific group within the receptor type. Table 7.3 presents the objectives and sub-objectives set for each of the criteria in the MCA.

Table 7.3 - Criteria and Objectives of the MCA

Criteria	Objective	Sub-Objective
Social	Minimise risk to human health and life	Minimise risk to human health and life of residents
		Minimise risk to high vulnerability properties
	Minimise risk to community	Minimise risk to social infrastructure and amenity
		Minimise risk to local employment
Economic	Minimise economic risk	Minimise economic risk
	Minimise risk to transport infrastructure	Minimise risk to transport infrastructure
	Minimise risk to utility infrastructure	Minimise risk to utility infrastructure
	Manage Risk to agriculture	Manage Risk to agriculture
Environmental	Support the objectives of the WFD	Provide no impediment to the achievement of water body objectives and, if possible, contribute to the achievement of water body objectives
	Support the objectives of the Habitats Directive	Avoid detrimental effects to, and where possible enhance, Natura 2000 network, protected species and their key habitats, recognising relevant landscape features and stepping stones.
	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	Avoid damage to or loss of, and where possible enhance, nature conservation sites and protected species or other know species of conservation concern.
	Protect, and where possible enhance, fisheries resource within the catchment	Maintain existing, and where possible create new, fisheries habitat including the maintenance or improvement of conditions that allow upstream migration for fish species
	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	Protect, and where possible enhance, visual amenity, landscape protection zones and views into / from designated scenic areas within the river corridor
	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting	Avoid damage to or loss of features, institutions and collections of architectural value and their setting.
		Avoid damage to or loss of features, institutions and collections of archaeological value and their setting.
Technical	Ensure flood risk management options are operationally robust	Ensure flood risk management options are operationally robust
	Minimise health and safety risks associated with the construction, operation and maintenance of flood risk management options	Minimise health and safety risks associated with the construction, operation and maintenance of flood risk management options
	Ensure flood risk management options are adaptable to future flood risk, and the potential impacts of climate change	Ensure flood risk management options are adaptable to future flood risk, and the potential impacts of climate change

7.3.2 Scoring Options

A scoring system was devised for the MCA to assess each option in a robust, clear and transparent way. A score was given for how well an option achieved an objective but also accounts for the importance of the objective relative to other objectives and how important the receptors within the area being studied are relative to the receptor group being considered.

To enable the scoring of the objectives, indicators were set. Indicators are parameters, measurable and numeric where possible, by which the success of the option in meeting a particular objective can be gauged. For example a social objective is to "minimise risk to human health and life of residents" and the indicator is "the number of residential properties at risk from flooding during the 0.1% AEP event". The difference that the option being assessed makes to the number of residential properties at risk can be calculated as a percentage and applied to the maximum achievable score value to give the actual option score.

The success of the option in achieving the particular objective in question is quantified by how much it goes beyond a specified basic requirement and achieves a specified aspirational target. As such basic requirements and aspirational targets have been set in terms of the defined indicator.

The basic requirement represents a neutral status or ‘no change’, whereby an option has no impact on the matter the objective relates to, or meets what might be termed for some objectives, minimum requirements for acceptability. If an option performs less well than the basic requirement, i.e. has a negative impact (a dis-benefit) or does not meet the minimum requirements for acceptability, it will score a negative-value score for that objective, but might still be considered further, depending on the degree of the dis-benefit or failure to meet the requirements. The basic requirement is therefore not an absolute minimum requirement for acceptability, but a benchmark to define positive versus negative impacts or performance.

The aim of an objective is defined by the aspirational target, whereby an option would be deemed as performing optimally with respect to the given objective if it were to meet the aspirational target. Typically this may represent complete removal of a risk, or the full achievement of another benefit, and it will be rare that any option will meet such aspirational targets for even one, let alone all, objectives. The aspirational targets are therefore not requirements that must be met, and it should be noted that very effective options may still fail to meet the aspirational targets.

The following rules have been applied to the MCA scoring:

- An option achieving the basic requirement is given a score of zero.
- An option meeting the aspirational target is given a score of five. Options achieving more than the aspirational target still score a maximum of five.
- An option achieving somewhere in between the basic requirement and the aspirational target is given a score proportional to the degree to which it achieves the objective beyond the basic requirement towards meeting the aspirational target.

- An option failing to meet the basic requirement is given a negative score of -1 to -5 depending on the impacts associated with the option.
- Where the performance or impact of the option becomes unacceptable a score of -999 is given and the option is rejected from further consideration.

Justification for each objective score has been included within the MCA tables providing the rationale for each score.

7.3.3 Weighting objectives

It is considered that some objectives are more important than others and to give them all equal importance would not reflect the significance of the benefit, or lack thereof, achieved. For example, an objective considering risk to life is more important that one considering social amenity sites. To reflect this in the scoring a global weighting has been applied. This gives an objective more or less weight in the overall assessment of the suitability or value of the option. Global weightings will remain constant nationally and were derived following consultation carried out at national stakeholder level between the OPW and a number of stakeholders.

It is also appreciated that for any given objective its importance will depend on the SSA and the type of receptor it is considering. For example, an objective considering the impact to environmentally designated sites may have more significance if the site is of international importance than of local importance. To account for this a local weighting is applied to the objective. The local weighting has been determined either numerically according to the degree of risk (e.g. annual average damage, number of properties) or by professional judgment including input from stakeholders and the public. Details of the local weighting rationale are included within the MCA tables.

7.4 PREFERRED FRM OPTIONS

Identification of the preferred FRM options is based on the following:

- **Criteria Scores:** Once the MCA has been applied, each option will have a weighted score for each objective. For each option, the scores for each of the four criteria have been summed to provide the Criteria Scores.

- **MCA Benefit Score:** To derive the MCA Benefit Score, the scores for the economic, social and environmental Criteria Scores have been summed. This score represents the net benefits of the option.

- **Option Selection MCA Score:** To derive the Option Selection MCA Score, the scores for all four of the criteria have been summed. This score compliments the MCA Benefit Score with the Technical Criteria Score, and hence includes all of the aspects that have been taken into account in considering the preferred option for a given location.

- **MCA Benefit – Cost Ratio (BCR):** The MCA Benefit Score has been divided by the cost of the option to provide a numerical, but non-monetarised, MCA Benefit - Cost Ratio that provides an indication of the overall benefits that can be delivered per Euro invested.

- The **Economic Benefit – Cost Ratio (BCR)** has been calculated using the more traditional techniques (i.e., the FHRC Multi-Coloured Manual, rather than the option appraisal MCA set out herein).

- **Consultation:** Consultation with the OPW, steering group and stakeholder group.

Preliminary FRM options have been reviewed by OPW and the South Eastern CFRAM Study progress group and steering group members. Professional judgement and stakeholder comment is required to identify the preferred options as some options may have a good monetary BCR but a poor overall net benefit/cost or vice versa and comparison between options may not always be clear. Recommendations can be made at this point to improve the options and identify preferred options to incorporate in the draft FRM Plan.

7.4.1 No potential options

In certain cases, no potential options were identified; this was mainly due to technical or economic reasons. Where this occurred an alternative SoP was considered i.e. the options with the best potential were assessed against a different design event. This was usually a 2% AEP flood event for fluvial flood risk and a 1% AEP flood event for coastal. The reduction in construction cost was compared with the reduced benefit that results from considering a lower SoP. Any options with a BCR ≥ 0.5 were continued in the optioneering process as a potential option. In addition to this all feasible methods identified at UoM or Sub Catchment level were included for each AFA. Where no potential options were identified the baseline condition was taken as the preferred option.

7.5 FUTURE CHANGE ASSESSMENT ALONGSIDE OPTION DEVELOPMENT

To address the challenge of climate change and other factors potentially affecting future flood risk, the OPW, as lead agency for flood risk management in Ireland, has adopted an approach in relation to assessing and providing for the potential impacts of future change for the Flood Risk Management Programme. This approach is aimed at the effective and efficient provision for the potential impacts of climate change and other factors in the management of existing, and particularly potential future, flood risks.

The approach requires that the possible impacts of future change, and the associated uncertainty in projections, shall be considered at all stages of activity under the national Flood Risk Management Programme, and the development, design and implementation of all policies, strategies, plans and measures for, or related to, flood risk management must be sustainable and should adopt an adaptive approach (i.e. including provision for future amendment or enhancement) or, where appropriate, an assumptive approach (i.e. including relevant allowances) with respect to such impacts.

FRM options are designed to perform for 50 years and during this option's lifetime it is expected that, flood events will become more severe and an option's subsequent design SoP will be reduced. The implications for flood risk change and the requirement for further measures and expenditure to maintain the SoP over this timescale may be significant. A phased future change review was therefore carried out alongside the hazard, risk and option development assessments to determine how sensitive hazard and risk are likely to be in particular AFAs, and, to assess potential option's ability to achieve the objective of adaptability.

A "sensitivity to future change" review was carried out using the hydrological and hydraulic analysis to ascertain the change in flood hazard and risk. This established the consequences of future change in any given area, whereby the number of additional properties was determined along with the AAD that may occur under the Mid-Range Future Scenario (MRFS) or the High End Future Scenario (HEFS). The degree of change in future damages, compared to present day values, was assessed to qualitatively identify the vulnerability of communities (either; highly-sensitive - requiring outline future change assessment of measures during CFRAM option development stage, or; less-sensitive requiring adaptation assessment to be undertaken at a later, detailed design, stage). The following rules were applied to assess the vulnerability:

- Low vulnerability: AAD change <25% & <€1m
- Moderate vulnerability: AAD change **>**25% & <€1m or AAD change < 25% & **>**€1m
- High vulnerability: AAD change **>**25% & **>**€1m

Within highly-sensitive AFAs a "future change adaptability" review was carried out, using qualitative expert engineering judgement supported by quantitative information obtained by modelling simulations of methods and options under consideration. The methods being proposed as preliminary option(s) were assessed in order to give an indication as to how readily they could be adapted and the likely design approach to provide additional protection (namely the Adaptive Approach, the Assumptive Approach or No Physical Provision).

This assessment was dependent on:

- the methods themselves, for example an embankment can be relatively readily added to or a channel could be dredged further but a culvert cannot provide more capacity readily.
- the watercourse's sensitivity to additional flow with the method in place. For example, when walls are being considered the additional height required is related to how close or set back they are from the watercourse or the effect of a downstream control structure such as a weir or culvert.
- the characteristics of the upstream catchment. For example some methods/options can be made adaptive by the addition of complementary measures or interventions at a future stage, such as Land use management or phased resilient living and retreat.

The review considered how potential measures/options could be made more adaptive (incorporating low or no-regrets decisions) by qualitatively assessing adjustments to reduce vulnerability, make

space for water, deliver co-benefits, build-in flexibility and consider deferring, removing or abandonment.

As part of the detailed assessment of the method/option, the alterations/interventions envisaged to develop from the present day's requirements to the likely future method/option considers the following:

- how the method could be adapted (e.g. add to its length, replace with a larger culvert, widen the channel, etc)
- what additional length, heights, capacity, etc would be required,
- what restrictions there are preventing this (e.g. where an existing structure would prevent a channel or bridge from being widened)
- what considerations would be required early in the design stage to accommodate the adaptation later (e.g. would a flood wall require a larger foundation to allow for additional height later).

The review was concluded with a statement of the method's ability to adapt and which options would be considered the most adaptable. Methods, that do not form part of any particular options, were considered as an alternative way to provide additional protection also. This assessment of adaptability enabled the options to be scored under objective 4c in the MCA appraisal process and will also be reported in the FRMPs.

8 OPTIONEERING OF UOM15 SPATIAL SCALE OF ASSESSMENTS

The following sections detail the findings of the optioneering process applied to the various areas within the two SSAs in UoM15.

8.1 UOM15

8.2 BALLYHALE AFA

8.3 BALLYRAGGET AFA

8.4 BALLYROAN AFA

8.5 CALLAN AFA

8.6 FRESHFORD AFA

8.7 INISHTIOGE AFA

8.8 KILKENNY (NORE) AFA

8.9 KILKENNY (BREAGAGH) AFA

8.10 MOUNTRATH AFA

8.11 RATHDOWNEY AFA

8.12 THOMASTOWN AFA

8. OPTIONEERING OF SSA'S

8.1 UoM15 Optioneering of FRM Options

Name	Local Authority	SSA	Status	Date
UoM15	Kilkenny & Laois • Ballyhale AFA • Ballyragget (Inc Borris) AFA • Ballyroan AFA • Callan AFA • Freshford AFA • Inistioge AFA • Kilkenny (Nore) AFA • Kilkenny (Breagagh) AFA • Mountrath AFA • Rathdowney AFA • Thomastown AFA	UoM	Final	13/06/2016

8.1.1 Source of flooding

Fluvial	Coastal Mechanism 1	Coastal Mechanism 2

8.1.2 Summary of Flood Risk within SSA boundary

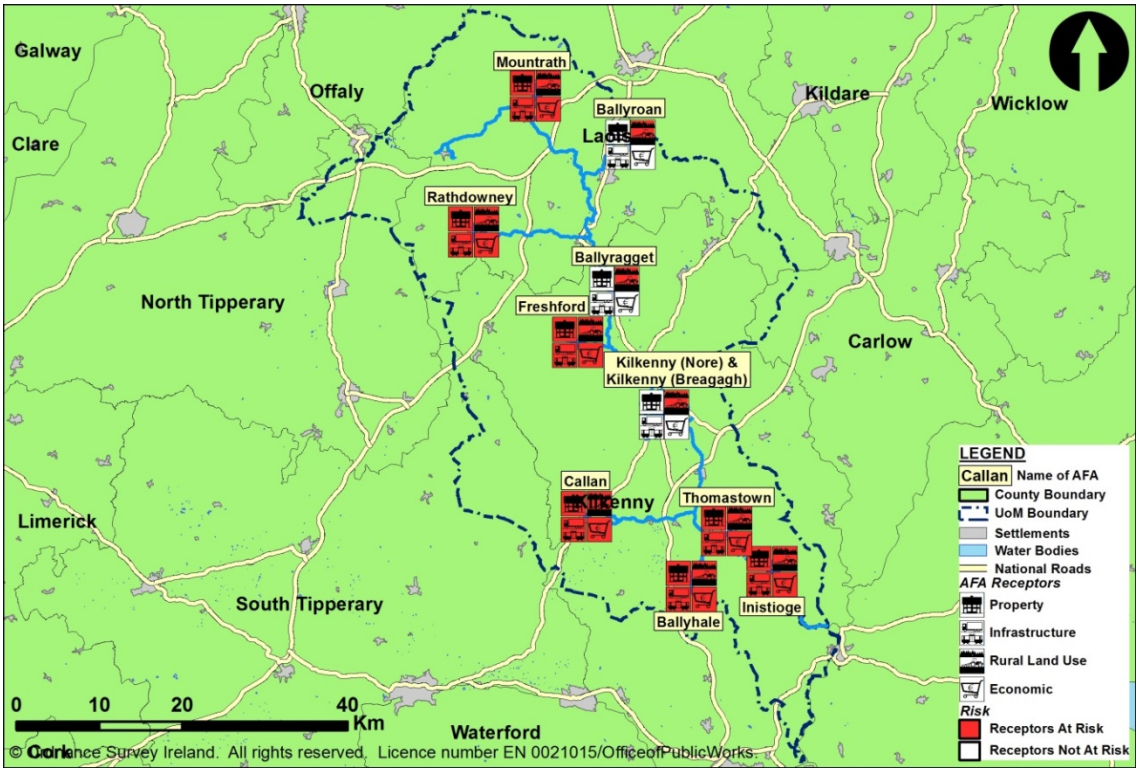


Figure 8.1.1 UoM15 Flood Risk during a 1% AEP Fluvial Flood Event

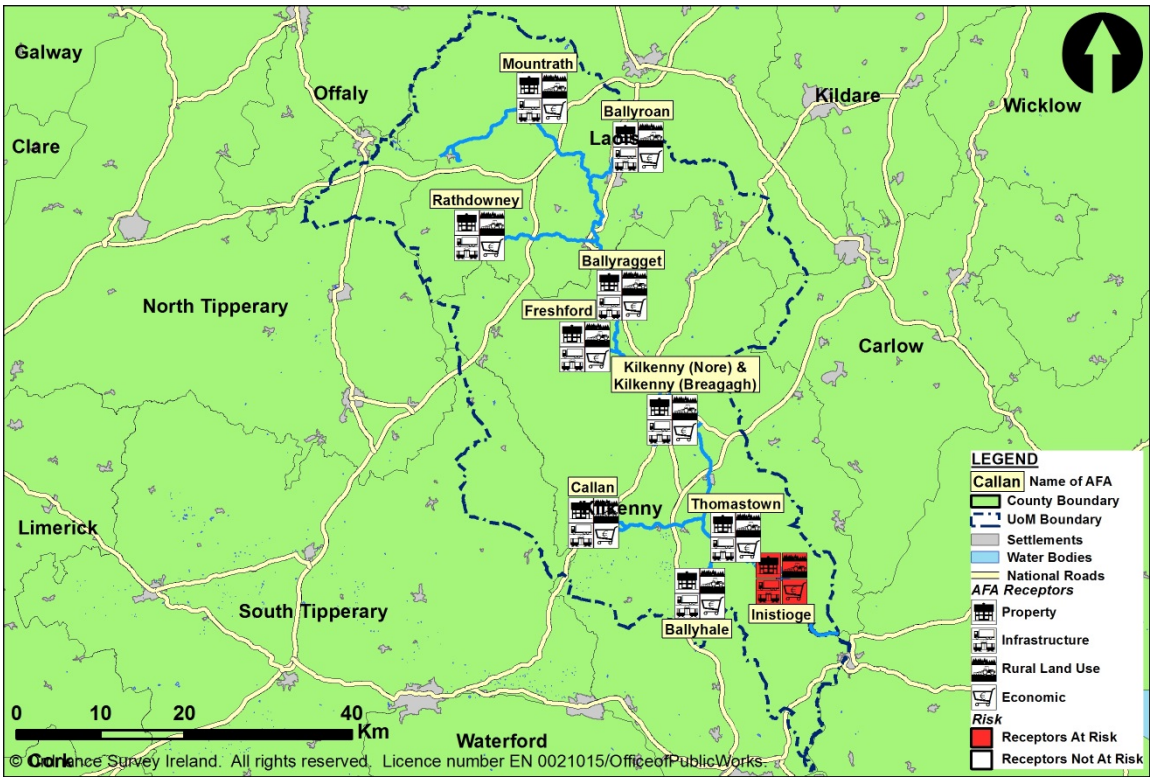


Figure 8.1.2 UoM15 Flood Risk during a 0.5% AEP Coastal Mechanism 1 Flood Event

Figures 8.1.1 and 8.1.2 summarise the flood risk to the main economic activities within UoM15. During a 1% AEP fluvial flood event residential properties, infrastructure and economic activities are affected within all AFAs included in UoM15 with the exception of Ballyroan and Ballyragget. Rural land is affected within all AFAs included in UoM15. The present flood risk in Kilkenny (Nore) AFA is mostly managed by the recently construction Kilkenny Flood Defence Scheme and therefore the residual risk is considered low.

During a 0.5% AEP coastal flood event (mechanism 1) residential properties, infrastructure, economic activities and rural land are affected within the Inistioge AFA only.

In Ballyhale, Callan, Freshford, Rathdowney and Thomastown and AFAs the onset of non-residential property damage occurs in the 50% AEP event, in Inistioge AFA damage commences in the 10% AEP event and in Mountrath and Kilkenny (Breagagh) AFAs the damage occurs in the 5% AEP event.

In Ballyhale, Callan, Freshford, Rathdowney, Thomastown and Inistioge AFAs the onset of residential property damage occurs in the 50% AEP event, in Kilkenny (Breagagh) damage commences in the 20% AEP event. In Mountrath AFA, the damage occurs in the 2% AEP event

8.1.3 Monetary Benefit Within the AFAs in UoM15

	Ballyhale AFA	Ballyragget AFA	Ballyroan AFA	Callan AFA	Freshford AFA
Annual Average Damage (AAD)	€ 578,088	€7,208	€194	€ 273,191	€ 2,095,292
Present Value Damage (pvD)	€ 12,418,483	€154,848	€4,164	€ 5,868,697	€ 45,011,056
Standard of Protection (SoP)	1% AEP	1%AEP	1%AEP	1% AEP	1%AEP
Number of Properties Benefiting from Design SoP	25	0	0	38	93
Minimum Present Value Benefit	€ 11,643,455	€0	€0	€ 4,536,411	€42,711,605
Capped Minimum Present Value Benefit	€ 4,116,936	€0	€0	€ 1,808,579	€13,421,732

	Inistioge AFA	Kilkenny (Breagagh) AFA	Kilkenny (Nore) AFA	Mountrath AFA	Rathdowney AFA	Thomastown AFA
Annual Average Damage (AAD)	€ 391,261	€44,093	€240,427	€101,833	€4,736,959	€ 2,254,361
Present Value Damage (pvD)	€ 8,405,073	€947,216	€5,164,862	€2,187,578	€101,759,363	€ 48,428,183
Standard of Protection (SoP)	0.5% AEP	1%AEP	1%AEP	1%AEP	1%AEP	1% AEP
Number of Properties Benefiting from Design SoP	30	37	20	40	44	135
Minimum Present Value Benefit	€ 7,575,324	€677,301	€0	€1,546,066	€99,430,040	€ 45,390,058
Capped Minimum Present Value Benefit	€ 6,546,412	€677,301	€0	€1,546,066	€8,488,850	€ 16,479,422

8.1.4 Monetary Damage for Present Day and Future Scenarios within the AFAs in UoM15

	Ballyhale AFA	Ballyragget AFA	Ballyroan AFA	Callan AFA	Freshford AFA
AAD (present day scenario)	€ 578,088	€7,208	€194	€ 273,191	€2,095,292
AAD (MRFS)	€812,095	€25,216	€2,406	€1,037,880	€5,688,223
AAD (HEFS)	€1,575,748	€75,490	€6,329	€4,106,326	€7,869,183

	Inistioge AFA	Kilkenny (Breagagh) AFA	Kilkenny (Nore) AFA	Mountrath AFA	Rathdowney AFA	Thomastown AFA
AAD (present day scenario)	€334,263 €56,998	€44,093	€240,427	€101,833	€4,736,959	€ 2,254,361
AAD (MRFS)	€798,606 €183,529	€206,714	€1,918,342	€262,106	€5,281,545	€4,578,264
AAD (HEFS)	€1,395,937 €341,941	€392,031	€13,565,661	€992,382	€6,141,565	€7,848,239

Fluvial risk Coastal Mechanism 1 Coastal Mechanism 2

8.1.5 Short Listing FRM Methods

Method	Review Comment	Continue Screening
Do Nothing	Consider at AFA SSA - Reject	✗
Maintain Existing Regime	Consider at AFA SSA - Reject	✗
Do Minimum	Consider at AFA SSA - Reject	✗
Planning and Development Control	Consider Further	✓
Building Regulations	Consider Further	✓
Sub-catchment Wide SuDs	Consider Further	✓
Land Use Management	Consider Further	✓
Strategic Development Management	Consider Further	✓
Storage	Consider at Sub-Sub-catchment and AFA SSA – Reject	✗
Improvement of Channel Conveyance	Consider at Sub-Sub-catchment and AFA SSA – Reject	✗
Hard Defences	Consider at Sub-catchment and AFA SSA – Reject	✗
Relocation of Properties	Consider at AFA SSA - Reject	✗
Diversion of Flow	Consider at AFA SSA - Reject	✗
Flood Warning/Forecasting	Consider Further	✓
Public Awareness Campaign	Consider Further	✓
Individual Property Protection	Consider at AFA SSA - Reject	✗
Other Works	Consider at AFA SSA - Reject	✗

8.1.5.1 Feasibility Review Summary

Method	Technical Screening	Economic Screening	Environmental and Cultural Heritage Screening	Social Screening
Planning and Development Control	✓	✓	✓	✓
Building Regulations	✓	✓	✓	✓
Sub-catchment Wide SuDs	✓	✓	✓	✓
Land Use Management	✓	-	✓	✓
Strategic Development Management	✓	✓	✓	✓
Hard Defences	✓	×		
Flood Warning/Forecasting	✓	✓	✓	✓
Public Awareness Campaign	✓	✓	✓	✓

× - Reject ✓ - Progress ? - Progress, potential for impacts identified ! - Progress, potential for significant impacts identified

8.1.5.2 Justification for Rejection/Retention

Method	Tech	Econ	Env	Soc
Planning and Development Control	✓	✓	✓	✓
This method manages future flood risk for new development and is applicable throughout UoM15.				
Method	Tech	Econ	Env	Soc
Building Regulations	✓	✓	✓	✓
This method manages future flood risk for new development and is applicable throughout UoM15.				
Method	Tech	Econ	Env	Soc
Sub-catchment Wide SuDs	✓	✓	✓	✓
This method manages future flood risk for new development and is applicable throughout UoM15.				
Method	Tech	Econ	Env	Soc
Land Use Management	✓	-	✓	✓
This method focuses on retaining water and slowing run-off in the catchment thereby lowering water levels and reducing the associated flood risk within the watercourses. This can be achieved by a number of				

techniques for example planting, restoring meanders and attenuation ponds. Land use management methods can be applied to any catchment with characteristics that provide favourable conditions to make land use management an effective method in managing the flood risk.

This measure potentially supports flood risk management in combination with other methods and may be applicable throughout UoM15. Figure 8.1.3 shows the output of Land Use Management screening for UoM15. The output largely shows the UoM15 Catchment is unsuitable for Land Use Management methods. 6.5% of the 2,595km^2 catchment was classed as Very Low sensitivity to reducing runoff, 45.2% was classed as Low sensitivity, 37.5% was classed as Moderate sensitivity and 10.8% was classed as High sensitivity.

A classification of 1 identifies areas where NFM measures would have little impact in reducing the runoff and a classification of 4 identifies areas where NFM measures would a significant impact in reducing the runoff (Section 7.1.7).

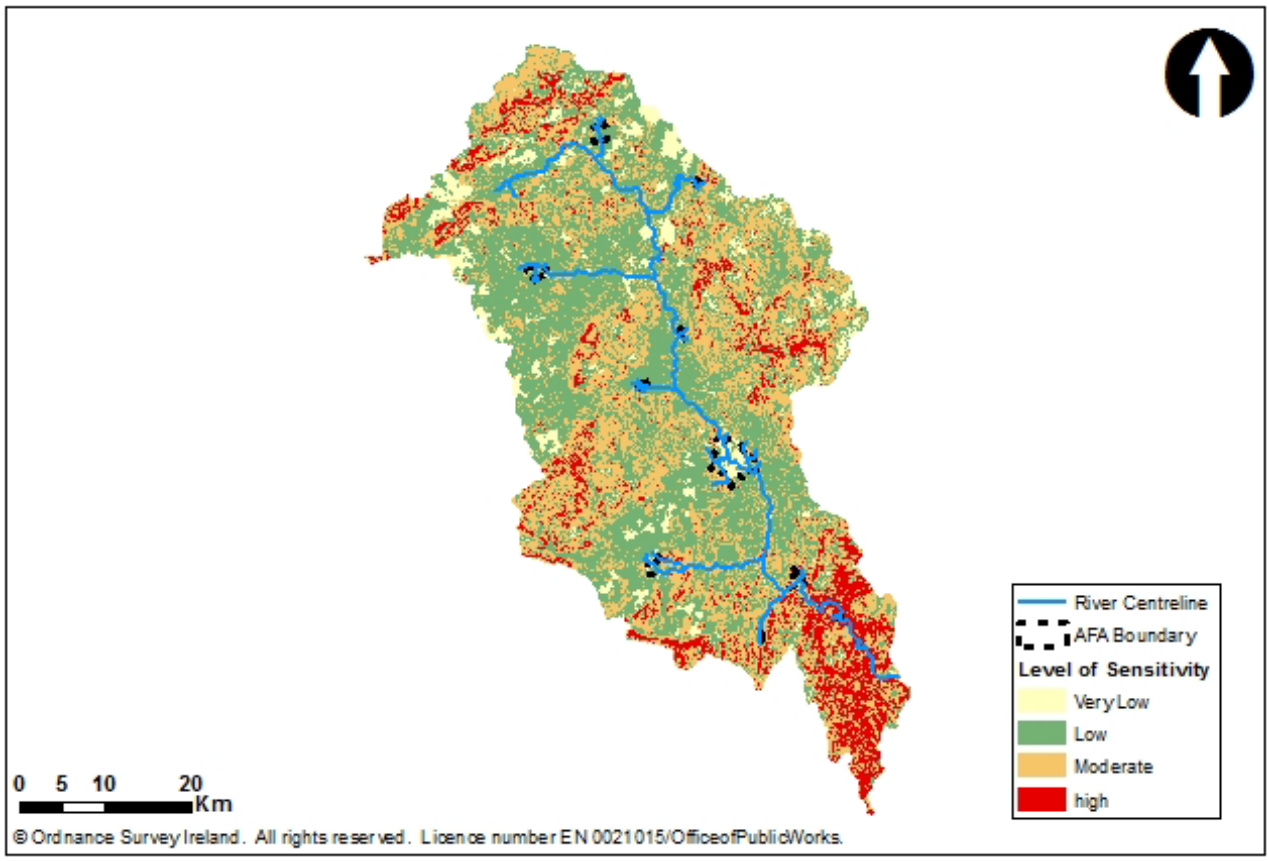


Figure 8.1.3 UoM15 Land Use Management Screening Results

This method is not feasible at UoM SSA, nor for any UoM15 Sub-catchments, however its technical feasibility within each AFA has been assessed in further detail as part of this analysis. The method's applicability at AFA scale is subject to the measures it is taken in combination with, therefore the AFA SSA progresses this feasibility analysis to determine the overall suitability of the method at AFA level.

Ballyhale AFA

The Ballyhale AFA spans across one catchment as shown in Figure 8.1.4. Catchment 1 drains into the Ballyhale watercourse and discharges to the Little Arrigal River. All the properties at risk during a 1% AEP fluvial flood event are located in catchment 1. In assessing the suitability of this catchment for land use management the following criteria was considered; the area of catchment 1 upstream of the properties at risk is 20.4km^2, the land use for catchment 1 is predominantly agricultural with woodland and to a lesser extent bogland and mineral extraction sites located in the upper catchment. Catchment 1 has a relatively steep

gradient throughout the catchment.

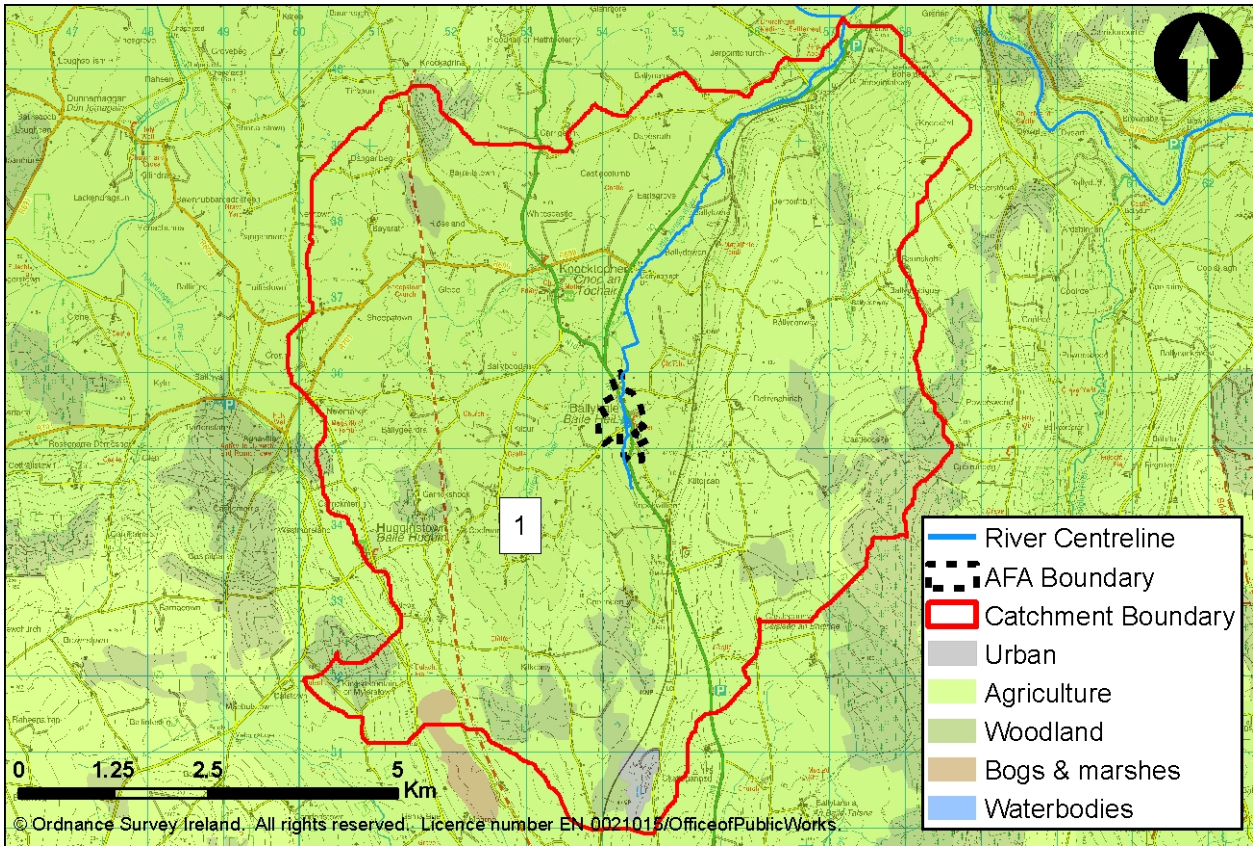


Figure 8.1.4 Land Use of the Ballyhale Catchment

While land use management methods can be applied to any catchment it is the suitability of a catchment to progress as a pilot area that the screening process is based on. Catchment 1 does have a large portion of agricultural land use that would provide enough area to employ NFM methods. Therefore catchment 1 would be suitable as a pilot area.

The River Barrow and River Nore SAC and the River Nore SPA are within and downstream of Ballyhale. This catchment is considered a suitable pilot area. Progressing Land Use Management in a pilot area should not take precedence over other methods which will provide the design SoP. This method should therefore be progressed only if all other methods be found unsuitable.

Ballyragget (Inc Borris) AFA

The Land Use Management FRM method is not applicable in Ballyragget AFA as no properties are at risk during the 1% AEP event within this AFA.

Ballyroan AFA

The Land Use Management FRM method is not applicable in Ballyroan AFA as no properties are at risk during the 1% AEP event within this AFA.

Callan AFA

The Callan AFA spans across 4 catchments as shown in Figure 8.1.5. Catchment 1 is a catchment of the Kings River which falls from the Slieveardagh Mountains and discharges to the River Nore. The other 3 catchments, labelled 2-4 in Figure 8.1.5, fall from the local high ground to the Kings River. All the properties at risk during a 1% AEP fluvial flood event are located in catchment 1. In assessing the suitability of these catchments for land use management the following criteria was considered; the size of catchment 1 is 203km^2, the land use for catchment 1 is predominantly agricultural with some woodland areas distributed throughout the catchment. The catchment is relatively steep at near the source due the presence of the

Slieveardagh Mountains.

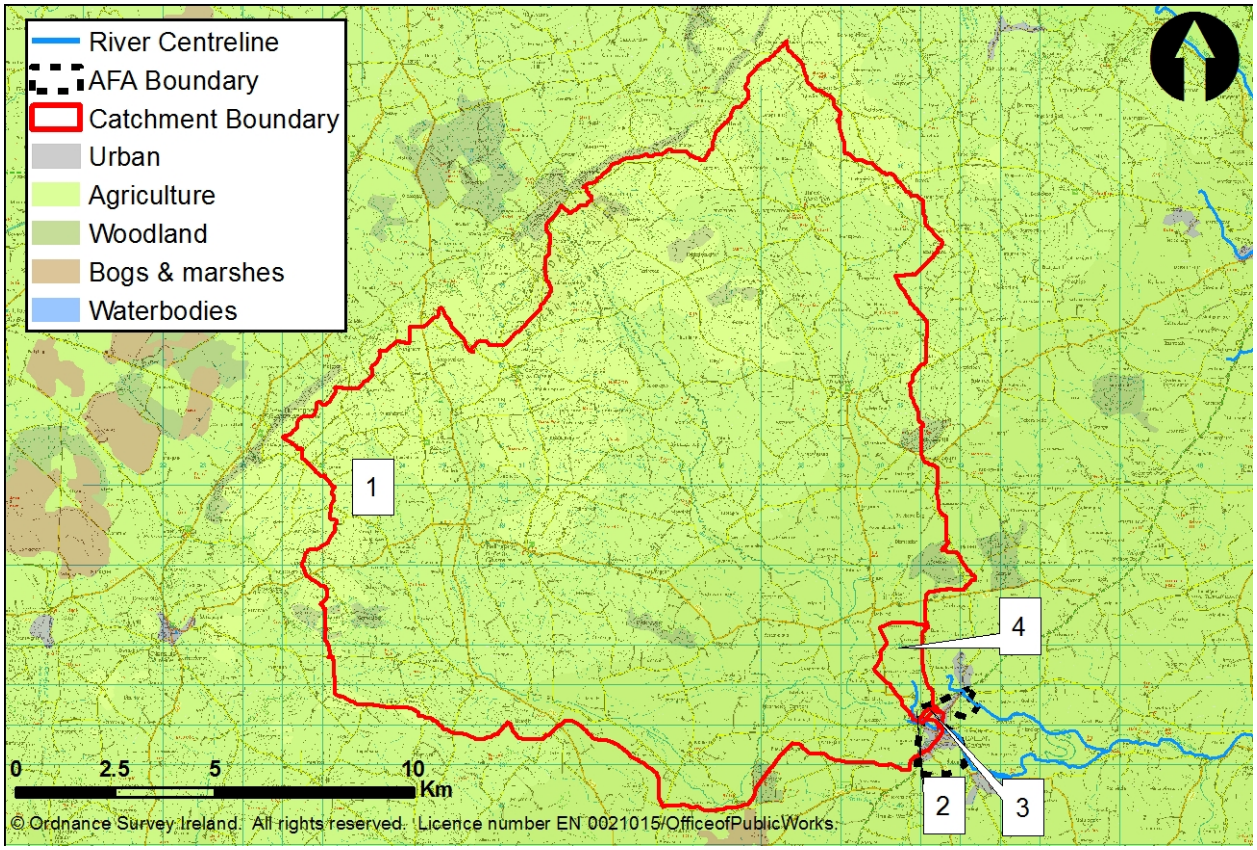


Figure 8.1.5 Land Use of Callan Catchments

While land use management methods can be applied to any catchment it is the suitability of a catchment to progress as a pilot area that the screening process is based on. Catchment 1 is a relatively large catchment and would require a large number of NFM features to make the method effective. This would be a technically complex method to apply and monitor. In addition to this the large number of stakeholders and land owners to liaise with would make the implementation of this method difficult. Therefore catchment 1 was considered unsuitable as a pilot area and consequently rejected from the screening process.

Freshford AFA

The Freshford AFA spans across 4 catchments as shown in Figure 8.1.6. Catchment 1 is the main Nuenna River catchment. The other 4 catchments, in Figure 8.1.6, contain tributaries of the Nuenna River. The properties at risk during a 1% AEP fluvial flood event are located in catchments 1-4. In assessing the suitability of these catchments for land use management the following criteria was considered, the areas of catchments 1-4 are 35km^2, 31km^2, 3.4km^2 and 30km^2 respectively, the land use for catchments 1-4 is predominantly agricultural with some woodland distributed throughout the catchment and an urban area at the confluences of these watercourses. Catchments1, 2 and 4 are relatively steep in their upper areas.

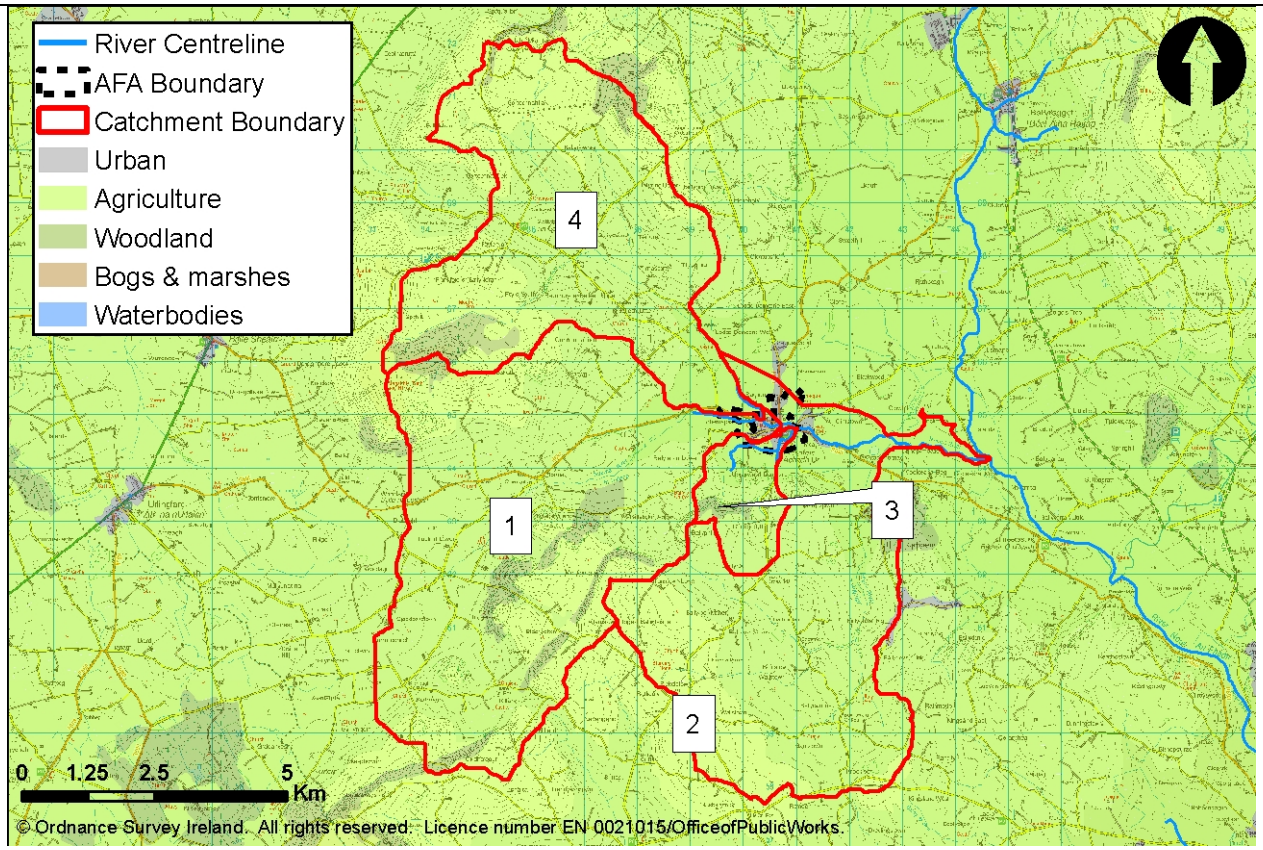


Figure 8.1.6 Land Use of Freshford Catchments

While land use management methods can be applied to any catchment it is the suitability of a catchment to progress as a pilot area that the screening process is based on. Catchments 1-4 do have a large portion of agricultural land use that would provide enough area for employing NFM methods. Therefore, Freshford AFA would be suitable as a pilot area.

The AFA is over 3km upstream of the River Barrow and River Nore SAC and the River Nore SPA. FRM methods to be aware of River Barrow and River Nore SAC and River Nore SPA. Progressing Land Use Management in a pilot area should not take precedence over other methods which will provide the design SoP. This method should therefore be progressed only if all other methods be found unsuitable.

Inistioge AFA

The Land Use Management FRM method is not applicable in for the Inistioge AFA as many of the properties at risk are at risk from coastal mechanism 1 flooding.

Kilkenny (Nore) AFA

The Land Use Management FRM method was not assessed for Kilkenny (Nore) AFA, since the present flood risk in Kilkenny (Nore) AFA is mostly managed by the recently construction Kilkenny Flood Alleviation Scheme and therefore the residual risk is considered low.

Kilkenny (Breagagh) AFA

The Kilkenny (Breagagh) AFA spans across 1 catchment as shown in Figure 8.1.7.Figure 8.1.8 In assessing the suitability of the Breagagh River catchment for land use management the following criteria was considered; firstly the area of Breagagh River catchment upstream of the properties at risk, is 20 km^2, (<40 km^2). Also, land use for catchment is predominantly agricultural; the general topography of the Breagagh catchment is relatively level to slightly undulatory, with the upper catchment generally steeper. While land use management methods can be applied to any catchment, the above outlined criteria would deem the Breagagh River catchment as potentially suitable and therefore this area should progress as a pilot area and

this method should therefore be progressed only if all other methods be found unsuitable.

The River Barrow and River Nore SAC and the River Nore SPA are within, downstream of and upstream of the Breagagh River. Progressing Land Use Management in a pilot area should not take precedence over other methods which will provide the design SoP. This method should therefore be progressed only if all other methods be found unsuitable.

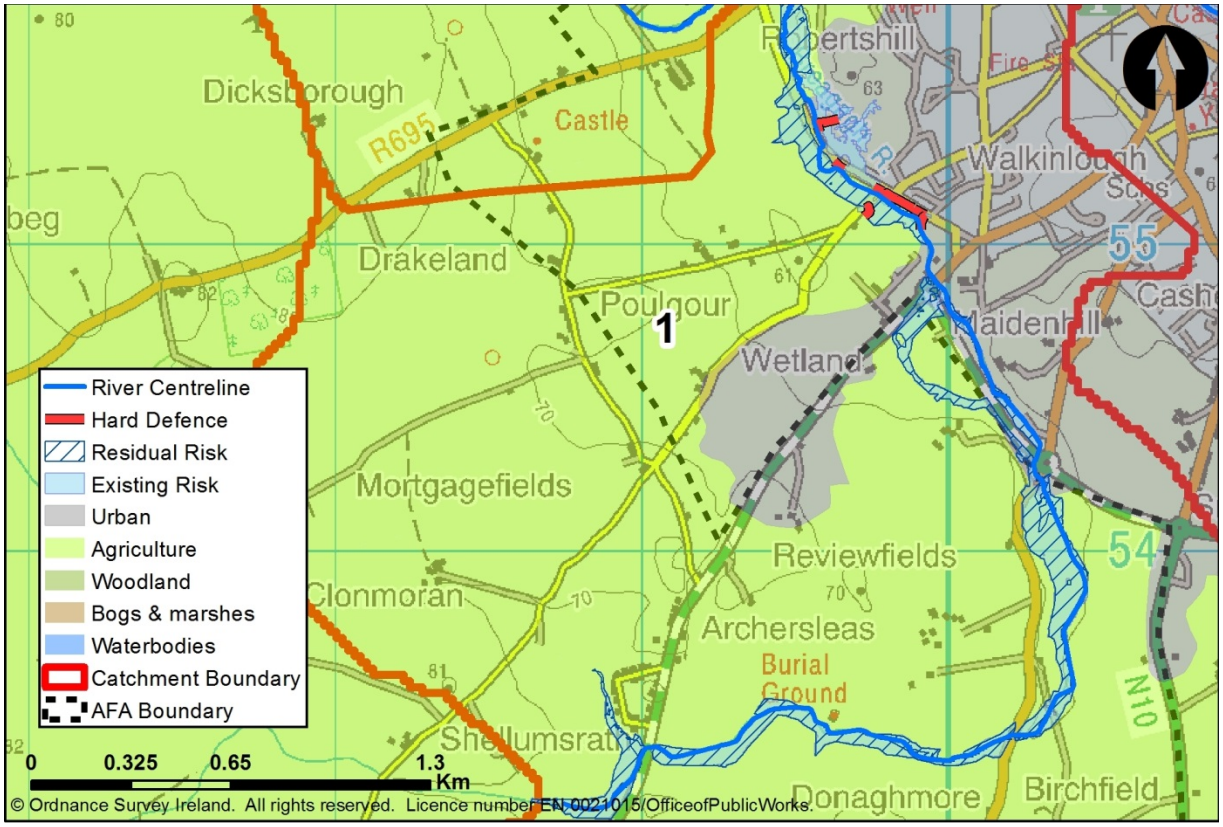


Figure 8.1.7 Land Use of Kilkenny (Breagagh) AFA Catchment

Mountrath AFA

The Mountrath AFA spans across 4 catchments as shown in Figure 8.1.8. Catchment 1 is the main Mountrath River catchment. The other 3 catchments, in Figure 8.1.8, contain tributaries of the Mountrath River. The properties at risk during a 1% AEP fluvial flood event are located in catchments 2 and 4. In assessing the suitability of these catchments for land use management the following criteria was considered the areas of catchments 1-4 are 26.7km^2, 2.8km^2, 2.3km^2 and 20km^2 respectively, the land use for catchments 1-4 is predominantly agricultural with some woodland and bogland distributed throughout the catchment and an urban area at the confluences of these watercourses. Catchments 1, 2 and 4 are relatively steep in the upper areas.

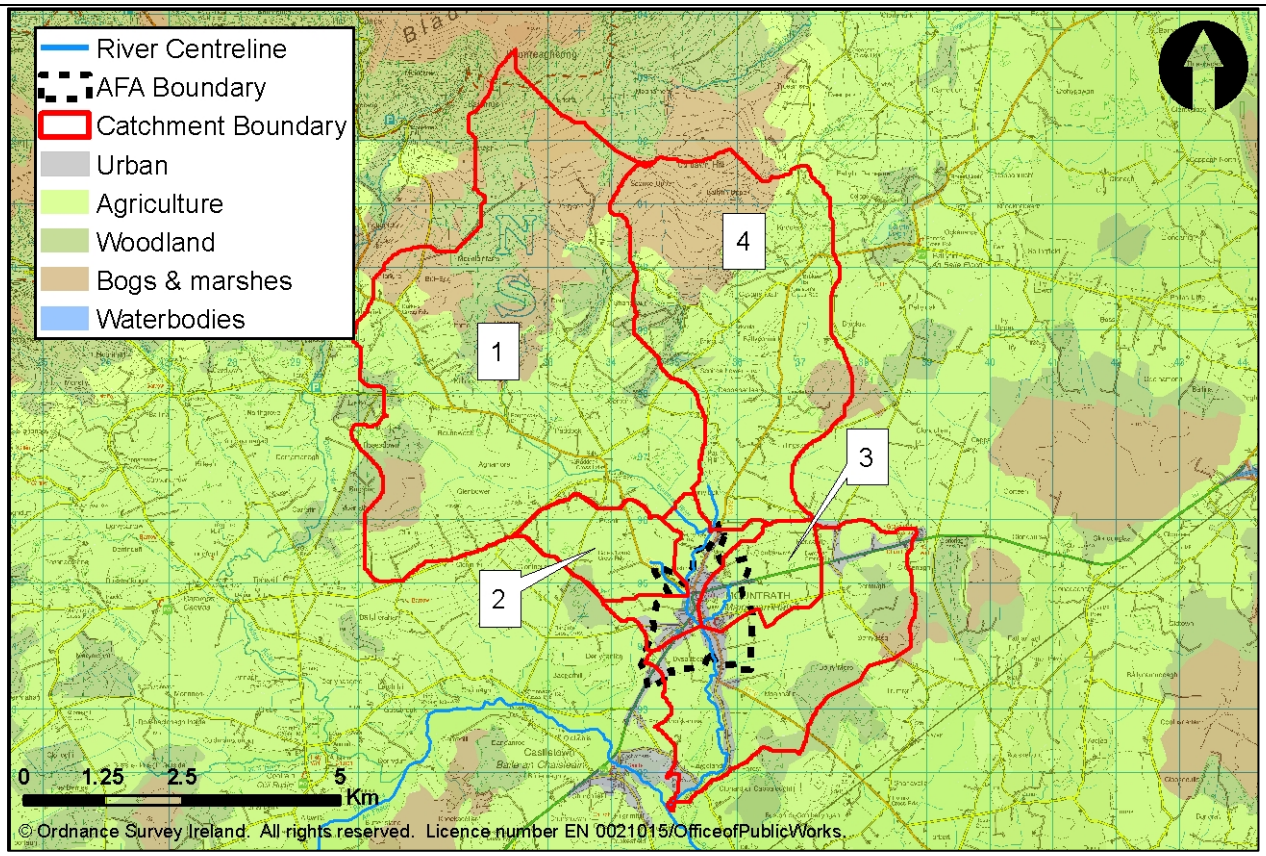


Figure 8.1.8 Land Use of Mountrath Catchments

While land use management methods can be applied to any catchment it is the suitability of a catchment to progress as a pilot area that the screening process is based on. Catchments 1-4 do have a large portion of agricultural land use that would provide enough area for employing NFM methods. There is a larger portion of urban area in catchment 3 however the flood risk generated by this watercourse contributes little to the overall flood risk to flood cell 3 which is mainly attributed to the Mountrath River Therefore Mountrath AFA would be suitable as a pilot area.

The River Barrow and River Nore SAC is within, upstream of and downstream of Mountrath. FRM Methods to be aware of River Barrow and River Nore SAC and River Nore SPA. Progressing Land Use Management in a pilot area should not take precedence over other methods which will provide the design SoP. This method should therefore be progressed only if all other methods be found unsuitable.

Rathdowney AFA

The Rathdowney AFA spans across 4 catchments as shown in Figure 8.1.9. The properties at risk during a 1% AEP fluvial flood event are located in all 4 catchments; the catchment areas were calculated to be 0.18km^2, 0.26km^2, 2.57km^2 and 12.89km^2 respectively. The land use was found to be predominantly agricultural. Some significant urban areas were identified in some catchments, particularly catchment 1 and 2. The Rathdowney catchments are generally steeper in the upper catchments and become flatter in the urbanised areas within the AFA where the at risk properties are located.

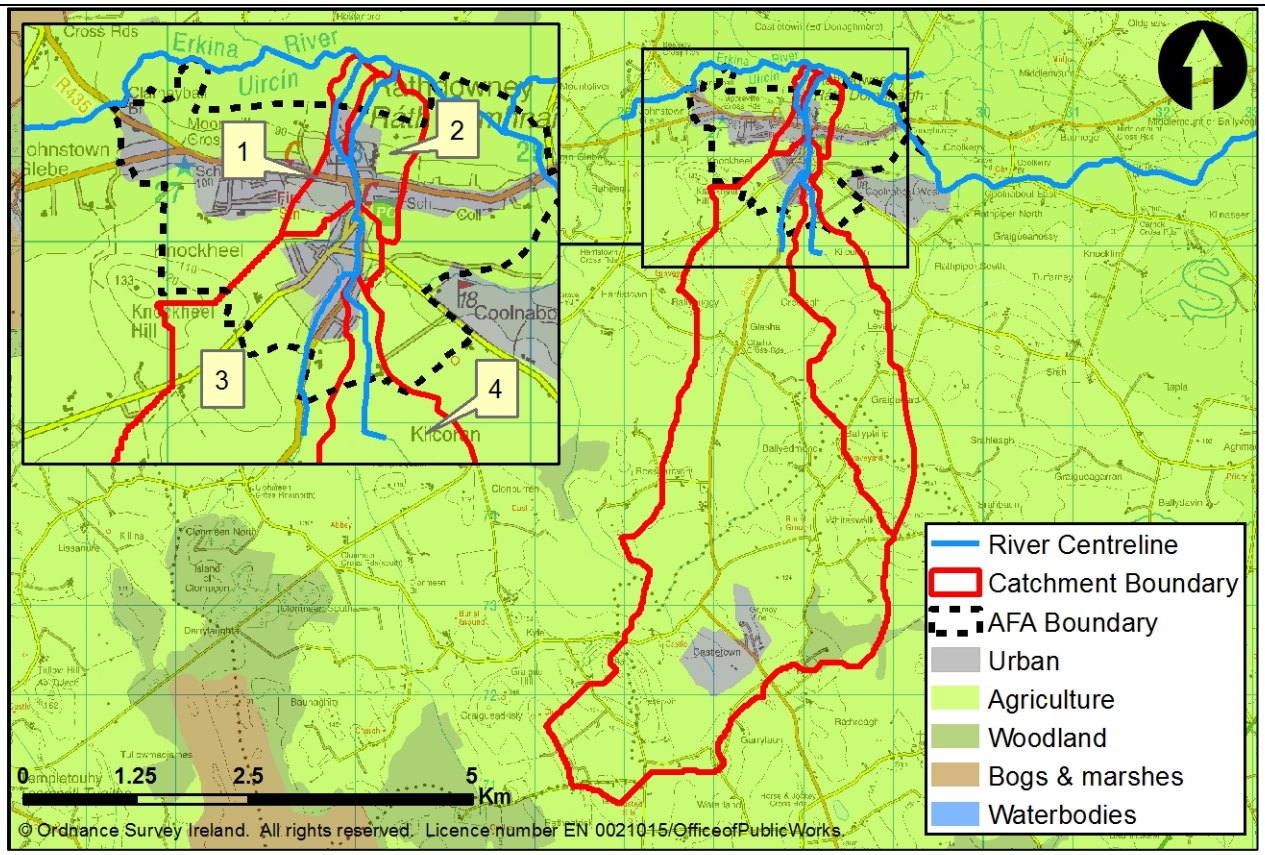


Figure 8.1.9 Land Use of Rathdowney Catchments

Although the catchments would be favourable in terms of spatial scale, the predominance of urbanisation associated with catchments 1 and 2 would render Land Use Management as unfeasible. Considering that there would be little benefit in the application of land use management, it was concluded that Rathdowney AFA and surrounding catchments should not proceed as a potential pilot study.

Thomastown AFA

The Thomastown AFA spans across 2 catchments as shown in Figure 8.1.10. Catchment 1 is a sub-catchment of the River Nore. The other catchment, labelled 2 in Figure 8.1.10, falls from a local source to the River Nore. All the properties at risk during a 1% AEP fluvial flood event are in catchment 1. In assessing the suitability of catchment1 for land use management the following criteria was considered; the size of catchment 1 is 2,416km^2, the land use for catchment 1 is predominantly agricultural with some woodland areas distributed throughout the catchment.

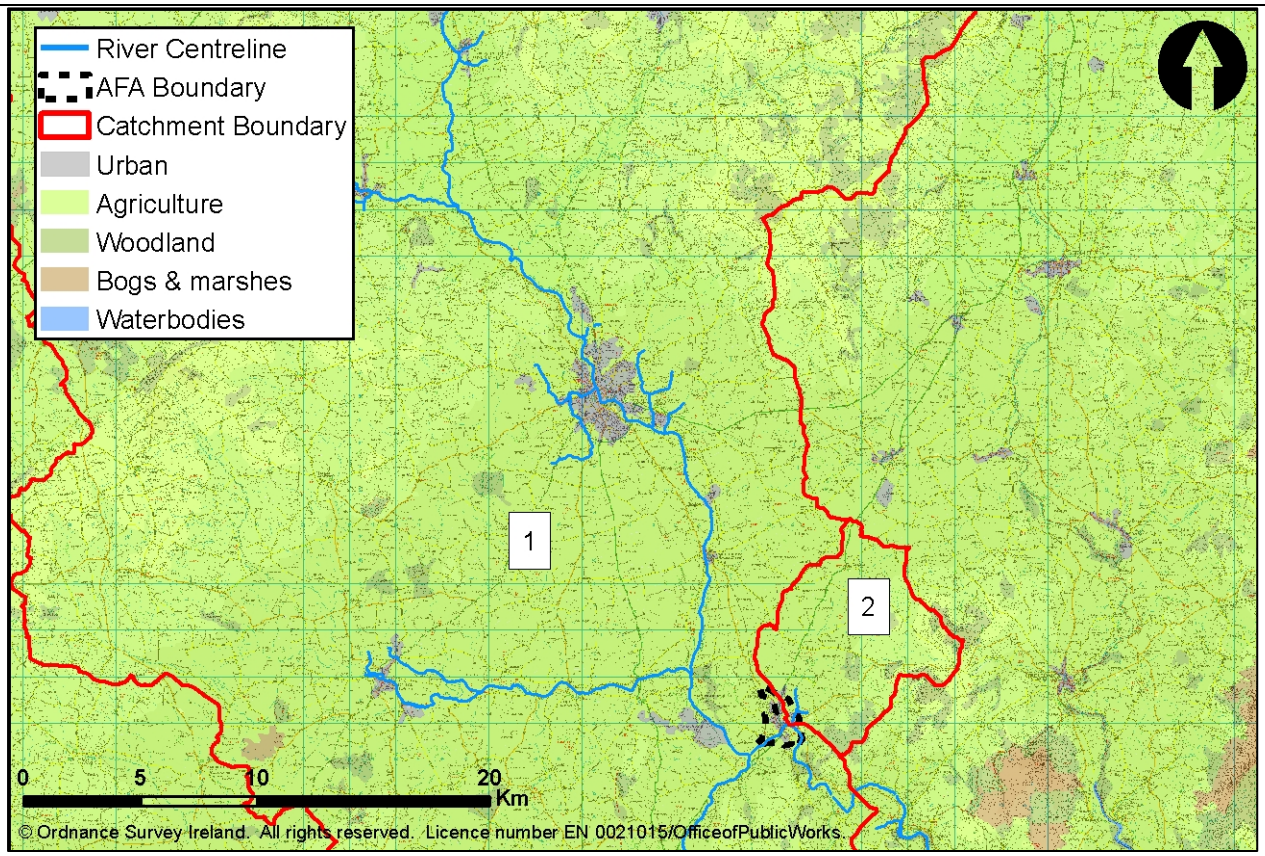


Figure 8.1.10 Land Use of Thomastown Catchments

While land use management methods can be applied to any catchment it is the suitability of a catchment to progress as a pilot area that the screening process is based on. The size of the River Nore catchment at the Thomastown AFA is considered too large to be put forward as a pilot for Land Use Management. It would require a large number of NFM features to make the method effective. This would be a technically complex method to apply and monitor. In addition to this the large number of stakeholders and land owners to liaise with would make the implementation of this method difficult. Therefore catchment 1 is considered unsuitable as a pilot area and consequently rejected from the screening process.

A summary table of the potential effectiveness of land use management for each AFA is provided in the summary section of this report.

Method	Tech	Econ	Env	Soc
Strategic Development Management	✓	✓	✓	✓
This method manages future flood risk for new development and is applicable throughout UoM15.				
Method	Tech	Econ	Env	Soc
Hard Defences	✓	×		
Consideration of a tidal barrier across Waterford is discussed in the UoM14 (Barrow Hydrometric Area) POR as this measure would potentially benefit AFAs in the tidal influence of both the UoM14 and UoM15. The method was found to be economically unfeasible and was rejected from the screening process.				

Method	Tech	Econ	Env	Soc
Flood Warning/Forecasting	✓	✓	✓	✓

This method provides a warning to property owners that a flood event is imminent. This allows a period of time to defend the property from flooding or move contents out of flood risk areas. The waring time depends on whether a warning or forecasting system is operational. As this method's effectiveness relies on human intervention there is an element of uncertainty associated with it. In addition to this it is recognised that this method does not prevent flooding but rather allows the properties at risk to be prepared for flooding. As such a limited amount of damage can be expected to be prevented, the actual amount being dependent on the warning time available. Where the warning period is greater than 12 hrs it is assumed that 10% of the flood damage would be avoided. Between 12-6hrs 6% of flood damage would be avoided. Between 6-2hrs 4% of the flood damage would be avoided. And where the warning period is less than 2hrs no flood damage would be avoided.

This assessment assumes that decisions on meteorological and tidal forecasting will be taken at national level and focuses on the assessment of river gauges (which may be augmented by rainfall gauges).

This measure potentially supports flood risk management in combination with other methods and may be applicable throughout UoM15. It is assessed in further detail at the AFA scale subject to the measures it is taken in combination with; the operational elements cost at UoM scale can be spread across AFAs and the infrastructure may be mutually beneficial.

River gauge locations have been identified for each AFA within UoM15 where feasible. Increased forecasting accuracy may also be achieved by locating a series of rainfall gauges within each catchment at a density of approximately 1 per 100km^2.

River Nore

A review was carried out as to where river gauges could be placed in UoM15 in order to provide flood warning to properties at risk from the River Nore. Properties are at risk from the River Nore in the Thomastown and Inistioge AFAs. The River Nore becomes tidally influenced downstream of Thomastown so a fluvial forecasting system for Inistioge should be combined with a tidal forecasting system. A decision on tidal forecasting will be taken at national level.

There are a number of active gauging stations currently located in UoM15 and where possible it is recommended that these stations would be modified to provide real-time data for forecasting. While locating the gauge close to the properties at risk would increase the accuracy of the gauge, as it represents a larger proportion of the catchment, locating it as far upstream of the at risk properties as possible would provide the maximum warning time. Figure 8.1.11 shows the location of the existing river gauges which could be used to provide flood warning. This includes a river gauge at the location of the first property at risk on each watercourse as well as gauges upstream of the properties at risk. This will allow for calibration, validation and fine tuning of the forecasting system.

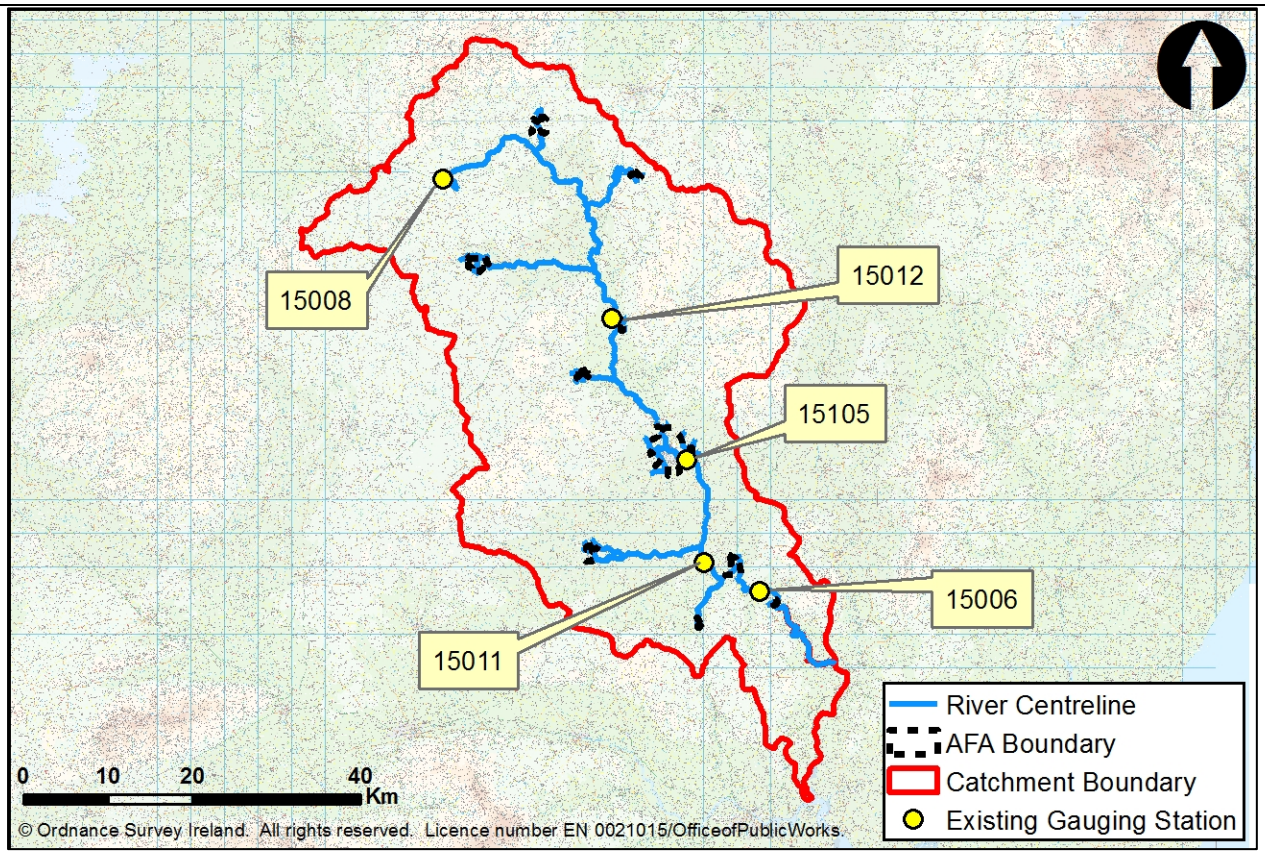


Figure 8.1.11 Location of proposed gauging stations on the River Nore

Gauging station 15011 is located approximately 4km upstream of the first properties at risk on the River Nore in the Thomastown AFA. Gauging station 15008 is located approximately 84km upstream as shown in Figure 8.1.11. The Thomastown hydraulic model showed that the average speed of water travel along the River Nore would be approximately 1.3m/s and therefore the travel time between gauges 15008 and the properties at risk in Thomastown would be approximately 18 hours.

Gauging stations 15012 and 15105 are located approximately 40km and 18km upstream of the properties at risk in Thomastown respectively. The estimated travel times from these gauging stations to Thomastown are therefore 8.5 hours and 4 hours. Incorporating these 2 stations into the flood warning/forecasting system would improve forecasting accuracy.

Gauging station 15006 is located approximately 3km upstream of the first properties at risk on the River Nore in the Inistioge AFA. The properties at risk in Inistioge are approximately 10km downstream of Thomastown. The estimated travel time between Thomastown and Inistioge is therefore estimated to be approximately 2 hours.

Flood warning/forecasting is therefore technically feasible for properties at risk from the River Nore, providing between 18-20 hours warning time. Additional gauging stations are currently installed along the River Nore at various locations and including these stations within a flood warning/forecasting system for the Nore catchment would allow for additional calibration and improve accuracy. Figure 8.1.12 summarises the estimated warning time available for various locations along the Nore catchment relative to Inistioge.

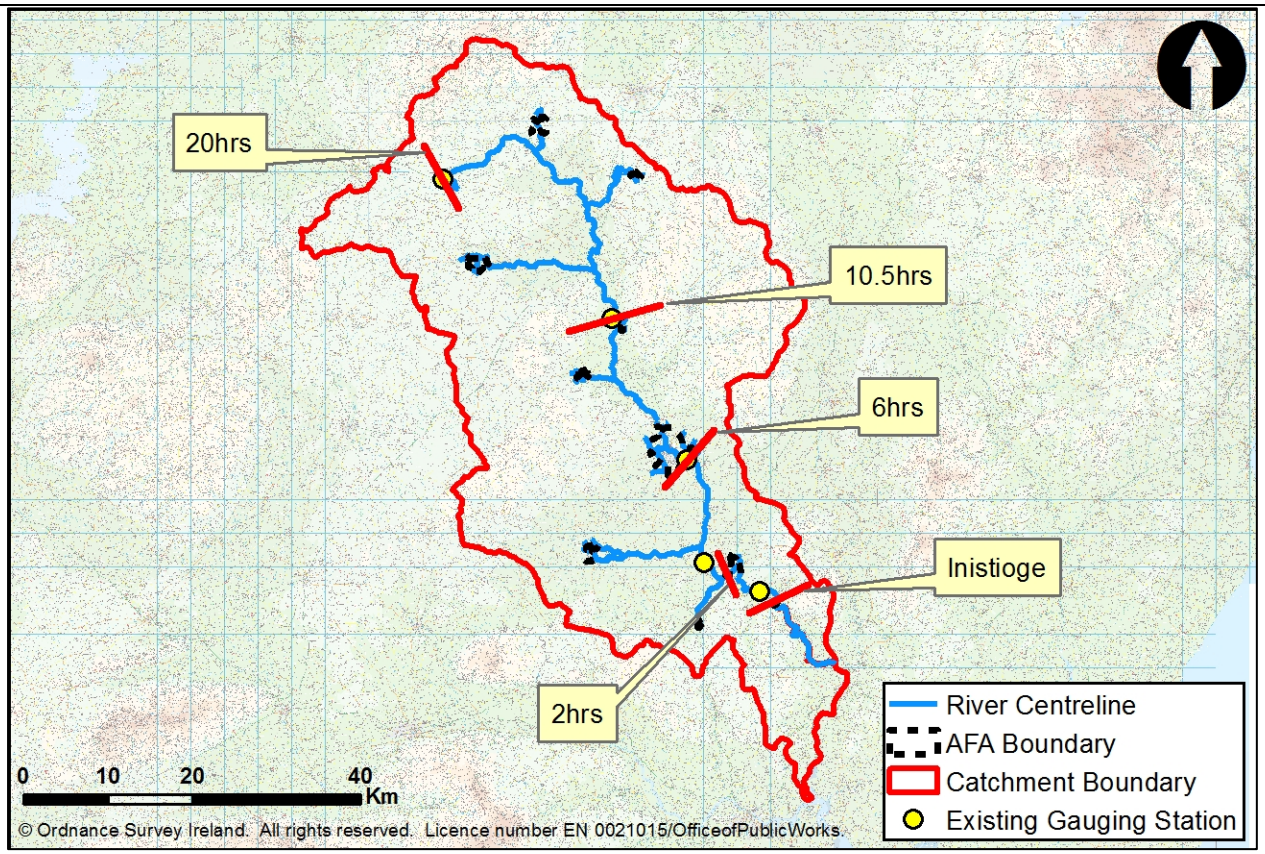


Figure 8.1.12 Estimated warning time available relative to Inistioge

Ballyhale AFA

A review was carried out as to where a river gauge could be placed on the Ballyhale watercourse in order to provide flood warning to the properties at risk of fluvial flooding. While locating the gauge close to the properties at risk would increase the accuracy of the gauge, as it represents a larger proportion of the catchment, locating it as far upstream of the at risk properties as possible would provide the maximum warning time. Figure 8.1.13 shows the proposed location of the new river gauging stations. Proposed gauging station 1a is located approximately 3.2km upstream of the first at risk properties on the Ballyhale watercourse, as far up the catchment as possible. Proposed gauging station 1b is located adjacent to the first properties at risk and would allow for calibration, fine tuning and validation. An estimate of the travel time for a 1% AEP flood event between gauge 1a and the properties at risk was made using the hydraulic model. This showed that the average speed of water travel along the Ballyhale watercourse would be 0.7m/s and therefore the travel time between gauge 1a and the properties at risk would be approximately 1 hour 15mins.

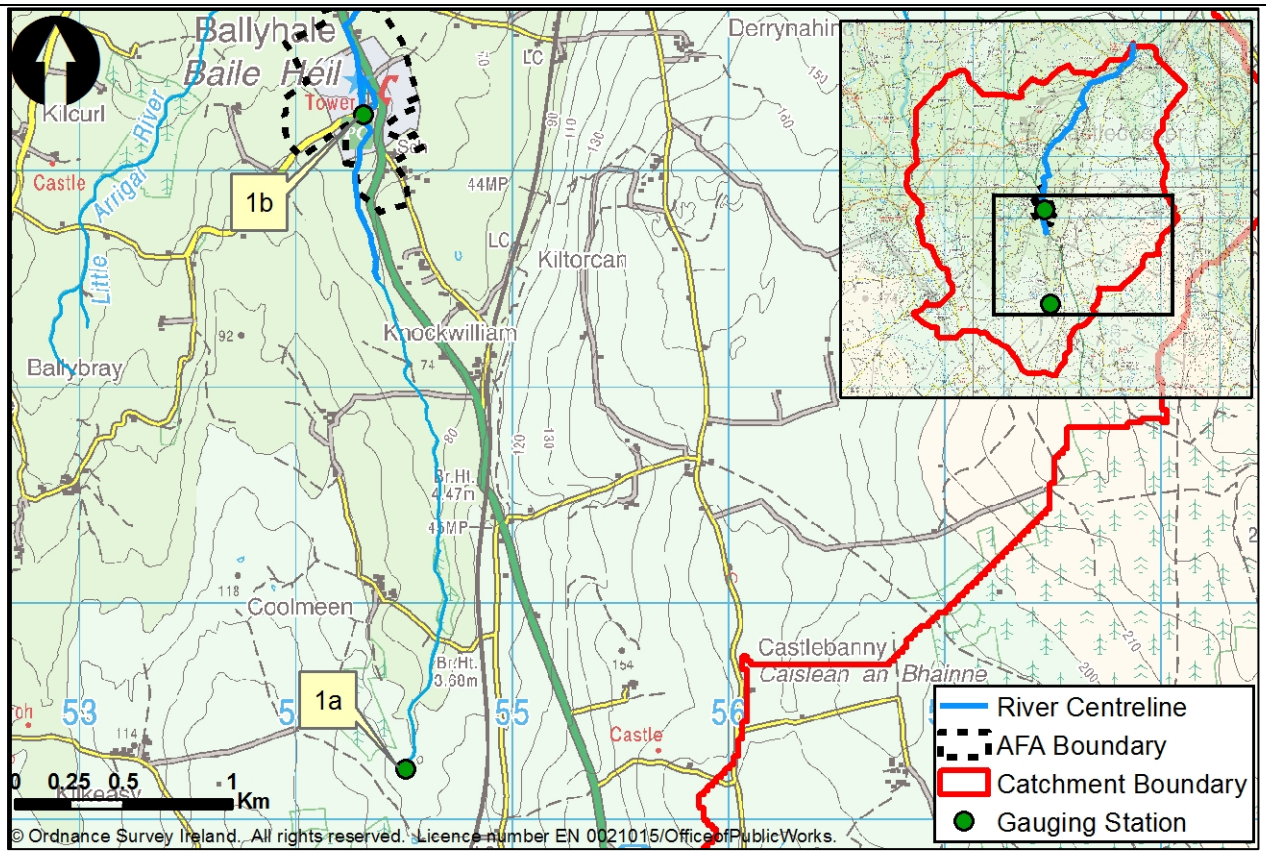


Figure 8.1.13 Location of proposed gauging stations in Ballyhale AFA

As the available warning time on the Ballyhale watercourse is less than 2 hours, flood warning/forecasting is considered to be technically unfeasible for this watercourse.

Ballyragget (Inc Borris) AFA

The Flood Warning/Forecasting FRM method is not applicable in Ballyragget AFA as no properties are at risk during the 1% AEP event within this AFA.

Ballyroan AFA

The Flood Warning/Forecasting FRM method is not applicable in Ballyroan AFA as no properties are at risk during the 1% AEP event within this AFA.

Callan AFA

A review was carried out as to where a river gauge could be placed on the Kings River in order to provide flood warning to the properties at risk. Figure 8.1.14 shows the proposed location of three new river gauges. Gauge 1c on the figure is located at the first properties at risk, gauge 1a is located 8.2km upstream of the properties at risk on the Munster Water and gauge 1b is located 8.2km upstream of the properties at risk on the Kings River. An estimate of the travel time for a 1% AEP flood event to travel from each gauge to the properties at risk was made using the Callan hydraulic model. This showed that the average speed of water travel along the river between the gauge and at risk properties is estimated to be approximately 1.1m/s. Thus the travel time of a 1% AEP flood event from the proposed river gauges 1a/1b to the properties at risk would be approximately 2 hours.

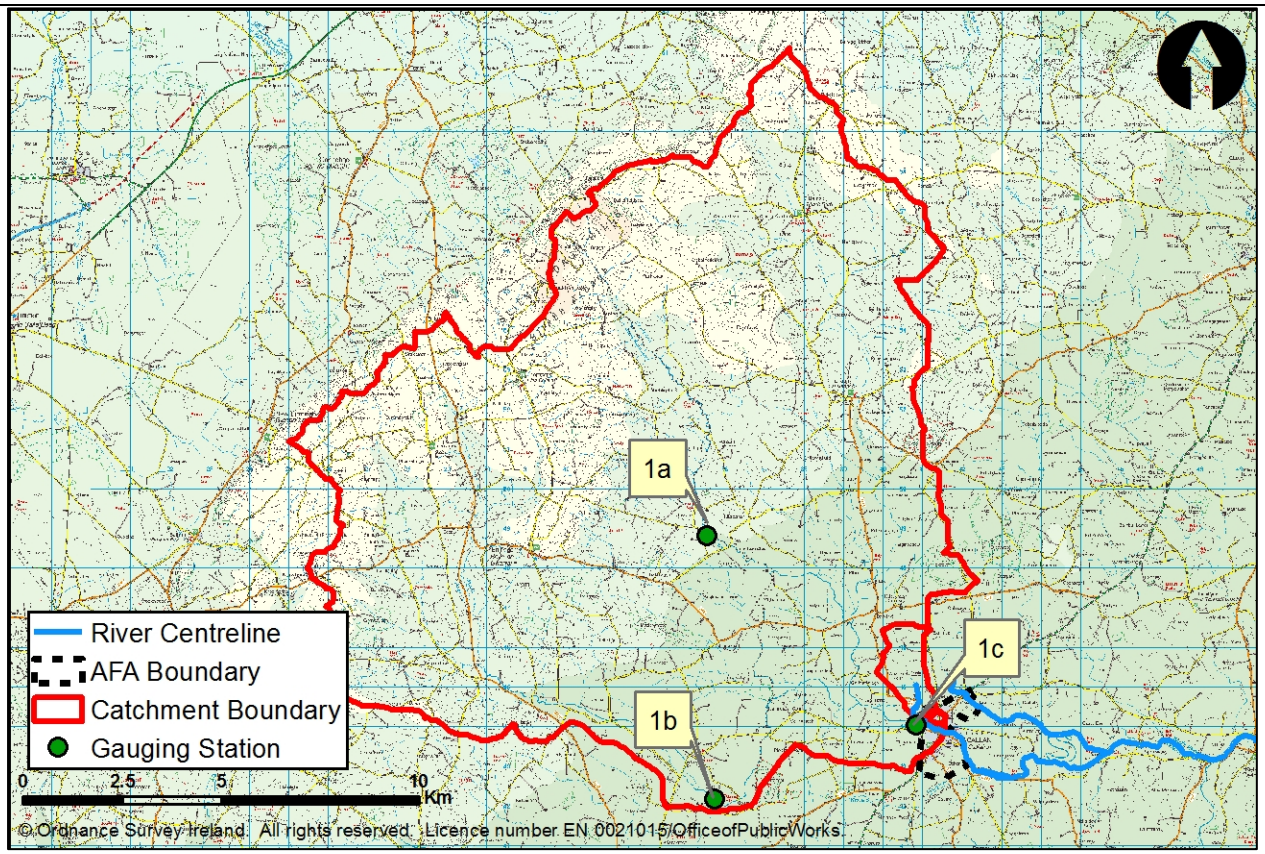


Figure 8.1.14 Location of proposed gauging stations in Callan AFA

The minimum assumed warning time to allow flood warning/forecasting to be technically feasible is 2hrs. As the available warning time the proposed gauging stations 1a/1b is 2 hours, flood warning/forecasting is considered to be technically feasible.

Freshford AFA

A review was carried out as to where river gauges could be placed in order to provide flood warning to the properties at risk of fluvial flooding in the Freshford AFA. Figure 8.1.15 shows the location of the proposed new river gauging stations. Proposed gauging stations 1a and 1b are located on the Nuenna River and Freshford North River respectively, approximately 5.0km and 6.5km upstream of the first properties at risk. Proposed gauging station 1c is located adjacent to the first properties at risk and would allow for calibration, fine tuning and validation. The Freshford hydraulic model showed that the average speed of water travel along the Nuenna and Freshford North Rivers would be 0.9m/s and 1.0m/s respectively. Thus the estimated travel time between proposed gauges 1a/1b and the properties at risk would be approximately 1 hour 30mins and 1 hour 50mins respectively. Properties are also at risk further downstream on the Nuenna River, however the additional warning time available to these properties is negligible.

Proposed gauging stations 2a and 2b are located on the Ballylarkin River and Upperwood River respectively, approximately 2.2km and 1.6km upstream of the first properties at risk. Proposed gauging station 2c is located adjacent to the first properties at risk and would allow for calibration, fine tuning and validation. The Freshford hydraulic model showed that the average speed of water travel along the Ballylarkin and Upperwood Rivers would be 0.8m/s. The estimated travel time between proposed gauges 2a/2b and the properties at risk would therefore be approximately 45mins and 30mins respectively.

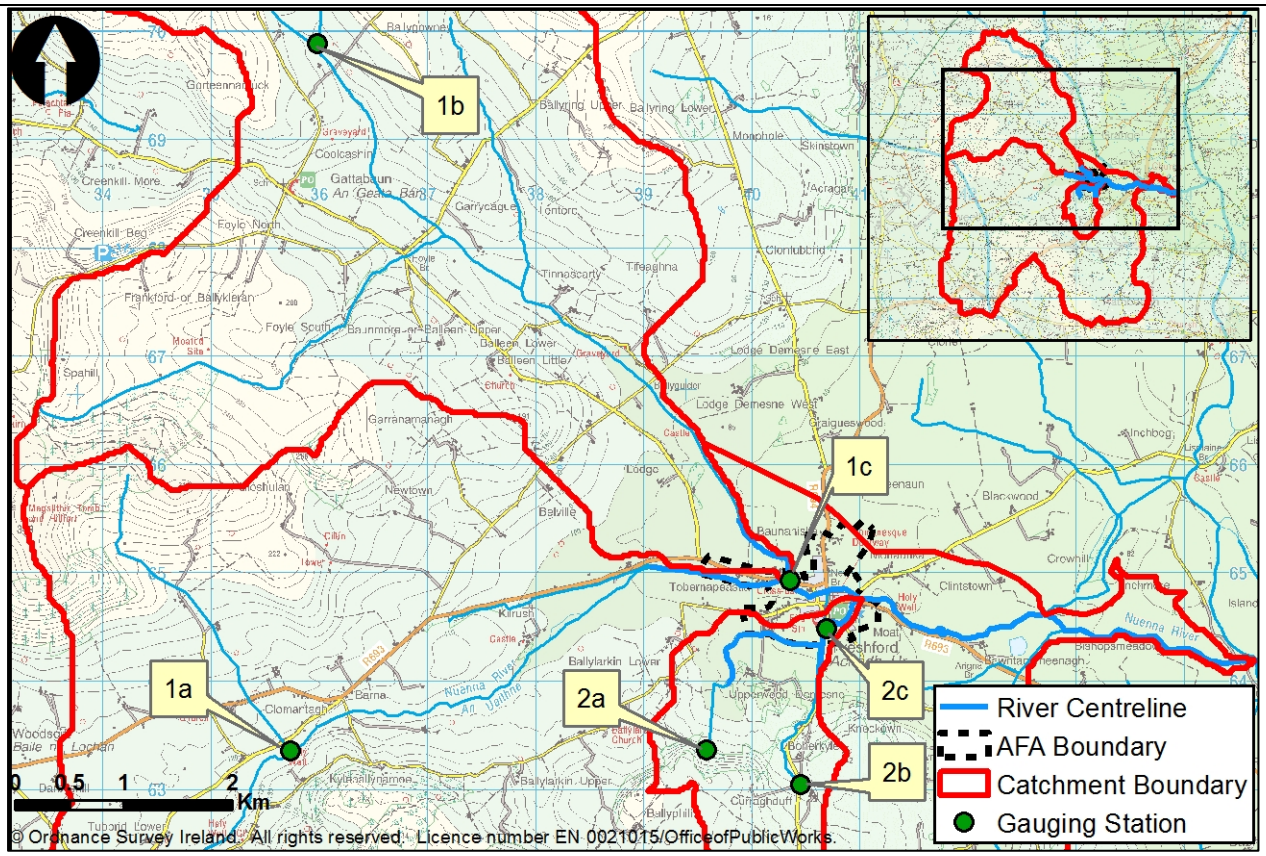


Figure 8.1.15 Location of proposed gauging stations in Freshford AFA

As the available warning time on all of the watercourses in the Freshford AFA is less than 2 hours, flood warning/forecasting is considered to be technically unfeasible.

Inistioge AFA

All properties at risk in the Inistioge AFA are subject to flooding from the River Nore. As discussed previously flood warning/forecasting on the River Nore is feasible for the Inistioge AFA, providing up to approximately 20 hours warning time.

The River Nore becomes tidally influenced downstream of Thomastown so a fluvial forecasting system for Inistioge should be combined with a tidal forecasting system. A decision on tidal forecasting will be taken at national level.

Kilkenny (Nore) AFA

The Flood Warning/Forecasting FRM method was not assessed for Kilkenny (Nore) AFA, since the present flood risk in Kilkenny (Nore) AFA is mostly managed by the recently construction Kilkenny Flood Alleviation Scheme and therefore the residual risk is considered low.

Kilkenny (Breagagh) AFA

The application of flood warning / forecasting was tested at UoM scale. No suitable location far enough upstream of the Robertshill flood cell is available to provide sufficient warning. It is estimated that a flood forecasting gauging system needs to be located approximately 44.6km upstream of the flood cell, in order to allow for a 2 hour warning time (1% AEP peak moving at 6.2m/sec). Considering that no suitable location is identified this method is not considered technically feasible.

Mountrath AFA

A review was carried out as to where river gauges could be placed on the Coles River in order to provide flood warning to the properties at risk of fluvial flooding. Figure 8.1.16 shows the proposed location of the

new river gauging stations. Proposed gauging station 1a is located approximately 700m upstream of the first at risk properties on the Coles River. Proposed gauging station 1b is located adjacent to the first properties at risk and would allow for calibration, fine tuning and validation. The Mountrath hydraulic model showed that the average speed of water travel along the Coles River would be 0.1m/s and therefore the travel time between gauge 1a and the properties at risk would be approximately 2 hours.

Proposed gauging stations 2a-2d are located on the Mountrath and Derryluck Rivers, approximately 5.0km upstream of the first properties at risk. Gauging station 15027 is located on the Mountrath River adjacent to the properties at risk. The Mountrath hydraulic model showed that the average speed of water travel along the Mountrath River would be 0.7m/s. The estimated travel time between proposed gauges 2a-2d and the properties at risk would therefore be approximately 2 hours.

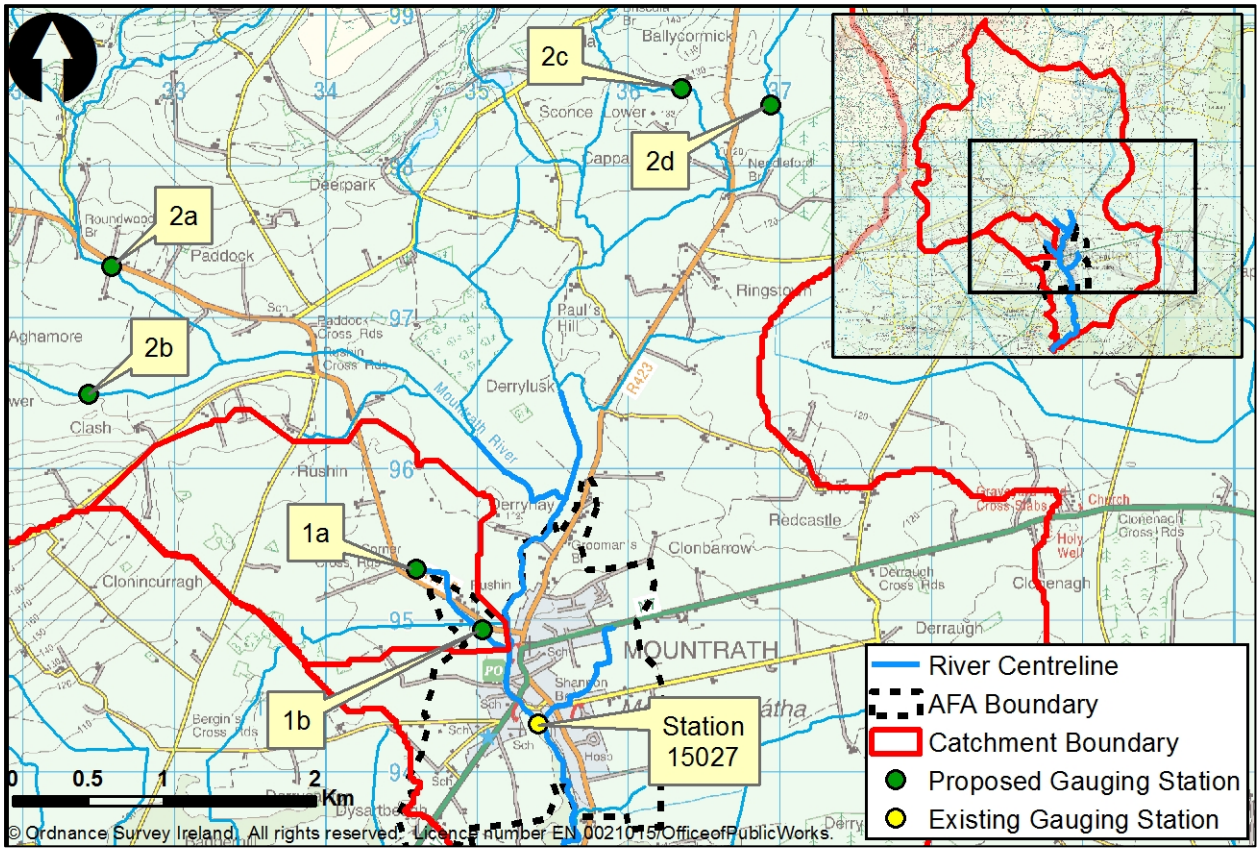


Figure 8.1.16 Location of proposed gauging stations in Mountrath AFA

As the available warning time on the Coles, Mountrath and Derryluck Rivers is 2 hours, flood warning/forecasting on these rivers is considered to be technically feasible.

Rathdowney AFA

A review was carried out as to where river gauges could be placed on the Glasha River in order to provide flood warning to the properties at risk of fluvial flooding. Figure 8.1.17 shows the proposed location of the new river gauging stations. Proposed gauging station 1a is located approximately 1.5km upstream of the first at risk properties on the Glasha River. Proposed gauging station 1b is located adjacent to the first properties at risk and would allow for calibration, fine tuning and validation. The Rathdowney hydraulic model showed that the average speed of water travel along the Glasha River would be 0.2m/s and therefore the travel time between gauge 1a and the properties at risk would be approximately 2 hours.

Proposed gauging station 2a is located on the Kilcoran watercourse, approximately 1.5km upstream of the first properties at risk. Proposed gauging station 2b is located adjacent to the first properties at risk. The Rathdowney hydraulic model showed that the average speed of water travel along the Kilcoran watercourse would be 0.2m/s. The estimated travel time between proposed gauge 2a and the properties at risk would

therefore be approximately 2 hours.

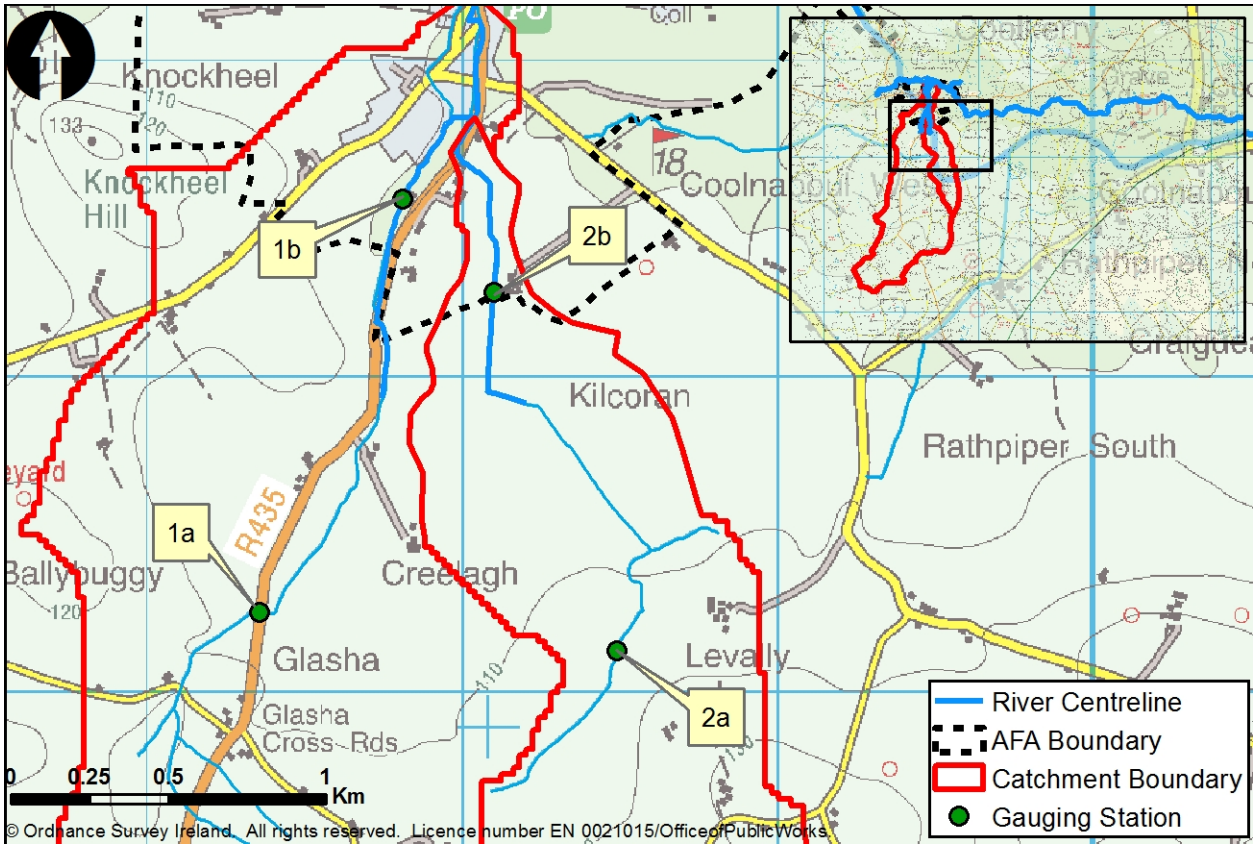


Figure 8.1.17 Location of proposed gauging stations in Rathdowney AFA

As the available warning time on both the Glasha River and Kilcoran watercourse is 2 hours, flood warning/forecasting on these rivers is considered to be technically feasible. Properties are also at risk further downstream on the Glasha River, and flood warning/forecasting is technically feasible for these properties as the warning time available will be greater than 2 hours.

Thomastown AFA

All properties at risk in the Thomastown AFA are subject to flooding from the River Nore. As discussed previously flood warning/forecasting on the River Nore is feasible for the Thomastown AFA, providing up to approximately 18 hours warning time.

Summary of Potential Warning Times

The following table summarises the potential warning times available to the AFAs where flood forecasting and warning was found applicable.

AFA	Warning time from principle river	Warning times from tributaries of the principle river
Callan AFA	2 hrs-	2 hrs
Inishtioge AFA	20hrs	<2 hrs
Mountrath AFA	2 hrs-	2hrs
Rathdowney AFA	2hrs	-

Thomastown AFA	18 hrs	-

Method	Tech	Econ	Env	Soc
Public Awareness Campaign	✓	✓	✓	✓

This measure supports flood risk management by informing resilient behaviour, in combination with other methods and is applicable throughout UoM15.

Summary

The following measures are appropriate throughout the UoM:

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

Hard defences in the form of a tidal barrier to protect coastal flood risk across multiple AFAs were assessed (reported in UoM14 SSA) and found to not be economically viable.

Flood warning/forecasting was also assessed for the River Nore watercourse as a whole and it was found to be technically feasible. Flood forecasting would provide between 4-18 hours warning time for the Thomastown AFA as well as providing warning for the Inistioge AFA. However as the Inistioge AFA would also be affected by a 0.5% AEP coastal flood event these fluvial gauges should be combined with a tidal forecasting system. A decision on tidal forecasting will be taken at national level.

A summary of the potential effectiveness of land use management for each AFA and of flood warning and forecasting systems for properties at risk in each AFA is as follows:

	Land Use Management	Flood Warning/Forecasting
Ballyhale AFA	✓	×
Ballyragget (Inc Borris) AFA	No risk	No risk
Ballyroan AFA	No risk	No risk
Callan AFA	×	✓
Freshford AFA	✓	×
Inistioge AFA	×	✓
Kilkenny (Breagagh) AFA	✓	×
Kilkenny (Nore) AFA	-	-
Mountrath AFA	✓	✓
Rathdowney AFA	×	✓
Thomastown AFA	×	✓

8. OPTIONEERING OF SSA'S

8.2 Ballyhale Optioneering of FRM Options

Name	Local Authority	Unique ID	SSA	Status	Date
Ballyhale	Kilkenny	150181	AFA	Final	13/06/2016

8.2.1 Source of flooding

Fluvial	Coastal Mechanism 1	Coastal Mechanism 2

8.2.2 Flood Cells

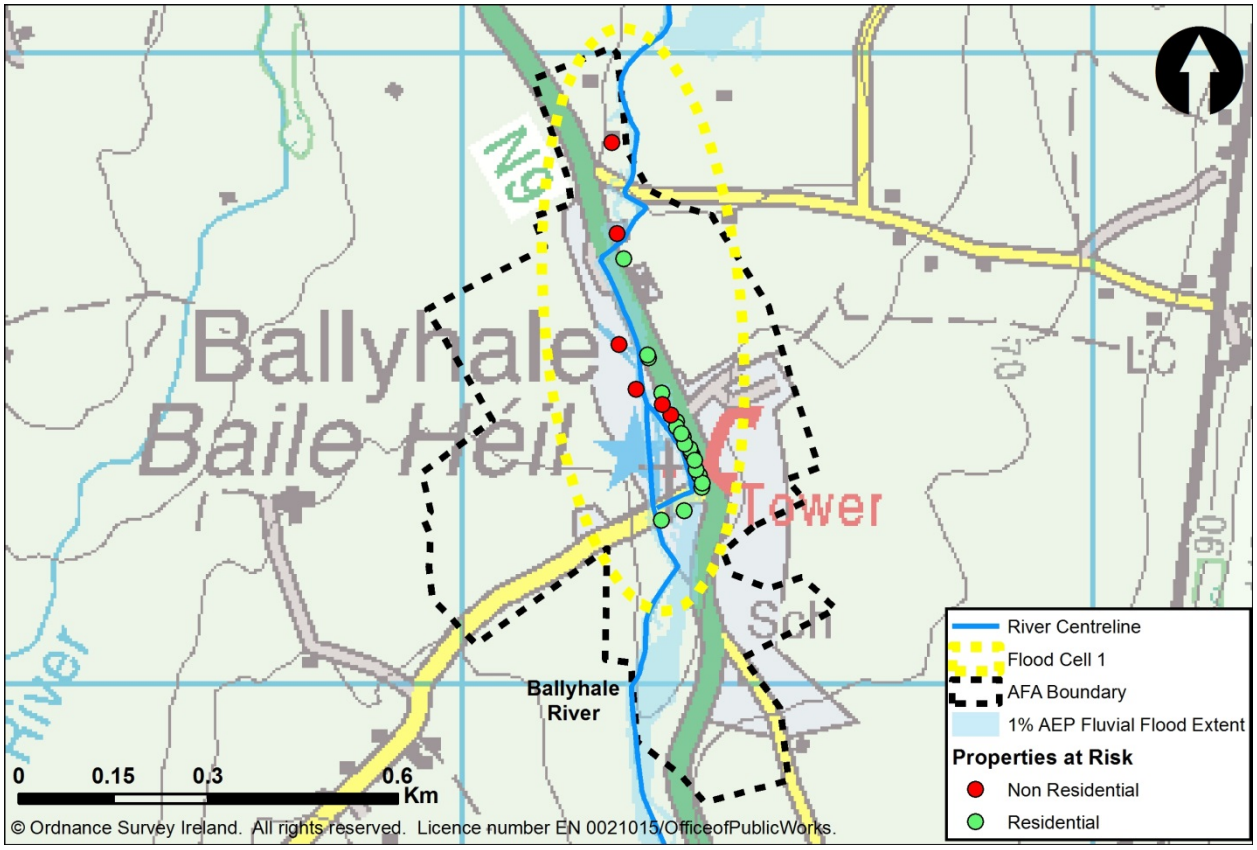


Figure 8.2.1 Ballyhale AFA Flood Cells within a 1% AEP Fluvial Flood Extent

Flood Cell 1:

During a 1%AEP fluvial flood event out of bank flooding occurs on the Ballyhale watercourse upstream of the Ballyhale AFA due to low bank levels. Flood waters subsequently flow overland into the AFA where the regional road joins the N9, south of the Ballyhale church. Flooding is also attributed to the combined impact of a series of restrictive structures (four bridges and a culvert) and low bank levels where the watercourse flows behind the terrace downstream of the church.

Out of bank flooding also occurs on the Ballyhale watercourse during a 1% AEP flood event due to insufficient culvert capacity at the culvert ID: 15BHAL00154I and the bridge ID: 5BHAL00146D causing inundation of the floodplain.

25 properties are located within this floodplain and would be affected by flooding during a 1% AEP flood event. Given that there are no flood cells located immediately downstream of this flood cell the flood risk in flood cell 1 is considered local.

Summary of Flood Cells:

As shown in Figure 8.2.1 the main flood risk originates from the Ballyhale watercourse as water levels during 1%AEP fluvial event exceed the top of bank levels due to insufficient channel and culvert capacity. As there is one flood mechanism to consider and one flood cell it is therefore appropriate to screen flood cell 1 as a discrete area. (Section 8.2.6)

On completion of the optioneering screening assessment all FRM methods considered will be combined to form complete options for the Ballyhale AFA as detailed in Section 8.2.7.

8.2.3 Existing Regime

The existing regime considers all activities currently carried out which impact on the management of flood risk. The level and frequency of maintenance is considered, along with inspection, and any other specific activity (for example the operation of locks, barrages, sluice gates and valves).

The Ballyhale watercourses are not located within a Drainage District or an Arterial Drainage scheme and for the most part are in private lands and are not the responsibility of Kilkenny County Council. As the degree of flood risk stays as present, with some properties frequently flooded, the existing regime does not provide the preferred standard of protection.

8.2.4 Summary of Flood Risk within SSA boundary

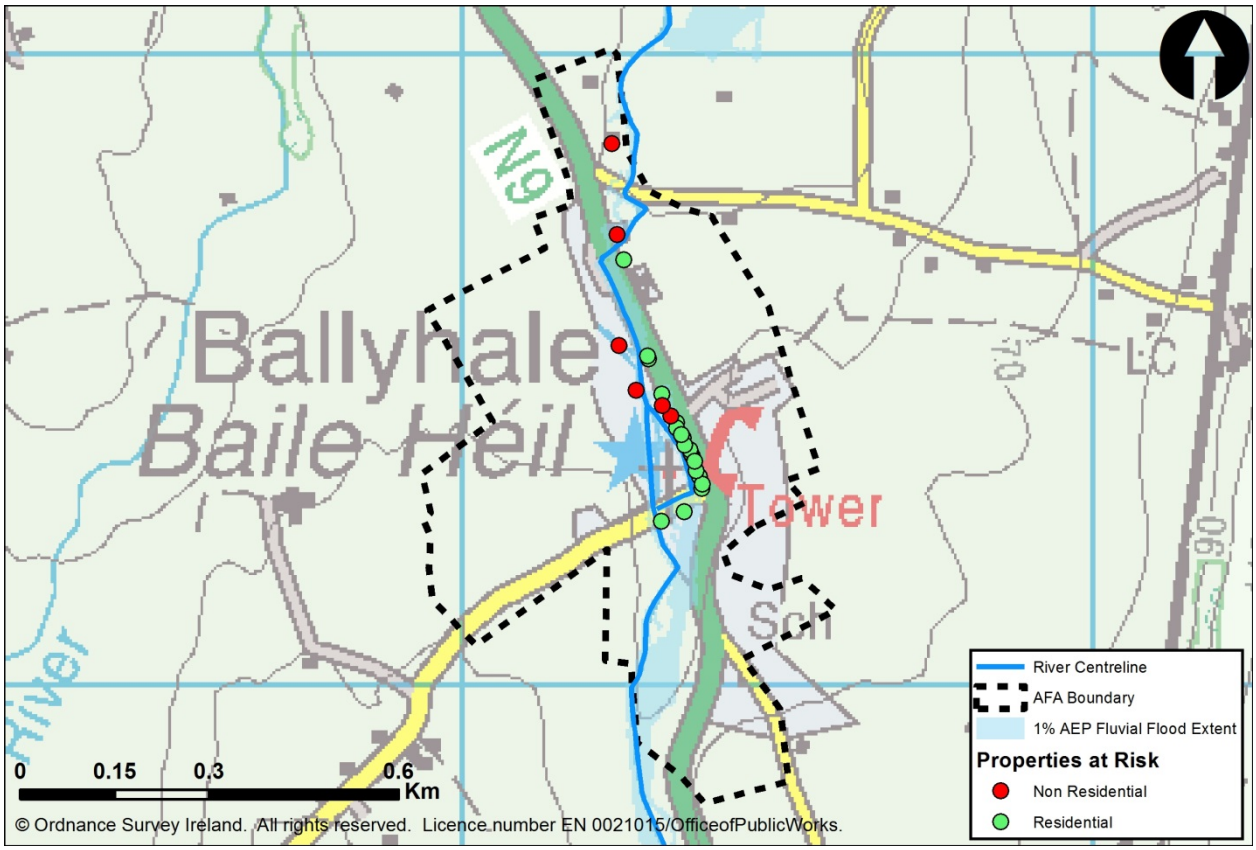


Figure 8.2.2 Flood risk in Ballyhale AFA within a 1% AEP Fluvial Flood Extent

In Ballyhale AFA the onset of residential and non-residential property damage occurs in the 50% AEP event.

8.2.5 Monetary Damage and Benefit

	Flood Cell 1	Total in AFA
Annual Average Damage (AAD)	€ 578,088	€ 578,088
Present Value Damage (pvD)	€ 12,418,483	€ 12,418,483
Standard of Protection (SoP)	1% AEP	1% AEP
Number of Properties Benefiting from Design SoP	25	25
Minimum Present Value Benefit	€ 11,643,455	€ 11,643,455
Capped Minimum Present Value Benefit	€ 4,116,936	€ 4,116,936

*The sum of the flood cell AAD or pvD values may not equate to the values presented for the Total in SSA due to flooding greater than the 1% AEP occurring outside the flood cell extents.

8.2.6 Short Listing FRM Methods – Local Cell

Method	Review Comment	Continue Screening
		Flood Cell 1
Do Nothing	Consider Further	✓
Additional Maintenance	Consider Further	✓
Do Minimum	Consider Further	✓
Planning and Development Control	Consider at UoM SSA - Reject	×
Building Regulations	Consider at UoM SSA - Reject	×
Catchment Wide SuDs	Consider at UoM SSA - Reject	×
Land Use Management	Consider Further	✓
Strategic Development Management	Consider at UoM SSA - Reject	×
Storage	Consider Further	✓
Improvement of Channel Conveyance	Consider Further	✓
Hard Defences	Consider Further	✓
Relocation of Properties	Consider Further	✓
Diversion of Flow	Consider Further	✓
Flood Warning/Forecasting	Consider Further	✓
Public Awareness Campaign	Consider at UoM SSA - Reject	×
Individual Property Protection	Consider Further	✓
Other Works	Consider Further	✓

8.2.6.1 Feasibility Review Summary for Local Cell (flood cell 1)

Method	Technical Screening	Economic Screening	Environmental and Cultural Heritage Screening	Social Screening
Do nothing	×			
Addtional Maintenance	×			
Do Minimum	×			
Land Use Management	✓	-	✓	✓
Storage	✓	✓	!	✓
Improvement of Channel Conveyance	×			
Hard Defences	✓	✓	!	✓
Relocation of properties	✓	×		
Diversion of Flow (combined)	✓	✓	!	✓
Flood Warning/Forecasting	×			
Individual Property Protection	×			
Other Works	×			

× - Reject ✓ - Progress ? - Progress, potential for impacts identified ! - Progress, potential for significant impacts identified

8.2.6.2 Justification for Rejection/Retention

Method	Tech	Econ	Env	Soc
Do nothing	×			

The do nothing FRM method would involve stopping the current maintenance regime. This is an unacceptable outcome in terms of contributing to design SoP and therefore was rejected from the screening process.

Method	Tech	Econ	Env	Soc
Additional Maintenance	×			

This method considers whether improvements can be made to augment the existing maintenance regime which will provide a significant beneficial impact on flood risk in the AFA.

The review of flood risk within flood cell 1, has identified that out of bank flooding occurs on the Ballyhale watercourse due to insufficient channel and culvert capacity. Therefore it is expected that implementing

any additional maintenance on this watercourse would have minimal impact on the overall flood risk.

Increasing maintenance activities on the relevant watercourses will not significantly contribute to achieving the preferred SoP and therefore will not be pursued under the CFRAM Study.

Method	Tech	Econ	Env	Soc
Do Minimum	✗			

This method is appropriate where an isolated/single issue exists which can be easily addressed in order to reduce the flood risk, for example the removal of a pinch point/obstruction, or the upgrade of a blockage prone culvert screen, etc. These activities would be considered relatively straightforward, discrete and low cost. The design SoP must be achieved for this method to progress.

Within flood cell 1 the Do Minimum method would involve clearing the channel of the Ballyhale watercourse. Addressing the issue however would have minimal impact on the overall flood risk as it would not provide the additional conveyance needed within the channel. This is an unacceptable outcome in terms of contributing to achieving the design standard of flood protection and therefore was rejected from the screening process.

Method	Tech	Econ	Env	Soc
Land Use Management	✓	-	✓	✓

The application of land use management measures was tested at UoM scale. Flood cell 1 is located within a catchment which is considered suitable as a pilot area and should progress in the optioneering process should no other method providing the full SoP be found suitable.

Method	Tech	Econ	Env	Soc
Storage	✓	✓	!	✓

This method considers areas where flood water can be stored and then released at a controlled rate therefore reducing the flow rate through the AFA and reducing the level of flood risk. This can be achieved by using existing depressions to create online or offline storage areas or by identifying pinch points which could be dammed such as a restricted point along a valley. Storage areas can be effective either upstream of the risk areas or within the risk area where parks or open areas are located.

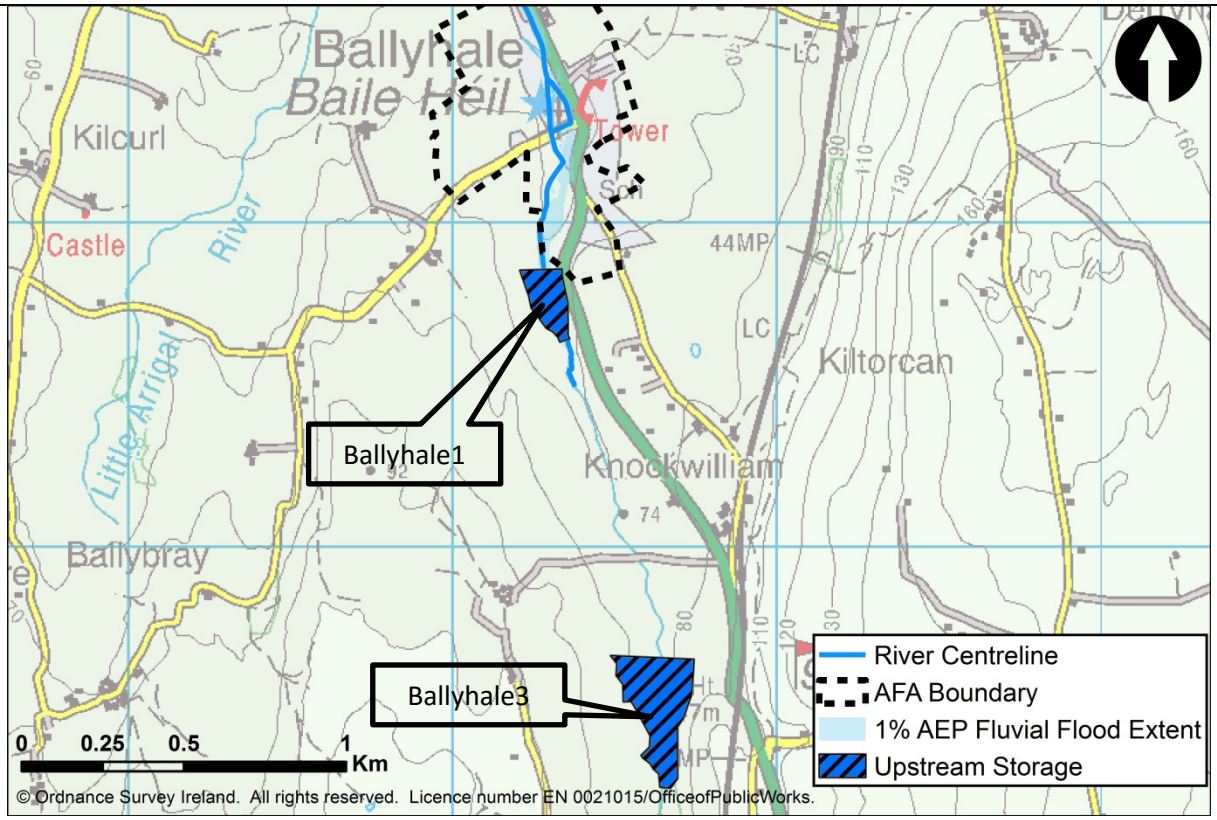


Figure 8.2.3 Location of Storage

A review of the surrounding land was carried out and two areas upstream of the Ballyhale AFA were identified that together could provide up to 87,671m^3 of storage (see Figure 8.2.3). This volume would be sufficient to reduce the 1%AEP fluvial flood levels in flood cell 1 to the equivalent of the 50%AEP fluvial event therefore storage can only provide partial protection for a 1%AEP fluvial event as the 50% AEP water levels downstream of Ballyhale storage area 1 overtop the right hand bank impacting a number of properties within the AFA. An economic review was carried out and estimated that the total cost of storing this amount of water, including an embankment, culvert and overtopping weir, is approximately €1.4m. Therefore this method is economically viable.

The River Barrow and River Nore SAC and the River Nore SPA are within and downstream of Ballyhale. The Thomastown Quarry SAC is over 7km north east of Ballyhale, but it is not hydraulically linked to the AFA. Hugginstown Fen SAC is over 3km upcatchment of the AFA to the south.

The Storage method in Ballyhale would aim not to cause hydrological alterations that might impact these nearby environmentally sensitive sites. Therefore this method was put forward for consideration in the optioneering process.

Method	Tech	Econ	Env	Soc
Improvement of Channel Conveyance	x			

This method focuses on increasing watercourse conveyance thereby lowering water levels and reducing the associated flood risk. This can be achieved by lowering bed level, widening/reshaping channels, removing channel/structure constrictions, culverting reaches of watercourse and reducing roughness of the channel. While some of these activities can also form part of the 'Do Minimum' method, Improvement of Channel Conveyance differs in that it holistically addresses all risk areas while the other two methods consider one or more discrete activities.

In flood cell 1 there are several structures on the Ballyhale watercourse that restrict flow during a 1%AEP fluvial event contributing to out of bank flooding in the Ballyhale AFA. These structures located close to Ballyhale church adjacent to the N9 road, have been identified as the bridge ID: 15BCUH00009D, 15BCUH00008D, bridge ID: 15BCUH00007D, bridge ID: 15BCUH00005D and culvert ID: 15BCUH00002.

Downstream on the Ballyhale watercourse there are another two structures which have also been identified as having insufficient capacity during a 1%AEP fluvial event. The first is the culvert ID: 15BHAL000154I and to a lesser extent the bridge 15BHAL00239E. The culvert (ID: 15BHAL000154I) is 48.5m in length and runs below a building.

The watercourse that flows around Ballyhale church is a heavily modified channel with both property boundaries and buildings forming the banks of the channel. Therefore any improvement in channel capacity would be restricted to lowering the bed level. Improving the conveyance of the channel through excavation or upgrading of the critical structures adjacent to the church area would increase the water levels downstream. Given that the culvert 15BHAL000154I downstream already experiences insufficient capacity during a 1%AEP fluvial event and that this culvert runs beneath a building it would be unfeasible to carry out the necessary works to consider Improvement of Channel Conveyance in the optioneering process. Therefore this method was rejected form the screening process.

Method	Tech	Econ	Env	Soc
Hard Defences	✓	✓	!	✓

The term Hard Defences refers to physical barriers which prevent water from entering an area such as flood walls, embankments and barrages. As a general rule Hard Defences are kept as far back from the river channel or coast line as possible allowing the floodplain function to remain active. Where this is not possible, due to flood risk receptors being located within the floodplain, Hard Defences are placed around the property boundary to afford it protection. Where space allows flood embankments are used but where space is restricted flood walls are utilised.

A review was carried out to ascertain where Hard Defences would be required to protect existing property within flood cell 1. Figure 8.2.4 shows the location of the Hard Defences required to protect properties during the 1% AEP event.

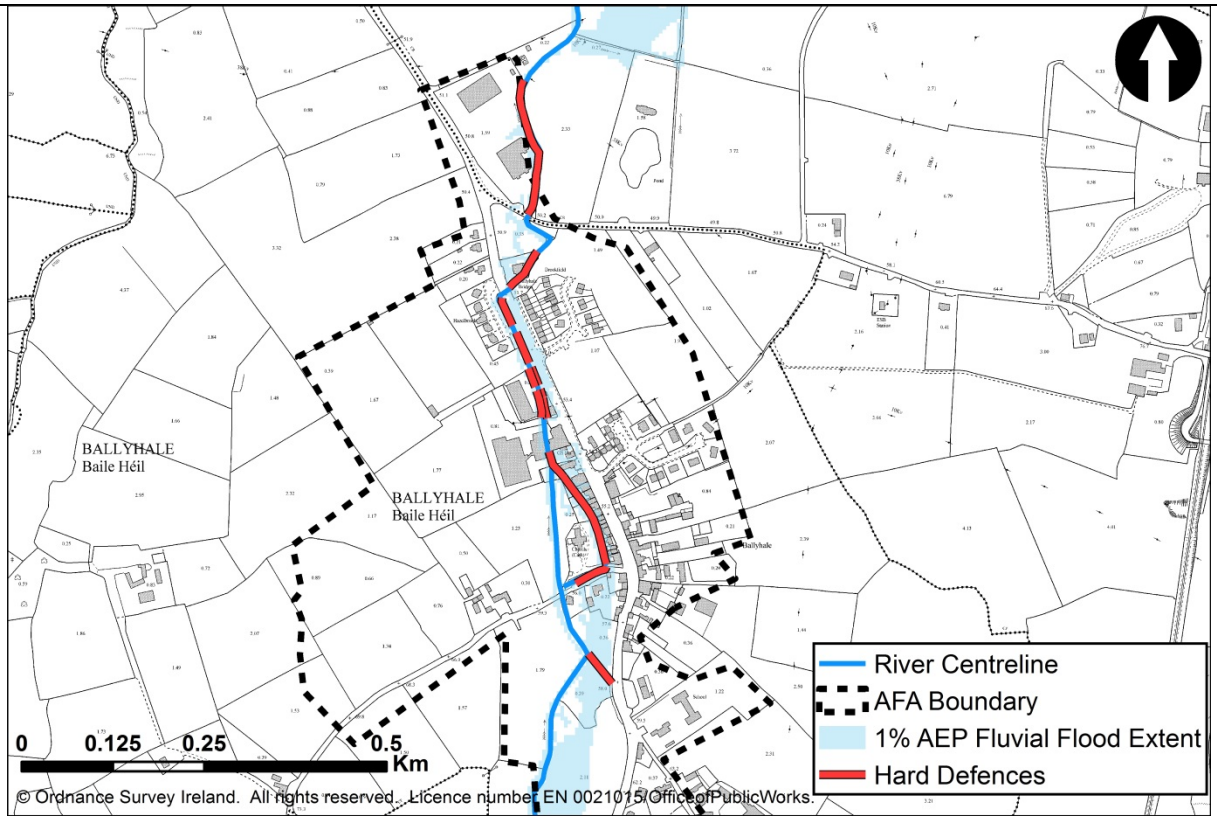


Figure 8.2.4 Location of Hard Defences in flood cell 1

In order to ascertain the effectiveness of Hard Defences a hydraulic model was constructed to simulate the method. The model showed that hard defences would protect to the 1% AEP flood event with an average height of 0.97m and a total length of 752m. An economic review estimated the cost of the hard defences to be approximately €1.7m making this method economically viable.

The River Barrow and River Nore SAC and the River Nore SPA are within and downstream of Ballyhale. The Thomastown Quarry SAC is over 7km north east of Ballyhale, but is not hydraulically linked to the AFA. Hugginstown Fen SAC is over 3km upcatchment of the AFA to the south.

The Hard Defences method in Ballyhale would aim not to cause hydrological alterations that might impact these nearby environmentally sensitive sites. Therefore this method was put forward for consideration in the optioneering process.

Method	Tech	Econ	Env	Soc
Relocation of properties	✓	×		

To relocate a property is to abandon the existing at risk property and provide an alternative in a location not at risk. While this method is, in theory, possible, it is not practical for a whole town of many at risk properties. Its use is more applicable for discrete areas where single properties or clusters of properties are located.

There are 25 properties at risk during a 1% AEP fluvial event within flood cell 1. An economic review estimated the cost of relocating these properties as €14.3m. This method was therefore considered economically unviable and was therefore rejected from the screening process

Method	Tech	Econ	Env	Soc
Diversion of Flow	✓	✓	!	✓

This method involves directing some of the floodwater via a new route thereby reducing flow and associated flood risk along the original route. This would be carried out upstream of where floodwaters reach the area of at risk properties. The new flow route would normally consist of a constructed open channel and/or culvert system or an existing linear feature able to convey the flow to a designated discharge point.

A review was carried to identify locations where a Flow Diversion route could be constructed in the vicinity of flood cell 1. One location was identified where flow could be diverted from the Ballyhale watercourse immediately downstream of the bridge (ID: 15BHAL001754D) to the Little Arrigal River, of which the Ballyhale watercourse is already a tributary, thereby bypassing Ballyhale town as shown in Figure 8.2.5.

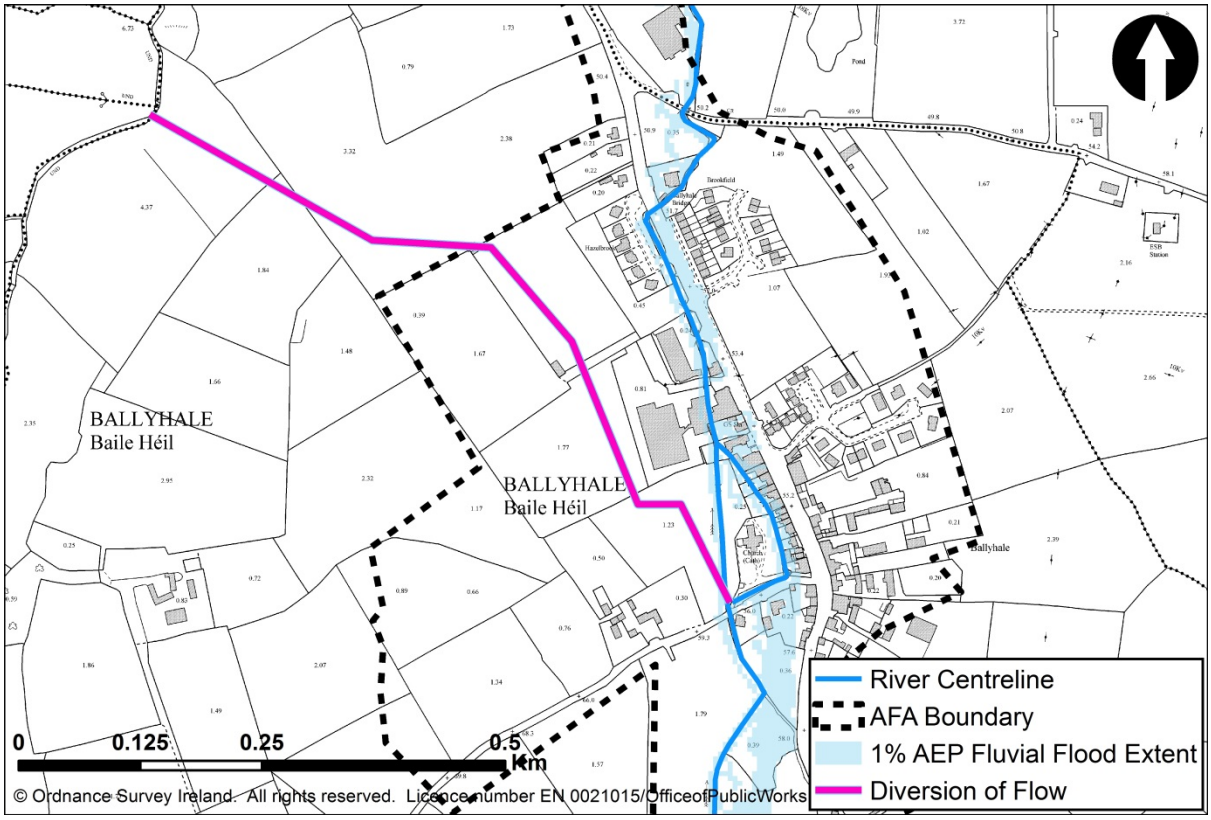


Figure 8.2.5 Location of Flow Diversion for flood cell 1

A hydraulic assessment was carried out to estimate the flow the diversion channel would need to convey to provide the required SoP in flood cell 1. A diversion flow of $5m^3/s$, reducing the flow along the existing Ballyhale watercourse to the baseflow, $0.4m^3/s$, would provide protection to all affected properties in flood cell 1 during the 1%AEP flood event. This would require 850m of channel circa 6m wide and 1m deep.

The proposed discharge location into the Little Arrigal River is not within the extent of the modelled watercourse. However this location is approximately 1.5km upstream of the existing discharge location of the Ballyhale watercourse. The channel capacity of the Little Arrigal River and the two existing bridges on the N9 and the N10 between the proposed discharge point and the existing confluence of the watercourses would also have to be assessed to ensure that no receptors are affected.

There is no other infrastructure to consider along the indicated diversion route, however the final routing in the area of the GAA pitch should be subject to consultation at detailed design stage. The level of the proposed discharge location is approximately 48.01m OD Malin and is lower than the bed level at the

beginning of the proposed channel which was surveyed at 55.72m OD Malin. Therefore this FRM method is technically feasible. However deeper excavation may be required in some areas where the topography rises rather than falls. A control structure would also have to be constructed at the bridge (ID: 15BHAL001754D) to regulate the flow between the proposed diversion channel and the existing Ballyhale watercourse.

An economic review estimated the flow diversion to be approximately €0.3m making this method economically viable.

The River Barrow and River Nore SAC and the River Nore SPA are within and downstream of Ballyhale. The Thomastown Quarry SAC is over 7km north east of Ballyhale, but is not hydraulically linked to the AFA. Hugginstown Fen SAC is over 3km upcatchment of the AFA to the south.

The Diversion of Flow method in Ballyhale would aim not to cause hydrological alterations that might impact these nearby environmentally sensitive sites. Therefore this method was taken forward for consideration in the optioneering process.

Method	Tech	Econ	Env	Soc
Flood Warning/Forecasting	✗			

The application of flood warning / forecasting was tested at UoM scale. There is no suitable location far enough upstream to place a gauge which would provide sufficient warning for flood cell 1. This method is technically unfeasible and therefore rejected.

Method	Tech	Econ	Env	Soc
Individual Property Protection	✗			

This method is aimed at individual properties that are remote from the main risk areas. Where the AFA being considered consists of a small number of remote properties this method is a feasible solution. But for AFAs with multiple properties at risk this method would only be considered an add on to a primary method. Individual property protection could consist of flood gates and vent seals on the building structure itself. Where flood depths are over 0.6m this method becomes unfeasible and flood resilience techniques would be recommended over flood gates. As this method is temporary and relies of human intervention there is an element of uncertainty as to whether the full SoP will be met for every flood event. As such it is assumed that 20% of the flood damage will be avoided.

The modelled flood depths for 10 of the 25 properties at risk in a 1% AEP fluvial event are above 0.6m therefore this method is not technically feasible for flood cell 1. This method was consequently removed from the screening process

Method	Tech	Econ	Env	Soc
Other Works	✗			

No other works were identified for these flood cells

8.2.6.3 Summary of Feasibility Review – Flood Cell 1

The following FRM methods have been carried forward to address the flood risk arising from flood cell 1;

- Storage
- Hard Defences
- Diversion of Flow

The Ballyhale 1 and Ballyhale 2 storage areas would not provide the full SoP for a 1%AEP fluvial event however it would provide partial protection during the 1%AEP fluvial event. Thus storage would have to be considered in combination with a reduced amount of Hard Defences to manage the overland flow into the AFA (Section 8.2.2) and to provide the full SoP within flood cell 1.

The Diversion of Flow method would also not provide the full SoP for a 1%AEP fluvial event however it would provide partial protection during the 1%AEP fluvial event. Consequently diversion of flow would have to be considered with a reduced amount of Hard Defences to manage the overland flow into the AFA (Section 8.2.2) and to provide the full SoP within flood cell 1 for a 1%AEP fluvial event.

Hard Defences can provide the full protection to all properties during the 1% AEP flood event. As mentioned above Storage and the Diversion of Flow can only provide partial protection to the properties at risk in flood cell 1. Storage and Diversion of flow therefore have to be used in conjunction with Hard Defences to form a complete option.

8.2.7 Selection of Options

Method	Option 1	Option 2	Option 3	Option 4	Option 5
Storage	✓				
Hard Defences	✓	✓	✓		
Diversion of Flow			✓		

Storage can only provide partial protection during a 1%AEP fluvial event. This method would need to be combined with Hard Defences to provide the full SoP for the Ballyhale AFA.

For flood cell 1 Hard Defences can provide the full SoP to the properties at risk from a 1%AEP fluvial event.

Diversion of Flow can only provide partial protection during a 1%AEP fluvial event . This method would need to be combined with Hard Defences to provide the full SoP for the Ballyhale AFA.

8.2.7.1 Option 1 details – Storage and Hard Defences

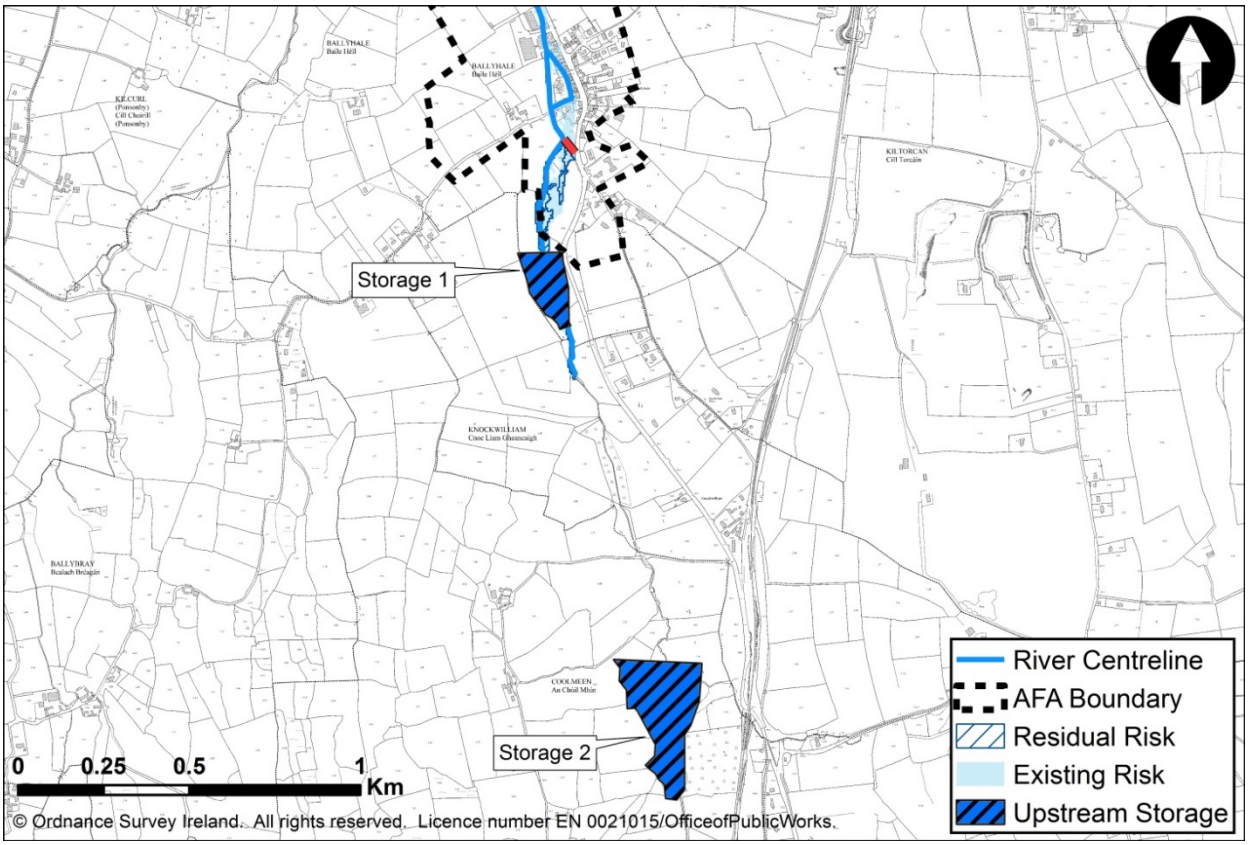


Figure 8.2.6 Ballyhale AFA Option 1

At risk properties would be protected by two storage areas, Ballyhale 1 and Ballyhale 3, which would store up to 87,671m^3 and a series of flood embankments and walls. These hard defences would protect to the 1% AEP flood event with an average height of 1m and a total length of 290m.

Figure 8.2.6 presents the effect of the potential option on the design flood event by overlaying the present day flood extent (labelled existing risk) with the flood extent that would occur after the option is put in place (labelled residual risk).

In addition to these methods the following was also identified at UoM level (see section 8.1) to be included in any potential option identified:

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

Option Item	Quantity	Construction Cost
Storage Embankments	Ballyhale 1: 135m length, 3m high Ballyhale 3: 257m length, 3m high	€ 211,288
Storage Culvert	17m length, diameter 0.825m	€ 289,964
Storage Weir	6.55m length, 2m height	€ 27,465
Hard Defences Embankment	52m length, 0.95m high	€ 6,694
Total MCA-Benefit Score	**Option Cost (€millions)**	**MCA-Benefit Score / Cost Ratio**
1481	1.48	998.34

Economic Appraisal (Cost-Benefit Analysis) Outcomes			
Area NPVd (uncapped)	**Option Cost**	**Option NPVb (capped)**	**Benefit - Cost Ratio**
€ 12,418,485	€ 1,483,045	€ 4,116,935	2.78

8.2.7.2 Option 2 details - Hard Defences

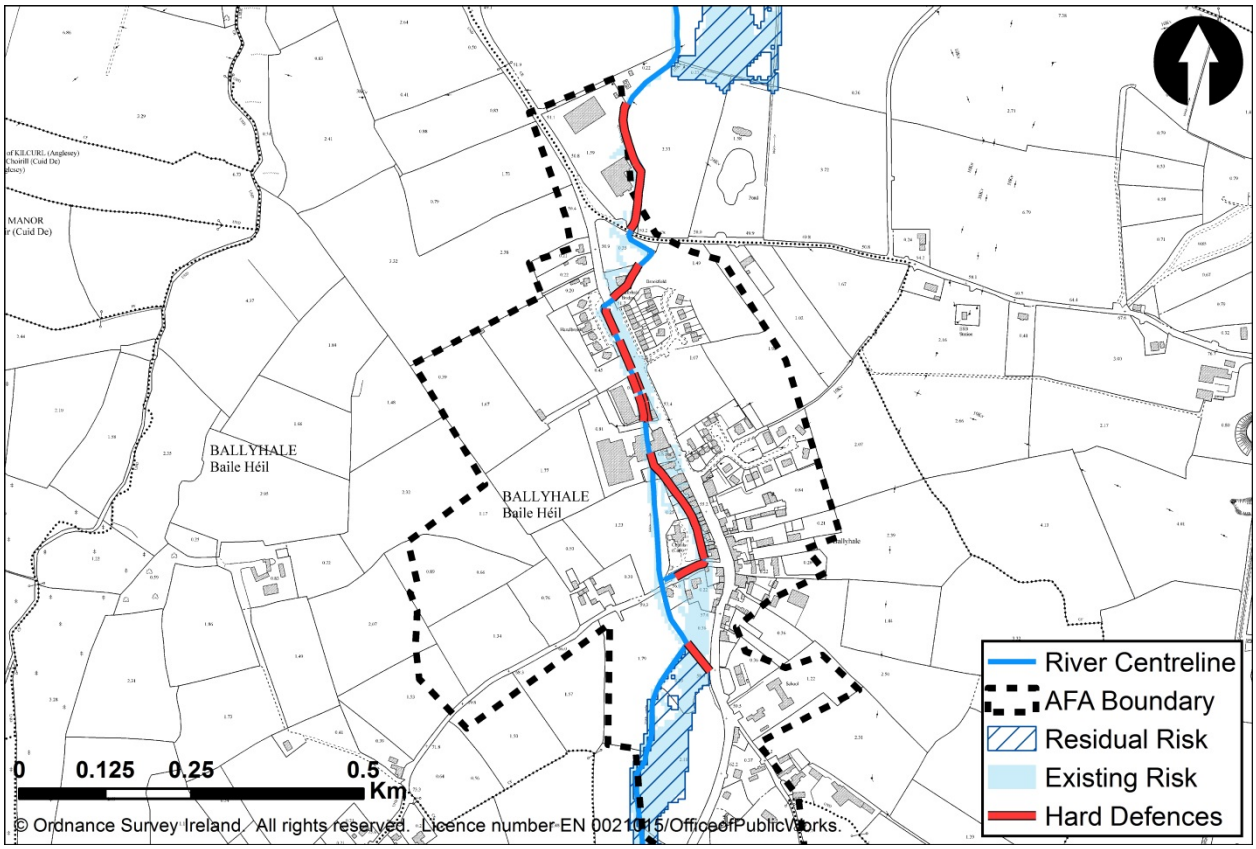


Figure 8.2.7 Ballyhale AFA Option 2

At risk properties in flood cell 1 would be protected by a series of walls and embankments. These hard defences would be set back from the river channel where possible as shown in Figure 8.2.7 These hard defences would protect to the 1%AEP fluvial event with an average height of 0.97m and a total length of 752m.

Figure 8.2.7 presents the effect of the potential option on the design flood event by overlaying the present day flood extent (labelled existing risk) with the flood extent that would occur after the option is put in place (labelled residual risk).

In addition to these methods the following was also identified at UoM level (see section 8.1) to be included in any potential option identified:

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

Option Item	Quantity		Construction Cost
Wall	508m length, 0.97m high		€ 670,191
Embankments	244.4m length, 0.83m high		€ 39,082
Total MCA-Benefit Score	**Option Cost (€millions)**		**MCA-Benefit Score / Cost Ratio**
1575	1.71		919.69
Economic Appraisal (Cost-Benefit Analysis) Outcomes			
Area NPVd (uncapped)	**Option Cost**	**Option NPVb (capped)**	**Benefit - Cost Ratio**
€ 12,418,485	€ 1,712,078	€ 4,116,935	2.40

8.2.7.3 Option 3 details - Diversion of Flow and Hard Defences

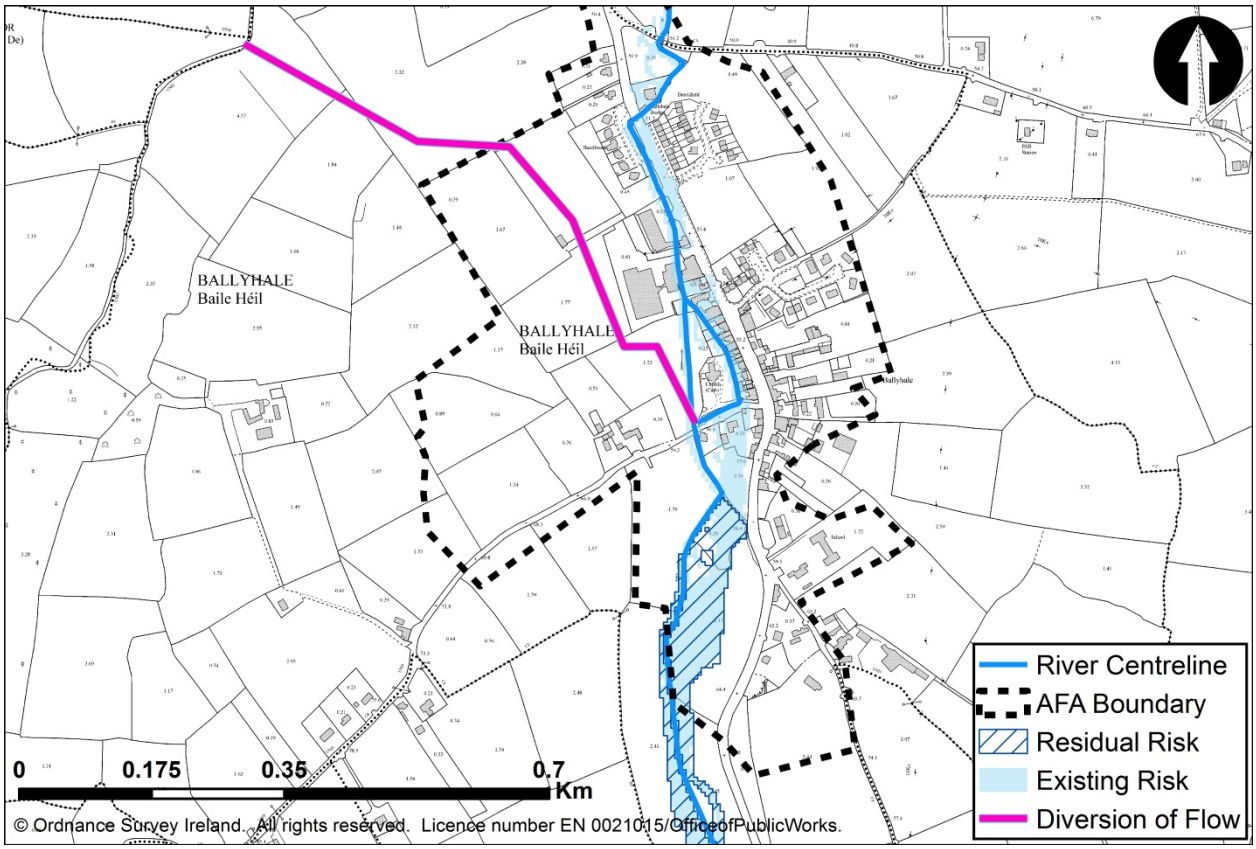


Figure 8.2.8 Ballyhale AFA Option 3

At risk properties would be protected by an embankment and a flow diversion channel from the Ballyhale watercourse to the Little Arrigal River. These defences would protect to the 1% AEP flood event with an average embankment height of 0.9m and a total length of 53m. The flow diversion is located immediately downstream of the bridge (ID: 15BHAL001754D) where a weir structure would also be required to regulate the flow between the proposed channel and the existing channel. The result is a reduced flow along the Ballyhale watercourse therefore significantly reducing the number hard defences required.

Figure 8.2.8 presents the effect of the potential option on the design flood event by overlaying the present day flood extent (labelled existing risk) with the flood extent that would occur after the option is put in place (labelled residual risk).

In addition to these methods the following was also identified at UoM level (see section 8.1) to be included in any potential option identified:

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

Option Item	Quantity		Construction Cost
Excavation on Land	3,764m^3		€ 63,988
Weir	Control structure, 12m wide weir		€ 68,053
Hard Defences Embankment	52m length, 0.95m high		€ 6,694
Total MCA-Benefit Score	**Option Cost (€millions)**		**MCA-Benefit Score / Cost Ratio**
1415	0.43		3260.78
Economic Appraisal (Cost-Benefit Analysis) Outcomes			
Area NPVd (uncapped)	**Option Cost**	**Option NPVb (capped)**	**Benefit - Cost Ratio**
€ 12,418,485	€ 433,818	€ 4,116,935	9.49

8.2.7.4 AFA Sensitivity to Future Change

During a MRFS 1% AEP flood event the increase in flood extent is minimal due to the topography of the valley which the Ballyhale watercourse flows through. This would result in an additional 3 properties being at risk bringing the property count from 25 in the present day 1% AEP fluvial event to 28. The AAD would increase from €578,088 to €812,095. As a result the Ballyhale AFA would be considered to be at moderate vulnerability from the MRFS.

During a HEFS 1% AEP flood event the increase in flood extent is minimal due to the topography of the valley which the Ballyhale watercourse flows through. This would result in an additional 5 properties being at risk bringing the property count from 25 in the present day 1% AEP fluvial event to 30. The AAD would increase from €578,088 to €1,575,748. As a result the Ballyhale AFA would be considered to be at moderate vulnerability from the HEFS.

The main area of additional flood risk is a larger width of the present day 1%AEP fluvial event extent which spans the length of the Ballyhale AFA as shown in Figure 8.2.9

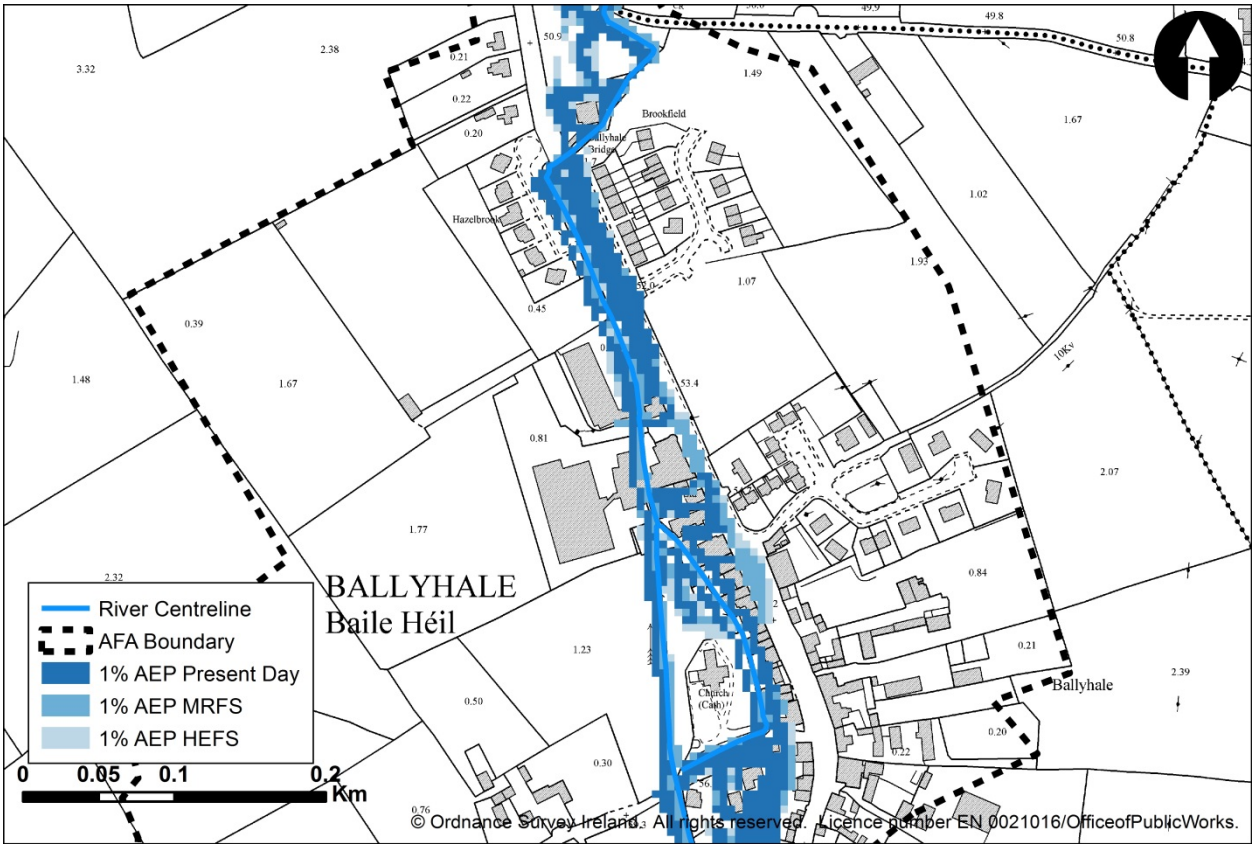


Figure 8.2.9 Ballyhale Future Change Fluvial Flood Extents

8.2.7.5 Future Change Adaptability

The following discusses the adaptability of the potential FRM methods proposed in Ballyhale AFA:

Storage Flood Cell 1 - This method could be adapted by making use of a third storage area that was not previously required to address the present day flood risk from a 1% AEP fluvial event. This storage area, Ballyhale 2, would provide an additional 52,602m^3. For the Ballyhale storage area to address future potential flood risk the volume required would need to be increased from 83.083m^3 to 99,700m^3 or 108,083m^3, for the MRFS or HEFS respectively which would raise concerns over the residual risk and social impact. There is also an access road adjacent that would need to be considered in detailed design. Due to significant costs involved in constructing a third storage area and the other negative visual and social impacts within an environmentally sensitive area is considered to have **moderate to poor** adaptability.

Hard Defences Flood Cell 1 - This method could be adapted by increasing the height of the walls. The length of the wall would not need to be adjusted. A review of the effect of the MRFS and the HEFS showed that the existing and proposed walls would require an increase of approximately 0.07m and 0.11m under the MRFS and HEFS respectively. This additional height could be accommodated. To ensure that this wall would be adaptable the design would need to account for the potential increase in height. This method is considered to be **readily adaptable**.

Diversion of Flow Flood Cell 1 – This method would not need to be adapted. The dimensions of the proposed diversion channel were based on the dimensions of the current diversion channel. The route was altered so as to divert the flow away from Ballyhale village. The dimensions of the proposed channel is designed to convey a flow of 7.8m3/s. This exceeds the peak HEFS discharge, therefore this is method is inherently or **readily adaptable**.

The potential **options** identified have been further assessed using 5 criteria in an attempt to identify low – or no regret combinations of measures.

1. **Does the option reduce vulnerability?** In addition to the methods above other methods aimed at reducing future flood risk have been discussed in section 8.1 at UoM scale and are detailed in each potential option. These methods, such as building regulations and planning & development control will reduce the impact to potential future receptors. Given that Ballyhale has a moderate area of open space some of these methods including a strategic development plan would be highly effective. there would be limited scope for some of these methods to impact on the area being assessed. Since there is a relatively small increase in the number of properties affected in the MRFS and HEFS there is a need to ensure that future receptors at risk are prepared through methods such as public awareness campaign
2. **Does the option make space for water?** Options which provide additional space for water or does not restrict it are more likely to perform well in future scenarios. Options which include hard defences restrict the water making water levels more sensitive to increased flow. Option 1 and 2 would create this situation. Option 3 would make space for water.
3. **Does the option deliver co-benefits?** No co-benefits were identified.
4. **Does the option provide flexibility?** A review of the potential options show that overall for the option proposed, Options 2 and 3, have good adaptability as the existing and proposed defences could be raised or the channel modified with minimal cost, effort and impact.
5. **Does the option allow for deferring/removing or abandoning?** Given the present day risk there is no allowance for options to be deferred or any that could be removed later

An objective for each potential option is to ensure that flood risk can be managed effectively and sustainably into the future accounting for the potential impacts of climate change. Based on this future change adaptability assessment the table below summarises how well each option achieves this objective.

Summary of Option Adaptability		
Option	**Description**	**Score**
Option 1 – Storage and Hard Defences (FC 1)	Option is adaptable at significant cost, difficulty and impact	1
Option 2 – Hard Defences (FC1)	Option is adaptable at moderate cost, difficulty and impact	3
Option 3 – Diversion of flow and Hard Defences (FC 1)	Option is adaptable at moderate cost, difficulty and impact	4

8.2.7.6 Local Authority Comments

LA representatives reviewed preliminary options in February 2016.

8.2.7.7 Summary

There is moderate confidence in both the hydrology and hydraulics of the Ballyhale AFA. Due to the lack of flood event data available, it was only possible to conduct a limited verification exercise on this model. However the model is shown to be a reasonable representation of the flood mechanisms described from the available flood event records and considered to be performing satisfactorily for design event simulation.

The following potential options, with a BCR ≥ 0.5 have been identified:

- Option 1 – Storage and Hard Defences (FC 1)
- Option 2 – Hard Defences (FC 1)
- Option 3 – Diversion of Flow and Hard Defences (FC 1)

Alongside any potential option the existing regime should continue with maintenance being carried out ad hoc when resources allow. Maintenance of the option structures should also form part of the ongoing regime once in place.

Methods also were identified at UoM level (see section 8.1) that are applicable to Ballyhale AFA, that if implemented, will serve to avoid increasing flood risk in the future :

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

No communities are located upstream that would be affected by any of the potential options identified.

The Ballyhale AFA is located within the River Barrow And River Nore SAC therefore this specially designated area would need to be addressed during the development of the preferred option. Ballyhale Church and the Bridge (R448) located within the Ballyhale AFA are listed on the NIAH register. These buildings would also need to be addressed during the development of the preferred option.

It should be noted that Ballyhale has a moderate sensitivity to climate change and is suitable for an adaptive approach be incorporated into detailed design.

These recommendations should be taken forward with a view to identification of a preferred option for the flood risk management plan.

8. OPTIONEERING OF SSA'S

8.3 Ballyraggett optioneering of FRM Options

Name	Local Authority	Unique ID	SSA	Status	Date
Ballyragget	Kilkenny	150182	AFA	Final	

8.3.1 Source of flooding

Fluvial	Coastal Mechanism 1	Coastal Mechanism 2

8.3.2 Flood Cells

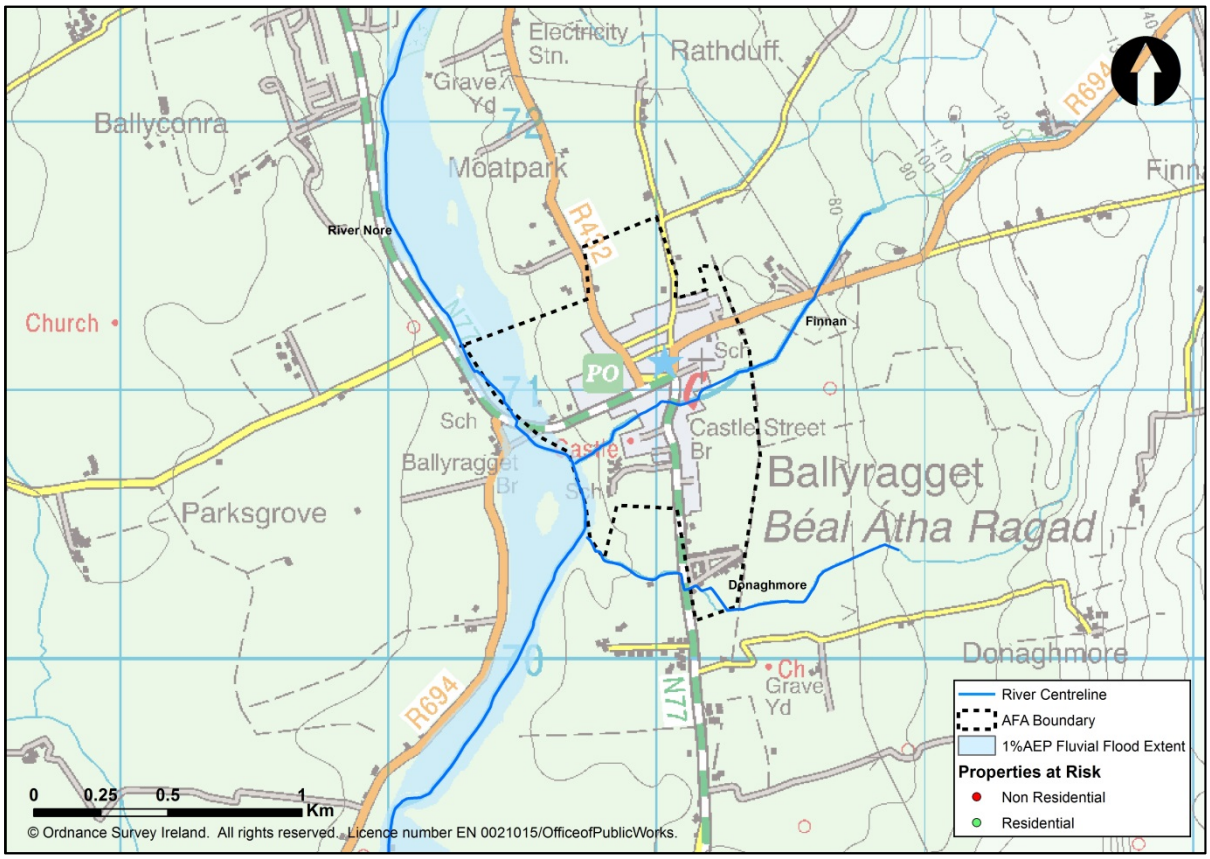


Figure 8.3.1 Ballyraggett AFA Flood Cells within a 1% AEP Fluvial Flood Extent

Summary of Flood Cells:

As shown in Figure 8.3.1 there are no properties at flood risk during the 1% AEP event, therefore no flood cells have been identified.

8.3.3 Existing Regime

The existing regime considers all activities currently carried out which impact on the management of flood risk. The level and frequency of maintenance is considered, along with inspection, and any other specific activity (for example the operation of locks, barrages, sluice gates and valves).

The watercourses that run through Ballyragget AFA include the River Finnan and Donaghmore. These rivers join with the River Nore that flow along the western edge of the AFA boundary. The watercourses associated with Ballyraggett AFA are not included within any Drainage District or Arterial scheme. They are, for the most part, in private lands and are not the responsibility of Kilkenny County Council. Nevertheless, inspection and maintenance are carried out as and when resources are available. Since there is no flood risk associated with Ballyragget AFA, it is recommended that the existing regime is maintained.

8.3.4 Monetary Damage and Benefit

	Total in AFA
Annual Average Damage (AAD)	€7,208
Present Value Damage (pvD)	€154,848
Standard of Protection (SoP)	1% AEP
Number of Properties Benefiting from Design SoP	0*
Minimum Present Value Benefit	€0
Capped Minimum Present Value Benefit	€0

***** There are no residential or non-residential properties at risk within this AFA.

8.3.5 Selection of Options

No options were required as there are no properties at risk of flooding during the 1% AEP event.

There are no properties at risk of flooding during the 1% AEP event in Ballyragget AFA. However methods were identified at UoM level (see section 8.1) to be included, along with maintaining the existing regime:

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

8.3.5.1 AFA Sensitivity to Future Change

As shown Figure 8.3.2, there is no significant change in the MRFS and HEFS 1% AEP events. The spatial extent of flooding is constricted by the River Nore fluvial basin topography. There is some slight flooding along the River Donaghmore close to its downstream extent. This would result in an additional 4 properties being at risk during the MRFS 1% AEP event, bringing the property county from 0 in the present day 1% AEP fluvial event to 4. The AAD would increase from €7,208 to €25,216. As a result, Ballyragget would be considered to be at moderate vulnerability from the MRFS.

During a HEFS 1% AEP flood event the increase in flood extent is minimal. This would result in an

additional 5 properties being at risk, bringing the property county from 0 in the present day 1% AEP fluvial event to 5. The AAD would increase from €7,208 to €75,490. As a result, the Ballyragget AFA would be considered to be at moderate vulnerability from the HEFS.

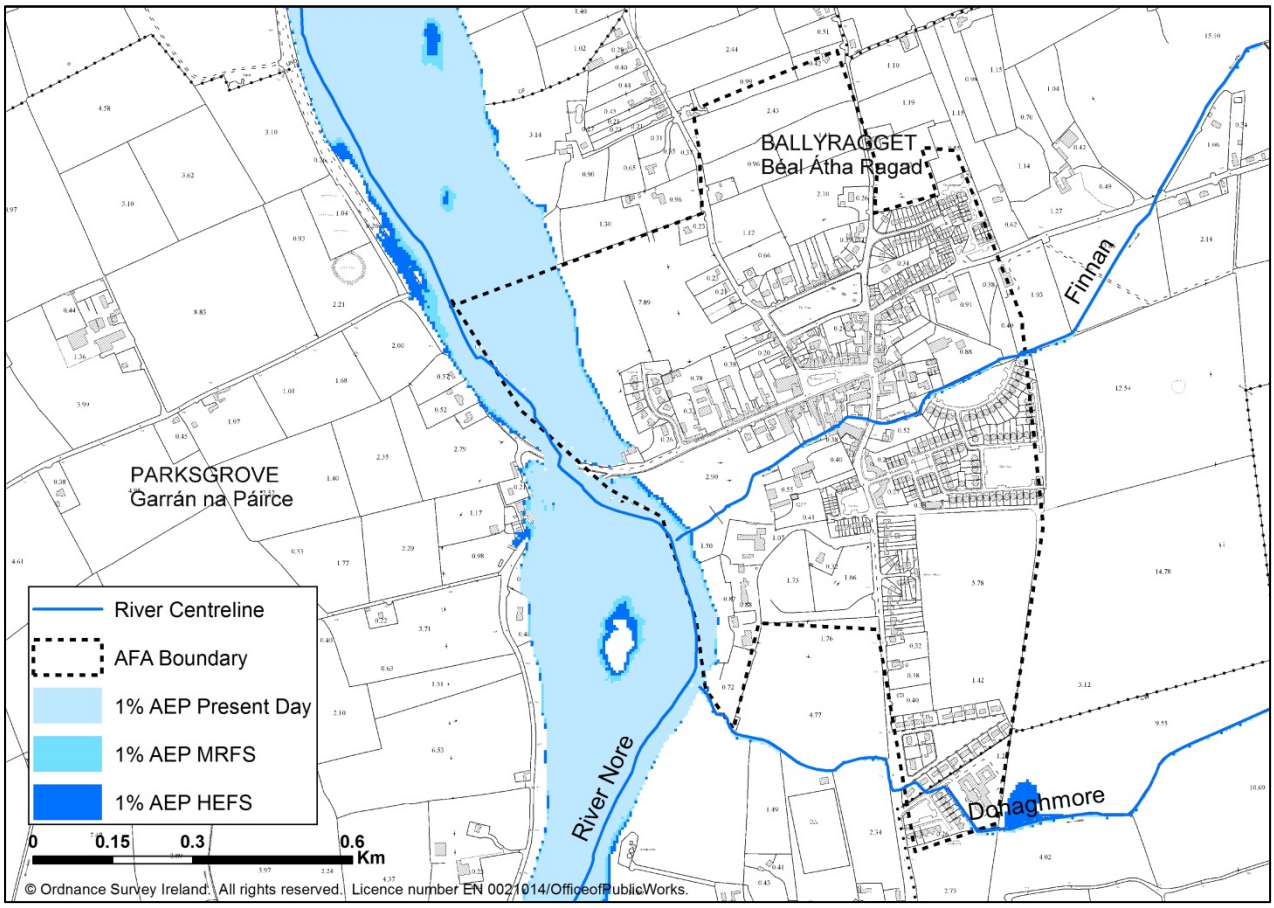


Figure 8.3.2 Ballyragget AFA Future Change Flood Extents

8.3.5.2 Local Authority Comments

LA representatives reviewed the preliminary version of this Ballyragget POR report in November 2015. Comments were made regarding the flooding of several properties located outside of the AFA.

8.3.5.3 Summary

There is good confidence in both the hydrology and hydraulics of Ballyragget AFA due to the presence of several gauging stations and flood extent verification events.

There is no present day flood risk associated with Ballyragget AFA. Furthermore, future changes assessment identified that Ballyragget AFA is moderately sensitive to future change.

As no risk was identified in Ballyragget AFA and therefore no options were developed, the existing regime should continue in order to maintain the current SoP. The existing and future flood extents should be considered for any proposed planning and development.

Methods also were identified at UoM level (see section 8.1) that are applicable to Ballyragget AFA, that if implemented, will serve to avoid increasing flood risk in the future :

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

Kilkenny AFA is located downstream and should be taken into consideration for any future works carried out in Ballyragget.

No risk was identified in Ballyragget AFA however the existing regime should be maintained to retain the required SoP.

The Minor Works Scheme is available to the local authorities to address any local flood problems with local solutions.

8. OPTIONEERING OF SSA'S

8.4 Ballyroan optioneering of FRM Options

Name	Local Authority	Unique ID	SSA	Status	Date
Ballyroan	Laois	150183	AFA	Final	

8.4.1 Source of flooding

Fluvial	Coastal Mechanism 1	Coastal Mechanism 2

8.4.2 Flood Cells

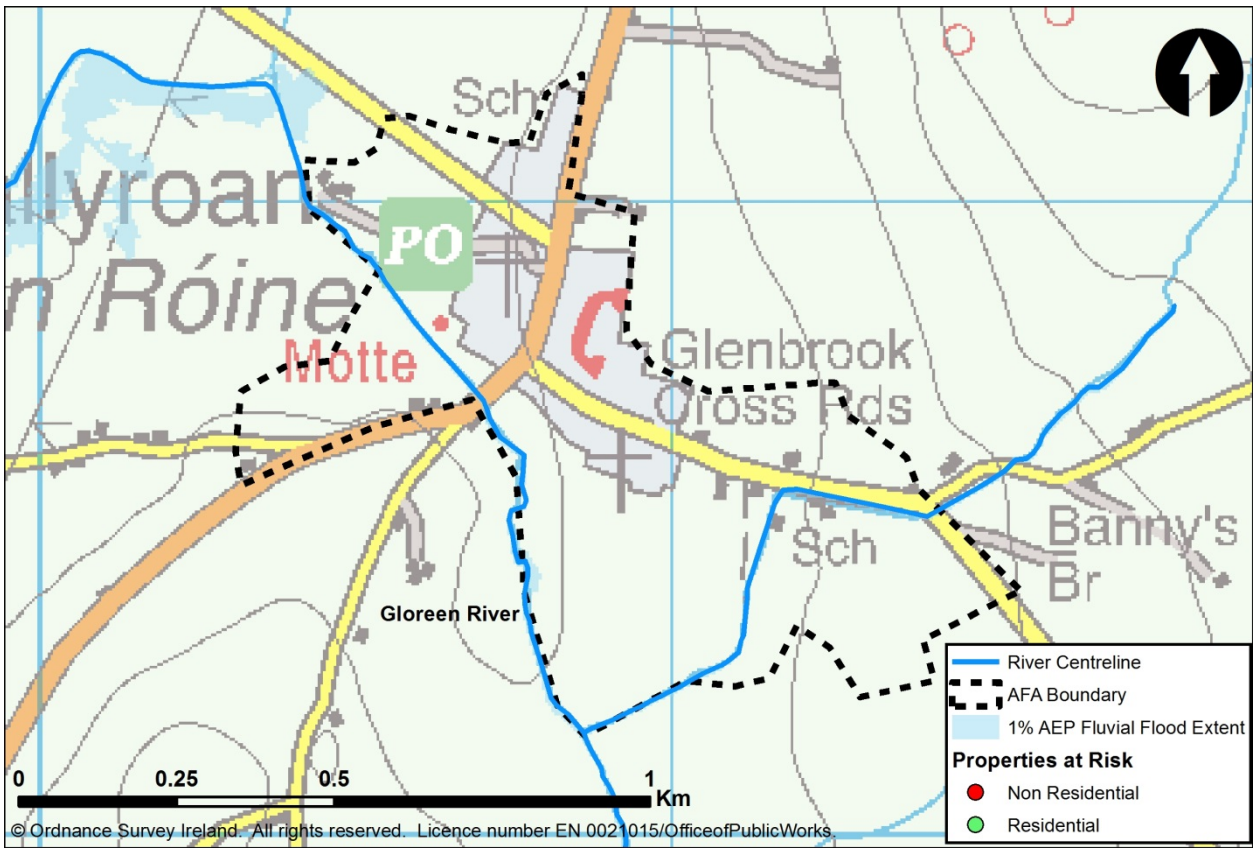


Figure 8.4.1 **Ballyroan AFA Flood Cells within a 1% AEP Fluvial Flood Extent**

Summary of Flood Cells:

As shown in Figure 8.4.1 there are no properties at risk during the 1% AEP event, therefore no flood cells have been identified.

8.4.3 Existing Regime

The existing regime considers all activities currently carried out which impact on the management of flood risk. The level and frequency of maintenance is considered, along with inspection, and any other specific activity (for example the operation of locks, barrages, sluice gates and valves).

The watercourses within Ballyroan are not located within a Drainage District or an Arterial Drainage scheme. They are, for the most part, in private lands and are not the responsibility of Kilkenny County Council. Nevertheless, inspection and maintenances are carried out as and when resources and are available. Since there is no flood risk associated with Ballyroan AFA, it is recommended that the existing regime is maintained.

8.4.4 Monetary Damage and Benefit

	Total in AFA
Annual Average Damage (AAD)	€194
Present Value Damage (pvD)	€4,164
Preferred Standard of Protection (SoP)	1% AEP
Number of Properties Benefiting from Design SoP	0*
Minimum Present Value Benefit	€0
Capped Minimum Present Value Benefit	€0

* There are no residential or non-residential properties at risk within this AFA.

8.4.5 Selection of Options

There are no properties at risk of flooding during the 1% AEP event therefore no options were developed. However methods were identified at UoM level (see section 8.1) to be included in the Ballyroan AFA:

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

8.4.5.1 AFA Sensitivity to Future Change

As shown in Figure 8.4.2, during a MRFS 1% AEP flood event there would be a slight increase in flood extent; This would result in an additional 2 properties being at risk during the MRFS 1% AEP event, bringing the property county from 0 in the present day 1% AEP fluvial event to 2. The AAD would increase from €194 to €2,406. As a result, Ballyroan AFA would be considered to be at low vulnerability from the MRFS.

During a HEFS 1% AEP flood event there would be a further increase in flood extent; This would result in an additional 2 properties being at risk, bringing the property county from 0 in the present day 1% AEP fluvial event to 2. The AAD would increase from €194 to €6,329. As a result Ballyroan AFA

would be considered to be at low vulnerability from the HEFS.

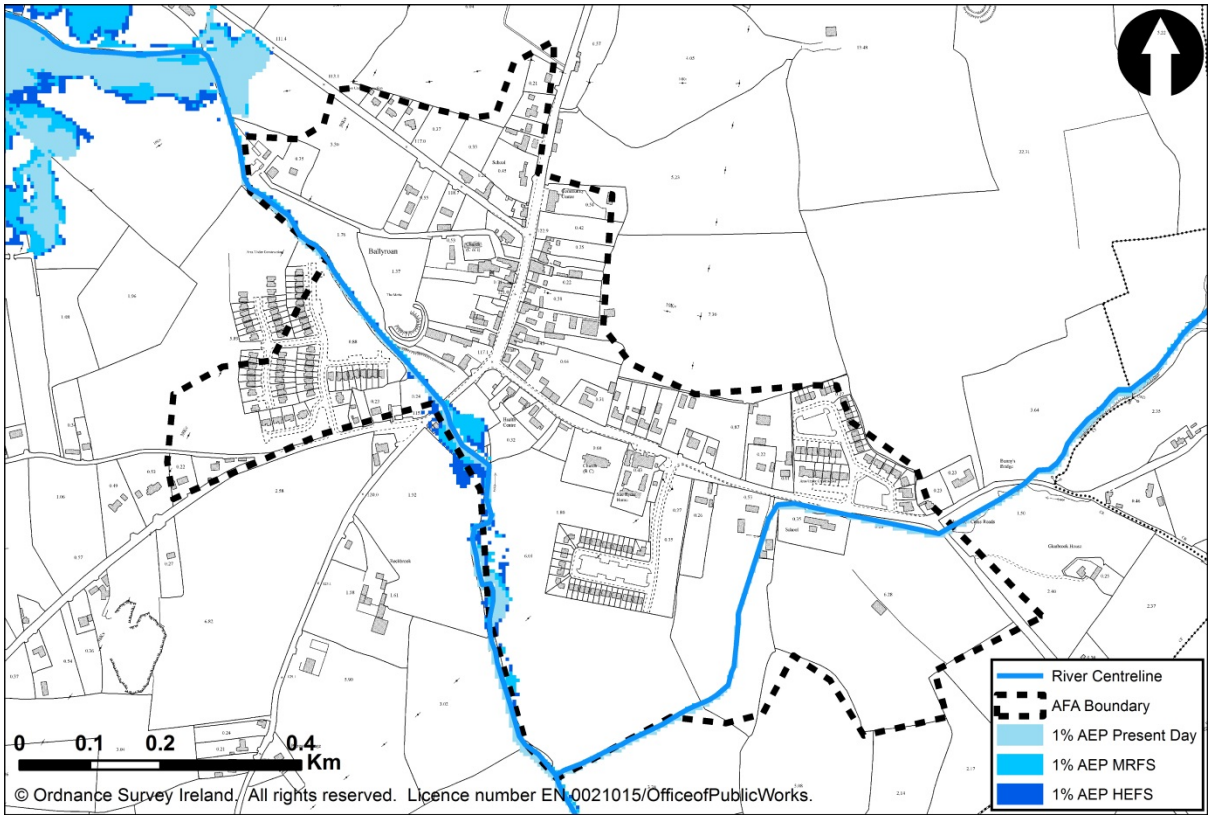


Figure 8.4.2 Future Change Flood Extents

8.4.5.2 Local Authority Comments

LA representatives reviewed preliminary options in December 2015.

8.4.5.3 Summary

There is moderate confidence in both the hydrology and hydraulics of the Ballyroan AFA due to the lack of flood extent verification events and gauging station.

No risk was identified in Ballyroan AFA and therefore no options were developed, the existing regime should continue in order to maintain the current SoP. The existing and future flood extents should be considered for any proposed planning and development.

Methods also were identified at UoM level (see section 8.1) that are applicable to Ballyhale AFA, that if implemented, will serve to avoid increasing flood risk in the future :

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

AFAs are located downstream (with Ballyragget and Kilkenny the closest AFAs) which should be taken into consideration for any future works carried out in Ballyroan.

It should be noted that Ballyroan has a low sensitivity to climate change.

No risk was identified in Ballyroan AFA however the existing regime should be maintained to retain the required SoP.

The Minor Works Scheme is available to the local authorities to address any local flood problems with local solutions.

8. OPTIONEERING OF SSA'S

8.5 Callan Optioneering of FRM Options

Name	Local Authority	Unique ID	SSA	Status	Date
Callan	Kilkenny	150185	AFA	Final	15/06/2016

8.5.1 Source of flooding

Fluvial	Coastal Mechanism 1	Coastal Mechanism 2

8.5.2 Flood Cells

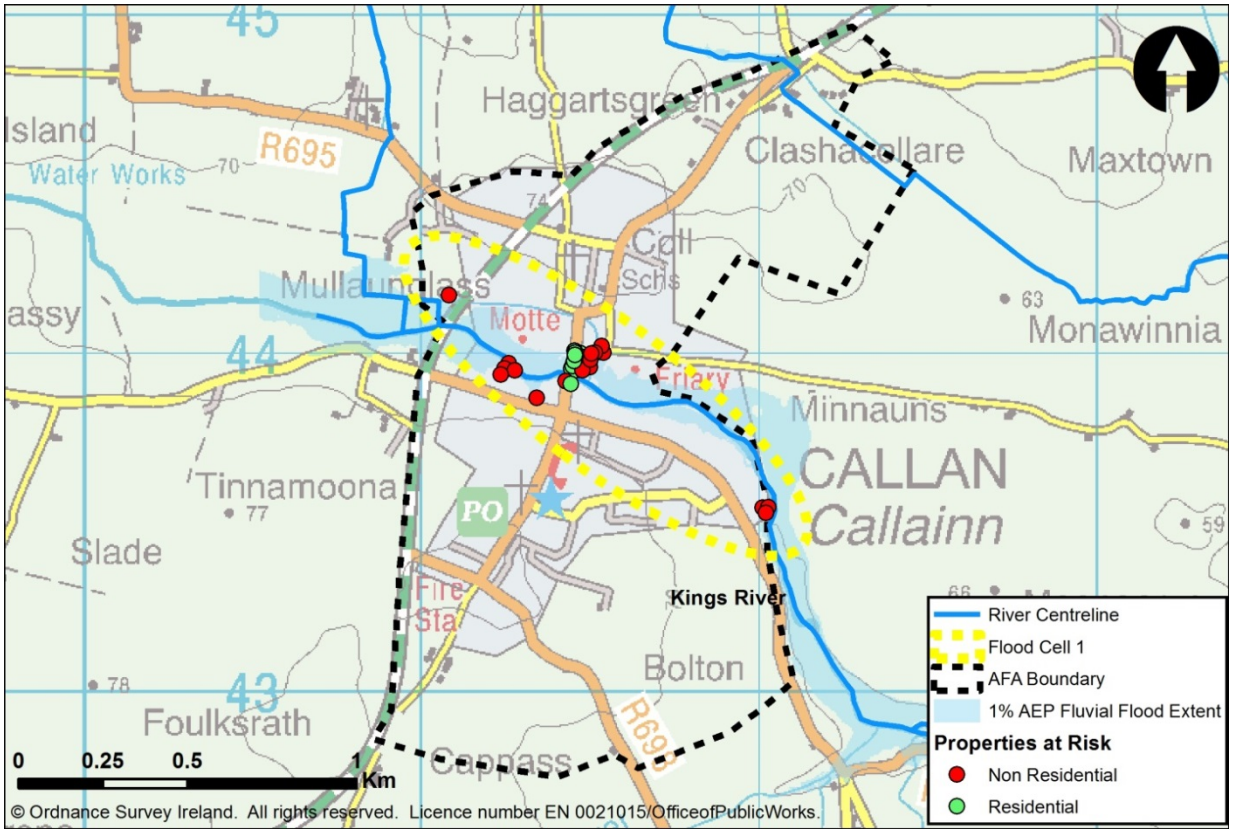


Figure 8.5.1 Callan AFA Flood Cells within a 1% Fluvial Flood Extent

Flood Cell 1:

Out of bank flooding occurs on the Kings River during a 1% AEP flood event due to insufficient channel capacity resulting in inundation of the floodplain. 38 properties in the Callan AFA are located within this floodplain and would be affected by flooding during a 1% AEP flood event. Given that there are no flood cells located immediately downstream of this flood cell the flood risk in flood cell 1 is considered local.

Summary of Flood Cells:

As shown in Figure 8.5.1 the main flood risk originates from the Kings River as water levels during the 1%AEP fluvial event exceed the top of bank levels where crest levels are low. As there is one flood mechanism to consider and one flood cell it is therefore appropriate to screen flood cell 1 as a discrete area assessing options applicable to localised works in Section 8.5.6.

On completion of the optioneering screening assessment all FRM methods considered will be combined to form complete options for the Callan AFA as detailed in Section 8.5.7.

8.5.3 Existing Regime

The existing regime considers all activities currently carried out which impact on the management of flood risk. The level and frequency of maintenance is considered, along with inspection, and any other specific activity (for example the operation of locks, barrages, sluice gates and valves).

The Callan watercourses are not located within a Drainage District or an Arterial Drainage scheme. They are, for the most part, in private land and are not the responsibility of Kilkenny County Council. As the degree of flood risk stays as present, with some properties frequently flooded, the existing regime does not provide the preferred standard of protection.

8.5.4 Summary of Flood Risk within SSA boundary

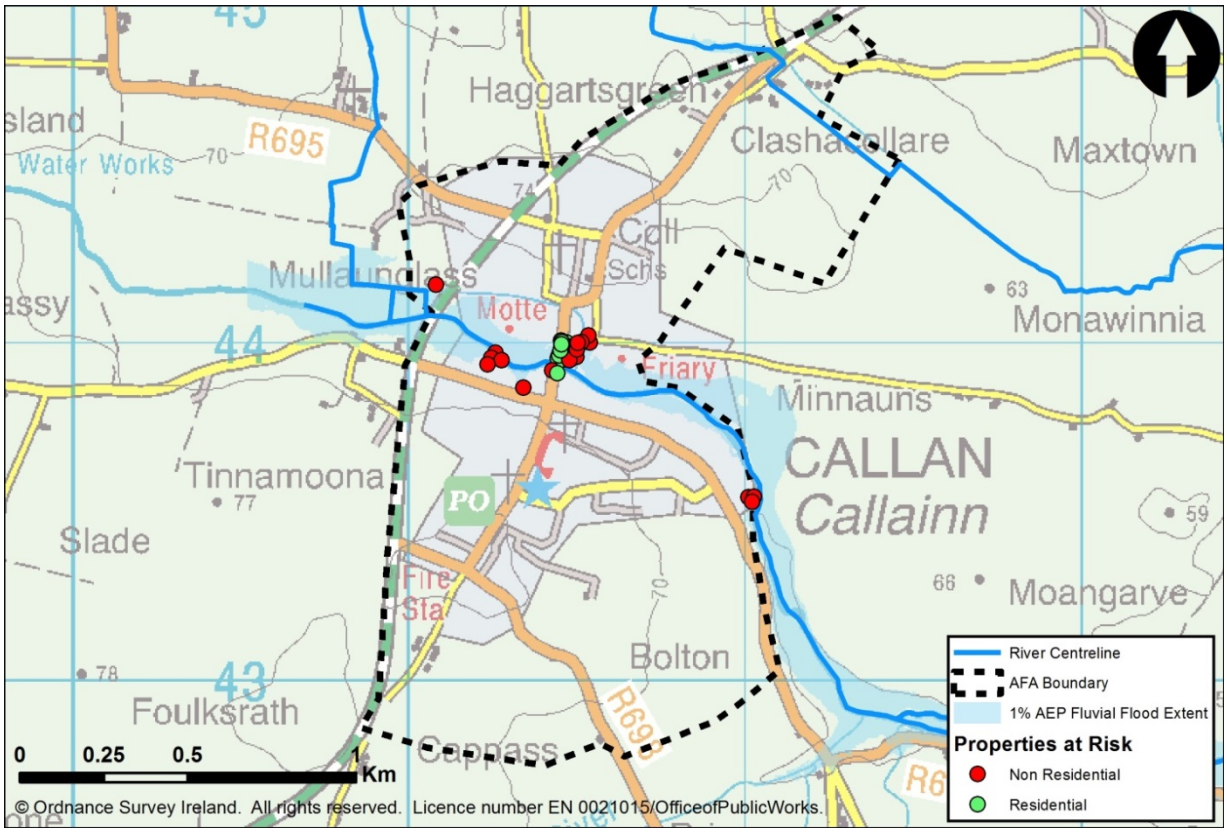


Figure 8.5.2 Flood risk in Callan AFA within a 1% Fluvial Flood Extent

In Callan AFA the onset of residential and non-residential property damage occurs in the 50% AEP event.

8.5.5 Monetary Damage and Benefit

	Flood Cell 1	Total in AFA
Annual Average Damage (AAD)	€ 273,191	€ 273,191
Present Value Damage (pvD)	€ 5,868,697	€ 5,868,697
Standard of Protection (SoP)	1% AEP	1% AEP
Number of Properties Benefiting from Design SoP	38	38
Minimum Present Value Benefit	€ 4,536,411	€ 4,536,411
Capped Minimum Present Value Benefit	€ 1,808,579	€ 1,808,579

*The sum of the flood cell AAD or pvD values may not equate to the values presented for the Total in SSA due to flooding greater than the 1% AEP occurring outside the flood cell extents.

8.5.6 Short Listing FRM Methods – Local Cell

Method	Review Comment	Continue Screening
		Flood Cell 1
Do Nothing	Consider Further	✓
Additional Maintenance	Consider Further	✓
Do Minimum	Consider Further	✓
Planning and Development Control	Consider at UoM SSA- Reject	×
Building Regulations	Consider at UoM SSA - Reject	×
Catchment Wide SuDs	Consider at UoM SSA - Reject	×
Land Use Management	Consider Further	✓
Strategic Development Management	Consider at UoM SSA - Reject	×
Storage	Consider Further	✓
Improvement of Channel Conveyance	Consider Further	✓
Hard Defences	Consider Further	✓
Relocation of Properties	Consider Further	✓
Diversion of Flow	Consider Further	✓
Flood Warning/Forecasting	Consider Further	✓
Public Awareness Campaign	Consider at UoM SSA - Reject	×
Individual Property Protection	Consider Further	✓
Other Works	Consider Further	✓

8.5.6.1 Feasibility Review Summary for Local Cell (flood cell 1)

Method	Technical Screening	Economic Screening	Environmental and Cultural Heritage Screening	Social Screening
Do nothing	×			
Additional Maintenance	×			
Do Minimum	×			
Land Use Management	×			
Storage	×			
Improvement of Channel Conveyance	✓	✓	?	✓
Hard Defences	✓	✓	?	✓
Relocation of properties	✓	×		
Diversion of Flow	×			
Flood Warning/Forecasting	✓	✓	✓	✓
Individual Property Protection	×			
Other Works	×			

× - Reject ✓ - Progress ? - Progress, potential for impacts identified ! - Progress, potential for significant impacts identified

8.5.6.2 Justification for Rejection/Retention

Method	Tech	Econ	Env	Soc
Do nothing	×			

The do nothing FRM method would involve stopping the current maintenance regime. This would not provide the preferred SoP and therefore was rejected from the screening process.

Method	Tech	Econ	Env	Soc
Additional Maintenance	×			

This method considers whether improvements can be made to augment the existing maintenance regime which will provide a significant beneficial impact on flood risk in the AFA. A review was carried out of the existing watercourse network. This included assessing the channel vegetation, the amount of debris present in the channels and the likelihood of structures blocking.

Increasing maintenance activities on the relevant watercourses will not significantly contribute to achieving the preferred SoP and therefore will not be pursued under the CFRAM Study.

Method	Tech	Econ	Env	Soc
Do Minimum	✗			

This method is appropriate where an isolated/single issue exists which can be easily addressed in order to reduce the flood risk, for example the removal of a pinch point/obstruction, or the upgrade of a blockage prone culvert screen, etc. These activities would be considered relatively straightforward, discrete and low cost. Do Minimum is a standalone method, as it cannot be combined with others without contradicting its definition, therefore the design SoP must be achieved for this method to progress.

Within flood cell 1 the Do Minimum method would involve clearing the channel of the Kings River. This however would have minimal impact on the overall flood risk as it would not provide the additional conveyance needed within the channel. This is an unacceptable outcome in terms of contributing to achieving the design standard of flood protection and therefore was rejected from the screening process.

Method	Tech	Econ	Env	Soc
Land Use Management	✗			

The application of land use management measures was tested at UoM scale. Catchment 1 is a relatively large catchment and would require a large number of NFM features to make the method effective. This would be a technically complex method to apply and monitor. This method is technically unfeasible and hence rejected from the screening process.

Method	Tech	Econ	Env	Soc
Storage	✗			

This method considers areas where flood water can be stored and then released at a controlled rate, therefore reducing the flow rate along the HPW and reducing the level of flood risk. This can be achieved by using existing or creating new depressions to create online or offline storage areas or by identifying pinch points which could be dammed such as a restricted point along a valley. Storage areas can be effective either upstream of the risk areas or within the risk area where parks or open areas are located.

A review of the surrounding land was carried out but no suitable location was found to accommodate the 1.1million m^3 of storage required during a 1%AEP event. This method is therefore considered technically unfeasible and rejected.

Method	Tech	Econ	Env	Soc
Improvement of Channel Conveyance	✓	✓	?	✓

This method focuses on increasing watercourse conveyance thereby lowering water levels and reducing the associated flood risk. This can be achieved by lowering bed levels, widening/reshaping channels, removing channel/structure constrictions, culverting reaches of watercourse, reducing roughness of the channel and sealing manholes.

A review of the various techniques available was carried out and reducing the bed level of the Callan River by approximately 0.7m over a length of 1.6km and removing the footbridge (ID 15CALLAN00012D) would sufficiently reduce water levels in order to prevent flooding. The proposed section of watercourse where this work would be carried out is shown in Figure 8.5.3.

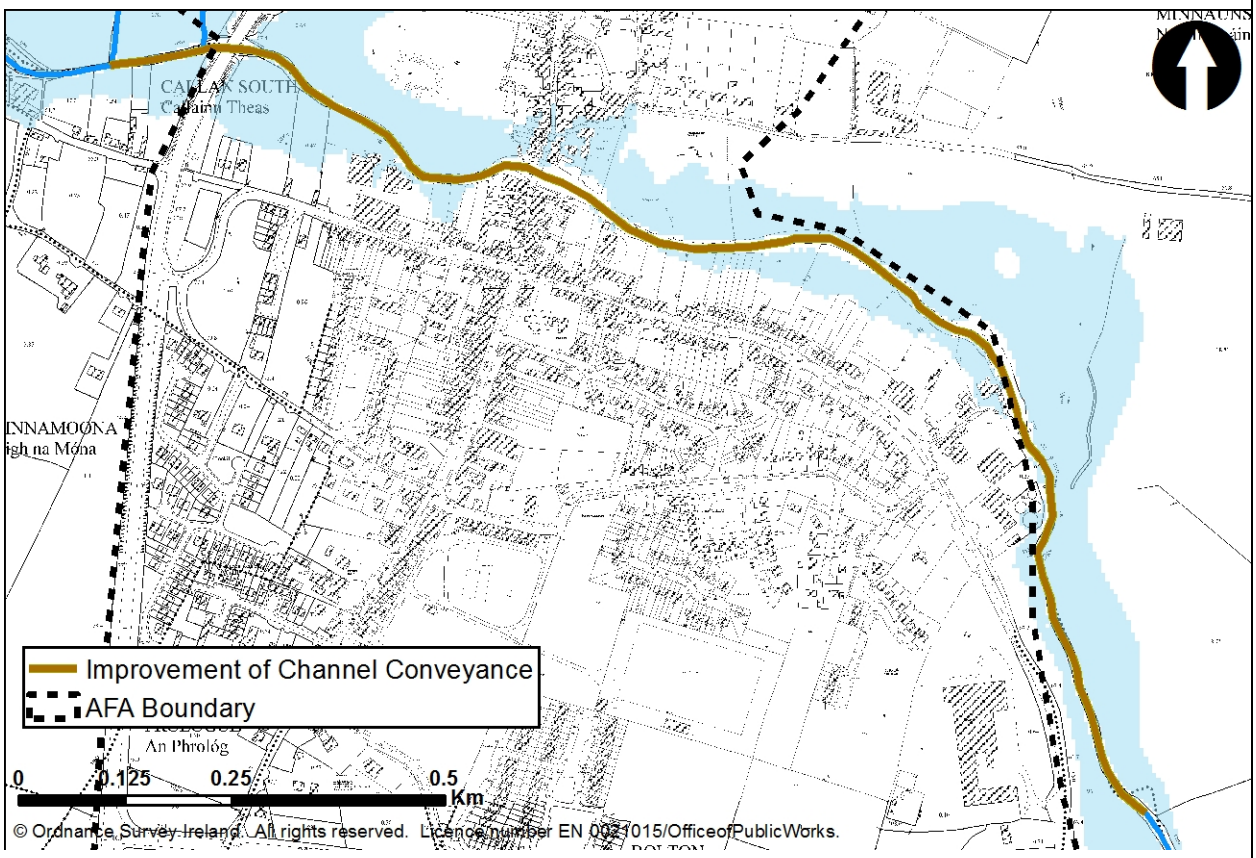


Figure 8.5.3 Location of Improvement of Channel Conveyance in flood cell 1

Two other bridges are located on this section of the Callan watercourse, and works to underpin these bridges would be needed as part of this method. An economic review estimated the total cost of these works including dredging the river channel, underpinning two bridges, removing the footbridge and replacing it with a clear span footbridge to be approximately €2.4m This method is therefore considered potentially economically viable.

The River Barrow and River Nore SAC and the River Nore SPA are within, downstream of and upstream of Callan. The Lower River Suir SAC is over 9km south west of Callan, however is not hydraulically linked to the AFA.

Improvement of the Channel Conveyance within the Callan AFA would provide the full SoP during a 1%AEP fluvial event therefore this method was taken forward for consideration in the optioneering process.

Method	Tech	Econ	Env	Soc
Hard Defences	✓	✓	?	✓

The term Hard Defences refers to physical barriers which prevent water from entering an area such as flood walls, embankments and barrages. As a general rule Hard Defences are kept as far back from the river channel or coast line as possible allowing the floodplain function to remain active. Where this is not possible, due to flood risk receptors being located within the floodplain, Hard Defences are placed around the property boundary to afford it protection. Where space allows flood embankments are used

but where space is restricted flood walls are utilised.

A review was carried out to ascertain where additional Hard Defences would be required to protect existing property within flood cell 1. The existing hard defences have a SoP of 10%AEP therefore these defences would have to be upgraded to meet the required SoP of 1%AEP. Figure 8.5.4 shows the location of the existing defences and the Hard Defences required to protect properties during the 1% AEP event.

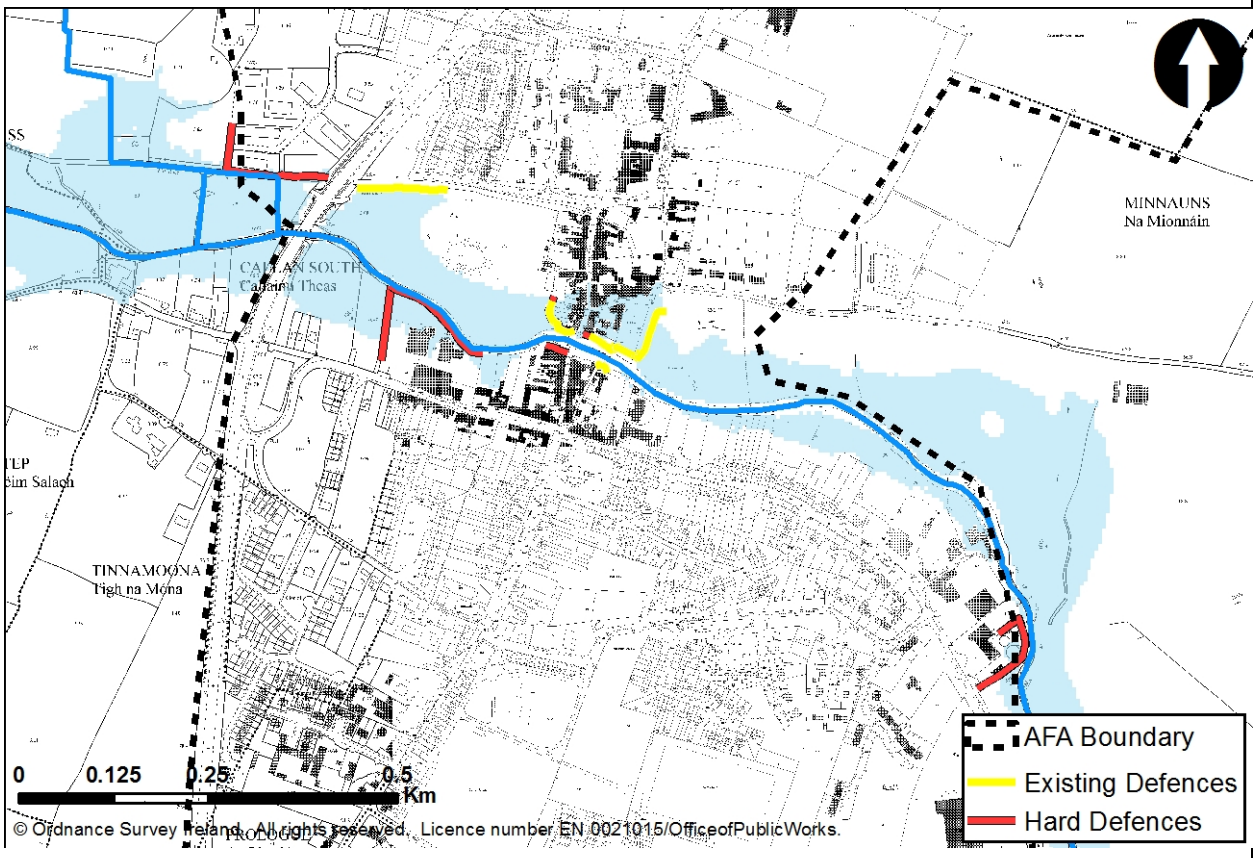


Figure 8.5.4 Location of Hard Defences in flood cell 1

In order to ascertain the effectiveness of Hard Defences a hydraulic model was constructed to simulate the method. The model showed that hard defences with an average height of 1.6m and a total length of 733m would protect to the 1% AEP flood event. Tanking would also be required for 2 properties immediately downstream of the bridge on Lower Bridge St. (15CALLAN00009D). This is necessary as the gable walls of these properties form part of the river channel and their finished floor level is below the peak water level during a 1%AEP fluvial event.

An economic review estimated the cost of the hard defences to be approximately €2.8m making this method potentially economically viable.

The River Barrow and River Nore SAC and the River Nore SPA are within, downstream of and upstream of Callan. The Lower River Suir SAC is over 9km south west of Callan, however is not hydraulically linked to the AFA.

Hard Defences within the Callan AFA would provide the full SoP during a 1%AEP fluvial event therefore this method was taken forward for consideration in the optioneering process.

Method	Tech	Econ	Env	Soc
Relocation of properties	✓	×		

To relocate a property is to abandon the existing at risk property and provide an alternative in a location not at risk. While this method is, in theory, possible, it is not practical for a whole community of many at risk properties. Its use is more applicable for discrete areas where single properties or clusters of properties are located.

In practice it is always technically possible to relocate properties, however due to the socially negative impacts it should only be considered should no other method be found suitable. There are 38 properties at risk during a 1% AEP fluvial event within flood cell 1. An economic review estimated the cost of relocating these properties as €12.5m. This method was therefore considered economically unviable and was rejected from the screening process.

Method	Tech	Econ	Env	Soc
Diversion of Flow	×			

This method involves directing some of the floodwater via a new route thereby reducing flow and associated flood risk along the original route. This would be carried out upstream of where floodwaters reach the area of at risk properties. The new flow route would normally consist of a constructed open channel and/or culvert system or an existing linear feature able to convey the flow to a designated discharge point.

A review was carried out to identify locations where one or more Flow Diversion routes could be constructed to address the flood risk during a 1%AEP fluvial event in flood cell 1. No suitable routes were identified to convey the flow from the Kings River during a 1%AEP fluvial event away from the properties at risk, hence this method was rejected.

Method	Tech	Econ	Env	Soc
Flood Warning/Forecasting	✓	✓	✓	✓

The application of flood warning / forecasting was tested at UoM scale. A suitable location far enough upstream of flood cells 1 is available to provide sufficient warning. This method can only provide warning for other methods and does not provide the preferred SoP as a standalone method. Therefore the method should only be considered if no other methods are suitable during the optioneering process.

An economic review estimated that the cost of providing two hydrometric gauging station with simple forecasting systems would be approximately €141k. This method is therefore economically viable.

The River Barrow and River Nore SAC and the River Nore SPA are within, downstream of and upstream of Callan. The proposed gauging stations are therefore within these environmental designations. However it is likely that flood forecasting would have minimal impact to designated sites in the vicinity of the Callan AFA.

Method	Tech	Econ	Env	Soc
Individual Property Protection	×			

This method is aimed at individual properties that are remote from the main risk areas. Where the AFA being considered consists of a small number of remote properties this method is a feasible solution. But for areas with multiple properties at risk this method would only be considered an add on to a primary method. Individual property protection could consist of flood gates and vent seals on the building structure itself. Where flood depths are over 0.6m this method becomes unfeasible and flood resilience techniques would be recommended over flood gates. As this method is temporary and relies of human intervention there is an element of uncertainty as to whether the full SoP will be met for every flood event. As such it is assumed that 20% of the flood damage will be avoided.

The flood modelled depths for 27 of the 38 properties at risk during a 1%AEP fluvial event are above 0.6m therefore this method is not technically feasible for flood cell 1.

Method	Tech	Econ	Env	Soc
Other Works	×			

No other works were identified for these flood cells

8.5.6.3 Summary of Feasibility Review – Flood Cell 1

The following FRM methods have been carried forward to address the flood risk arising from flood cell 1;

- Improvement of Channel Conveyance and
- Hard Defences.

Flood Warning/Forecasting cannot provide the required SoP and should therefore only be used if other methods are deemed unsuitable later in the optioneering process.

Both Improvement of Channel Conveyance and Hard Defences can provide the full protection to all properties during the 1% AEP flood event. Therefore Improvement of Channel Conveyance and Hard Defences will be considered individually as standalone methods to the address the risk caused within flood cell 1.

8.5.7 Selection of Options

Method	Option 1	Option 2	Option 3	Option 4	Option 5
Improvement of Channel Conveyance	✓				
Hard Defences		✓			

For flood cell 1 Improvement of Channel Conveyance can provide the full SoP to the properties at risk.

For flood cell 1 Hard Defences can provide the full SoP to the properties at risk.

8.5.7.1 Option 1 details – Improvement of Channel Conveyance

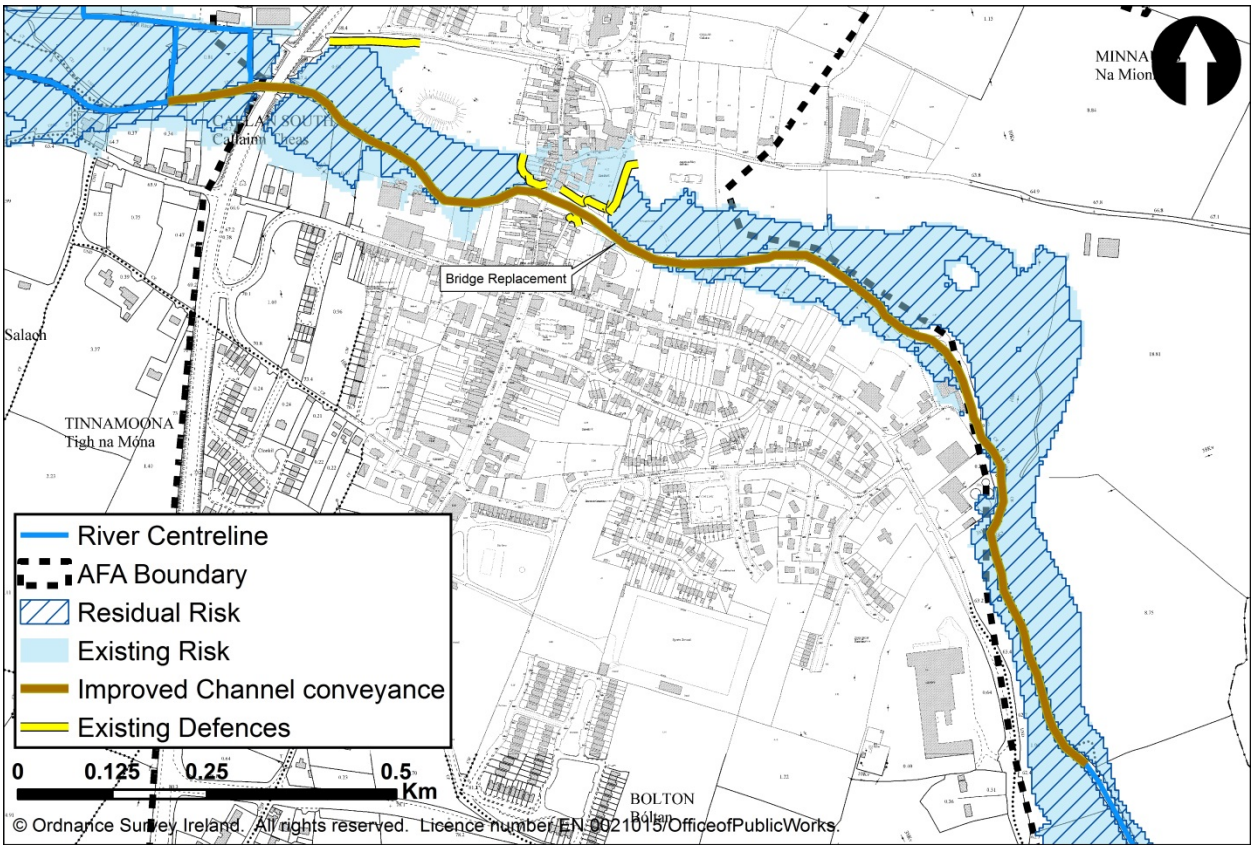


Figure 8.5.5 Callan AFA Option 1

At risk properties would be protected by lowering the bed level of Kings River within the Callan AFA. Lowering the bed level would require approximately 19,200m^3 of material to be dredged, the underpinning of two bridges, the removal of the footbridge and replacing it with a clear span bridge.

In addition to these methods the following was also identified at UoM level (see section 8.1) to be included in any potential option identified:

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

Option Item	Quantity	Construction Cost
In-Channel Excavation	19,200m^3	€ 614,720
Bridge underpinning	15CALLAN00003D 15CALLAN00009D	€ 237,410
Bridge removal	15CALLAN00012D	€ 6,240
Bridge construction	Clear span 40m^2 footbridge	€ 95,200
Total MCA-Benefit Score	**Option Cost (€millions)**	**MCA-Benefit Score / Cost Ratio**
696	2.4	295.16

Economic Appraisal (Cost-Benefit Analysis) Outcomes			
Area NPVd (uncapped)	**Option Cost**	**Option NPVb (capped)**	**Benefit - Cost Ratio**
€ 5,868,697	€ 2,357,008	€ 1,808,579	0.77

8.5.7.2 Option 2 details - Hard Defences

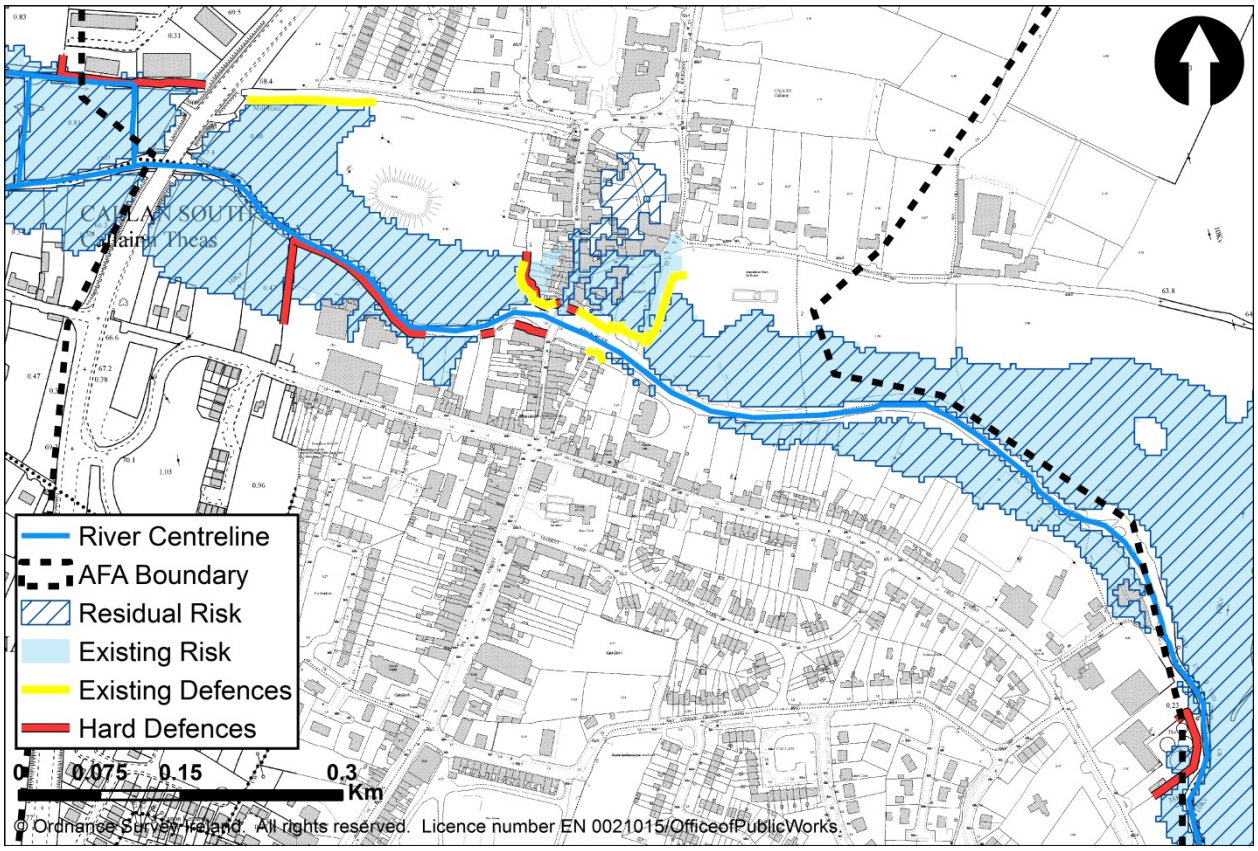


Figure 8.5.6 Callan AFA Option 2

At risk properties in flood cell 1 would be protected by a series of walls, embankments and tanking of 2 properties where the gable walls form part of the river channel. These hard defences would be set back from the river channel where possible as shown in Figure 8.5.6. These hard defences would protect to the 1%AEP fluvial event with an average height of 1.6m and a total length of 733m.

Figure 8.5.6 presents the effect of the potential option on the design flood event by overlaying the present day flood extent (labelled existing risk) with the flood extent that would occur after the option is put in place (labelled residual risk).

In addition to these methods the following was also identified at UoM level (see section 8.1) to be included in any potential option identified:

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

Option Item	Quantity		Construction Cost
Walls	442m length, 1.52m high		€ 840,769
Embankments	291m length, 1.91m high		€ 129,135
Tanking	2 properties		€ 8,400
Total MCA-Benefit Score	**Option Cost (€millions)**		**MCA-Benefit Score / Cost Ratio**
1206	2.36		509.71
Economic Appraisal (Cost-Benefit Analysis) Outcomes			
Area NPVd (uncapped)	**Option Cost**	**Option NPVb (capped)**	**Benefit - Cost Ratio**
€ 5,868,697	€ 2,365,433	€ 1,808,579	0.76

8.5.7.3 AFA Sensitivity to Future Changes

During a MRFS 1% AEP flood event the increase in flood extent is moderate as flood water overtops low points on both the left right hand banks of the Kings River. This would result in an additional 51 properties being at risk bringing the property count from 38 in the present day 1% AEP fluvial event to 89. The main area of additional flood risk is confined to the properties in the natural depression either side of Bridge St as shown in Figure 8.5.7. The AAD would increase from €273,191 to €1,037,880. As a result the Callan AFA would be considered to be at moderate vulnerability from the MRFS.

During a HEFS 1% AEP flood event the increase in flood extent is moderate as flood water overtops new low points in the on both the left right hand banks of the Kings River. This would result in an additional 71 properties being at risk bringing the property count from 38 in the present day 1% AEP fluvial event to 109. The main area of additional flood risk is confined to the properties in the natural depression either side of Bridge St as shown in Figure 8.5.7. The AAD would increase from €273,191 to €4,106,326. As a result the Callan AFA would be considered to be at high vulnerability from the HEFS.

The main area of additional flood risk is in and around the Westcourt Business Park, immediately upstream of the N76 bridge. A new flow path, exploiting the Pawlerth watercourse, would create an extended area of potential flood risk as shown in Figure 8.5.7. These properties do not flood in the present day scenario.

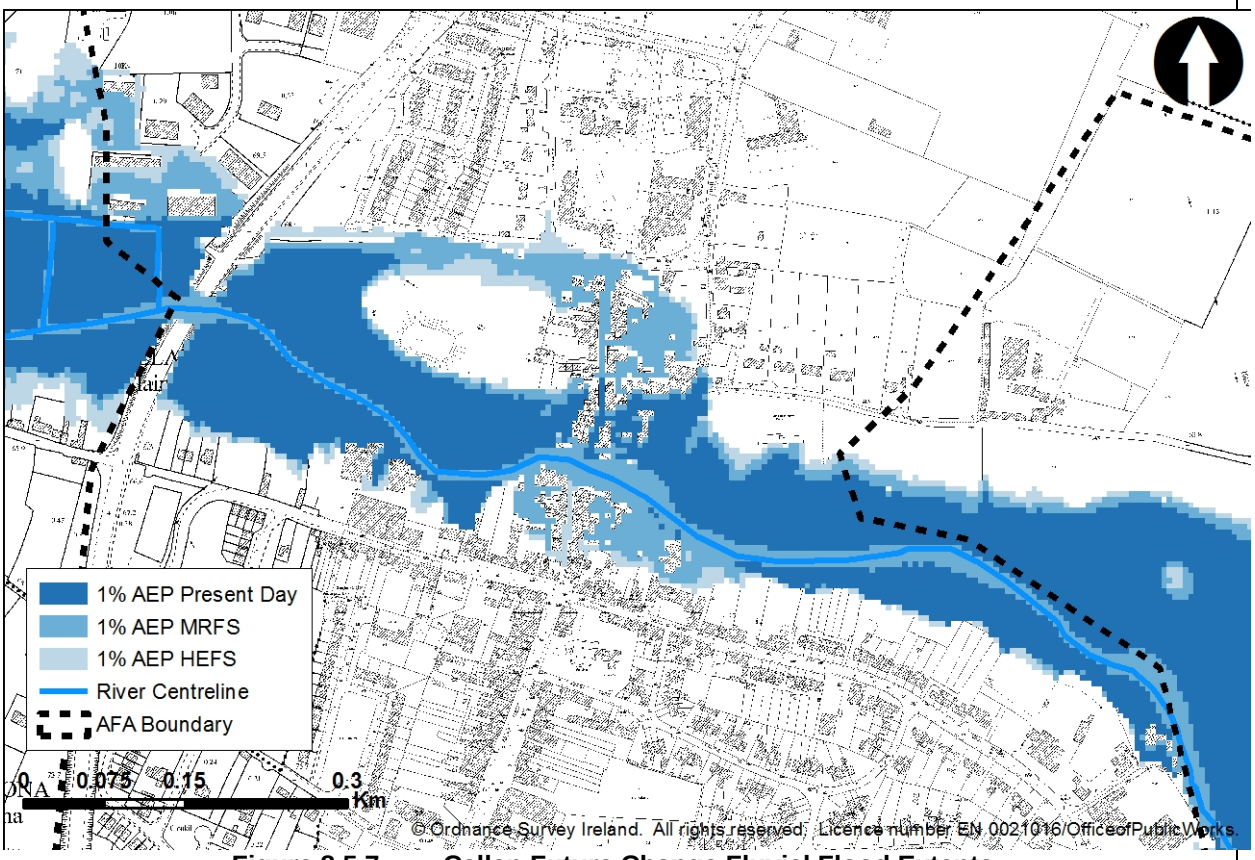


Figure 8.5.7 Callan Future Change Fluvial Flood Extents

8.5.7.4 Future Change Adaptability

The following discusses the adaptability of the potential FRM methods proposed in Callan AFA:

Improvement of Channel Conveyance Flood Cell 1 - This method could be adapted by lowering the bed level by 0.5m to convey the additional flow for the MRFS. The bed level would need to be lowered by 2m and widened by 4m to convey the additional flow for the HEFS. In addition 3 bridges would have to be underpinned. Given the number of bridges that would require additional underpinning this method is considered to have **moderate to poor** adaptability.

Hard Defences Flood Cell 1 - This method could be adapted by increasing the height of the walls. The length of the wall would also need to be adjusted. A review of the effect of the MRFS and the HEFS showed that the existing and proposed walls would require an increase by approximately 0.3m and 0.5m under the MRFS and HEFS respectively. This additional height could be accommodated. To ensure that this wall would be adaptable the design would need to account for the potential increase in height. This method is considered to be **moderate adaptability**.

Other

Note that additional Hard Defences would also be required on the Pawlerth watercourse to protect against flooding under the MRFS and HEFS for those properties that were not at risk under the present day.

The potential **options** identified have been further assessed using 5 criteria in an attempt to identify low – or no regret combinations of measures.

1. **Does the option reduce vulnerability?** In addition to the methods above other methods aimed at reducing future flood risk have been discussed in section 8.1 at UoM scale and are detailed in each potential option. These methods, such as building regulations and planning & development control will reduce the impact to potential future receptors. Given that Callan has a large area of open space some of these methods including a strategic development plan would be highly effective. There would be limited scope for some of these methods to impact on the area being assessed. Since there is a relatively large increase in the number of properties affected in the MRFS and HEFS there is a need to ensure that future receptors at risk are prepared through methods such as public awareness campaign
2. **Does the option make space for water?** Options which provide additional space for water or does not restrict it are more likely to perform well in future scenarios. Option 1 would create this situation. Options which include hard defences restrict the water making water levels more sensitive to increased flow. Option 2 would create this situation
3. **Does the option deliver co-benefits?** No co-benefits were identified.
4. **Does the option provide flexibility?** A review of the potential options shows that overall for the option proposed, Hard Defences in flood cell 1, has moderate adaptability as the existing and proposed defences could be raised with moderate cost, effort and impact.
5. **Does the option allow for deferring/removing or abandoning?** Given the present day risk there is no allowance for options to be deferred or any that could be removed later

An objective for each potential option is to ensure that flood risk can be managed effectively and sustainably into the future accounting for the potential impacts of climate change. Based on this future change adaptability assessment the table below summarises how well each option achieves this objective.

Summary of Option Adaptability		
Option	**Description**	**Score**
Option 1 – Improvement Channel Conveyance (FC 1)	Option is adaptable at moderate cost, difficulty and impact	2
Option 2 – Hard Defences (FC1)	Option is adaptable at moderate cost, difficulty and impact	3

8.5.7.5 Local Authority Comments

LA representatives reviewed preliminary options in April 2016.

8.5.7.6 Summary

There is moderate confidence in both the hydrology and hydraulics of the Callan AFA. Due to the lack of flood event data available, it was only possible to conduct a limited verification exercise on this model. However the model is shown to be a reasonable representation of the flood mechanisms described from the available flood event records and considered to be performing satisfactorily for design event simulation.

The following potential options, with a BCR ≥ 0.5 have been identified:

- Option 1 – Improvement of Channel Conveyance (FC 1) and FRM measures identified for UoM15
- Option 2 – Hard Defences (FC 1), and FRM measures identified for UoM15

Alongside any potential option the existing regime should continue with maintenance being carried out ad hoc when resources allow. Maintenance of the option structures should also form part of the ongoing regime once in place.

Methods also were identified at UoM level (see section 8.1) that are applicable to Callan AFA, that if implemented, will serve to avoid increasing flood risk in the future :

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

No communities are located upstream or downstream that would be affected by any of the potential options identified.

The Callan AFA is located within the River Barrow And River Nore SAC therefore this specially designated area would need to be addressed during the development of the preferred option. There are also 2 NIAH buildings within the AFA. These buildings in addition to Callan Bridge would also need to be addressed during the development of the preferred option.

It should be noted that has moderate / high sensitivity to climate change and is suitable for an assumptive approach be incorporated into detailed design.

These recommendations should be taken forward with a view to identification of a preferred option for the flood risk management plan.

List of background information to be included:

1. Costings
- Flood cell 1 – Whole Life Costs- Improvement of Channel Conveyance
- Flood cell 1 – Whole Life Costs- Hard Defences

2. MCA
- Option 1 – Improvement of Channel Conveyance
- Option 2 - Hard Defences

3. Potential Option drawings
- Option 1 – Improvement of Channel Conveyance
- Option 2 - Hard Defences

8. OPTIONEERING OF SSA'S

8.6 Freshford Optioneering of FRM Options

Name	Local Authority	Unique ID	SSA	Status	Date
Freshford	Kilkenny	150190	AFA	Final	13/06/2016

8.6.1 Source of flooding

Fluvial	Coastal Mechanism 1	Coastal Mechanism 2

8.6.2 Flood Cells

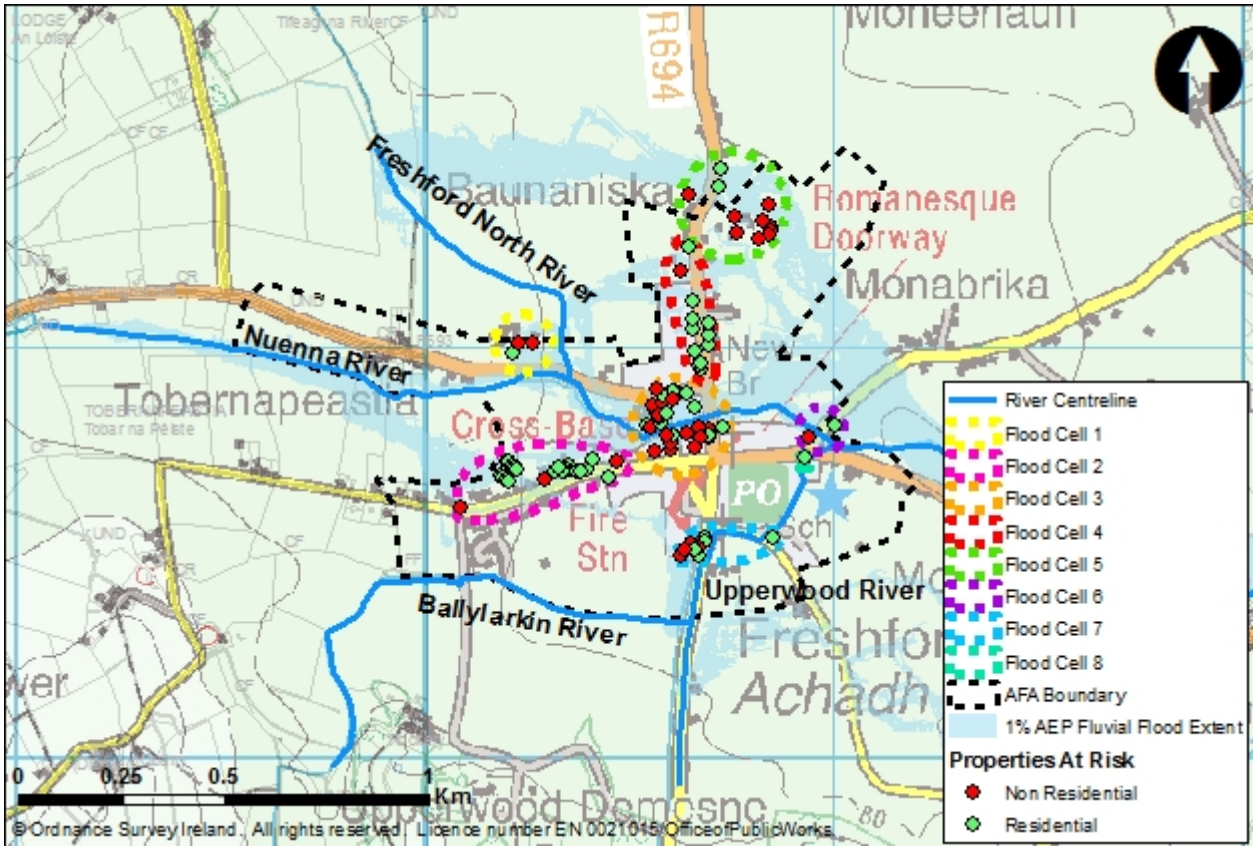


Figure 8.6.1 Freshford AFA Flood Cells within a 1% AEP Fluvial Flood Extent

Flood Cell 1:
Out of bank flooding would occur on the Nuenna River and Freshford North River during a 1% AEP flood event due to insufficient channel capacity and would inundate the floodplain. Three properties are located on the periphery of this floodplain and would be affected by flooding during a 1% AEP flood event. Given that flood cells 3 & 6 are located downstream, and flood cells 2, 4, 5, 7 & 8 are subsequently affected, the flood risk to flood cell 1 is considered complex.

Flood Cell 2:
Out of bank flooding would occur on the Nuenna River during a 1% AEP flood event due to insufficient channel capacity and would inundate the floodplain. A combination of out of bank flow from both upstream and downstream of the flood cell would result in 23 properties being affected. Given that flood cells 7 & 8 are affected by overland flow from this flood cell, the flood risk to flood cell 2 is considered complex.
Flood Cell 3:
Out of bank flooding would occur on the Nuenna River during a 1% AEP flood event due to insufficient channel capacity and would inundate the floodplain affecting 31 properties. Given that flood cells 1 & 6 are located upstream and downstream respectively and flood cells 2, 4 & 5, which are adjacent, would be affected, the flood risk in flood cell 3 is considered complex.
Flood Cell 4:
Out of bank flooding would occur on the Nuenna River and Freshford North River during a 1% AEP flood event due to insufficient channel capacity and would inundate the floodplain. The combined out of bank flow would affect 12 properties in flood cell 4. Given that flood cells 1 & 6 are located upstream and downstream respectively and flood cells 3 & 5 which are adjacent would be subsequently affected, the flood risk in flood cell 4 is considered complex.
Flood Cell 5:
Out of bank flooding would occur on the Nuenna River and Freshford North River during a 1% AEP flood event due to insufficient channel capacity and would inundate the flood plain affecting 11 properties. Given that flood cell 5 is affected by overland flow from flood cells 1, 3 & 4, the flood risk to flood cell 5 is considered complex.
Flood Cell 6:
Out of bank flooding would occur on the Nuenna River and Freshford North River during a 1%AEP flood event due to insufficient channel capacity and would inundate the flood plain affecting 2 properties. Given that flood cells 1 & 3 are located upstream, the flood risk to flood cell 6 is considered complex.
Flood Cell 7:
Out of bank flooding would occur on the Upperwood River and the Nuenna River during a 1%AEP flood event due to insufficient channel capacity and would inundate the flood plain affecting 10 properties. Given that flood cell 8 is located downstream, the flood risk to flood cell 7 is considered complex.
Flood Cell 8:
Out of bank flooding would occur on the Upperwood River during a 1%AEP flood event due to insufficient channel capacity and would inundate the flood plain affecting 1 property. Given that flood cell 7 is located upstream, the flood risk to flood cell 8 is considered complex.

Summary of Flood Cells:

As shown in Figure 8.6.1 the main flood risk originates from the Nuenna River and Freshford North River with further risk from the Upperwood River. Flood cells 1-8 are affected by the flood mechanisms from these rivers with a complex system of interaction between them. Due to the complexity and interaction between these flood cells it is considered appropriate that they are screened together as one large complex system in the screening process (Section 8.6.5).

8.6.3 Existing Regime

The existing regime considers all activities currently carried out which impact on the management of flood risk. The level and frequency of maintenance is considered, along with inspection, and any other specific activity (for example the operation of locks, barrages, sluice gates and valves).

The watercourses in Freshford are, for the most part, in private lands and are not the responsibility of Kilkenny County Council. Nevertheless, inspection and maintenances are carried out as and when resources are available. The existing regime does not provide the preferred standard of protection and maintaining the existing regime will only be suggested as an appropriate method should no other options pass the optioneering process.

8.6.4 Summary of Flood Risk within SSA boundary

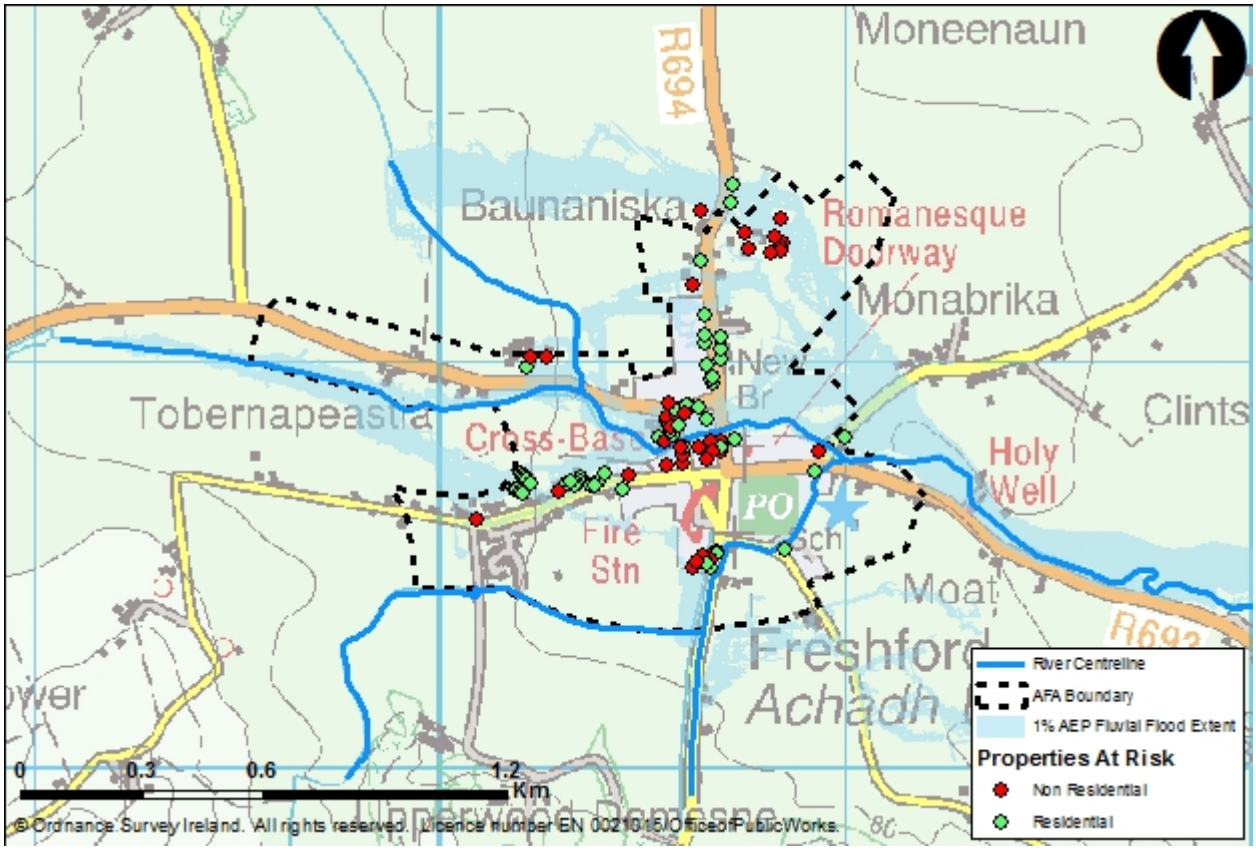


Figure 8.6.2 Flood Risk in Freshford AFA within a 1% AEP Fluvial Flood Extent

In Freshford AFA residential and non-residential property damage occurs in the 50% AEP event.

Monetary Damage and Benefit

	Flood Cells 1-8	Total in AFA
Annual Average Damage (AAD)	€ 2,087,598	€ 2,095,292
Present Value Damage (pvD)	€ 44,845,781	€ 45,011,056
Preferred Standard of Protection (SoP)	1%AEP	1%AEP
Number of Properties Benefiting from Design SoP	93	93
Minimum Present Value Benefit	€42,711,605	€42,711,605
Capped Minimum Present Value Benefit	€13,421,732	€13,421,732

*The sum of the flood cell AAD or pvD values may not equate to the values presented for the Total in SSA due to flooding greater than the 1% AEP occurring outside the flood cell extents.

8.6.5 Short Listing FRM Methods – Complex Cells

Method	Review Comment	Continue Screening
		Flood Cells 1-8
Do Nothing	Consider Further	✓
Additional Maintenance	Consider Further	✓
Do Minimum	Consider Further	✓
Planning and Development Control	Consider at UoM SSA - Reject	×
Building Regulations	Consider at UoM SSA - Reject	×
Catchment Wide SuDs	Consider at UoM SSA - Reject	×
Land Use Management	Consider Further	✓
Strategic Development Management	Consider at UoM SSA - Reject	×
Storage	Consider Further	✓
Improvement of Channel Conveyance	Consider Further	✓
Hard Defences	Consider Further	✓
Relocation of Properties	Consider Further	✓
Diversion of Flow	Consider Further	✓
Flood Warning/Forecasting	Consider Further	✓
Public Awareness Campaign	Consider at UoM SSA - Reject	×
Individual Property Protection	Consider Further	✓
Other Works	Consider Further	✓

8.6.5.1 Feasibility Review Summary for Complex Cells (flood cells 1-8)

Method	Technical Screening	Economic Screening	Environmental and Cultural Heritage Screening	Social Screening
Do nothing	×			
Additional Maintenance	×			
Do Minimum	×			
Land Use Management	✓	✓	?	✓
Storage	✓	✓	?	✓
Improvement of Channel Conveyance	✓	✓	?	✓
Hard Defences	×			
Relocation of properties	✓	×		
Diversion of Flow	✓	✓	?	✓
Flood Warning/Forecasting	×			
Individual Property Protection	×			
Other Works	×			

× - Reject ✓ - Progress ? - Progress, potential for impacts identified ! - Progress, potential for significant impacts identified

8.6.5.2 Justification for Rejection/Retention

Method	Tech	Econ	Env	Soc
Do nothing	×			

The do nothing FRM method would involve stopping the current maintenance regime. This would not provide the preferred SoP and therefore was rejected from the screening process.

Method	Tech	Econ	Env	Soc
Additional Maintenance	×			

This method considers whether improvements can be made to augment the existing maintenance regime which will provide a significant beneficial impact on flood risk in the AFA. A review was carried out of the existing watercourse network. This included assessing the channel vegetation, the amount of debris present in the channels and the likelihood of structures blocking.

Increasing maintenance activities on the relevant watercourses will not significantly contribute to achieving the preferred SoP and therefore will not be pursued under the CFRAM Study.

Method	Tech	Econ	Env	Soc
Do Minimum	✗			

This is appropriate where an isolated/single issue exists which can be easily addressed in order to reduce the flood risk, for example the removal of a pinch point/obstruction, or the upgrade of a blockage prone culvert screen, etc. These activities would be considered relatively straightforward, discrete and low cost. Do Minimum is a standalone method, as it cannot be combined with others without contradicting its definition, therefore the design SoP must be achieved for this method to progress.

In flood cells 1-8, there are no areas where a do minimum approach is suitable or would have any significant impact on flood risk. This is an unacceptable outcome in terms of contributing to achieving a 1%AEP standard of flood protection and this method was rejected from the screening process.

Method	Tech	Econ	Env	Soc
Land Use Management	✓	✓	?	✓

This method is considered in section 8.1 at UoM scale. The screening found that Catchments 1-4 do have a large portion of agricultural land use that would provide enough area for employing NFM methods. Therefore Freshford AFA would be suitable as a pilot area. Progressing Land Use Management in a pilot area should not take precedence over other methods which will provide the design SoP. This method should therefore be progressed only if all other methods be found unsuitable.

Method	Tech	Econ	Env	Soc
Storage	✓	✓	?	✓

This method considers areas where flood water can be stored and then released at a controlled rate therefore reducing the flow rate through the AFA and reducing the level of flood risk. This can be achieved by using existing depressions to create online or offline storage areas or by identifying pinch points which could be dammed such as a restricted point along a valley. Storage areas can be effective either upstream of the risk areas or within the risk area where parks or open areas are located.

A review of the surrounding topography was carried out to locate possible storage areas. Six potential storage areas were identified as shown in Figure 8.6.3.

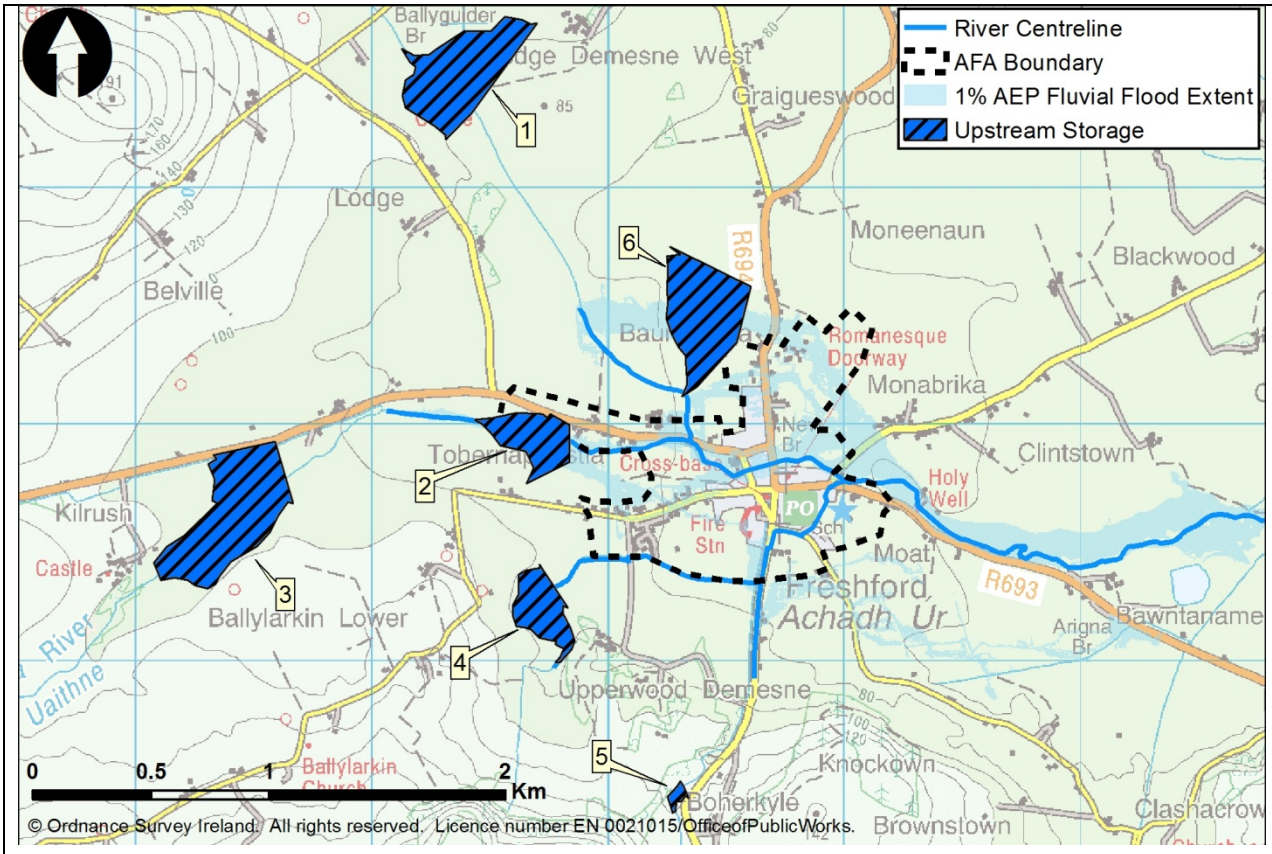


Figure 8.6.3 Potential storage areas for Freshford AFA

For Flood Cell 2, which contains properties at risk of flooding from the Nuenna River, there is potential for storage to provide protection to all properties at risk. The volume of water required to be stored on the Nuenna River has been estimated to be 102,406 m^3. Potential storage area 3 identified in Figure 8.6.3 is needed to provide the design SoP to all properties at risk in flood cell 2. Construction of this storage area would require an embankment with an average height of 3.4m and a total length of approximately 455m. In addition, 1 culvert is required to act as a flow control device and convey flow through the embankment.

For Flood Cells 4 and 5, which contain properties at risk of flooding from the Freshford North River, there is potential for storage to provide protection to all properties at risk. The volume of water required to be stored on the Freshford North River has been estimated to be 221,976 m^3. Potential storage areas 1 and 6 identified in Figure 8.6.3 are needed to provide the design SoP to all properties at risk in flood cells 4 and 5. Construction of storage area 1 would require an embankment with an average height of 3.8m and a total length of approximately 615m. In addition, 1 culvert is required to act as a flow control device and convey flow through the embankment. Construction of storage area 6 would require an embankment with an average height of 3.4m and a total length of approximately 850m. In addition, a weir on the Freshford North River and a new channel is required to convey the flood water to the storage area. One culvert through the embankment and a new flow return channel are also required.

For Flood Cells 7 and 8, which contain properties at risk of flooding from the Ballylarkin and Upperwood Rivers, there is potential for storage to provide protection to all properties at risk. The volume of water required to be stored on the Ballylarkin River has been estimated to be 29,356 m^3. Potential storage area 4 identified in Figure 8.6.3 is needed to provide the design SoP to all properties at risk in flood cells 7 and 8. Construction of storage area 4 would require an embankment with an average height of 2.7m and a total length of approximately 85m. In addition, 1 culvert is required to act as a flow control device and convey flow through the embankment. A further potential storage area – Storage area 5 (Figure 8.6.3) was identified on the Upperwood Watercourse but does not provide the storage required to provide the full SoP to properties at risk within flood cells 7 and 8.

Storage is not technically feasible as a standalone method for flood cells 1, 3 & 6. Storage area 2 (Figure 8.6.3) was identified as a potential storage location, however, the storage available in Storage areas 2 and 3 combined is not sufficient to protect the properties in flood cells 1, 3 and 6. Similarly, the combination of storage areas 1 and 6 on the Freshford North River do not provide sufficient storage to protect the properties in flood cells 1, 3 and 6. Therefore, Storage could only be used in conjunction with another method to protect flood cells 1, 3 and 6 in order to create a complete option. An economic review estimated the cost of constructing 4 storage areas (1, 3, 4 and 6) to be €2.95m making this method potentially economically viable subject to the costs of the measure with which it is combined.

The proposed storage areas are not located within any environmental designations; however there may be potential impacts to the River Barrow and River Nore SAC and the River Nore SPA downstream of the flood cells.

Method	Tech	Econ	Env	Soc
Improvement of Channel Conveyance	✓	✓	?	✓

This method focuses on increasing watercourse conveyance thereby lowering water levels and reducing the associated flood risk. This can be achieved by lowering bed level, widening/reshaping channels, removing channel/structure constrictions, culverting reaches of watercourse and reducing roughness of the channel. While some of these activities can also form part of the 'Do Minimum' method, Improvement of Channel Conveyance differs in that it holistically addresses all risk areas while the other two methods consider one or more discrete activities.

In Flood cell 1, the predicted flooding is due to insufficient channel capacity from both the Nuenna and Freshford North Rivers. Raised river bed levels and the presence of two weirs on the Nuenna River and one weir on the Freshford North river contribute to the reduced channel capacity. Lowering of bed levels and removal of structure constrictions were identified as the only suitable methods to significantly improve channel conveyance. Two reaches were identified as having the potential to be dredged in order to improve channel conveyance (Reach 1 and Reach 2 - Figure 8.6.4, Figure 8.6.6 and Figure 8.6.7). The total length of river subject to dredging was calculated to be 681 metres requiring a total volume of 6,031 m^3 to be excavated. Underpinning of one existing bridge and removal of three existing weirs would also be required.

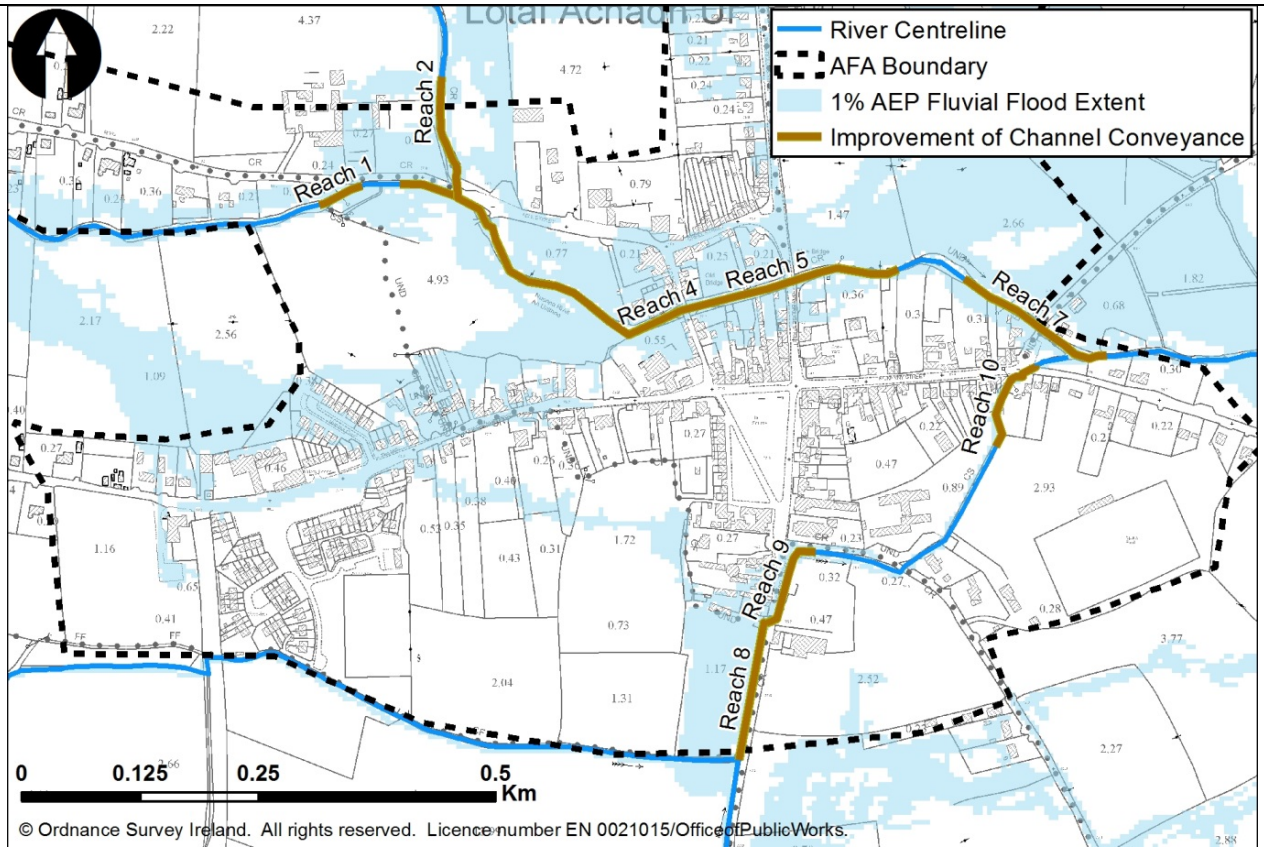


Figure 8.6.4 Locations identified for Channel Improvement on the Nuenna, Freshford North & Upperwood Rivers

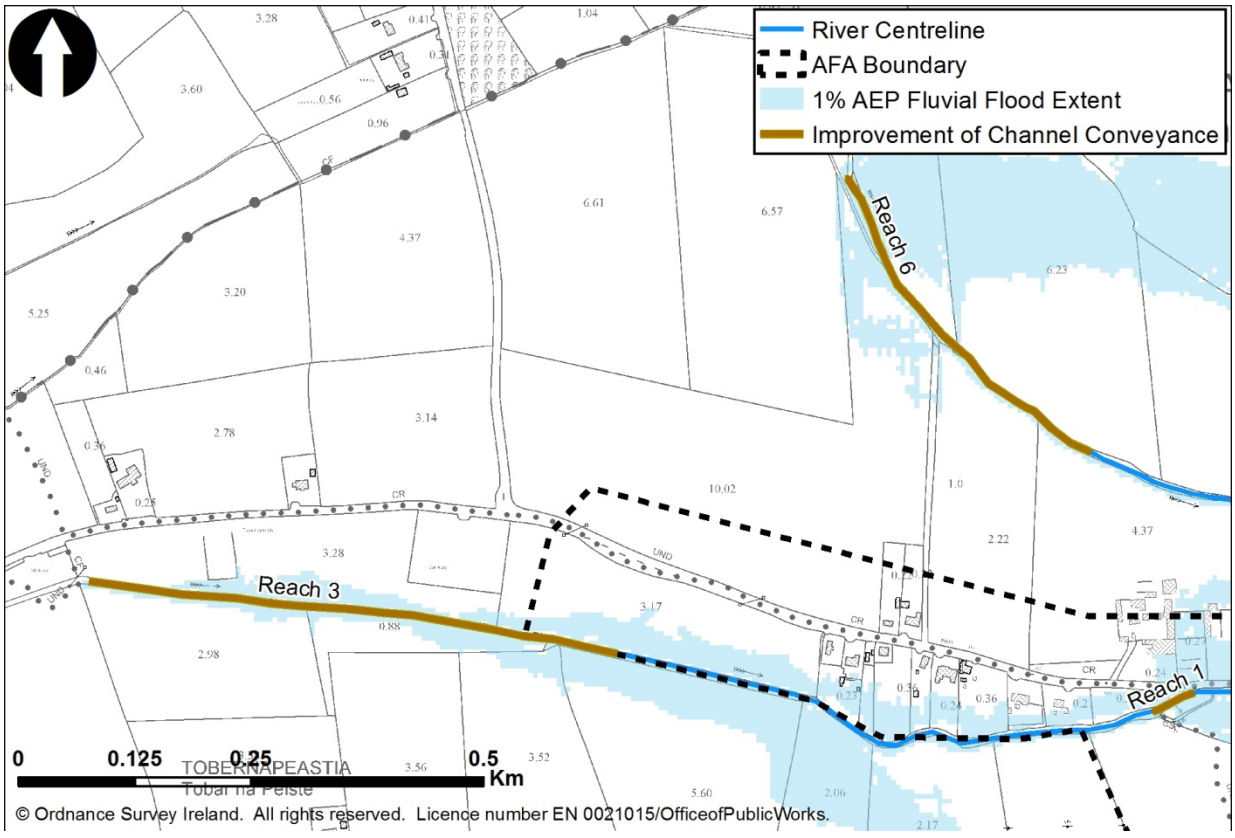


Figure 8.6.5 Locations identified for Channel Improvement on the Nuenna and Freshford North

Rivers

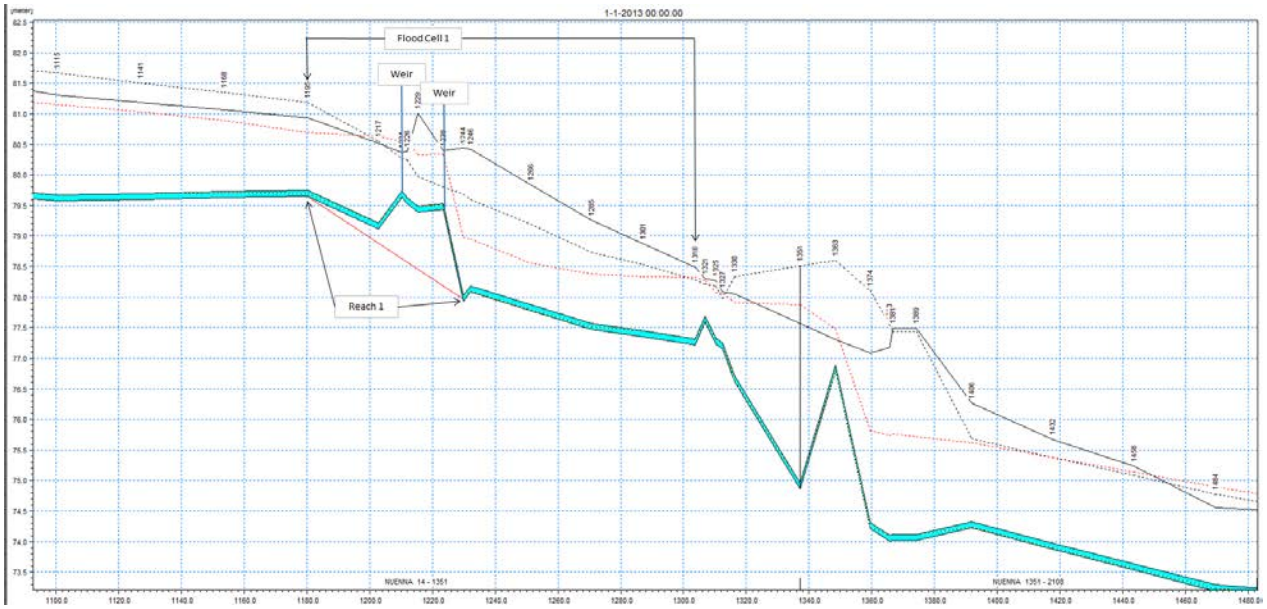


Figure 8.6.6 Long section of Nuenna River highlighting Reach 1

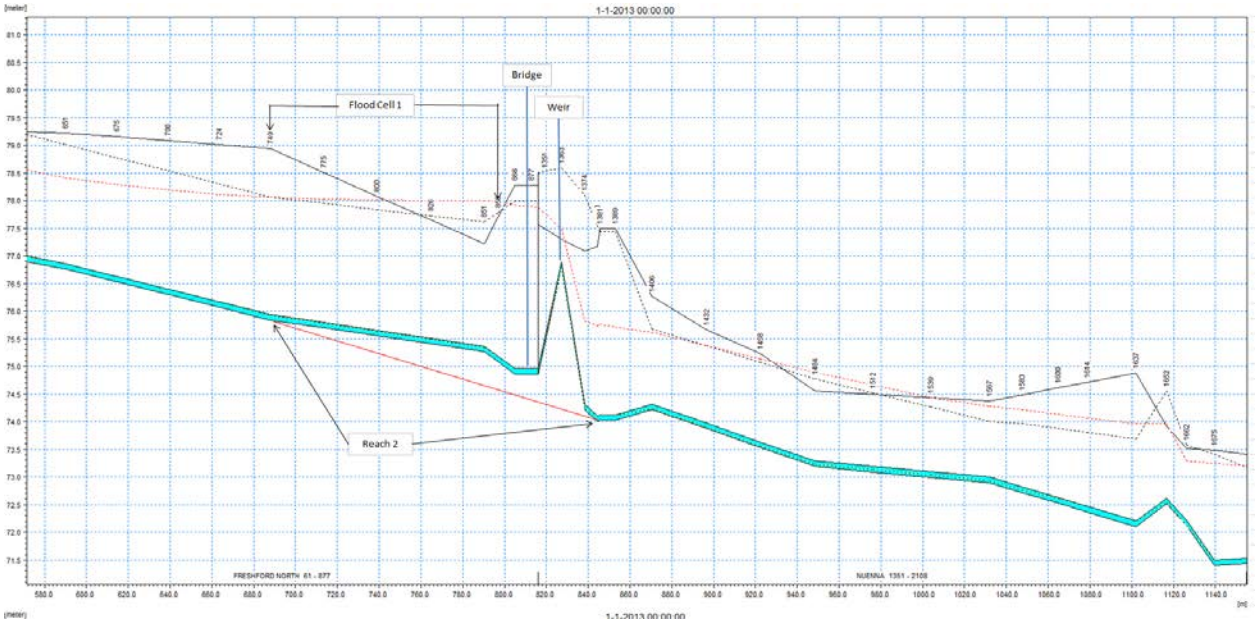


Figure 8.6.7 Long section of Freshford North River highlighting Reach 2

In Flood cell 2, the predicted flooding is due to insufficient channel capacity from the Nuenna River. Raised river bed levels contribute to the reduced channel capacity, again lowering bed levels and removing structure constrictions were identified as the only suitable methods to significantly improve channel conveyance. There was one reach identified which had the potential to lower bed levels at the upstream source of flooding for Flood Cell 2 (Reach 3 in Figure 8.6.5 and Figure 8.6.8). One reach was identified as having the potential to be dredged in order to improve channel conveyance at the downstream source of flooding for Flood Cell 2 (Reach 4 in Figure 8.6.4 and Figure 8.6.9).

In Flood cell 3, the predicted flooding is due to insufficient channel capacity from the Nuenna River with raised river bed levels contributing to the reduced channel capacity. Lowering bed levels and removing structure constrictions were identified as the only suitable methods to significantly improve channel conveyance. One reach was identified as having the potential to be dredged in order to improve channel

conveyance at the downstream source of flooding for Flood cell 3 (Reach 5 in Figure 8.6.4 and Figure 8.6.9).

The total length of reaches 3, 4 and 5 subject to dredging was calculated to be 980 metres requiring a total volume of 10,600 m^3 to be excavated. Underpinning of three existing bridges and removal of one existing weir would also be required.

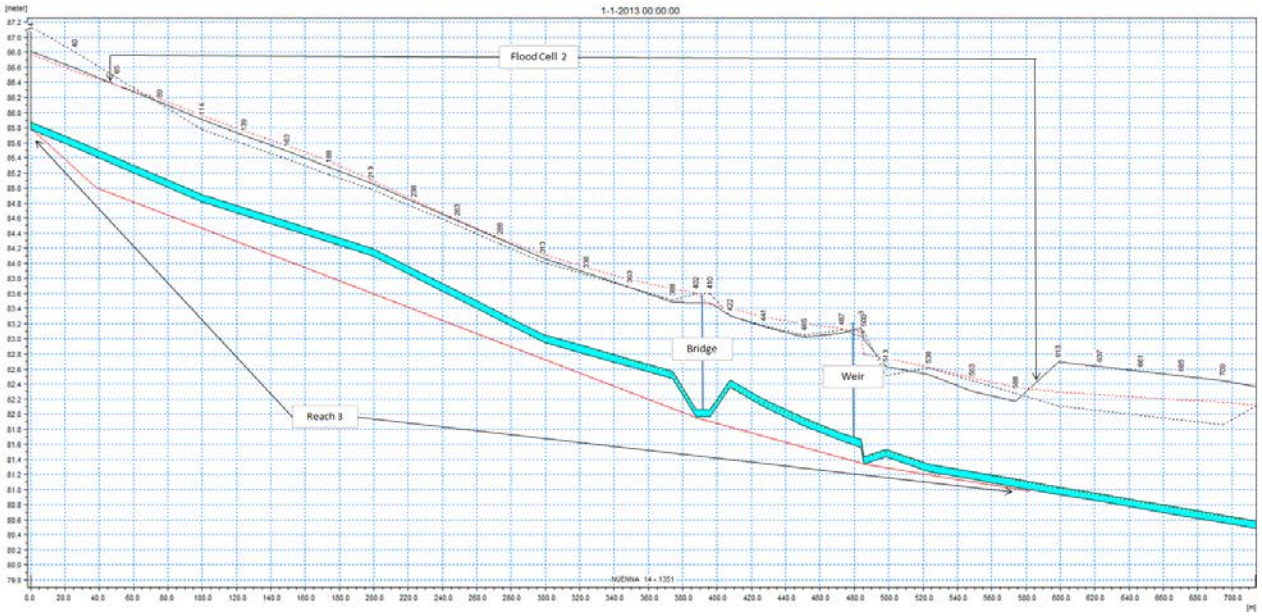


Figure 8.6.8 Long section of Nuenna River highlighting Reach 3

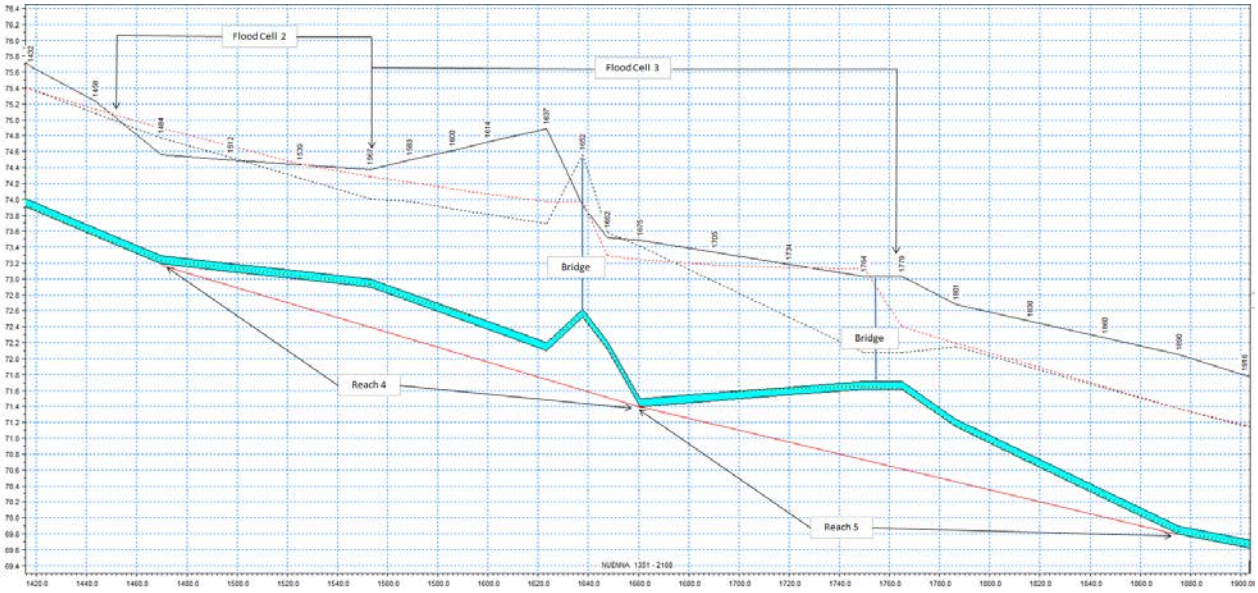


Figure 8.6.9 Long section of Nuenna River highlighting Reaches 4 and 5

In Flood cell 4, the predicted flooding is due to insufficient channel capacity already identified above for Flood cells 1, 2 and 3.

In Flood cell 5, the predicted flooding is due to insufficient channel capacity on the Freshford North River. A review indicated that lowering bed levels and removing structure constrictions were the only suitable methods to significantly improve channel conveyance. One reach was identified as having the potential to be dredged in order to improve channel conveyance (Reach 6 in Figure 8.6.5 and Figure 8.6.10). The total length to be dredged was calculated to be 407 metres, requiring excavation of a total volume of 3,907 m^3.

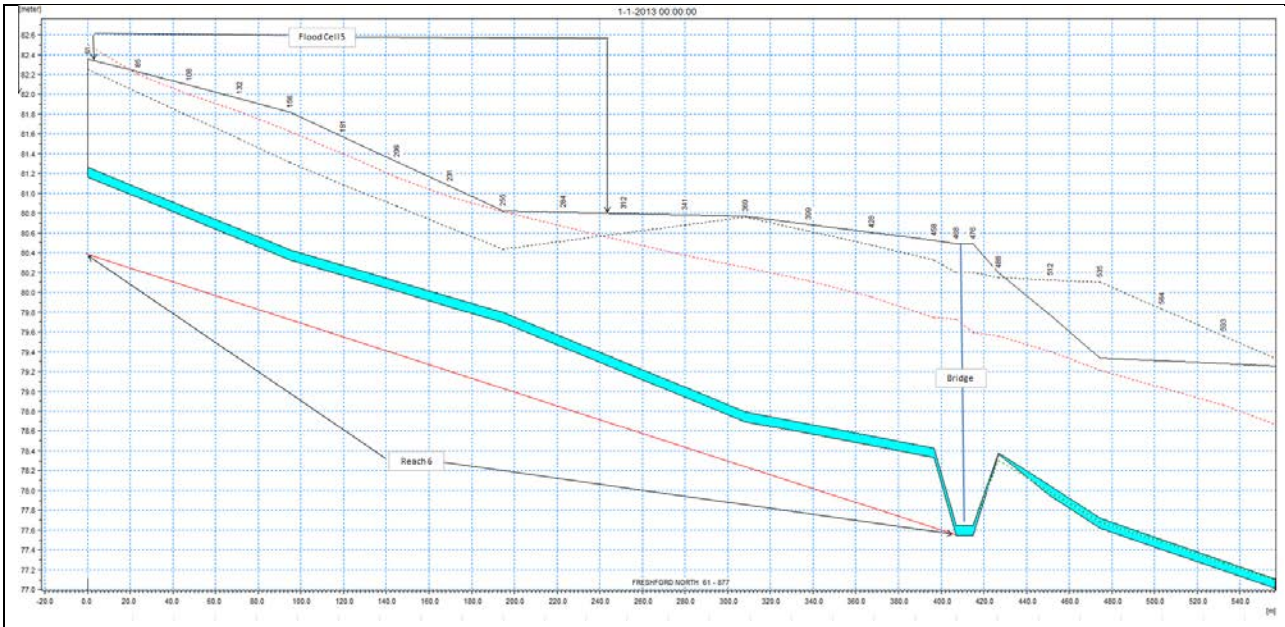


Figure 8.6.10 Long section of Nuenna River highlighting Reach 6

In Flood cell 6, the predicted flooding is due to insufficient channel capacity from the Nuenna River. One reach was identified as having the potential to be dredged in order to improve channel conveyance (Reach 7 in Figure 8.6.4 and Figure 8.6.11). The total length of river subject to dredging was calculated to be 175 metres requiring a total volume of 860 m^3 to be excavated. Underpinning of one existing bridge would also be required.

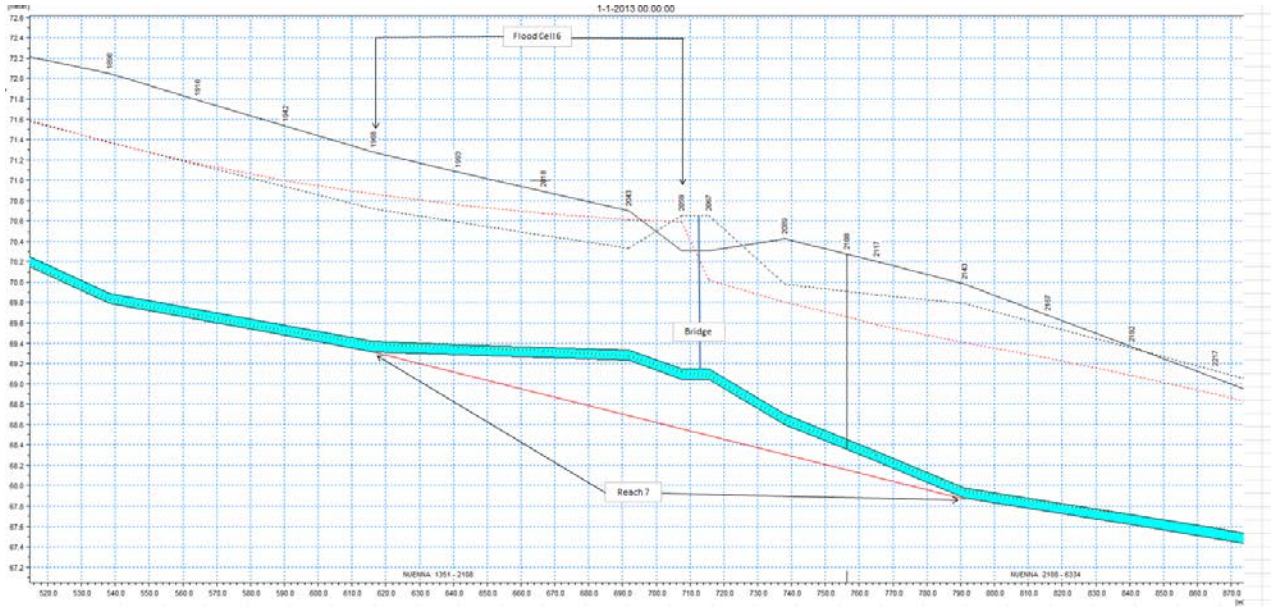


Figure 8.6.11 Long section of Upperwood Watercourse highlighting Reach 7

In Flood cell 7, the predicted flooding is due to insufficient channel capacity from the Upperwood watercourse. Two reaches were identified as having the potential to be dredged in order to improve channel conveyance (Reach 8 and Reach 9 in Figure 8.6.4 and Figure 8.6.12). The total length of river subject to dredging was calculated to be 255 metres requiring a total volume of 760 m^3 to be excavated. Underpinning of two existing bridges would also be required.

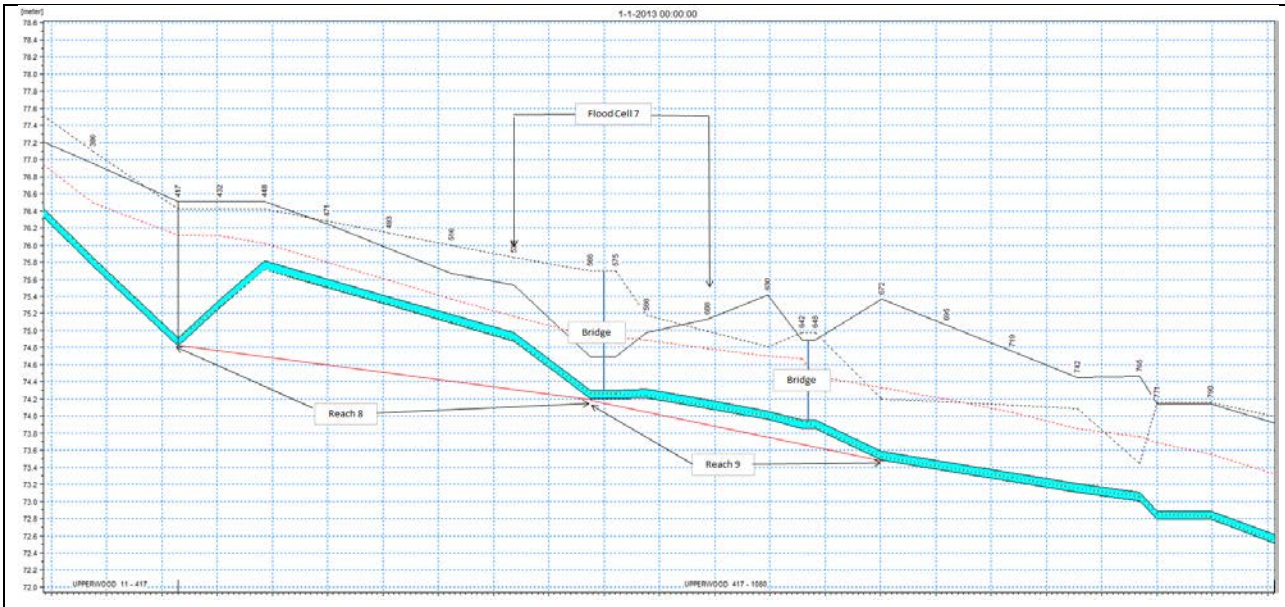


Figure 8.6.12 Long section of Upperwood Watercourse highlighting Reaches 8 and 9

In Flood cell 8, the predicted flooding is due to insufficient channel capacity from the Upperwood watercourse. One reach was identified as having the potential to be dredged in order to improve channel conveyance (Reach 10 in Figure 8.6.4 and Figure 8.6.13). The total length of river subject to dredging was calculated to be 110 metres requiring a total volume of 170 m^3 to be excavated. Underpinning of two existing bridges would also be required.

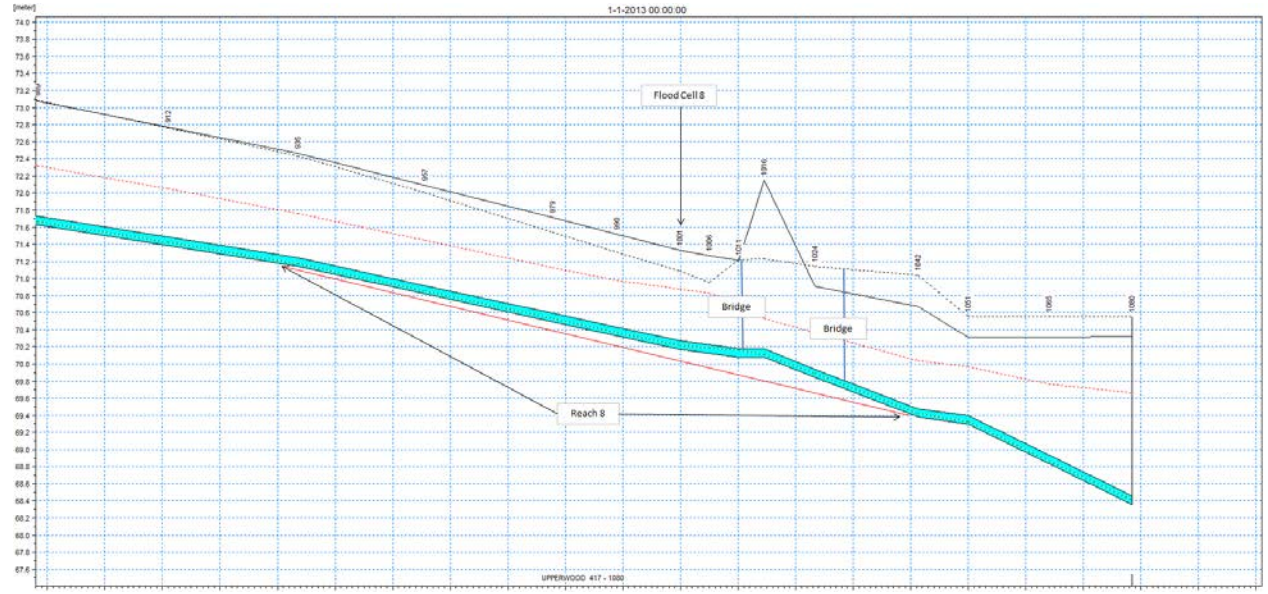


Figure 8.6.13 Long section of Upperwood Watercourse highlighting Reach 10

A further improvement of channel conveyance which could be used in combination with other FRM methods to provide the preferred SoP and prevent further flooding would be the lowering of bed level by approximately 0.4m between Chainage 140 and Chainage 356 along the Upperwood watercourse, shown below in Figure 8.6.14.

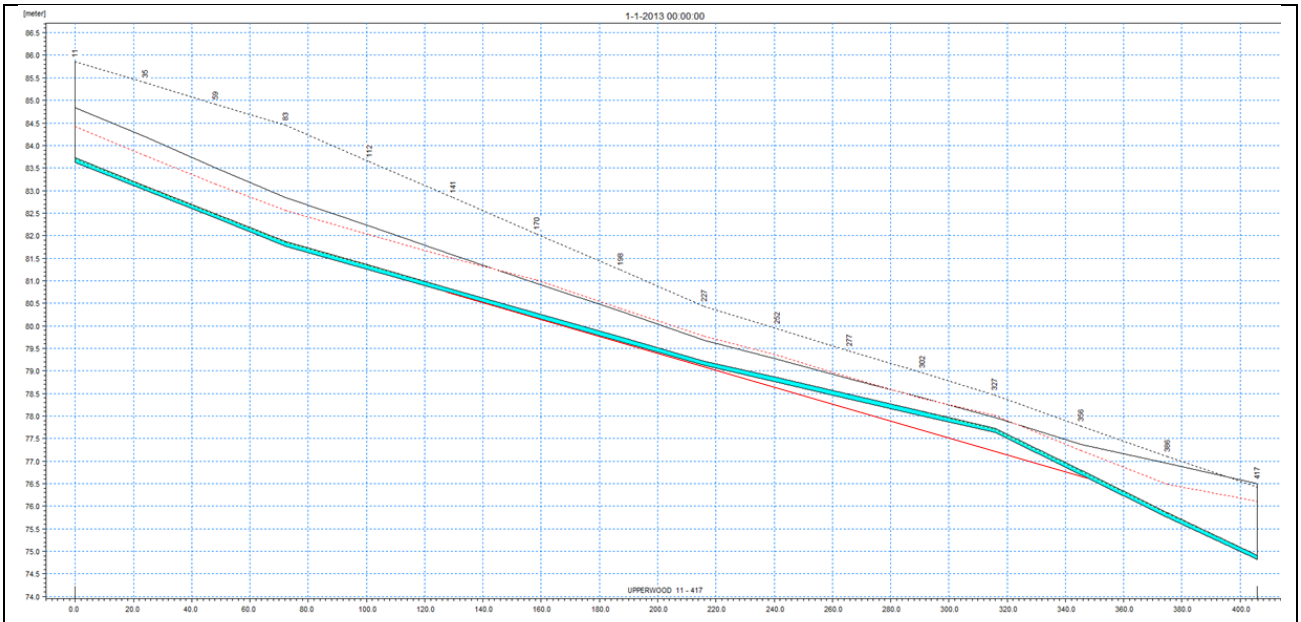


Figure 8.6.14 Long Section of Upperwood Watercourse highlighting potential for improvement of channel conveyance in combined methods

Improvement of channel conveyance is unsuitable as a standalone FRM method as it cannot provide the preferred SoP to all properties at risk. This method may be suitable as part of a combined method, subject to the cost of the methods with which it is combined.

The AFA is over 3km upstream of the River Barrow and River Nore SAC and the River Nore SPA. The Cullahill Mountain SAC and the Spahill and Clomantagh Hill SAC are over 7km upcatchment of the AFA. There are no UNESCO World Heritage Sites in the vicinity of, or downstream of the AFA, and any AFA specific FRM methods to be employed.

Method	Tech	Econ	Env	Soc
Hard Defences	✗			

The term Hard Defences refers to physical barriers which prevent water from entering an area such as flood walls, embankments and barrages. As a general rule Hard Defences are kept as far back from the river channel or coast line as possible allowing the floodplain function to remain active. Where this is not possible, due to flood risk receptors being located within the floodplain, Hard Defences are placed around the property boundary to afford it protection. Where space allows flood embankments are used but where space is restricted flood walls are utilised.

A review was carried out to ascertain where Hard Defences would be required to protect existing property within flood cells 1-8. Figure 8.6.16 and Figure 8.6.15 shows the location of the Hard Defences required to protect properties during the 1% AEP event.

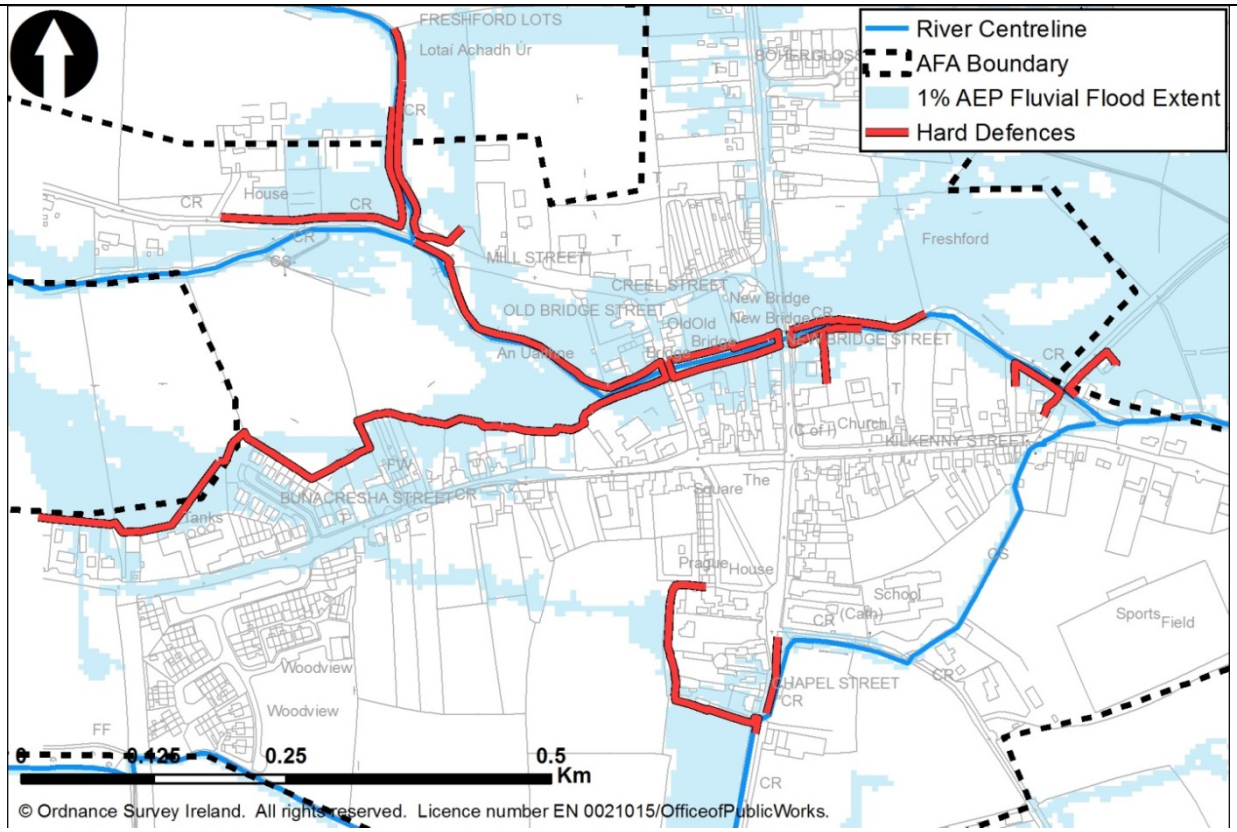


Figure 8.6.15 Location of Hard Defences for flood cells 1-4 and 6-8

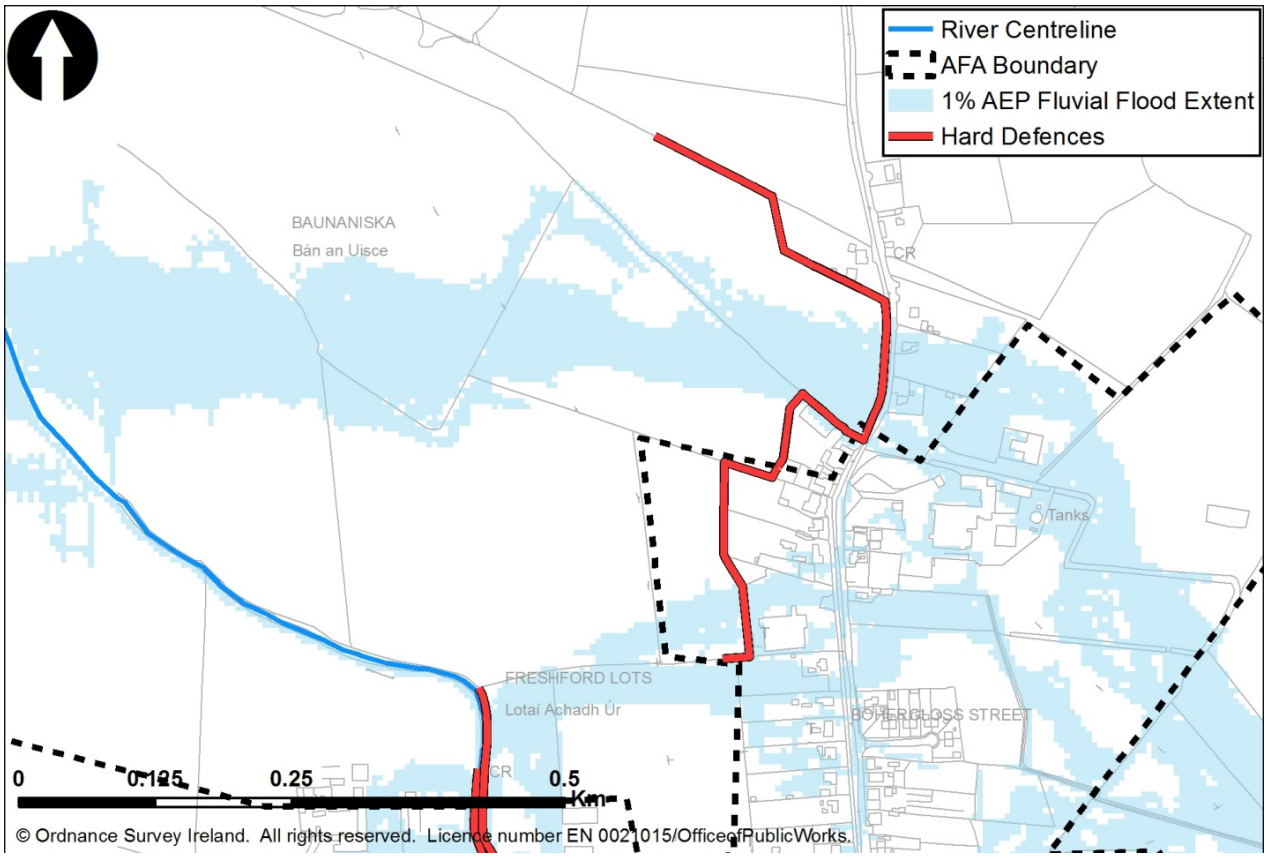


Figure 8.6.16 Location of Hard Defences for flood cell 5

In order to ascertain the effectiveness of Hard Defences a hydraulic model was constructed to simulate the method. The model showed these hard defences would protect to the 1% AEP flood event with a total wall length of 642m and a total embankment length of 2.75 km. However, 300m of these hard defences would be greater than 3m high which is considered technically unfeasible. Therefore, this method was rejected from the screening process.

Method	Tech	Econ	Env	Soc
Relocation of properties	✓	✗		

To relocate a property is to abandon the existing at risk property and provide an alternative in a location not at risk. While this method is, in theory, possible, it is not practical for a whole town of many at risk properties. Its use is more applicable for discrete areas where single properties or clusters of properties are located.

An assessment of the distribution of properties within flood cells 1-8 was carried out. Although undesirable due to the number of properties that would require relocation, this method is considered technically feasible. An economic review estimated the cost of relocation of properties to be €34m making this method economically unviable.

Method	Tech	Econ	Env	Soc
Diversion of Flow	✓	✓	?	✓

This method involves directing some of the floodwater via a new route thereby reducing flow and associated flood risk along the original route. This would be carried out upstream of where floodwaters reach the area of at risk properties. The new flow route would normally consist of a constructed open channel and/or culvert system or an existing linear feature able to convey the flow to a designated discharge point.

A review was carried to identify potential Flow Diversion routes in the vicinity of flood cells 1-8. It was established that two flow diversion channels would be required in order to provide the required SoP to all properties within flood cells 1-8. The first route identified, diverts flow from the Freshford North River, upstream of all of the flood cells, to the Nuenna River (downstream of the flood cells) bypassing Freshford town to the north as shown in Figure 8.6.17. The second route identified diverts flow from the Nuenna River, upstream of all of the flood cells, to the Nuenna River (downstream of the flood cells) bypassing Freshford town to the south as shown in Figure 8.6.17. This route involves following the existing route of the Ballylarkin River for 600 m.

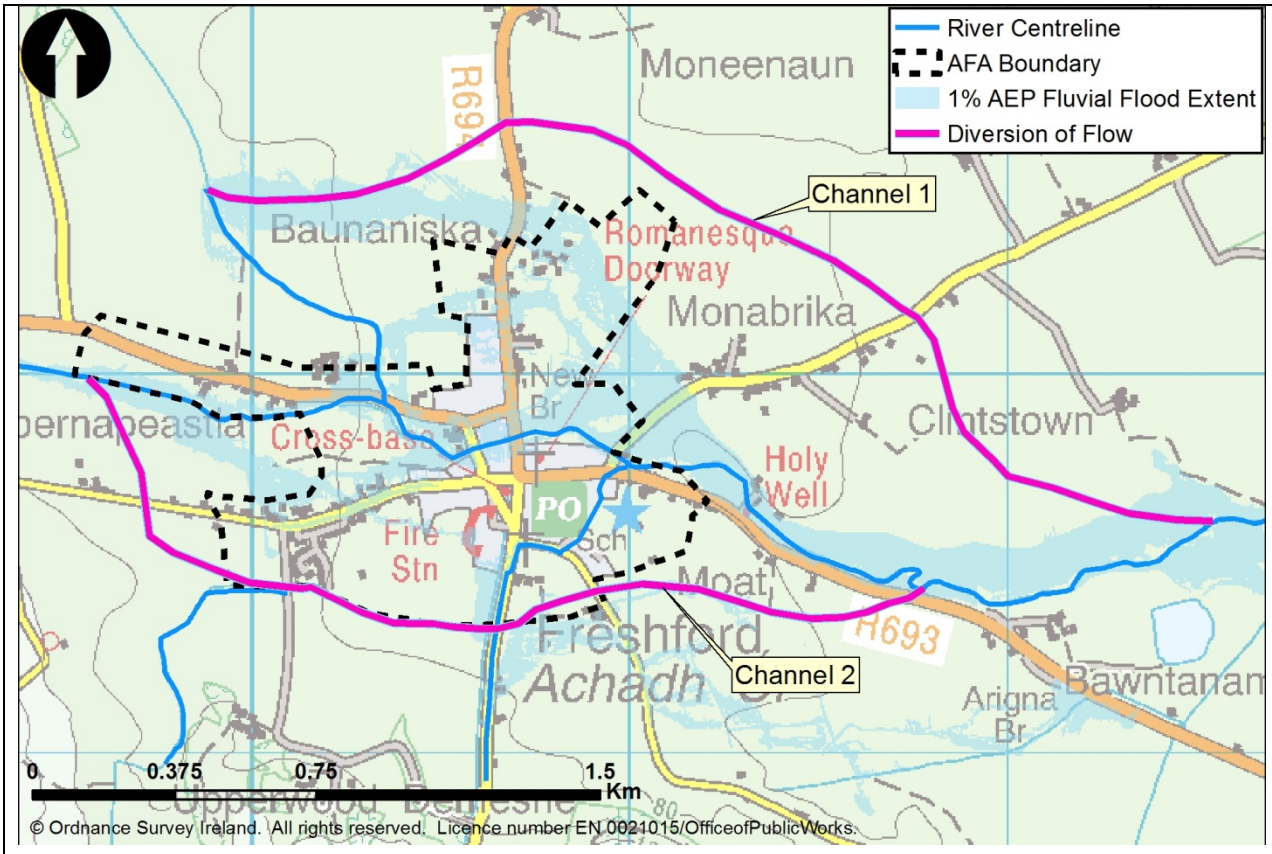


Figure 8.6.17 Location of Flow Diversion Channel 1 and Channel 2

A channel and culvert capacity assessment was carried out to estimate the flow that each diversion channel would convey. A reduction in peak flow of 9.4 m^3/s is required to prevent flooding to receptors – it is assumed that each diversion channel would be required to convey this discharge. Channel 1 is required to be 3.12km long, 3m wide and 1.5m deep. The road crossings would require two 2.1m x 1m box culverts. Channel 2 is required to be 2.6km long, 3.5m wide for the first 878m and 3m wide for the remainder and 1.5m deep. The 600m reach of Channel 2 which follows the Ballylarkin River has sufficient depth but requires widening by 3m to avoid increasing the flood risk locally. The road crossings would require five 2.1m x 1m box culverts, a weir control at the confluence with the Upperwood watercourse is also required.

An economic review estimated the flow diversion to be approximately €3.53m making this method economically viable.

The AFA is over 3km upstream of the River Barrow and River Nore SAC and the River Nore SPA. The Cullahill Mountain SAC and the Spahill and Clomantagh Hill SAC are over 7km upcatchment of the AFA. There are no UNESCO World Heritage Sites in the vicinity of, or downstream of the AFA, and any AFA specific FRM methods to be employed.

Method	Tech	Econ	Env	Soc
Flood Warning/Forecasting	x			

This method is considered in section 8.1 at UoM scale. The screening found flood warning/forecasting is not technically feasible as the available warning time on all of the watercourses in the Freshford AFA is less than 2 hours – therefore flood warning/forecasting is considered to be technically unfeasible and rejected.

Method	Tech	Econ	Env	Soc
Individual Property Protection	×			

This method is aimed at individual properties that are remote from the main risk areas. Where the AFA being considered consists of a small number of remote properties this method is a feasible solution. But for AFAs with multiple properties at risk this method would only be considered an add on to a primary method. Individual property protection could consist of flood gates and vent seals on the building structure itself. Where flood depths are over 0.6m this method becomes unfeasible and flood resilience techniques would be recommended over flood gates. As this method is temporary and relies of human intervention there is an element of uncertainty as to whether the full SoP will be met for every flood event. As such it is assumed that 20% of the flood damage will be avoided.

This method would not provide the preferred SoP to the affected properties. Given the generally grouped nature of properties and a significant proportion of those affected having a flood depth of greater than 0.6m, this method would not be technically the best method to use. For these reasons this method is considered technically unfeasible and rejected.

Method	Tech	Econ	Env	Soc
Other Works	×			

No other works were identified for these flood cells

8.6.5.3 Summary of Feasibility Review – Flood Cells 1-8

The following FRM methods have been carried forward to address the flood risk arising from flood cells 1-8;

- Storage
- Improvement of Channel Conveyance and
- Diversion of Flow.

Land Use Management should only be progressed should no other method providing the full SoP be found suitable in the Selection of Options phase.

Storage can provide the full SoP to 57 out of the 93 properties at risk during the 1% AEP fluvial flood event. As this method does not provide protection to all properties, this will need to be combined with another suitable method.

Improvement of Channel Conveyance and Diversion of Flow cannot provide the preferred SoP to all properties and will also need to be combined with another suitable method.

8.6.7 Selection of Options

Method	Option 1	Option 2	Option 3	Option 4
Improvement of Channel Conveyance	✓	✓		
Diversion of Flow	✓	✓		
Storage (flood cells 2, 4, 5, 7 and 8)		✓		

None of the above FRM methods can provide the full SoP to all properties so the methods are required to be combined.

Improvement of Channel Conveyance occurs along the Nuenna River and the Upperwood River.

For flood cells 2, 4, 5, 7 and 8; Storage can provide the full SoP to all properties.

8.6.7.1 Option 1 details – Diversion of Flow and Improvement of Channel Conveyance

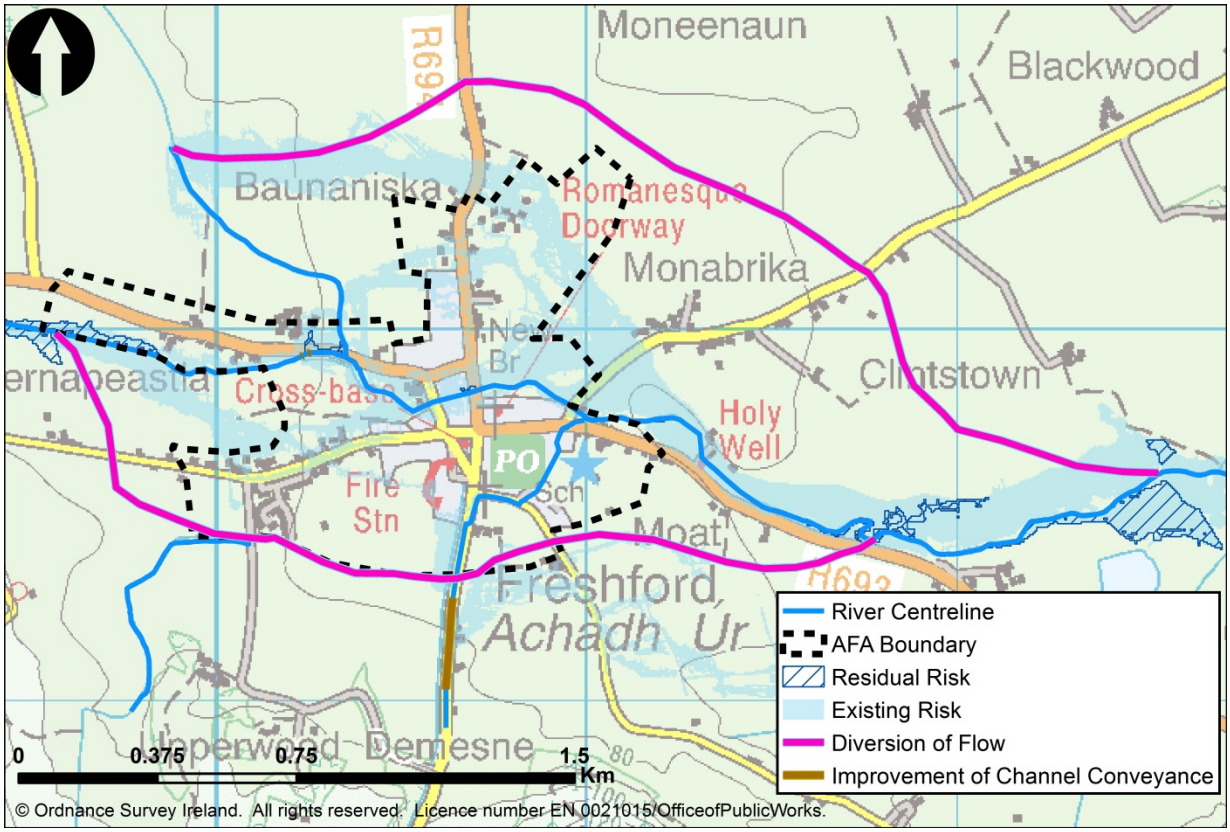


Figure 8.6.18 Freshford AFA Option 1

At risk properties would be protected by the construction of two flow diversion channels Channel 1 being 3.12km long, 3m wide and 1.5m deep and Channel 2 being 2.6km long, 3.5m wide for the first

878m and 3m wide for the remainder and 1.5m deep. This option would require seven 2.1m x 1m box culverts and a weir control at the confluence with the Upperwood watercourse. Two weirs would be removed on the Nuenna River (02WEIR02 at Chainage 1227 and 03WEIR01 and Chainage 1240). Improvement of Channel conveyance of the Upperwood River would involve the lowering of 216m of channel by 0.4m.

Figure 8.6.18 presents the effect of the potential option on the design flood event by overlaying the present day flood extent (labelled existing risk) with the flood extent that would occur after the option is put in place (labelled residual risk).

In addition to these methods the following was also identified at UoM level (see section 8.1) to be included in any potential option identified:

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

Option Item	Quantity	Construction Cost
Excavation on land	Two diversion channels total length 5.72km	€755,956
Excavation in channel	One reach, total length of 216m	€3,739
Weir construction	Three weirs	€102,300
Weir removal	Two weirs	€54,863
Culverts	Seven no.	€151,650

Total MCA-Benefit Score	Option Cost (€millions)	MCA-Benefit Score / Cost Ratio
1991	3.80	523.64

Economic Appraisal (Cost-Benefit Analysis) Outcomes			
Area NPVd (uncapped)	**Option Cost**	**Option NPVb (capped)**	**Benefit - Cost Ratio**
€45,011,056	€3,802,493	€13,421,732	3.53

8.6.7.2 Option 2 details – Storage, Diversion of Flow and Improvement of Channel Conveyance

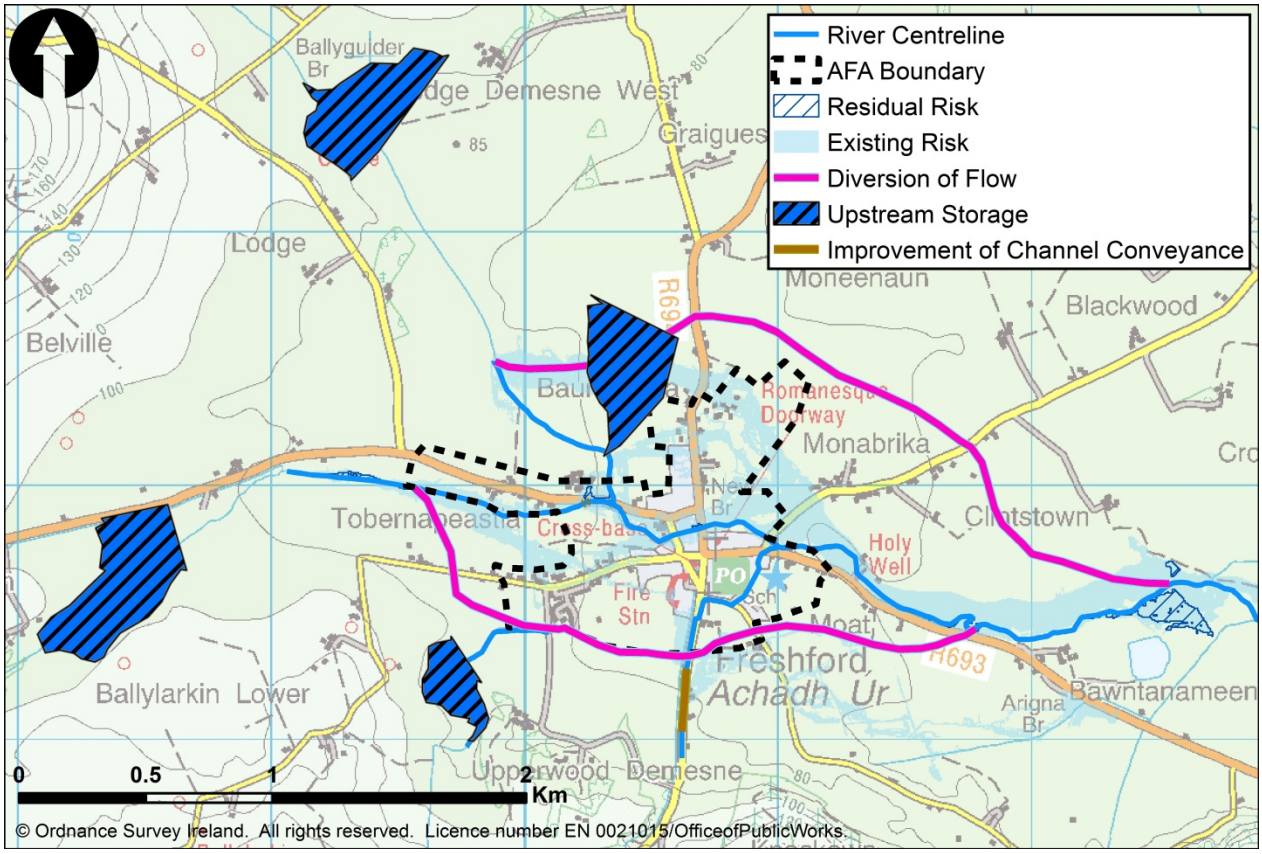


Figure 8.6.19 Freshford AFA Option 2

At risk properties would be protected by the construction of storage areas 1, 3, 4 and 6 in addition to construction of two flow diversion channels. Channel 1 being 3.12km long, 2.5m wide and 1.3m deep and Channel 2 being 2.6km long, 3m wide for the first 878m and 2.5m wide for the remainder and 1.3m deep. This option would require seven 2.1m x 1m box culverts and a weir control at the confluence with the Upperwood watercourse. Two weirs would be removed on the Nuenna River (02WEIR02 at Chainage 1227 and 03WEIR01 and Chainage 1240). Improvement of Channel conveyance of the Upperwood River would involve the lowering of 216m of channel by 0.4m.

Figure 8.6.19 presents the effect of the potential option on the design flood event by overlaying the present day flood extent (labelled existing risk) with the flood extent that would occur after the option is put in place (labelled residual risk).

In addition to these methods the following was also identified at UoM level (see section 8.1) to be included in any potential option identified:

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

Option Item	Quantity		Construction Cost
Embankments	Four embankments, total length of 2.0km and average height of 2m		€1,036,535
Excavation on land	Two diversion channels - 33,752m^3 of material removal		€573,793
Excavation in channel	One reach, total length of 216m		€3,739
Weir removal	Two weirs		€54,863
Culverts	Seven no.		€201,128
Total MCA-Benefit Score	**Option Cost (€millions)**		**MCA-Benefit Score / Cost Ratio**
1741	6.11		285.18
Economic Appraisal (Cost-Benefit Analysis) Outcomes			
Area NPVd (uncapped)	**Option Cost**	**Option NPVb (capped)**	**Benefit - Cost Ratio**
€45,011,056	€6,105,347	€13,421,732	2.20

8.6.7.3 AFA Sensitivity to Future Change

During a MRFS 1% AEP flood event the increase in flood extent is significant in the Flood Cell 7 area (Figure 8.6.22). This scenario would result in an additional 65 properties being at risk bringing the property count from 93 in the present day 1% AEP event to 158. The AAD would increase from €2,095,292 to €5,688,223. As a result Freshford AFA would be considered to be at high vulnerability from the MRFS.

During a HEFS 1% AEP flood event there would be a significant increase in flood extent (Figure 8.6.20 and Figure 8.6.22). This would result in an additional 85 properties being at risk bringing the property count from 93 in the present day 1% AEP event to 178. The AAD would increase from €2,095,292 to €7,869,183. As a result Freshford AFA would be considered to be at high vulnerability from the HEFS.

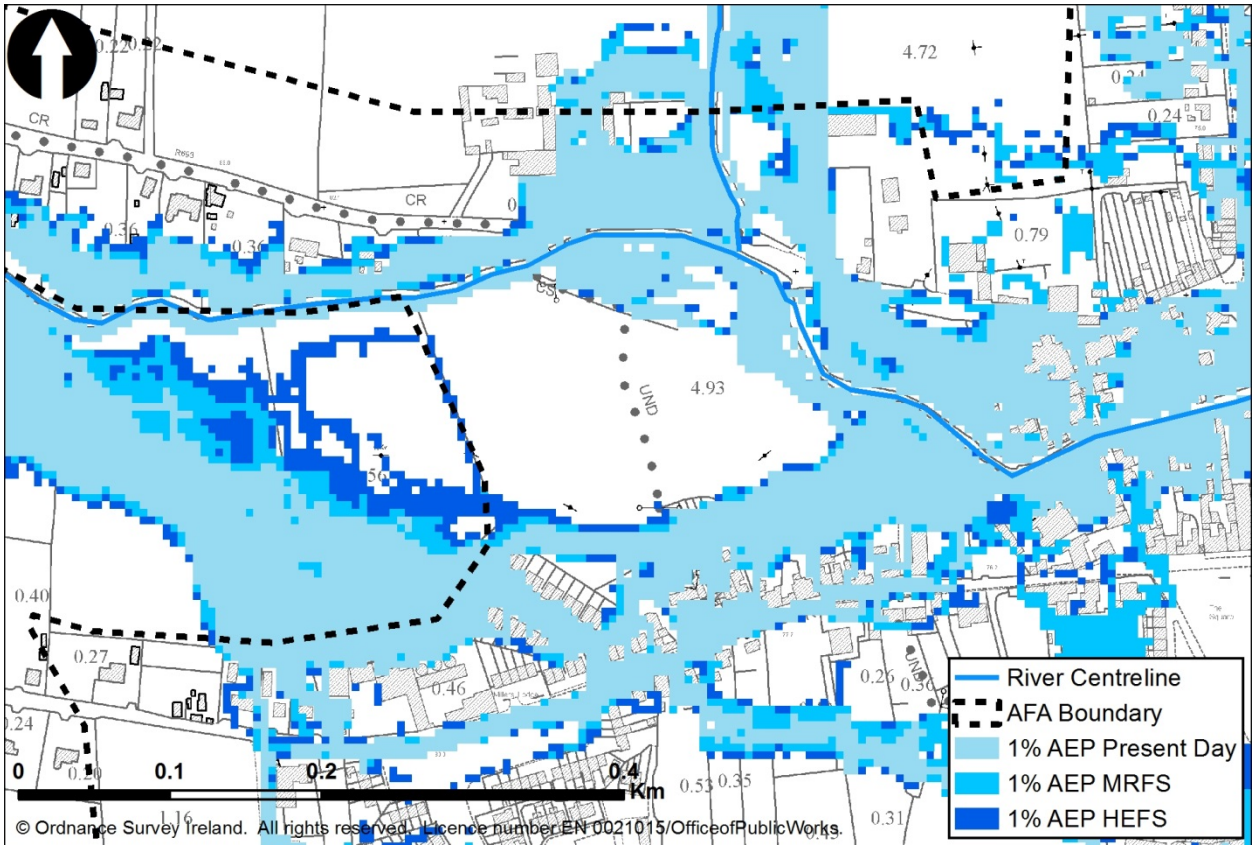


Figure 8.6.20 Future Change Flood Extents (Flood Cells 1 and 2)

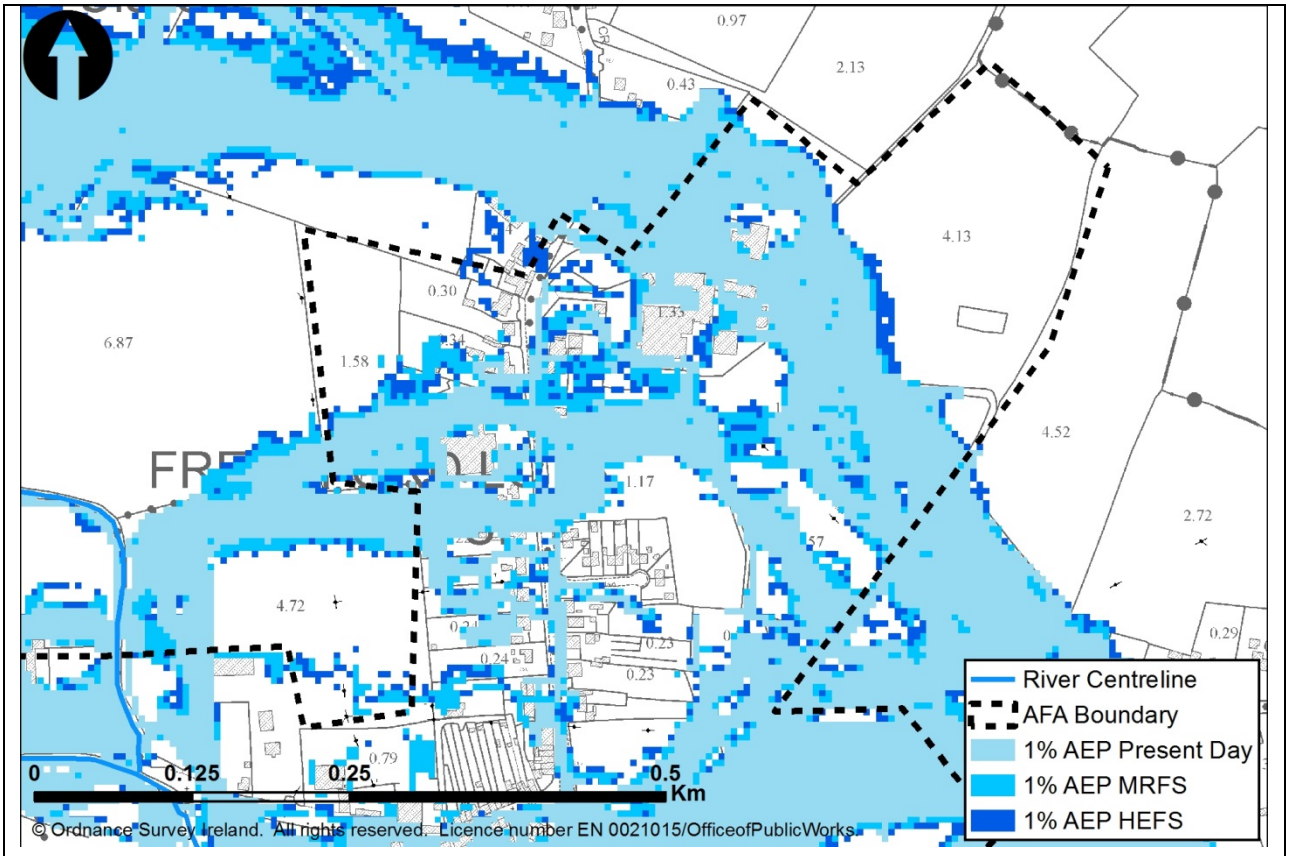


Figure 8.6.21 Future Change Flood Extents (Flood Cells 4 and 5)

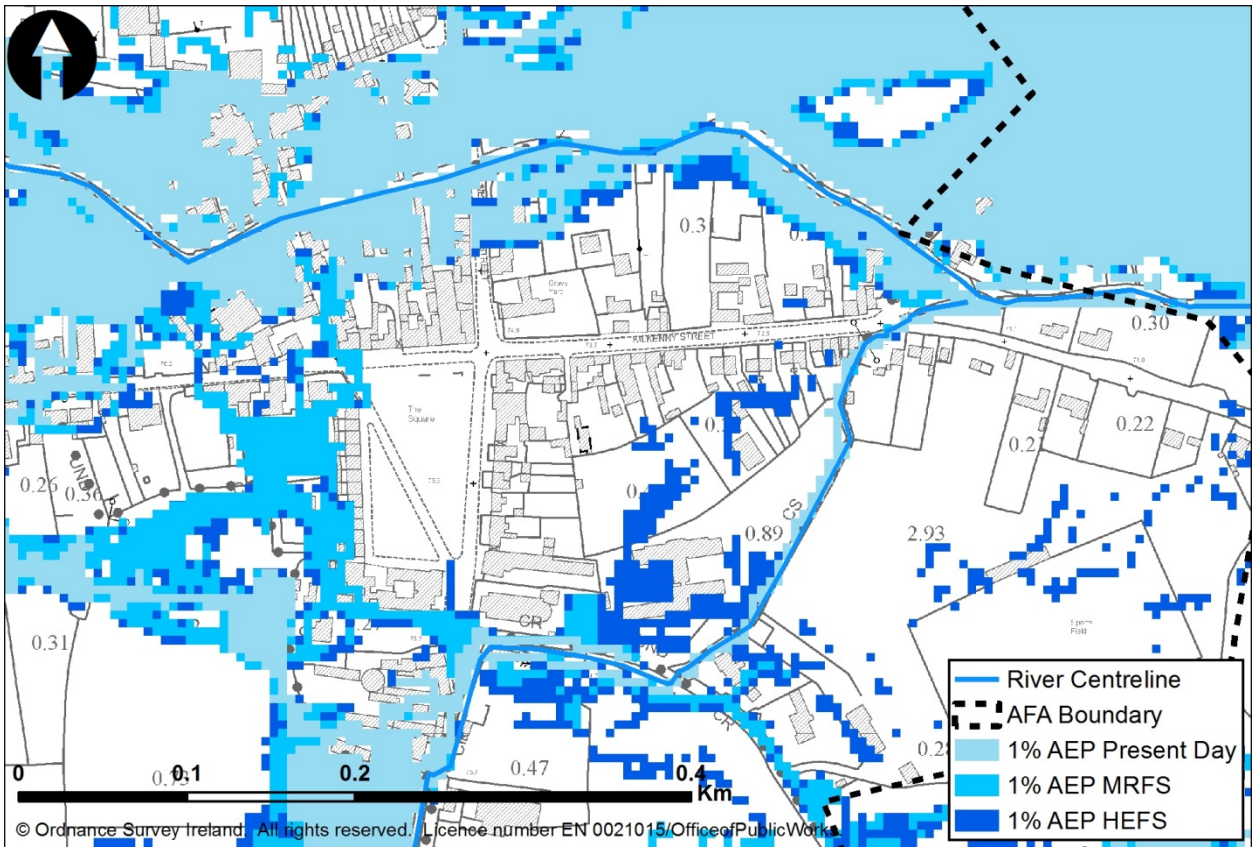


Figure 8.6.22 Future Change Flood Extents (Flood Cells 3, 6, 7 and 8)

8.6.7.4 Future Change Adaptability

The following discusses the adaptability of the potential FRM methods proposed in Freshford AFA:

Diversion of flow (all flood cells) - This method could be adapted by increasing the capacity of the diversion channel and culverts. This could be achieved by excavating a larger channel to increase capacity and the replacement of the proposed culverts allowing access under existing roads or the construction of additional secondary culverts under the existing roads. While the channel can be readily adapted the culverts are not and would require an assumptive approach in that a larger culvert can be construction presently, or the inlet and outlet configuration designed to allow an additional culvert to be laid in the future. This method is considered to have **moderate to poor** adaptability.

Storage (all flood cells) - This method could be adapted by increasing the height of the retaining structures and extending their length to tie into high ground. As the retaining structures are embankments, they would need to be designed to accommodate additional height in the future. The height of the embankment would need to be greater than 3.4m for one of the storage areas, for the HEFS. The storage required is therefore greater than the maximum storage available meaning that this method is considered to be **not adaptable**.

Improvement of Channel Conveyance – This method could be adapted by further excavation of the channel, whether widening the channel or deepening it. The current proposal is to remove two weirs along the Nuenna River and to deepen the 216m of channel on the Upperwood River by 0.4m. If the flow were to increase to the MRFS or HEFS the channel would be insufficient to convey the 1% AEP flow. As the adaptation of this method would involve further dredging of the channel, this method is considered to have moderate adaptability.

The potential **option** identified has been further assessed using 5 criteria in an attempt to identify low – or no regret combinations of measures.

1. **Does the option reduce vulnerability?** In addition to these methods other methods aimed at reducing future flood risk has been discussed in section 8.1 at UoM scale. These methods will reduce the vulnerability of potential future receptors. Given that there is a relatively large increase in the number of properties affected in the MRFS and HEFS there is a need to ensure that future receptors at risk are prepared, especially as the option is considered to have moderate to poor adaptability.
2. **Does the option make space for water?** Options which provide additional space for water or does not restrict it are more likely to perform well in future scenarios. Options which include hard defences do restrict the water making water levels more sensitive to increased flow – none of the identified options for Freshford would create this situation. Options 3 and 4 which incorporate storage areas would make space for water.
3. **Does the option deliver co-benefits?** No co-benefits were identified.
4. **Does the option provide flexibility?** The identified options are considered to have poor adaptability and flexibility. Alternative FRM methods could be added to provide an increased SoP. Hard defences could be considered where height restrictions permit, making the option more flexible.
5. **Does the option allow for deferring/removing or abandoning?** Given the present day risk there is no allowance for options to be deferred or any that could be removed later.

An objective for each potential option is to ensure that flood risk can be managed effectively and sustainably into the future accounting for the potential impacts of climate change. Based on this future changes adaptability assessment the table below summarises how well the option achieves this objective.

Summary of option adaptability		
Option	**Description**	**Score**
Option 1 - Diversion of Flow and Channel Conveyance	Option is adaptable at significant cost, difficulty and impact	1
Option 2 – Storage, Diversion of Flow and Improvement of Channel Conveyance	Option is not adaptable	0

8.6.7.5 Local Authority Comments

Representatives from Kilkenny County Council reviewed the options on 16/12/15.

8.6.7.6 Summary

There is moderate confidence in both the hydrology and hydraulics of the Freshford AFA due to the presence of flood extent verification events but no gauging station data. There is also considered to be a risk of significant groundwater flooding in the area.

The following potential options, with a BCR ≥ 0.5 have been identified:

- Option 1 - Diversion of Flow and Improvement of Channel Conveyance
- Option 2 – Storage, Diversion of Flow and Improvement of Channel Conveyance

Alongside any potential option the existing regime should continue with maintenance being carried out ad hoc when resources allow. Maintenance of the option structures will also form part of the ongoing regime once in place.

Methods also were identified at UoM level (see section 8.1) that are applicable to Freshford AFA, that if implemented, will serve to avoid increasing flood risk in the future :

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

No communities are located upstream or downstream that would be affected by any of the potential options identified. However any interactions with the drainage system in the urbanised area may need to be addressed during the development of the preferred option.

No critical environmental, cultural heritage or social issues have been identified.

It should be noted that this area is sensitive to climate change and is suitable for an assumptive approach be incorporated into detailed design.

These recommendations should be taken forward with a view to identification of a preferred option for the flood risk management plan.

8. OPTIONEERING OF SSA'S

8.7 Inistioge Optioneering of FRM Options

Name	Local Authority	Unique ID	SSA	Status	Date
Inistioge	Kilkenny	150192	AFA	Final	13/06/2016

8.7.1 Source of flooding

Fluvial	Coastal Mechanism 1	Coastal Mechanism 2

8.7.2 Flood Cells

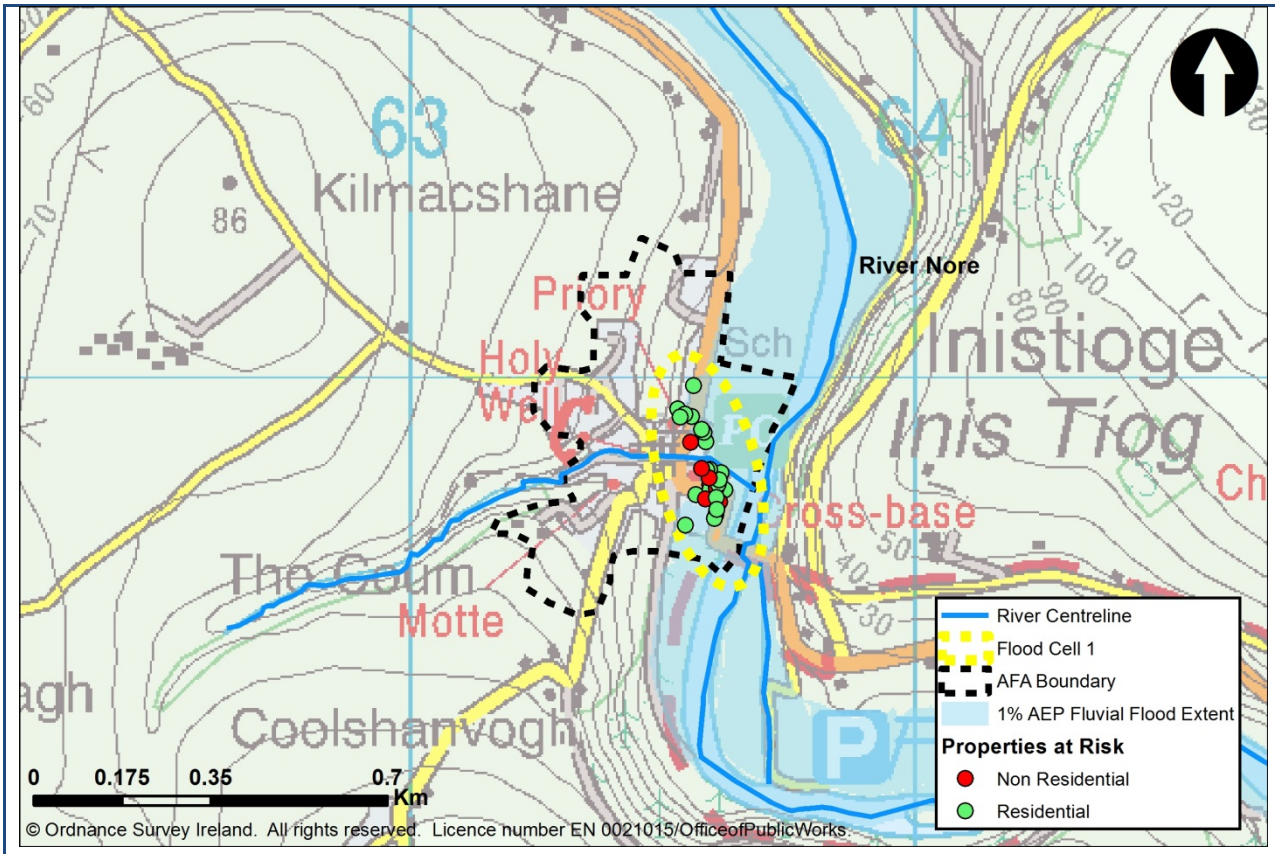


Figure 8.7.1 Inistioge AFA Flood Cells within a 1% AEP Fluvial Flood Extent

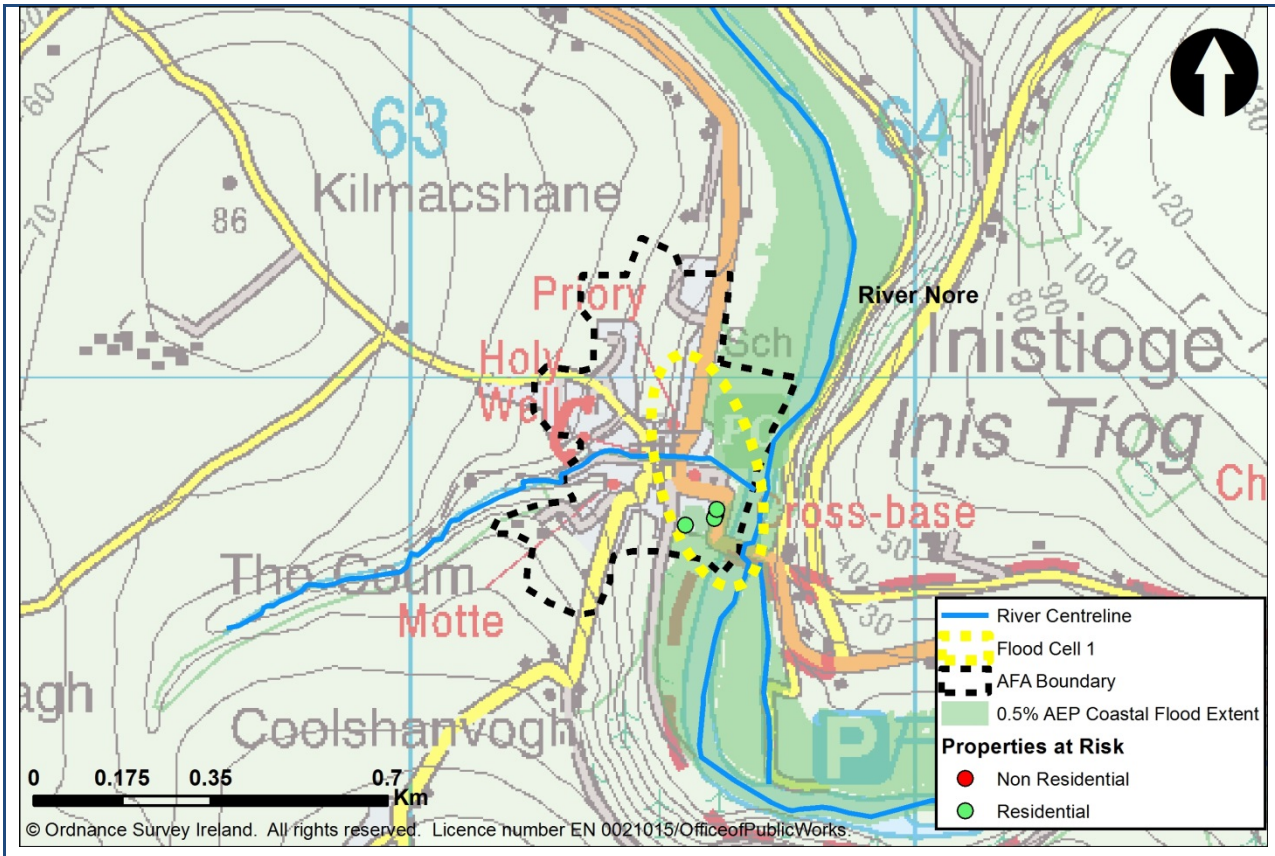


Figure 8.7.2 Inistioge AFA Flood Cells within a 0.5% AEP Coastal Mechanism 1 Flood Extent

Flood Cell 1:

The tidal limit on the River Nore extends approximately 2km upstream of Inistioge. Tidal inundation and out of bank fluvial flooding are very interactive in Inistioge. During a 1%AEP fluvial event the lack of channel capacity convey the flood water, is exacerbated during high tide levels. Consequently out of bank flooding occurs in the low lying ground immediately upstream and downstream of the Inistioge urban area. 30 properties at risk of being flooded during a 1% AEP fluvial event are located within flood cell 1. During a 0.5% AEP tidal event the water levels in the Inistioge AFA also exceed the top of bank levels resulting in tidal inundation, again, in the low lying ground immediately upstream and downstream of Inistioge. These flood extents represent the natural flood plains of the lower reaches of the River Nore and are within the intertidal stretch of the River Nore. 4 properties at risk of being flooded during a 0.5% AEP tidal flood event are located within flood cell 1.

Given that the flood cell 1 is impacted by two flood mechanisms it is considered complex.

Summary of Flood Cells:

Although the Inistioge AFA is located in an intertidal area the 1%AEP fluvial flood extents are greater than the 0.5% AEP tidal flood extents, as shown in Figure 8.7.1 and Figure 8.7.2. Therefore the fluvial flood mechanism is considered the dominant flood mechanism. Due to the nature of the flood mechanism and interaction between the extents of the flooding associated with a 1% AEP fluvial event and 0.5% AEP tidal event, it is appropriate to screen flood cell 1 as a discrete area, see Section 8.7.6.

On completion of the optioneering screening assessment any methods deemed suitable will be combined to form complete options for the Inistioge AFA as detailed in Section 8.7.7.

8.7.3 Existing Regime

The existing regime considers all activities currently carried out which impact on the management of flood risk. The level and frequency of maintenance is considered, along with inspection, and any other specific activity (for example the operation of locks, barrages, sluice gates and valves).

The Inistioge watercourses are not located within a Drainage District or an Arterial Drainage scheme. The reach of the River Nore within the Inistioge AFA is, for the most part, in private lands and not the responsibility of Kilkenny County Council. Nevertheless, inspection and maintenances are carried out as and when resources are available. As there are some properties frequently flooded, the existing regime does not provide the required standard of protection.

8.7.4 Summary of Flood Risk within SSA boundary

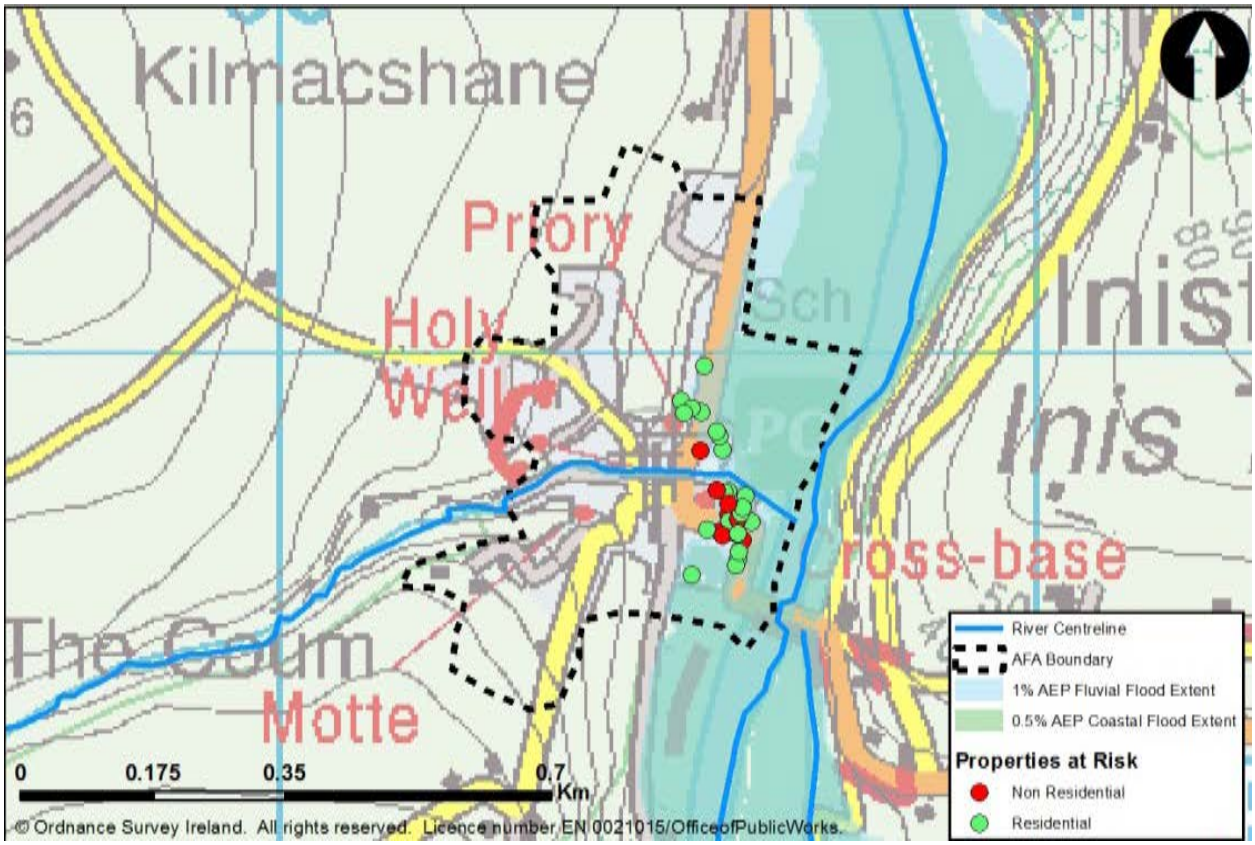


Figure 8.7.3 Flood risk in Inistioge AFA within a 1% AEP Fluvial Flood Extent and within a 0.5% AEP Coastal Mechanism 1 Flood Extent

In Inistioge AFA the onset of residential property damage occurs in the 50% AEP event. Flooding commences at non-residential properties in the 10% AEP event.

8.7.5 Monetary Damage and Benefit

	Flood Cell 1	Total in AFA*
Annual Average Damage (AAD)	€ 391,261	€ 391,261
Present Value Damage (pvD)	€ 8,405,073	€ 8,405,073
Standard of Protection (SoP)	0.5% AEP	0.5% AEP
Number of Properties Benefiting from Design SoP	30	30
Minimum Present Value Benefit	€ 7,575,324	€ 7,575,324
Capped Minimum Present Value Benefit	€ 6,546,412	€ 6,546,412

*The sum of the flood cell AAD or pvD values may not equate to the values presented for the Total in SSA due to flooding greater than the 1% AEP occurring outside the flood cell extents.

8.7.6 Short Listing FRM Methods – Local Cells

Method	Review Comment	Continue Screening
		Flood Cell 1
Do Nothing	Consider Further	✓
Additional Maintenance	Consider Further	✓
Do Minimum	Consider Further	✓
Planning and Development Control	Consider at UoM SSA - Reject	×
Building Regulations	Consider at UoM SSA - Reject	×
Catchment Wide SuDs	Consider at UoM SSA - Reject	×
Land Use Management	This method would not be effective in this Flood Cell - Reject	×
Strategic Development Management	Consider at UoM SSA - Reject	×
Storage	Consider Further for fluvial dominated flood cells	✓
Improvement of Channel Conveyance	Consider Further for fluvial dominated flood cells	✓
Hard Defences	Consider Further	✓
Relocation of Properties	Consider Further	✓
Diversion of Flow	Consider Further for fluvial dominated flood cells	✓
Flood Warning/Forecasting	Consider Further for fluvial dominated flood cells	✓
Public Awareness Campaign	Consider at UoM SSA - Reject	×
Individual Property Protection	Consider Further	✓
Other Works	Consider Further	✓

8.7.6.1 Feasibility Review Summary for Local Cell (flood cell 1)

Method	Technical Screening	Economic Screening	Environmental and Cultural Heritage Screening	Social Screening
Do nothing	×			
Additional Maintenance	×			
Do Minimum	×			
Storage	×			
Improvement of Channel Conveyance	×			
Hard Defences	✓	✓	?	✓
Relocation of properties	✓	×		
Diversion of Flow	×			
Flood Warning/Forecasting	✓	✓	✓	✓
Individual Property Protection	×			
Other Works	×			

× - Reject ✓ - Progress ? - Progress, potential for impacts identified ! - Progress, potential for significant impacts identified

8.7.6.2 Justification for Rejection/Retention

Method	Tech	Econ	Env	Soc
Do nothing	×			

The do nothing FRM method would involve stopping the current maintenance regime. This would not provide the preferred SoP and therefore was rejected from the screening process.

Method	Tech	Econ	Env	Soc
Additional Maintenance	×			

This method considers whether improvements can be made to augment the existing maintenance regime which will provide a significant beneficial impact on flood risk in the AFA. A review was carried out of the existing watercourse network. This included assessing the channel vegetation, the amount of debris present in the channels and the likelihood of structures blocking.

Increasing maintenance activities on the relevant watercourses will not significantly contribute to achieving the preferred SoP and therefore will not be pursued under the CFRAM Study.

Method	Tech	Econ	Env	Soc
Do Minimum	×			

This method is appropriate where an isolated/single issue exists which can be easily addressed in order to reduce the flood risk, for example the removal of a pinch point/obstruction, or the upgrade of a blockage prone culvert screen, etc. These activities would be considered relatively straightforward, discrete and low cost. Do Minimum is a standalone method, as it cannot be combined with others without contradicting its definition, therefore the design SoP must be achieved for this method to progress.

Within flood cell 1 there is little scope to implement a do minimum approach apart from vegetation clearance of the channel of the River Nore. This however would have minimal impact on the overall flood risk as it would not provide the additional conveyance needed within the channel. This is an unacceptable outcome in terms of contributing to achieving the design standard of flood protection and was therefore rejected from the screening process.

Method	Tech	Econ	Env	Soc
Storage	×			

This method considers areas where flood water can be stored and then released at a controlled rate, therefore reducing the flow rate along the HPW and reducing the level of flood risk. This can be achieved by using existing or creating new depressions to create online or offline storage areas or by identifying pinch points which could be dammed such as a restricted point along a valley. Storage areas can be effective either upstream of the risk areas or within the risk area where parks or open areas are located.

A review of the surrounding land was carried out but no suitable location was found to accommodate the volume required to reduce the River Nore flow associated with a 0.5% AEP tidal event or 1%AEP fluvial event sufficiently to provide the required SoP . This method is therefore considered technically unfeasible and rejected.

Method	Tech	Econ	Env	Soc
Improvement of Channel Conveyance	×			

This method focuses on increasing watercourse conveyance thereby lowering water levels and reducing the associated flood risk. This can be achieved by lowering bed levels, widening/reshaping channels, removing channel/structure constrictions, culverting reaches of watercourse, reducing roughness of the channel and sealing manholes.

There is no opportunity for the Improvement of Channel Conveyance method within flood cell 1. The capacity of the river at Inistioge is tidally influenced and even if dredged would remain so thus it is not possible to provide sufficient capacity within the channel to convey flood waters away from the flood risk area during a 1%AEP fluvial event. Consequently this method was not considered technically feasible and was removed from the screening process.

Method	Tech	Econ	Env	Soc
Hard Defences	✓	✓	?	✓

The term Hard Defences refers to physical barriers which prevent water from entering an area such as flood walls, embankments and barrages. As a general rule Hard Defences are kept as far back from the river channel or coast line as possible allowing the floodplain function to remain active. Where this is not possible, due to flood risk receptors being located within the floodplain, Hard Defences are placed around the property boundary to afford it protection. Where space allows flood embankments are used but where space is restricted flood walls are utilised.

A review was carried out to ascertain where Hard Defences would be required to protect existing property within flood cell 1. Figure 8.7.4 shows the location of the Hard Defences required to protect properties during the 1%AEP fluvial event and 0.5% AEP tidal event.

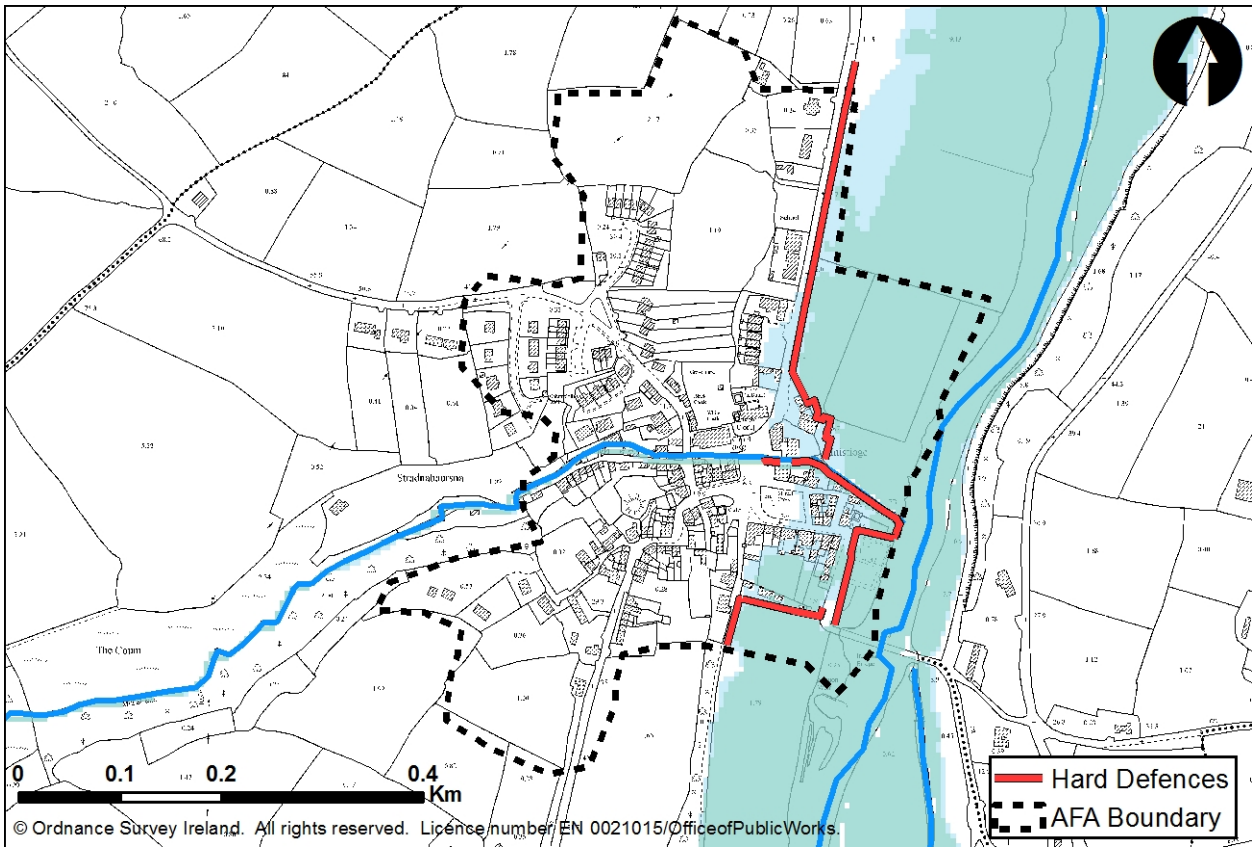


Figure 8.7.4 Location of Hard Defences in flood cell 1

In order to ascertain the effectiveness of Hard Defences a hydraulic model was constructed to simulate the method. The model showed that hard defences would protect to the 1% AEP fluvial event and the 0.5% AEP tidal flood event with an average height of 1.7m and a total length of 870m. An economic review estimated the cost of the hard defences to be approximately €1.5m making this method economically viable.

The River Barrow and River Nore SAC and the River Nore SPA are within, downstream of and upstream of Inistioge. The Thomastown Quarry SAC is over 8km upcatchment of the AFA.

FRM Methods are set back from watercourse where possible due to SAC and SPA designation and being a FPM sensitive area.

The Hard Defences method in Inistioge would aim not to cause hydrological or coastal process alterations that might impact these nearby environmentally sensitive sites. The Hard Defences proposed are set back from watercourse where possible due to SAC and SPA designation and being a FPM sensitive area.

Therefore this method will be put forward for consideration in the optioneering process.

Method	Tech	Econ	Env	Soc
Relocation of properties	✓	×		

To relocate a property is to abandon the existing at risk property and provide an alternative in a location not at risk. While this method is, in theory, possible, it is not practical for a whole community of many at risk properties. Its use is more applicable for discrete areas where single properties or clusters of properties are located.

There are 30 properties at risk during a 1% AEP fluvial event and 0.5% AEP tidal event within flood cell 1. An economic review estimated the cost of relocating these properties as €12.7m. This method was therefore considered economically unviable and was rejected from the screening process.

Method	Tech	Econ	Env	Soc
Diversion of Flow	×			

This method involves directing some of the floodwater via a new route thereby reducing flow and associated flood risk along the original route. This would be carried out upstream of where floodwaters reach the area of at risk properties. The new flow route would normally consist of a constructed open channel and/or culvert system or an existing linear feature able to convey the flow to a designated discharge point.

A review was carried out to assess the practicality of flow diversion. Due to the topography in the area no location was found where this method could be carried out, it is therefore considered technically unfeasible and rejected.

Method	Tech	Econ	Env	Soc
Flood Warning/Forecasting	✓	✓	✓	✓

The application of flood warning / forecasting was tested at UoM scale. A suitable location far enough upstream of flood cell 1 is available to provide sufficient warning. This method can only provide warning for other methods and does not provide the required SoP as a standalone method. Therefore the method should only be considered if no other methods are suitable during the optioneering process.

An economic review estimated that the cost of providing 1 hydrometric gauging station with simple forecasting systems located immediately upstream of the properties at risk to link in the existing gauges would be approximately €47k. This method is therefore economically viable.

The proposed gauging station is not within any environmental designations and it is unlikely that flood forecasting would have any impact to designated sites in the vicinity of the Inistioge AFA.

Method	Tech	Econ	Env	Soc
Individual Property Protection	×			

This method is aimed at individual properties that are remote from the main risk areas. Where the AFA being considered consists of a small number of remote properties this method is a feasible solution. But for areas with multiple properties at risk this method would only be considered an add on to a primary method. Individual property protection could consist of flood gates and vent seals on the building structure itself. Where flood depths are over 0.6m this method becomes unfeasible and flood resilience techniques would be recommended over flood gates. As this method is temporary and relies of human intervention there is an element of uncertainty as to whether the full SoP will be met for every flood event. As such it is assumed that 20% of the flood damage will be avoided.

The modelled flood depths for 16 of the 30 properties at risk during a 1%AEP fluvial event are greater than 0.6m therefore this method is not technically feasible for flood cell 1.

Method	Tech	Econ	Env	Soc
Other Works	×			

No other works were identified for these flood cells

8.7.6.3 Summary of Feasibility Review – Flood Cell 1

The following FRM method has been carried forward to address the flood risk arising from flood cell 1;

- Hard Defences

Flood Warning/Forecasting cannot provide the required SoP and should therefore only be used if other methods are deemed unsuitable later in the optioneering process.

Hard Defences can provide the full protection to all properties during the 1% AEP fluvial event and 0.5% AEP tidal event in flood cell 1. Therefore it can be considered in the optioneering process as a standalone method.

8.7.7 Selection of Options

Method	Option 1	Option 2	Option 3	Option 4	Option 5
Hard Defences	✓				

For flood cell 1 Hard Defences can provide the full SoP to the properties at risk.

8.7.7.1 Option 1 details - Hard Defences

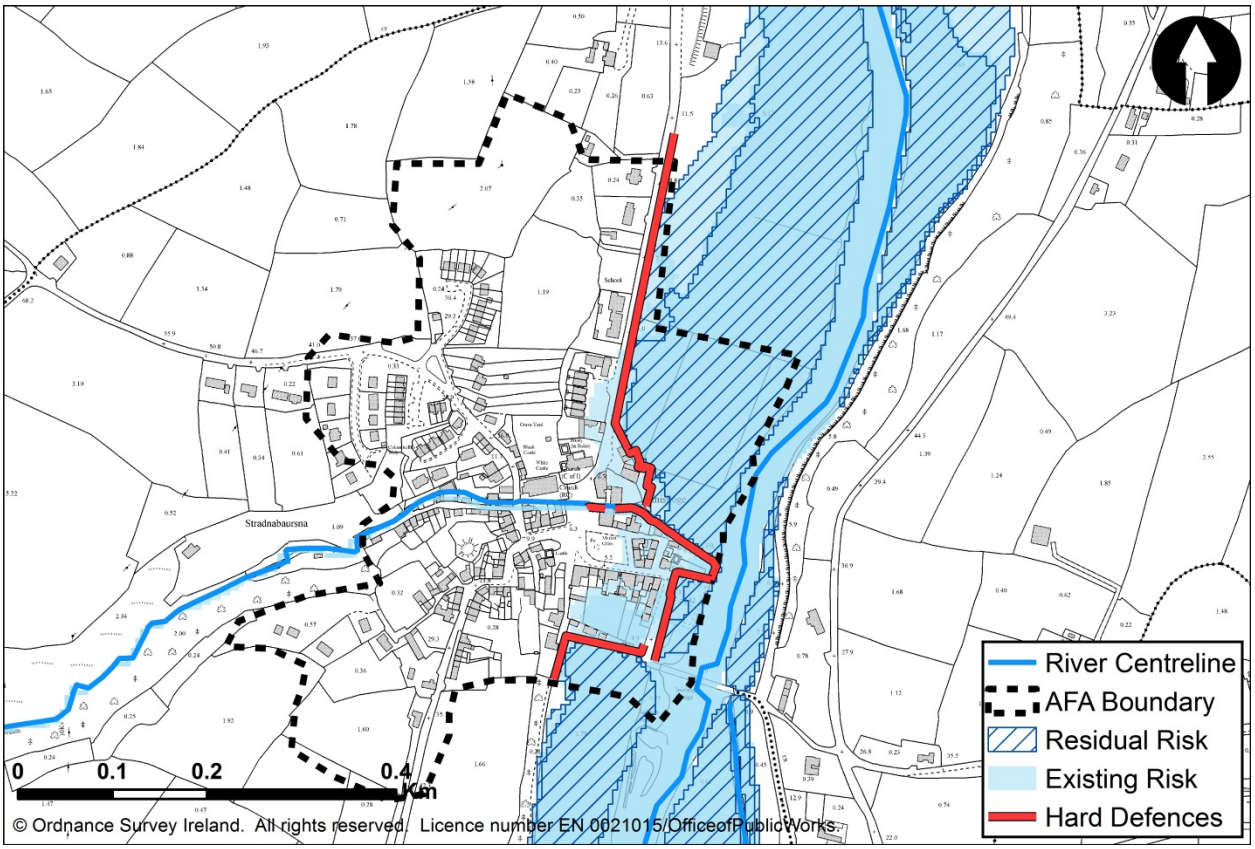


Figure 8.7.5 Inistioge AFA Option 1

At risk properties would be protected by a series of walls and embankments in flood cell 1. These hard defences would protect to the 0.5% tidal event and the 1% AEP fluvial event with an average height of 1.7m and a total length of 870m.

Figure 8.7.5 presents the effect of the potential option on the design flood event by overlaying the present day flood extent (labelled existing risk) with the flood extent that would occur after the option is put in place (labelled residual risk).

In addition to these methods the following was also identified at UoM level (see section 8.1) to be included in any potential option identified:

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

Option Item	Quantity	Construction Cost
Wall	162m length, 1.81m high	€ 364,039
Embankments	660m length, 1.44m high	€ 228,569
Total MCA-Benefit Score	**Option Cost (€millions)**	**MCA-Benefit Score / Cost Ratio**
1341	1.49	900.11

Economic Appraisal (Cost-Benefit Analysis) Outcomes			
Area NPVd (uncapped)	**Option Cost**	**Option NPVb (capped)**	**Benefit - Cost Ratio**
€ 8,405,073	€ 1,489,836	€ 6,546,412	4.39

8.7.7.2 AFA Sensitivity to Future Change

During a MRFS 1% fluvial flood event the increase in flood extent is minimal as the topography rises steeply from the flood plain within the AFA. This would result in an additional 16 properties being at risk bringing the property count from 30 in the present day 1% AEP fluvial event to 46.

During a MRFS 0.5% tidal flood event the increase in flood extent is minimal as the topography rises steeply from the flood plain within the AFA. This would result in an additional 7 properties being at risk bringing the property count from 4 in the present day 0.5% AEP Tidal event to 7.

The main area of additional flood risk is confined to the properties in the Inistioge urban area as it forms part of the flood plain as shown in Figure 8.7.6 and Figure 8.7.7. The AAD would increase from €391,261 to €982,135. As a result the Inistioge AFA would be considered to be at moderate vulnerability from the MRFS.

During a HEFS 1% fluvial flood event the increase in flood extent is minimal as the topography rises steeply from the flood plain within the AFA. This would result in an additional 24 properties being at risk bringing the property count from 30 in the present day 1% AEP fluvial event to 54.

During a HEFS 0.5% tidal flood event the increase in flood extent is minimal as the topography rises steeply from the flood plain within the AFA. This would result in an additional 5 properties being at risk bringing the property count from 4 in the present day 0.5% AEP Tidal event to 9.

The main area of additional flood risk is confined to the properties in the Inistioge urban area as it forms part of the flood plain as shown in Figure 8.7.6 and Figure 8.7.7. The AAD would increase from €391,261 to €1,737,878. As a result the Inistioge AFA would be considered to be at high vulnerability from the HEFS.

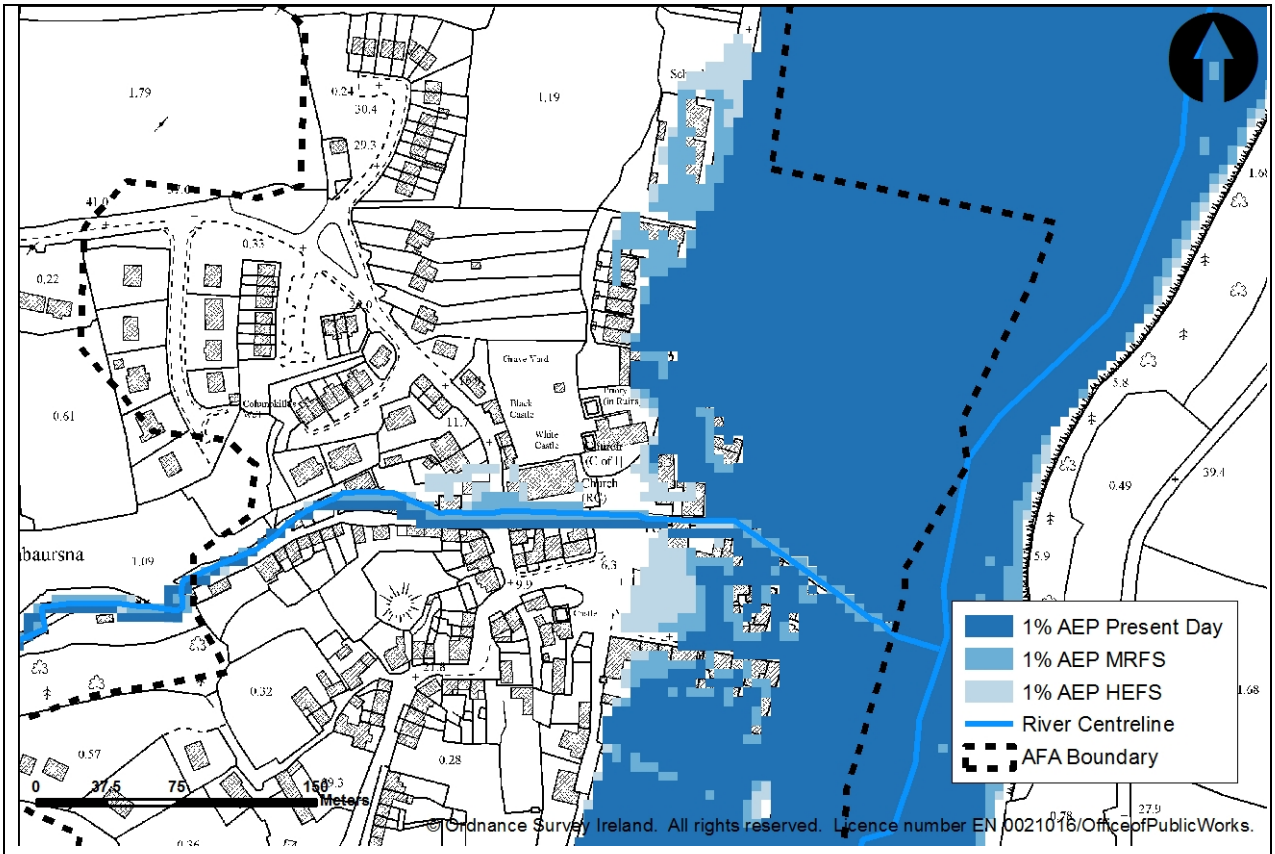


Figure 8.7.6 Inisitoge Future Change Fluvial Flood Extents

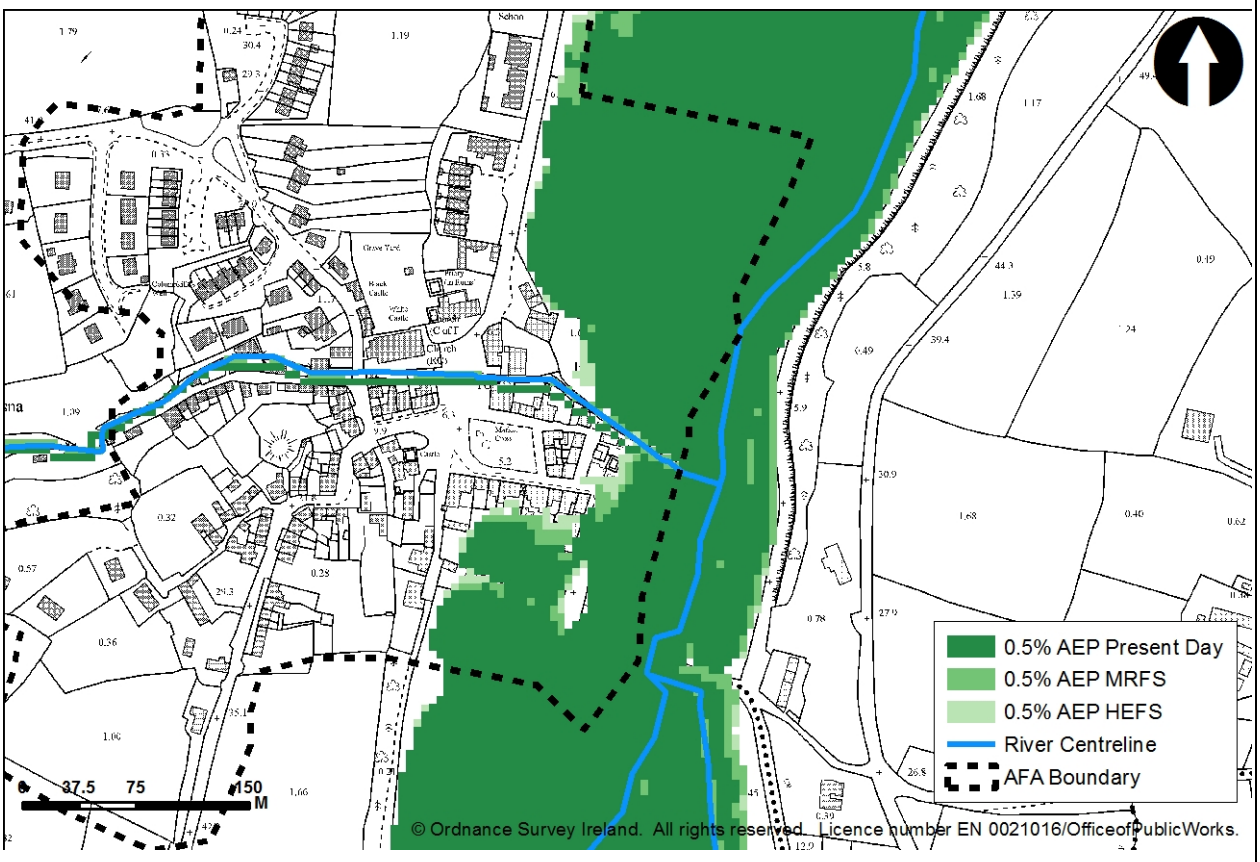


Figure 8.7.7 Inistioge Future Change Coastal Flood Extents

8.7.7.3 Future Change Adaptability

The following discusses the adaptability of the potential FRM methods proposed in Inistioge AFA:

Hard Defences Flood Cell 1 - This method could be adapted by increasing the height of the walls. The length of the wall would not need to be adjusted. A review of the effect of the MRFS and the HEFS showed that the existing and proposed walls and embankments would require an increase 0.4m and 1m under the MRFS and HEFS. This additional height could be accommodated. To ensure that this wall would be adaptable the design would need to account for the potential increase in height. This method is considered to be **moderate adaptability**

The potential **option** identified has been further assessed using 5 criteria in an attempt to identify low – or no regret combinations of measures.

1. **Does the option reduce vulnerability?** In addition to the methods above other methods aimed at reducing future flood risk have been discussed in section 8.1 at UoM scale and are detailed in each potential option. These methods, such as building regulations and planning & development control will reduce the impact to potential future receptors. Given that Inisitioge has a moderate area of open space some of these methods including a strategic development plan would be highly effective. there would be limited scope for some of these methods to impact on the area being assessed. Since there is a relatively large increase in the number of properties affected in the MRFS and HEFS there is a need to ensure that future receptors at risk are prepared through methods such as public awareness campaign
2. **Does the option make space for water?** The FRM method selected to address the flood risk in flood cell 1 would make space for water where proposed Hard Defences are set back from the river bank at the extent of the flood plain. However it would not make space for water where the proposed walls are protecting at risk properties from out of bank flooding. These walls were designed to contain water as the river flows through the Inistioge urban area.
3. **Does the option deliver co-benefits?** No co-benefits were identified.
4. **Does the option provide flexibility?** A review of the potential option shows that overall for the option proposed, Hard Defences in flood cell 1, has moderate adaptability as the existing and proposed defences could be raised with moderate cost, effort and impact.
5. **Does the option allow for deferring/removing or abandoning?** Given the present day risk there is no allowance for options to be deferred or any that could be removed later

An objective for each potential option is to ensure that flood risk can be managed effectively and sustainably into the future accounting for the potential impacts of climate change. Based on this future changes adaptability assessment the table below summarises how well each option achieves this objective.

Summary of Option Adaptability

Option	Description	Score
Option 1 – Hard Defence (FC 1)	Option is adaptable at moderate cost, difficulty and impact	3

8.7.7.4 Local Authority Comments

LA representatives reviewed preliminary options in April 2015 and made the following comments:

- December/January 2016 flooding up to the crossbar of goalposts on the pitch
- Surface water flooding is also an issue

8.7.7.5 Summary

There is moderate confidence in both the hydrology and hydraulics of the Inistioge AFA. Due to the lack of flood event data available, it was only possible to conduct a limited verification exercise on this model. However the model is shown to be a reasonable representation of the flood mechanisms described from the available flood event records and considered to be performing satisfactorily for design event simulation.

The following potential options, with a BCR ≥ 0.5 have been identified:

- Option 1 – Hard Defences (FC 1) and FRM measures identified for UoM15

Alongside any potential option the existing regime should continue with maintenance being carried out ad hoc when resources allow. Maintenance of the option structures should also form part of the ongoing regime once in place.

Methods also were identified at UoM level (see section 8.1) that are applicable to Inishtioge AFA, that if implemented, will serve to avoid increasing flood risk in the future :

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

A number of rural communities are located downstream that may be affected by the identified option. The flow at the downstream model boundary was reviewed for the 1% AEP current scenario versus the 1% AEP with the option in place scenario. There was a negligible flow difference between the hydraulic model simulations.

The Inistioge AFA is located within the River Barrow And River Nore SAC therefore this specially designated area would need to be addressed during the development of the preferred option. There are also 25 NIAH buildings within the AFA These buildings would also need to be addressed during the development of the preferred option.

It should be noted that has a moderate to high sensitivity to climate change and is suitable for an assumptive approach be incorporated into detailed design.

These recommendations should be taken forward with a view to identification of a preferred option for the flood risk management plan.

8. OPTIONEERING OF SSA'S

8.8 Kilkenny (Nore) Optioneering of FRM Options

Name	Local Authority	Unique ID	SSA	Status	Date
Kilkenny (Nore)	Kilkenny	150193	AFA	Final	20/07/2017

8.8.1 Source of flooding

Fluvial	Coastal Mechanism 1	Coastal Mechanism 2

8.8.2 Flood Cells

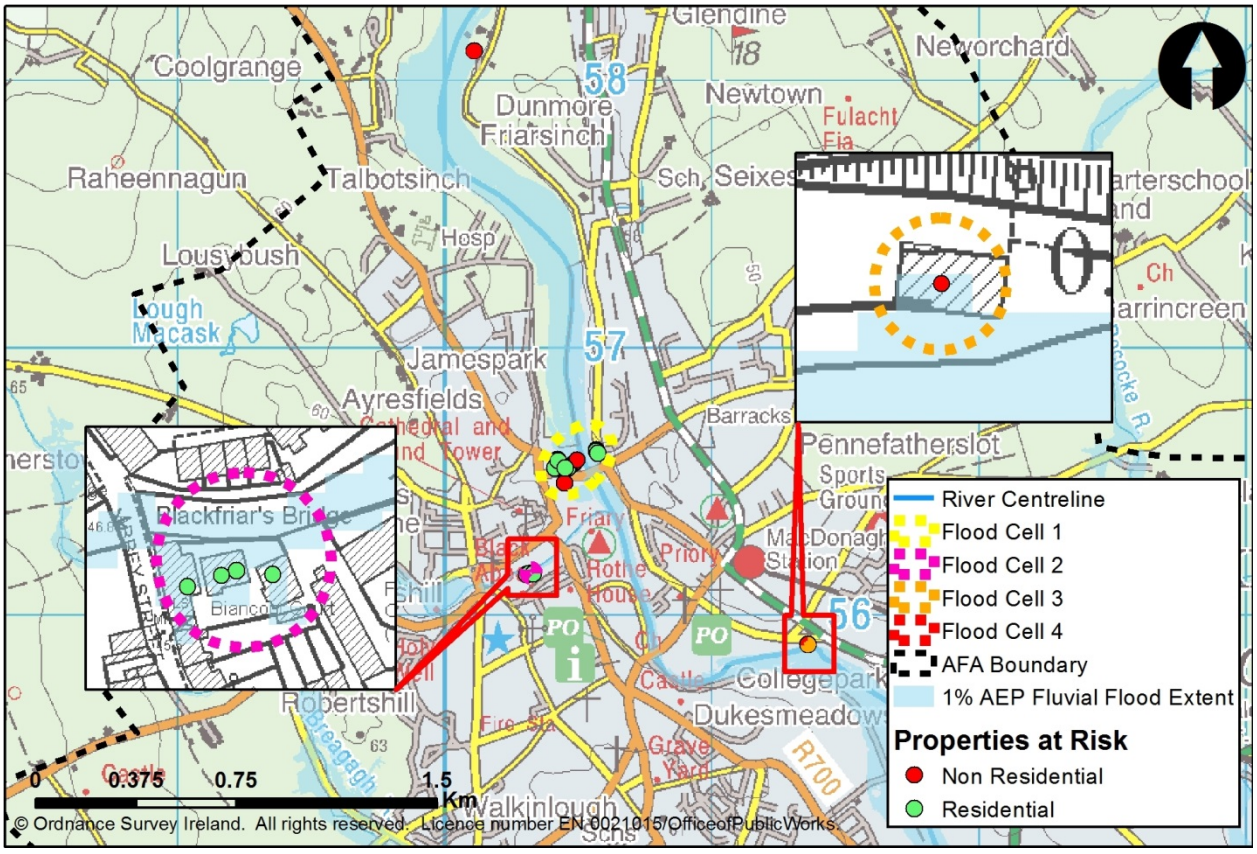


Figure 8.8.1 Kilkenny (Nore) AFA Flood Cells within a 1% AEP Fluvial Flood Extent

Flood Cell 1:

14 properties located upstream of Greens Bridge are flooded during the 1% AEP fluvial flood event. These properties are located on both banks of the River Nore, particularly in Green Street and Nore Way. The presence of Greens Bridge causes flood waters to back-up during flows greater than a 10% AEP on the Nore Way side and 1% AEP on Green Street. Flood waters overtop the defences during these events. This flood cell is considered as local.

Flood Cell 2:
The River Breagagh floods out of bank downstream of the Blackfriar's Bridge. Four residential properties within Bianconi Court are at risk of flooding during a 1% AEP fluvial event. A series of flood defences are located upstream and downstream of this area, however this location is not protected by defences. Flooding associated with this flood cell is considered as local.
Flood Cell 3:
Flooding occurs on the left bank (north) of the River Nore, 1 property is flooded during a 1% AEP event. During the occurrence of high flows, greater than 10% AEP, a Sewage Treatment Works is flooded. Flooding associated with this flood cell is considered as local.
Flood Cell 4:
To the North of Kilkenny (Nore) AFA, the River Nore floods out of bank, mainly due to insufficient channel capacity. During high flows, starting at the 1% AEP, a warehouse is at risk. Considering that only 1 property is affected, this flood cell can be considered as local.
Summary of Flood Cell:
The Flood Cells associated with Kilkenny (Nore) AFA have each been deemed to be local. The protection of at risk properties identified within the above listed flood cells and individual flooding issues, will be pursued further via the OPW minor works programme.

8.8.4 Existing Regime

The existing regime considers all activities currently carried out which impact on the management of flood risk. The level and frequency of maintenance is considered, along with inspection, and any other specific activity (for example the operation of locks, barrages, sluice gates and valves).

The Kilkenny Flood Defence Scheme completed in 2005 protects the town from the River Nore, and a downstream section of the Breagagh River. Flood defences (walls and embankments) were constructed along the River Nore and Breagagh River, as well as channel dredging and widening works on the River Nore. Prior to the completion of this flood defence scheme the extent of flooding within the Kilkenny (Nore) AFA was significantly greater. These flood defences were implemented under the Arterial Drainage Act and are therefore currently maintained by OPW.

The remainder of the watercourses through Kilkenny (Nore) AFA are, for the most part, in private lands and are not the responsibility of Kilkenny County Council. Nevertheless, inspection and maintenance are carried out as and when resources are available.

The present flood risk in Kilkenny (Nore) AFA is mostly managed by the Kilkenny Flood Defence Scheme and therefore the residual risk is considered low.

In Kilkenny (Nore) AFA the onset of residential property damage occurs in the 10% AEP event in flood cell one, in the 2% AEP event in flood cell two. There are no residential properties at risk in flood cells three and four.

Flooding commences at non-residential properties in the 50% AEP event in flood cell one, in the 10% AEP event in flood cell three and in the 1% AEP event in flood cell four.

8.8.5 Monetary Damage and Benefit

	Flood Cell 1	Flood Cell 2	Flood Cell 3	Flood Cell 4	Total in AFA*
Annual Average Damage (AAD)	€36,134	€9,247	€318	€508	€240,427
Present Value Damage (pvD)	€776,235	€198,654	€6,834	€10,928	€5,164,862
Preferred Standard of Protection (SoP)	1% AEP	1% AEP	1% AEP	1% AEP	1%AEP
Number of Properties Benefiting from Design SoP	14	4	1	1	20
Minimum Present Value Benefit	€0	€0	€0	€0	€0
Capped Minimum Present Value Benefit	€0	€0	€0	€0	€0

*The sum of the flood cell AAD or pvD values may not equate to the values presented for the “Total in SSA” due to flooding greater than the 1% AEP occurring outside the flood cell extents.

8.8.6 Selection of Options

The present flood risk in the Kilkenny (Nore) AFA is mostly managed by the Kilkenny Flood Defence Scheme and therefore the residual risk is considered low. However, the methods listed below, identified at UoM level (*see* section 8.1) should be included with maintaining the existing regime:

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

8.8.6.1 AFA Sensitivity to Future Change

As shown in Figure 8.8.2 to Figure 8.8.5 inclusive, Kilkenny (Nore) AFA shows a significant increase in the flood extents during the occurrence of MRFS and HEFS 1% AEP events. The flood defence scheme located along sections of the Rivers Nore and the downstream extent of the River Breagagh, defending the centre of Kilkenny (Nore) AFA is overtopped and outflanked. The main areas at risk include the vicinity around Blackfrair's Bridge, Irish Town and St Francis' Abbey and Greens Bridge. Other notable areas include College Park and the area around St Johns Bridge. The extent of flooding associated with Kilkenny is influenced by a combination of fluvial basin topography and urban infrastructure.

During the MRFS 1% AEP flood 226 properties will be at risk, bringing the property count from 20 in the present day 1% AEP event to 246. The AAD would increase from €240,427 to €1,918,342. As a result Kilkenny (Nore) AFA would be considered to be at high vulnerability from the MRFS.

During the HEFS 1% AEP flood event there would be a significant increase in flood extent. This would result in 432 properties being at risk bringing the property count from 20 in the present day 1% AEP event to 452. The AAD would increase from €240,427 to €13,565,661. As a result Kilkenny AFA would be considered to be at high vulnerability from the HEFS.

The addition of Kilkenny (Nore) AFA properties at risk affected by future scenarios and the associated increased of annual average damage would indicate that this AFA is considered to be at a high vulnerability level.

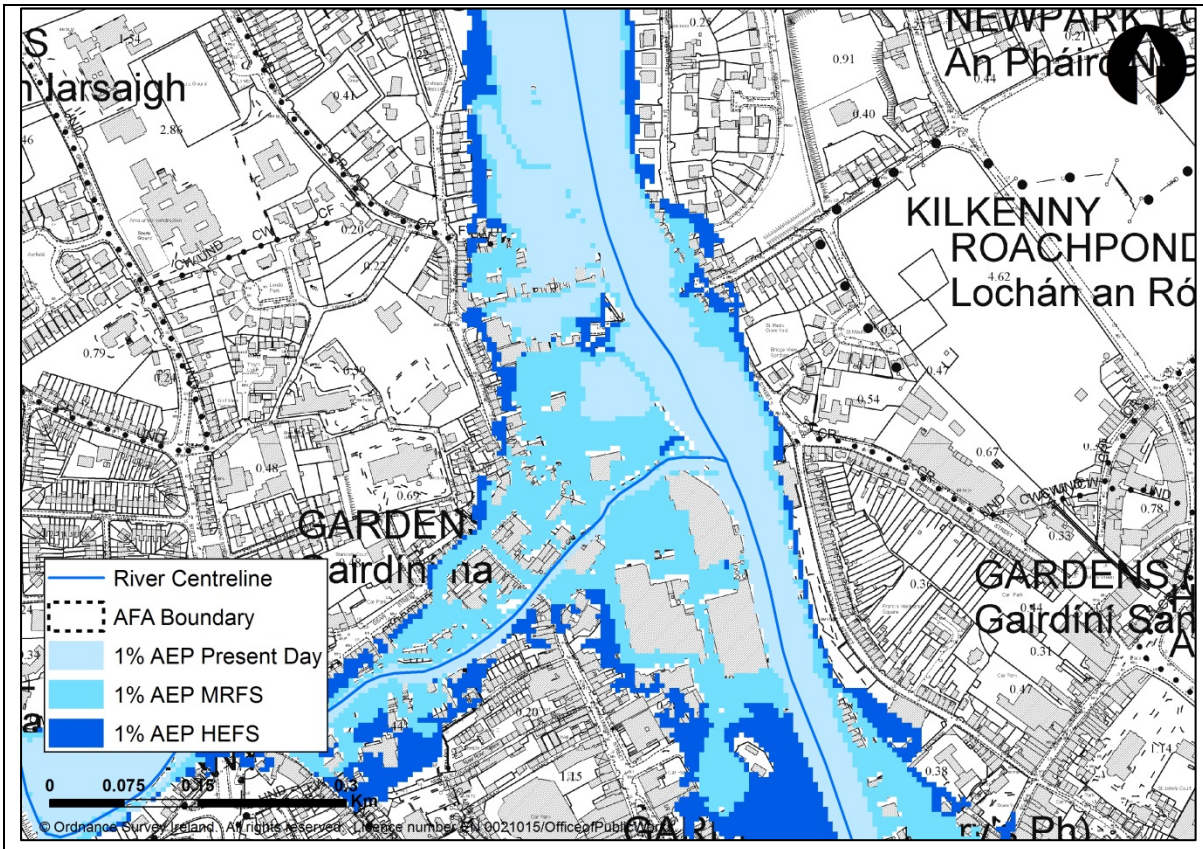


Figure 8.8.2 Kilkenny (Nore) AFA Future Change Flood Extents (Flood Cell 1)

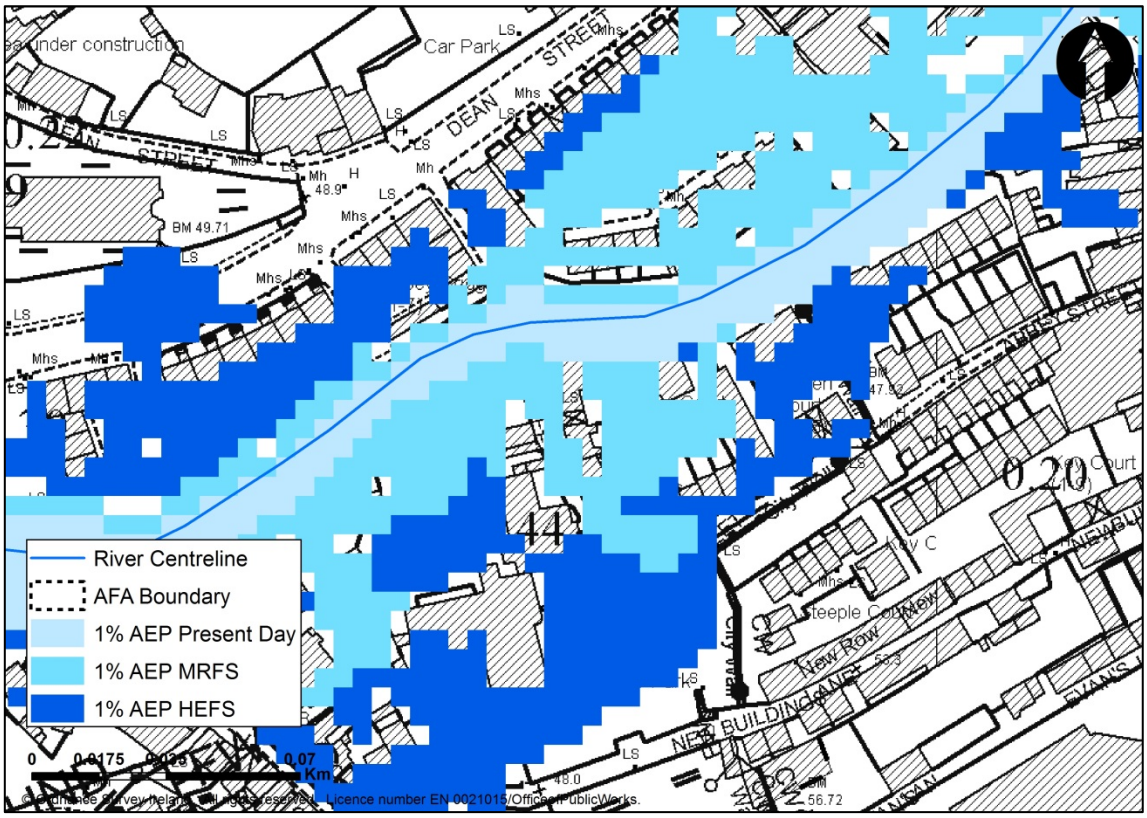


Figure 8.8.3 Kilkenny (Nore) AFA Future Change Flood Extents (Flood Cell 2)

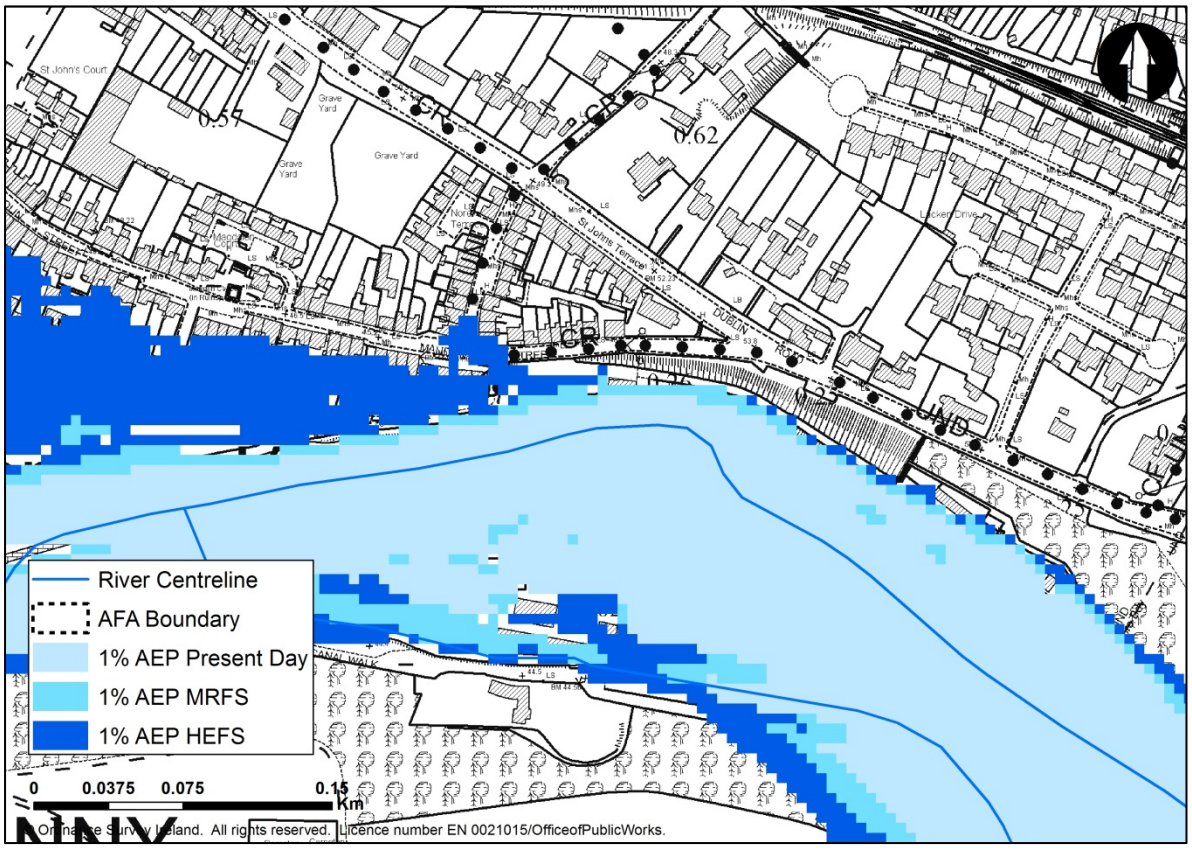


Figure 8.8.4 Kilkenny (Nore) AFA Future Change Flood Extents (Flood Cell 3)

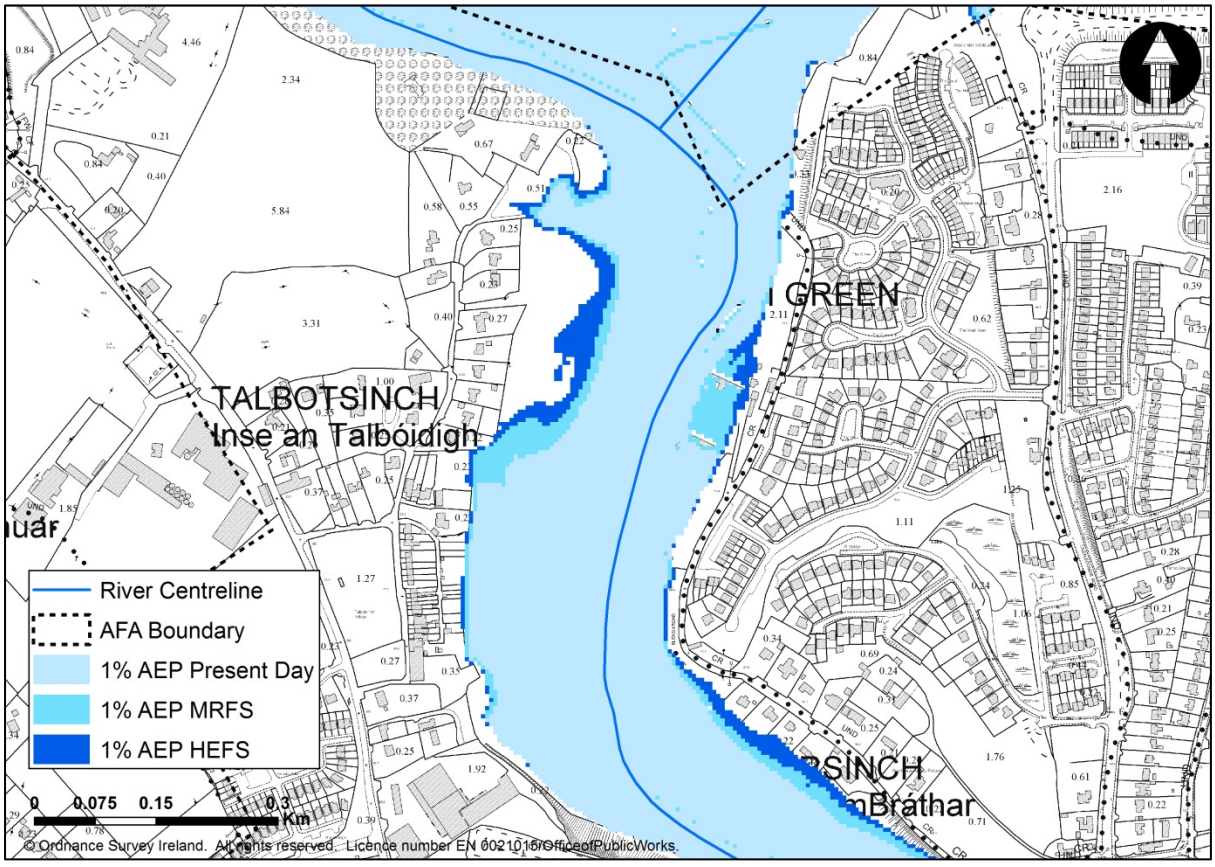


Figure 8.8.5 Kilkenny (Nore) AFA Future Change Flood Extents (Flood Cell 4)

8.8.6.2 Local Authority Comments

LA representatives reviewed the preliminary version of this Kilkenny POR report (which initially combined the Breagagh and Nore AFAs) in November 2015 and again in February 2016. Comments indicated that minor works were being considered to address localised flooding issues.

8.8.6.3 Summary

The Nore River forms part of the Kilkenny Model, with good confidence in both the hydrology and hydraulics of this model due to the presence of several gauging stations (including 15104, 15002, 15105 and 15050) and flood extent verification events (post 2005).

As a consequence of the emplacement of a flood defence scheme (2005), Kilkenny (Nore) AFA has benefitted. As outlined in Section 8.8.2, present day flooding associated with Kilkenny is mainly localised. These flooding issues associated with the above mentioned flood cells will be pursued via the OPW minor works programme. Following this, it is recommended that the existing regime (alongside the Flood Defence scheme and Minor Works) is maintained within Kilkenny (Nore) AFA.

A future change assessment identified that Kilkenny (Nore) AFA is sensitive to climate change. These future flood extents should be considered for any proposed planning and development.

Methods also were identified at UoM level (see section 8.1) that are applicable to Kilkenny (Nore) AFA, that if implemented, will serve to avoid increasing flood risk in the future:

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

Thomastown, Inistioge and Ballyhale AFAs are located downstream of Kilkenny and should be taken into consideration for any future works carried out.

The present flood risk in Kilkenny (Nore) AFA is mostly managed by the Kilkenny Flood Defence Scheme and therefore the residual risk is considered low.

Minor Works Scheme is available to the local authorities to address any local residual flood problems with local solutions.

8. OPTIONEERING OF SSA'S

8.9 Kilkenny (Breagagh) Optioneering of FRM Options

Name	Local Authority	Unique ID	SSA	Status	Date
Kilkenny	Kilkenny	150194	AFA	Final	20/07/2017

8.9.1 Source of flooding

Fluvial	Coastal Mechanism 1	Coastal Mechanism 2

8.9.2 Flood Cells

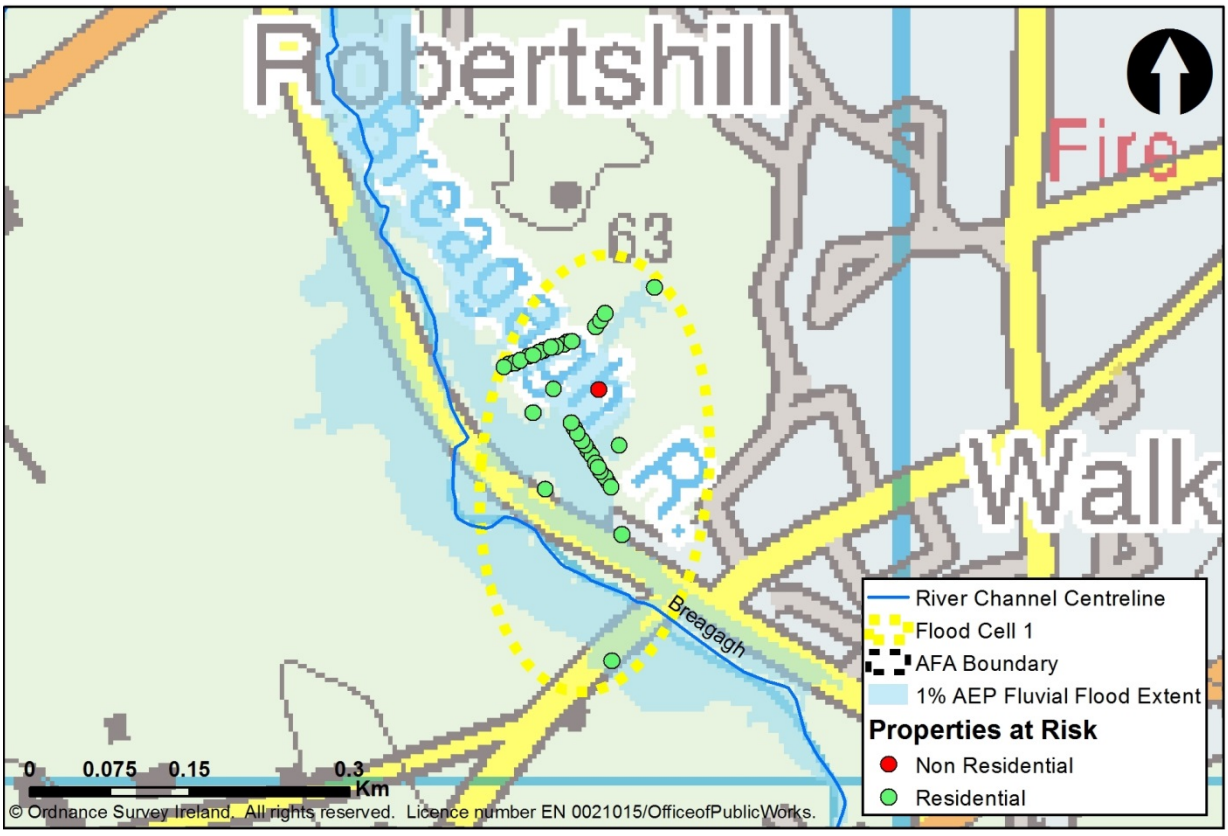


Figure 8.9.1: Map of Model Extents

The Robertshill flood cell:

As shown in Figure 8.9.1, flooding within The Robertshill flood cell is mainly the result of insufficient channel capacity associated with the Breagah River. During episodes of high flow, flooding is exasperated by the presence of restrictive structures including the 15BREA00172D (White Bridge) and 15BREA00257D. During a 1% AEP flood event, the flood flow paths run in a NNW and SSE direction,

eventually flooding the Circular Road and Robertshill area. 36 properties mainly located on the right bank (east) of the River Breagagh are at risk during a 1% AEP fluvial flood event. While a single isolated property is located on the left bank, located close to the structure 15BREA00257D. Flooding associated with this flood cell is considered as local.

Summary of Flood Cell:

As shown in Figure 8.9.1, the flood risk at the Robertshill area of Kilkenny originates from the Breagagh River. This flood cell is a discrete area associated with a single flood mechanism. It is therefore appropriate to screen this flood cell as standalone area to assess the options applicable as localised works (*see* Section 8.9.6).

On completion of the optioneering screening assessment measures will be combined to form complete options for the Kilkenny (Breagagh) AFA as detailed in Section 8.9.7.

8.9.3 Existing Regime

The existing regime considers all activities currently carried out which impact on the management of flood risk. The level and frequency of maintenance is considered, along with inspection, and any other specific activity (for example the operation of locks, barrages, sluice gates and valves).

The Kilkenny City Flood Relief Scheme was initiated in 1995 and constructed from 2001 to 2005 under the Arterial Drainage (Amendment) Act, 1995. OPW continues to have statutory responsibility for inspection and maintenance of the Scheme, which includes the Nore and lower Breagagh through Kilkenny. The Scheme, which comprises flood defence walls, embankments, and channel conveyance improvements, provides protection against a 100 -Year flood (1% Annual Exceedance Probability) for approximately 200 properties. The Robertshill area is not protected by the Kilkenny City Flood Relief Scheme and as such does not benefit from any associated maintenance.

8.9.4 Summary of Flood Risk within SSA boundary

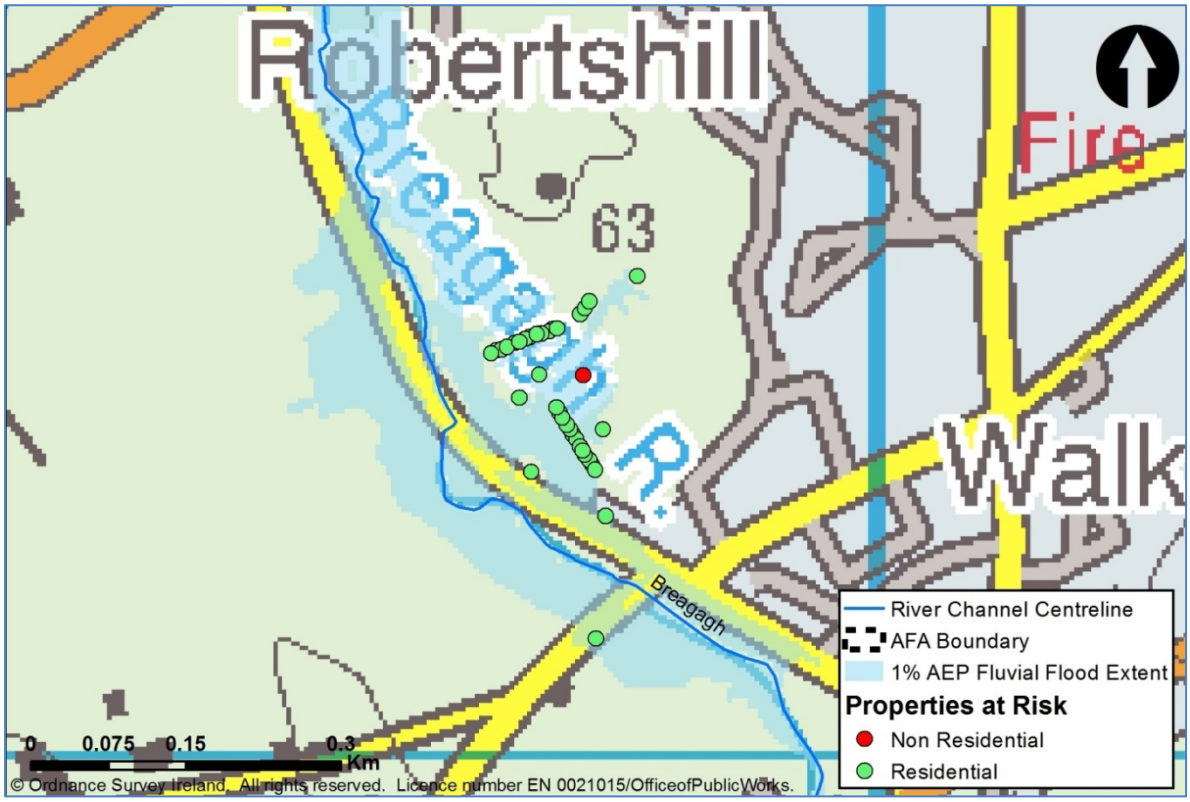


Figure 8.9.2: Flood risk in Breagagh (Kilkenny AFA) within a 1% AEP Fluvial Flood Extent

Within the Kilkenny (Breagagh) flood cell, the onset of non-residential property damage occurs in the 5% AEP event. While flooding commences at residential properties during the 20% AEP event.

8.9.5 Monetary Damage and Benefit

	Flood Cell	Total in AFA
Annual Average Damage (AAD)	€36,756	*€44,093
Present Value Damage (pvD)	€789,596	*€947,216
Preferred Standard of Protection (SoP)	1% AEP	1% AEP
Number of Properties Benefiting from Design SoP	37	37
Minimum Present Value Benefit	€677,301	€677,301
Capped Minimum Present Value Benefit	€677,301	€677,301

*The sum of the flood cell AAD or pvD values may not equate to the values presented for the Total in SSA due to flooding greater than the 1% AEP occurring outside the flood cell extents. Above Figures refer to Kilkenny (Breagagh) AFA

8.9.6 Short Listing FRM Methods - Local Cell

Method	Review Comment	Continue Screening
		Flood Cell
Do Nothing	Consider Further	✓
Additional Maintenance	Consider Further	✓
Do Minimum	Consider Further	✓
Planning and Development Control	Consider at UoM SSA - Reject	×
Building Regulations	Consider at UoM SSA - Reject	×
Catchment Wide SuDs	Consider at UoM SSA - Reject	×
Land Use Management	Consider Further	✓
Strategic Development Management	Consider at UoM SSA - Reject	×
Storage	Consider Further	✓
Improvement of Channel Conveyance	Consider Further	✓
Hard Defences	Consider Further	✓
Relocation of Properties	Consider Further	✓
Diversion of Flow	Consider Further	✓
Flood Warning/Forecasting	Consider Further	✓
Public Awareness Campaign	Consider at UoM SSA - Reject	×
Individual Property Protection	Consider Further	✓
Other Works	Consider Further	✓

8.9.6.1 Feasibility Review Summary for Flood Cell

Method	Technical Screening	Economic Screening	Environmental and Cultural Heritage Screening	Social Screening
Do nothing	×			
Additional Maintenance	×			
Do Minimum	×			
Land Use Management	✓	-	?	✓
Storage	✓	×		
Improvement of Channel Conveyance	✓	×		
Hard Defences	✓	✓	?	✓
Relocation of properties	✓	×		
Flood Warning/Forecasting	×			
Diversion of Flow	×			
Individual Property Protection	×			
Other Works	×			

× - Reject ✓ - Progress ? - Progress, potential for impacts identified ! - Progress, potential for significant impacts identified

8.9.6.2 Justification for Rejection/Retention

Method	Tech	Econ	Env	Soc
Do nothing	×			

The do nothing FRM method would involve stopping any current maintenance regime. The expected outcome would be increased vegetation in channel and sedimentation. This would reduce the conveyance capacity of the watercourse causing higher water levels for any given flow. Given that there are properties at risk during the high frequency flood events it is expected that the level of flood risk would be increased. This is an unacceptable outcome in terms of contributing to design SoP and should therefore be rejected from the screening process.

Method	Tech	Econ	Env	Soc
Additional Maintenance	✗			

This method can include clearance of channels and is also appropriate where an isolated/single issue exists which can be easily addressed in order to reduce the flood risk, for example the removal of a pinch point/obstruction, or the upgrade of a blockage prone culvert screen, etc. These activities would be considered relatively straightforward, discrete and low cost. Increasing maintenance activities on the Breagagh River will not significantly contribute to achieving the preferred SoP and therefore will not be pursued under the CFRAM Study.

Method	Tech	Econ	Env	Soc
Do Minimum	✗			

Within the Robertshill flood cell the 'Do Minimum' method would involve clearing the channel of the Breagagh River and insuring that the critical structure 15BREA0172D 'White Bridge' is kept clear of debris. This however would have minimal impact on the overall flood risk associated with the Breagagh River, as it would not provide the additional conveyance needed within the channel. This is an unacceptable outcome in terms of contributing to achieving the design standard of flood protection and therefore was rejected from the screening process.

Method	Tech	Econ	Env	Soc
Land Use Management	✓	-	✓	✓

Kilkenny (Breagagh) AFA is in the Breagagh River catchment basin. In assessing the suitability of this catchment for land use management the following criteria was considered; firstly the area of Breagagh River catchment upstream of the properties at risk, is 20 km^2, (<40 km^2). Also, land use for catchment is predominantly agricultural; the general topography of the Breagagh catchment is relatively level to slightly undulatory, with the upper catchment generally steeper. While land use management methods can be applied to any catchment, the above outlined criteria would deem the Breagagh River catchment as potentially suitable and therefore this area should progress as a pilot area and this method should therefore be progressed only if all other methods be found unsuitable.

The River Barrow and River Nore SAC and the River Nore SPA are within, downstream of and upstream of the Breagagh River. Progressing Land Use Management in a pilot area should not take precedence over other methods which will provide the design SoP. This method should therefore be progressed only if all other methods be found unsuitable.

Method	Tech	Econ	Env	Soc
Storage	✓	✗		

This method considers areas where flood water can be stored and then released at a controlled rate, therefore reducing the flow rate along the HPW and reducing the level of flood risk. This can be achieved by using existing or creating new depressions to create online or offline storage areas or by identifying pinch points which could be dammed such as a restricted point along a valley. Storage areas can be effective either upstream of the risk areas or within the risk area where parks or open areas are located.

A review of the surrounding topography was carried out to locate possible storage areas. One potential storage area was identified that would alleviate flooding within the Robertshill flood cell as shown Figure 8.9.3. A technical assessment has shown that storage would provide protection to 25 properties at risk (i.e. partial protection). The volume of water required to be stored on the Breagagh River has been estimated to be 352,904m^3. The construction of a storage area would require a series of embankments with a height up to 4m and total length of approximately 2,162m. In addition, 1 culvert is to be provided to act as a flow control device and convey flow through the embankment. An economic review estimated the cost of constructing the storage area to be €4,220,231 making this method economically unviable. The cost of this measure would increase further when combined with other measures required to provide the full SoP.

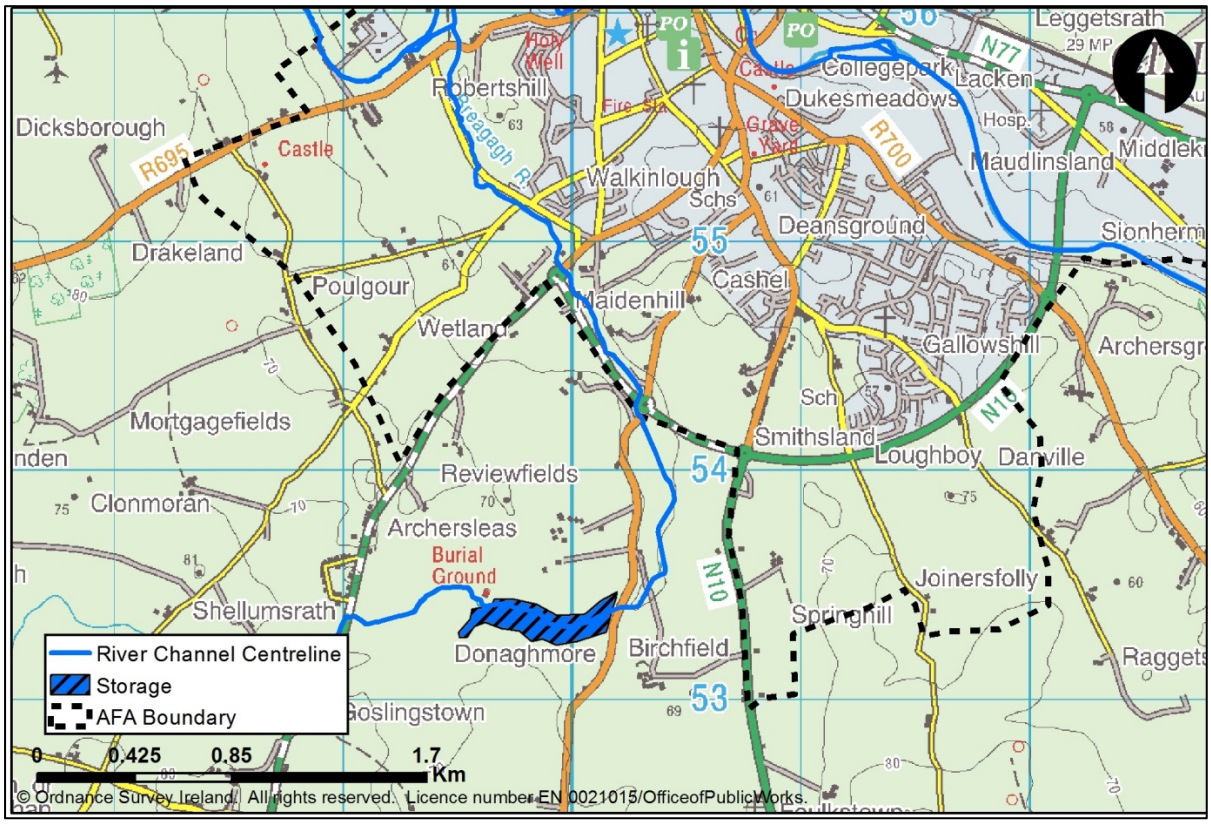


Figure 8.9.3: Potential Storage within the Breagagh River Catchment

Method	Tech	Econ	Env	Soc
Improvement of Channel Conveyance	✓	✗		

This method focuses on increasing watercourse conveyance thereby lowering water levels and reducing the associated flood risk. This can be achieved by lowering bed level, widening/reshaping channels, removing channel/structure constrictions, culverting reaches of watercourse and reducing roughness of the channel.

For the Robertshill flood cell, conveyance of the River Breagagh could be improved by dredging the channel for 1.1km. This section runs parallel with the Circular Road as illustrated Figure 8.9.4. These measures would lower the peak water levels along this entire reach and provide the required standard of protection. The works entail the excavation of approximately 7,372.2m^3 of bed material and lowering the river bed by up to 2.2m, increasing channel capacity and allowing for a 1% AEP total flow of

approximately 25m^3/s.

Works would also entail the underpinning of three bridges including 15BREA0257D and 227D. These measures would lower the peak water levels along this entire reach and provide the required standard of protection.

A new 6m clear span road bridge where the Breagagh River passes under the R695, replacing the former White Bridge (15BREA0172D) is also required.

The total cost of this method is estimated to be €1,472,752 rendering this method as economically unviable.

Figure 8.9.4: Location of Potential Channel Improvements in The Robertshill flood cell

Method	Tech	Econ	Env	Soc
Hard Defences	✓	✓	?	✓

Hard Defences refers to physical barriers which prevent water from entering an area such as flood walls, embankments and barrages. As a general rule Hard Defences should be kept as far back from the river channel as possible allowing the floodplain function to remain active. Where this is not possible, due to flood risk receptors being located within the floodplain, Hard Defences are placed around the property boundary to afford it protection. Where space allows flood embankments are used but where space is restricted flood walls are utilised.

A review was carried out to ascertain where Hard Defences would be required along the Breagagh River to protect properties at risk within the flood cell.

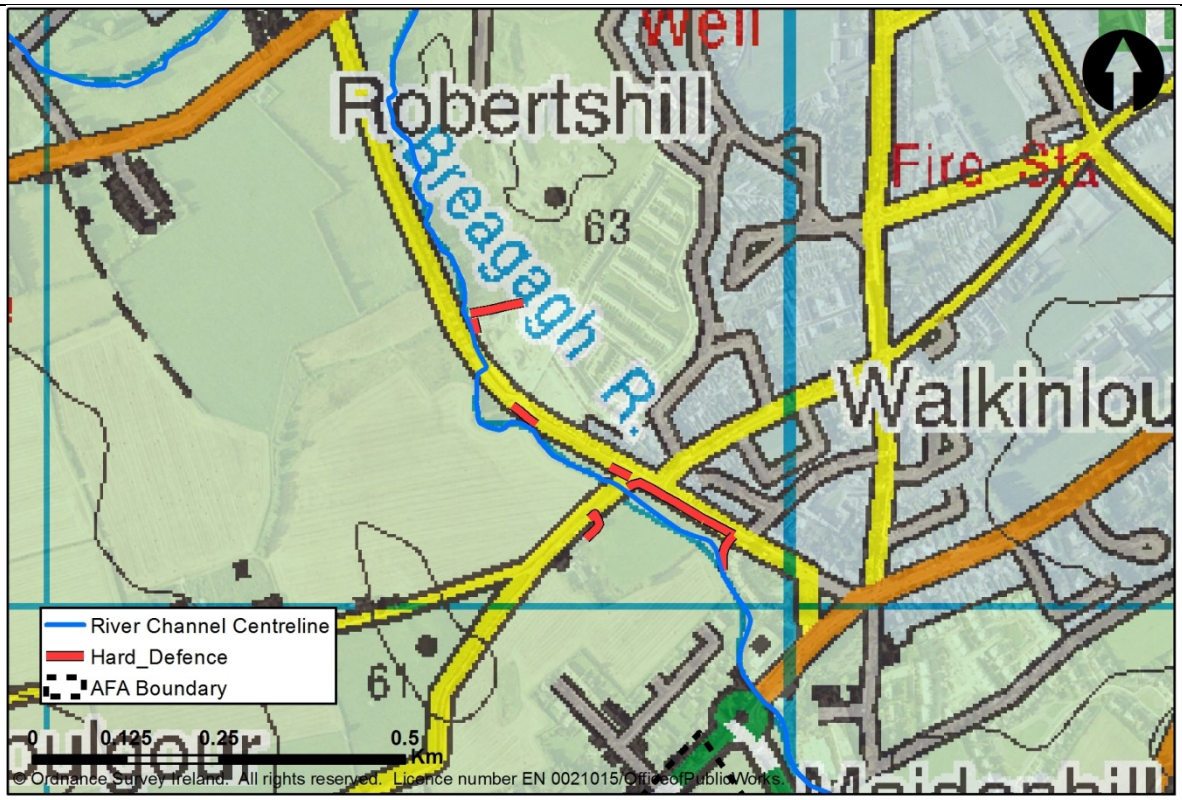


Figure 8.9.5: Location of Potential Hard Defence The Robertshill flood cell (Breagagh)

As shown in Figure 8.9.5, Hard Defences would be positioned along the various sections of the Circular Road, where the Breagagh River spills out of bank during a 1% AEP flood. This includes a series of walls and an embankment measuring an average height of 0.97m (ranging between 0.6m to 1.6m) with a total length of 0.46km.

It is estimated that the emplacement of hard defences would cost €1,225,768 rendering this method as economically unviable.

While this method is economically unviable it is the most cost effective method which can provide the full SoP to all properties within the Robertshill flood cell and should be considered further in order to assess the overall option's BCR.

The AFA is within the Nore Lower FPM sensitive area. Mount Juliet pNHA is over 12km downstream of the AFA. The proposed hard defences are not within any of these designations. Ballykeefe Wood pNHA and Nature Reserve is over 7km west of Kilkenny, however is not hydraulically linked to the AFA. IWeBS key sites in the vicinity.

Method	Tech	Econ	Env	Soc
Flood Warning / Forecasting	×			

The application of flood warning / forecasting was tested at UoM scale. No suitable location far enough upstream of the Robertshill flood cell is available to provide sufficient warning. It is estimated that a flood forecasting gauging system needs to be located approximately 44.6km upstream of the flood cell, in order to allow for a 2 hour warning time (1% AEP peak moving at 6.2m/sec). Considering that no

suitable location is identified this method is not considered technically feasible.

Method	Tech	Econ	Env	Soc
Relocation of properties	✓	×		

To relocate a property is to abandon the existing at risk property and provide an alternative in a location not at risk. While this method is, in theory, possible, it is not practical for a whole town of many at risk properties. Its use is more applicable for discrete areas where single properties or clusters of properties are located.

There are 37 properties at risk during a 1% AEP fluvial event within the Robertshill area. An economic review estimated the cost of relocating these properties as €18.5m. This method was therefore considered economically unviable and was therefore rejected from the screening process.

Method	Tech	Econ	Env	Soc
Diversion of Flow	×			

This method involves directing some of the floodwater via a new route thereby reducing flow and associated flood risk along the original route. This would be carried out upstream of where floodwaters reach the area of at risk properties. The new flow route would normally consist of a constructed open channel and/or culvert system or an existing linear feature able to convey the flow to a designated discharge point.

A review was carried out to identify locations where a Flow Diversion route could be constructed in the Breagagh River catchment, within the vicinity of the Robertshill flood cell. No suitable locations were identified mainly due to urbanisation and no suitable route.

Method	Tech	Econ	Env	Soc
Individual Property Protection	✓	✓	✓	✓

While this method would not provide the required design SoP due to its temporary nature and associated uncertainty it may be advantageous to consider as an alternative should all other methods which do provide the design SoP fail the pass through the screening process. . The estimated cost to provide protection measures for all the properties located within the Robertshill flood cell is €332,785 therefore rendering this method as economically viable.

The properties at risk are not located within any environmental designations and it is unlikely that Individual Property Protection would have any impact to designated sites in the vicinity of the properties at risk.

Method	Tech	Econ	Env	Soc
Other Works	×			

No other works were identified for this flood cell.

Summary of Feasibility Review –

The following FRM methods have been carried forward to address the flood risk arising in the Robertshill flood cell;

- Land Use Management
- Hard Defences

Hard Defences can provide the full SoP to all properties. While this method is economically unviable it is the most cost effective method which can provide the full SoP to all properties at risk and has therefore been taken forward to option selection.

The Breagagh River catchment area is considered a suitable area to consider Land Use Management as an FRM method and it is recommended that it is considered as a pilot as only 1 FRM method which provides the full SoP was found to pass through the screening process and this has a marginal BCR.

Individual Property Protection can only provide partial protection. Individual Property Protection should therefore only be used should all other methods be deemed unsuitable later in the optioneering process

8.9.7 Selection of Options

Method	Option 1	Option 2	Option 3	Option 4	Option 5
Hard Defence	✓	✓			
Land Use Management		✓			

Hard Defences is the most cost effective FRM method which can provide the full SoP to all properties at risk, and has therefore been considered further.

Land Use Management has also been considered as a pilot option for the Breagagh catchment, as no economically viable FRM method, which provides the full SoP to all properties have been identified. This would be carried out in combination with Hard Defences.

As a potential FRM option which provides the full SoP has been identified, Individual Property Protection was not considered further.

8.9.7.1 Option 1 Details –Hard Defences

Figure 8.9.6: (Breagagh) Option 1 –Hard Defences

At risk properties would be protected by a series of flood walls and embankments located along the Breagagh River. The hard defences will provide a SoP of 1% AEP for fluvial flood events with an average height of 0.97m and a total length of 0.46km.

Figure 8.9.6 presents the effect of the potential option on the design flood event by overlaying the present day flood extent (labelled existing risk) with the post option flood extent (labelled residual risk).

In addition to this method the following is also identified at UoM level (see section 8.1) to be included in any potential option identified:

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

As the BCR is less than 1 this option is economically unviable. It is therefore considered a potential option, subject to a more detailed economic assessment.

Option Item	Quantity	Construction Cost
Flood wall	418m length, 0.5m high (average)	€512,894
Flood embankment	51m length, 1.23m high	€14,395

Total MCA-Benefit Score	Option Cost (€millions)	MCA-Benefit Score / Cost Ratio
883	€1.23	720.37

Economic Appraisal (Cost-Benefit Analysis) Outcomes			
Area NPVd (uncapped)	Option Cost	Option NPVb (capped)	Benefit - Cost Ratio
€947,216	€1,225,768	€677,301	0.55

8.9.7.2 Option 2 Details –Hard Defences & Land Use Management

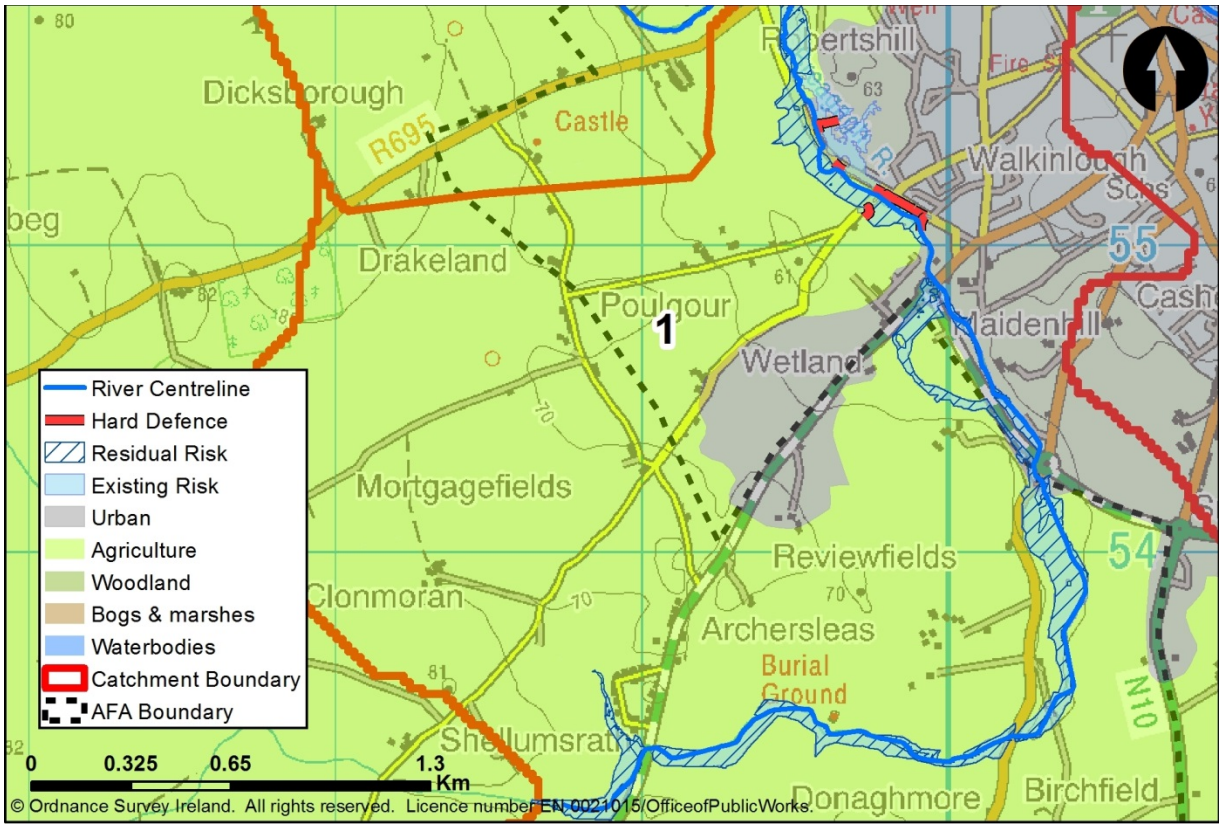


Figure 8.9.7: Land Use of the Breagagh River Catchment

The Breagagh catchment is considered to be suitable as a potential pilot area for Land Use Management. This would be used in combination with Hard Defences in order to provide a fluvial SoP

of 1% AEP to all properties. It is recommended that the viability of this method is analysed further through detailed design.

In addition to Land Use Management measures, at risk properties would be protected by a series of flood walls and embankments located close to the Breagagh River. The hard defences would have an average height of 0.97m and a total length of 0.46km.

It is assumed that implementation of Land Use Management measures will be a sunk cost. An allowance for maintenance of these features has been incorporated into the total option cost.

Figure 8.9.7 presents the effect of the potential option on the design flood event by overlaying the present day flood extent (labelled existing risk) with the post option flood extent (labelled residual risk).

In addition to these methods the following was also identified at UoM level (see section 8.1) to be included in any potential option identified:

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

Option Item	Quantity	Construction Cost
Flood wall	418m length, 0.5m high (average)	€512,894
Flood embankment	51m length, 1.23m high	€14,395
Total MCA-Benefit Score	**Option Cost (€millions)**	**MCA-Benefit Score / Cost Ratio**
816	€1.24	660.14

Economic Appraisal (Cost-Benefit Analysis) Outcomes			
Area NPVd (uncapped)	**Option Cost**	**Option NPVb (capped)**	**Benefit - Cost Ratio**
€947,216	€1,235,668	€677,301	0.548

8.9.7.3 AFA Sensitivity to Future Change

As shown in Figure 8.9.8, the Breagagh River shows an increase in flood extents during the occurrence of MRFS and HEFS 1% AEP events. The extent of flooding associated with The Robertshill flood cell is influenced by a combination of fluvial basin topography and urban infrastructure.

During the MRFS 1% AEP flood event an additional 26 properties will be at risk, bringing the property count from 37 in the present day 1% AEP event to 63. The AAD would increase from €44,093 to €206,714. As a result the Robertshill flood cell would be considered to be at High vulnerability from the MRFS 1% AEP flood event.

During the HEFS 1% AEP flood event there would be an increase in flood extent. This would result in a further 47 properties being at risk bringing the property count from 37 in the present day 1% AEP event to 84. The AAD would increase from €44,093 to €392,031. As a result the Robertshill flood cell would be considered to be at High vulnerability from the HEFS 1% AEP flood event.

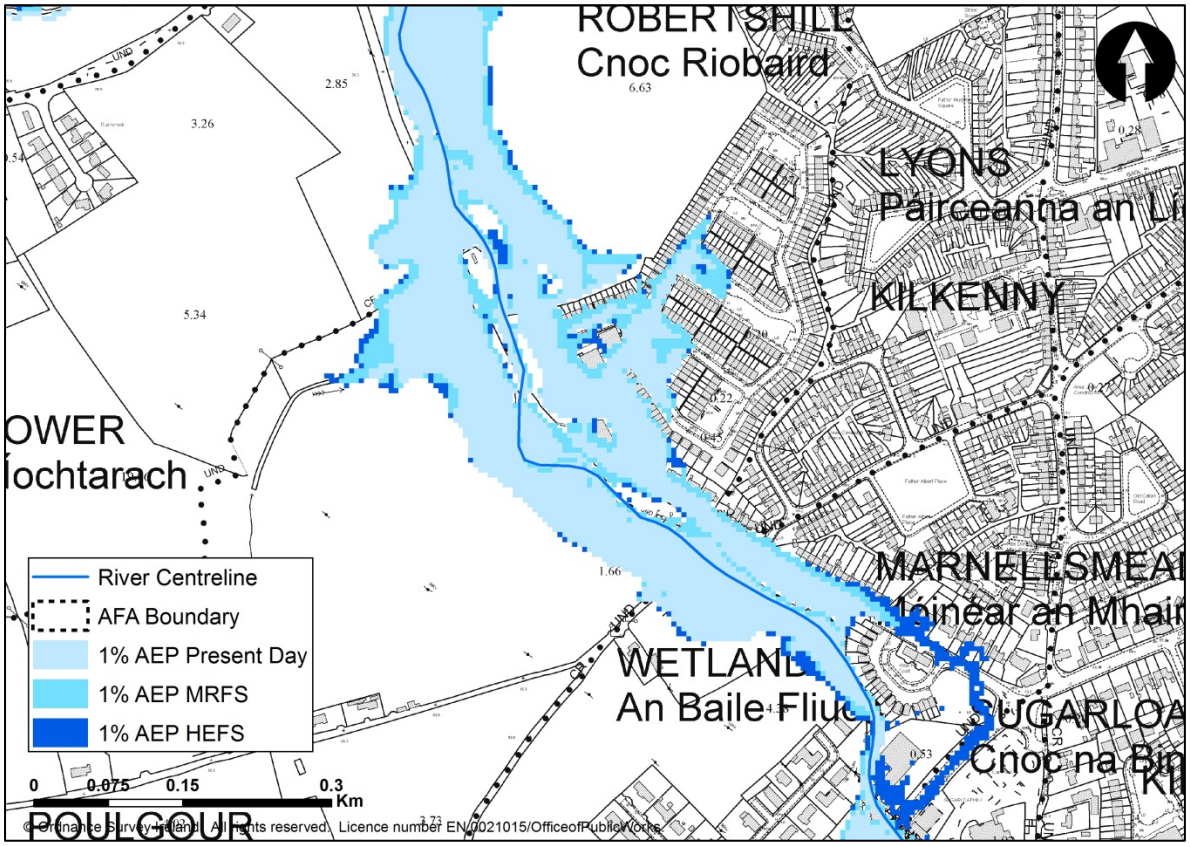


Figure 8.9.8: Future Change Flood Extents (The Robertshill flood cell)

8.9.7.4 Future Changes Adaptability

The following discusses the adaptability of the potential FRM **methods** proposed in the Kilkenny (Breagagh) AFA:

Hard Defences- This method could be adapted by increasing the height of the hard defences and extending their length. A review of the effect of the MRFS and the HEFS showed that the hard defences would need to be increased from an average height range of 0.97m for current event scenario to 1.31m and 1.38m, for the MRFS and HEFS, respectively.

This additional height could be accommodated. The review also showed that the additional length of hard defence required would be minimal. To ensure that these hard defences would be adaptable the design would need to account for the potential increase in height. This method is considered to have a **moderate** adaptability.

The potential **options** identified have been further assessed using 5 criteria in an attempt to identify low – or no regret combinations of measures.

1. **Does the option reduce vulnerability?** In addition to the methods above other methods

aimed at reducing future flood risk have been discussed in section 8.1 at UoM scale and are detailed in each potential option. These methods, such as building regulations and planning & development control will reduce the impact to potential future receptors. Given that Robertshill is currently suburban and the area to the west is relatively rural, hard defence may be highly effective. Considering that there is a relatively large increase in the number of properties affected during the MRFS and HEFS there is a need to ensure that the owners and users of future receptors at risk are prepared through methods such as public awareness campaign.

2. **Does the option make space for water?** Options which provide additional space for water or does not restrict it are more likely to perform well in future scenarios. Options which include hard defences restrict the water making water levels more sensitive to increased flow. Both options 1 and 2 would create this situation downstream due to hard defences.
3. **Does the option deliver co-benefits?** No co-benefits were identified. However option 2, Hard Defences & Land Use Management, has potential to deliver co-benefits with environmental and recreational objectives.
4. **Does the option provide flexibility?** A review of the potential options show that option 1, Hard Defences, is the most adaptable to the MRFS and HEFS. It is unlikely that the Land Use Management features of option 2 can be adapted to account for future flows; however the Hard Defences could be adapted as with option 1.
5. **Does the option allow for deferring/removing or abandoning?** Given the present day risk there is no allowance for options to be deferred or any that could be removed later. However should opportunity ever arise, option 2 is most easily reverted.

An objective for each potential option is to ensure that flood risk can be managed effectively and sustainably into the future accounting for the potential impacts of climate change. Based on this future changes adaptability assessment the table below summarises how well each option achieves this objective.

Summary of Option Adaptability

Option	Description	Score
Option 1 – Hard Defences	Option is adaptable at moderate cost, difficulty and impact	3
Option 2 – Hard Defences & Land Use Management	Option is adaptable at moderate cost, difficulty and impact	3

8.9.7.5 Local Authority Comments

No LA comments have been received regarding this version of options recommended for the Breagagh River flood cell.

8.9.7.6 Summary

The Breagagh River forms part of the Kilkenny Model, with good confidence in both the hydrology and hydraulics of this model due to the presence of several gauging stations (including 15104, 15002, 15105 and 15050) and flood extent verification events (post 2005).

The following potential options, with a BCR ≥ 0.55 have been identified:

- Option 1 – Hard Defences
- Option 2 – Hard Defences & Land Use Management

Alongside any potential option the existing regime should continue with maintenance being carried out ad hoc when resources allow. Maintenance of the option structures where applicable will also form part of the ongoing regime once in place.

Thomastown, Inistioge and Ballyhale AFAs are all located downstream of Kilkenny (Breagagh) AFA and should be taken into consideration for any future works carried out.

Option 2 would require significant engagement with local landowners upstream in order to implement land use management measures.

No critical environmental, cultural heritage or social issues have been identified.

As a consequence of the emplacement of a flood defence scheme (2005), Kilkenny (Nore) AFA has benefitted. As outlined in Section 8.8.2, present day flooding associated with Kilkenny is therefore localised and mainly associated with the Breagagh River. A future change assessment identified that the Robertshill flood cell is sensitive to change and is suitable for an adaptive approach to be incorporated into the detailed design.

These recommendations should be taken forward with a view to identification of a preferred option for the flood risk management plan.

8. OPTIONEERING OF SSA'S

8.10 Mountrath Optioneering of FRM Options

Name	Local Authority	Unique ID	SSA	Status	Date
Mountrath	Laois	150198	AFA	Final	13/06/2016

8.10.1 Source of flooding

Fluvial	Coastal Mechanism 1	Coastal Mechanism 2

8.10.2 Flood Cells

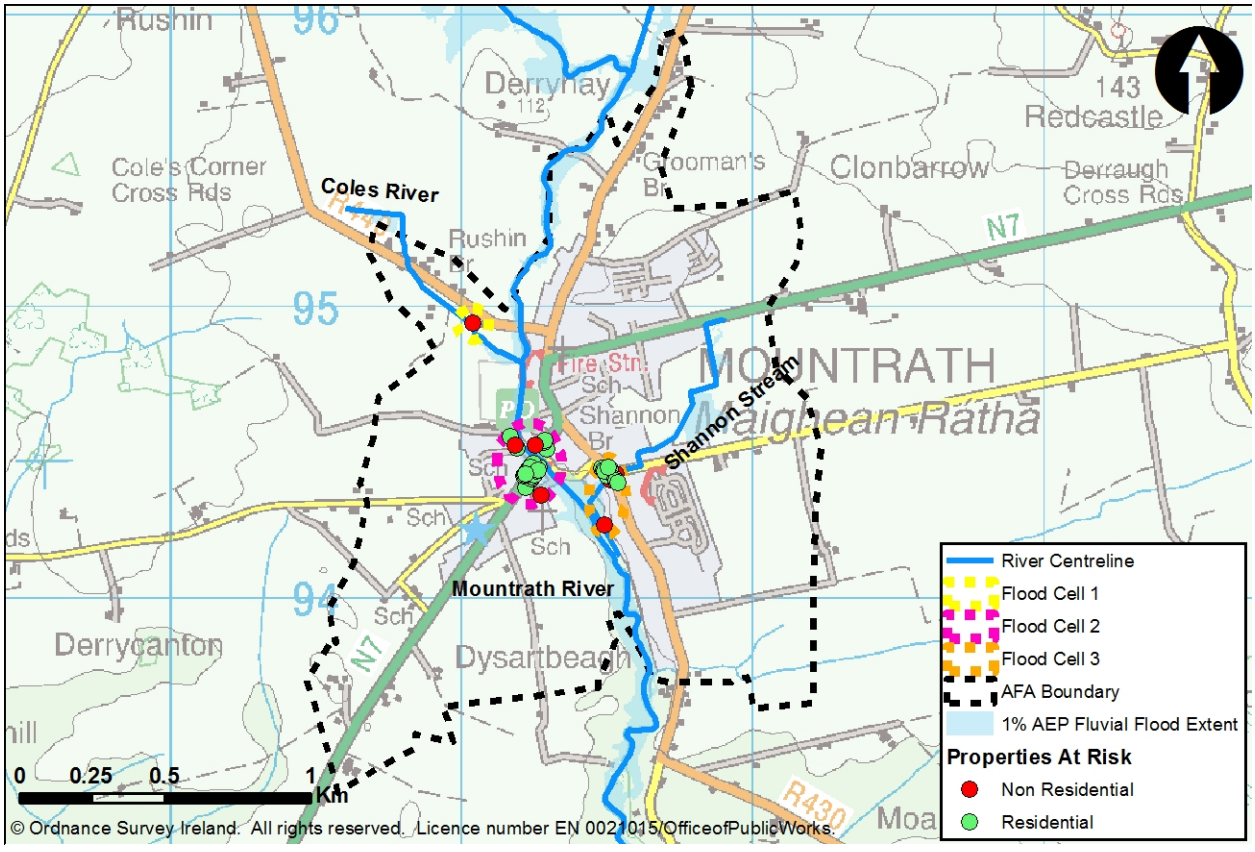


Figure 8.10.1 Mountrath AFA Flood Cells within a 1% AEP Fluvial Flood Extent

Flood Cell 1:
Out of bank flooding would occur in the Coles River during a 1% AEP flood event due to insufficient channel capacity in flood cell 1. One property is affected which is located on the left bank. Given that flood cells 2 & 3 are located immediately downstream of this flood cell the flood risk in flood cell 1 is considered complex.

Flood Cell 2:

Out of bank flooding occurs from the Mountrath River during a 1% AEP fluvial flood event due to insufficient capacity at bridge 15MRAT00421D. This causes flooding on both banks upstream of the bridge affecting 16 properties. A high number of properties are affected within this flood cell and flood cells 1 & 3 are located upstream and downstream respectively. Flood cell 2 is therefore considered complex.

Flood Cell 3:

On the Shannon Stream, flooding occurs due to a combination of insufficient capacity of the culvert approximately 70m downstream of Shannon Street and high water levels from the Mountrath River backing up the Shannon Stream and overflowing from the section of open watercourse south-west of Shannon Street. 12 properties adjacent to Shannon Street are affected by this flooding. One additional property in this flood cell is affected due to a combination of overland flow from the Shannon Stream and high water levels in the Mountrath River. The total number of properties at risk within this flood cell is therefore 13. As there is a relatively high number of properties affected due to multiple flood mechanisms, and as flood cells 1 & 2 are located upstream, this flood cell is considered complex.

Summary of Flood Cells:

The Flood Cells identified for the Mountrath AFA have each been deemed to be complex and as such will be screened together in order to ensure any hydraulic interaction between the flood cells is accounted for and the preferred level of protection is achieved at each location.

On completion of the optioneering screening assessment all flood cells will be combined to form complete options for Mountrath AFA as detailed in section 8.10.7.

8.10.3 Existing Regime

The existing regime considers all activities currently carried out which impact on the management of flood risk. The level and frequency of maintenance is considered, along with inspection, and any other specific activity (for example the operation of locks, barrages, sluice gates and valves).

The Mountrath watercourses are not located within a Drainage District or an Arterial Drainage scheme. They are, for the most part, in private lands and are not the responsibility of Laois County Council. Nevertheless, inspection and maintenance are carried out as and when resources are available.

8.10.4 Summary of Flood Risk within SSA boundary

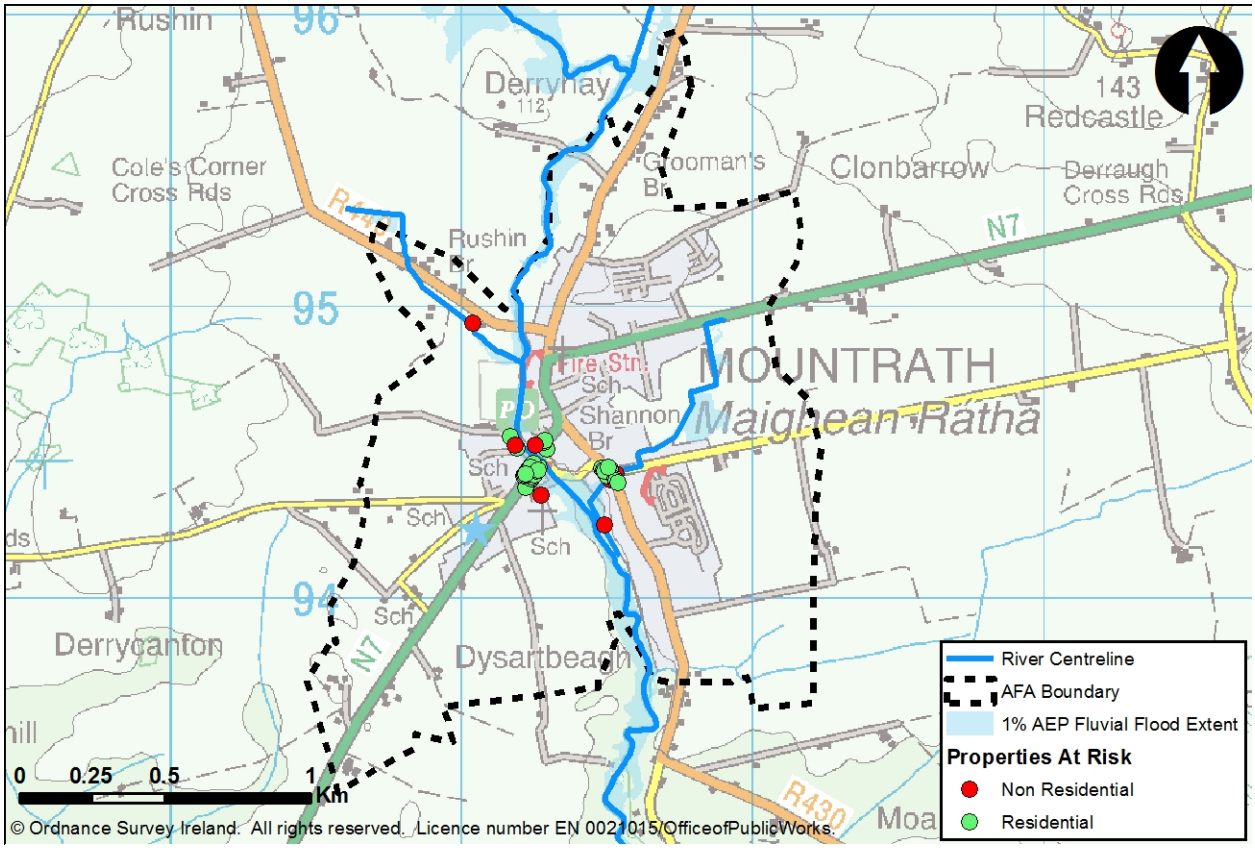


Figure 8.10.2 Flood risk in Mountrath AFA within a 1% Fluvial Flood Extent

In Mountrath AFA the onset of residential and non-residential property damage occurs in the 50% AEP event.

8.10.5 Monetary Damage and Benefit

	Flood Cells 1, 2 & 3	Total in AFA
Annual Average Damage (AAD)*	€99,013	€101,833
Present Value Damage (pvD)*	€2,126,997	€2,187,578
Preferred Standard of Protection (SoP)	1%AEP	1%AEP
Number of Properties Benefiting from Design SoP	40	40
Minimum Present Value Benefit	€1,546,066	€1,546,066
Capped Minimum Present Value Benefit	€1,546,066	€1,546,066

*The sum of the flood cell AAD or pvD values may not equate to the values presented for the Total in SSA due to flooding greater than the 1% AEP occurring outside the flood cell extents.

8.10.6 Short Listing FRM Methods – Complex Cells

Method	Review Comment	Continue Screening
		Flood Cells 1, 2 & 3
Do Nothing	Consider Further	✓
Additional Maintenance	Consider Further	✓
Do Minimum	Consider Further	✓
Planning and Development Control	Consider at UoM SSA - Reject	×
Building Regulations	Consider at UoM SSA - Reject	×
Catchment Wide SuDs	Consider at UoM SSA - Reject	×
Land Use Management	Consider Further	✓
Strategic Development Management	Consider at UoM SSA - Reject	×
Storage	Consider Further	✓
Improvement of Channel Conveyance	Consider Further	✓
Hard Defences	Consider Further	✓
Relocation of Properties	Consider Further	✓
Diversion of Flow	Consider Further	✓
Flood Warning/Forecasting	Consider Further	✓
Public Awareness Campaign	Consider at UoM SSA - Reject	×
Individual Property Protection	Consider Further	✓
Other Works	Consider Further	✓

8.10.6.1 Feasibility Review Summary for Complex Cells (flood cells 1, 2 & 3)				
Method	**Technical Screening**	**Economic Screening**	**Environmental and Cultural Heritage Screening**	**Social Screening**
Do Nothing	×			
Additional Maintenance	×			
Do Minimum	×			
Land Use Management	✓	-	✓	✓
Storage	✓	×		
Improvement of Channel Conveyance	✓	✓	!	✓
Hard Defences	✓	✓	!	✓
Relocation of properties	✓	×		
Diversion of Flow	×			
Flood Warning/Forecasting	✓	✓	✓	✓
Individual Property Protection	✓	✓	✓	✓
Other Works	×			
× - Reject ✓ - Progress ? - Progress, potential for impacts identified ! - Progress, potential for significant impacts identified				

8.10.6.2 Justification for Rejection/Retention				
Method	Tech	Econ	Env	Soc
Do nothing	×			
The Do Nothing FRM method would involve stopping the current maintenance regime. This would not provide the preferred SoP and therefore was rejected from the screening process.				
Method	Tech	Econ	Env	Soc
Additional Maintenance	×			
This method considers whether improvements can be made to augment the existing maintenance regime which will provide a significant beneficial impact on flood risk in the AFA. A review was carried out of the existing watercourse network. This included assessing the channel vegetation, the amount of debris present in the channels and the likelihood of structures blocking. Increasing maintenance activities on the relevant watercourses will not significantly contribute to achieving				

the preferred SoP and therefore will not be pursued under the CFRAM Study.

Method	Tech	Econ	Env	Soc
Do Minimum	✗			

This method is appropriate where an isolated/single issue exists which can be easily addressed in order to reduce the flood risk, for example the removal of a pinch point/obstruction, or the upgrade of a blockage prone culvert screen, etc. These activities would be considered relatively straightforward, discrete and low cost. Do Minimum is a standalone method, as it cannot be combined with others without contradicting its definition, therefore the design SoP must be achieved for this method to progress.

Within flood cells 1, 2 & 3 there is little opportunity to improve the conditions in the watercourse and therefore little scope to reduce the overall flood risk. This is an unacceptable outcome in terms of contributing to achieving a design SoP and was therefore rejected from the screening process.

Method	Tech	Econ	Env	Soc
Land Use Management	✓	-	✓	✓

The application of land use management measures was tested at UoM scale. Flood cells 1-3 are located within catchments which are considered suitable as a pilot area and should progress in the optioneering process should no other method providing the full SoP be found suitable.

Method	Tech	Econ	Env	Soc
Storage	✓	✗		

This method considers areas where flood water can be stored and then released at a controlled rate therefore reducing the flow rate through the AFA and reducing the level of flood risk. This can be achieved by using existing depressions to create online or offline storage areas or by identifying pinch points which could be dammed such as a restricted point along a valley. Storage areas can be effective either upstream of the risk areas or within the risk area where parks or open areas are located.

A review of the surrounding land was carried out and suitable storage areas were identified, as shown in Figure 8.10.3. Storage cannot reduce the 1% AEP event flow in the Mountrath River to the equivalent of the 50% AEP. By incorporating the storage area ‘Mountrath 1’ it is possible to attenuate the 1% AEP event flow to that of a 2% AEP. This would provide protection to 14 of the 40 properties at risk in flood cells 1, 2 & 3.

An economic assessment was carried out and it was estimated that the embankments, control weirs and culverts for the ‘Mountrath 1’ storage area amounts to €1.58m. This method is therefore economically unviable and was rejected from the screening process.

A potential storage area was identified on the Shannon Stream as shown in Figure 8.10.3, however this was considered technically unfeasible as one of the main sources of flood risk on this watercourse is flow from the Mountrath River backing up the Shannon Stream. Storage on the Shannon Stream would not address this flood mechanism and it was therefore rejected from the screening process.

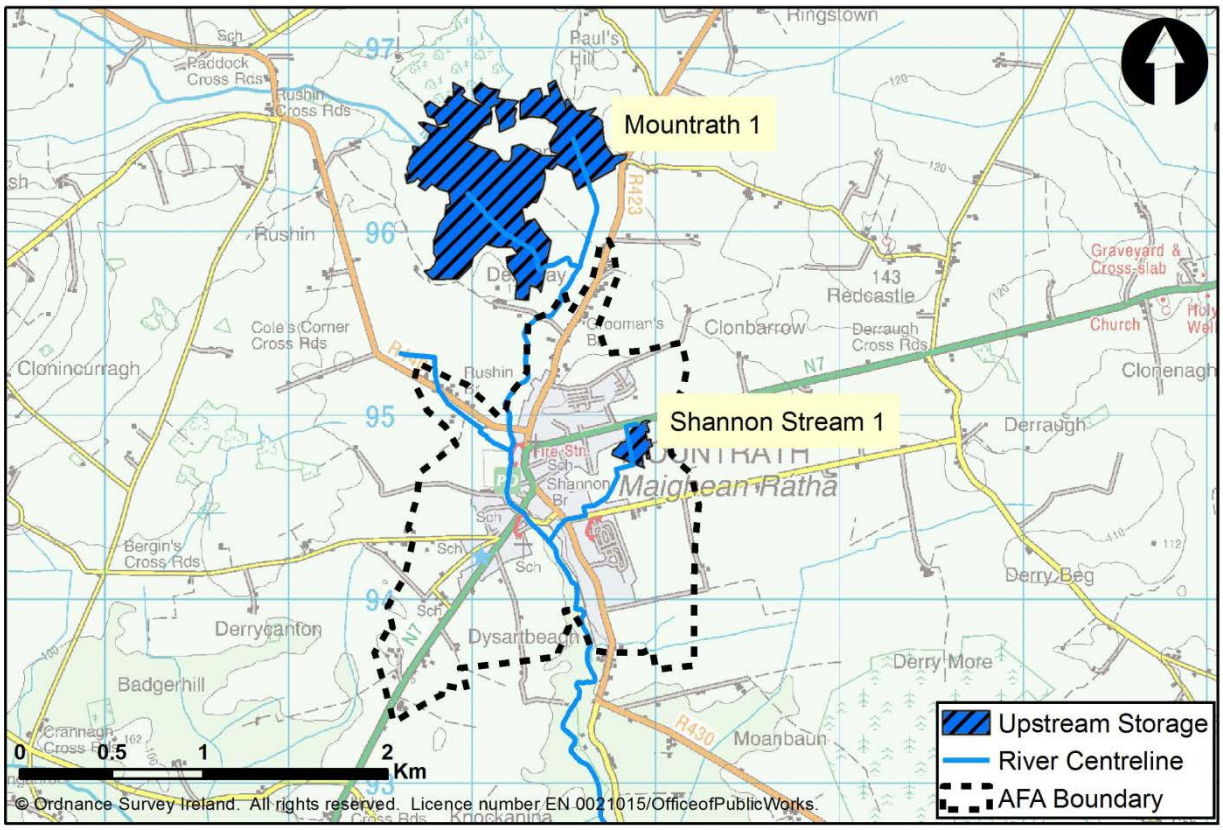


Figure 8.10.3 Location of Storage Areas Identified in Mountrath AFA

Method	Tech	Econ	Env	Soc
Improvement of Channel Conveyance	✓	✓	!	✓

This method focuses on increasing watercourse conveyance thereby lowering water levels and reducing the associated flood risk. This can be achieved by lowering bed level, widening/reshaping channels, removing channel/structure constrictions, culverting reaches of watercourse and reducing roughness of the channel.

Flooding occurs in flood cell 1 due to low bank levels and a culvert on the Coles watercourse restricting flow at 15COLE00017. Upgrading this culvert to convey the 1% AEP event flow of 1.63m^3/s would require a culvert size of 2m wide x 0.8 high, which does not fit in the channel. The bed level is also relatively uniform with little opportunity identified to increase channel conveyance by lowering the bed level. It was found that widening the channel by around 2.5m and lowering the bed by 1m would convey the 1% AEP event flow as well as accommodate an upgraded culvert whilst providing the upgraded culvert with the required cover. The location of these works is shown in Figure 8.10.4. An economic review estimated that the cost of in channel excavation, maintenance of the channel and upgraded culvert would be approximately €189,400 which is economically viable, subject to the cost to the methods with which it is combined.

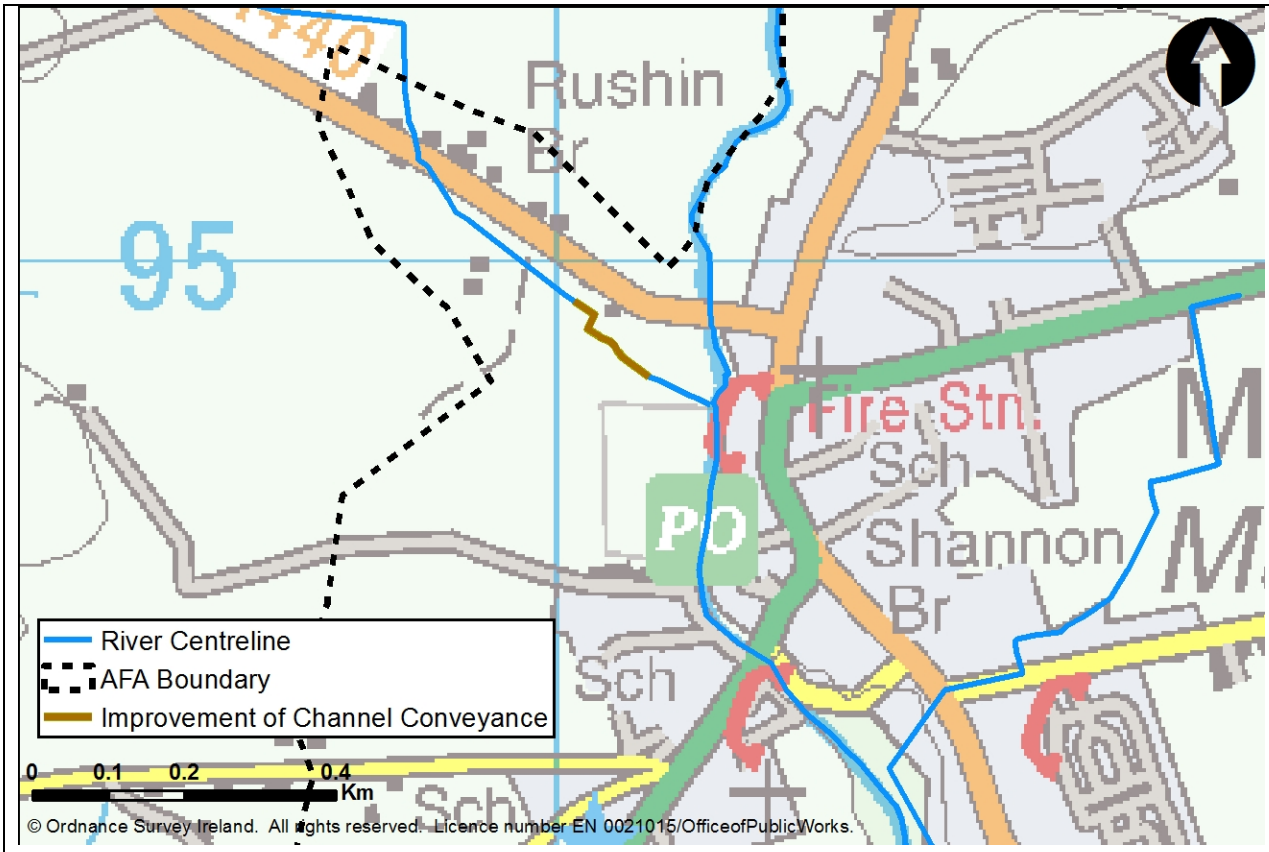


Figure 8.10.4 Location of Improvement of Channel Conveyance in Flood Cell 1

In flood cell 2 flooding occurs due to insufficient channel capacity. A review was carried out to assess if increasing capacity of the Mountrath River at this location would prevent flooding. It was determined that the bed level of the channel would have to be lowered by more than 0.5m over a length of over 600m. A sewer pipe crosses the Mountrath River downstream of the R445 bridge, preventing the channel from being lowered. It is therefore considered technically unfeasible to increase channel conveyance in flood cell 2.

In flood cell 3 flooding occurs due to flow from the Mountrath River backing up the Shannon Stream and spilling out a section of open channel south west of Shannon Street. The culvert downstream of this open channel also has insufficient capacity. Channel conveyance in flood cell 3 could be improved by replacing this section of open watercourse with a box culvert of dimensions 2.0m x 0.9m and linking this culvert directly to the Mountrath River. This section of culvert is shown in Figure 8.10.5. An economic review estimated the cost of this culvert upgrade to be €589,000. This method is therefore economically viable, subject to the cost to the methods with which it is combined.

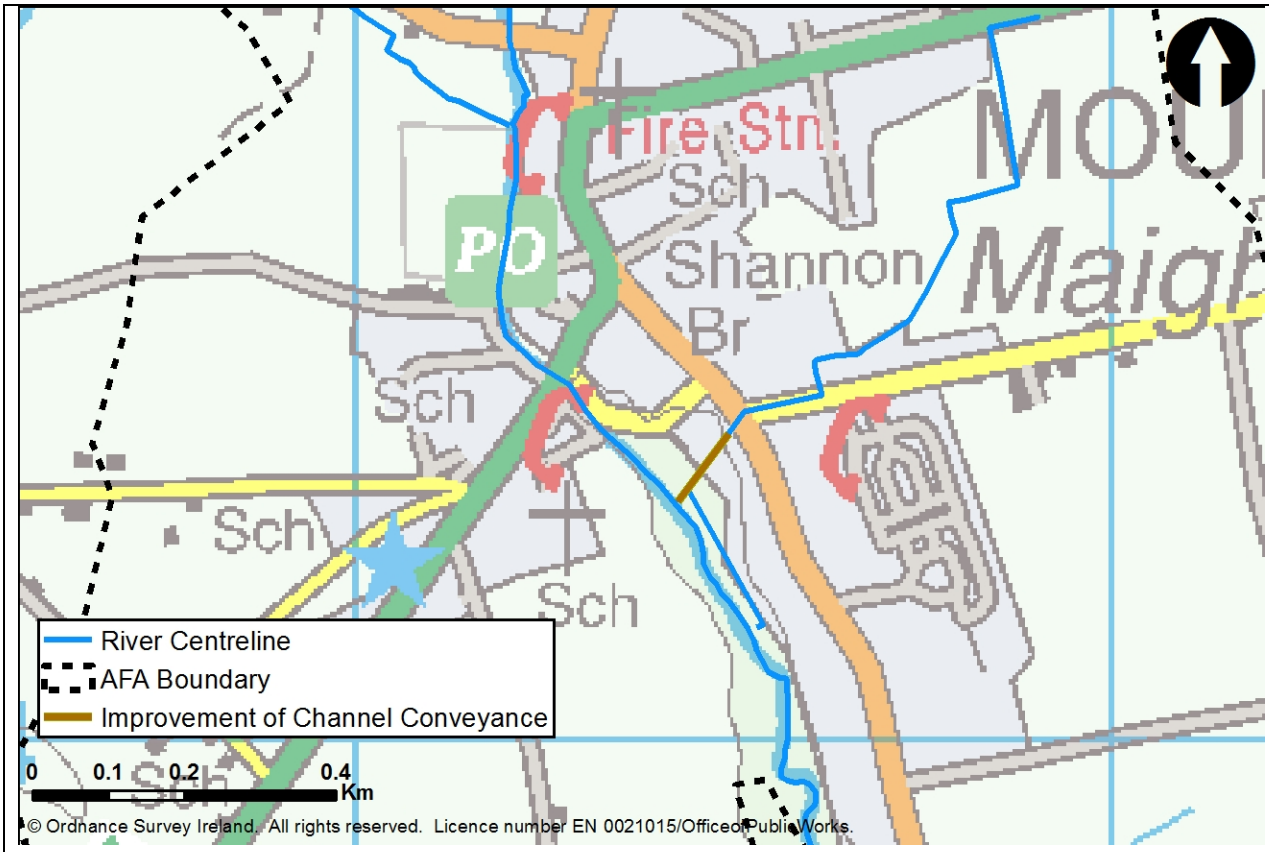


Figure 8.10.5 Location of Improvement of Channel Conveyance in Flood Cell 3

Improvement of channel conveyance is unsuitable as a standalone FRM method as it cannot provide the preferred SoP to all properties at risk. This method may be suitable as part of a combined method, subject to the cost of the methods with which it is combined.

The River Barrow and River Nore SAC is within, upstream of and downstream of Mountrath. The River Nore SPA is 3km downstream of the AFA. FRM Methods should be aware of River Barrow and River Nore SAC, and potential environmental impacts have been identified. No negative social impacts have been identified.

Method	Tech	Econ	Env	Soc
Hard Defences	✓	✓	!	✓

The term Hard Defences refers to physical barriers which prevent water from entering an area such as flood walls, embankments and barrages. As a general rule Hard Defences are kept as far back from the river channel or coast line as possible allowing the floodplain function to remain active. Where this is not possible, due to flood risk receptors being located within the floodplain, Hard Defences are placed around the property boundary to afford it protection. Where space allows flood embankments are used but where space is restricted flood walls are utilised.

A review was carried out to ascertain where Hard Defences would be required to protect existing property within flood cells 1, 2 & 3. Figure 8.10.6 shows the location of the Hard Defences required to protect properties during the 1% AEP event.

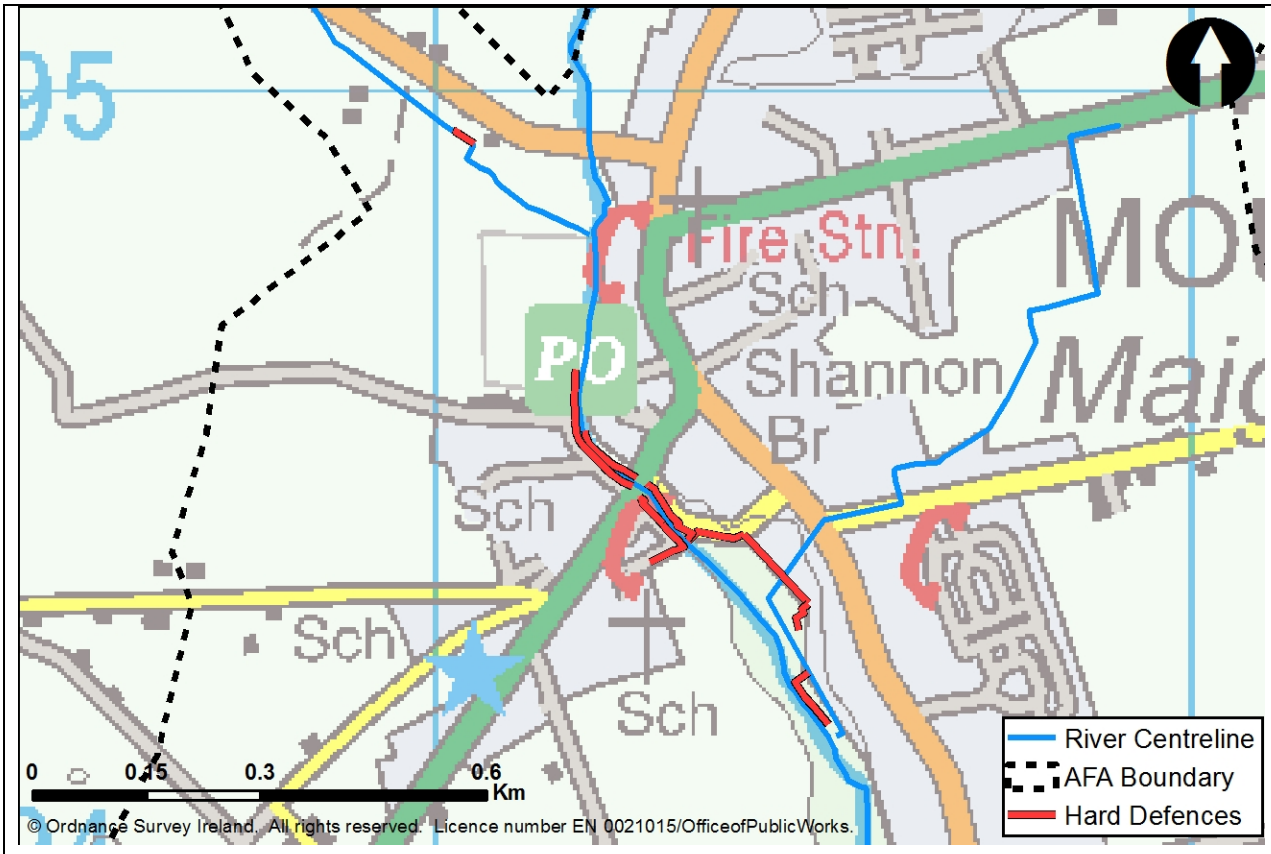


Figure 8.10.6 Location of Hard Defences in Flood Cells 1, 2 & 3

In order to ascertain the effectiveness of Hard Defences a hydraulic model was constructed to simulate the method. Due to the backwater effect of the Mountrath River at the downstream end of the Shannon Stream and various constrictions within this area including a section of open watercourse located within the boundary of a residential property, it was not possible to provide the preferred SoP to all properties at risk within flood cell 3 using hard defences as a standalone method. These hard defences would therefore need to be combined with works to culvert this section of open watercourse. The model showed these hard defences would protect to the 1% AEP flood event with an average height of approximately 1.0m and a total length of 910m. An economic review estimated the cost of the hard defences to be approximately €1.94m. This FRM method is the most cost effective which can provide the preferred SoP to properties in flood cell 2. It will therefore be taken forward to option selection.

The River Barrow and River Nore SAC is within, upstream of and downstream of Mountrath. The River Nore SPA is 3km downstream of the AFA. FRM Methods should be aware of River Barrow and River Nore SAC, and potential environmental impacts have been identified.

Method	Tech	Econ	Env	Soc
Relocation of properties	✓	×		

To relocate a property is to abandon the existing at risk property and provide an alternative in a location not at risk. While this method is, in theory, possible, it is not practical for a whole town of many at risk properties. Its use is more applicable for discrete areas where single properties or clusters of properties are located.

The 40 properties at risk during the 1% AEP event may be suitable for relocation, however the cost to relocate these properties, based on market value, is €18.3m. This method is therefore economically unviable and was rejected from the screening process.

Method	Tech	Econ	Env	Soc
Diversion of Flow	✗			

This method involves directing some of the floodwater via a new route thereby reducing flow and associated flood risk along the original route. This would be carried out upstream of where floodwaters reach the area of at risk properties. The new flow route would normally consist of a constructed open channel and/or culvert system or an existing linear feature able to convey the flow to a designated discharge point.

A review was carried to identify any locations where a Flow Diversion route could be constructed in the vicinity of flood cells 1, 2 & 3. Due to the density of properties there are no suitable paths for diversion of flow to be carried out to alleviate flood risk in all 3 flood cells. This FRM option was deemed technically unfeasible and was rejected from the screening process.

Method	Tech	Econ	Env	Soc
Flood Warning / Forecasting	✓	✓	✓	✓

The application of flood warning / forecasting was tested at UoM scale. Suitable locations far enough upstream of flood cells 1-3 are available to provide sufficient warning. This method can only provide warning for other methods and does not provide the preferred SoP as a standalone method. Therefore this method should only be considered if no other methods are suitable during the optioneering process.

An economic review estimated that the cost of providing six hydrometric gauging stations with simple forecasting systems would be approximately €284,950. This method is therefore economically viable.

The proposed gauging stations are not within any environmental designations and it is unlikely that flood forecasting would have any impact to designated sites in the vicinity of the Mountrath AFA.

Method	Tech	Econ	Env	Soc
Individual Property Protection	✓	✓	✓	✓

This method is aimed at individual properties that are remote from the main risk areas. Where the AFA being considered consists of a small number of remote properties this method is a feasible solution. But for AFAs with multiple properties at risk this method would only be considered an add on to a primary method. Individual property protection could consist of flood gates and vent seals on the building structure itself. Where flood depths are over 0.6m this method becomes unfeasible and flood resilience techniques would be recommended over flood gates. As this method is temporary and relies of human intervention there is an element of uncertainty as to whether the preferred SoP will be met for every flood event. As such it is assumed that 20% of the flood damage will be avoided.

While this method would not provide the preferred design SoP due to its temporary nature and associated uncertainty it may be advantageous to consider as an alternative should all other methods which do provide the design SoP fail to pass through the screening process. The estimated cost to provide protection measures for these properties is €607,380. This method is therefore economically viable.

The properties at risk are not located within any environmental designations and it is unlikely that Individual Property Protection would have any impact to designated sites in the vicinity of the properties at risk.

Method	Tech	Econ	Env	Soc
Other Works	×			
No other works were identified for these flood cells.				

Summary of Feasibility Review – Flood Cells 1, 2 & 3

The following FRM methods have been carried forward to address the flood risk arising from flood cells 1, 2 & 3;

- Hard Defences and
- Improvement of Channel Conveyance

Hard Defences can provide the preferred SoP to all properties during the 1% AEP fluvial flood event when it is combined with Improvement of Channel Conveyance for flood cell 3.

Improvement of Channel Conveyance can also provide the preferred SoP to the property at risk in flood cell 1 as an alternative to Hard Defences.

The Mountrath AFA is considered a suitable area to consider Land Use Management as an FRM method and it is recommended that it is considered as a pilot should the other feasible methods listed above be found unsuitable.

Individual Property Protection and Flood Warning/Forecasting can provide only partial protection to all properties. This method should therefore only be used should all other methods be deemed unsuitable later in the optioneering process.

8.10.7 Selection of Options

Method	Option 1	Option 2	Option 3	Option 4	Option 5
Hard Defences	✓	✓			
Improvement of Channel Conveyance (FC3)	✓	✓			
Improvement of Channel Conveyance (FC1)		✓			

For flood cell 1 Hard Defences or Improvement of Channel Conveyance can provide the preferred SoP to the property at risk.

For flood cell 2 Hard Defences is the only suitable FRM method which has been identified.

For flood cell 3 it was identified that Hard Defences and Improvement of Channel Conveyance need to be combined in order to provide the preferred SoP to the properties at risk.

As a feasible option has been identified, Land Use Management is no longer to be considered in the Mountrath AFA as a pilot option.

8.10.7.1 Option 1 details - Hard Defences & Improvement of Channel Conveyance (FC3)

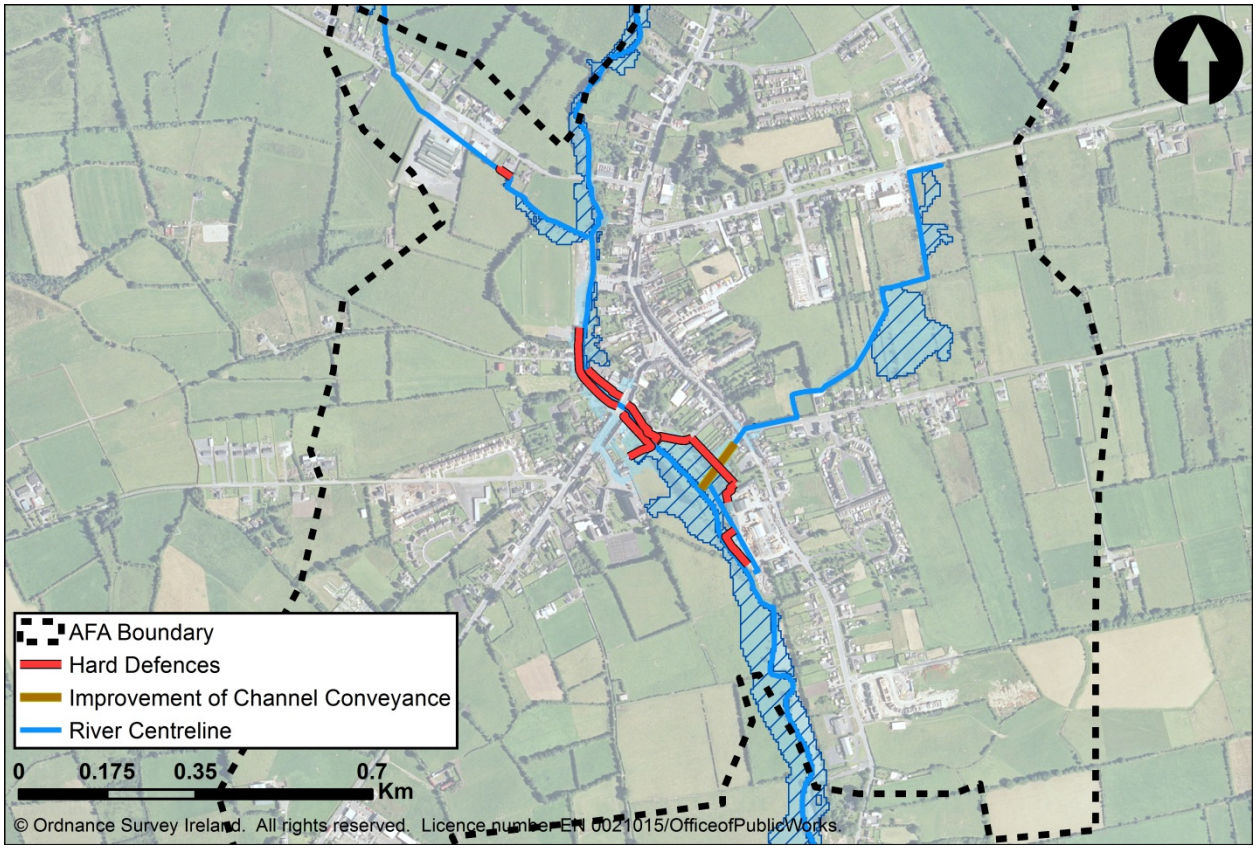


Figure 8.10.7 Mountrath AFA Option 1

At risk properties would be protected by a series of flood walls and embankments, along with culverting of an open section of watercourse at the downstream end of the Shannon Stream. The hard defences will provide an SoP of 1% AEP for fluvial flood events with an average height of 1.0m and a total length of 910m. A new 2.0m x 0.9m box culvert of 110m length will be constructed at the downstream end of the Shannon Stream in order to culvert the existing open section of watercourse and connect the Shannon Stream to the Mountrath River.

Option Item	Quantity	Construction Cost
Flood wall	475m length, 1.1m high (average)	€739,100
Flood embankment	435m length, 0.9m high (average)	€69,680
Culvert construction	110m length, 2.0m x 0.9m box culvert	€140,460
Total MCA-Benefit Score	**Option Cost (€millions)**	**MCA-Benefit Score / Cost Ratio**
352	2.65	132.69

Economic Appraisal (Cost-Benefit Analysis) Outcomes			
Area NPVd (uncapped)	**Option Cost**	**Option NPVb (capped)**	**Benefit - Cost Ratio**
€2,187,578	€2,649,262	€1,546,066	0.58

8.10.7.2 Option 2 details - Hard Defences and Improvement of Channel Conveyance (FC1&3)

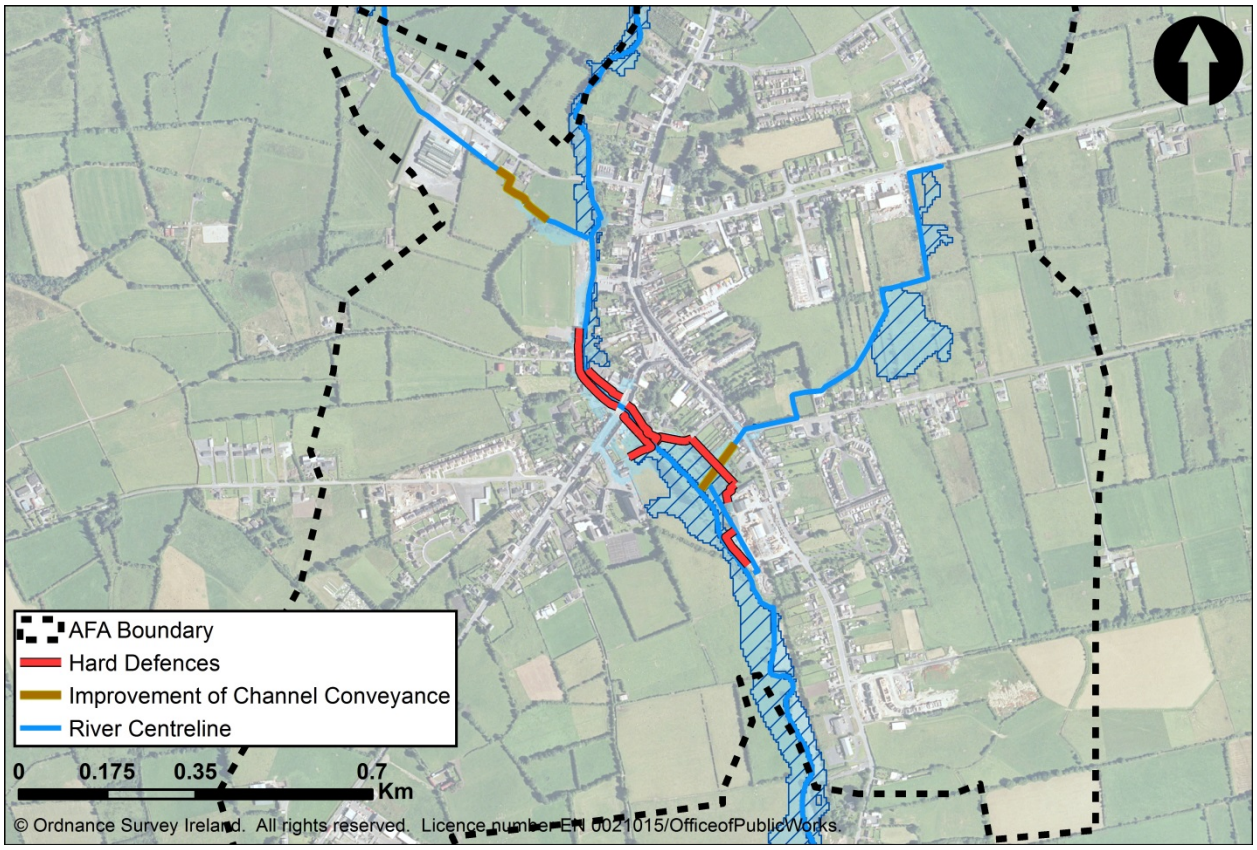


Figure 8.10.8 Mountrath AFA Option 2

At risk properties would be protected by a series of flood walls and embankments, culverting of an open section of watercourse at the downstream end of the Shannon Stream, widening and deepening the Coles River and upgrading the culvert at 15COLE00017. The hard defences will provide an SoP of 1% AEP for fluvial flood events with an average height of 1.0m and a total length of 875m. A new 2.0m x 0.9m box culvert of 110m length will be constructed at the downstream end of the Shannon Stream in order to culvert the existing open section of watercourse and connect the Shannon Stream to the Mountrath River. The channel of the Coles River will be widened by approximately 2.5m and deepened by 1.0m, and the culvert at 15COLE00017 will be upgraded to a box culvert of dimensions 2.0m x 0.8m.

Option Item	Quantity	Construction Cost
Flood wall	440m length, 1.2m high (average)	€701,320
Flood embankment	435m length, 0.9m high (average)	€69,810
In-channel excavation	395m^3 material removal	€13,460
Culvert construction	110m length, 2.0m x 0.9m box culvert 4m length, 2.0m x 0.8m box culvert	€144,844

Total MCA-Benefit Score	Option Cost (€millions)	MCA-Benefit Score / Cost Ratio
221	2.67	82.48

Economic Appraisal (Cost-Benefit Analysis) Outcomes			
Area NPVd (uncapped)	**Option Cost**	**Option NPVb (capped)**	**Benefit - Cost Ratio**
€2,187,578	€2,673,838	€1,546,066	0.58

8.10.7.3 AFA Sensitivity to Future Change

As shown in Figure 8.10.9, during a MRFS 1% AEP flood event there is a significant increase in flood extent. This would result in 28 additional properties being at risk bringing the property count from 40 in the present day 1% AEP event to 68. The AAD would increase from €101,833 to €262,106. As a result the Mountrath AFA would be considered to be at moderate vulnerability from the MRFS.

During a HEFS 1% AEP flood event there would also be a significant increase in flood extent. This would result in an additional 37 properties being at risk bringing the property count from 40 in the present day 1% AEP event to 77. The AAD would increase from €101,833 to €992,382. As a result the Mountrath AFA would be considered to be at moderate vulnerability from the HEFS.

The main areas of additional flood risk are adjacent to Patrick Street and Shannon Street.

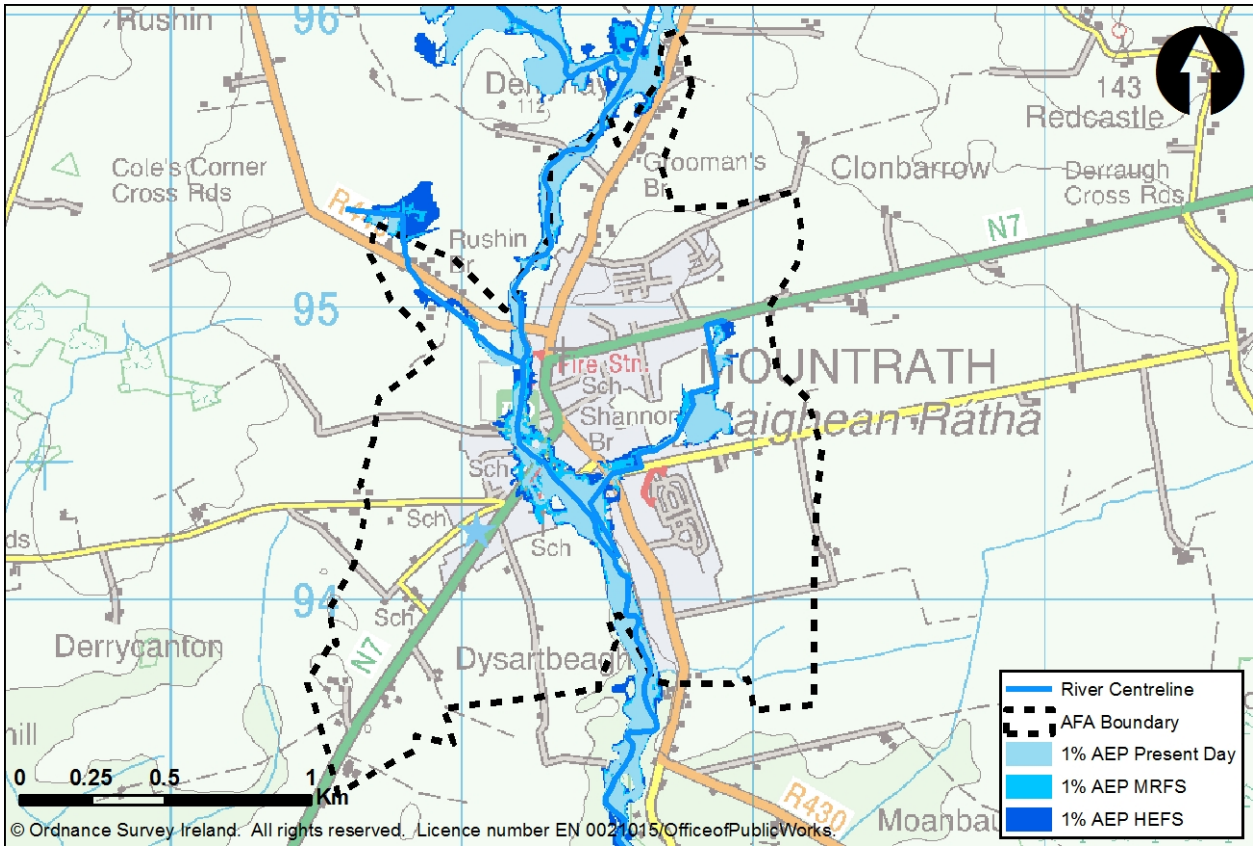


Figure 8.10.9 Future Change Flood Extents – Mountrath AFA

8.10.7.4 Future Change Adaptability

The following discusses the adaptability of the potential FRM **methods** proposed in Mountrath AFA:

Improvement of Channel Conveyance Flood Cell 1 - This method could be adapted by further reducing the bed level of the Coles River and upgrading the culvert capacity. The culvert would need to be replaced in order to increase capacity which would require substantial structural replacement works. This method is considered to have **poor** adaptability.

Hard Defences Flood Cell 1 – This method could be adapted by increasing the height of the wall and extending its length. A review of the effect of the MRFS and the HEFS showed that the wall would need to be increased from an average height of 0.39m to 0.53m and 0.57m respectively. This additional height could be accommodated. The review also showed that the additional length of wall required would be approximately 50m. To ensure that this wall would be adaptable the design would need to account for the potential increase on height. This method is considered to have **moderate** adaptability.

Hard Defences Flood Cells 2 & 3 – This method could be adapted by increasing the height of the walls and embankments and extending their length. A review of the effect of the MRFS and the HEFS showed that the hard defences would need to be increased from an average height of 1.03m to 1.36m and 1.64m respectively. This additional height could be accommodated. The review also showed that the additional length of hard defence required would be approximately 400-500m. To ensure that these defences would be adaptable the design would need to account for the potential increase on height including additional embankment footprint. This method is considered to have **moderate** adaptability.

Improvement of Channel Conveyance Flood Cell 3 - This method could be adapted by increasing the culvert capacity at the downstream end of the Shannon Stream. The culvert would need to be replaced in order to increase capacity which would require substantial structural replacement works. This method is considered to have **poor** adaptability.

The potential **options** identified have been further assessed using 5 criteria in an attempt to identify low – or no regret combinations of measures.

1. **Does the option reduce vulnerability?** In addition to the methods above other methods aimed at reducing future flood risk have been discussed in section 8.1 at UoM scale and are detailed in each potential option. These methods, such as building regulations and planning & development control will reduce the impact to potential future receptors. Given that some areas of Mountrath are highly developed currently there would be limited scope for some of these methods to impact on the area being assessed. Since there is a relatively large increase in the number of properties affected in the MRFS and HEFS there is a need to ensure that the owners and users of future receptors at risk are prepared through methods such as public awareness campaign. This is relevant to both options as they contain methods with poor adaptability.
2. **Does the option make space for water?** Options which provide additional space for water or does not restrict it are more likely to perform well in future scenarios. Options which include hard defences restrict the water making water levels more sensitive to increased flow. Both options have a restrictive effect due to the inclusion of hard defences, however option 2 is slightly less restrictive.
3. **Does the option deliver co-benefits?** No co-benefits were identified.
4. **Does the option provide flexibility?** A review of the potential options show that both options have poor adaptability to the MRFS and HEFS. However alternative FRM methods could be added to both options to provide an increased SoP.
5. **Does the option allow for deferring/removing or abandoning?** Given the present day risk there is no allowance for options to be deferred or any that could be removed later. However should opportunity ever arise, option 2 is most easily reverted.

An objective for each potential option is to ensure that flood risk can be managed effectively and sustainably into the future accounting for the potential impacts of climate change. Based on this future changes adaptability assessment the table below summarises how well each option achieves this objective.

Summary of Option Adaptability

Option	Description	Score
Option 1 – Hard Defences & Improvement of Channel Conveyance (FC3)	Option is adaptable only at significant cost, difficulty and impact	1
Option 2 - Hard Defences & Improvement of Channel Conveyance (FC1&3)	Option is adaptable only at significant cost, difficulty and impact	1

8.10.7.5 Local Authority Comments

LA representatives reviewed preliminary options in December 2015.

8.10.7.6 Summary

There is moderate confidence in both the hydrology and hydraulics of the Mountrath AFA. Limited information is available relating to flooding within the Mountrath AFA and the Mountrath gauging station is not suitable for model calibration as no significant flood events have occurred since its installation. As a result, model calibration was not possible. Good qualitative support for the model results was achieved however from the limited information available.

The following potential options, with a BCR ≥ 0.5 have been identified:

- Option 1 - Hard Defences & Improvement of Channel Conveyance (FC3)
- Option 2 – Hard Defences & Improvement of Channel Conveyance (FC1&3)

Alongside any potential option the existing regime should continue with maintenance being carried out ad hoc when resources allow. Maintenance of the option structures will also form part of the ongoing regime once in place.

Methods also were identified at UoM level (see section 8.1) that are applicable toMountrath AFA, that if implemented, will serve to avoid increasing flood risk in the future :

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

A number of communities and AFAs are located downstream of the Mountrath AFA. The flow at the downstream model boundary was reviewed for the 1% AEP current scenario versus the 1% AEP with the option in place scenario. The flow in the Mountrath River at the downstream end of the AFA was found to increase by approximately 1.1m3/s (3%) and the water level was found to increase by approximately 25mm.

No critical environmental, cultural heritage or social issues have been identified.

It should be noted that this area is moderately sensitive to climate change and is suitable for an assumptive approach be incorporated into detailed design.

These recommendations should be taken forward with a view to identification of a preferred option for the flood risk management plan.

8. OPTIONEERING OF SSA'S

8.11 Rathdowney optioneering of FRM Options

Name	Local Authority	Unique ID	SSA	Status	Date
Rathdowney	Laois	150200	AFA	Final	13/06//2016

8.11.1 Source of flooding

Fluvial	Coastal Mechanism 1	Coastal Mechanism 2

8.11.2 Flood Cells

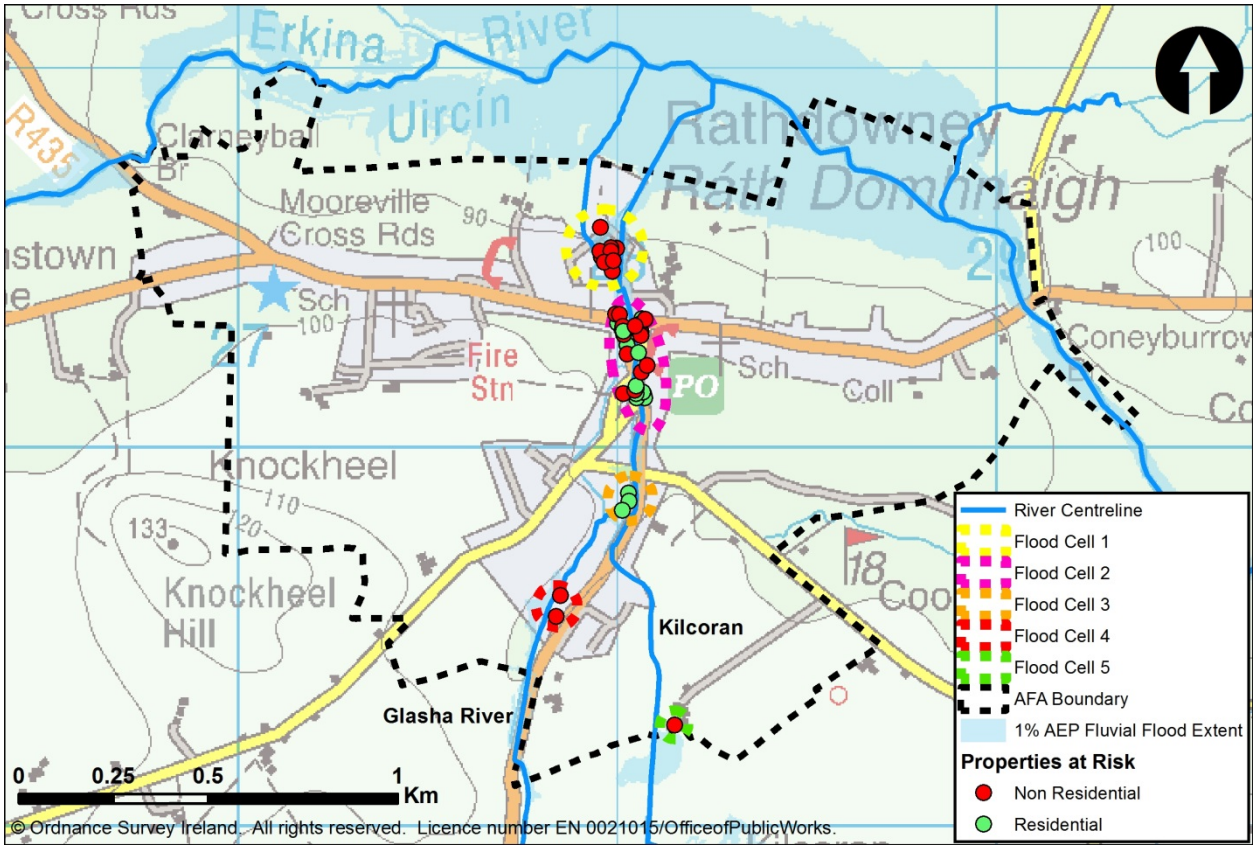


Figure 8.11.1 Rathdowney AFA Flood Cells within a 1% AEP Fluvial Flood Extent

Flood Cell 1:
Out of bank flooding, occurs due to a combination of insufficient channel capacity, bridge capacity and culvert capacity. As the Glasha River progresses through Rathdowney it passes through a series of bridges and a culvert. Some of these have been identified as critical structures causing raised water levels. During a 1% AEP fluvial event 9 comercial properties are at risk. Flood Cell 1 is considered complex.

Flood Cell 2:

In flood cell 2, 17 residential and 12 commercial properties are at risk during the 1% AEP event. Flooding in this location is due to insufficient channel capacity and a number of critical structures which have insufficient capacity to convey the flow. As flood cell 2 has a number of properties affected, and is located upstream of flood cell 1, it is considered complex.

Flood Cell 3:

Three residential properties located on the right bank of the Glasha River are at risk during the 1% AEP event. The flood cell is located upstream of flood cell 2 and any optioneering will directly impact Flood Cell 2. Therefore Flood cell 3 is considered complex.

Flood Cell 4:

Two commercial properties in flood cell 4 are affected during the 1% AEP event on the Glasha River due to insufficient channel capacity. Flood cell 4 is affected by a single flood mechanism and is a discrete area affecting few properties. The flood risk is considered local.

Flood Cell 5:

A large commercial property is at risk during the 1% AEP event on the Kilcoran watercourse. Flood cell 5 is affected by a single flood mechanism and is a discrete area affecting a single property. The flood risk is therefore considered local.

Summary of Flood Cells:

As shown in Figure 8.11.1 the main flood risk in Rathdowney originates from the Glasha River. Due to the complexity and interaction of the flooding in flood cells 1, 2 & 3 it is considered appropriate to screen the flood risk together in the optioneering process.

Two properties are at risk in flood cell 4. Due to the nature of the flood mechanism and the extent of the flooding associated with a 1% fluvial event, it is appropriate to screen flood cell 4 as a standalone area.

Flood cell 5 is a discrete area with one property at risk and a single flood mechanism to consider. It is therefore appropriate to screen this flood cell as a standalone area assessing options applicable to localised works, see section 8.11.7

On completion of the optioneering screening assessment all flood cells will be used to form complete options for the Rathdowney AFA as detailed in section 8.11.9.

8.11.3 Existing Regime

The existing regime considers all activities currently carried out which impact on the management of flood risk. The level and frequency of maintenance is considered, along with inspection, and any other specific activity (for example the operation of locks, barrages, sluice gates and valves).

A number of Rathdowney watercourses are located within a Drainage District. Further details of operations in this district are presented in section 6.3.

The other watercourses within Rathdowney which are not located within a Drainage District are for the most part, in private lands and are not the responsibility of the Local Authority (Laois County Council). Nevertheless, inspection and maintenances are carried out as and when resources are available.The existing regime does not provide the preferred SoP.

8.11.4 Summary of Flood Risk within SSA boundary

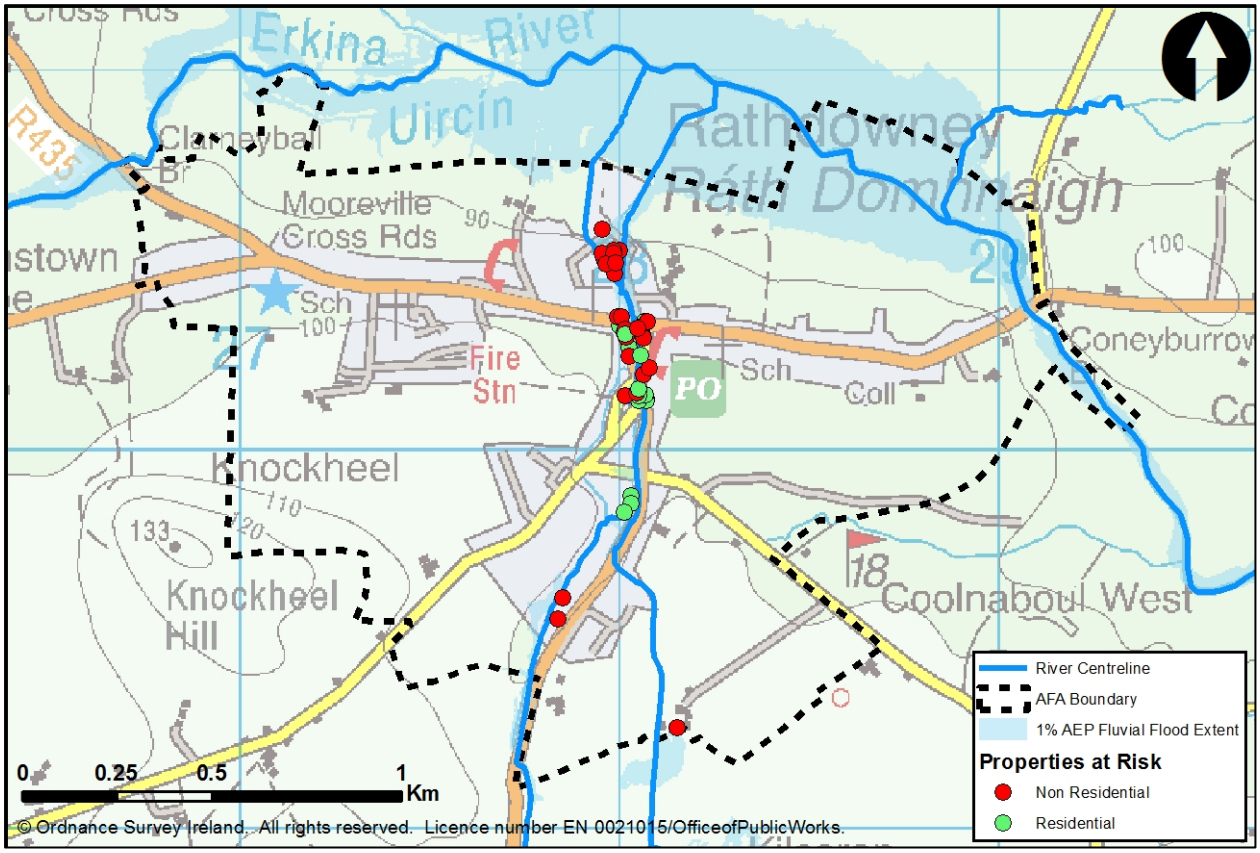


Figure 8.11.2 Flood risk in Rathdowney AFA within a 1% AEP Fluvial Flood Extent

In Rathdowney AFA the onset of residential property damage occurs in the 50% AEP event in flood cells one, two, three and four. There are no residential properties at risk in flood cell five.

Flooding commences at non-residential properties in the 50% AEP event in flood cells one, two and three. In flood cell four the flooding of non-residential properties commences in the 2year AEP event. There are no non-residential properties at risk in flood cell four.

8.11.6 Monetary Damage and Benefit

	Flood Cells 1, 2 & 3	Flood Cell 4	Flood Cell 5	Total in AFA
Annual Average Damage (AAD)	€4,820,887	€837,638	€8,870	€4,736,959
Present Value Damage (pvD)	€83,409,449	€17,994,140	€190,547	€101,759,363
Preferred Standard of Protection (SoP)	1% AEP	1% AEP	1% AEP	1% AEP
Number of Properties Benefiting from Design SoP	41	2	1	44
Minimum Present Value Benefit	€81,816,925	€17,544,476	€152,013	€99,430,040
Capped Minimum Present Value Benefit	€5,585,439	€2,834,772	€152,013	€8,488,850

*The sum of the flood cell AAD or pvD values may not equate to the values presented for the Total in SSA due to flooding greater than the 1% AEP occurring outside the flood cell extents.

8.11.7 Short Listing FRM Methods – Complex Cells (Flood Cell 1, 2 & 3)

Method	Review Comment	Continue Screening
		Flood Cells 1, 2 & 3
Do Nothing	Consider Further	✓
Additional Maintenance	Consider Further	✓
Do Minimum	Consider Further	✓
Planning and Development Control	Consider at UoM SSA - Reject	×
Building Regulations	Consider at UoM SSA - Reject	×
Catchment Wide SuDs	Consider at UoM SSA - Reject	×
Land Use Management	Consider Further	✓
Strategic Development Management	Consider at UoM SSA - Reject	×
Storage	Consider Further	✓
Improvement of Channel Conveyance	Consider Further	✓
Hard Defences	Consider Further	✓
Relocation of Properties	Consider Further	✓
Diversion of Flow	Consider Further	✓
Flood Warning/Forecasting	Consider Further	✓
Public Awareness Campaign	Consider at UoM SSA - Reject	×
Individual Property Protection	Consider Further	✓
Other Works	Consider Further	✓

8.11.7.2 Feasibility Review Summary of FRM Methods for flood cells 1, 2 & 3

Method	Technical Screening	Economic Screening	Environmental and Cultural Heritage Screening	Social Screening
Do Nothing	×			
Additional Maintenance	×			
Do Minimum	×			
Land Use Management	×			
Storage	✓	✓	!	✓
Improvement of Channel Conveyance	×			
Hard Defences	✓	✓	!	✓
Relocation of properties	✓	×		
Diversion of Flow	×			
Flood Warning/Forecasting	✓	✓	✓	✓
Individual Property Protection	×			
Other Works	×			

× - Reject ✓ - Progress ? - Progress, potential for impacts identified ! - Progress, potential for significant impacts identified

8.11.7.3 Justification for Rejection/Retention

Method	Tech	Econ	Env	Soc
Do nothing	×			

The do nothing FRM method would involve stopping the current maintenance regime. This would not provide the preferred SoP and therefore was rejected from the screening process.

Method	Tech	Econ	Env	Soc
Additional Maintenance	×			

This method considers whether improvements can be made to augment the existing maintenance regime which will provide a significant beneficial impact on flood risk in the AFA. A review was carried out of the existing watercourse network. This included assessing the channel vegetation, the amount of debris present in the channels and the likelihood of structures blocking.

Increasing maintenance activities on the relevant watercourses will not significantly contribute to achieving the preferred SoP and therefore will not be pursued under the CFRAM Study.

Method	Tech	Econ	Env	Soc
Do Minimum	×			

This method is appropriate where an isolated/single issue exists which can be easily addressed in order to reduce the flood risk, for example the removal of a pinch point/obstruction, or the upgrade of a blockage prone culvert screen, etc. These activities would be considered relatively straightforward, discrete and low cost. Do Minimum is a standalone method, as it cannot be combined with others without contradicting its definition, therefore the design SoP must be achieved for this method to progress.

Within flood cells 1, 2 & 3 there are no obvious locations where the do minimum method could be applied to significantly reduce flood risk. Additional channel clearance would have minimal impact on the overall flood risk due to the capacity restriction and the location of receptors. This is an unacceptable outcome in terms of contributing to achieving a 1%AEP standard of flood protection and was therefore rejected from the screening process.

Method	Tech	Econ	Env	Soc
Land Use Management	×			

The application of land use management measures was tested at UoM scale. Due to the high percentage of urbanisation present in the catchments the method is considered unsuitable to benefit flood cells 1,2 & 3. This method is technically unfeasible and rejected.

Method	Tech	Econ	Env	Soc
Storage	✓	✓	!	✓

This method considers areas where flood water can be stored and then released at a controlled rate, therefore reducing the flow rate along the HPW and reducing the level of flood risk. This can be achieved by using existing or creating new depressions to create online or offline storage areas or by identifying pinch points which could be dammed such as a restricted point along a valley. Storage areas can be effective either upstream of the risk areas or within the risk area where parks or open areas are located.

A review of the surrounding topography was carried out to identify potential storage areas. One storage location was identified to benefit flood cells 1, 2 & 3. Two seperate bunds (one 350m long by 2.1m high, the other 105m long by 2.5m high) could create a storage area across 2 watercourses, The Glasha River and Kilcoran River .This storage area could potentially provide enough storage to reduce the current 1%AEP flow along these watercourses to less than the equivalent of the current 50%AEP flow thus reducing the flood risk in Rathdowney as shown in Figure 8.11.3.

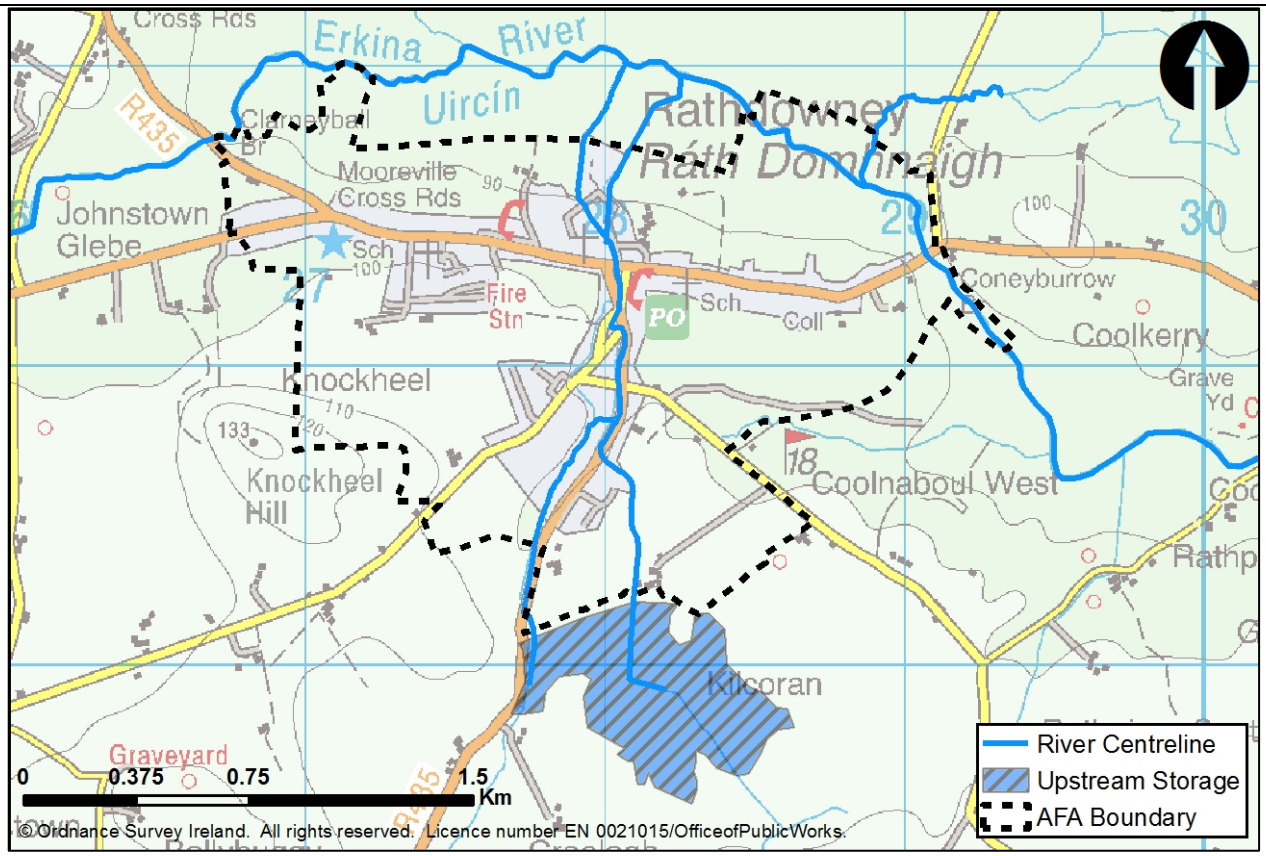


Figure 8.11.3 Potential Storage Areas

The volume of water required to be stored before reaching flood cells 1,2 & 3 has been estimated to be 135,014m^3 and the volume available is 137,538m^3. While this storage option would reduce the flow passing the properties at risk, it would not provide protection to all at risk properties. Storage should be considered as a partial solution to be used in conjunction with another method to create a complete option. However, this storage option will also benefit flood cell 4 and flood cell 5, protecting all properties in those cells from flood risk . An economic review estimated the cost of constructing the storage area to be €2,532,200 making this method economically viable subject to the costs of the measure with which it is combined.

The River Barrow and River Nore SAC and the River Nore SPA are 4km downstream of Rathdowney and are therefore hydraulically linked to the AFA. Galmoy Fen SAC is over 4km upcatchment of the AFA. Cullahill Mountain SAC and Spahill and Clomantagh Hill SAC are over 8km south east of Rathdowney, however are not hydraulically linked to the AFA.

Method	Tech	Econ	Env	Soc
Improvement of Channel Conveyance	×			

This method focuses on increasing watercourse conveyance thereby lowering water levels and reducing the associated flood risk. This can be achieved by lowering bed levels, widening/reshaping channels, removing channel/structure constrictions, culverting reaches of watercourse, reducing roughness of the channel and sealing manholes. A review of the various FRM method techniques, as listed above, was carried out for flood cells 1 and 2 and the following techniques were found to be the most appropriate way to implement this method.

To alleviate the fluvial flooding, within flood cells 1,2 & 3, channel excavation, underpinning of seven bridges and replacing one culvert is required. It is not possible to widen the channel because of the close proximity of properties along the Glasha watercourse. However there is also a second source of flooding, due to high water

levels in on the Erkina River backing up into the Glasha reach which would not be addressed by the channel conveyance works. Consequently this method was therefore considered technically unfeasible and rejected.

Method	Tech	Econ	Env	Soc
Hard Defences	✓	✓	!	✓

The term Hard Defences refers to physical barriers which prevent water from entering an area such as flood walls, embankments and barrages. As a general rule Hard Defences are kept as far back from the river channel or coast line as possible allowing the floodplain function to remain active. Where this is not possible, due to flood risk receptors being located within the floodplain, Hard Defences are placed around the property boundary to afford it protection. Where space allows flood embankments are used but where space is restricted flood walls are utilised.

A review was carried out to ascertain where Hard Defences would be required to protect existing properties within flood cells 1,2 & 3. The model showed that in order to protect to the 1% AEP fluvial flood event an excessive length and height of hard defence would be required. Hard Defences was then considered as a partial solution to be used in conjunction with Storage. Figure 8.11.4 shows the location of the Hard Defences required to protect properties during the 50% AEP event in flood cells 1 and 2. There are currently walls at these locations, however they are not formalised defences. In order to ascertain the effectiveness of Hard Defences a hydraulic model was constructed to simulate the method. The model showed that Hard Defences with an average height of 1.5m and a total length of 0.7km were required. The estimated cost to carry these works out would be €4,699,845 making this method economically viable.

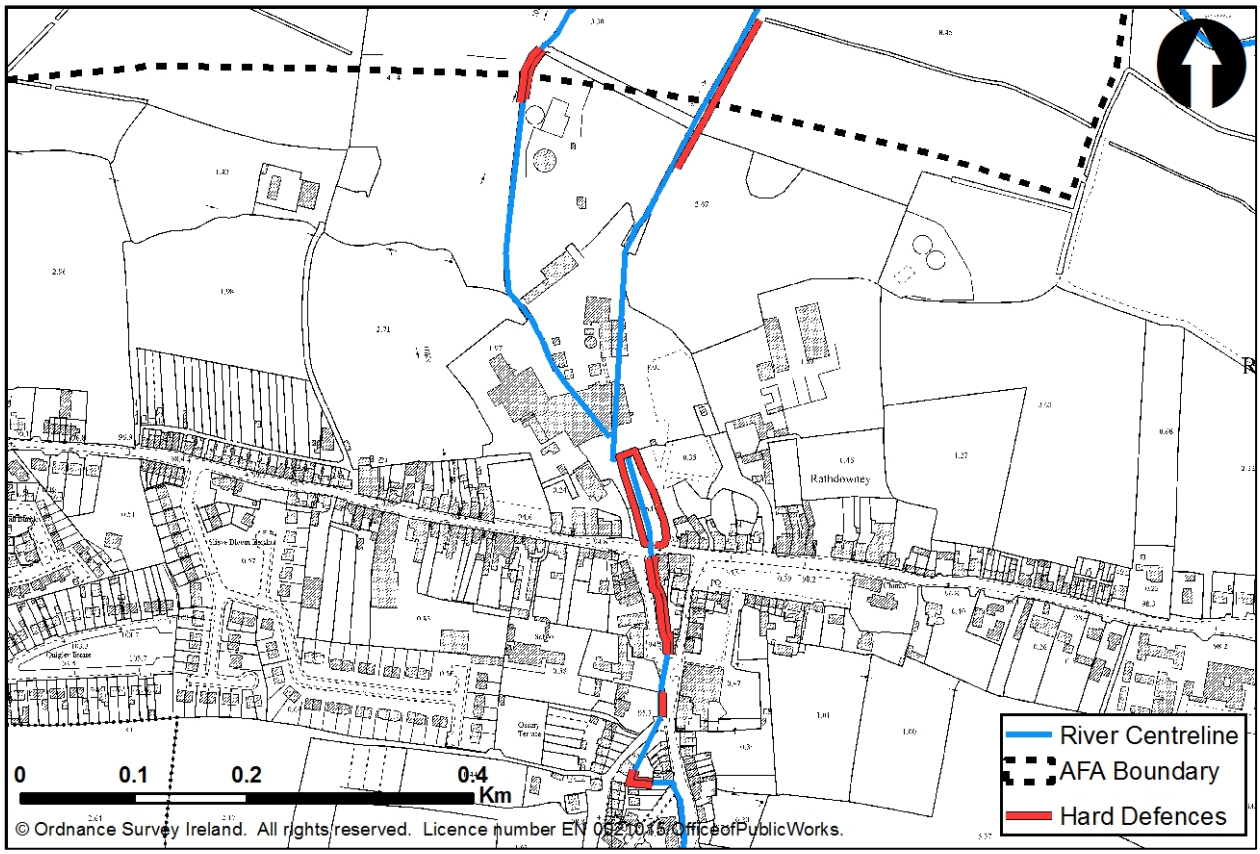


Figure 8.11.4 Location of Hard Defences

The River Barrow and River Nore SAC and the River Nore SPA are 4km downstream of Rathdowney and are therefore hydraulically linked to the AFA. Galmoy Fen SAC is over 4km upcatchment of the AFA. Cullahill Mountain SAC and Spahill and Clomantagh Hill SAC are over 8km south east of Rathdowney, however are not

hydraulically linked to the AFA.

Method	Tech	Econ	Env	Soc
Relocation of properties	✓	×		

To relocate a property is to abandon the existing at risk property and provide an alternative in a location not at risk. While this method is, in theory, possible, it is not practical for a whole community of many at risk properties. Its use is more applicable for discrete areas where single properties or clusters of properties are located.

In practice it is always technically possible to relocate properties, however due to the socially negative impacts it should only be considered should no other method be found suitable. An assessment of the distribution of properties within flood cells 1, 2 & 3 was carried out. There are 54 properties at risk during the 1% AEP event which may be suitable for relocation. The capped market value for the affected properties was approx. € 22m which is in excess of the Present Value Benefit. This method was therefore considered economically unviable.

Method	Tech	Econ	Env	Soc
Diversion of Flow	×			

This method involves directing some of the floodwater via a new route thereby reducing flow and associated flood risk along the original route. This would be carried out upstream of where floodwaters reach the area of at risk properties. The new flow route would normally consist of a constructed open channel and/or culvert system or an existing linear feature able to convey the flow to a designated discharge point.

A review was carried to identify locations where a Flow Diversion route could be constructed in the vicinity of flood cells 1, 2 & 3. Due to the surrounding topography, no location was found where this method could be carried out. This method was therefore considered technically unfeasible.

Method	Tech	Econ	Env	Soc
Flood Warning/Forecasting	✓	✓	✓	✓

The application of flood warning/forecasting was tested at UoM scale. A suitable location far enough upstream of flood cells 1,2 & 3 is available to provide sufficient warning. This method can only provide warning for other methods and does not provide the required SoP as a standalone method. Therefore the method should only be considered if no other methods are suitable during the optioneering process.

An economic review estimated that the cost of providing four hydrometric gauging stations with simple forecasting systems would be approximately €189,968. This method is therefore economically viable.

The proposed gauging station is not within any environmental designations and it is unlikely that flood forecasting would have any impact to designated sites in the vicinity of the Rathdowney AFA.

Method	Tech	Econ	Env	Soc
Individual Property Protection	×			

This method is aimed at individual properties that are remote from the main risk areas. Where the AFA being considered consists of a small number of remote properties this method is a feasible solution. But for areas with multiple properties at risk this method would only be considered an add on to a primary method. Individual property protection could consist of flood gates and vent seals on the building structure itself. Where flood depths are over 0.6m this method becomes unfeasible and flood resilience techniques would be recommended over flood gates. As this method is temporary and relies of human intervention there is an element of uncertainty as to whether the full SoP will be met for every flood event. As such it is assumed that 20% of the flood damage will be avoided.

Flood cells 1,2 & 3 contain a large number of grouped properties, and there are predicted flood depths greater than 0.6m in flood cells 1 & 2 for properties impacted by flooding. This method is therefore technically unfeasible.

Method	Tech	Econ	Env	Soc
Other Works	×			

No other works were identified for this flood cell.

8.11.7.4 Summary of Feasibility Review – Flood Cells 1, 2 & 3

The following FRM method has been carried forward to address the flood risk arising from flood cells 1, 2 & 3;

- Storage and Hard Defences

Storage can't provide the full SoP to most properties at risk in flood cell 1,2 & 3 during the 1% AEP fluvial flood event therefore Storage is not a standalone method, however, storage can be combined with Hard Defences. Hard Defences also cannot be used as a standalone method due to the excessive length and height required, but can be used in conjunction with Storage to provide full protection to all properties within flood cells 1,2 & 3.

Flood Warning/Forecasting can only provide partial protection to the properties. This method should therefore only be used should all other methods be deemed unsuitable later in the optioneering process.

8.11.8 Short Listing FRM Methods – Local Cells (Flood Cell 4 & 5)

Method	Review Comment	Continue Screening	
		Flood Cell 4	Flood Cell 5
Do Nothing	Consider Further	✓	✓
Additional Maintenance	Consider Further	✓	✓
Do Minimum	Consider Further	✓	✓
Planning and Development Control	Consider at UoM SSA - Reject	×	×
Building Regulations	Consider at UoM SSA - Reject	×	×
Catchment Wide SuDs	Consider at UoM SSA - Reject	×	×
Land Use Management	Consider Further	✓	✓
Strategic Development Management	Consider at UoM SSA - Reject	×	×
Storage	Consider Further	✓	✓
Improvement of Channel Conveyance	Consider Further	✓	✓
Hard Defences	Consider Further	✓	✓
Relocation of Properties	Consider Further	✓	✓
Diversion of Flow	Consider Further	✓	✓
Flood Warning/Forecasting	Consider Further	✓	✓
Public Awareness Campaign	Consider at UoM SSA - Reject	×	×
Individual Property Protection	Consider Further	✓	✓
Other Works	Consider Further	✓	✓

8.11.8.1 Feasibility Review Summary of FRM Methods for flood cell 4

Method	Technical Screening	Economic Screening	Environmental and Cultural Heritage Screening	Social Screening
Do Nothing	×			
Additional Maintenance	×			
Do Minimum	×			
Land Use Management	×			
Storage	✓	✓	!	✓
Improvement of Channel Conveyance	✓	✓	!	✓
Hard Defences	×			
Relocation of properties	✓	✓	?	✓
Diversion of Flow	×			
Flood Warning/Forecasting	✓	✓	✓	✓
Individual Property Protection	×			
Other Works	×			

× - Reject ✓ - Progress ? - Progress, potential for impacts identified ! - Progress, potential for significant impacts identified

8.11.8.2 Justification for Rejection/Retention

Method	Tech	Econ	Env	Soc
Do nothing	×			

The do nothing FRM method would involve stopping the current maintenance regime. This would not provide the preferred SoP and therefore was rejected from the screening process.

Method	Tech	Econ	Env	Soc
Additional Maintenance	×			

Increasing maintenance activities on the relevant watercourses will not significantly contribute to achieving the preferred SoP and therefore will not be pursued under the CFRAM Study.

Method	Tech	Econ	Env	Soc
Do Minimum	×			
Within flood cell 4 there are no obvious locations where the do minimum method would greatly reduce flood risk. Additional channel clearance would have minimal impact on the overall flood risk due to the capacity restriction and the location of receptors. This is an unacceptable outcome in terms of contributing to achieving a 1%AEP standard of flood protection and this method was therefore rejected from the screening process.				
Method	Tech	Econ	Env	Soc
Land Use Management	×			
The application of land use management measures was tested at UoM scale. Due to the high percentage of urbanisation present in catchments the method is considered unsuitable to benefit flood cells 4. This method is technically unfeasible and therefore rejected.				
Method	Tech	Econ	Env	Soc
Storage	✓	✓	!	✓
The storage on this river was reviewed as part of the storage option for flood cells 1,2 & 3. As discussed in Section 8.11.7 a suitable location was identified. This storage option would reduce the flow passing the properties at risk from 1% AEP fluvial event to below a 50% AEP event. This reduction in out of bank flooding would protect all the at risk properties within flood cell 4. An economic review estimated the cost of constructing the storage area to be €2,532,200 making this method economically viable. The River Barrow and River Nore SAC and the River Nore SPA are 4km downstream of Rathdowney. Galmoy Fen SAC is over 4km upcatchment of the AFA. Cullahill Mountain SAC and Spahill and Clomantagh Hill SAC are over 8km south east of Rathdowney, however are not hydraulically linked to the AFA.				
Method	Tech	Econ	Env	Soc
Improvement of Channel Conveyance	✓	✓	!	✓
In flood cell 4 improving the channel conveyance would reduce water levels and prevent flooding during the 1% AEP event. Dredging an 241m stretch of channel along the Glasha River would need to be carried out to improve the conveyance of the channel.				

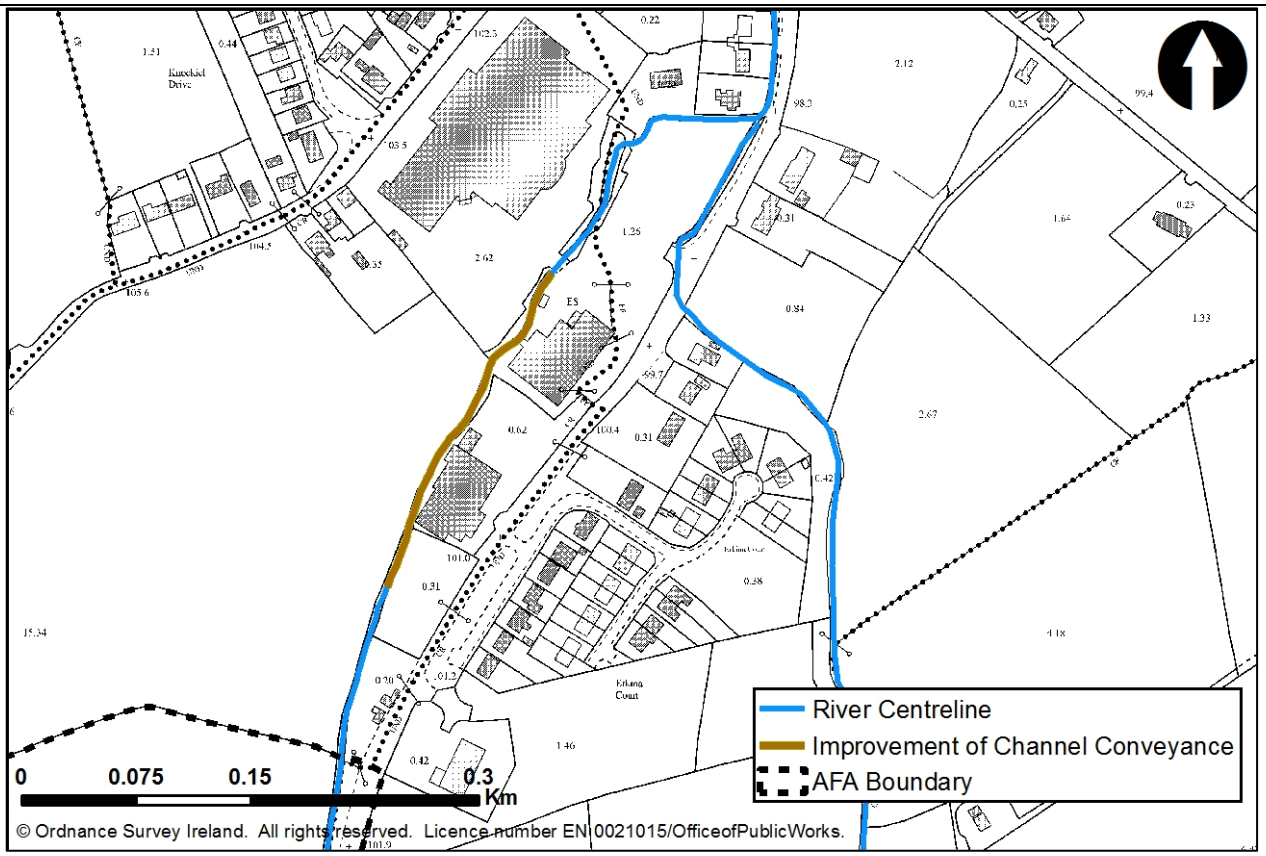


Figure 8.11.5 Improvement of Channel Conveyance in Flood Cell 4

The estimated cost to carry these works out would be €68,470 making this method economically viable.

The River Barrow and River Nore SAC and the River Nore SPA are 4km downstream of Rathdowney and are therefore hydraulically linked to the AFA. Galmoy Fen SAC is over 4km upcatchment of the AFA. Cullahill Mountain SAC and Spahill and Clomantagh Hill SAC are over 8km south east of Rathdowney, however are not hydraulically linked to the AFA.

Method	Tech	Econ	Env	Soc
Hard Defences	✗			

A review was carried out to ascertain where Hard Defences would be required to protect existing properties within flood cell 4. In order to ascertain the effectiveness of Hard Defences a hydraulic model was constructed to simulate the method. The model showed that in order to protect to the 1% AEP fluvial flood event an excessive length and height of hard defence would be required. Hard Defences was therefore considered technically unfeasible and removed from the screening process.

Method	Tech	Econ	Env	Soc
Relocation of properties	✓	✓	?	✓

In practice it is always technically possible to relocate properties, however due to the socially negative impacts it should only be considered should no other method be found suitable. The cost to relocate the properties, based on the market value, is € 2.8m making this method economically viable. There are no perceived environmental or social issues unviable identified for this FRM.

Method	Tech	Econ	Env	Soc
Diversion of Flow	×			

A review was carried to identify locations where a Flow Diversion could be constructed in the vicinity of flood cell 4. Due to the surrounding topography no location was found where this method could be carried out. This method was therefore considered technically unfeasible and rejected.

Method	Tech	Econ	Env	Soc
Flood Warning/Forecasting	✓	✓	✓	✓

The application of flood warning/forecasting was tested at UoM scale. A suitable location far enough upstream of flood cells 4 is available to provide sufficient warning. This method can only provide warning for other methods and does not provide the required SoP as a standalone method. Therefore the method should only be considered if no other methods are suitable during the optioneering process.

An economic review estimated that the cost of providing two hydrometric gauging stations with simple forecasting systems would be approximately €94,984. This method is therefore economically viable.

The proposed gauging station is not within any environmental designations and it is unlikely that flood forecasting would have any impact to designated sites in the vicinity of the Rathdowney AFA.

Method	Tech	Econ	Env	Soc
Individual Property Protection	×			

Flood cell 4 contains two properties, however one of these properties has predicted flood depths greater than 0.6m. This method is therefore technically unfeasible.

Method	Tech	Econ	Env	Soc
Other Works	×			

No other works were identified for this flood cell.

8.11.8.3 Summary of Feasibility Review – Flood Cell 4

The following FRM methods have been carried forward to address the flood risk arising from flood cell 4;

- Storage
- Improvement of Channel Conveyance

Due to the socially negative impacts associated with Relocation of Properties the method should only be considered if no other method is found suitable.

Flood Warning/Forecasting does not provide the full SoP to the properties within flood cell 4 and should only be considered if no other methods are suitable.

Storage can provide the full protection to all properties during the 1% AEP fluvial flood event in flood cell 4. Improvement of Channel Conveyance can only provide partial protection, therefore Storage is the preferred method and is carried forward to address the flood risk arising from flood cell 4.

8.11.8.4 Feasibility Review Summary of FRM Methods for flood cell 5

Method	Technical Screening	Economic Screening	Environmental and Cultural Heritage Screening	Social Screening
Do Nothing	×			
Additional Maintenance	×			
Do Minimum	×			
Land Use Management	×			
Storage	✓	✓	!	✓
Improvement of Channel Conveyance	✓	✓	!	✓
Hard Defences	✓	✓	!	✓
Relocation of properties	✓	✓	✓	?
Diversion of Flow	×			
Flood Warning/Forecasting	✓	✓	✓	✓
Individual Property Protection	×			
Other Works	×			

× - Reject ✓ - Progress ? - Progress, potential for impacts identified ! - Progress, potential for significant impacts identified

8.11.8.5 Justification for Rejection/Retention

Method	Tech	Econ	Env	Soc
Do nothing	×			

The do nothing FRM method would involve stopping the current maintenance regime. This would not provide the preferred SoP and therefore was rejected from the screening process.

Method	Tech	Econ	Env	Soc
Additional Maintenance	×			

Increasing maintenance activities on the relevant watercourses will not significantly contribute to achieving the preferred SoP and therefore will not be pursued under the CFRAM Study.

Method	Tech	Econ	Env	Soc
Do Minimum	×			
Within flood cell 5 there are no obvious locations where the do minimum method would significantly reduce flood risk. Additional channel clearance would have minimal impact on the overall flood risk due to capacity restrictions and the location of the receptor. This is an unacceptable outcome in terms of contributing to achieving a 1%AEP standard of flood protection and do minimum was therefore rejected from the screening process.				
Method	Tech	Econ	Env	Soc
Land Use Management	×			
The application of land use management measures was tested at UoM scale. Due to the high percentage of urbanisation present in the catchments the method is considered unsuitable to benefit flood cell 5. This method is technically unfeasible and rejected.				
Method	Tech	Econ	Env	Soc
Storage	✓	✓	!	✓
The storage on this river was reviewed as part of the storage option for flood cell 1,2 & 3. As discussed in Section 8.11.7 a suitable location was identified. This storage option would reduce the flow passing the properties at risk from 1% AEP fluvial event to below a 50% AEP event. This reduction in out of bank flooding would protect all the properties at risk in flood cell 5. An economic review estimated the cost of constructing the storage area to be €2,532,200 making this method economically viable. This option is benefitting all flood cells and is deemed suitable for the optioneering process. The River Barrow and River Nore SAC and the River Nore SPA are 4km downstream of Rathdowney and are therefore hydraulically linked to the AFA. Galmoy Fen SAC is over 4km upcatchment of the AFA. Cullahill Mountain SAC and Spahill and Clomantagh Hill SAC are over 8km south east of Rathdowney, however are not hydraulically linked to the AFA.				
Method	Tech	Econ	Env	Soc
Improvement of Channel Conveyance	✓	✓	!	✓
In flood cell 5 improving the channel conveyance would reduce water levels and protect the at risk property during the 1% AEP event. Along the Kilcoran River upgrading one culvert from 0.4m diameter to 1.35m diameter would be sufficient to improve the conveyance of the channel.				

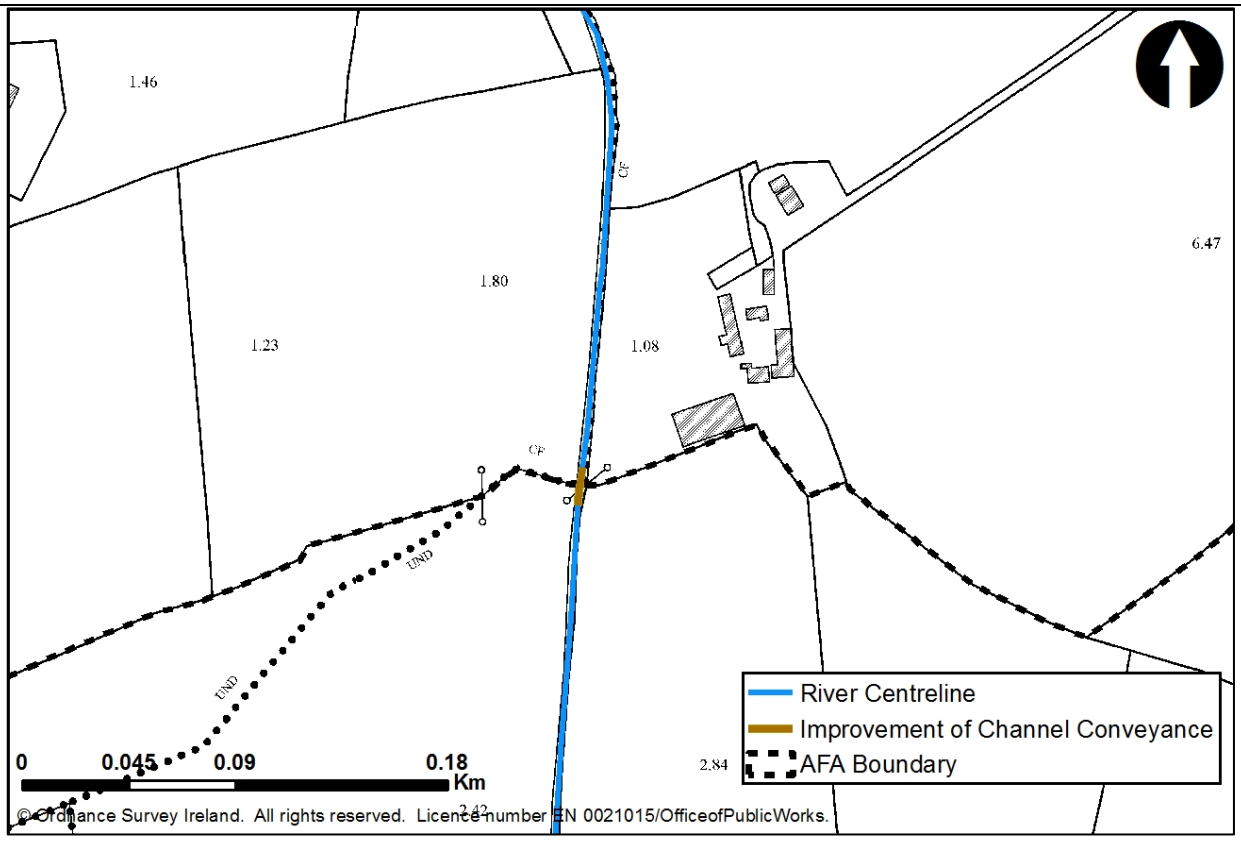


Figure 8.11.6 Improvement of Channel Conveyance in Flood Cell 5

The estimated cost to carry these works out would be €239,205 making this method economically viable.

The River Barrow and River Nore SAC and the River Nore SPA are 4km downstream of Rathdowney and are therefore hydraulically linked to the AFA. Galmoy Fen SAC is over 4km upcatchment of the AFA. Cullahill Mountain SAC and Spahill and Clomantagh Hill SAC are over 8km south east of Rathdowney, however are not hydraulically linked to the AFA.

Method	Tech	Econ	Env	Soc
Hard Defences	✓	✓	!	✓

A review was carried out to ascertain where Hard Defences would be required to protect the existing properties in flood cell 5. Figure 8.11.7 shows the location of the Hard Defences required to protect properties during the 1% AEP event. In order to ascertain the effectiveness of Hard Defences a hydraulic model was constructed to simulate the method. The model showed that hard defences would protect to the 1% AEP flood event with an average height of 0.75m and a total length of 113m. The estimated cost to carry these works out would be €46,905 making this method economically viable.

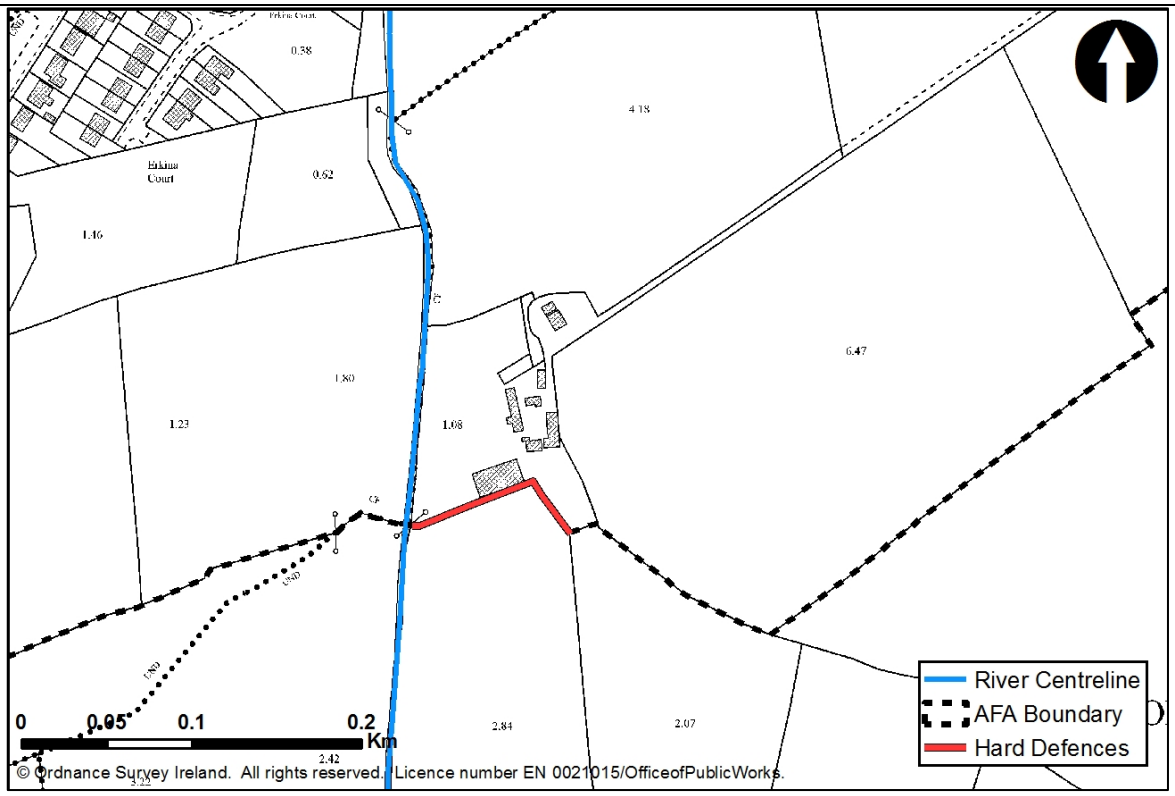


Figure 8.11.7 Location of Hard Defences in flood cell 5

The River Barrow and River Nore SAC and the River Nore SPA are 4km downstream of Rathdowney and are therefore hydraulically linked to the AFA. Galmoy Fen SAC is over 4km upcatchment of the AFA. Cullahill Mountain SAC and Spahill and Clomantagh Hill SAC are over 8km south east of Rathdowney, however are not hydraulically linked to the AFA.

Method	Tech	Econ	Env	Soc
Relocation of properties	✓	✓	✓	?

To relocate a property is to abandon the existing at risk property and provide an alternative in a location not at risk. While this method is, in theory, possible, it is not practical for a whole town of many at risk properties. Its use is more applicable for discrete areas where single properties or clusters of properties are located.

In practice it is always technically possible to relocate properties, however due to the socially negative impacts it should only be considered should no other method be found suitable. The cost to relocate the property in flood cell 5, based on the market value, is € 177,380 making this method economically viable.

Method	Tech	Econ	Env	Soc
Diversion of Flow	×			

A review was carried to identify if a Flow Diversion route could be constructed in the vicinity of flood cell 5. Due to the surrounding topography no location was found where this method could be carried out. This method is therefore considered technically unfeasible and rejected.

Method	Tech	Econ	Env	Soc
Flood Warning/Forecasting	✓	✓	✓	✓

The application of flood warning/forecasting was tested at UoM scale. A suitable location far enough upstream of flood cells 5 is available to provide sufficient warning. This method can only provide warning for other methods and does not provide the required SoP as a standalone method. Therefore the method should only be considered if no other methods are suitable during the optioneering process.

An economic review estimated that the cost of providing two hydrometric gauging stations with simple forecasting systems would be approximately €94,984. This method is therefore economically viable.

The proposed gauging station is not within any environmental designations and it is unlikely that flood forecasting would have any impact to designated sites in the vicinity of the Rathdowney AFA.

Method	Tech	Econ	Env	Soc
Individual Property Protection	×			

The property located in flood cell 5 has predicted flood depths greater than 0.6m. This method is therefore technically unfeasible and rejected.

Method	Tech	Econ	Env	Soc
Other Works	×			

No other works were identified for this flood cell.

8.11.8.6 Summary of Feasibility Review – Flood Cell 5

The following FRM method has been carried forward to address the flood risk arising from flood cell 5;

- Storage
- Improvement of Channel Conveyance
- Hard Defences

Due to the socially negative impacts associated with Relocation of Properties this method should only be considered if no other method is found suitable.

Flood Warning/Forecasting does not provide the full SoP to the properties within flood cell 4 and should only be considered if no other methods are suitable.

Improvement of Channel Conveyance and Hard Defences would provide full protection to the property at risk however Storage has been reviewed for flood cells 1,2,3 & 4 and consequently removes the flood risk within flood cell 5. Therefore Storage is the preferred method and is carried forward to address the flood risk arising from flood cell 5.

8.11.9 Selection of Options

Method	Option 1	Option 2	Option 3	Option 4	Option 5
Storage	✓				
Hard Defences	✓				

Hard Defences in Flood cells 1 & 2 can be used in conjunction with Storage and therefore provide the full SoP to all properties.

8.11.9.1 Option 1 details – Storage & Hard Defences

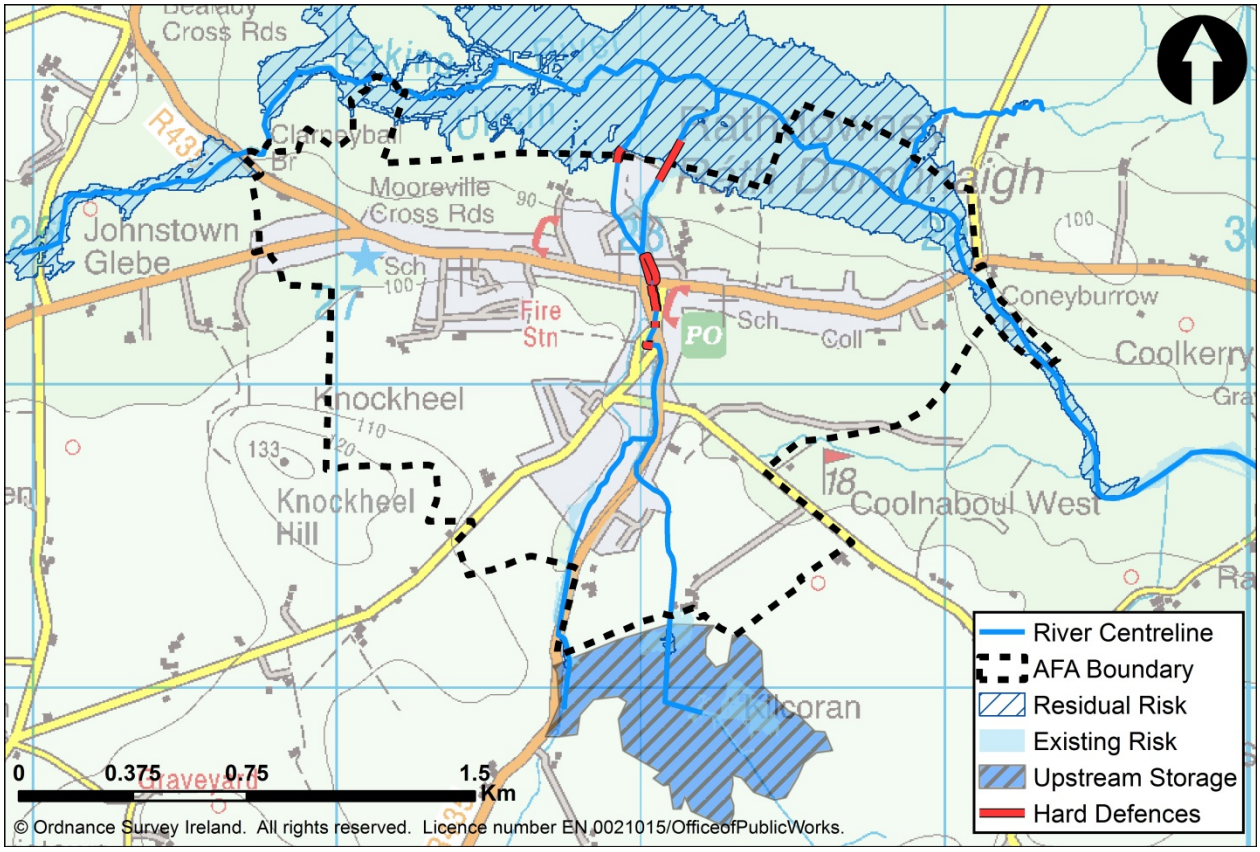


Figure 8.11.8 Rathdowney AFA Option 1

A number of at risk properties would be protected by storage provided along the Glasha River and the Kilcoran watercourse. The total storage required is 135,014m^3. The result is a reduced flow along the Glasha River, the remaining properties still at risk will be protected by Hard Defences, which have an average height of 1.5m and a total length of 0.7km.

Figure 8.11.8 presents the effect of the potential option on the design flood event by overlaying the present day flood extent (labelled existing risk) with the flood extent that would occur after the option is put in place (labelled residual risk).

The combination of these methods would protect to the 1% AEP flood. In addition to these methods the

following was also identified at UoM level (see section 8.1) to be included in any potential option identified:

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

Option Item	Quantity	Construction Cost
Wall	453m length, 2m high (average)	€1,084,593
Embankment	251m length, 0.8m high (average) 455m of 10m piled flood embankment for Storage	€919,493
Weir Construction	Overflow Structure from Storage Unit	€36,254
Culvert Cost	Control Structure from Storage Unit	€89,539

Total MCA-Benefit Score	Option Cost (€millions)	MCA-Benefit Score / Cost Ratio
1071	5.08	210.99

Economic Appraisal (Cost-Benefit Analysis) Outcomes			
Area NPVd (uncapped)	**Option Cost**	**Option NPVb (capped)**	**Benefit - Cost Ratio**
€101,759,363	€5,076,129	€8,488,850	1.67

8.11.9.2 AFA Sensitivity to Future Change

As shown in Figure 8.11.9, during a MRFS 1% AEP flood event there is minimal change to the flood extents due to the topography of the surrounding area. An additional 15 properties are estimated to be at risk of flooding when compared to the present day flood risk. The AAD would increase from €4,736,959 to €5,281,545. As a result Rathdowney AFA would be considered to be at moderate vulnerability from the MRFS.

During the HEFS 1% AEP flood event the flood extent, while larger than the MRFS, is minimal also. An additional 21 properties are estimated to be at flood risk when compared to the present day flood risk. The AAD would increase from €4,736,959 to €6,141,565. As a result Rathdowney AFA would be considered to be at moderate vulnerability from the HEFS.

The main area of additional flood risk is in the Johnstown Road area.

The number of additional properties affected by future scenarios indicates a significant increase to the annual average damage and the Rathdowney AFA would be considered to be at moderate vulnerability. Options were therefore assessed to their adaptability to climate change.

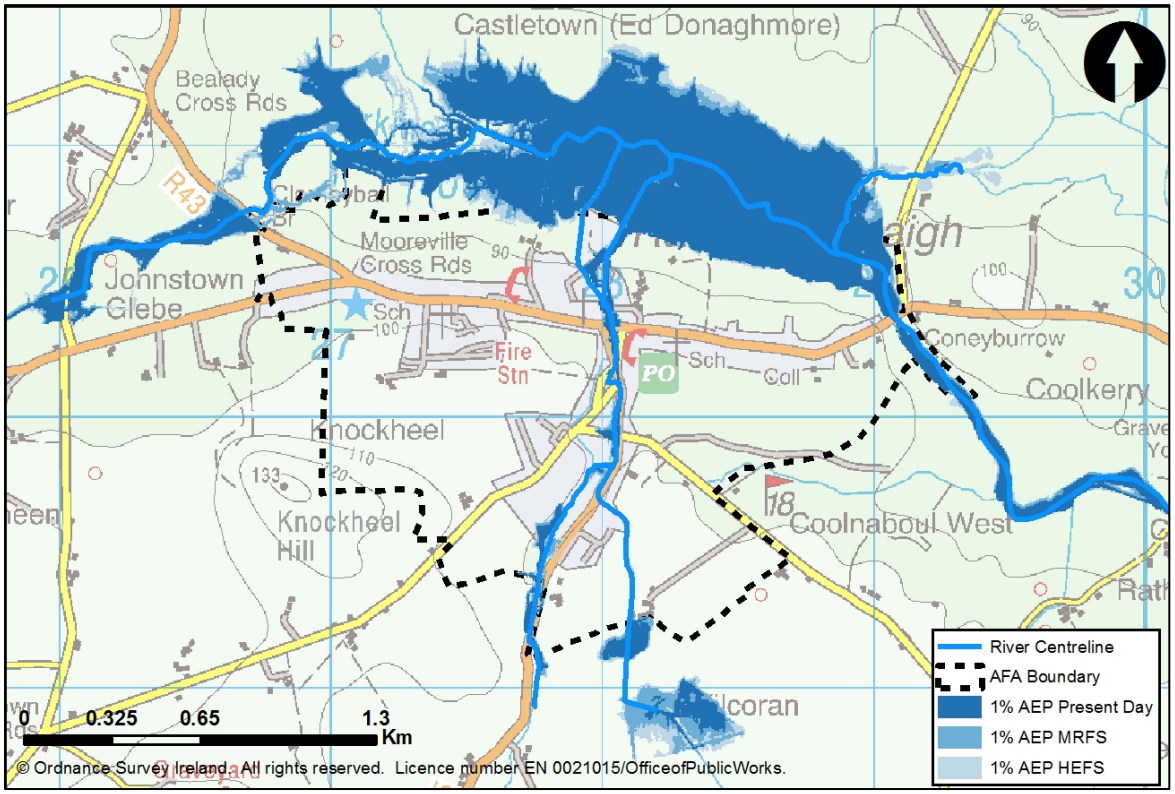


Figure 8.11.9 Future Change Flood Extents

8.11.9.3 Future Change Adaptability

The following discusses the adaptability of the potential FRM **methods** proposed in Rathdowney AFA:

Hard Defences - This method could be adapted by increasing the height of the wall and extending its length. A review of the effect of the MRFS and the HEFS showed that the walls would need to be increased to a maximum of 2.66m to 3.03m and 3.09m respectively. This would raise concerns over the residual risk and social impact. The review also showed that the additional length of wall preferred would be minimal. This method is considered to be **not adaptable.**

Storage - This method could also be adapted by increasing the height of the retaining structure. As the retaining structure is an embankment it would need to be designed to accommodate additional height in the future. For the Rathdowney storage area the volume required would need to be increased from 135,014m^3 to 162016m^3 or 175518m^3, for the MRFS or HEFS respectively. There are some properties present upstream of the storage area and the R435 road would need raised and strengthened. Therefore this storage method would be considered to be **not adaptable.**

The potential **options** identified have been further assessed using 5 criteria in an attempt to identify low – or no regret combinations of measures.

1. **Does the option reduce vulnerability?** In addition to the methods above other methods aimed at reducing future flood risk have been discussed in section 8.1 at UoM scale and are detailed in each potential option. These methods, such as building regulations and planning & development control will reduce the impact to potential future receptors. Given that Rathdowney is a rural town with areas for development there maybe potential for some of these methods to impact on the area being assessed. Since there is a relatively large increase in the number of properties affected in the MRFS and HEFS there is a need to ensure that the owners and users of future receptors at risk are prepared through methods such as public awareness campaign. This is most relevant to options with methods with poor or no adaptability such as option 1.
2. **Does the option make space for water?** Options which provide additional space for water or do not restrict it are more likely to perform well in future scenarios. Options which include hard defences restrict the water making water levels more sensitive to increased flow. Option 1 would create this situation.
3. **Does the option deliver co-benefits?** No co-benefits were identified.
4. **Does the option provide flexibility?** A review of the potential options show that neither option is adaptable to the MRFS and HEFS. However alternative FRM methods could be added to either option to provide an increased SoP.
5. **Does the option allow for deferring/removing or abandoning?** Given the present day risk there is no allowance for options to be deferred or any that could be removed later.

An objective for each potential option is to ensure that flood risk can be managed effectively and sustainably into the future accounting for the potential impacts of climate change. Based on this future changes adaptability assessment the table below summarises how well each option achieves this objective.

Summary of Option Adaptability		
Option	**Description**	**Score**
Option 1 – Hard Defences & Storage	Option is only adaptable at significant cost, but provides no impediment to future interventions	0

8.11.9.4 Local Authority Comments

LA representatives reviewed the preliminary options during early 2016.

8.11.9.5 Summary

There is good confidence in both the hydrology and hydraulics of the Rathdowney AFA/HPW due to the presence of a gauging station and flood extent verification events.

The following potential options, with a BCR ≥ 0.5 have been identified:

- Option 1 – Hard Defences & Storage

Alongside any potential option the existing regime should continue with maintenance being carried out ad hoc when resources allow. Maintenance of the option structures will also form part of the ongoing regime once in place.

Methods also were identified at UoM level (see section 8.1) that are applicable to Rathdowney AFA, that if implemented, will serve to avoid increasing flood risk in the future :

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

Ballyragget AFA is located downstream that may be affected by any of the potential options identified. There are also a number of rural locations downstream of the Rathdowney AFA. The flow at the downstream model boundary was reviewed for the1% AEP current scenario versus the 1% AEP with the option in place scenario. There was a negligible flow difference between the hydraulic model simulations.

No critical environmental, cultural heritage or social issues have been identified.

It should be noted that this area is moderately sensitive to climate change however there is no physical provision to be incorporated into detailed design.

These recommendations should be taken forward with a view to identification of a preferred option for the flood risk management plan.

8. OPTIONEERING OF SSA'S

8.12 Thomastown Optioneering of FRM Options

Name	Local Authority	Unique ID	SSA	Status	Date
Thomastown	Kilkenny	150201	AFA	Final	13/06/2016

8.12.1 Source of flooding

Fluvial	Coastal Mechanism 1	Coastal Mechanism 2

8.12.2 Flood Cells

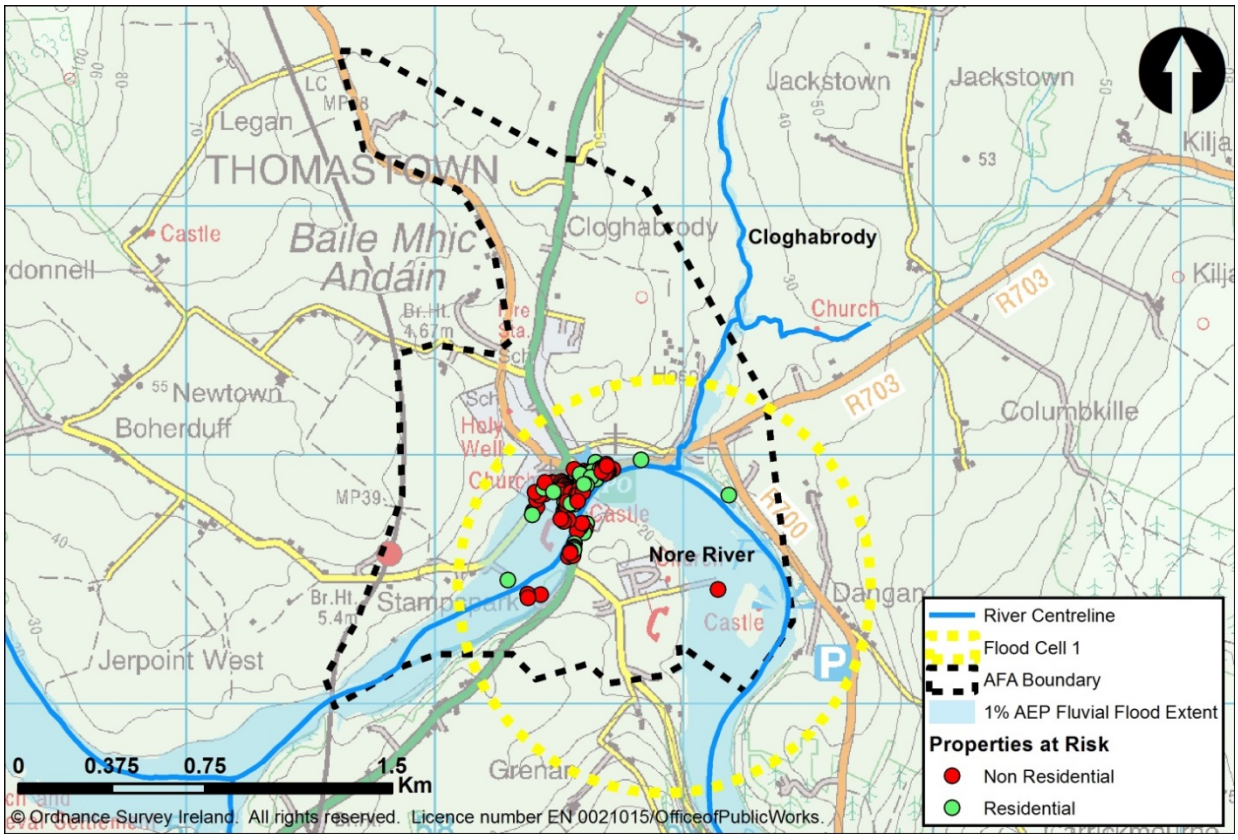


Figure 8.12.1 Thomastown AFA Flood Cell within a 1% AEP Fluvial Flood Extent

Flood Cell 1:
Out of bank flooding would occur on the River Nore during a 1% AEP fluvial event due to insufficient channel capacity and would inundate the floodplain on both sides of the channel within flood cell 1. 135 properties are located within and on the periphery of this floodplain and would be affected by a 1%AEP flood event. Given that there are no flood cells located immediately downstream of this flood cell the flood risk in flood cell 1 is considered local.

Summary of Flood Cells:

As shown in Figure 8.12.1 the main flood risk originates from the River Nore, and to a lesser extent the Cloghabrody watercourse, as water levels during 1%AEP fluvial event exceed the top of bank levels. As there is one flood mechanism to consider and one flood cell it is therefore appropriate to screen flood cell 1 as a standalone area assessing options applicable to localised works. (Section 8.12.6)

On completion of the optioneering screening assessment all FRM methods considered will be combined to form complete options for the Thomastown AFA as detailed in Section 8.12.8.

8.12.3 Existing Regime

The existing regime considers all activities currently carried out which impact on the management of flood risk. The level and frequency of maintenance is considered, along with inspection, and any other specific activity (for example the operation of locks, barrages, sluice gates and valves).

The Thomastown watercourse is not located within a Drainage District or an Arterial Drainage scheme. The watercourses in Thomastown are, for the most part, in private lands and are not the responsibility of Kilkenny county Council. As the degree of flood risk stays as present, with some properties frequently flooded, the existing regime does not provide the required standard of protection.

8.12.4 Summary of Flood Risk within SSA boundary

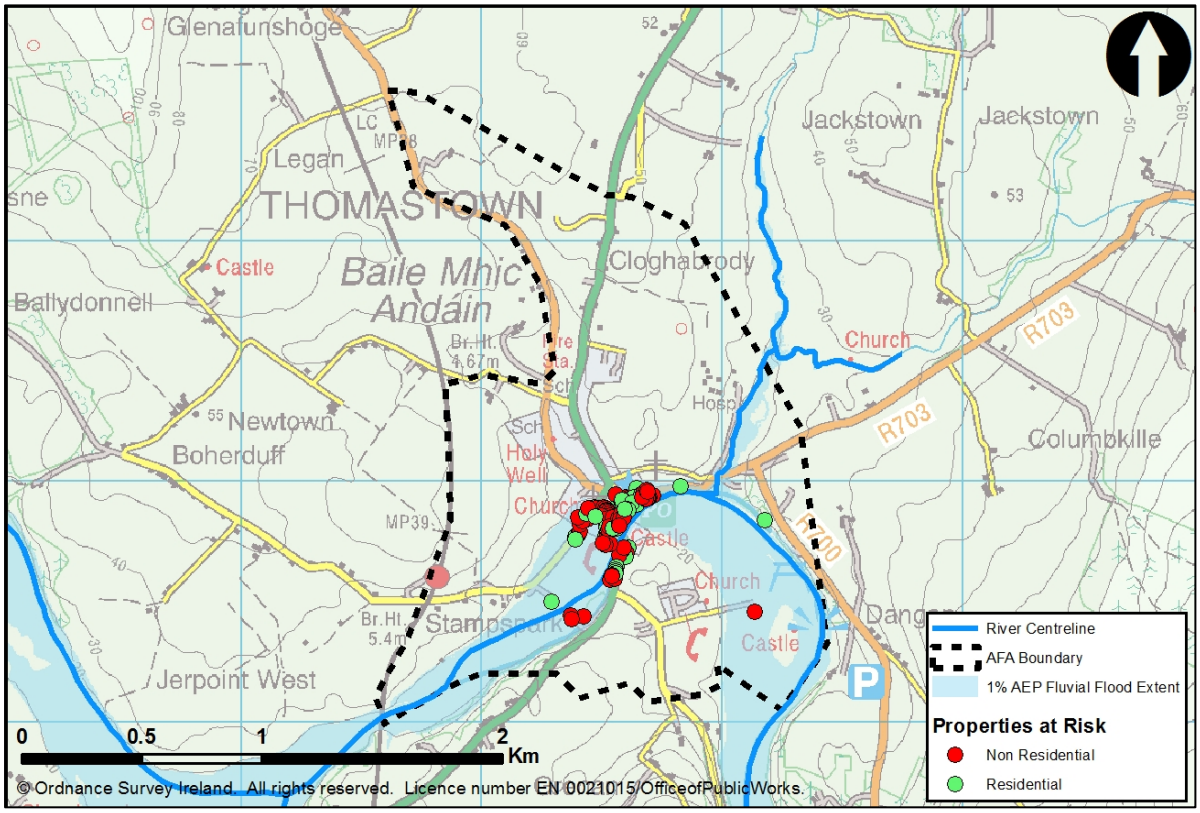


Figure 8.12.2 Flood risk in Thomastown AFA within a 1% AEP Fluvial Flood Extent

In Thomastown AFA the onset of residential and non-residential property damage occurs in the 50% AEP event.

8.12.5 Monetary Damage and Benefit

	Flood Cell 1	Total in AFA
Annual Average Damage (AAD)	€ 2,254,361	€ 2,254,361
Present Value Damage (pvD)	€ 48,428,183	€ 48,428,183
Standard of Protection (SoP)	1% AEP	1% AEP
Number of Properties Benefiting from Design SoP	135	135
Minimum Present Value Benefit	€ 45,390,058	€ 45,390,058
Capped Minimum Present Value Benefit	€ 16,479,422	€ 16,479,422

*The sum of the flood cell AAD or pvD values may not equate to the values presented for the Total in SSA due to flooding greater than the 1% AEP occurring outside the flood cell extents.

8.12.7 Short Listing FRM Methods – Local Cell

Method	Review Comment	Continue Screening
		Flood Cell 1
Do Nothing	Consider Further	✓
Additional Maintenance	Consider Further	✓
Do Minimum	Consider Further	✓
Planning and Development Control	Consider at UoM SSA - Reject	×
Building Regulations	Consider at UoM SSA - Reject	×
Catchment Wide SuDs	Consider at UoM SSA - Reject	×
Land Use Management	Consider Further	✓
Strategic Development Management	Consider at UoM SSA - Reject	×
Storage	Consider Further	✓
Improvement of Channel Conveyance	Consider Further	✓
Hard Defences	Consider Further	✓
Relocation of Properties	Consider Further	✓
Diversion of Flow	Consider Further	✓
Flood Warning/Forecasting	Consider Further	✓
Public Awareness Campaign	Consider at UoM SSA - Reject	×
Individual Property Protection	Consider Further	✓
Other Works	Consider Further	✓

8.12.7.1 Feasibility Review Summary for Local Cell (flood cell 1)

Method	Technical Screening	Economic Screening	Environmental and Cultural Heritage Screening	Social Screening
Do nothing	×			
Additional Maintenance	×			
Do Minimum	×			
Land Use Management	×			
Storage	×			
Improvement of Channel Conveyance	×			
Hard Defences	✓	✓	!	✓
Relocation of properties	✓	×		
Diversion of Flow	×			
Flood Warning/Forecasting	✓	✓	✓	✓
Individual Property Protection	×			
Other Works	×			

× - Reject ✓ - Progress ? - Progress, potential for impacts identified ! - Progress, potential for significant impacts identified

8.12.7.2 Justification for Rejection/Retention

Method	Tech	Econ	Env	Soc
Do nothing	×			

The do nothing FRM method would involve stopping the current maintenance regime. This is an unacceptable outcome in terms of contributing to design SoP and therefore was rejected from the screening process.

Method	Tech	Econ	Env	Soc
Additional Maintenance	×			

This method considers whether improvements can be made to augment the existing maintenance regime which will provide a significant beneficial impact on flood risk in the AFA. A review was carried out of the existing watercourse network. This included assessing the channel vegetation, the amount of debris present in the channels and the likelihood of structures blocking.

Increasing maintenance activities on the relevant watercourses will not significantly contribute to achieving the preferred SoP and therefore will not be pursued under the CFRAM Study.

Method	Tech	Econ	Env	Soc
Do Minimum	✗			

This method is appropriate where an isolated/single issue exists which can be easily addressed in order to reduce the flood risk, for example the removal of a pinch point/obstruction, or the upgrade of a blockage prone culvert screen, etc. These activities would be considered relatively straightforward, discrete and low cost. The design SoP must be achieved for this method to progress.

Within flood cell 1 the Do Minimum method would involve clearing the channel of the River Nore. Addressing the issue however would have minimal impact on the overall flood risk as it would not provide the additional conveyance needed within the channel. This is an unacceptable outcome in terms of contributing to achieving the design standard of flood protection and hence this method was rejected from the screening process.

Method	Tech	Econ	Env	Soc
Land Use Management	✗			

The application of land use management measures was tested at UoM scale. Due to the large size of the catchment of the River Nore at the Thomastown AFA the method is considered unsuitable to benefit flood cell 1. This method is technically unfeasible and hence rejected.

Method	Tech	Econ	Env	Soc
Storage	✗			

This method considers areas where flood water can be stored and then released at a controlled rate, therefore reducing the flow rate along the HPW and reducing the level of flood risk. This can be achieved by using existing or creating new depressions to create online or offline storage areas or by identifying pinch points which could be dammed such as a restricted point along a valley. Storage areas can be effective either upstream of the risk areas or within the risk area where parks or open areas are located.

The volume of water required to be stored in order to sufficiently reduce flows to prevent flooding in Thomastown has been estimated to be over 5 million m^3. A review of the surrounding land was carried out but no suitable location was found to accommodate this volume of water. Therefore this method is considered technically unfeasible and rejected.

Method	Tech	Econ	Env	Soc
Improvement of Channel Conveyance	✗			

This method focuses on increasing watercourse conveyance thereby lowering water levels and reducing the associated flood risk. This can be achieved by lowering bed levels, widening/reshaping channels, removing channel/structure constrictions, culverting reaches of watercourse, reducing roughness of the channel and sealing manholes.

A review of the various techniques available was carried out and channel modification was found to be the most appropriate way to implement this method. To reduce the 1%AEP fluvial event water levels to below top of bank levels thereby retaining the flood water in-channel, channel excavation and bridge underpinning was examined. It is possible to widen the channel in certain sections along the River Nore

(see Figure 8.12.3). It is estimated that 218,400m^3 of material would need to be excavated from the channel and the bridge on Market St. (15NORE02554D) would need to be underpinned, see Figure 8.12.4.

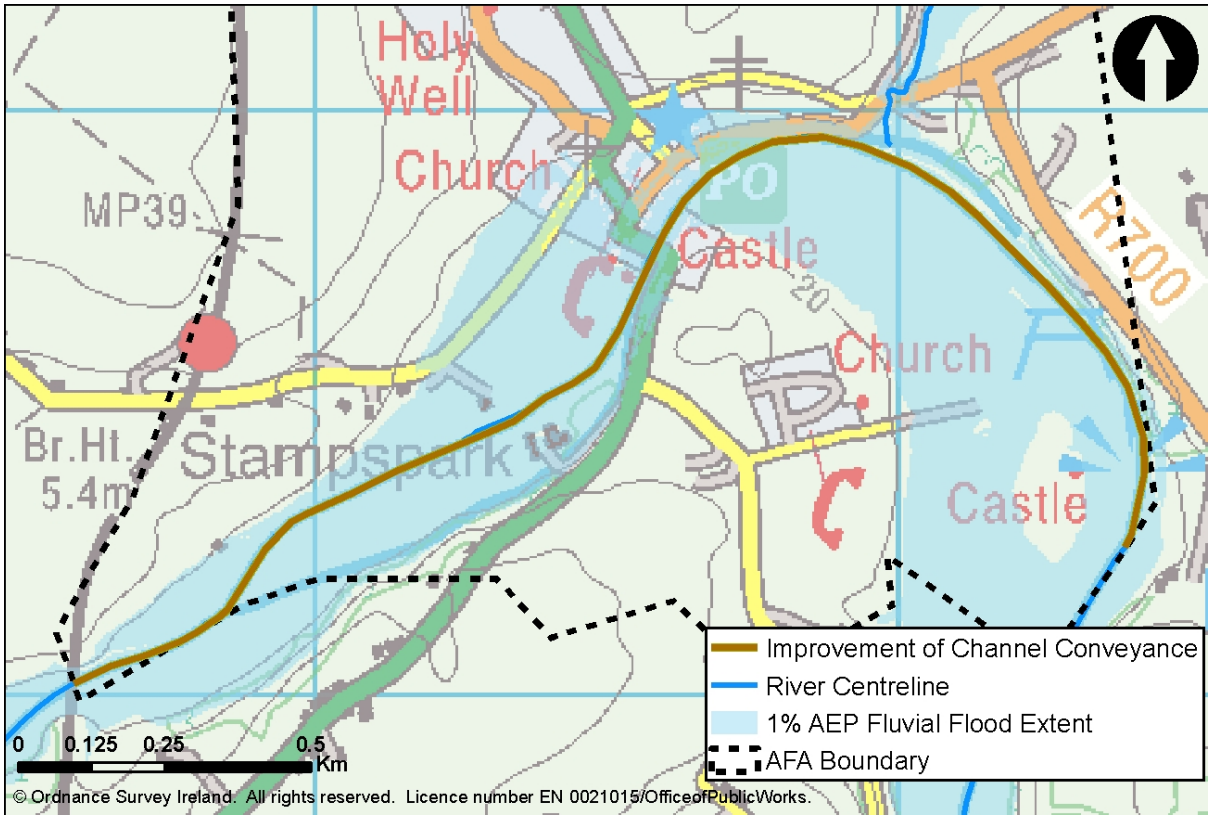


Figure 8.12.3 Location of Improvement of Channel Conveyance in flood cell 1

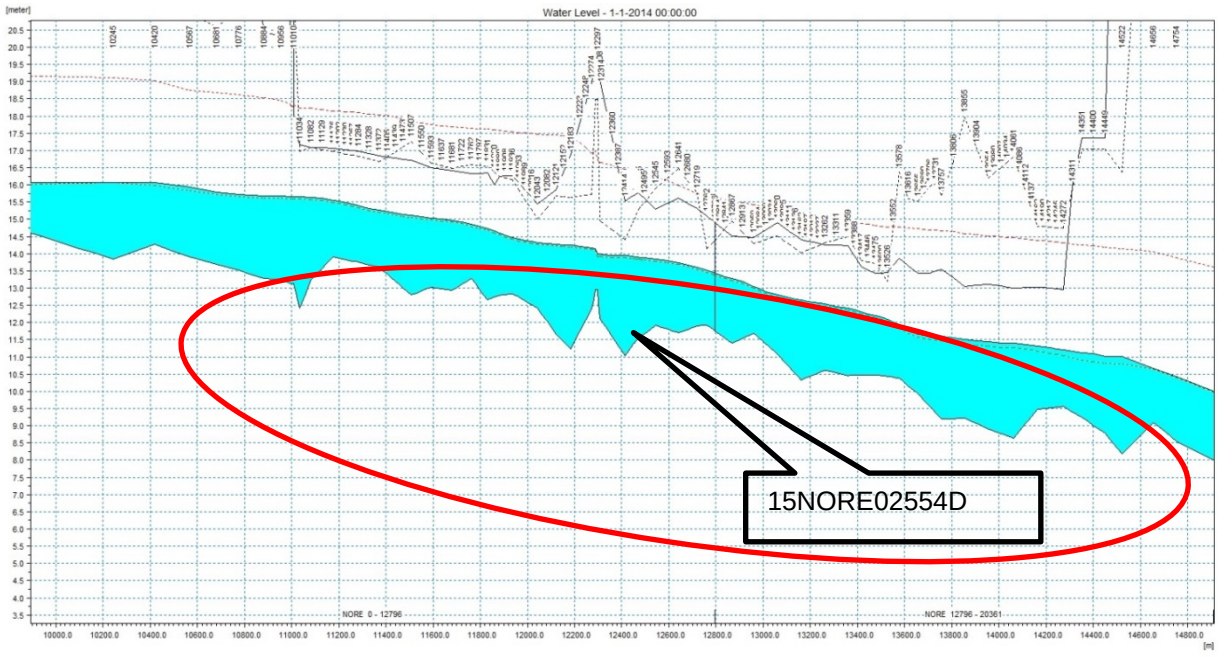


Figure 8.12.4 Long section of the River Nore highlighting areas for improved conveyance

To remove this volume of would require dropping the bed level by 2m in places. Therefore this technique is considered technically unfeasible as excavations of this depth would compromise bank stability and

the stability of existing walls in the AFA which have a high heritage standing both locally and nationally.

Method	Tech	Econ	Env	Soc
Hard Defences	✓	✓	!	✓

The term Hard Defences refers to physical barriers which prevent water from entering an area such as flood walls, embankments and barrages. As a general rule Hard Defences are kept as far back from the river channel or coast line as possible allowing the floodplain function to remain active. Where this is not possible, due to flood risk receptors being located within the floodplain, Hard Defences are placed around the property boundary to afford it protection. Where space allows flood embankments are used but where space is restricted flood walls are utilised.

A review was carried out to ascertain where Hard Defences would be required to protect existing property within flood cell 1. Figure 8.12.5 shows the location of the Hard Defences required to protect properties during the 1% AEP event.

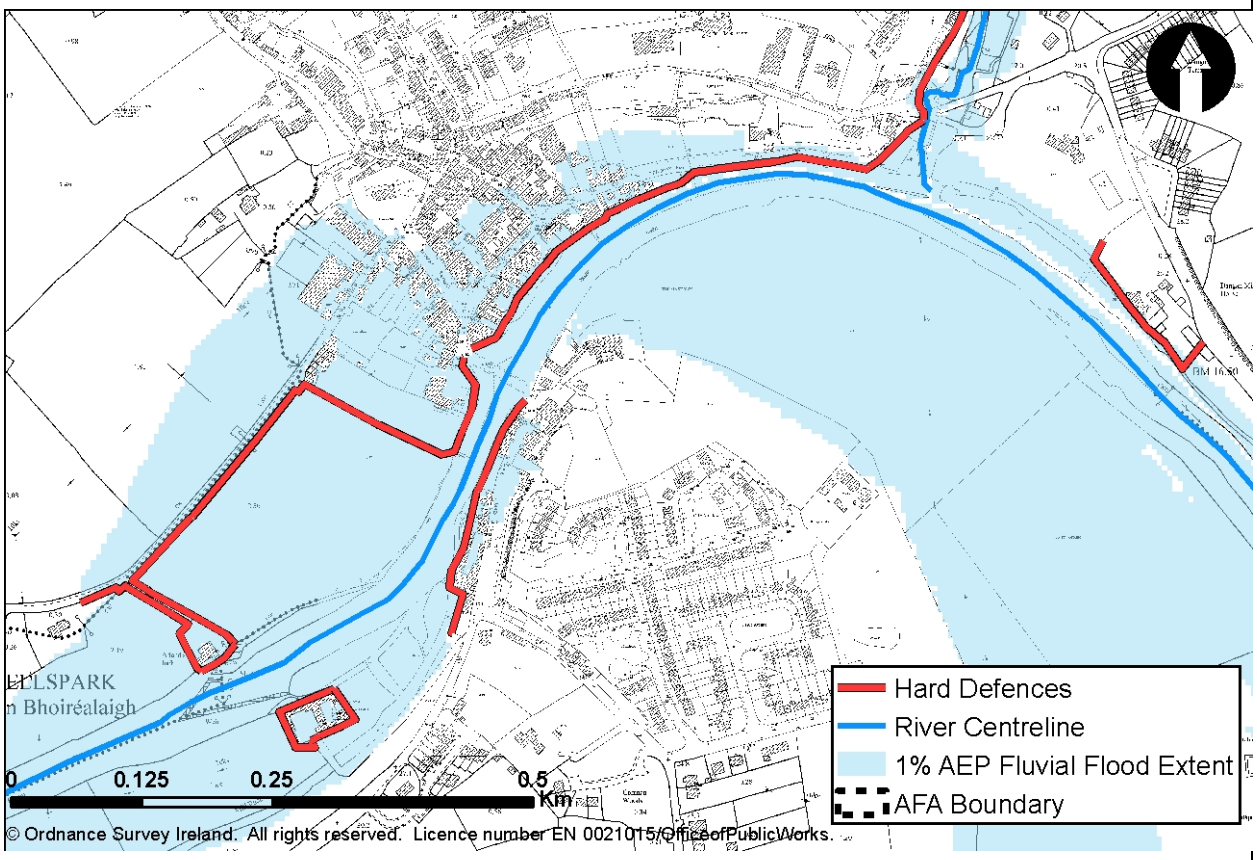


Figure 8.12.5 Location of Hard Defences in flood cell 1

In order to ascertain the effectiveness of Hard Defences a hydraulic model was constructed to simulate the method. The model showed that hard defences would protect to the 1% AEP flood event with an average height of 1.9m and a total length of 2.2km. The Hard Defences would also include raising the road near the entrance to the hospital and a flood gate at the Grennan Craft School. An economic review estimated the cost of the hard defences to be approximately €13.3m making this method economically viable.

The River Barrow and River Nore SAC and the River Nore SPA are within, downstream of and upstream of Thomastown. The Thomastown Quarry SAC is within the AFA. Any works associated with construction within the Thomastown AFA would need to be aware of River Barrow and River Nore SAC and River Nore SPA. The Hard Defences method in Thomastown would aim not to cause hydrological

alterations that might impact these nearby environmentally sensitive sites. Therefore this method will be put forward for consideration in the optioneering process.

Method	Tech	Econ	Env	Soc
Relocation of properties	✓	×		

To relocate a property is to abandon the existing at risk property and provide an alternative in a location not at risk. While this method is, in theory, possible, it is not practical for a whole community of many at risk properties. Its use is more applicable for discrete areas where single properties or clusters of properties are located.

In practice it is always technically possible to relocate properties, however considering the socially negative impacts it should only be considered should no other method be found suitable. There are 135 properties at risk during a 1% AEP fluvial event within flood cell 1. An economic review estimated the cost of relocating these properties as €36.6m. This method was therefore considered economically unviable and was rejected from the screening process

Method	Tech	Econ	Env	Soc
Diversion of Flow	×			

This method involves directing some of the floodwater via a new route thereby reducing flow and associated flood risk along the original route. This would be carried out upstream of where floodwaters reach the area of at risk properties. The new flow route would normally consist of a constructed open channel and/or culvert system or an existing linear feature able to convey the flow to a designated discharge point.

A review was carried out to assess the suitability of a flow diversion. Due to the topography in the area no location was found where this method could be carried out, it is therefore considered technically unfeasible and rejected.

Method	Tech	Econ	Env	Soc
Flood Warning/Forecasting	✓	✓	✓	✓

The application of flood warning / forecasting was tested at UoM scale. A suitable location far enough upstream of flood cell 1 is available to provide sufficient warning. This method can only provide warning for other methods and does not provide the required SoP as a standalone method. Therefore the method should only be considered if no other methods are suitable during the optioneering process.

An economic review estimated that the cost of providing two hydrometric gauging station with simple forecasting systems would be approximately €142,476. This method is therefore economically viable.

Method	Tech	Econ	Env	Soc
Individual Property Protection	×			

This method is aimed at individual properties that are remote from the main risk areas. Where the AFA being considered consists of a small number of remote properties this method is a feasible solution. But for areas with multiple properties at risk this method would only be considered an add on to a primary method. Individual property protection could consist of flood gates and vent seals on the building structure itself. Where flood depths are over 0.6m this method becomes unfeasible and flood resilience techniques would be recommended over flood gates. As this method is temporary and relies of human

intervention there is an element of uncertainty as to whether the full SoP will be met for every flood event. As such it is assumed that 20% of the flood damage will be avoided.

Flood cell 1 contains a large number of discrete and grouped properties and there are predicted flood depths greater than 0.6m for 61 of the 135 properties impacted by flooding. This method is therefore technically unfeasible as a standalone option for the whole AFA.

There is a pilot community flood response project for Thomastown, to progress flood alert and community flood response schemes. These schemes are intended to facilitate a community based response to flood events by improving the resilience and preparedness of the local community. The scheme includes the provision of an early flood warning system and flood barriers for individual property protection in Thomastown. The proposed scheme will include a detailed building survey to identify all potential flow paths through the affected properties. The survey will also consider the type of foundation and floor in the property along with other factors which may affect the viability of any proposed measures.

Method	Tech	Econ	Env	Soc
Other Works	×			

No other works were identified for these flood cells

8.12.7.3 Summary of Feasibility Review – Flood Cell 1

The following FRM methods have been carried forward to address the flood risk arising from flood cell 1;

- Hard Defences

Hard Defences can provide the full protection to all properties during the 1% AEP fluvial event while Flood Warning/Forecasting can only provide partial protection to the properties in flood cell 1. Therefore hard defences can be considered in the optioneering process as a standalone method.

8.12.8 Selection of Options

Method	Option 1	Option 2	Option 3	Option 4	Option 5
Hard Defences	✓				

For flood cell 1 Hard Defences can provide the full SoP to the properties at risk.

8.12.8.1 Option 1 details – Hard Defences

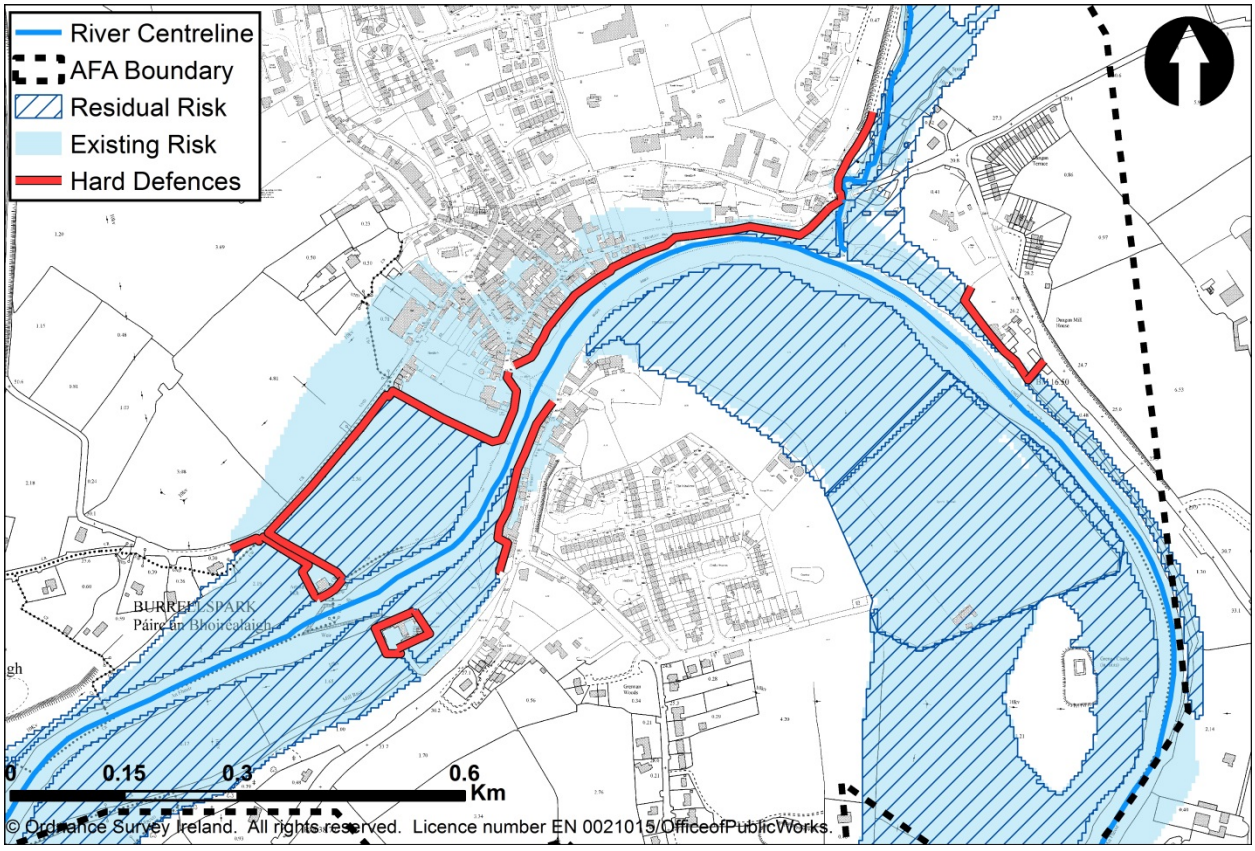


Figure 8.12.6 Thomastown AFA Option 1

At risk properties would be protected by hard defences would protect to the 1% AEP flood event with an average height of 1.9m and a total length of 2.2km..

Figure 8.11.6 presents the effect of the potential option on the design flood event by overlaying the present day flood extent (labelled existing risk) with the flood extent that would occur after the option is put in place (labelled residual risk).

In addition to these methods the following was also identified at UoM level (see section 8.1) to be included in any potential option identified:

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs

- Strategic Development Management
- Public Awareness Campaign

Option Item	Quantity	Construction Cost
Wall	936m length, 2.5m high	€ 4,770,106
Embankment	1233m length, 1.7m high	€ 965,163
Flood gate	Hinge 2X3m	€ 38,000
Road raise	11m, entrance to the hospital	€ 8,558

Total MCA-Benefit Score	Option Cost (€millions)	MCA-Benefit Score / Cost Ratio
1447	12.7	114.15

Economic Appraisal (Cost-Benefit Analysis) Outcomes			
Area NPVd (uncapped)	Option Cost	Option NPVb (capped)	Benefit - Cost Ratio
€ 48,428,183	€ 12,677,764	€ 16,479,422	1.3

8.12.8.2 AFA Sensitivity to Future Change

During a MRFS 1% AEP flood event the increase in flood extent is minimal as the topography rises steeply from the flood plain within the AFA. This would result in an additional 25 properties being at risk bringing the property count from 135 in the present day 1% AEP fluvial event to 160. The main area of additional flood risk is confined to the properties in the Thomastown urban area as it forms part of the flood plain as shown in Figure 8.12.7. The AAD would increase from €2,254,361 to €4,578,264. As a result the Thomastown AFA would be considered to be at high vulnerability from the MRFS.

During a HEFS 1% AEP flood event the increase in flood extent is minimal as the topography rises steeply from the flood plain within the AFA. This would result in an additional 47 properties being at risk bringing the property count from 135 in the present day 1% AEP fluvial event to 182. The main area of additional flood risk is confined to the properties in the Thomastown urban area as it forms part of the flood plain asshown in Figure 8.12.7. The AAD would increase from €2,254,361 to €7,848,239. As a result the Thomastown AFA would be considered to be at high vulnerability from the HEFS.

The main area of additional flood risk is a larger width of the present day 1%AEP fluvial event extent which spans the length of the Thomastown AFA as shown in Figure 8.12.7

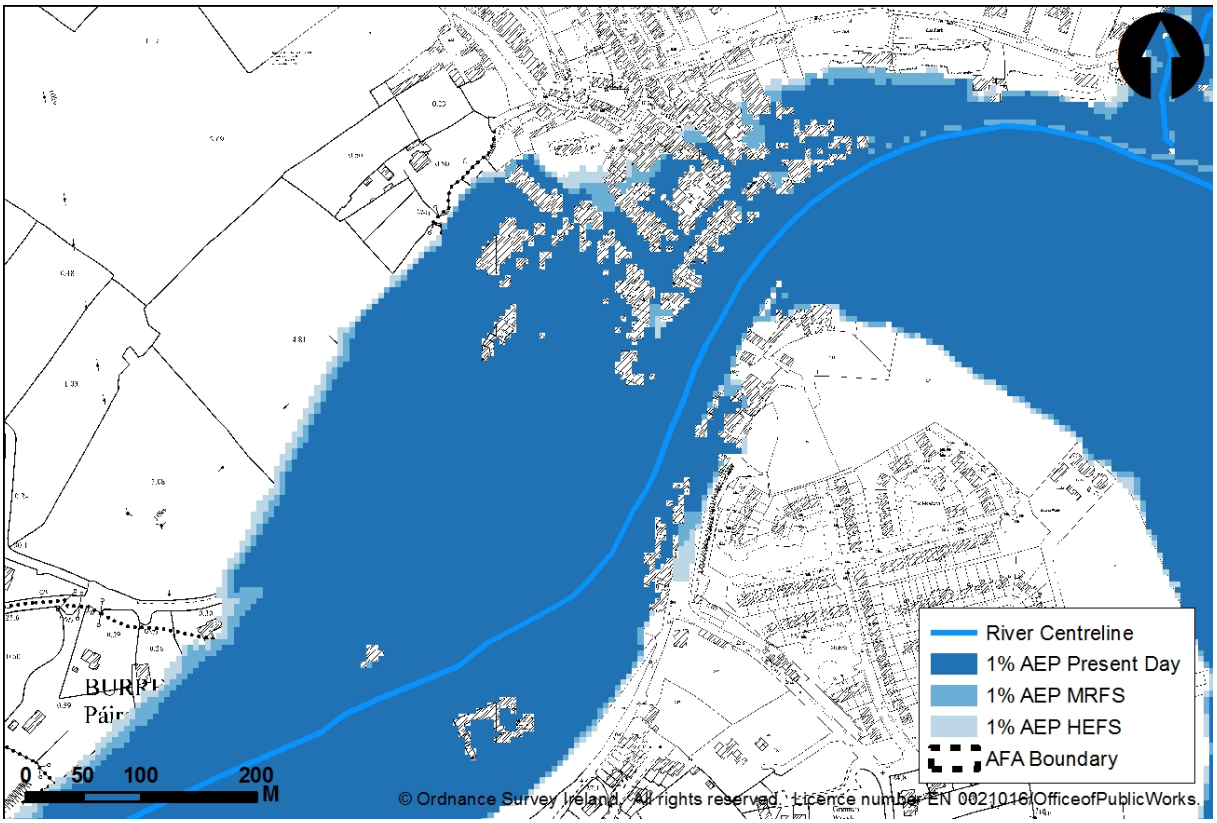


Figure 8.12.7 Thomastown Future Change Fluvial Flood Extents

8.12.8.3 Future Change Adaptability

The following discusses the adaptability of the potential FRM methods proposed in Thomastown AFA:

Hard Defences Flood Cell 1 - This method could be adapted by increasing the height of the walls. The length of the wall would not need to be adjusted. A review of the effect of the MRFS and the HEFS showed that the existing and proposed walls would require an increase by approximately 0.55m and 1.13m under the MRFS and HEFS respectively upstream of Thomastown Bridge on the floodplain. A review of the effect of the MRFS and the HEFS showed that the existing and proposed walls would require an increase by approximately 0.23m and 0.52m under the MRFS and HEFS respectively

downstream of Thomastown Bridge along the channel. This additional height could be accommodated. To ensure that this wall would be adaptable the design would need to account for the potential increase in height. This method is considered to be **moderate to poor adaptability** due to the visual and social impact of increasing the height.

The potential **options** identified have been further assessed using 5 criteria in an attempt to identify low – or no regret combinations of measures.

1. **Does the option reduce vulnerability?** In addition to the methods above other methods aimed at reducing future flood risk have been discussed in section 8.1 at UoM scale and are detailed in each potential option. These methods, such as building regulations and planning & development control will reduce the impact to potential future receptors. Given that Thomastown has a moderate area of open space some of these methods including a strategic development plan would be highly effective. there would be limited scope for some of these methods to impact on the area being assessed. Since there is a moderate increase in the number of properties affected in the MRFS and HEFS there is a need to ensure that future receptors at risk are prepared through methods such as public awareness campaign
2. **Does the option make space for water?** The FRM method selected to address the flood risk in flood cell 1 would make space for water where proposed Hard Defences are set back from the river bank at the extent of the flood plain. However it would not make space for water where the existing walls are protecting at risk properties from out of bank flooding. These walls were designed to contain water as the river flows through the Thomastown urban area.
3. **Does the option deliver co-benefits?** No co-benefits were identified.
4. **Does the option provide flexibility?** A review of the potential option shows that overall for the option proposed, Hard Defences in flood cell 1, has moderate to poor adaptability as the existing and proposed defences could be raised with moderate cost but significant effort and impact. However alternative FRM methods could be added to the option to provide an increased SoP.
5. **Does the option allow for deferring/removing or abandoning?** Given the present day risk there is no allowance for options to be deferred or any that could be removed later

An objective for each potential option is to ensure that flood risk can be managed effectively and sustainably into the future accounting for the potential impacts of climate change. Based on this future changes adaptability assessment the table below summarises how well each option achieves this objective.

Summary of Option Adaptability

Option	Description	Score
Option 1 – Hard Defence (FC 1)	Option is adaptable at moderate cost, difficulty and impact	2

8.12.8.4 Local Authority Comments

LA representatives reviewed preliminary options in April 2016 and made the following comments:

- Queried the extent of the proposed wall on the right hand bank downstream of the bridge

8.12.8.5 Summary

There is good confidence in both the hydrology and hydraulics of the Thomastown AFA. Model flows were validated against the estimated flows at HEP check points to ensure the model is well anchored to hydrological estimates. There are no significant instabilities shown in the model results. Overall, the model is performing well and is supported by historic information. The model calibrates well with the one event where calibration of recorded gauge data was possible.

The following potential options, with a BCR ≥ 0.5 have been identified:

- Option 1 – Hard Defences (FC 1) and FRM measures identified for UoM15

Alongside any potential option the existing regime should continue with maintenance being carried out ad hoc when resources allow. Maintenance of the option structures should also form part of the ongoing regime once in place.

Methods also were identified at UoM level (see section 8.1) that are applicable to Thomastown AFA, that if implemented, will serve to avoid increasing flood risk in the future :

- Planning and Development Control
- Building Regulations
- Sub-catchment Wide SuDs
- Strategic Development Management
- Public Awareness Campaign

The Inistioge AFA is located downstream that may be affected by the identified option. There are also a number of rural locations downstream of the Thomastown AFA. The flow at the downstream model boundary was reviewed for the1% AEP current scenario versus the 1% AEP with the option in place scenario. There was a negligible flow difference between the hydraulic model simulations.

The Thomastown AFA is located within the River Barrow And River Nore SAC therefore this specially designated area would need to be addressed during the development of the preferred option. There are also 38 NIAH buildings within the AFA These buildings would also need to be addressed during the development of the preferred option.

It should be noted that Thomastown has a high sensitivity to climate change and is suitable for an assumptive approach be incorporated into detailed design.

These recommendations should be taken forward with a view to identification of a preferred option for the flood risk management plan.

9 SUMMARY OF FRM OPTIONS

Table 9.1 summarises the optioneering appraisal for each AFA within UoM15 considering all SSAs. Details of specific recommendations for the UoM and each AFA can be found in section 8.

Table 9.1 – Summary of Preliminary Options Identified at AFA SSA within UoM15

AFA	Design flood event (AEP)	Number of properties at risk in design flood event	Options	Area NPVd	Option NPVb (capped)	Option Cost (€m)	Benefit – Cost Ratio	Total MCA-Benefit Score	MCA-Benefit Score / Cost Ratio	Sensitivity to MRFS	Sensitivity to HEFS
UoM15	-	-	• Sustainable Planning and Development Management • Public Awareness Campaign	-	-	-	-	-	-	-	-
Ballyhale	1% Fluvial	25	• Option 1 – Storage & Hard Defences	€ 12,418,483	€ 4,116,935	€ 1,483,045	2.78	1481	998.34	Moderate	Moderate
			• Option 2 – Hard Defences	€ 12,418,483	€ 4,116,935	€ 1,712,078	2.40	1575	919.69		
			• Option 3 – Diversion of Flow & Hard Defences	€ 12,418,483	€ 4,116,935	€ 433,818	9.49	1415	3260.78		

AFA	Design flood event (AEP)	Number of properties at risk in design flood event	Options	Area NPVd	Option NPVb (capped)	Option Cost (€m)	Benefit – Cost Ratio	Total MCA-Benefit Score	MCA-Benefit Score / Cost Ratio	Sensitivity to MRFS	Sensitivity to HEFS
Ballyragget	1% Fluvial	0	• Maintain Existing Regime	€7,208	€0	-	-	-	-	Low	Low
Ballyroan	1% Fluvial	0	• Maintain Existing Regime	€194	€0	-	-	-	-	Low	Low
Callan	1% Fluvial	38	• Option 1 – Improvement of Channel Conveyance	€ 5,868,697	€ 1,808,579	€ 2,357,008	0.77	696	295.16	Moderate	High
			• Option 2 – Hard Defences	€ 5,868,697	€ 1,808,579	€ 2,365,433	0.76	1206	509.71		
Freshford	1% Fluvial	93	• Option 1 – Improvement of Channel Conveyance	€45,011,056	€13,421,732	€3,802,493	3.53	1991	523.64	High	High
			• Option 2 – Storage, Diversion of Flow and Improvement of Channel Conveyance	€45,011,056	€13,421,732	€6,105,347	2.2	1741	285.18		

AFA	Design flood event (AEP)	Number of properties at risk in design flood event	Options	Area NPVd	Option NPVb (capped)	Option Cost (€m)	Benefit – Cost Ratio	Total MCA-Benefit Score	MCA-Benefit Score / Cost Ratio	Sensitivity to MRFS	Sensitivity to HEFS
Inistioge	1% Fluvial	30	• Hard Defences	€8,405,073	€6,546,412	1,489,836	4.39	1341	900.11	Moderate	High
Kilkenny (Breagagh)	1% Fluvial	37	• Hard Defences	€947,216	€677,301	€1,225,765	0.55	883	720.37	High	High
			• Hard Defences and Land Use Management	€947,216	€677,301	€1,235,668	0.548	816	660.137		
Kilkenny (Nore)	1% Fluvial	20	• Maintain Existing Regime	€5,164,862	-	-	-	-	-		
Mountrath	1% Fluvial	40	• Option 1 - Hard Defences and Improvement of Channel Conveyance	€2,187,578	€1,546,066	€2,649,262	0.58	352	132.69	Moderate	Moderate
			• Option 2 – Hard Defences and Improvement of Channel Conveyance	€2,187,578	€1,546,066	€2,673,838	0.58	221	82.48		

AFA	Design flood event (AEP)	Number of properties at risk in design flood event	Options	Area NPVd	Option NPVb (capped)	Option Cost (€m)	Benefit – Cost Ratio	Total MCA-Benefit Score	MCA-Benefit Score / Cost Ratio	Sensitivity to MRFS	Sensitivity to HEFS
Rathdowney	1% Fluvial	44	• Option 1 – Storage & Hard Defences	€101,759,363	€8,488,850	€5,076,129	1.67	1071	210.99	Moderate	Moderate
Thomastown	1% Fluvial	135	• Hard Defences	€ 48,428,183	€ 16,479,422	€ 12,677,764	1.3	1447	114.15	High	High

10 REFERENCES

1. EC Directive on the Assessment and Management of Flood Risks (2007/60/EC)
2. S.I. No. 122/2010 - European Communities (Assessment and Management of Flood Risks) Regulations 2010
3. South Eastern CFRAM Study, UoM15 Inception Report, IBE0601Rp0008 (RPS, 2012)
4. South Eastern CFRAM Study, UoM15 Hydrology Report, IBE0601Rp0010 (RPS, 2013)
5. South Eastern CFRAM Study, UoM15 Hydraulics Report, IBE0601Rp0015 (RPS, 2014)
6. Culvert Design and Operation Guide - R168 (CIRIA, 1997)
7. Flood and Coastal Erosion Risk Management A Manual for Economic Appraisals (FHRC & EA, 2013)
8. Identification of catchments sensitive to land use change (EA, 2008)

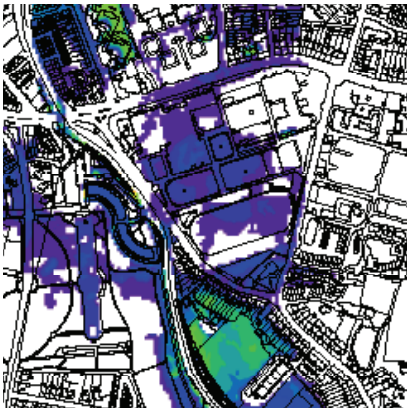
RPS

SOUTH EASTERN CFRAM
CATCHMENT FLOOD RISK ASSESSMENT AND MANAGEMENT STUDY

South Eastern CFRAM Study

UoM15 Preliminary Options Report Appendices

IBE0601Rp0025



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Oifig na nOibreacha Poiblí

Appendix A

Ballyhale AFA
Additional Information

List of background information included:

1. Costings

- Option 1 – Whole Life Costs- Storage and Hard Defences
- Option 2 – Whole Life Costs- Hard Defences
- Option 3 – Whole Life Costs- Diversion of Flow and Hard Defences

2. MCA

- Option 1 – Storage and Hard Defences
- Option 2 - Hard Defences
- Option 3- Diversion of Flow with Hard Defences

3. Potential Option drawings

- Option 1 – Storage and Hard Defences
- Option 2 - Hard Defences
- Option 3 - Diversion of Flow with Hard Defences

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	**Emma Holland**	**Date:**	**12/12/2015**
Checked by:	**Mark Wilson**	**Date:**	**12/12/2015**

Project reference	IBE0601

Project name:	SE CFRAM Study_Ballyhale_Option 1

Base date for estimates (year 0)	Oct-2013
Scaling factor (e.g. €m, €k, €)	€

Construction Price Index (CPI)	**1.000**
Method Factor - to take into account particular site issues /constraints	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		-

Capital costs	**Cost (€)**	**Comment**
Total wall costs		
Total embankment costs	€217,944.00	*Embankment for Storage 1 and 3 and overland lfow*
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs	€27,465.00	
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs	€289,964.00	
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€535,373	
Apply update to unit rate (CPI) if appropriate (cell N15)	€535,373	
Enter appropriate preliminaries estimate (%)	18%	
Sub Total	€631,740	
Optimism Bias	45%	*In channel*
Total capital cost (€)	€916,023	
Consider amendments based on site issues/constraints (cell N16)	€916,023	
Total capital cost (€)	€916,023	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs		
Total embankment O&M costs	€1,421.00	*3.2 * total length of embankment*
Total automatic gate O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs	€1,875.00	*storage overtopping weir*
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs	€1,194.00	*storage culvert*
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€4,490	
NPV O&M	€95,823	
Optimism Bias	45%	
NPV O&M with Optimism Bias	€138,944	

Other costs	**Cost (€)**	**Comment**
Other costs (design, supervision, archaeology, environment, site investigation, art)	€428,078	*Design and supervision (13%), Archaeology and environment (10%), Land (10%), Site investigation (€100,000), Art (€25,500), Works access and Haul roads*

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€1,483,045	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€916,023.2
Annual maintenance cost (€)	€4,490.0
Other cost (€)	€428,077.7
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**	**Total PVc (€k):**		**1011846**
	Cash sum	0	916023	220010	0	1136033	**1011846**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	916023			916023.2	916023.2
1	0.961538			4490		4490.0	4317.3
2	0.925			4490		4490.0	4151.3
3	0.889			4490		4490.0	3991.6
4	0.855			4490		4490.0	3838.1
5	0.822			4490		4490.0	3690.5
6	0.790			4490		4490.0	3548.5
7	0.760			4490		4490.0	3412.0
8	0.731			4490		4490.0	3280.8
9	0.703			4490		4490.0	3154.6
10	0.676			4490		4490.0	3033.3
11	0.650			4490		4490.0	2916.6
12	0.625			4490		4490.0	2804.4
13	0.601			4490		4490.0	2696.6
14	0.577			4490		4490.0	2592.9
15	0.555			4490		4490.0	2493.1
16	0.534			4490		4490.0	2397.2
17	0.513			4490		4490.0	2305.0
18	0.494			4490		4490.0	2216.4
19	0.475			4490		4490.0	2131.1
20	0.456			4490		4490.0	2049.2
21	0.439			4490		4490.0	1970.4
22	0.422			4490		4490.0	1894.6
23	0.406			4490		4490.0	1821.7
24	0.390			4490		4490.0	1751.6
25	0.375			4490		4490.0	1684.3
26	0.361			4490		4490.0	1619.5
27	0.347			4490		4490.0	1557.2
28	0.333			4490		4490.0	1497.3
29	0.321			4490		4490.0	1439.7
30	0.308			4490		4490.0	1384.4
31	0.296			4490		4490.0	1331.1
32	0.285			4490		4490.0	1279.9
33	0.274			4490		4490.0	1230.7
34	0.264			4490		4490.0	1183.3
35	0.253			4490		4490.0	1137.8
36	0.244			4490		4490.0	1094.1
37	0.234			4490		4490.0	1052.0
38	0.225			4490		4490.0	1011.5
39	0.217			4490		4490.0	972.6
40	0.208			4490		4490.0	935.2
41	0.200			4490		4490.0	899.2
42	0.193			4490		4490.0	864.7
43	0.185			4490		4490.0	831.4
44	0.178			4490		4490.0	799.4
45	0.171			4490		4490.0	768.7
46	0.165			4490		4490.0	739.1
47	0.158			4490		4490.0	710.7
48	0.152			4490		4490.0	683.4
49	0.146			4490		4490.0	657.1
							95823.2

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	**Emma Holland**	**Date:**	**12/12/2015**
Checked by:	**Mark Wilson**	**Date:**	**12/12/2015**

Project reference	IBE0601	**Project name:**	SE CFRAM Study_Ballyhale_Option 2

Base date for estimates (year 0)	Oct-2013
Scaling factor (e.g. €m, €k, €)	€

Construction Price Index (CPI)	**1.000**
Method Factor - to take into account particular site issues /constraints	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		-

Capital costs	**Cost (€)**	**Comment**
Total wall costs	€670,191.00	*507m of flood wall*
Total embankment costs	€39,082.00	*781m of flood embankment*
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€709,273	
Apply update to unit rate (CPI) if appropriate (cell N15)	€709,273	
Enter appropriate preliminaries estimate (%)	17%	
Sub Total	€829,849	
Optimism Bias	41%	
Total capital cost (€)	€1,170,088	
Consider amendments based on site issues/constraints (cell N16)	€1,170,088	
Total capital cost (€)	€1,170,088	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs	€203.00	*0.4 * length of wall*
Total embankment O&M costs	€781.00	*3.2 * total length of embankment*
Total automatic gate O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€984	
NPV O&M	€21,000	
Optimism Bias	41%	
NPV O&M with Optimism Bias	€29,610	

Other costs	**Cost (€)**	**Comment**
Other costs (design, supervision, archaeology, environment, site investigation, art)	€512,380	*Design and supervision (13%), Archaeology and environment (10%), Land (10%), Site investigation (€100,000), Art (€25,500), Works access and Haul roads*

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€1,712,078	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€1,170,087.7
Annual maintenance cost (€)	€984.0
Other cost (€)	€512,379.9
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**	**Total PVc (€k):**		**1191088**
	Cash sum	0	1170088	48216	0	1218304	**1191088**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	1170088			1170087.7	1170087.7
1	0.961538			984		984.0	946.2
2	0.925			984		984.0	909.8
3	0.889			984		984.0	874.8
4	0.855			984		984.0	841.1
5	0.822			984		984.0	808.8
6	0.790			984		984.0	777.7
7	0.760			984		984.0	747.8
8	0.731			984		984.0	719.0
9	0.703			984		984.0	691.3
10	0.676			984		984.0	664.8
11	0.650			984		984.0	639.2
12	0.625			984		984.0	614.6
13	0.601			984		984.0	591.0
14	0.577			984		984.0	568.2
15	0.555			984		984.0	546.4
16	0.534			984		984.0	525.4
17	0.513			984		984.0	505.2
18	0.494			984		984.0	485.7
19	0.475			984		984.0	467.0
20	0.456			984		984.0	449.1
21	0.439			984		984.0	431.8
22	0.422			984		984.0	415.2
23	0.406			984		984.0	399.2
24	0.390			984		984.0	383.9
25	0.375			984		984.0	369.1
26	0.361			984		984.0	354.9
27	0.347			984		984.0	341.3
28	0.333			984		984.0	328.1
29	0.321			984		984.0	315.5
30	0.308			984		984.0	303.4
31	0.296			984		984.0	291.7
32	0.285			984		984.0	280.5
33	0.274			984		984.0	269.7
34	0.264			984		984.0	259.3
35	0.253			984		984.0	249.4
36	0.244			984		984.0	239.8
37	0.234			984		984.0	230.5
38	0.225			984		984.0	221.7
39	0.217			984		984.0	213.2
40	0.208			984		984.0	205.0
41	0.200			984		984.0	197.1
42	0.193			984		984.0	189.5
43	0.185			984		984.0	182.2
44	0.178			984		984.0	175.2
45	0.171			984		984.0	168.5
46	0.165			984		984.0	162.0
47	0.158			984		984.0	155.8
48	0.152			984		984.0	149.8
49	0.146			984		984.0	144.0
							21000.0

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	**Emma Holland**	**Date:**	**12/12/2015**
Checked by:	**Mark Wilson**	**Date:**	**12/12/2015**

Project reference	IBE0601

Project name:	SE CFRAM Study_Ballyhale_Option 3

Base date for estimates (year 0)	Oct-2013
Scaling factor (e.g. €m, €k, €)	€

Construction Price Index (CPI)	**1.000**
Method Factor - to take into account particular site issues /constraints	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		-

Capital costs	**Cost (€)**	**Comment**
Total wall costs		
Total embankment costs	€6,656.00	*52m of embankment for overland flow*
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs	€63,988.00	*3764m^3*
Total weir construction costs	€68,053.00	*controll structure*
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€138,697	
Apply update to unit rate (CPI) if appropriate (cell N15)	€138,697	
Enter appropriate preliminaries estimate (%)	20%	
Sub Total	€166,436	
Optimism Bias	45%	
Total capital cost (€)	€241,333	
Consider amendments based on site issues/constraints (cell N16)	€241,333	*166.4*
Total capital cost (€)	€241,333	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs		
Total embankment O&M costs	€166.00	*3.2 * total length of embankment*
Total automatic gate O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs	€1,875.00	
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€2,041	
NPV O&M	€43,558	
Optimism Bias	45%	
NPV O&M with Optimism Bias	€63,159	

Other costs	**Cost (€)**	**Comment**
Other costs (design, supervision, archaeology, environment, site investigation, art)	€129,326	*Design and supervision (13%), Archaeology and environment (10%), Land (10%), Site investigation (10%), Art (€25,500), Works access and Haul roads*

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€433,818	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€241,332.8
Annual maintenance cost (€)	€2,041.0
Other cost (€)	€129,326.1
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**	**Total PVc (€k):**		**284891**
	Cash sum	0	241333	100009	0	341342	**284891**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	241333			241332.8	241332.8
1	0.961538			2041		2041.0	1962.5
2	0.925			2041		2041.0	1887.0
3	0.889			2041		2041.0	1814.4
4	0.855			2041		2041.0	1744.7
5	0.822			2041		2041.0	1677.6
6	0.790			2041		2041.0	1613.0
7	0.760			2041		2041.0	1551.0
8	0.731			2041		2041.0	1491.3
9	0.703			2041		2041.0	1434.0
10	0.676			2041		2041.0	1378.8
11	0.650			2041		2041.0	1325.8
12	0.625			2041		2041.0	1274.8
13	0.601			2041		2041.0	1225.8
14	0.577			2041		2041.0	1178.6
15	0.555			2041		2041.0	1133.3
16	0.534			2041		2041.0	1089.7
17	0.513			2041		2041.0	1047.8
18	0.494			2041		2041.0	1007.5
19	0.475			2041		2041.0	968.7
20	0.456			2041		2041.0	931.5
21	0.439			2041		2041.0	895.7
22	0.422			2041		2041.0	861.2
23	0.406			2041		2041.0	828.1
24	0.390			2041		2041.0	796.2
25	0.375			2041		2041.0	765.6
26	0.361			2041		2041.0	736.2
27	0.347			2041		2041.0	707.9
28	0.333			2041		2041.0	680.6
29	0.321			2041		2041.0	654.4
30	0.308			2041		2041.0	629.3
31	0.296			2041		2041.0	605.1
32	0.285			2041		2041.0	581.8
33	0.274			2041		2041.0	559.4
34	0.264			2041		2041.0	537.9
35	0.253			2041		2041.0	517.2
36	0.244			2041		2041.0	497.3
37	0.234			2041		2041.0	478.2
38	0.225			2041		2041.0	459.8
39	0.217			2041		2041.0	442.1
40	0.208			2041		2041.0	425.1
41	0.200			2041		2041.0	408.8
42	0.193			2041		2041.0	393.0
43	0.185			2041		2041.0	377.9
44	0.178			2041		2041.0	363.4
45	0.171			2041		2041.0	349.4
46	0.165			2041		2041.0	336.0
47	0.158			2041		2041.0	323.1
48	0.152			2041		2041.0	310.6
49	0.146			2041		2041.0	298.7
							43557.9

Option Appraisal and the Multi-Criteria Analysis

Name of modeller	**Emma Holland**
Name of assessor	**Emma Holland**
Date of Assessment	**19/01/2016**
Option ID	**Option 1**
Option Type	Structural Option
Option Location	Ballyhale
Option Details	Upstream Storage and Hard Defences
AEP	1.0%
Option Cost	€1,483,045.00
Economic Benefit	€4,116,936.00

Multi-Criteria Analysis Summary

Ballyhale Option 1

1. Technical Criteria

Objective 1.A	Ensure flood risk management options are operationally robust	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Level of risk score	3	*There is a requirement for simple control structure for the option to operate, with regular monitoring and maintenance required, but a very low likelihood of system / operation failure*
Adjustment	No adjustment	*The level of risk score has not been adjusted*
Total Option Score	3.0	*Option score + adjustment*
Weighted Option Score	**300**	*Global weighting x Local weighting x Total option score*

Objective 1.B	Minimise health and safety risk in construction, maintenance and operation of the flood risk management option	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Option Score	2.0	*The following hazards have been identified: working near water (construction), working with heavy plant machinery, working near water (O&M)*
Adjustment	0.0	*There have been no adjustments made to the option score*
Total Option Score	2.0	*Option score + adjustment*
Weighted Option Score	**200**	*Global weighting x Local weighting x Total option score*

Objective 1.C	Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Adaptability Score	1	*Option is adaptable only at significant cost*
Adjustment	No adjustment	*The adaptability score has not been adjusted*
Total Option Score	1.0	*Option score + adjustment*
Weighted Option Score	**100**	*Global weighting x Local weighting x Total option score*

Technical Score	600

Multi-Criteria Analysis Summary

Ballyhale Option 1

2. Economic Criteria

Objective 2.A	Reduce economic damages	
Assigned Weightings		
Global Weighting	24.0	*Nationally Constant Value*
Local Weighting	4.6	*AAD for the SSA / €75,000*
AAD for the SSA	€ 344,466.19	*Baseline Scenario*
Option Scoring		
Reduced AAD	€ 23,907.56	*Defended Scenario*
Total Option Score	4.7	*0.05 X Percentage Reduction in AAD*
Weighted Option Score	**513**	*Global weighting x Local weighting x Total option score*

Objective 2.B	Minimise risk to transport infrastructure	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	12.5	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	0.3	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.9	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the option score*
Total Option Score	4.9	*Option score + adjustment*
Weighted Option Score	**245**	*Global weighting x Local weighting x Total option score*

Objective 2.C	Minimise risk to utility infrastructure	
Assigned Weightings		
Global Weighting	14.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	1.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	0.0	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	0.0	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the total option score*
Total Option Score	0.0	*Option score + adjustment*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 2.D	Manage risk to agriculture	
Assigned Weightings		
Global Weighting	12.0	*Nationally Constant Value*
Local Weighting	3.0	*Agricultural activity in the area is mainly grazing on pasture land, with some smaller areas of crop production on arable land downstream of the AFA.*
Option Scoring		
Total Option Score	-1	*Downstream of the storage area flood waters are reduced to 50% AEP flows and kept inchannel. However the storage areas themselves represent an increase in flooded agricultural land.*
Weighted Option Score	**-36**	*Global weighting x Local weighting x Total option score*

Economic Score	721

Multi-Criteria Analysis Summary

Ballyhale Option 1

3. Social Criteria

Objective 3.A (i)	Minimise risk to human health and life - Residents	
Assigned Weightings		
Global Weighting	27.0	*Nationally Constant Value*
Local Weighting	5.9	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.3	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	5	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**642**	*Global weighting x Local weighting x Total option score*

Objective 3.A (ii)	Minimise risk to human health and life - High vulnerability properties	
Assigned Weightings		
Global Weighting	17.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	1.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	0.0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 3.B (i)	Minimise risk to community - Social Infrastructure and Amenity	
Assigned Weightings		
Global Weighting	9.0	*Nationally Constant Value*
Local Weighting	25.1	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.3	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Enhancement or Creation of Social Amenity Sites	0.0	*Adjustment in relation to the Enhancement or creation of social amenity sites (Structural Option)*
Total Option Score	4.9	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**222**	*Global weighting x Local weighting x Total option score*

Objective 3.B (ii)	Minimise risk to community - Local Employment	
Assigned Weightings		
Global Weighting	7.0	*Nationally Constant Value*
Local Weighting	7.8	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.2	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	4.9	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**172**	*Global weighting x Local weighting x Total option score*

Social Score	1036

Multi-Criteria Analysis Summary

Ballyhale Option 1

4. Environmental Criteria

Objective 4.A	Support the objectives of the WFD	
Assigned Weightings		
Global Weighting	16.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Total Option Score	-2	*Construction phase impacts of small upstream storage on rough grazing land and creation of walls and embankments set back from non-sensitive waterbody, upstream of sensitive waterbody. In stream and on bank works. Upstream storage only operational in flood conditions.*
Weighted Option Score	**-160**	*Global weighting x Local weighting x Total option score*

Objective 4.B	Support the objectives of the Habitats and Birds Directives	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	5.0	*The River Barrow and River Nore SAC is within and downstream of Ballyhale. The River Nore SPA is over 6km downstream of the AFA. The Thomastown Quarry SAC is over 7km north east of Ballyhale, but is not hydraulically linked to the AFA. Hugginstown Fen SAC is over 3km upcatchment of the AFA to the south.*
Option Scoring		
Total Option Score	-1	*Potential for direct construction phase impacts from construction of walls and embankments adjacent to and upstream of SAC. Potential for indirect impacts to SAC from sedimentation during construction. Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice. Embankments and walls should be set back from watercourse as far as possible.*
Weighted Option Score	**-50**	*Global weighting x Local weighting x Total option score*

Objective 4.C	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	
Assigned Weightings		
Global Weighting	5.0	*Nationally Constant Value*
Local Weighting	3.0	*The AFA is within the Nore Lower FPM sensitive area. The Thomastown pNHA is over 6km downstream of the AFA. Hugginstown Fen pNHA and Kilkeasy Bog pNHA are over 3km upcatchment of the AFA to the south.*
Option Scoring		
Total Option Score	-1.0	*Potential for indirect impacts within Nore Freshwater Pearl Mussel sensitive area from sedimentation during construction. Direct localised loss and disturbance to flora and fauna in footprint of works. No impacts to national, regional or local designations. Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-15**	*Global weighting x Local weighting x Total option score*

Objective 4.D	Protect and where possible enhance fisheries resource within the catchment (Inland Fisheries Only)	
Assigned Weightings		
Global Weighting	13.0	*Nationally Constant Value*
Local Weighting	4.0	*The AFA is off the Little Arrigal River, which is a tributary of the River Nore designated salmonid river. Trout fishing on the river downstream of the AFA, including one fish farm off the Little Arrigal River.*
Option Scoring		
Total Option Score	-1.0	*Slight potential for indirect impacts to downstream River Nore fisheries and local fishing from sedimentation during construction. Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-52**	*Global weighting x Local weighting x Total option score*

Objective 4.E	Protect, and where possible enhance, landscape character and visual amenity within the zone of influence	
Assigned Weightings		
Global Weighting	8.0	*Nationally Constant Value*
Local Weighting	1.0	*The Kilkenny CDP 2008-2014 LAP demonstrates that Ballyhale is within the south western hills landscape area. The AFA is at the foot of hills with no specific landscape sensitivity. There may however be local views of importance.*
Option Scoring		
Total Option Score	-1.0	*Construction phase and permanent impacts on local views from those to be protected. Creation of hard defences prior to establishment of screening.*
Weighted Option Score	**-8**	*Global weighting x Local weighting x Total option score*

Objective 4.F (i)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	2.0	*There are 10 NIAH buildings within the AFA of regional importance, a few of which are in close proximity to the river.*
Option Scoring		
Total Option Score	1.0	*Potential for impacts to the setting of 2 NIAH structures from construction of hard defences. Increased protection from flooding to several NIAH structures.*
Weighted Option Score	**8**	*Global weighting x Local weighting x Total option score*

Objective 4.F (ii)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	2.0	*There are 6 monuments within the AFA, however all are of low vulnerability to flooding and none are in state care or have preservation orders.*
Option Scoring		
Total Option Score	0.0	*No effects on archaeological features.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Environmental Score	-277

Option Appraisal and the Multi-Criteria Analysis

Name of modeller	**Emma Holland**
Name of assessor	**Emma Holland**
Date of Assessment	**19/01/2016**
Option ID	**Option 2**
Option Type	Structural Option
Option Location	Ballyhale
Option Details	Hard Defences
AEP	1.0%
Option Cost	€1,712,078.00
Economic Benefit	€4,116,936.00

Multi-Criteria Analysis Summary

Ballyhale Option 2

1. Technical Criteria

Objective 1.A	Ensure flood risk management options are operationally robust	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Level of risk score	5	*No reliance on systems or intervention, with limited monitoring / maintenance requirements*
Adjustment	No adjustment	*The level of risk score has not been adjusted*
Total Option Score	5.0	*Option score + adjustment*
Weighted Option Score	**500**	*Global weighting x Local weighting x Total option score*

Objective 1.B	Minimise health and safety risk in construction, maintenance and operation of the flood risk management option	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Option Score	2.0	*The following hazards have been identified: working near water (construction), working with heavy plant machinery, working near water (O&M)*
Adjustment	0.0	*There have been no adjustments made to the option score*
Total Option Score	2.0	*Option score + adjustment*
Weighted Option Score	**200**	*Global weighting x Local weighting x Total option score*

Objective 1.C	Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Adaptability Score	3	*Option is adaptable at moderate cost*
Adjustment	No adjustment	*The adaptability score has not been adjusted*
Total Option Score	3.0	*Option score + adjustment*
Weighted Option Score	**300**	*Global weighting x Local weighting x Total option score*

Technical Score	1000

Multi-Criteria Analysis Summary

Ballyhale Option 2

2. Economic Criteria

Objective 2.A	Reduce economic damages	
Assigned Weightings		
Global Weighting	24.0	*Nationally Constant Value*
Local Weighting	4.6	*AAD for the SSA / €75,000*
AAD for the SSA	€ 344,466.19	*Baseline Scenario*
Option Scoring		
Reduced AAD	€ 23,907.56	*Defended Scenario*
Total Option Score	4.7	*0.05 X Percentage Reduction in AAD*
Weighted Option Score	**513**	*Global weighting x Local weighting x Total option score*

Objective 2.B	Minimise risk to transport infrastructure	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	12.5	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	0.3	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.9	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the option score*
Total Option Score	4.9	*Option score + adjustment*
Weighted Option Score	**245**	*Global weighting x Local weighting x Total option score*

Objective 2.C	Minimise risk to utility infrastructure	
Assigned Weightings		
Global Weighting	14.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	1.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	0.0	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	0.0	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the total option score*
Total Option Score	0.0	*Option score + adjustment*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 2.D	Manage risk to agriculture	
Assigned Weightings		
Global Weighting	12.0	*Nationally Constant Value*
Local Weighting	3.0	*Agricultural activity in the area is mainly grazing on pasture land, with some smaller areas of crop production on arable land downstream of the AFA.*
Option Scoring		
Total Option Score	3	*Reduction in the amount of agricultural land flooded with option in place*
Weighted Option Score	**108**	*Global weighting x Local weighting x Total option score*

Economic Score	865

Multi-Criteria Analysis Summary

Ballyhale Option 2

3. Social Criteria

Objective 3.A (i)	Minimise risk to human health and life - Residents	
Assigned Weightings		
Global Weighting	27.0	*Nationally Constant Value*
Local Weighting	5.9	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.3	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	5	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**642**	*Global weighting x Local weighting x Total option score*

Objective 3.A (ii)	Minimise risk to human health and life - High vulnerability properties	
Assigned Weightings		
Global Weighting	17.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	1.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	0.0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 3.B (i)	Minimise risk to community - Social Infrastructure and Amenity	
Assigned Weightings		
Global Weighting	9.0	*Nationally Constant Value*
Local Weighting	25.1	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.3	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Enhancement or Creation of Social Amenity Sites	0.0	*Adjustment in relation to the Enhancement or creation of social amenity sites (Structural Option)*
Total Option Score	4.9	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**222**	*Global weighting x Local weighting x Total option score*

Objective 3.B (ii)	Minimise risk to community - Local Employment	
Assigned Weightings		
Global Weighting	7.0	*Nationally Constant Value*
Local Weighting	7.8	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.2	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	4.9	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**172**	*Global weighting x Local weighting x Total option score*

Social Score	1036

Multi-Criteria Analysis Summary

Ballyhale Option 2

4. Environmental Criteria

Objective 4.A	Support the objectives of the WFD	
Assigned Weightings		
Global Weighting	16.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Total Option Score	-2	*Construction phase impacts from creation of walls and embankments set back from non-sensitive waterbody, upstream of sensitive waterbody. In stream and on bank works.*
Weighted Option Score	**-160**	*Global weighting x Local weighting x Total option score*

Objective 4.B	Support the objectives of the Habitats and Birds Directives	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	5.0	*The River Barrow and River Nore SAC is within and downstream of Ballyhale. The River Nore SPA is over 6km downstream of the AFA. The Thomastown Quarry SAC is over 7km north east of Ballyhale, but is not hydraulically linked to the AFA. Hugginstown Fen SAC is over 3km upcatchment of the AFA to the south.*
Option Scoring		
Total Option Score	-2	*Potential for direct construction phase impacts from construction of walls and embankments adjacent to and upstream of SAC. Potential for indirect impacts to SAC from sedimentation during construction. Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice. Embankments and walls should be set back from watercourse as far as possible.*
Weighted Option Score	**-100**	*Global weighting x Local weighting x Total option score*

Objective 4.C	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	
Assigned Weightings		
Global Weighting	5.0	*Nationally Constant Value*
Local Weighting	3.0	*The AFA is within the Nore Lower FPM sensitive area. The Thomastown pNHA is over 6km downstream of the AFA. Hugginstown Fen pNHA and Kilkeasy Bog pNHA are over 3km upcatchment of the AFA to the south.*
Option Scoring		
Total Option Score	-1.0	*Potential for indirect impacts within Nore Freshwater Pearl Mussel sensitive area from sedimentation during construction. Direct localised loss and disturbance to flora and fauna in footprint of works. No impacts to national, regional or local designations. Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-15**	*Global weighting x Local weighting x Total option score*

Objective 4.D	Protect and where possible enhance fisheries resource within the catchment (Inland Fisheries Only)	
Assigned Weightings		
Global Weighting	13.0	*Nationally Constant Value*
Local Weighting	4.0	*The AFA is off the Little Arrigal River, which is a tributary of the River Nore designated salmonid river. Trout fishing on the river downstream of the AFA, including one fish farm off the Little Arrigal River.*
Option Scoring		
Total Option Score	-1.0	*Slight potential for indirect impacts to downstream River Nore fisheries and local fishing from sedimentation during construction. Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-52**	*Global weighting x Local weighting x Total option score*

Objective 4.E	Protect, and where possible enhance, landscape character and visual amenity within the zone of influence	
Assigned Weightings		
Global Weighting	8.0	*Nationally Constant Value*
Local Weighting	1.0	*The Kilkenny CDP 2008-2014 LAP demonstrates that Ballyhale is within the south western hills landscape area. The AFA is at the foot of hills with no specific landscape sensitivity. There may however be local views of importance.*
Option Scoring		
Total Option Score	-1.0	*Construction phase and permanent impacts on local views from those to be protected. Creation of hard defences prior to establishment of screening.*
Weighted Option Score	**-8**	*Global weighting x Local weighting x Total option score*

Objective 4.F (i)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	2.0	*There are 10 NIAH buildings within the AFA of regional importance, a few of which are in close proximity to the river.*
Option Scoring		
Total Option Score	1.0	*Potential for impacts to the setting of 2 NIAH structures from construction of hard defences. Increased protection from flooding to several NIAH structures.*
Weighted Option Score	**8**	*Global weighting x Local weighting x Total option score*

Objective 4.F (ii)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	2.0	*There are 6 monuments within the AFA, however all are of low vulnerability to flooding and none are in state care or have preservation orders.*
Option Scoring		
Total Option Score	0.0	*No effects on archaeological features.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Environmental Score	-327

Option Appraisal and the Multi-Criteria Analysis

Name of modeller	**Emma Holland**
Name of assessor	**Emma Holland**
Date of Assessment	**19/01/2016**
Option ID	**Option 3**
Option Type	Structural Option
Option Location	Ballyhale
Option Details	Diversion of Flow and Hard Defences (Embankment)
AEP	1.0%
Option Cost	€433,818.00
Economic Benefit	€4,116,936.00

Multi-Criteria Analysis Summary

Ballyhale Option 3

1. Technical Criteria

Objective 1.A	Ensure flood risk management options are operationally robust	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Level of risk score	5	*No reliance on systems or intervention, with limited monitoring / maintenance requirements*
Adjustment	No adjustment	*The level of risk score has not been adjusted*
Total Option Score	5.0	*Option score + adjustment*
Weighted Option Score	**500**	*Global weighting x Local weighting x Total option score*

Objective 1.B	Minimise health and safety risk in construction, maintenance and operation of the flood risk management option	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Option Score	3.0	*The following hazards have been identified: working near water (O&M), working with heavy plant machinery*
Adjustment	0.0	*There have been no adjustments made to the option score*
Total Option Score	3.0	*Option score + adjustment*
Weighted Option Score	**300**	*Global weighting x Local weighting x Total option score*

Objective 1.C	Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Adaptability Score	3	*Option is adaptable at moderate cost*
Adjustment	1	*The diversion of flow element of the option would be more easily technically and economically to adapt*
Total Option Score	4.0	*Option score + adjustment*
Weighted Option Score	**400**	*Global weighting x Local weighting x Total option score*

Technical Score	1200

Multi-Criteria Analysis Summary

Ballyhale Option 3

2. Economic Criteria

Objective 2.A	Reduce economic damages	
Assigned Weightings		
Global Weighting	24.0	*Nationally Constant Value*
Local Weighting	4.6	*AAD for the SSA / €75,000*
AAD for the SSA	€ 344,466.19	*Baseline Scenario*
Option Scoring		
Reduced AAD	€ 23,907.56	*Defended Scenario*
Total Option Score	4.7	*0.05 X Percentage Reduction in AAD*
Weighted Option Score	**513**	*Global weighting x Local weighting x Total option score*

Objective 2.B	Minimise risk to transport infrastructure	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	12.5	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	0.3	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.9	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the option score*
Total Option Score	4.9	*Option score + adjustment*
Weighted Option Score	**245**	*Global weighting x Local weighting x Total option score*

Objective 2.C	Minimise risk to utility infrastructure	
Assigned Weightings		
Global Weighting	14.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	1.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	0.0	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	0.0	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the total option score*
Total Option Score	0.0	*Option score + adjustment*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 2.D	Manage risk to agriculture	
Assigned Weightings		
Global Weighting	12.0	*Nationally Constant Value*
Local Weighting	3.0	*Agricultural activity in the area is mainly grazing on pasture land, with some smaller areas of crop production on arable land downstream of the AFA.*
Option Scoring		
Total Option Score	3	*Reduction in the amount of agricultural land flooded with option in place*
Weighted Option Score	**108**	*Global weighting x Local weighting x Total option score*

Economic Score	865

Multi-Criteria Analysis Summary

Ballyhale Option 3

3. Social Criteria

Objective 3.A (i)	Minimise risk to human health and life - Residents	
Assigned Weightings		
Global Weighting	27.0	*Nationally Constant Value*
Local Weighting	5.9	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.3	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	5	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**642**	*Global weighting x Local weighting x Total option score*

Objective 3.A (ii)	Minimise risk to human health and life - High vulnerability properties	
Assigned Weightings		
Global Weighting	17.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	1.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	0.0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 3.B (i)	Minimise risk to community - Social Infrastructure and Amenity	
Assigned Weightings		
Global Weighting	9.0	*Nationally Constant Value*
Local Weighting	25.1	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.3	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Enhancement or Creation of Social Amenity Sites	0.0	*Adjustment in relation to the Enhancement or creation of social amenity sites (Structural Option)*
Total Option Score	4.9	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**222**	*Global weighting x Local weighting x Total option score*

Objective 3.B (ii)	Minimise risk to community - Local Employment	
Assigned Weightings		
Global Weighting	7.0	*Nationally Constant Value*
Local Weighting	7.8	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.2	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	4.9	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**172**	*Global weighting x Local weighting x Total option score*

Social Score	1036

Multi-Criteria Analysis Summary

Ballyhale Option 3

4. Environmental Criteria

Objective 4.A	Support the objectives of the WFD	
Assigned Weightings		
Global Weighting	16.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Total Option Score	-4	*Construction phase impacts from creation of embankment set back from non-sensitive waterbody. Short term construction and permanent impacts of flow diversion from trib of Little Arrigal River into the Little Arrigal River sensitive waterbody.*
Weighted Option Score	**-320**	*Global weighting x Local weighting x Total option score*

Objective 4.B	Support the objectives of the Habitats and Birds Directives	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	5.0	*The River Barrow and River Nore SAC is within and downstream of Ballyhale. The River Nore SPA is over 6km downstream of the AFA. The Thomastown Quarry SAC is over 7km north east of Ballyhale, but is not hydraulically linked to the AFA. Hugginstown Fen SAC is over 3km upcatchment of the AFA to the south.*
Option Scoring		
Total Option Score	-2	*Potential for direct temporary construction phase impacts from construction of flow diversion into SAC. Increased flow to Little Arrigal River during flood conditions. Some impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-100**	*Global weighting x Local weighting x Total option score*

Objective 4.C	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	
Assigned Weightings		
Global Weighting	5.0	*Nationally Constant Value*
Local Weighting	3.0	*The AFA is within the Nore Lower FPM sensitive area. The Thomastown pNHA is over 6km downstream of the AFA. Hugginstown Fen pNHA and Kilkeasy Bog pNHA are over 3km upcatchment of the AFA to the south.*
Option Scoring		
Total Option Score	-1.0	*Potential for indirect impacts within Nore Freshwater Pearl Mussel sensitive area from sedimentation during construction. Direct localised loss and disturbance to flora and fauna in footprint of works. No impacts to national, regional or local designations. Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-15**	*Global weighting x Local weighting x Total option score*

Objective 4.D	Protect and where possible enhance fisheries resource within the catchment (Inland Fisheries Only)	
Assigned Weightings		
Global Weighting	13.0	*Nationally Constant Value*
Local Weighting	4.0	*The AFA is off the Little Arrigal River, which is a tributary of the River Nore designated salmonid river. Trout fishing on the river downstream of the AFA, including one fish farm off the Little Arrigal River.*
Option Scoring		
Total Option Score	-1.0	*Slight potential for indirect impacts to downstream River Nore fisheries and local fishing from sedimentation during construction. Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-52**	*Global weighting x Local weighting x Total option score*

Objective 4.E	Protect, and where possible enhance, landscape character and visual amenity within the zone of influence	
Assigned Weightings		
Global Weighting	8.0	*Nationally Constant Value*
Local Weighting	1.0	*The Kilkenny CDP 2008-2014 LAP demonstrates that Ballyhale is within the south western hills landscape area. The AFA is at the foot of hills with no specific landscape sensitivity. There may however be local views of importance.*
Option Scoring		
Total Option Score	-1.0	*Construction phase and permanent impacts on local views from those to be protected. Creation of hard defences prior to establishment of screening.*
Weighted Option Score	**-8**	*Global weighting x Local weighting x Total option score*

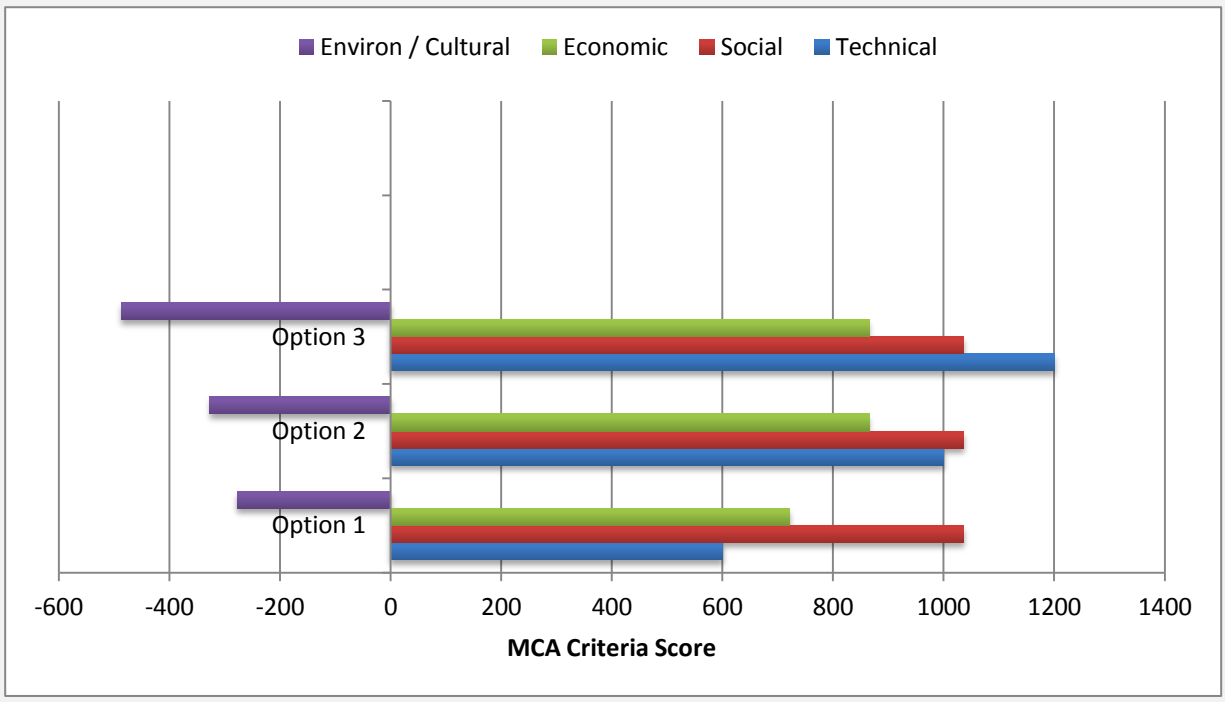
Objective 4.F (i)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	2.0	*There are 10 NIAH buildings within the AFA of regional importance, a few of which are in close proximity to the river.*
Option Scoring		
Total Option Score	1.0	*Potential for impacts to the setting of 2 NIAH structures from construction of hard defences. Increased protection from flooding to several NIAH structures.*
Weighted Option Score	**8**	*Global weighting x Local weighting x Total option score*

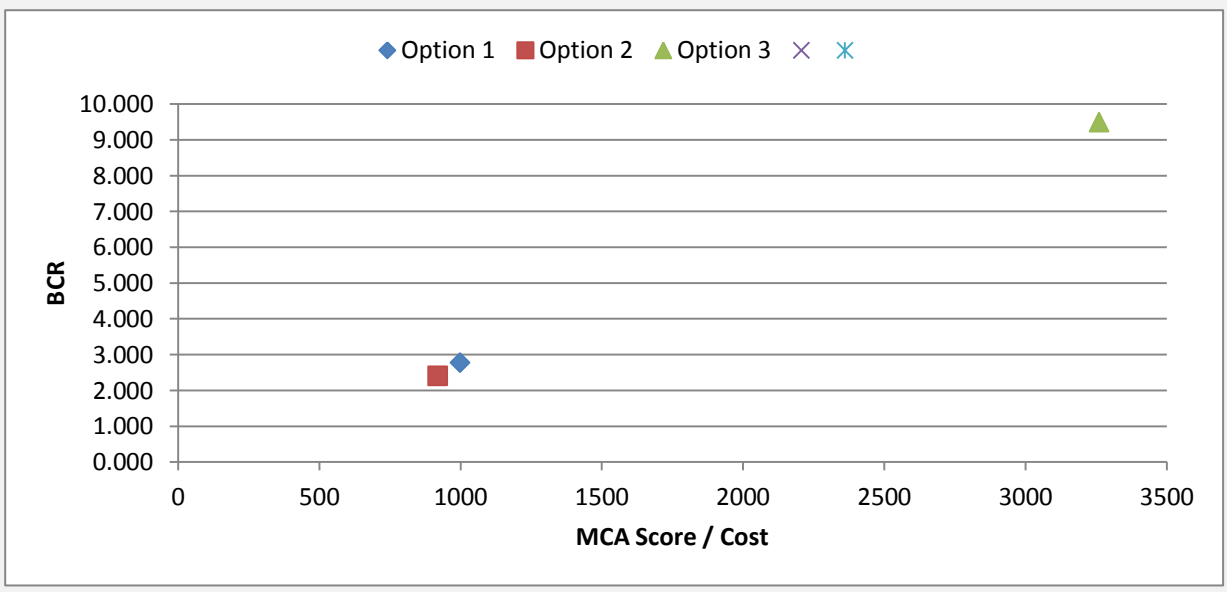
Objective 4.F (ii)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	2.0	*There are 6 monuments within the AFA, however all are of low vulnerability to flooding and none are in state care or have preservation orders.*
Option Scoring		
Total Option Score	0.0	*No effects on archaeological features.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Environmental Score	-487

Option Comparison
Ballyhale

Option No.	MCA Appraisal Scores				TOTAL - MCA Benefit Score	Cost (€millions)	MCA Score / Cost	BCR
	Technical	Social	Economic	Environ / Cultural				
Option 1	600	1036	721	-277	1481	1.483	998.341	2.776
Option 2	1000	1036	865	-327	1575	1.712	919.692	2.405
Option 3	1200	1036	865	-487	1415	0.434	3260.78	9.490





BALLYBOODAN
Baile Mhuadáin

Part of KNOCKTOPHER MANOR
Maínéar Chnoc an Tóchair (Cuid De)

BALLYHALE
Baile Héil

BALLYHALE
Baile Héil

KILCURL
(Ponsonby)
Cill Choirill
(Ponsonby)

KILTORCAN
Cill Toircáin

Storage 1

KNOCKWILLIAM
Cnoc Liam Gheancaigh

BALLYBRAY
Bealach Bréagán

COOLMEEN
An Chúil Mhín

Storage 3

0 0.25 0.5 1 Km

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Ballyhale - Option 1

- River Centreline
- AFA Boundary
- Residual Risk
- Existing Risk
- Hard Defences
- Upstream Storage

BALLYHALE
Baile Héil

BALLYHALE
Baile Héil

Brookfield

Hazelbrook

Ballyhale Bridge

Pond

ESB Station

Church (Cath)

School

Ballyhale

0 0.075 0.15 0.3 Km

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Ballyhale - Option 2

- River Centreline
- AFA Boundary
- Residual Risk
- Existing Risk
- Hard Defences
- River Centreline

BALLYHALE
Baile Héil

BALLYHALE
Baile Héil

Brookfield

Ballyhale Bridge

Hazelbrook

Ballyhale

School

Church (Cath)

GS Sta

10KV

UND

CR

0 0.075 0.15 0.3 Km

Ballyhale - Option 3

- River Centreline
- AFA Boundary
- Residual Risk
- Existing Risk
- Hard Defences
- Diversion of Flow

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Appendix B

Callan AFA
Additional Information

List of background information included:

1. Costings
- Option 1 – Whole Life Costs- Improvement of Channel Conveyance
- Option 2 – Whole Life Costs- Hard Defences

2. MCA
- Option 1 – Improvement of Channel Conveyance
- Option 2 - Hard Defences

3. Potential Option drawings
- Option 1 – Improvement of Channel Conveyance
- Option 2 - Hard Defences

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	**Emma Holland**	**Date:**	**15/12/2015**
Checked by:	**Mark Wilson**	**Date:**	**15/06/2016**

Project reference	IBE0601

Project name:	SE CFRAM Study_Callan_Option 1 - CC

Base date for estimates (year 0)	Oct-2013
Scaling factor (e.g. €m, €k, €)	€

Construction Price Index (CPI)	**1.000**
Method Factor - to take into account particular site issues /constraints	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		-

Capital costs	**Cost (€)**	**Comment**
Total wall costs		
Total embankment costs		
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs	€614,720.00	*19,200m^3 to be removed*
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs	€95,200.00	*40m^2 foot bridge bridge (clear span)*
Total bridge removal costs	€6,240.00	*40m^2 foot bridge bridge*
Total bridge underpinning costs	€237,410.00	*24m total underpinning length*
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€953,570	
Apply update to unit rate (CPI) if appropriate (cell N15)	€953,570	
Enter appropriate preliminaries estimate (%)	20%	
Sub Total	€1,144,284	
Optimism Bias	45%	*In channel*
Total capital cost (€)	€1,659,212	
Consider amendments based on site issues/constraints (cell N16)	€1,659,212	
Total capital cost (€)	€1,659,212	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs		
Total embankment O&M costs		
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs	€800.00	*Average cost used*
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€800	
NPV O&M	€17,073	
Optimism Bias	45%	*In channel*
NPV O&M with Optimism Bias	€24,756	

Other costs	**Cost (€)**	**Comment**
Other costs (design, supervision, archaeology, environment, site investigation, art)	€673,040	*Design and supervision (13%), Archaeology and environment (10%), Land (10%), Site investigation (€100,000), Art (€25,500)*

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€2,357,008	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€1,659,211.8
Annual maintenance cost (€)	€800.0
Other cost (€)	€673,039.9
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**	**Total PVc (€k):**		**1676285**
	Cash sum	0	1659212	39200	0	1698412	**1676285**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	1659212			1659211.8	1659211.8
1	0.961538			800		800.0	769.2
2	0.925			800		800.0	739.6
3	0.889			800		800.0	711.2
4	0.855			800		800.0	683.8
5	0.822			800		800.0	657.5
6	0.790			800		800.0	632.3
7	0.760			800		800.0	607.9
8	0.731			800		800.0	584.6
9	0.703			800		800.0	562.1
10	0.676			800		800.0	540.5
11	0.650			800		800.0	519.7
12	0.625			800		800.0	499.7
13	0.601			800		800.0	480.5
14	0.577			800		800.0	462.0
15	0.555			800		800.0	444.2
16	0.534			800		800.0	427.1
17	0.513			800		800.0	410.7
18	0.494			800		800.0	394.9
19	0.475			800		800.0	379.7
20	0.456			800		800.0	365.1
21	0.439			800		800.0	351.1
22	0.422			800		800.0	337.6
23	0.406			800		800.0	324.6
24	0.390			800		800.0	312.1
25	0.375			800		800.0	300.1
26	0.361			800		800.0	288.6
27	0.347			800		800.0	277.5
28	0.333			800		800.0	266.8
29	0.321			800		800.0	256.5
30	0.308			800		800.0	246.7
31	0.296			800		800.0	237.2
32	0.285			800		800.0	228.0
33	0.274			800		800.0	219.3
34	0.264			800		800.0	210.8
35	0.253			800		800.0	202.7
36	0.244			800		800.0	194.9
37	0.234			800		800.0	187.4
38	0.225			800		800.0	180.2
39	0.217			800		800.0	173.3
40	0.208			800		800.0	166.6
41	0.200			800		800.0	160.2
42	0.193			800		800.0	154.1
43	0.185			800		800.0	148.1
44	0.178			800		800.0	142.4
45	0.171			800		800.0	137.0
46	0.165			800		800.0	131.7
47	0.158			800		800.0	126.6
48	0.152			800		800.0	121.8
49	0.146			800		800.0	117.1

17073.2

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	**Emma Holland**	**Date:**	**15/12/2015**
Checked by:	**Mark Wilson**	**Date:**	**15/12/2015**

Project reference	IBE0601	**Project name:**	SE CFRAM Study_Callan_Option 2

Base date for estimates (year 0)	Oct-2013	**Construction Price Index (CPI)**	**1.000**
Scaling factor (e.g. €m, €k, €)	€	**Method Factor - to take into account particular site issues /constraints**	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		-

Capital costs	**Cost (€)**	**Comment**
Total wall costs	€840,769.00	
Total embankment costs	€129,135.00	
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs	€8,400.00	
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€978,304	
Apply update to unit rate (CPI) if appropriate (cell N15)	€978,304	
Enter appropriate preliminaries estimate (%)	20%	
Sub Total	€1,173,965	
Optimism Bias	41%	
Total capital cost (€)	€1,655,290	
Consider amendments based on site issues/constraints (cell N16)	€1,655,290	
Total capital cost (€)	€1,655,290	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs	€177.00	
Total embankment O&M costs	€931.00	
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs	€168.00	
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€1,276	
NPV O&M	€27,232	
Optimism Bias	41%	
NPV O&M with Optimism Bias	€38,397	

Other costs	**Cost (€)**	**Comment**
Other costs (design, supervision, archaeology, environment, site investigation, art)	€671,746	*Design and supervision (13%), Archaeology and environment (10%), Land (10%), Site investigation (€100,000), Art (€25,500)*

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€2,365,433	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€1,655,290.4
Annual maintenance cost (€)	€1,276.0
Other cost (€)	€671,745.8
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**	**Total PVc (€k):**		**1682522**
	Cash sum	0	1655290	62524	0	1717814	**1682522**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	1655290			1655290.4	1655290.4
1	0.961538			1276		1276.0	1226.9
2	0.925			1276		1276.0	1179.7
3	0.889			1276		1276.0	1134.4
4	0.855			1276		1276.0	1090.7
5	0.822			1276		1276.0	1048.8
6	0.790			1276		1276.0	1008.4
7	0.760			1276		1276.0	969.7
8	0.731			1276		1276.0	932.4
9	0.703			1276		1276.0	896.5
10	0.676			1276		1276.0	862.0
11	0.650			1276		1276.0	828.9
12	0.625			1276		1276.0	797.0
13	0.601			1276		1276.0	766.3
14	0.577			1276		1276.0	736.9
15	0.555			1276		1276.0	708.5
16	0.534			1276		1276.0	681.3
17	0.513			1276		1276.0	655.1
18	0.494			1276		1276.0	629.9
19	0.475			1276		1276.0	605.6
20	0.456			1276		1276.0	582.3
21	0.439			1276		1276.0	560.0
22	0.422			1276		1276.0	538.4
23	0.406			1276		1276.0	517.7
24	0.390			1276		1276.0	497.8
25	0.375			1276		1276.0	478.6
26	0.361			1276		1276.0	460.2
27	0.347			1276		1276.0	442.5
28	0.333			1276		1276.0	425.5
29	0.321			1276		1276.0	409.2
30	0.308			1276		1276.0	393.4
31	0.296			1276		1276.0	378.3
32	0.285			1276		1276.0	363.7
33	0.274			1276		1276.0	349.7
34	0.264			1276		1276.0	336.3
35	0.253			1276		1276.0	323.4
36	0.244			1276		1276.0	310.9
37	0.234			1276		1276.0	299.0
38	0.225			1276		1276.0	287.5
39	0.217			1276		1276.0	276.4
40	0.208			1276		1276.0	265.8
41	0.200			1276		1276.0	255.6
42	0.193			1276		1276.0	245.7
43	0.185			1276		1276.0	236.3
44	0.178			1276		1276.0	227.2
45	0.171			1276		1276.0	218.4
46	0.165			1276		1276.0	210.0
47	0.158			1276		1276.0	202.0
48	0.152			1276		1276.0	194.2
49	0.146			1276		1276.0	186.7
							27231.7

Option Appraisal and the Multi-Criteria Analysis

Name of modeller	**Emma Holland**
Name of assessor	**Emma Holland**
Date of Assessment	**14/06/2014**
Option ID	**Option 1**
Option Type	Structural Option
Option Location	Callan
Option Details	Improvement of Channel Conveyance
AEP	1.0%
Option Cost	€2,357,008.00
Economic Benefit	€1,808,579.00

Multi-Criteria Analysis Summary

Callan Option 1

1. Technical Criteria

Objective 1.A	Ensure flood risk management options are operationally robust	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Level of risk score	4	*No reliance on systems or intervention, with more regular monitoring and intermittent, but potentially substantial, maintenance requirements*
Adjustment	No adjustment	*The level of risk score has not been adjusted*
Total Option Score	4.0	*Option score + adjustment*
Weighted Option Score	**400**	*Global weighting x Local weighting x Total option score*

Objective 1.B	Minimise health and safety risk in construction, maintenance and operation of the flood risk management option	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Option Score	2.0	*The following hazards have been identified: working near water (construction), working with heavy plant machinery, working near water (O&M)*
Adjustment	0.0	*There have been no adjustments made to the option score*
Total Option Score	2.0	*Option score + adjustment*
Weighted Option Score	**200**	*Global weighting x Local weighting x Total option score*

Objective 1.C	Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Adaptability Score	2	*Option is adaptable at moderate to significant cost*
Adjustment	No adjustment	*The adaptability score has not been adjusted*
Total Option Score	2.0	*Option score + adjustment*
Weighted Option Score	**200**	*Global weighting x Local weighting x Total option score*

Technical Score	800

Multi-Criteria Analysis Summary

Callan Option 1

2. Economic Criteria

Objective 2.A	Reduce economic damages	
Assigned Weightings		
Global Weighting	24.0	*Nationally Constant Value*
Local Weighting	2.3	*AAD for the SSA / €75,000*
AAD for the SSA	€ 172,378.26	*Baseline Scenario*
Option Scoring		
Reduced AAD	€ 36,536.08	*Defended Scenario*
Total Option Score	3.9	*0.05 X Percentage Reduction in AAD*
Weighted Option Score	**217**	*Global weighting x Local weighting x Total option score*

Objective 2.B	Minimise risk to transport infrastructure	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	5.4	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	0.3	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.7	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the option score*
Total Option Score	4.7	*Option score + adjustment*
Weighted Option Score	**235**	*Global weighting x Local weighting x Total option score*

Objective 2.C	Minimise risk to utility infrastructure	
Assigned Weightings		
Global Weighting	14.0	*Nationally Constant Value*
Local Weighting	50.0	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	1.3	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.9	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the total option score*
Total Option Score	4.9	*Option score + adjustment*
Weighted Option Score	**341**	*Global weighting x Local weighting x Total option score*

Objective 2.D	Manage risk to agriculture	
Assigned Weightings		
Global Weighting	12.0	*Nationally Constant Value*
Local Weighting	4.0	*Although most of the Callan AFA is urbanised the surrounding lands are in pasture and arable land. Fertile soils from Goresbridge to Callan (central plain) have marked this area as the 'golden vein' of the County.*
Option Scoring		
Total Option Score	2	*Reduction is the area of agricultural land flooded during a 1%AEP fluvial event*
Weighted Option Score	**96**	*Global weighting x Local weighting x Total option score*

Economic Score	889

Multi-Criteria Analysis Summary

Callan Option 1

3. Social Criteria

Objective 3.A (i)	Minimise risk to human health and life - Residents	
Assigned Weightings		
Global Weighting	27.0	*Nationally Constant Value*
Local Weighting	1.6	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No adjustment*
Capped Local Weighting	1.6	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.4	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	4	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**157**	*Global weighting x Local weighting x Total option score*

Objective 3.A (ii)	Minimise risk to human health and life - High vulnerability properties	
Assigned Weightings		
Global Weighting	17.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	1.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	0.0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 3.B (i)	Minimise risk to community - Social Infrastructure and Amenity	
Assigned Weightings		
Global Weighting	9.0	*Nationally Constant Value*
Local Weighting	40.1	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	2.2	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Enhancement or Creation of Social Amenity Sites	0.0	*Adjustment in relation to the Enhancement or creation of social amenity sites (Structural Option)*
Total Option Score	4.7	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**213**	*Global weighting x Local weighting x Total option score*

Objective 3.B (ii)	Minimise risk to community - Local Employment	
Assigned Weightings		
Global Weighting	7.0	*Nationally Constant Value*
Local Weighting	7.3	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.8	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	4.4	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**155**	*Global weighting x Local weighting x Total option score*

Social Score	524

Multi-Criteria Analysis Summary

Callan Option 1

4. Environmental Criteria

Objective 4.A	Support the objectives of the WFD	
Assigned Weightings		
Global Weighting	16.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Total Option Score	-4	*Improvement of channel conveyance in a sensitive waterbody. Potential for permanent morphological impacts. Potential for recurring impacts. Increased protection from flooding to Callan waste water treatment works.*
Weighted Option Score	**-320**	*Global weighting x Local weighting x Total option score*

Objective 4.B	Support the objectives of the Habitats and Birds Directives	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	5.0	*The River Barrow and River Nore SAC and the River Nore SPA are within, downstream of and upstream of Callan. The Lower River Suir SAC is over 9km south west of Callan, however is not hydraulically linked to the AFA.*
Option Scoring		
Total Option Score	-5	*Improvement of channel conveyance within SAC. Potential for direct loss of habitat and displacement of species during construction works, which may re-establish and return following works. Likely indirect sedimentation impacts downstream to SAC, SPA and Nore Lower FPM sensitive area during works. Increased flows through town and potential increased sedimentation downstream. Potential hydrological changes to riparian habitats at Callan. Potential for some mitigation for impacts with good site practices and timing of works.*
Weighted Option Score	**-250**	*Global weighting x Local weighting x Total option score*

Objective 4.C	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	
Assigned Weightings		
Global Weighting	5.0	*Nationally Constant Value*
Local Weighting	4.0	*The AFA is within the Nore Lower FPM sensitive area. The Kyleadohir Nature Reserve and pNHA is 6km upstream of the AFA. The Ballykeefe Wood Nature Reserve and pNHA is over 6km upcatchment of the AFA to the north. Garryrickin Nature Reserve and pNHA is over 4km upcatchment of the AFA to the south. The Mount Juliet pNHA is over 12km downstream of the AFA.*
Option Scoring		
Total Option Score	-3.0	*Potential for direct, local loss of habitat and displacement of species during construction works, which may re-establish and return following works. Likely indirect sedimentation impacts downstream to Nore Lower FPM sensitive area during works. Increased flows through town and potential increased sedimentation downstream. Potential for some mitigation for impacts with good site practices and timing of works.*
Weighted Option Score	**-60**	*Global weighting x Local weighting x Total option score*

Objective 4.D	Protect and where possible enhance fisheries resource within the catchment (Inland Fisheries Only)	
Assigned Weightings		
Global Weighting	13.0	*Nationally Constant Value*
Local Weighting	2.0	*Low fishing potential in Callan itself, however downstream the Nore and Kings River are known for good stocks of brown trout. The best of the fishing on the main channel of the Nore is upstream of Thomastown and on the Kings River.*
Option Scoring		
Total Option Score	-4.0	*Improvement of channel conveyance upstream of sensitive fisheries habitat. In channel direct dredging impacts and indirect downstream sedimentation impacts. Increased flows through town and potential increased sedimentation downstream. Increased protection from flooding to Callan waste water treatment works.*
Weighted Option Score	**-104**	*Global weighting x Local weighting x Total option score*

Objective 4.E	Protect, and where possible enhance, landscape character and visual amenity within the zone of influence	
Assigned Weightings		
Global Weighting	8.0	*Nationally Constant Value*
Local Weighting	2.0	*In the landscape appraisal for County Kilkenny, as part of Kilkenny County Development Plan 2008 - 2014, Callan is within the Kilkenny western basin, with no specific landscape protection. The views west into Co. Tipperary from the Callan/Clonmel Road N.76 are to be protected. River banks are classified as vulnerable in the appraisal*
Option Scoring		
Total Option Score	0.0	*Short term construction phase impacts from dredging and underpinning works on local views of river. No impacts on the wider landscape.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 4.F (i)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	4.0	*There are 80 NIAH buildings of national and regional importance within the AFA. Several of these structures are within close proximity to the Kings River in the town. Callan is regarded as being a historic town.*
Option Scoring		
Total Option Score	0.0	*Potential for physical impacts to NIAH bridges, Callan Bridge and the footbridge, during underpinning works. Increased protection from flooding for several NIAH buildings in Callan.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 4.F (ii)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	4.0	*There are 3 monuments in state care within the AFA, however all are of low vulnerability to flooding. Callan is regarded as being a historic town. There are 22 other monuments in the town, all of which are of low vulnerability to flooding.*
Option Scoring		
Total Option Score	1.0	*Increased protection to several monuments (water mills and a well) in Callan. Monuments are not in state care and have no preservation orders.*
Weighted Option Score	**16**	*Global weighting x Local weighting x Total option score*

Environmental Score	-718

Option Appraisal and the Multi-Criteria Analysis

Name of modeller	**Emma Holland**
Name of assessor	**Emma Holland**
Date of Assessment	**19/01/2016**
Option ID	**Option 2**
Option Type	Structural Option
Option Location	Callan
Option Details	Hard Defences
AEP	1.0%
Option Cost	€2,365,433.00
Economic Benefit	€1,808,579.00

Multi-Criteria Analysis Summary

Callan Option 2

1. Technical Criteria

Objective 1.A	Ensure flood risk management options are operationally robust	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Level of risk score	4	*No reliance on systems or intervention, with more regular monitoring and intermittent, but potentially substantial, maintenance requirements*
Adjustment	No adjustment	*The level of risk score has not been adjusted*
Total Option Score	4.0	*Option score + adjustment*
Weighted Option Score	**400**	*Global weighting x Local weighting x Total option score*

Objective 1.B	Minimise health and safety risk in construction, maintenance and operation of the flood risk management option	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Option Score	2.0	*The following hazards have been identified: working near water (construction), working with heavy plant machinery, working near water (O&M)*
Adjustment	0.0	*There have been no adjustments made to the option score*
Total Option Score	2.0	*Option score + adjustment*
Weighted Option Score	**200**	*Global weighting x Local weighting x Total option score*

Objective 1.C	Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Adaptability Score	3	*Option is adaptable at moderate cost*
Adjustment	No adjustment	*The adaptability score has not been adjusted*
Total Option Score	3.0	*Option score + adjustment*
Weighted Option Score	**300**	*Global weighting x Local weighting x Total option score*

Technical Score	900

Multi-Criteria Analysis Summary

Callan Option 2

2. Economic Criteria

Objective 2.A	Reduce economic damages	
Assigned Weightings		
Global Weighting	24.0	*Nationally Constant Value*
Local Weighting	2.3	*AAD for the SSA / €75,000*
AAD for the SSA	€ 172,378.26	*Baseline Scenario*
Option Scoring		
Reduced AAD	€ 36,536.08	*Defended Scenario*
Total Option Score	3.9	*0.05 X Percentage Reduction in AAD*
Weighted Option Score	**217**	*Global weighting x Local weighting x Total option score*

Objective 2.B	Minimise risk to transport infrastructure	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	5.4	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	0.3	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.7	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the option score*
Total Option Score	4.7	*Option score + adjustment*
Weighted Option Score	**235**	*Global weighting x Local weighting x Total option score*

Objective 2.C	Minimise risk to utility infrastructure	
Assigned Weightings		
Global Weighting	14.0	*Nationally Constant Value*
Local Weighting	50.0	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	1.3	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.9	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the total option score*
Total Option Score	4.9	*Option score + adjustment*
Weighted Option Score	**341**	*Global weighting x Local weighting x Total option score*

Objective 2.D	Manage risk to agriculture	
Assigned Weightings		
Global Weighting	12.0	*Nationally Constant Value*
Local Weighting	4.0	*Although most of the Callan AFA is urbanised the surrounding lands are in pasture and arable land. Fertile soils from Goresbridge to Callan (central plain) have marked this area as the 'golden vein' of the County.*
Option Scoring		
Total Option Score	0	*No significant reduction in area of flooded agricultural land*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Economic Score	793

Multi-Criteria Analysis Summary

Callan Option 2

3. Social Criteria

Objective 3.A (i)	Minimise risk to human health and life - Residents	
Assigned Weightings		
Global Weighting	27.0	*Nationally Constant Value*
Local Weighting	1.6	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No adjustment*
Capped Local Weighting	1.6	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.4	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	4	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**157**	*Global weighting x Local weighting x Total option score*

Objective 3.A (ii)	Minimise risk to human health and life - High vulnerability properties	
Assigned Weightings		
Global Weighting	17.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	1.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	0.0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 3.B (i)	Minimise risk to community - Social Infrastructure and Amenity	
Assigned Weightings		
Global Weighting	9.0	*Nationally Constant Value*
Local Weighting	40.1	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	2.2	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Enhancement or Creation of Social Amenity Sites	0.0	*Adjustment in relation to the Enhancement or creation of social amenity sites (Structural Option)*
Total Option Score	4.7	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**213**	*Global weighting x Local weighting x Total option score*

Objective 3.B (ii)	Minimise risk to community - Local Employment	
Assigned Weightings		
Global Weighting	7.0	*Nationally Constant Value*
Local Weighting	7.3	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.8	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	4.4	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**155**	*Global weighting x Local weighting x Total option score*

Social Score	524

Multi-Criteria Analysis Summary

Callan Option 2

4. Environmental Criteria

Objective 4.A	Support the objectives of the WFD	
Assigned Weightings		
Global Weighting	16.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Total Option Score	0	*Creation of walls and embankments, mostly set back from sensitive waterbody. Temporary construction phase impacts from in-stream and on-bank works. Potential for excavation and restoration of banks. Increased protection from flooding to Callan waste water treatment works.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 4.B	Support the objectives of the Habitats and Birds Directives	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	5.0	*The River Barrow and River Nore SAC and the River Nore SPA are within, downstream of and upstream of Callan. The Lower River Suir SAC is over 9km south west of Callan, however is not hydraulically linked to the AFA.*
Option Scoring		
Total Option Score	-1	*Creation of walls and embankments, set back from SAC and SPA boundaries. Slight potential for some direct localised loss of habitat and displacement of species during construction works, which may re-establish and return following works. Slight potential for indirect sedimentation impacts downstream to SAC, SPA and Nore Lower FPM sensitive area during works. Potential for mitigation for impacts with good site practices and timing of works.*
Weighted Option Score	**-50**	*Global weighting x Local weighting x Total option score*

Objective 4.C	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	
Assigned Weightings		
Global Weighting	5.0	*Nationally Constant Value*
Local Weighting	4.0	*The AFA is within the Nore Lower FPM sensitive area. The Kyleadohir Nature Reserve and pNHA is 6km upstream of the AFA. The Ballykeefe Wood Nature Reserve and pNHA is over 6km upcatchment of the AFA to the north. Garryrickin Nature Reserve and pNHA is over 4km upcatchment of the AFA to the south. The Mount Juliet pNHA is over 12km downstream of the AFA.*
Option Scoring		
Total Option Score	-1.0	*Creation of walls and embankments, set back from Kings River. Slight potential for some direct localised loss of habitat and displacement of species during construction works, which may re-establish and return following works. Slight potential for indirect sedimentation impacts downstream to Nore Lower FPM sensitive area during works. Potential for mitigation for impacts with good site practices and timing of works.*
Weighted Option Score	**-20**	*Global weighting x Local weighting x Total option score*

Objective 4.D	Protect and where possible enhance fisheries resource within the catchment (Inland Fisheries Only)	
Assigned Weightings		
Global Weighting	13.0	*Nationally Constant Value*
Local Weighting	2.0	*Low fishing potential in Callan itself, however downstream the Nore and Kings River are known for good stocks of brown trout. The best of the fishing on the main channel of the Nore is upstream of Thomastown and on the Kings River.*
Option Scoring		
Total Option Score	-1.0	*Construction phase impacts adjacent to sensitive waterbody. Potential for some in-stream and on-bank works. Increased protection from flooding to Callan waste water treatment works.*
Weighted Option Score	**-26**	*Global weighting x Local weighting x Total option score*

Objective 4.E	Protect, and where possible enhance, landscape character and visual amenity within the zone of influence	
Assigned Weightings		
Global Weighting	8.0	*Nationally Constant Value*
Local Weighting	2.0	*In the landscape appraisal for County Kilkenny, as part of Kilkenny County Development Plan 2008 - 2014, Callan is within the Kilkenny western basin, with no specific landscape protection. The views west into Co. Tipperary from the Callan/Clonmel Road N.76 are to be protected. River banks are classified as vulnerable in the appraisal*
Option Scoring		
Total Option Score	-1.0	*Construction of local flood embankments prior to the establishment of screening. Some local, permanent impacts on views from properties to be protected.*
Weighted Option Score	**-16**	*Global weighting x Local weighting x Total option score*

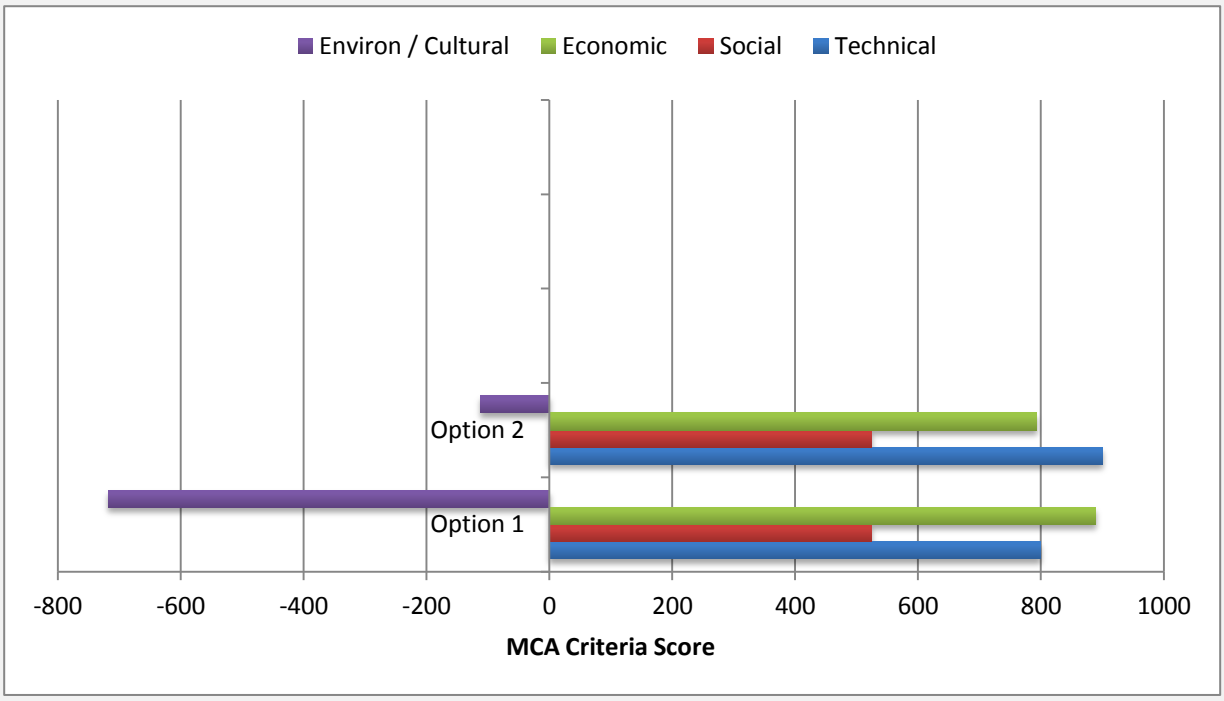
Objective 4.F (i)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	4.0	*There are 80 NIAH buildings of national and regional importance within the AFA. Several of these structures are within close proximity to the Kings River in the town. Callan is regarded as being a historic town.*
Option Scoring		
Total Option Score	0.0	*Potential for impacts on the setting of NIAH bridges from creation of hard defences. Increased protection from flooding for several NIAH buildings in Callan.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

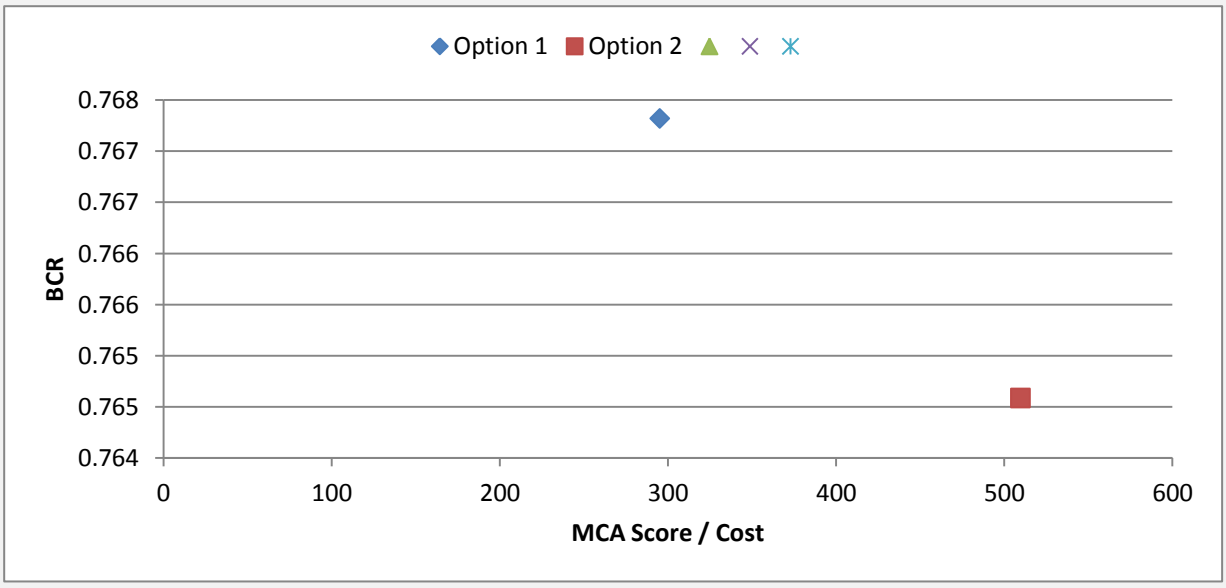
Objective 4.F (ii)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	4.0	*There are 3 monuments in state care within the AFA, however all are of low vulnerability to flooding. Callan is regarded as being a historic town. There are 22 other monuments in the town, all of which are of low vulnerability to flooding.*
Option Scoring		
Total Option Score	0.0	*No effects on archaeological features.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Environmental Score	-112

Option Comparison
Callan

Option No.	MCA Appraisal Scores				TOTAL - MCA Benefit Score	Cost (€millions)	MCA Score / Cost	BCR
	Technical	Social	Economic	Environ / Cultural				
Option 1	800	524	889	-718	696	2.357	295.158	0.767
Option 2	900	524	793	-112	1206	2.365	509.712	0.765





CALLAN SOUTH
Callainn Theas

TINNAMOONA
Tigh na Móna

MINN[illegible]
Na Mionnáin

Bridge Replacement

Callan - Option 1

- River Centreline
- AFA Boundary
- Residual Risk
- Existing Risk
- Existing Defences
- Improvement of Channel Conveyance

0 0.1 0.2 0.4 Km

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CALLAN NORTH
Callainn Thuaidh

CALLAN SOUTH
Callainn Theas

TINNAMOONA
Tigh na Mona

Callan - Option 2

- River Centreline
- AFA Boundary
- Residual Risk
- Existing Risk
- Hard Defences

0 0.1 0.2 0.4 Km

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Appendix C

Freshford AFA
Additional Information

List of background information included:

1. Costings
- Option 1 – PVc summary of Whole Life Cost
- Option 2 – PVc summary of Whole Life Cost

2. MCA
- Option 1 - Diversion of Flow and Improvement of Channel Conveyance
- Option 2 – Storage, Diversion of Flow and Improvement of Channel Conveyance

3. Potential Option Drawings
- Option 1 - Diversion of Flow and Improvement of Channel Conveyance
- Option 2 – Storage, Diversion of Flow and Improvement of Channel Conveyance

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	**SP**	**Date:**	**15/12/2015**
Checked by:	**Mark Wilson**	**Date:**	**21/04/2016**

Project reference	IBE0601

Project name:		SE CFRAM Study_Freshford AFA_Option 1

Base date for estimates (year 0)	Oct-2013
Scaling factor (e.g. €m, €k, €)	€

Construction Price Index (CPI)	**1.000**
Method Factor - to take into account particular site issues /constraints	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		*h total length of 5.72km, ICC on Upperwood and ICC (removal of 2*

Capital costs	**Cost (€)**	**Comment**
Total wall costs		
Total embankment costs		
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs	€3,739.00	*Lowering bed level by 0.4m from Ch140-356 on Upperwood*
Total excavation on land costs	€755,956.00	*44,468m^3 of material removal*
Total weir construction costs	€102,300.00	*3 weirs costed*
Total weir removal costs	€54,863.00	*removal of 2 weirs of Nuenna, 02WEIR02 & 03WEIR01*
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs	€151,650.00	*40m of culvert for CH1 & 100m of culvert CH2 + 5m Control culvert*
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€1,068,508	
Apply update to unit rate (CPI) if appropriate (cell N15)	€1,068,508	
Enter appropriate preliminaries estimate (%)	20%	
Sub Total	€1,282,210	
Optimism Bias	45%	*In channel*
Total capital cost (€)	€1,859,204	
Consider amendments based on site issues/constraints (cell N16)	€1,859,204	
Total capital cost (€)	€1,859,204	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs		
Total embankment O&M costs		
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs	€5,625.00	
Total weir removal O&M costs	€3,120.00	*Years 1-3 only*
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs	€32,885.00	
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€38,510	
NPV O&M	€830,518	
Optimism Bias	45%	*In channel*
NPV O&M with Optimism Bias	€1,204,252	

Other costs	**Cost (€)**	**Comment**
Other costs (design, supervision, archaeology, environment, site investigation, art)	€739,037	*Design and supervision (13%), Archaeology and environment (10%), Land (10%), Site investigation (€100,000), Art (€25,500)*

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€3,802,493	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€1,859,203.9
Annual maintenance cost (€)	€38,510.0
Other cost (€)	€739,037.3
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**	**Total PVc (€k):**		**2681064**
	Cash sum	0	1859204	1886990	0	3746194	**2681064**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	1859204			1859203.9	1859203.9
1	0.961538			38510		38510.0	37028.8
2	0.925			38510		38510.0	35604.7
3	0.889			38510		38510.0	34235.2
4	0.855			38510		38510.0	32918.5
5	0.822			38510		38510.0	31652.4
6	0.790			38510		38510.0	30435.0
7	0.760			38510		38510.0	29264.4
8	0.731			38510		38510.0	28138.9
9	0.703			38510		38510.0	27056.6
10	0.676			38510		38510.0	26016.0
11	0.650			38510		38510.0	25015.4
12	0.625			38510		38510.0	24053.2
13	0.601			38510		38510.0	23128.1
14	0.577			38510		38510.0	22238.6
15	0.555			38510		38510.0	21383.2
16	0.534			38510		38510.0	20560.8
17	0.513			38510		38510.0	19770.0
18	0.494			38510		38510.0	19009.6
19	0.475			38510		38510.0	18278.5
20	0.456			38510		38510.0	17575.5
21	0.439			38510		38510.0	16899.5
22	0.422			38510		38510.0	16249.5
23	0.406			38510		38510.0	15624.5
24	0.390			38510		38510.0	15023.6
25	0.375			38510		38510.0	14445.7
26	0.361			38510		38510.0	13890.1
27	0.347			38510		38510.0	13355.9
28	0.333			38510		38510.0	12842.2
29	0.321			38510		38510.0	12348.3
30	0.308			38510		38510.0	11873.4
31	0.296			38510		38510.0	11416.7
32	0.285			38510		38510.0	10977.6
33	0.274			38510		38510.0	10555.4
34	0.264			38510		38510.0	10149.4
35	0.253			38510		38510.0	9759.0
36	0.244			38510		38510.0	9383.7
37	0.234			38510		38510.0	9022.8
38	0.225			38510		38510.0	8675.7
39	0.217			38510		38510.0	8342.1
40	0.208			38510		38510.0	8021.2
41	0.200			38510		38510.0	7712.7
42	0.193			38510		38510.0	7416.1
43	0.185			38510		38510.0	7130.8
44	0.178			38510		38510.0	6856.6
45	0.171			38510		38510.0	6592.9
46	0.165			38510		38510.0	6339.3
47	0.158			38510		38510.0	6095.5
48	0.152			38510		38510.0	5861.0
49	0.146			38510		38510.0	5635.6
							821860.1

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	**SP**	**Date:**	**15/12/2015**
Checked by:	**Mark Wilson**	**Date:**	**21/04/2016**

Project reference	IBE0601	**Project name:**		SE CFRAM Study_Freshford AFA_Option 2

Base date for estimates (year 0)	Oct-2013
Scaling factor (e.g. €m, €k, €)	€

Construction Price Index (CPI)	**1.000**
Method Factor - to take into account particular site issues /constraints	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		*Four storage areas and dredging a total length of 1.8 km*

Capital costs	**Cost (€)**	**Comment**
Total wall costs		
Total embankment costs	€1,036,535.00	*2005m of embankment for storage*
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs	€3,739.00	*Lowering bed level by 0.4m from Ch140-356 on Upperwood*
Total excavation on land costs	€573,793.00	*33,752.5m^3 of material removal*
Total weir construction costs	€121,525.00	*3 weirs costed + 4m length of weirs at 2m high*
Total weir removal costs	€54,863.00	*removal of 2 weirs of Nuenna, 02WEIR02 & 03WEIR01*
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs	€201,128.00	*80m of culvert for storage*
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€1,991,583	
Apply update to unit rate (CPI) if appropriate (cell N15)	€1,991,583	
Enter appropriate preliminaries estimate (%)	16%	
Sub Total	€2,310,236	
Optimism Bias	45%	*In channel*
Total capital cost (€)	€3,349,843	
Consider amendments based on site issues/constraints (cell N16)	€3,349,843	
Total capital cost (€)	€3,349,843	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs		
Total embankment O&M costs	€6,416.00	*Length * 3.2*
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs	€7,500.00	*Average cost used*
Total weir removal O&M costs	€3,120.00	*Years 1-3 only*
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs	€34,476.00	*Average cost used*
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€48,392	
NPV O&M	€1,041,415	
Optimism Bias	45%	
NPV O&M with Optimism Bias	€1,510,051	

Other costs	**Cost (€)**	**Comment**
Other costs (design, supervision, archaeology, environment, site investigation, art)	€1,245,453	*Design and supervision (13%), Archaeology and environment (10%), Land (10%), Site investigation (€100,000), Art (€38,000)*

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€6,105,347	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€3,349,842.6
Annual maintenance cost (€)	€48,392.0
Other cost (€)	€1,245,453.1
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**	**Total PVc (€k):**		**4382599**
	Cash sum	0	3349843	2371208	0	5721051	**4382599**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	3349843			3349842.6	3349842.6
1	0.961538			48392		48392.0	46530.8
2	0.925			48392		48392.0	44741.1
3	0.889			48392		48392.0	43020.3
4	0.855			48392		48392.0	41365.7
5	0.822			48392		48392.0	39774.7
6	0.790			48392		48392.0	38244.9
7	0.760			48392		48392.0	36773.9
8	0.731			48392		48392.0	35359.6
9	0.703			48392		48392.0	33999.6
10	0.676			48392		48392.0	32691.9
11	0.650			48392		48392.0	31434.5
12	0.625			48392		48392.0	30225.5
13	0.601			48392		48392.0	29063.0
14	0.577			48392		48392.0	27945.2
15	0.555			48392		48392.0	26870.4
16	0.534			48392		48392.0	25836.9
17	0.513			48392		48392.0	24843.2
18	0.494			48392		48392.0	23887.7
19	0.475			48392		48392.0	22968.9
20	0.456			48392		48392.0	22085.5
21	0.439			48392		48392.0	21236.0
22	0.422			48392		48392.0	20419.3
23	0.406			48392		48392.0	19633.9
24	0.390			48392		48392.0	18878.8
25	0.375			48392		48392.0	18152.7
26	0.361			48392		48392.0	17454.5
27	0.347			48392		48392.0	16783.1
28	0.333			48392		48392.0	16137.6
29	0.321			48392		48392.0	15517.0
30	0.308			48392		48392.0	14920.2
31	0.296			48392		48392.0	14346.3
32	0.285			48392		48392.0	13794.5
33	0.274			48392		48392.0	13264.0
34	0.264			48392		48392.0	12753.8
35	0.253			48392		48392.0	12263.3
36	0.244			48392		48392.0	11791.6
37	0.234			48392		48392.0	11338.1
38	0.225			48392		48392.0	10902.0
39	0.217			48392		48392.0	10482.7
40	0.208			48392		48392.0	10079.5
41	0.200			48392		48392.0	9691.8
42	0.193			48392		48392.0	9319.1
43	0.185			48392		48392.0	8960.7
44	0.178			48392		48392.0	8616.0
45	0.171			48392		48392.0	8284.6
46	0.165			48392		48392.0	7966.0
47	0.158			48392		48392.0	7659.6
48	0.152			48392		48392.0	7365.0
49	0.146			48392		48392.0	7081.7
							1032756.5

Option Appraisal and the Multi-Criteria Analysis

Name of modeller	**Stephen Patterson**
Name of assessor	**Maria Nixon**
Date of Assessment	**15/03/2016**
Option ID	**Option 1**
Option Type	Structural Option
Option Location	Freshford
Option Details	Diversion of Flow and ICC
AEP	1.0%
Option Cost	€3,802,493.00
Economic Benefit	€13,421,732.00

Multi-Criteria Analysis Summary
Freshford Option 1

1. Technical Criteria

Objective 1.A	Ensure flood risk management options are operationally robust	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Level of risk score	4	*No reliance on systems or intervention, with more regular monitoring and intermittent, but potentially substantial, maintenance requirements*
Adjustment	No adjustment	*The level of risk score has not been adjusted*
Total Option Score	4.0	*Option score + adjustment*
Weighted Option Score	**400**	*Global weighting x Local weighting x Total option score*

Objective 1.B	Minimise health and safety risk in construction, maintenance and operation of the flood risk management option	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Option Score	3.0	*The following hazards have been identified: working near water (construction), working with heavy plant machinery*
Adjustment	0.0	*There have been no adjustments made to the option score*
Total Option Score	3.0	*Option score + adjustment*
Weighted Option Score	**300**	*Global weighting x Local weighting x Total option score*

Objective 1.C	Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Adaptability Score	1	*Option is adaptable only at significant cost*
Adjustment	No adjustment	*The adaptability score has not been adjusted*
Total Option Score	1.0	*Option score + adjustment*
Weighted Option Score	**100**	*Global weighting x Local weighting x Total option score*

Technical Score	800

Multi-Criteria Analysis Summary

Freshford Option 1

2. Economic Criteria

Objective 2.A	Reduce economic damages	
Assigned Weightings		
Global Weighting	24.0	*Nationally Constant Value*
Local Weighting	5.0	*AAD for the SSA / €75,000*
AAD for the SSA	€ 1,300,585.93	*Baseline Scenario*
Option Scoring		
Reduced AAD	€ 62,383.31	*Defended Scenario*
Total Option Score	4.8	*0.05 X Percentage Reduction in AAD*
Weighted Option Score	**571**	*Global weighting x Local weighting x Total option score*

Objective 2.B	Minimise risk to transport infrastructure	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	100.9	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	14.6	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.3	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the option score*
Total Option Score	4.3	*Option score + adjustment*
Weighted Option Score	**214**	*Global weighting x Local weighting x Total option score*

Objective 2.C	Minimise risk to utility infrastructure	
Assigned Weightings		
Global Weighting	14.0	*Nationally Constant Value*
Local Weighting	25.0	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	1.3	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.8	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the total option score*
Total Option Score	4.8	*Option score + adjustment*
Weighted Option Score	**333**	*Global weighting x Local weighting x Total option score*

Objective 2.D	Manage risk to agriculture	
Assigned Weightings		
Global Weighting	12.0	*Nationally Constant Value*
Local Weighting	3.0	*The AFA is a mix of urban and pasture land. There are pockets of arable land upstream and downstream of Freshford, however pasture land is dominant in the surrounding area.*
Option Scoring		
Total Option Score	2	*There is a reduction in flooding of agricultural land surrounding Freshford. However, there is a slight reduction in land along the banks of the river with channel widening in places.*
Weighted Option Score	**72**	*Global weighting x Local weighting x Total option score*

Economic Score	1189

Multi-Criteria Analysis Summary

Freshford Option 1

3. Social Criteria

Objective 3.A (i)	Minimise risk to human health and life - Residents	
Assigned Weightings		
Global Weighting	27.0	*Nationally Constant Value*
Local Weighting	14.8	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.9	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	5	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**635**	*Global weighting x Local weighting x Total option score*

Objective 3.A (ii)	Minimise risk to human health and life - High vulnerability properties	
Assigned Weightings		
Global Weighting	17.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	1.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	0.0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 3.B (i)	Minimise risk to community - Social Infrastructure and Amenity	
Assigned Weightings		
Global Weighting	9.0	*Nationally Constant Value*
Local Weighting	111.0	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	2.0	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Enhancement or Creation of Social Amenity Sites	0.0	*Adjustment in relation to the Enhancement or creation of social amenity sites (Structural Option)*
Total Option Score	4.9	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**221**	*Global weighting x Local weighting x Total option score*

Objective 3.B (ii)	Minimise risk to community - Local Employment	
Assigned Weightings		
Global Weighting	7.0	*Nationally Constant Value*
Local Weighting	35.4	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.9	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	4.9	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**170**	*Global weighting x Local weighting x Total option score*

Social Score	1027

Multi-Criteria Analysis Summary

Freshford Option 1

4. Environmental Criteria

Objective 4.A	Support the objectives of the WFD	
Assigned Weightings		
Global Weighting	16.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Total Option Score	-1	*Flow diversions within the same river to bypass the AFA. Non-sensitive waterbody. Flow diversions only operational during extreme flows. Reduced flood risk from 1% AEP events, including 1 WWTW.*
Weighted Option Score	**-80**	*Global weighting x Local weighting x Total option score*

Objective 4.B	Support the objectives of the Habitats and Birds Directives	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	3.0	*The AFA is over 3km upstream of the River Barrow and River Nore SAC and the River Nore SPA. The Cullahill Mountain SAC and the Spahill and Clomantagh Hill SAC are over 7km upcatchment of the AFA.*
Option Scoring		
Total Option Score	-1	*No direct impacts on existing SAC, SPA or Ramsar sites, however potential for indirect sedimentation impacts during construction works and increased sedimentation downstream of increased flows, which may impact on the River Barrow and River Nore SAC and the River Nore SPA. Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-30**	*Global weighting x Local weighting x Total option score*

Objective 4.C	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	
Assigned Weightings		
Global Weighting	5.0	*Nationally Constant Value*
Local Weighting	3.0	*The AFA is within the Nore Middle FPM sensitive area. There are FPM habitats 3km upstream of the confluence of the Nuenna River and River Nore. The AFA is over 3km upstream of the Inchbeg pNHA and over 8km upstream of the Ardaloo Fen pNHA. The Cullahill Mountain pNHA and the Spahill and Clomantagh Hill pNHA are over 7km upcatchment of the AFA.*
Option Scoring		
Total Option Score	-2.0	*No direct impacts on existing designated sites, however potential for indirect sedimentation impacts during construction works and increased sedimentation downstream of increased flows, which may impact on the Inchbeg pNHA and the FPM sensitive River Nore. Local loss of undesignated habitat and species from works, which may re-establish. Most construction impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-30**	*Global weighting x Local weighting x Total option score*

Objective 4.D	Protect and where possible enhance fisheries resource within the catchment (Inland Fisheries Only)	
Assigned Weightings		
Global Weighting	13.0	*Nationally Constant Value*
Local Weighting	3.0	*Brown trout are common in the Nueanna River in the vicinity of Freshford. The AFA is 3km upstream of the River Nore, which is a designated salmonid river with significant salmon and trout fishing in the area.*
Option Scoring		
Total Option Score	-3.0	*Flow diversions within the same river to bypass the AFA. Non-sensitive waterbody. Flow diversions only operational during extreme flows. Introduction of barriers that might inhibit fish passage*
Weighted Option Score	**-117**	*Global weighting x Local weighting x Total option score*

Objective 4.E	Protect, and where possible enhance, landscape character and visual amenity within the zone of influence	
Assigned Weightings		
Global Weighting	8.0	*Nationally Constant Value*
Local Weighting	1.0	*The Kilkenny CDP 2008-2014 Landscape Character Assessment designates Freshford as within the Slieveardagh Transition lands between the hills and the river valley. The transitional areas of the Slieveardagh uplands are not perceived as being of a special or sensitive nature.*
Option Scoring		
Total Option Score	-2.0	*Short term construction and permanent impacts in low sensitivity landscape from construction of bypass channels. No impacts within AFA.*
Weighted Option Score	**-16**	*Global weighting x Local weighting x Total option score*

Objective 4.F (i)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	3.0	*There are 36 NIAH buildings within the AFA of national, regional and local importance. Freshford is considered a historic town.*
Option Scoring		
Total Option Score	4.0	*Increased protection from severe flooding to 10 NIAH buildings in the AFA.*
Weighted Option Score	**48**	*Global weighting x Local weighting x Total option score*

Objective 4.F (ii)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	3.0	*There are 11 monuments within the AFA, however all are of low vulnerability to flooding and none are in state care or have preservation orders. Freshford is considered a historic town.*
Option Scoring		
Total Option Score	0.0	*No effects on archaeological heritage.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Environmental Score	-225

Option Appraisal and the Multi-Criteria Analysis

Name of modeller	**Stephen Patterson**
Name of assessor	**Maria Nixon**
Date of Assessment	**15/03/2016**
Option ID	**Option 2**
Option Type	Structural Option
Option Location	Freshford
Option Details	Storage, Diversion of Flow and Improvement of Channel Conveyance
AEP	1.0%
Option Cost	€6,105,347.00
Economic Benefit	€13,421,732.00

Multi-Criteria Analysis Summary
Freshford Option 2

1. Technical Criteria

Objective 1.A	Ensure flood risk management options are operationally robust	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Level of risk score	3	*There is a requirement for simple systems or interventions for the option to operate, with regular monitoring and maintenance required, but a very low likelihood of system / operation failure*
Adjustment	No adjustment	*The level of risk score has not been adjusted*
Total Option Score	3.0	*Option score + adjustment*
Weighted Option Score	**300**	*Global weighting x Local weighting x Total option score*

Objective 1.B	Minimise health and safety risk in construction, maintenance and operation of the flood risk management option	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Option Score	3.0	*The following hazards have been identified: working near water (construction), working with heavy plant machinery*
Adjustment	0.0	*There have been no adjustments made to the option score*
Total Option Score	3.0	*Option score + adjustment*
Weighted Option Score	**300**	*Global weighting x Local weighting x Total option score*

Objective 1.C	Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Adaptability Score		*#N/A*
Adjustment	No adjustment	*The adaptability score has not been adjusted*
Total Option Score	0.0	*Option score + adjustment*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Technical Score	600

Multi-Criteria Analysis Summary

Freshford Option 2

2. Economic Criteria

Objective 2.A	Reduce economic damages	
Assigned Weightings		
Global Weighting	24.0	*Nationally Constant Value*
Local Weighting	5.0	*AAD for the SSA / €75,000*
AAD for the SSA	€ 1,300,585.93	*Baseline Scenario*
Option Scoring		
Reduced AAD	€ 62,383.31	*Defended Scenario*
Total Option Score	4.8	*0.05 X Percentage Reduction in AAD*
Weighted Option Score	**571**	*Global weighting x Local weighting x Total option score*

Objective 2.B	Minimise risk to transport infrastructure	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	100.9	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	14.6	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.3	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the option score*
Total Option Score	4.3	*Option score + adjustment*
Weighted Option Score	**214**	*Global weighting x Local weighting x Total option score*

Objective 2.C	Minimise risk to utility infrastructure	
Assigned Weightings		
Global Weighting	14.0	*Nationally Constant Value*
Local Weighting	25.0	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	1.3	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.8	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the total option score*
Total Option Score	4.8	*Option score + adjustment*
Weighted Option Score	**333**	*Global weighting x Local weighting x Total option score*

Objective 2.D	Manage risk to agriculture	
Assigned Weightings		
Global Weighting	12.0	*Nationally Constant Value*
Local Weighting	3.0	*The AFA is a mix of urban and pasture land. There are pockets of arable land upstream and downstream of Freshford, however pasture land is dominant in the surrounding area.*
Option Scoring		
Total Option Score	2	*There is a reduction in flooding of agricultural land surrounding Freshford. However, there is a slight reduction in land along the banks of the river with channel widening in places.*
Weighted Option Score	**72**	*Global weighting x Local weighting x Total option score*

Economic Score	1189

Multi-Criteria Analysis Summary

Freshford Option 2

3. Social Criteria

Objective 3.A (i)	Minimise risk to human health and life - Residents	
Assigned Weightings		
Global Weighting	27.0	*Nationally Constant Value*
Local Weighting	14.8	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.9	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	5	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**635**	*Global weighting x Local weighting x Total option score*

Objective 3.A (ii)	Minimise risk to human health and life - High vulnerability properties	
Assigned Weightings		
Global Weighting	17.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	1.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	0.0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 3.B (i)	Minimise risk to community - Social Infrastructure and Amenity	
Assigned Weightings		
Global Weighting	9.0	*Nationally Constant Value*
Local Weighting	111.0	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	2.0	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Enhancement or Creation of Social Amenity Sites	0.0	*Adjustment in relation to the Enhancement or creation of social amenity sites (Structural Option)*
Total Option Score	4.9	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**221**	*Global weighting x Local weighting x Total option score*

Objective 3.B (ii)	Minimise risk to community - Local Employment	
Assigned Weightings		
Global Weighting	7.0	*Nationally Constant Value*
Local Weighting	35.4	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.9	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	4.9	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**170**	*Global weighting x Local weighting x Total option score*

Social Score	1027

Multi-Criteria Analysis Summary

Freshford Option 2

4. Environmental Criteria

Objective 4.A	Support the objectives of the WFD	
Assigned Weightings		
Global Weighting	16.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Total Option Score	-3	*Flow diversions within the same river to bypass the AFA and creation of online storage on non-sensitive waterbody, upstream of sensitive waterbody. Flow diversions and storage only operational during extreme flows. Permanent changes to river morphology. Reduced flood risk from 1% AEP events, including 1 WWTW.*
Weighted Option Score	**-240**	*Global weighting x Local weighting x Total option score*

Objective 4.B	Support the objectives of the Habitats and Birds Directives	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	3.0	*The AFA is over 3km upstream of the River Barrow and River Nore SAC and the River Nore SPA. The Cullahill Mountain SAC and the Spahill and Clomantagh Hill SAC are over 7km upcatchment of the AFA.*
Option Scoring		
Total Option Score	-1	*No direct impacts on existing SAC, SPA or Ramsar sites, however potential for indirect sedimentation impacts during construction works and increased sedimentation downstream of increased flows, which may impact on the River Barrow and River Nore SAC and the River Nore SPA. Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-30**	*Global weighting x Local weighting x Total option score*

Objective 4.C	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	
Assigned Weightings		
Global Weighting	5.0	*Nationally Constant Value*
Local Weighting	3.0	*The AFA is within the Nore Middle FPM sensitive area. There are FPM habitats 3km upstream of the confluence of the Nuenna River and River Nore. The AFA is over 3km upstream of the Inchbeg pNHA and over 8km upstream of the Ardaloo Fen pNHA. The Cullahill Mountain pNHA and the Spahill and Clomantagh Hill pNHA are over 7km upcatchment of the AFA.*
Option Scoring		
Total Option Score	-2.0	*No direct impacts on existing designated sites, however potential for indirect sedimentation impacts during construction works and increased sedimentation downstream of increased flows, which may impact on the Inchbeg pNHA and the FPM sensitive River Nore. Local loss of undesignated habitat and species from works, which may re-establish. Most construction impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*

Weighted Option Score	**-30**	*Global weighting x Local weighting x Total option score*

Objective 4.D	**Protect and where possible enhance fisheries resource within the catchment (Inland Fisheries Only)**	
Assigned Weightings		
Global Weighting	13.0	*Nationally Constant Value*
Local Weighting	3.0	*Brown trout are common in the Nueanna River in the vicinity of Freshford. The AFA is 3km upstream of the River Nore, which is a designated salmonid river with significant salmon and trout fishing in the area.*
Option Scoring		
Total Option Score	-5.0	*Flow diversions within the same river to bypass the AFA and online storage on non-sensitive waterbodies, upstream of sensitive waterbody. Flow diversions and storage only operational during extreme flows. Addition of several structures for flow diversions and storage that may be barriers to fish passage.*
Weighted Option Score	**-195**	*Global weighting x Local weighting x Total option score*

Objective 4.E	Protect, and where possible enhance, landscape character and visual amenity within the zone of influence	
Assigned Weightings		
Global Weighting	8.0	*Nationally Constant Value*
Local Weighting	1.0	*The Kilkenny CDP 2008-2014 Landscape Character Assessment designates Freshford as within the Slieveardagh Transition lands between the hills and the river valley. The transitional areas of the Slieveardagh uplands are not perceived as being of a special or sensitive nature.*
Option Scoring		
Total Option Score	-2.0	*Short term construction and permanent impacts in low sensitivity landscape from construction of bypass channels and storage areas, prior to mitigation establishment.*
Weighted Option Score	**-16**	*Global weighting x Local weighting x Total option score*

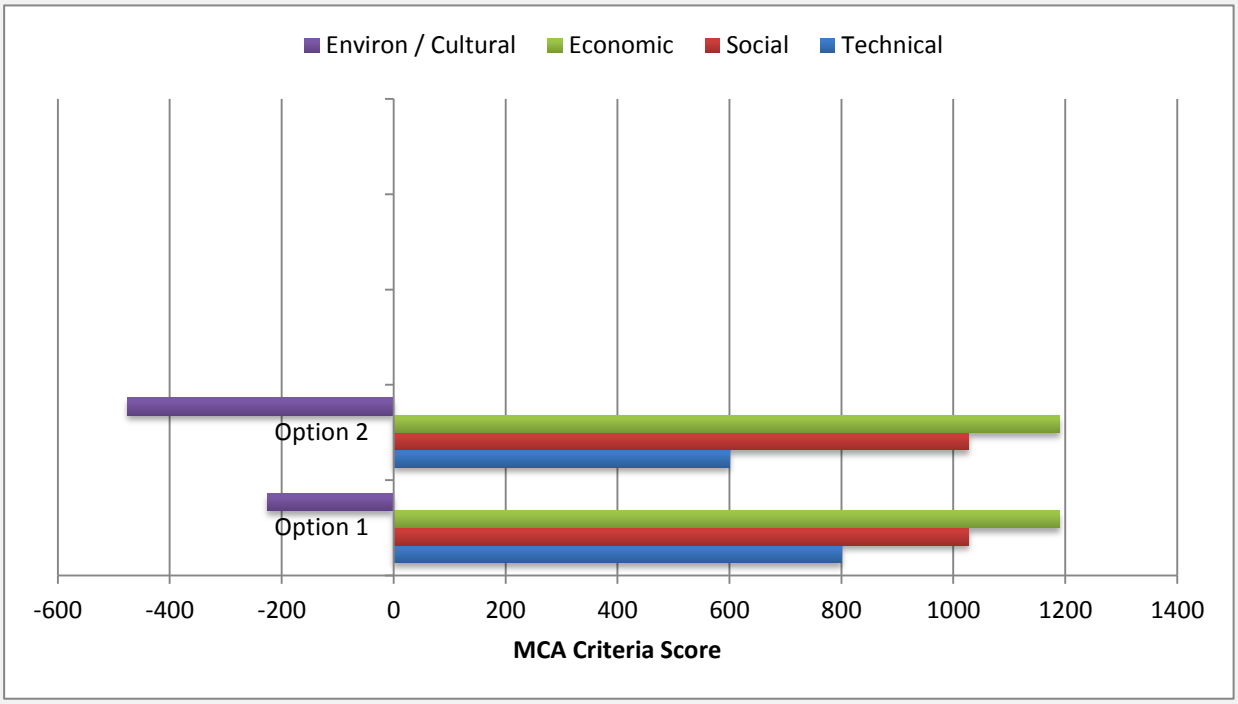
Objective 4.F (i)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	3.0	*There are 36 NIAH buildings within the AFA of national, regional and local importance. Freshford is considered a historic town.*
Option Scoring		
Total Option Score	4.0	*Increased protection from severe flooding to 10 NIAH buildings in the AFA.*
Weighted Option Score	**48**	*Global weighting x Local weighting x Total option score*

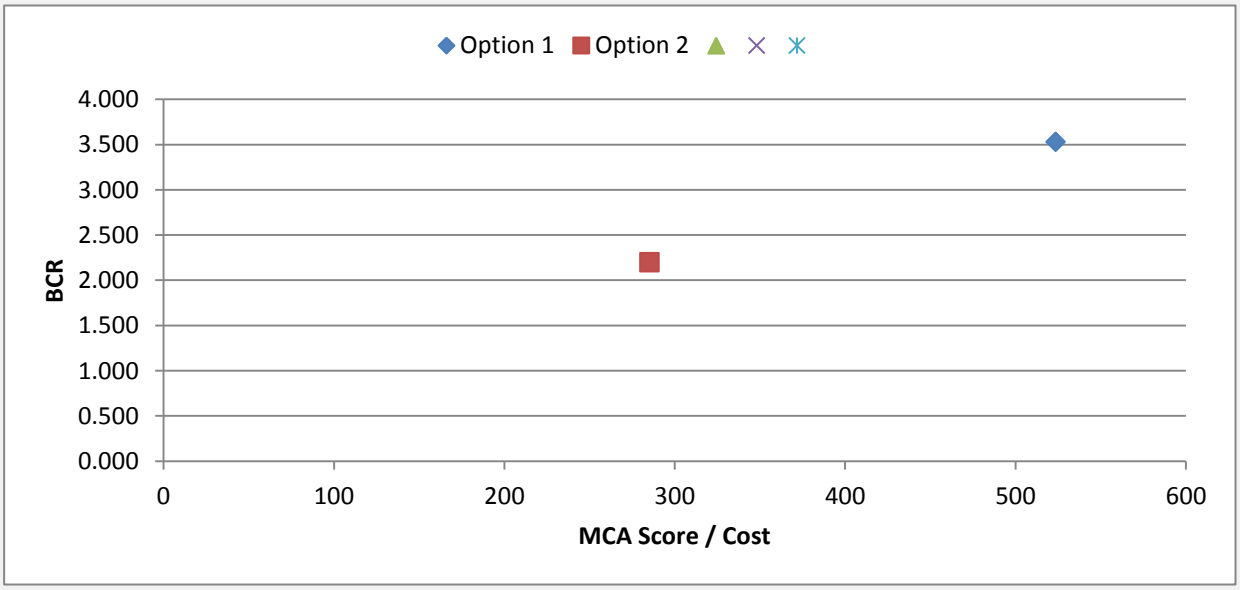
Objective 4.F (ii)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	3.0	*There are 11 monuments within the AFA, however all are of low vulnerability to flooding and none are in state care or have preservation orders. Freshford is considered a historic town.*
Option Scoring		
Total Option Score	-1.0	*Potential for direct physical impacts on or loss of Castle ruins (site) at Lodge Demesne West in the footprint of storage. Minor amendment to storage location could mitigate for this.*
Weighted Option Score	**-12**	*Global weighting x Local weighting x Total option score*

Environmental Score	-475

Option Comparison
Freshford

Option No.	MCA Appraisal Scores				TOTAL - MCA Benefit Score	Cost (€millions)	MCA Score / Cost	BCR
	Technical	Social	Economic	Environ / Cultural				
Option 1	800	1027	1189	-225	1991	3.802	523.642	3.530
Option 2	600	1027	1189	-475	1741	6.105	285.184	2.198





Castle

dge

Moneenaun

Blackwood

R694

Channel 1

Baunaniska

5

Romanesque Doorway

Monabrika

New Br

Tobernapeastia

Cross-base

Clintstown

Holy Well

PO

Sch

Fire Stn

Moat

Freshford

Achadh Úr

R693

Channel 2

wer

Upperwood Demesne

80

100

120

0 0.225 0.45 0.9 Km

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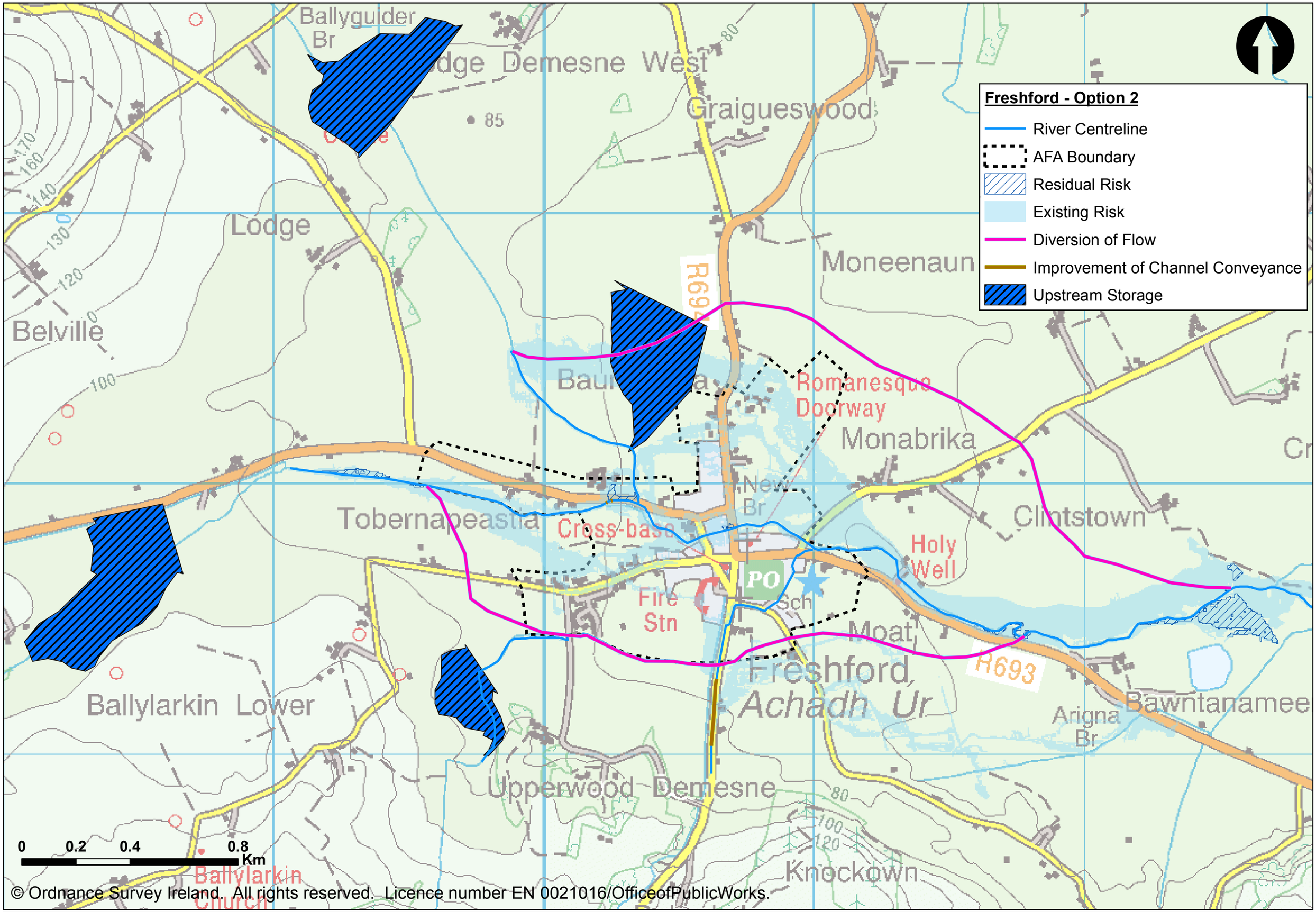
Freshford - Option 1

- River Centreline
- AFA Boundary
- Residual Risk
- Existing Risk
- Diversion of Flow
- Improvement of Channel Conveyance



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Appendix D

Inistioge AFA
Additional Information

List of background information included:

1. Costings
- Option 1 – PVc summary of Whole Life Cost – Hard Defences

2. MCA
- Option 1 - Hard Defences

3. Potential Option drawings
- Option 1 - Hard Defences

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	**Emma Holland**	**Date:**	**14/12/2015**
Checked by:	**Mark Wilson**	**Date:**	**14/12/2015**

Project reference	IBE0601

Project name:	SE CFRAM Study_Inistioge_Option 1_Hard Defence

Base date for estimates (year 0)	Oct-2013
Scaling factor (e.g. €m, €k, €)	€

Construction Price Index (CPI)	**1.000**
Method Factor - to take into account particular site issues /constraints	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		-

Capital costs	**Cost (€)**	**Comment**
Total wall costs	€364,039.00	*162m of Urban wall*
Total embankment costs	€228,569.00	*660m of embankment*
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€592,608	
Apply update to unit rate (CPI) if appropriate (cell N15)	€592,608	
Enter appropriate preliminaries estimate (%)	17%	
Sub Total	€693,351	
Optimism Bias	41%	
Total capital cost (€)	€977,625	
Consider amendments based on site issues/constraints (cell N16)	€977,625	
Total capital cost (€)	€977,625	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs	€65.00	
Total embankment O&M costs	€2,112.00	
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€2,177	
NPV O&M	€46,460	
Optimism Bias	41%	
NPV O&M with Optimism Bias	€65,509	

Other costs	**Cost (€)**	**Comment**
Other costs (design, supervision, archaeology, environment, site investigation, art)	€446,701	*Design and supervision (13%), Archaeology and environment (10%), Land (10%), Site investigation (10%), Art (€25,500), Works access, Haul road*

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€1,489,836	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€977,625.4
Annual maintenance cost (€)	€2,177.0
Other cost (€)	€446,701.4
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**	**Total PVc (€k):**		**1024086**
	Cash sum	0	977625	106673	0	1084298	**1024086**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	977625			977625.4	977625.4
1	0.961538			2177		2177.0	2093.3
2	0.925			2177		2177.0	2012.8
3	0.889			2177		2177.0	1935.3
4	0.855			2177		2177.0	1860.9
5	0.822			2177		2177.0	1789.3
6	0.790			2177		2177.0	1720.5
7	0.760			2177		2177.0	1654.3
8	0.731			2177		2177.0	1590.7
9	0.703			2177		2177.0	1529.5
10	0.676			2177		2177.0	1470.7
11	0.650			2177		2177.0	1414.1
12	0.625			2177		2177.0	1359.7
13	0.601			2177		2177.0	1307.4
14	0.577			2177		2177.0	1257.2
15	0.555			2177		2177.0	1208.8
16	0.534			2177		2177.0	1162.3
17	0.513			2177		2177.0	1117.6
18	0.494			2177		2177.0	1074.6
19	0.475			2177		2177.0	1033.3
20	0.456			2177		2177.0	993.6
21	0.439			2177		2177.0	955.3
22	0.422			2177		2177.0	918.6
23	0.406			2177		2177.0	883.3
24	0.390			2177		2177.0	849.3
25	0.375			2177		2177.0	816.6
26	0.361			2177		2177.0	785.2
27	0.347			2177		2177.0	755.0
28	0.333			2177		2177.0	726.0
29	0.321			2177		2177.0	698.1
30	0.308			2177		2177.0	671.2
31	0.296			2177		2177.0	645.4
32	0.285			2177		2177.0	620.6
33	0.274			2177		2177.0	596.7
34	0.264			2177		2177.0	573.8
35	0.253			2177		2177.0	551.7
36	0.244			2177		2177.0	530.5
37	0.234			2177		2177.0	510.1
38	0.225			2177		2177.0	490.4
39	0.217			2177		2177.0	471.6
40	0.208			2177		2177.0	453.4
41	0.200			2177		2177.0	436.0
42	0.193			2177		2177.0	419.2
43	0.185			2177		2177.0	403.1
44	0.178			2177		2177.0	387.6
45	0.171			2177		2177.0	372.7
46	0.165			2177		2177.0	358.4
47	0.158			2177		2177.0	344.6
48	0.152			2177		2177.0	331.3
49	0.146			2177		2177.0	318.6

Option Appraisal and the Multi-Criteria Analysis

Name of modeller	**Emma Holland**
Name of assessor	**Emma Holland**
Date of Assessment	**24/03/2016**
Option ID	**Option 1**
Option Type	Structural Option
Option Location	Inistioge
Option Details	Hard Defences
AEP	1%/0.5%
Option Cost	€1,489,836.00
Economic Benefit	€6,546,412.00

Multi-Criteria Analysis Summary

Inistioge Option 1

1. Technical Criteria

Objective 1.A	Ensure flood risk management options are operationally robust	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Level of risk score	4	*No reliance on systems or intervention, with more regular monitoring and intermittent, but potentially substantial, maintenance requirements*
Adjustment	No adjustment	*The level of risk score has not been adjusted*
Total Option Score	4.0	*Option score + adjustment*
Weighted Option Score	**400**	*Global weighting x Local weighting x Total option score*

Objective 1.B	Minimise health and safety risk in construction, maintenance and operation of the flood risk management option	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Option Score	2.0	*The following hazards have been identified: working near water (construction), working heavy plant, working near water (O&M)*
Adjustment	0.0	*There have been no adjustments made to the option score*
Total Option Score	2.0	*Option score + adjustment*
Weighted Option Score	**200**	*Global weighting x Local weighting x Total option score*

Objective 1.C	Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Adaptability Score	1	*Option is adaptable only at significant cost*
Adjustment	No adjustment	*The adaptability score has not been adjusted*
Total Option Score	1.0	*Option score + adjustment*
Weighted Option Score	**100**	*Global weighting x Local weighting x Total option score*

Technical Score	700

Multi-Criteria Analysis Summary

Inistioge Option 1

2. Economic Criteria

Objective 2.A	Reduce economic damages	
Assigned Weightings		
Global Weighting	24.0	*Nationally Constant Value*
Local Weighting	2.5	*AAD for the SSA / €75,000*
AAD for the SSA	€ 188,608.39	*Baseline Scenario*
Option Scoring		
Reduced AAD	€ 20,797.63	*Defended Scenario*
Total Option Score	4.4	*0.05 X Percentage Reduction in AAD*
Weighted Option Score	**268**	*Global weighting x Local weighting x Total option score*

Objective 2.B	Minimise risk to transport infrastructure	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	21.1	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	0.5	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.9	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the option score*
Total Option Score	4.9	*Option score + adjustment*
Weighted Option Score	**244**	*Global weighting x Local weighting x Total option score*

Objective 2.C	Minimise risk to utility infrastructure	
Assigned Weightings		
Global Weighting	14.0	*Nationally Constant Value*
Local Weighting	12.5	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	1.3	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.5	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the total option score*
Total Option Score	4.5	*Option score + adjustment*
Weighted Option Score	**315**	*Global weighting x Local weighting x Total option score*

Objective 2.D	Manage risk to agriculture	
Assigned Weightings		
Global Weighting	12.0	*Nationally Constant Value*
Local Weighting	3.0	*Agricultural activity in the area of Inistioge is mainly grazing on pasture land, with some smaller areas of arable land in the vicinity. Significant areas of land are taken up by forest and woodland, particularly along the river valley.*
Option Scoring		
Total Option Score	0	*No change to flooding of agricultural land in the area.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Economic Score	827

Multi-Criteria Analysis Summary

Inistioge Option 1

3. Social Criteria

Objective 3.A (i)	Minimise risk to human health and life - Residents	
Assigned Weightings		
Global Weighting	27.0	*Nationally Constant Value*
Local Weighting	7.5	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.3	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	5	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**645**	*Global weighting x Local weighting x Total option score*

Objective 3.A (ii)	Minimise risk to human health and life - High vulnerability properties	
Assigned Weightings		
Global Weighting	17.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	1.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	0.0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 3.B (i)	Minimise risk to community - Social Infrastructure and Amenity	
Assigned Weightings		
Global Weighting	9.0	*Nationally Constant Value*
Local Weighting	105.6	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	4.4	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Enhancement or Creation of Social Amenity Sites	0.0	*Adjustment in relation to the Enhancement or creation of social amenity sites (Structural Option)*
Total Option Score	4.8	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**216**	*Global weighting x Local weighting x Total option score*

Objective 3.B (ii)	Minimise risk to community - Local Employment	
Assigned Weightings		
Global Weighting	7.0	*Nationally Constant Value*
Local Weighting	1.4	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	1.4	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.2	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	4.4	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**44**	*Global weighting x Local weighting x Total option score*

Social Score	905

Multi-Criteria Analysis Summary

Inistioge Option 1

4. Environmental Criteria

Objective 4.A	Support the objectives of the WFD	
Assigned Weightings		
Global Weighting	16.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Total Option Score	-1	*Construction phase impacts from creation of walls and embankments set back from sensitive waterbody. Potential for some excavation and restoration of banks. Slight potential for indirect sedimentation impacts during construction. Impacts can be mitigated for with good planning and good construction practice.*
Weighted Option Score	**-80**	*Global weighting x Local weighting x Total option score*

Objective 4.B	Support the objectives of the Habitats and Birds Directives	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	5.0	*The River Barrow and River Nore SAC and the River Nore SPA are within, downstream of and upstream of Inistioge. The Thomastown Quarry SAC is over 8km upcatchment of the AFA.*
Option Scoring		
Total Option Score	-3	*Potential for direct construction phase impacts from construction of walls and embankments adjacent to and intersecting the River Barrow and River Nore SAC and the River Nore SPA. Potential for indirect impacts to SAC and SPA from sedimentation during construction. Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice. Embankments and walls should be set back from watercourse as far as possible.*
Weighted Option Score	**-150**	*Global weighting x Local weighting x Total option score*

Objective 4.C	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	
Assigned Weightings		
Global Weighting	5.0	*Nationally Constant Value*
Local Weighting	4.0	*The AFA is within the Nore Lower FPM sensitive area. The Inistioge pNHA and the Ice House pNHA are within close proximity to the AFA. The Mount Juliet pNHA is over 12km upstream of the AFA. The Thomastown pNHA is over 7km upstream of the AFA. Murphy's of the River pNHA, Rathsnagadan Wood pNHA, Kylecorragh Wood pNHA and the Barrow River Estuary pNHA, are all over 4km downstream of the AFA.*
Option Scoring		
Total Option Score	-3.0	*Slight potential for indirect upstream impacts to Nore Freshwater Pearl Mussel sensitive area from sedimentation during construction. Potential localised loss and disturbance to flora and fauna in footprint of works. Direct impacts within Inistioge pNHA and the setting of the pNHA. Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-60**	*Global weighting x Local weighting x Total option score*

Objective 4.D	Protect and where possible enhance fisheries resource within the catchment (Inland Fisheries Only)	
Assigned Weightings		
Global Weighting	13.0	*Nationally Constant Value*
Local Weighting	5.0	*River Nore is a designated salmonid river. Significant salmon and trout fishing in the area.*
Option Scoring		
Total Option Score	-1.0	*Slight potential for indirect impacts to River Nore fisheries and local fishing within AFA from sedimentation during construction. Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice. Potential for local impacts on access to fishing areas from defences, however this could be incorporated into design.*
Weighted Option Score	**-65**	*Global weighting x Local weighting x Total option score*

Objective 4.E	Protect, and where possible enhance, landscape character and visual amenity within the zone of influence	
Assigned Weightings		
Global Weighting	8.0	*Nationally Constant Value*
Local Weighting	4.0	*The Kilkenny CDP 2008-2014 LAP demonstrates that Inistioge is within the Nore Valley, which is an Area of High Amenity. The landscape in the area is considered sensitive.*
Option Scoring		
Total Option Score	-3.0	*Construction phase impacts in sensitive river corridor landscape. Creation of hard defences prior to establishment of screening. Permanent impacts on the local landscape, however defences mostly set back from river. Permanent local visual impacts on scenic views of the river corridor to those being protected and recreational users of the area.*
Weighted Option Score	**-96**	*Global weighting x Local weighting x Total option score*

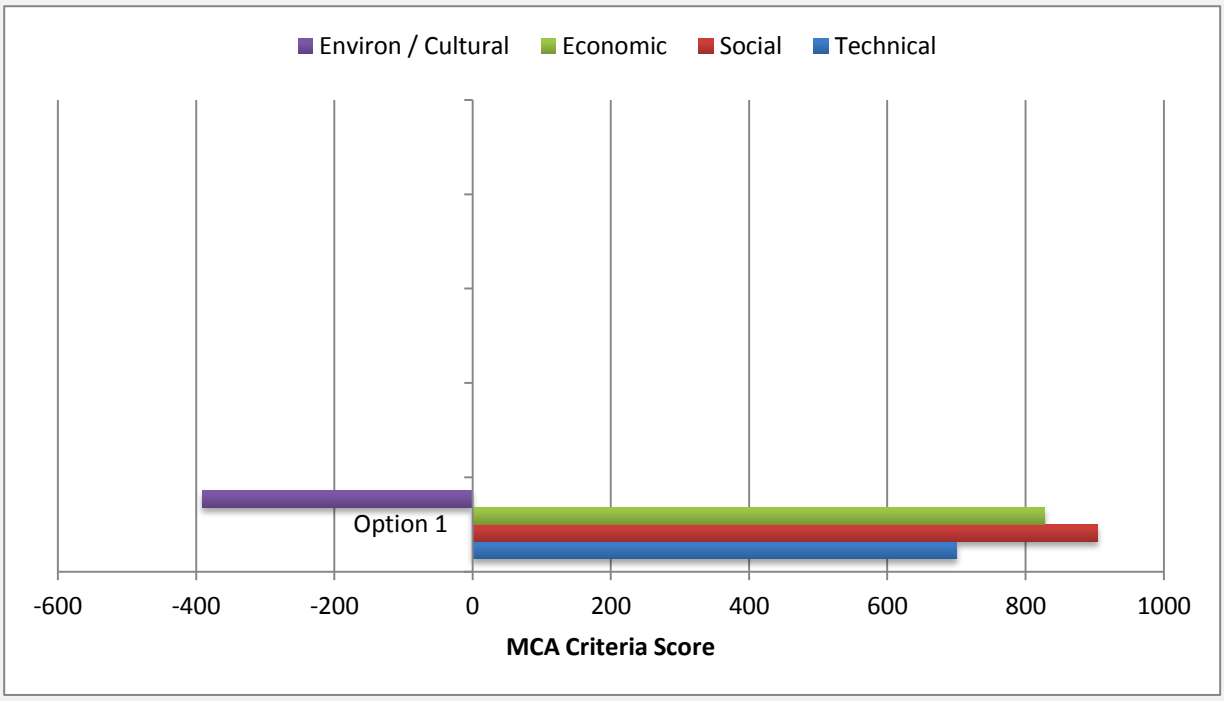
Objective 4.F (i)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	4.0	*There are 56 NIAH buildings within the AFA of national, regional and local importance. Inistioge is considered a historic town.*
Option Scoring		
Total Option Score	3.0	*Potential for physical impacts to the NIAH designated canalised river with sections of random rubble stone retaining walls. Potential impacts on the setting of several NIAH buildings from hard defences. Many NIAH buildings protected from flooding events, mainly in The Square and Church Street.*
Weighted Option Score	**48**	*Global weighting x Local weighting x Total option score*

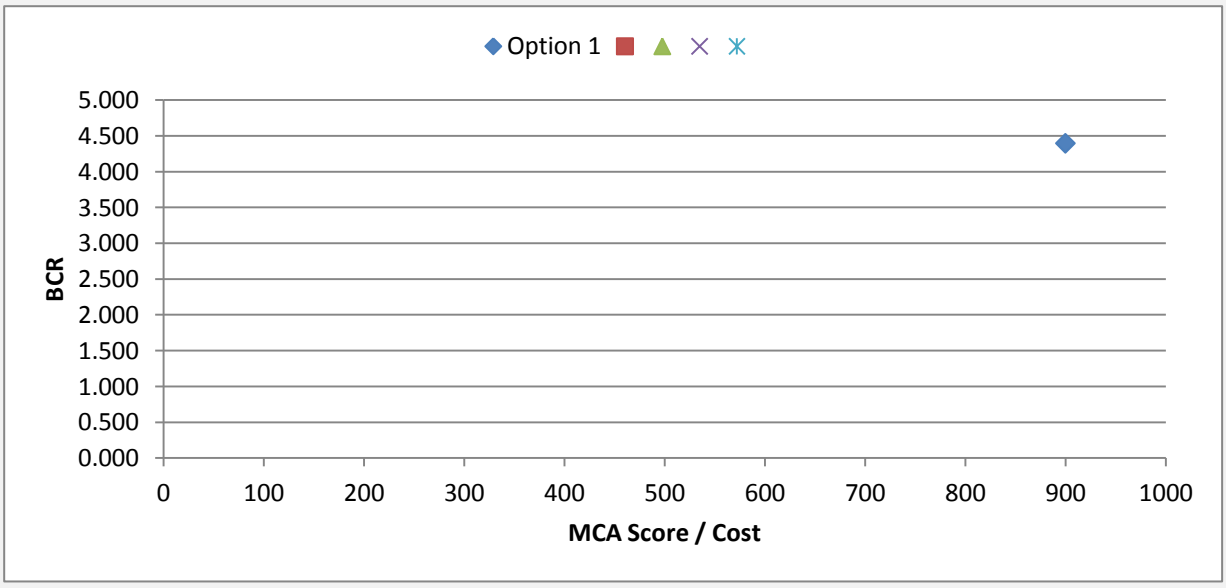
Objective 4.F (ii)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	3.0	*There are 14 monuments within the AFA, however all are of low vulnerability to flooding and none are in state care or have preservation orders. Inistioge is considered a historic town.*
Option Scoring		
Total Option Score	1.0	*Protection to flooding for one fortified house monument. Potential impacts on the setting of this historic town with hard defences, however increased protection to the town.*
Weighted Option Score	**12**	*Global weighting x Local weighting x Total option score*

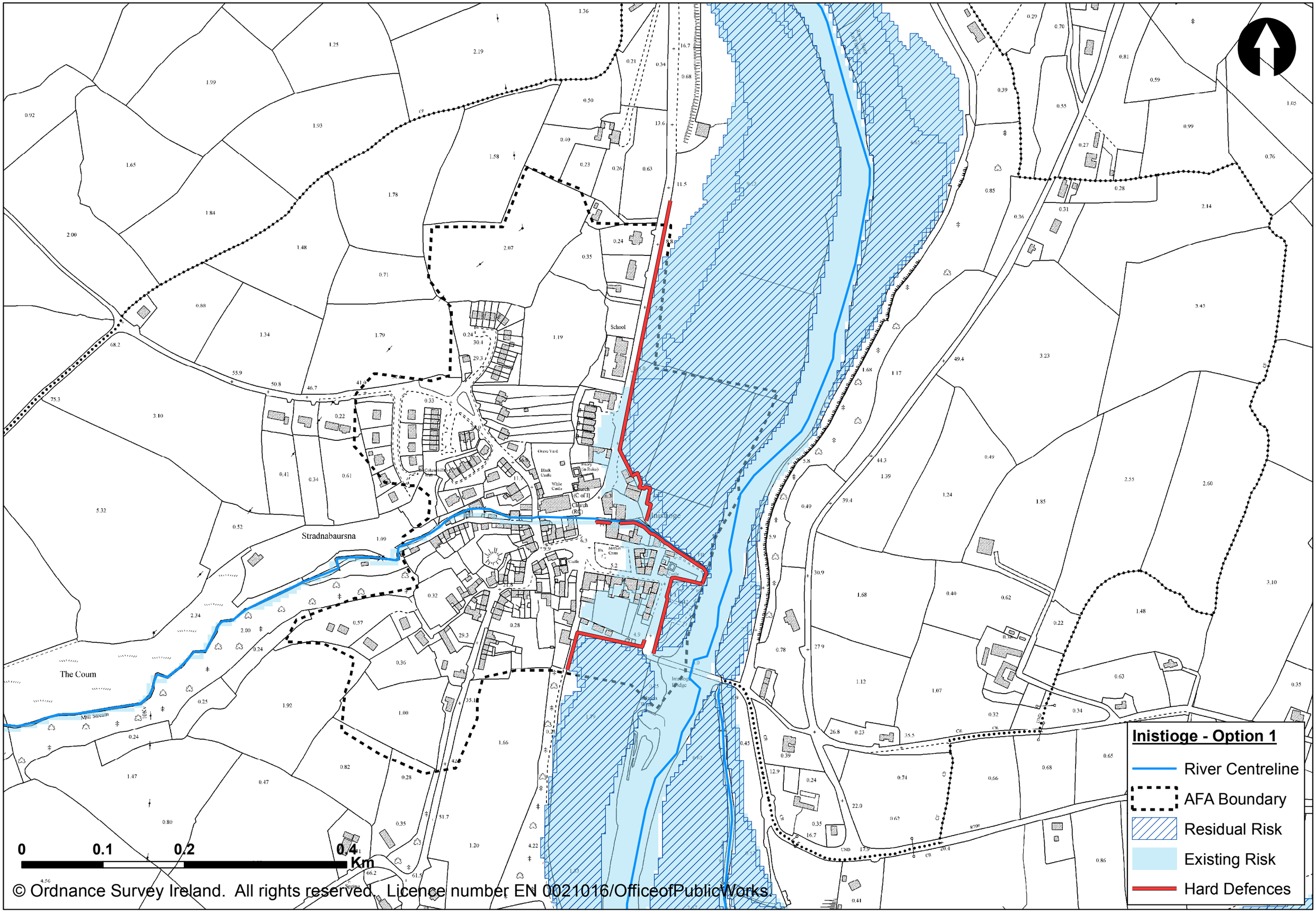
Environmental Score	-391

Option Comparison
Inistioge

Option No.	MCA Appraisal Scores				TOTAL - MCA Benefit Score	Cost (€millions)	MCA Score / Cost	BCR
	Technical	Social	Economic	Environ / Cultural				
Option 1	700	905	827	-391	1341	1.490	900.107	4.394







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Appendix E

Mountrath AFA
Additional Information

List of background information included:

1. Costings
- Option 1 – Whole Life Cost
- Option 2 – Whole Life Cost

2. MCA
- Option 1 - Hard Defences & Improvement of Channel Conveyance (FC3)
- Option 2 - Hard Defences & Improvement of Channel Conveyance (FC1&3)

3. Potential Option drawings
- Option 1 - Hard Defences & Improvement of Channel Conveyance (FC3)
- Option 2 - Hard Defences & Improvement of Channel Conveyance (FC1&3)

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	**David Irwin**	**Date:**	**03/05/2016**
Checked by:	**Mark Wilson**	**Date:**	**03/05/2016**

Project reference	IBE0601	**Project name:**	SE CFRAM Study_Mountrath_Option 1

Base date for estimates (year 0)	Oct-2013	**Construction Price Index (CPI)**	**1.000**
Scaling factor (e.g. €m, €k, €)	€	**Method Factor - to take into account particular site issues /constraints**	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	**Cost (€)**	**Comment**
Total wall costs	€739,099.00	*473m of wall*
Total embankment costs	€69,683.00	*434m of embankment*
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs	€140,455.00	*112m 2.0x0.9m box culvert*
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€949,237	
Apply update to unit rate (CPI) if appropriate (cell N15)	€949,237	
Enter appropriate preliminaries estimate (%)	20%	
Sub Total	€1,139,084	
Optimism Bias	45%	*In channel*
Total capital cost (€)	€1,651,672	
Consider amendments based on site issues/constraints (cell N16)	€1,651,672	
Total capital cost (€)	€1,651,672	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs	€189.00	*length * 0.4*
Total embankment O&M costs	€1,390.00	*length * 3.2*
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs	€8,960.00	*Average cost used*
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€10,539	
NPV O&M	€224,918	
Optimism Bias	45%	
NPV O&M with Optimism Bias	€326,131	

Other costs	**Cost (€)**	**Comment**
Other costs (design, supervision, archaeology, environment, site investigation, art)	€671,459	*Design and supervision (13%), Archaeology and environment (10%), Land (10%), Site investigation (€100,000), Art (€25,500), Works Access (€1/m)*

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€2,649,262	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€1,651,672.4
Annual maintenance cost (€)	€10,539.0
Other cost (€)	€671,458.9
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**	**Total PVc (€k):**		**1876590**
	Cash sum	0	1651672	516411	0	2168083	**1876590**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	1651672			1651672.4	1651672.4
1	0.961538			10539		10539.0	10133.7
2	0.925			10539		10539.0	9743.9
3	0.889			10539		10539.0	9369.1
4	0.855			10539		10539.0	9008.8
5	0.822			10539		10539.0	8662.3
6	0.790			10539		10539.0	8329.1
7	0.760			10539		10539.0	8008.8
8	0.731			10539		10539.0	7700.7
9	0.703			10539		10539.0	7404.6
10	0.676			10539		10539.0	7119.8
11	0.650			10539		10539.0	6845.9
12	0.625			10539		10539.0	6582.6
13	0.601			10539		10539.0	6329.5
14	0.577			10539		10539.0	6086.0
15	0.555			10539		10539.0	5851.9
16	0.534			10539		10539.0	5626.9
17	0.513			10539		10539.0	5410.4
18	0.494			10539		10539.0	5202.3
19	0.475			10539		10539.0	5002.3
20	0.456			10539		10539.0	4809.9
21	0.439			10539		10539.0	4624.9
22	0.422			10539		10539.0	4447.0
23	0.406			10539		10539.0	4275.9
24	0.390			10539		10539.0	4111.5
25	0.375			10539		10539.0	3953.4
26	0.361			10539		10539.0	3801.3
27	0.347			10539		10539.0	3655.1
28	0.333			10539		10539.0	3514.5
29	0.321			10539		10539.0	3379.3
30	0.308			10539		10539.0	3249.4
31	0.296			10539		10539.0	3124.4
32	0.285			10539		10539.0	3004.2
33	0.274			10539		10539.0	2888.7
34	0.264			10539		10539.0	2777.6
35	0.253			10539		10539.0	2670.7
36	0.244			10539		10539.0	2568.0
37	0.234			10539		10539.0	2469.3
38	0.225			10539		10539.0	2374.3
39	0.217			10539		10539.0	2283.0
40	0.208			10539		10539.0	2195.2
41	0.200			10539		10539.0	2110.7
42	0.193			10539		10539.0	2029.5
43	0.185			10539		10539.0	1951.5
44	0.178			10539		10539.0	1876.4
45	0.171			10539		10539.0	1804.3
46	0.165			10539		10539.0	1734.9
47	0.158			10539		10539.0	1668.1
48	0.152			10539		10539.0	1604.0
49	0.146			10539		10539.0	1542.3
							224917.8

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	**David Irwin**	**Date:**	**04/05/2016**
Checked by:	**Mark Wilson**	**Date:**	**04/05/2016**

Project reference	IBE0601	**Project name:**	SE CFRAM Study_Mountrath_Option 2

Base date for estimates (year 0)	Oct-2013	**Construction Price Index (CPI)**	**1.000**
Scaling factor (e.g. €m, €k, €)	€	**Method Factor - to take into account particular site issues /constraints**	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	**Cost (€)**	**Comment**
Total wall costs	€701,319.00	*441m of wall*
Total embankment costs	€69,810.00	*434m of embankment*
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs	€13,463.00	*393m3 of material removal*
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs	€144,844.00	*112m 2.0x0.9m box culvert + 4m 2.0mx0.8 culvert*
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€929,436	
Apply update to unit rate (CPI) if appropriate (cell N15)	€929,436	
Enter appropriate preliminaries estimate (%)	20%	
Sub Total	€1,115,323	
Optimism Bias	45%	*In channel*
Total capital cost (€)	€1,617,219	
Consider amendments based on site issues/constraints (cell N16)	€1,617,219	
Total capital cost (€)	€1,617,219	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs	€176.00	*length * 0.4*
Total embankment O&M costs	€1,392.00	*length * 3.2*
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs	€11,247.00	*Average cost used*
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€12,815	
NPV O&M	€273,491	
Optimism Bias	45%	
NPV O&M with Optimism Bias	€396,562	

Other costs	**Cost (€)**	**Comment**
Other costs (design, supervision, archaeology, environment, site investigation, art)	€660,057	*Design and supervision (13%), Archaeology and environment (10%), Land (10%), Site investigation (€100,000), Art (€25,500), Works Access (€1/m)*

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€2,673,838	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€1,617,218.6
Annual maintenance cost (€)	€12,815.0
Other cost (€)	€660,057.2
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**	**Total PVc (€k):**		**1890710**
	Cash sum	0	1617219	627935	0	2245154	**1890710**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	1617219			1617218.6	1617218.6
1	0.961538			12815		12815.0	12322.1
2	0.925			12815		12815.0	11848.2
3	0.889			12815		12815.0	11392.5
4	0.855			12815		12815.0	10954.3
5	0.822			12815		12815.0	10533.0
6	0.790			12815		12815.0	10127.9
7	0.760			12815		12815.0	9738.3
8	0.731			12815		12815.0	9363.8
9	0.703			12815		12815.0	9003.6
10	0.676			12815		12815.0	8657.4
11	0.650			12815		12815.0	8324.4
12	0.625			12815		12815.0	8004.2
13	0.601			12815		12815.0	7696.4
14	0.577			12815		12815.0	7400.3
15	0.555			12815		12815.0	7115.7
16	0.534			12815		12815.0	6842.0
17	0.513			12815		12815.0	6578.9
18	0.494			12815		12815.0	6325.8
19	0.475			12815		12815.0	6082.5
20	0.456			12815		12815.0	5848.6
21	0.439			12815		12815.0	5623.7
22	0.422			12815		12815.0	5407.4
23	0.406			12815		12815.0	5199.4
24	0.390			12815		12815.0	4999.4
25	0.375			12815		12815.0	4807.1
26	0.361			12815		12815.0	4622.2
27	0.347			12815		12815.0	4444.5
28	0.333			12815		12815.0	4273.5
29	0.321			12815		12815.0	4109.1
30	0.308			12815		12815.0	3951.1
31	0.296			12815		12815.0	3799.1
32	0.285			12815		12815.0	3653.0
33	0.274			12815		12815.0	3512.5
34	0.264			12815		12815.0	3377.4
35	0.253			12815		12815.0	3247.5
36	0.244			12815		12815.0	3122.6
37	0.234			12815		12815.0	3002.5
38	0.225			12815		12815.0	2887.0
39	0.217			12815		12815.0	2776.0
40	0.208			12815		12815.0	2669.2
41	0.200			12815		12815.0	2566.6
42	0.193			12815		12815.0	2467.8
43	0.185			12815		12815.0	2372.9
44	0.178			12815		12815.0	2281.7
45	0.171			12815		12815.0	2193.9
46	0.165			12815		12815.0	2109.5
47	0.158			12815		12815.0	2028.4
48	0.152			12815		12815.0	1950.4
49	0.146			12815		12815.0	1875.4
							273491.0

Option Appraisal and the Multi-Criteria Analysis

Name of modeller	**Laura Howe**
Name of assessor	**David Irwin**
Date of Assessment	**05/05/2016**
Option ID	**Option 1**
Option Type	Structural Option
Option Location	Mountrath
Option Details	Hard Defences Improvement of Channel Conveyance (FC3)
AEP	1.0%
Option Cost	€2,649,262.00
Economic Benefit	€1,546,066.00

Multi-Criteria Analysis Summary

Mountrath Option 1

1. Technical Criteria

Objective 1.A	Ensure flood risk management options are operationally robust	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Level of risk score	4	*Regular monitoring and intermittent maintenance required*
Adjustment	No adjustment	*The level of risk score has not been adjusted*
Total Option Score	4.0	*Option score + adjustment*
Weighted Option Score	**400**	*Global weighting x Local weighting x Total option score*

Objective 1.B	Minimise health and safety risk in construction, maintenance and operation of the flood risk management option	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Option Score	2.0	*The following hazards have been identified: Working near water (contruction), Heavy plant & machinery (construction), Working near water (O&M)*
Adjustment	0.0	*There have been no adjustments made to the option score*
Total Option Score	2.0	*Option score + adjustment*
Weighted Option Score	**200**	*Global weighting x Local weighting x Total option score*

Objective 1.C	Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Adaptability Score	1	*Option is adaptable only at significant cost*
Adjustment	No adjustment	*The adaptability score has not been adjusted*
Total Option Score	1.0	*Option score + adjustment*
Weighted Option Score	**100**	*Global weighting x Local weighting x Total option score*

Technical Score	700

Multi-Criteria Analysis Summary

Mountrath Option 1

2. Economic Criteria

Objective 2.A	Reduce economic damages	
Assigned Weightings		
Global Weighting	24.0	*Nationally Constant Value*
Local Weighting	1.0	*AAD for the SSA / €75,000*
AAD for the SSA	€ 52,273.00	*Baseline Scenario*
Option Scoring		
Reduced AAD	€ 16,865.00	*Defended Scenario*
Total Option Score	3.4	*0.05 X Percentage Reduction in AAD*
Weighted Option Score	**81**	*Global weighting x Local weighting x Total option score*

Objective 2.B	Minimise risk to transport infrastructure	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	44.5	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	1.6	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.8	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the option score*
Total Option Score	4.8	*Option score + adjustment*
Weighted Option Score	**241**	*Global weighting x Local weighting x Total option score*

Objective 2.C	Minimise risk to utility infrastructure	
Assigned Weightings		
Global Weighting	14.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	1.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	0.0	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	0.0	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the total option score*
Total Option Score	0.0	*Option score + adjustment*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 2.D	Manage risk to agriculture	
Assigned Weightings		
Global Weighting	12.0	*Nationally Constant Value*
Local Weighting	3.0	*Agriculture is the predominant landuse in the county, with pasture land for beef production being most common. Much of the AFA is urbanised, however the periphery of the AFA and the general area is in pasture land, with smaller pockets of bog and forest land.*
Option Scoring		
Total Option Score	0	*No change to flooding of agricultural land.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Economic Score	322

Multi-Criteria Analysis Summary

Mountrath Option 1

3. Social Criteria

Objective 3.A (i)	Minimise risk to human health and life - Residents	
Assigned Weightings		
Global Weighting	27.0	*Nationally Constant Value*
Local Weighting	4.8	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No adjustment*
Capped Local Weighting	4.8	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.5	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	4	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**582**	*Global weighting x Local weighting x Total option score*

Objective 3.A (ii)	Minimise risk to human health and life - High vulnerability properties	
Assigned Weightings		
Global Weighting	17.0	*Nationally Constant Value*
Local Weighting	0.1	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	1.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.1	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 3.B (i)	Minimise risk to community - Social Infrastructure and Amenity	
Assigned Weightings		
Global Weighting	9.0	*Nationally Constant Value*
Local Weighting	25.4	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	25.4	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Enhancement or Creation of Social Amenity Sites	0.0	*Adjustment in relation to the Enhancement or creation of social amenity sites (Structural Option)*
Total Option Score	0.0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 3.B (ii)	Minimise risk to community - Local Employment	
Assigned Weightings		
Global Weighting	7.0	*Nationally Constant Value*
Local Weighting	0.9	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	1.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.3	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	3.4	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**24**	*Global weighting x Local weighting x Total option score*

Social Score	605

Multi-Criteria Analysis Summary

Mountrath Option 1

4. Environmental Criteria

Objective 4.A	Support the objectives of the WFD	
Assigned Weightings		
Global Weighting	16.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Total Option Score	-3	*Construction phase impacts from creation of walls and embankments set back from sensitive Mountrath River. Potential for some excavation and restoration of banks. Culverting lower end of non-sensitive Shannon Stream, with permanent impacts. Construction phase impacts can be mitigated for with good planning, appropriate timing of works and good construction practice. Increased flows during flood events. Reduced flood risk from 1% AEP events.*
Weighted Option Score	**-240**	*Global weighting x Local weighting x Total option score*

Objective 4.B	Support the objectives of the Habitats and Birds Directives	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	5.0	*The River Barrow and River Nore SAC is within, upstream of and downstream of Mountrath. The River Nore SPA is 3km downstream of the AFA, while the Slieve Bloom Mountains SPA is over 4km upstream, along with the Slieve Bloom Mountains SAC. The Coolrain Bog SAC and Knockacoller Bog SAC are over 7km and 3km west of Mountrath respectively, however are not hydraulically linked to the AFA.*
Option Scoring		
Total Option Score	-3	*Potential for direct construction phase disturbance impacts from construction of walls and embankments and culverting of Shannon Stream adjacent to and upstream of the River Barrow and River Nore SAC. Potential for indirect impacts to SAC from sedimentation during construction. Construction impacts can be mitigated for with good planning, appropriate timing of works and good construction practice. Embankments and walls should be set back from watercourse as far as possible.*
Weighted Option Score	**-150**	*Global weighting x Local weighting x Total option score*

Objective 4.C	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	
Assigned Weightings		
Global Weighting	5.0	*Nationally Constant Value*
Local Weighting	5.0	*The AFA is within the Nore Freshwater Pearl Mussel catchment and the Nore Upper FPM sensitive area. Known FPM habitats are located 12km downstream of the AFA, on the River Nore. The Slieve Bloom Mountains Nature Reserve is over 7km upcatchment of the AFA. The Slieve Bloom Mountains pNHA is over 4km upstream of the AFA. The Forest House Wood pNHA, the Shanahoe Marsh pNHA and the River Nore / Abbeylix Woods Complex pNHA are 3km, 9km and 12km downstream of the AFA respectively, on the River Nore*
Option Scoring		
Total Option Score	-2.0	*Slight potential for indirect downstream impacts to Nore Freshwater Pearl Mussel sensitive area from sedimentation during construction. Potential localised loss and disturbance to flora and fauna in footprint of works in urban and semi-rural areas. No designations in vicinity. Construction impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-50**	*Global weighting x Local weighting x Total option score*

Objective 4.D	Protect and where possible enhance fisheries resource within the catchment (Inland Fisheries Only)	
Assigned Weightings		
Global Weighting	13.0	*Nationally Constant Value*
Local Weighting	2.0	*Trout fishing on the Mountrath River downstream of Mountrath. Salmon and trout fishing on the River Nore, downstream of Mountrath River, however mainly on the lower stretches. Local fishing activity at Mountrath.*
Option Scoring		
Total Option Score	-2.0	*Slight potential for indirect downstream impacts to River Nore fisheries and local fishing activity on Mountrath River from sedimentation during construction. Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-52**	*Global weighting x Local weighting x Total option score*

Objective 4.E	Protect, and where possible enhance, landscape character and visual amenity within the zone of influence	
Assigned Weightings		
Global Weighting	8.0	*Nationally Constant Value*
Local Weighting	3.0	*The Laois County LCA 2012-2018 places Mountrath as a river corridor in the lowland agricultural area of the county. The LCA recognises river corridors for scenic value, recreation, ecology, history and culture. The LCA looks to preserve and conserve these river corridors.*
Option Scoring		
Total Option Score	-4.0	*Construction phase and permanent impacts in sensitive river corridor landscape. Creation of hard defences prior to establishment of screening. Localised impacts to views for those to be protected.*
Weighted Option Score	**-96**	*Global weighting x Local weighting x Total option score*

Objective 4.F (i)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	3.0	*Mountrath is considered a historic town. There are 25 NIAH buildings of regional importance within the AFA, many of which are in close proximity to the Mountrath River.*
Option Scoring		
Total Option Score	1.0	*Protection to 1 NIAH building from severe flooding.*
Weighted Option Score	**12**	*Global weighting x Local weighting x Total option score*

Objective 4.F (ii)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	2.0	*Mountrath is considered a historic town. There are 2 monuments within the AFA with no specific protection, which are of low vulnerability to flooding. There are no monuments in the AFA with preservation orders or that are in state care.*
Option Scoring		
Total Option Score	0.0	*No effects on archaeological features.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Environmental Score	-576

Option Appraisal and the Multi-Criteria Analysis

Name of modeller	**Laura Howe**
Name of assessor	**David Irwin**
Date of Assessment	**05/05/2016**
Option ID	**Option 2**
Option Type	Structural Option
Option Location	Mountrath
Option Details	Hard Defences Improvement of Channel Conveyance (FC1&3)
AEP	1.0%
Option Cost	€2,673,838.00
Economic Benefit	€1,546,066.00

Multi-Criteria Analysis Summary

Mountrath Option 2

1. Technical Criteria

Objective 1.A	Ensure flood risk management options are operationally robust	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Level of risk score	4	*Regular monitoring and intermittent maintenance required*
Adjustment	No adjustment	*The level of risk score has not been adjusted*
Total Option Score	4.0	*Option score + adjustment*
Weighted Option Score	**400**	*Global weighting x Local weighting x Total option score*

Objective 1.B	Minimise health and safety risk in construction, maintenance and operation of the flood risk management option	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Option Score	2.0	*The following hazards have been identified: Working near water (contruction), Heavy plant & machinery (construction), Working near water (O&M)*
Adjustment	0.0	*There have been no adjustments made to the option score*
Total Option Score	2.0	*Option score + adjustment*
Weighted Option Score	**200**	*Global weighting x Local weighting x Total option score*

Objective 1.C	Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Adaptability Score	1	*Option is adaptable only at significant cost*
Adjustment	No adjustment	*The adaptability score has not been adjusted*
Total Option Score	1.0	*Option score + adjustment*
Weighted Option Score	**100**	*Global weighting x Local weighting x Total option score*

Technical Score	700

Multi-Criteria Analysis Summary

Mountrath Option 2

2. Economic Criteria

Objective 2.A	Reduce economic damages	
Assigned Weightings		
Global Weighting	24.0	*Nationally Constant Value*
Local Weighting	1.0	*AAD for the SSA / €75,000*
AAD for the SSA	€ 52,273.00	*Baseline Scenario*
Option Scoring		
Reduced AAD	€ 16,865.00	*Defended Scenario*
Total Option Score	3.4	*0.05 X Percentage Reduction in AAD*
Weighted Option Score	**81**	*Global weighting x Local weighting x Total option score*

Objective 2.B	Minimise risk to transport infrastructure	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	44.5	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	1.6	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.8	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the option score*
Total Option Score	4.8	*Option score + adjustment*
Weighted Option Score	**241**	*Global weighting x Local weighting x Total option score*

Objective 2.C	Minimise risk to utility infrastructure	
Assigned Weightings		
Global Weighting	14.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	1.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	0.0	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	0.0	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the total option score*
Total Option Score	0.0	*Option score + adjustment*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 2.D	Manage risk to agriculture	
Assigned Weightings		
Global Weighting	12.0	*Nationally Constant Value*
Local Weighting	3.0	*Agriculture is the predominant landuse in the county, with pasture land for beef production being most common. Much of the AFA is urbanised, however the periphery of the AFA and the general area is in pasture land, with smaller pockets of bog and forest land.*
Option Scoring		
Total Option Score	0	*No change to flooding of agricultural land.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Economic Score	322

Multi-Criteria Analysis Summary

Mountrath Option 2

3. Social Criteria

Objective 3.A (i)	Minimise risk to human health and life - Residents	
Assigned Weightings		
Global Weighting	27.0	*Nationally Constant Value*
Local Weighting	4.8	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No adjustment*
Capped Local Weighting	4.8	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.5	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	4	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**582**	*Global weighting x Local weighting x Total option score*

Objective 3.A (ii)	Minimise risk to human health and life - High vulnerability properties	
Assigned Weightings		
Global Weighting	17.0	*Nationally Constant Value*
Local Weighting	0.1	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	1.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.1	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 3.B (i)	Minimise risk to community - Social Infrastructure and Amenity	
Assigned Weightings		
Global Weighting	9.0	*Nationally Constant Value*
Local Weighting	25.4	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	25.4	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Enhancement or Creation of Social Amenity Sites	0.0	*Adjustment in relation to the Enhancement or creation of social amenity sites (Structural Option)*
Total Option Score	0.0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 3.B (ii)	Minimise risk to community - Local Employment	
Assigned Weightings		
Global Weighting	7.0	*Nationally Constant Value*
Local Weighting	0.9	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	1.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.3	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	3.4	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**24**	*Global weighting x Local weighting x Total option score*

Social Score	605

Multi-Criteria Analysis Summary

Mountrath Option 2

4. Environmental Criteria

Objective 4.A	Support the objectives of the WFD	
Assigned Weightings		
Global Weighting	16.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Total Option Score	-4	*Construction phase impacts from creation of walls and embankments set back from sensitive Mountrath River. Potential for some excavation and restoration of banks. Culverting lower end of non-sensitive Shannon Stream and increasing conveyance on Cole River. Permanent and recurring impacts from conveyance works. Construction phase impacts can be mitigated for with good planning, appropriate timing of works and good construction practice. Increased flows during flood events. Reduced flood risk from 1% AEP events.*
Weighted Option Score	**-320**	*Global weighting x Local weighting x Total option score*

Objective 4.B	Support the objectives of the Habitats and Birds Directives	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	5.0	*The River Barrow and River Nore SAC is within, upstream of and downstream of Mountrath. The River Nore SPA is 3km downstream of the AFA, while the Slieve Bloom Mountains SPA is over 4km upstream, along with the Slieve Bloom Mountains SAC. The Coolrain Bog SAC and Knockacoller Bog SAC are over 7km and 3km west of Mountrath respectively, however are not hydraulically linked to the AFA.*
Option Scoring		
Total Option Score	-3	*Potential for direct construction phase disturbance impacts from construction of walls and embankments, culverting of Shannon Stream and conveyance works on Cole River, adjacent to and upstream of the River Barrow and River Nore SAC. Potential for indirect impacts to SAC from sedimentation during construction. Construction impacts can be mitigated for with good planning, appropriate timing of works and good construction practice. Embankments and walls should be set back from watercourse as far as possible.*
Weighted Option Score	**-150**	*Global weighting x Local weighting x Total option score*

Objective 4.C	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	
Assigned Weightings		
Global Weighting	5.0	*Nationally Constant Value*
Local Weighting	5.0	*The AFA is within the Nore Freshwater Pearl Mussel catchment and the Nore Upper FPM sensitive area. Known FPM habitats are located 12km downstream of the AFA, on the River Nore. The Slieve Bloom Mountains Nature Reserve is over 7km upcatchment of the AFA. The Slieve Bloom Mountains pNHA is over 4km upstream of the AFA. The Forest House Wood pNHA, the Shanahoe Marsh pNHA and the River Nore / Abbeylix Woods Complex pNHA are 3km, 9km and 12km downstream of the AFA respectively, on the River Nore*
Option Scoring		
Total Option Score	-3.0	*Slight potential for indirect downstream impacts to Nore Freshwater Pearl Mussel sensitive area from sedimentation during construction. Increased sedimentation potential with conveyance works. Potential localised loss and disturbance to flora and fauna in footprint of works in urban and semi-rural areas. No designations in vicinity. Construction impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-75**	*Global weighting x Local weighting x Total option score*

Objective 4.D	Protect and where possible enhance fisheries resource within the catchment (Inland Fisheries Only)	
Assigned Weightings		
Global Weighting	13.0	*Nationally Constant Value*
Local Weighting	2.0	*Trout fishing on the Mountrath River downstream of Mountrath. Salmon and trout fishing on the River Nore, downstream of Mountrath River, however mainly on the lower stretches. Local fishing activity at Mountrath.*
Option Scoring		
Total Option Score	-3.0	*Slight potential for indirect downstream impacts to River Nore fisheries and local fishing activity on Mountrath River from sedimentation during construction. Increased sedimentation potential with conveyance works. Construction impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-78**	*Global weighting x Local weighting x Total option score*

Objective 4.E	Protect, and where possible enhance, landscape character and visual amenity within the zone of influence	
Assigned Weightings		
Global Weighting	8.0	*Nationally Constant Value*
Local Weighting	3.0	*The Laois County LCA 2012-2018 places Mountrath as a river corridor in the lowland agricultural area of the county. The LCA recognises river corridors for scenic value, recreation, ecology, history and culture. The LCA looks to preserve and conserve these river corridors.*
Option Scoring		
Total Option Score	-4.0	*Construction phase and permanent impacts in sensitive river corridor landscape. Creation of hard defences prior to establishment of screening. Localised impacts to views for those to be protected.*
Weighted Option Score	**-96**	*Global weighting x Local weighting x Total option score*

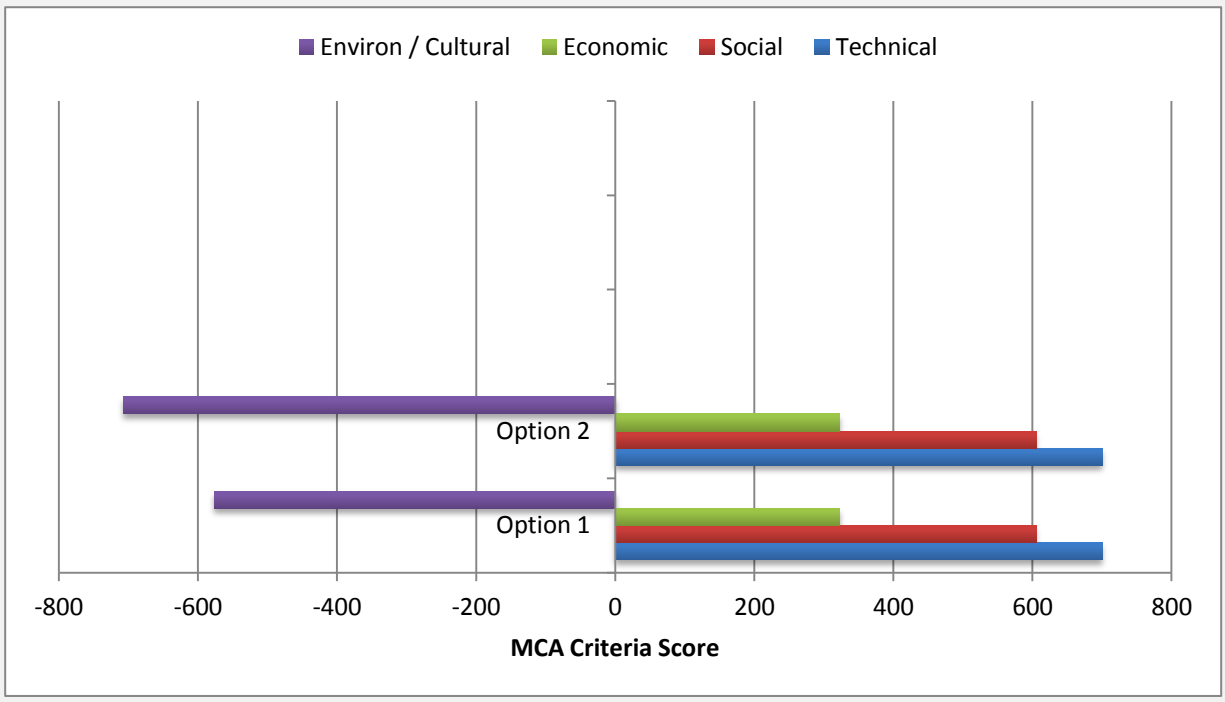
Objective 4.F (i)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	3.0	*Mountrath is considered a historic town. There are 25 NIAH buildings of regional importance within the AFA, many of which are in close proximity to the Mountrath River.*
Option Scoring		
Total Option Score	1.0	*Protection to 1 NIAH building from severe flooding.*
Weighted Option Score	**12**	*Global weighting x Local weighting x Total option score*

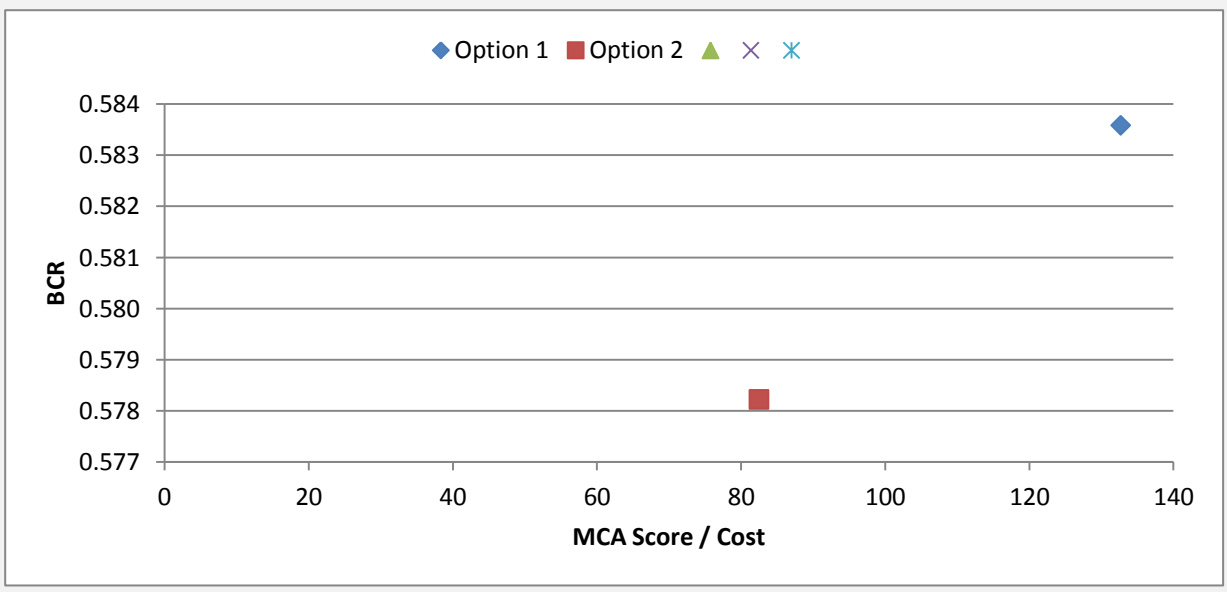
Objective 4.F (ii)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	2.0	*Mountrath is considered a historic town. There are 2 monuments within the AFA with no specific protection, which are of low vulnerability to flooding. There are no monuments in the AFA with preservation orders or that are in state care.*
Option Scoring		
Total Option Score	0.0	*No effects on archaeological features.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

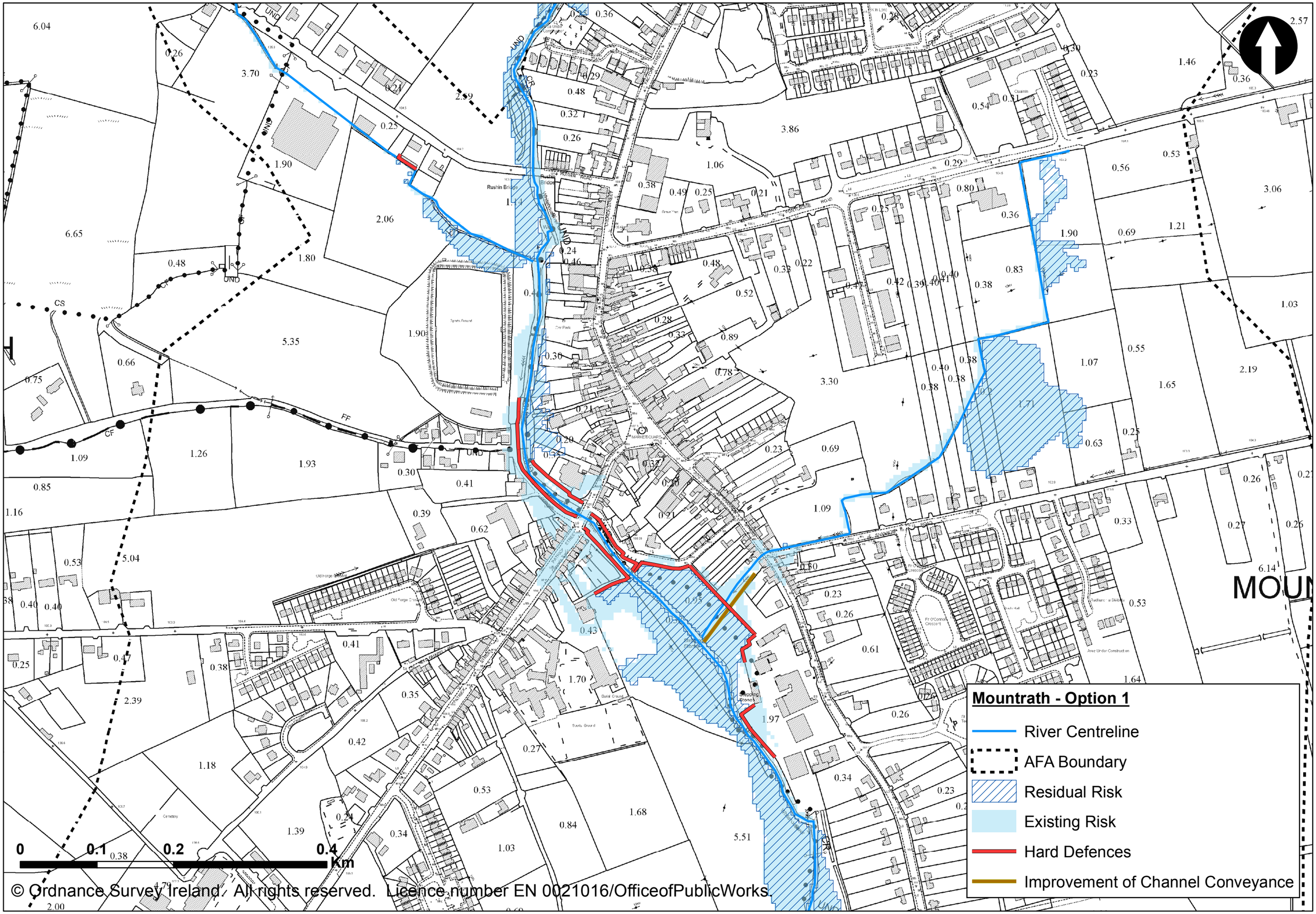
Environmental Score	-707

Option Comparison
Mountrath

Option No.	MCA Appraisal Scores				TOTAL - MCA Benefit Score	Cost (€millions)	MCA Score / Cost	BCR
	Technical	Social	Economic	Environ / Cultural				
Option 1	700	605	322	-576	352	2.649	132.688	0.584
Option 2	700	605	322	-707	221	2.674	82.4756	0.578







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Mountrath - Option 2

- River Centreline
- AFA Boundary
- Residual Risk
- Existing Risk
- Hard Defences
- Improvement of Channel Conveyance

0 0.1 0.2 0.4 Km

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Appendix F

Rathdowney AFA Additional Information

List of background information included:

1. Costings
- Option 1 – Whole Life Cost

2. MCA
- Option 1 – Storage & Hard Defences

3. Potential Option drawings
- Option 1 - Storage & Hard Defences

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	**Jennifer Canavan**	**Date:**	**04/04/2016**
Checked by:	**Mark Wilson**	**Date:**	**04/04/2016**

Project reference	IBE0601	**Project name:**	SE CFRAM Study_Rathdowney_Option 1 - Storage

Base date for estimates (year 0)	Oct-2013	**Construction Price Index (CPI)**	**1.000**
Scaling factor (e.g. €m, €k, €)	€	**Method Factor - to take into account particular site issues /constraints**	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		-

Capital costs	**Cost (€)**	**Comment**
Total wall costs	€1,084,593.00	*453m average height 1.97*
Total embankment costs	€919,493.00	*455m of 10m piled flood embankment for Storage + 250m standard embankments*
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs	€36,254.00	*storage control structures*
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs	€89,539.00	*storage control structures*
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€2,129,879	
Apply update to unit rate (CPI) if appropriate (cell N15)	€2,129,879	
Enter appropriate preliminaries estimate (%)	16%	
Sub Total	€2,470,660	
Optimism Bias	45%	*In channel*
Total capital cost (€)	€3,582,456	
Consider amendments based on site issues/constraints (cell N16)	€3,582,456	
Total capital cost (€)	€3,582,456	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs	€181.00	*0.4 * length of wall*
Total embankment O&M costs	€2,259.00	*3.2 * total length of embankment*
Total automatic gate O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs	€2,730.00	
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs	€398.00	
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€5,568	
NPV O&M	€118,829	
Optimism Bias	45%	
NPV O&M with Optimism Bias	€172,303	

Other costs	**Cost (€)**	**Comment**
Other costs (design, supervision, archaeology, environment, site investigation, art)	€1,321,370	*Design and supervision (13%), Archaeology and environment (10%), Land (10%), Site investigation (€100,000), Art (€38,000), Works access and Haul roads*

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€5,076,129	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€3,582,456.5
Annual maintenance cost (€)	€5,568.0
Other cost (€)	€1,321,369.6
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**	**Total PVc (€k):**		**3701286**
	Cash sum	0	3582456	272832	0	3855288	**3701286**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	3582456			3582456.5	3582456.5
1	0.961538			5568		5568.0	5353.8
2	0.925			5568		5568.0	5147.9
3	0.889			5568		5568.0	4949.9
4	0.855			5568		5568.0	4759.5
5	0.822			5568		5568.0	4576.5
6	0.790			5568		5568.0	4400.5
7	0.760			5568		5568.0	4231.2
8	0.731			5568		5568.0	4068.5
9	0.703			5568		5568.0	3912.0
10	0.676			5568		5568.0	3761.5
11	0.650			5568		5568.0	3616.9
12	0.625			5568		5568.0	3477.8
13	0.601			5568		5568.0	3344.0
14	0.577			5568		5568.0	3215.4
15	0.555			5568		5568.0	3091.7
16	0.534			5568		5568.0	2972.8
17	0.513			5568		5568.0	2858.5
18	0.494			5568		5568.0	2748.5
19	0.475			5568		5568.0	2642.8
20	0.456			5568		5568.0	2541.2
21	0.439			5568		5568.0	2443.4
22	0.422			5568		5568.0	2349.4
23	0.406			5568		5568.0	2259.1
24	0.390			5568		5568.0	2172.2
25	0.375			5568		5568.0	2088.7
26	0.361			5568		5568.0	2008.3
27	0.347			5568		5568.0	1931.1
28	0.333			5568		5568.0	1856.8
29	0.321			5568		5568.0	1785.4
30	0.308			5568		5568.0	1716.7
31	0.296			5568		5568.0	1650.7
32	0.285			5568		5568.0	1587.2
33	0.274			5568		5568.0	1526.2
34	0.264			5568		5568.0	1467.5
35	0.253			5568		5568.0	1411.0
36	0.244			5568		5568.0	1356.7
37	0.234			5568		5568.0	1304.6
38	0.225			5568		5568.0	1254.4
39	0.217			5568		5568.0	1206.1
40	0.208			5568		5568.0	1159.8
41	0.200			5568		5568.0	1115.1
42	0.193			5568		5568.0	1072.3
43	0.185			5568		5568.0	1031.0
44	0.178			5568		5568.0	991.4
45	0.171			5568		5568.0	953.2
46	0.165			5568		5568.0	916.6
47	0.158			5568		5568.0	881.3
48	0.152			5568		5568.0	847.4
49	0.146			5568		5568.0	814.8
							118829.3

Option Appraisal and the Multi-Criteria Analysis

Name of modeller	**Jennifer Canavan**
Name of assessor	**Jennifer Canavan**
Date of Assessment	**31/03/2016**
Option ID	**Option 1**
Option Type	Structural Option
Option Location	Rathdowney
Option Details	Storage & Hard Defences
AEP	1.0%
Option Cost	€5,076,129.00
Economic Benefit	€8,488,850.00

Multi-Criteria Analysis Summary

Rathdowney Option 1

1. Technical Criteria

Objective 1.A	Ensure flood risk management options are operationally robust	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Level of risk score	3	*There is a requirement for simple systems or interventions for the option to operate, with regular monitoring and maintenance required, but a very low likelihood of system / operation failure*
Adjustment	No adjustment	*The level of risk score has not been adjusted*
Total Option Score	3.0	*Option score + adjustment*
Weighted Option Score	**300**	*Global weighting x Local weighting x Total option score*

Objective 1.B	Minimise health and safety risk in construction, maintenance and operation of the flood risk management option	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Option Score	2.0	*The following hazards have been identified: Working Near Water , Working Near Water , Heavy Plant Machinery*
Adjustment	0.0	*There have been no adjustments made to the option score*
Total Option Score	2.0	*Option score + adjustment*
Weighted Option Score	**200**	*Global weighting x Local weighting x Total option score*

Objective 1.C	Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Adaptability Score		*#N/A*
Adjustment	No adjustment	*The adaptability score has not been adjusted*
Total Option Score	0.0	*Option score + adjustment*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Technical Score	500

Multi-Criteria Analysis Summary

Rathdowney Option 1

2. Economic Criteria

Objective 2.A	Reduce economic damages	
Assigned Weightings		
Global Weighting	24.0	*Nationally Constant Value*
Local Weighting	5.0	*AAD for the SSA / €75,000*
AAD for the SSA	€ 4,614,830.97	*Baseline Scenario*
Option Scoring		
Reduced AAD	€ 809,948.80	*Defended Scenario*
Total Option Score	4.1	*0.05 X Percentage Reduction in AAD*
Weighted Option Score	**495**	*Global weighting x Local weighting x Total option score*

Objective 2.B	Minimise risk to transport infrastructure	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	24.7	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	1.0	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.8	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the option score*
Total Option Score	4.8	*Option score + adjustment*
Weighted Option Score	**240**	*Global weighting x Local weighting x Total option score*

Objective 2.C	Minimise risk to utility infrastructure	
Assigned Weightings		
Global Weighting	14.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	1.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	0.0	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	0.0	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the total option score*
Total Option Score	0.0	*Option score + adjustment*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 2.D	Manage risk to agriculture	
Assigned Weightings		
Global Weighting	12.0	*Nationally Constant Value*
Local Weighting	3.0	*The AFA is a mix of urban and pasture land, while the surrounding area is dominated by pasture land. Large areas of bogland upstream of Rathdowney and recreational land downstream would limit agricultural production in the vicinity.*
Option Scoring		
Total Option Score	-1	*Downstream of the storage area flood waters are reduced to 50% & 5% AEP flows and kept inchannel. However the storage areas themselves represent an increase in flooded agricultural land.*
Weighted Option Score	**-36**	*Global weighting x Local weighting x Total option score*

Economic Score	698

Multi-Criteria Analysis Summary

Rathdowney Option 1

3. Social Criteria

Objective 3.A (i)	Minimise risk to human health and life - Residents	
Assigned Weightings		
Global Weighting	27.0	*Nationally Constant Value*
Local Weighting	3.8	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No adjustment*
Capped Local Weighting	3.8	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.3	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	5	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**463**	*Global weighting x Local weighting x Total option score*

Objective 3.A (ii)	Minimise risk to human health and life - High vulnerability properties	
Assigned Weightings		
Global Weighting	17.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	1.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	0.0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 3.B (i)	Minimise risk to community - Social Infrastructure and Amenity	
Assigned Weightings		
Global Weighting	9.0	*Nationally Constant Value*
Local Weighting	3.6	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	3.6	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.6	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Enhancement or Creation of Social Amenity Sites	0.0	*Adjustment in relation to the Enhancement or creation of social amenity sites (Structural Option)*
Total Option Score	4.1	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**135**	*Global weighting x Local weighting x Total option score*

Objective 3.B (ii)	Minimise risk to community - Local Employment	
Assigned Weightings		
Global Weighting	7.0	*Nationally Constant Value*
Local Weighting	41.6	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.8	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	4.9	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**172**	*Global weighting x Local weighting x Total option score*

Social Score	770

Multi-Criteria Analysis Summary

Rathdowney Option 1

4. Environmental Criteria

Objective 4.A	Support the objectives of the WFD	
Assigned Weightings		
Global Weighting	16.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Total Option Score	-1	*Construction phase impacts from on bank and in stream works in already modified waterbody. Storage area upstream of Rathdowney on Glasha River and Kilcoran River. Sensitive waterbodies. Reduced flood risk from 1% AEP events, including 1 IED site*
Weighted Option Score	**-80**	*Global weighting x Local weighting x Total option score*

Objective 4.B	Support the objectives of the Habitats and Birds Directives	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	3.0	*The River Barrow and River Nore SAC and the River Nore SPA are 4km downstream of Rathdowney. Galmoy Fen SAC is over 4km upcatchment of the AFA. Cullahill Mountain SAC and Spahill and Clomantagh Hill SAC are over 8km south east of Rathdowney, however are not hydraulically linked to the AFA.*
Option Scoring		
Total Option Score	-1	*No direct impacts on existing SAC, SPA or Ramsar sites, however very slight potential for indirect sedimentation impacts during construction works, which could impact on the River Barrow and River Nore SAC and the River Nore SPA. Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-30**	*Global weighting x Local weighting x Total option score*

Objective 4.C	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	
Assigned Weightings		
Global Weighting	5.0	*Nationally Constant Value*
Local Weighting	4.0	*The AFA is within the Nore Freshwater Pearl Mussel catchment and the Nore Upper FPM sensitive area. Known FPM habitats are located over 12km downstream of the AFA, on the River Nore. The Curragh and Goul River Marsh pNHA are 4km downstream of Rathdowney. The River Nore / Abbeylix Woods Complex pNHA is over 12km downstream of the AFA, on the River Nore. Galmoy Fen pNHA is over 4km upcatchment of the AFA. The Granstown Wood and Lough Nature Reserve and pNHA is over 4km north east of Rathdowney, however is not hydraulically linked to the AFA. Cuffsborough pNHA and Coolacurragh Wood pNHA are also over 4km north east of Rathdowney, however are not hydraulically linked to the AFA.*
Option Scoring		
Total Option Score	-1.0	*No direct impacts on existing designated sites, however very slight potential for indirect sedimentation impacts during construction works, which could impact on the Nore Freshwater Pearl Mussel catchment and the Nore Upper FPM sensitive area, along with the Curragh and Goul River Marsh pNHA. Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-20**	*Global weighting x Local weighting x Total option score*

Objective 4.D	Protect and where possible enhance fisheries resource within the catchment (Inland Fisheries Only)	
Assigned Weightings		
Global Weighting	13.0	*Nationally Constant Value*
Local Weighting	3.0	*Erkina River known for local trout fishing, upstream of the River Nore which is a designated salmonid river that has significant salmon and trout fishing.*
Option Scoring		
Total Option Score	-5.0	*Construction phase impacts from on bank and in stream defence works in already modified waterbody in Rathdowney. Introduction of barriers with online storage on Glasha River and Kilcoran River with negative impacts on fisheries potential.*
Weighted Option Score	**-195**	*Global weighting x Local weighting x Total option score*

Objective 4.E	Protect, and where possible enhance, landscape character and visual amenity within the zone of influence	
Assigned Weightings		
Global Weighting	8.0	*Nationally Constant Value*
Local Weighting	3.0	*The Laois County Council Landscape Character Assessment 2011-2017 designates Rathdowney as being in the lowland agricultural area. The assessment recognises the importance of river corridors for scenic value, looks to conserve the river and canal habitats and preserve the historic landscape along the Barrow and Nore. The Plan looks to reinforce the appearance of urban fringe areas adjacent to river corridors.*
Option Scoring		
Total Option Score	-4.0	*Augmentation of walls within Rathdowney historic town for flood risk management. Local impacts to views in town. Construction of storage area in rural / natural landscape.*
Weighted Option Score	**-96**	*Global weighting x Local weighting x Total option score*

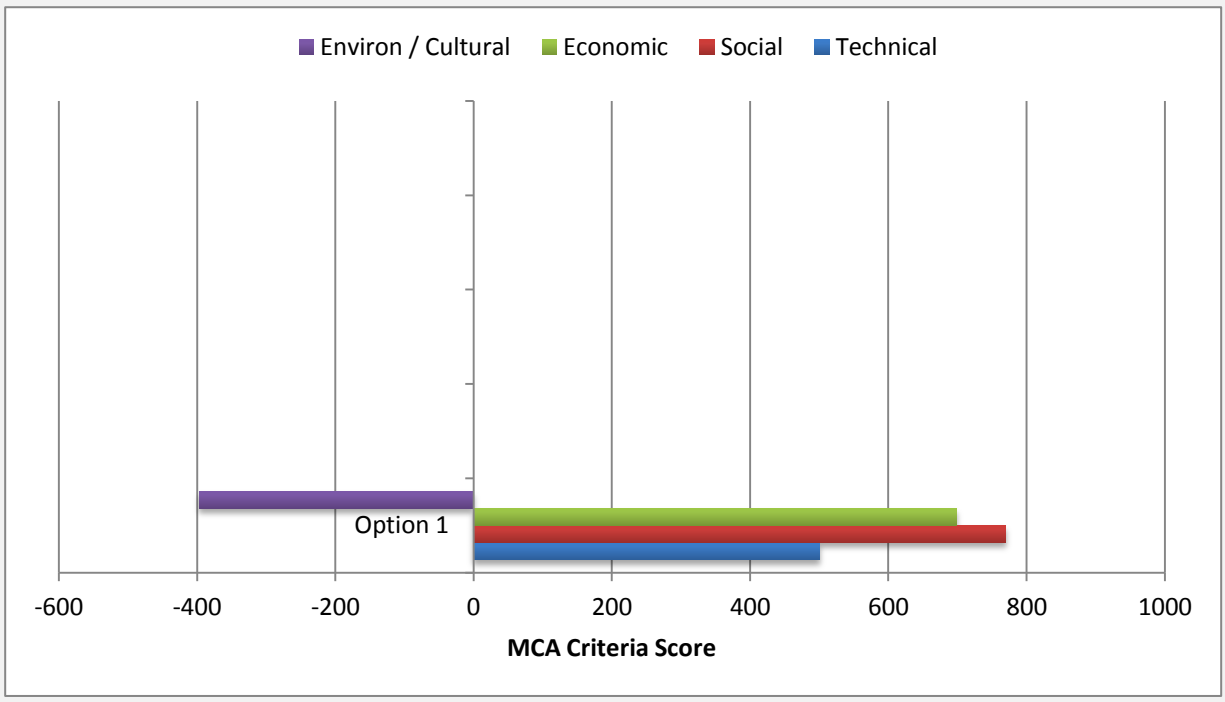
Objective 4.F (i)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	3.0	*There are 20 NIAH buildings within the AFA of regional importance. Rathdowney is regarded as a historic town.*
Option Scoring		
Total Option Score	2.0	*Increased protection from severe flooding to 2 NIAH buildings in the AFA.*
Weighted Option Score	**24**	*Global weighting x Local weighting x Total option score*

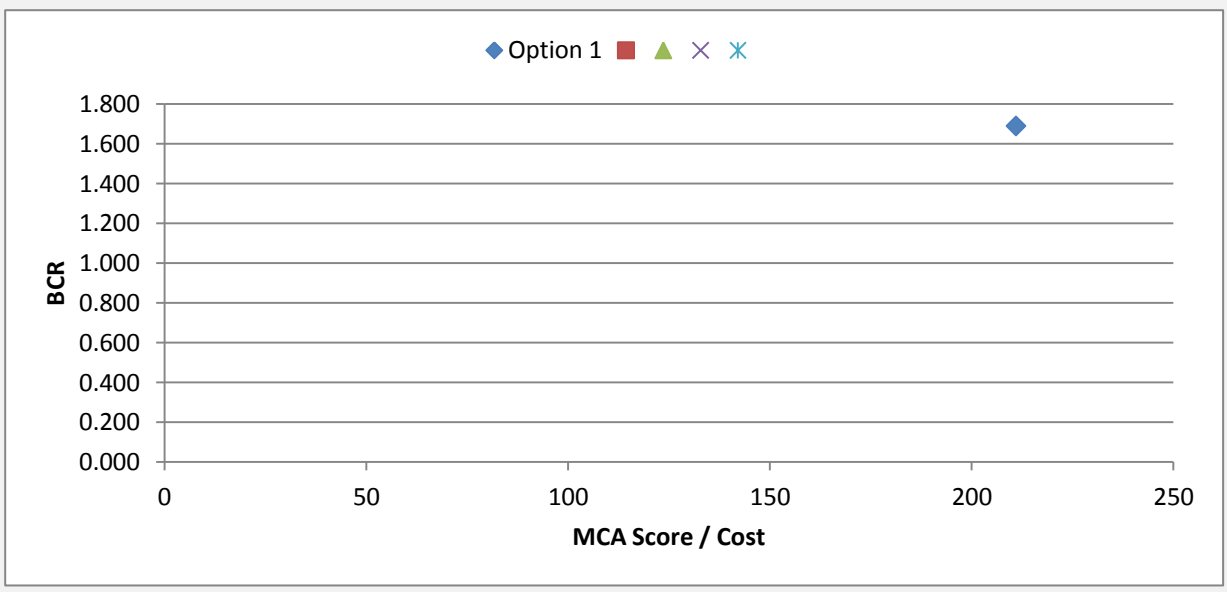
Objective 4.F (ii)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	2.0	*Rathdowney is considered a historic town. There are 4 monuments within the AFA with no specific protection, which are of low vulnerability to flooding. There are no monuments in the AFA with preservation orders or that are in state care.*
Option Scoring		
Total Option Score	0.0	*No effects on archaeological features.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

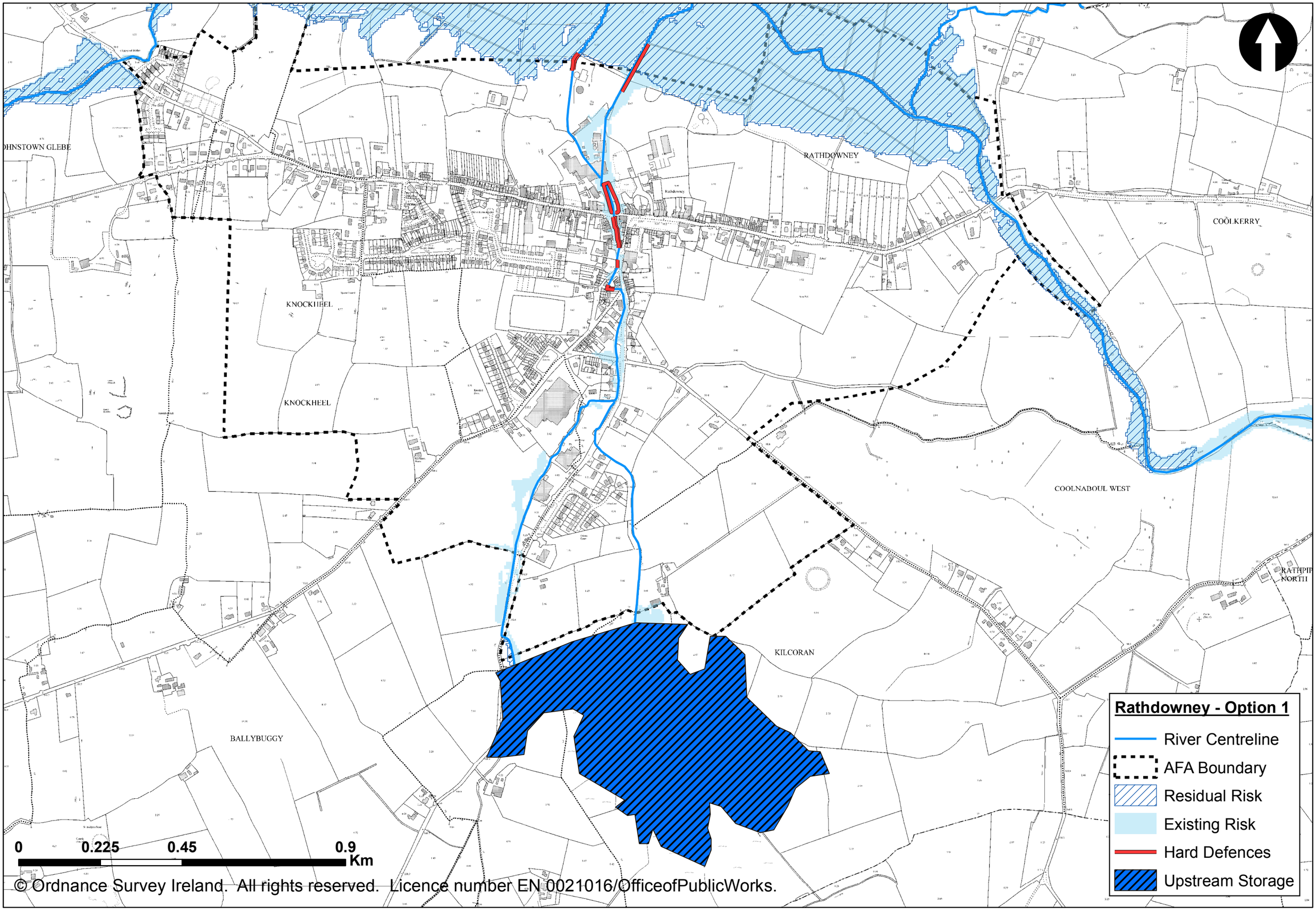
Environmental Score	-397

Option Comparison
Rathdownev

Option No.	MCA Appraisal Scores				TOTAL - MCA Benefit Score	Cost (€millions)	MCA Score / Cost	BCR
	Technical	Social	Economic	Environ / Cultural				
Option 1	500	770	698	-397	1071	5.076	210.993	1.689







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Appendix G

Thomastown AFA Additional Information

List of background information included:

1. Costings
- Option 1 – PVc summary of Whole Life Cost Hard Defences

2. MCA
- Option 1 –Hard Defences

3. Potential Option drawings
- Hard Defences

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	**Emma Holland**	**Date:**	**15/12/2015**
Checked by:	**Mark Wilson**	**Date:**	**22/04/2016**

Project reference	IBE0601

Project name:	SE CFRAM Study_Thomastown AFA_Option 1

Base date for estimates (year 0)	Oct-2013
Scaling factor (e.g. €m, €k, €)	€

Construction Price Index (CPI)	**1.000**
Method Factor - to take into account particular site issues /constraints	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	**Cost (€)**	**Comment**
Total wall costs	€4,770,106.00	*936m length, average 2.5m high*
Total embankment costs	€965,163.00	*1233m length, average1.7m high*
Total demountable barrier costs		
Total demountable gate costs	€38,000.00	*Hinge 2X3m*
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs	€8,558.00	*0.84m high, 1 in 50 Gradient 1m wide at highest point*
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€5,781,827	
Apply update to unit rate (CPI) if appropriate (cell N15)	€5,781,827	
Enter appropriate preliminaries estimate (%)	10%	
Sub Total	€6,360,010	
Optimism Bias	45%	
Total capital cost (€)	€9,222,014	
Consider amendments based on site issues/constraints (cell N16)	€9,222,014	
Total capital cost (€)	€9,222,014	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs	€375.00	*based on higher estimates due to the use of sheet piling*
Total embankment O&M costs	€7,768.00	*used higher estimates due to the use of piles*
Total demountable barrier O&M costs		
Total demountable gate O&M costs	€1,131.00	
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€9,274	
NPV O&M	€197,921	
Optimism Bias	45%	
NPV O&M with Optimism Bias	€286,985	

Other costs	**Cost (€)**	**Comment**
Other costs (design, supervision, archaeology, environment, site investigation, art)	€3,168,765	*Design and supervision (13%), Archaeology and environment (10%), Land (10%), Site investigation (€100,000), Art (€25,500)*

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€12,677,764	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€9,222,014.1
Annual maintenance cost (€)	€9,274.0
Other cost (€)	€3,168,764.6
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**	**Total PVc (€k):**		**9419935**
	Cash sum	0	9222014	454426	0	9676440	**9419935**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	9222014			9222014.1	9222014.1
1	0.961538			9274		9274.0	8917.3
2	0.925			9274		9274.0	8574.3
3	0.889			9274		9274.0	8244.6
4	0.855			9274		9274.0	7927.5
5	0.822			9274		9274.0	7622.6
6	0.790			9274		9274.0	7329.4
7	0.760			9274		9274.0	7047.5
8	0.731			9274		9274.0	6776.4
9	0.703			9274		9274.0	6515.8
10	0.676			9274		9274.0	6265.2
11	0.650			9274		9274.0	6024.2
12	0.625			9274		9274.0	5792.5
13	0.601			9274		9274.0	5569.7
14	0.577			9274		9274.0	5355.5
15	0.555			9274		9274.0	5149.5
16	0.534			9274		9274.0	4951.5
17	0.513			9274		9274.0	4761.0
18	0.494			9274		9274.0	4577.9
19	0.475			9274		9274.0	4401.8
20	0.456			9274		9274.0	4232.5
21	0.439			9274		9274.0	4069.7
22	0.422			9274		9274.0	3913.2
23	0.406			9274		9274.0	3762.7
24	0.390			9274		9274.0	3618.0
25	0.375			9274		9274.0	3478.8
26	0.361			9274		9274.0	3345.0
27	0.347			9274		9274.0	3216.4
28	0.333			9274		9274.0	3092.7
29	0.321			9274		9274.0	2973.7
30	0.308			9274		9274.0	2859.3
31	0.296			9274		9274.0	2749.4
32	0.285			9274		9274.0	2643.6
33	0.274			9274		9274.0	2541.9
34	0.264			9274		9274.0	2444.2
35	0.253			9274		9274.0	2350.2
36	0.244			9274		9274.0	2259.8
37	0.234			9274		9274.0	2172.9
38	0.225			9274		9274.0	2089.3
39	0.217			9274		9274.0	2008.9
40	0.208			9274		9274.0	1931.7
41	0.200			9274		9274.0	1857.4
42	0.193			9274		9274.0	1785.9
43	0.185			9274		9274.0	1717.2
44	0.178			9274		9274.0	1651.2
45	0.171			9274		9274.0	1587.7
46	0.165			9274		9274.0	1526.6
47	0.158			9274		9274.0	1467.9
48	0.152			9274		9274.0	1411.5
49	0.146			9274		9274.0	1357.2
							197920.8

Option Appraisal and the Multi-Criteria Analysis

Name of modeller	**Emma Holland**
Name of assessor	**Emma Holland**
Date of Assessment	**22/02/2016**
Option ID	**Option 1**
Option Type	Structural Option
Option Location	Thomastown
Option Details	Hard Defences
AEP	1.0%
Option Cost	€12,677,764.00
Economic Benefit	€16,479,422.00

Multi-Criteria Analysis Summary
Thomastown Option 1

1. Technical Criteria

Objective 1.A	Ensure flood risk management options are operationally robust	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Level of risk score	4	*No reliance on systems or intervention, with more regular monitoring and intermittent, but potentially substantial, maintenance requirements*
Adjustment	No adjustment	*The level of risk score has not been adjusted*
Total Option Score	4.0	*Option score + adjustment*
Weighted Option Score	**400**	*Global weighting x Local weighting x Total option score*

Objective 1.B	Minimise health and safety risk in construction, maintenance and operation of the flood risk management option	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Option Score	2.0	*The following hazards have been identified: working near water (construction), working with heavy plant machinery, working near water (O&M)*
Adjustment	0.0	*There have been no adjustments made to the option score*
Total Option Score	2.0	*Option score + adjustment*
Weighted Option Score	**200**	*Global weighting x Local weighting x Total option score*

Objective 1.C	Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Adaptability Score	2	*Option is adaptable at moderate to significant cost*
Adjustment	No adjustment	*The adaptability score has not been adjusted*
Total Option Score	2.0	*Option score + adjustment*
Weighted Option Score	**200**	*Global weighting x Local weighting x Total option score*

Technical Score	800

Multi-Criteria Analysis Summary

Thomastown Option 1

2. Economic Criteria

Objective 2.A	Reduce economic damages	
Assigned Weightings		
Global Weighting	24.0	*Nationally Constant Value*
Local Weighting	5.0	*AAD for the SSA / €75,000*
AAD for the SSA	€ 1,322,241.00	*Baseline Scenario*
Option Scoring		
Reduced AAD	€ 86,347.12	*Defended Scenario*
Total Option Score	4.7	*0.05 X Percentage Reduction in AAD*
Weighted Option Score	**561**	*Global weighting x Local weighting x Total option score*

Objective 2.B	Minimise risk to transport infrastructure	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	82.8	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	1.3	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.9	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the option score*
Total Option Score	4.9	*Option score + adjustment*
Weighted Option Score	**246**	*Global weighting x Local weighting x Total option score*

Objective 2.C	Minimise risk to utility infrastructure	
Assigned Weightings		
Global Weighting	14.0	*Nationally Constant Value*
Local Weighting	55.0	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	2.5	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.8	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the total option score*
Total Option Score	4.8	*Option score + adjustment*
Weighted Option Score	**334**	*Global weighting x Local weighting x Total option score*

Objective 2.D	Manage risk to agriculture	
Assigned Weightings		
Global Weighting	12.0	*Nationally Constant Value*
Local Weighting	3.0	*Agricultural activity in the area of Thomastown is mainly crop production on arable land, with the wider landscape being pasture land. Significant areas of land are taken up by forest and woodland, particularly along the river valley.*
Option Scoring		
Total Option Score	0	*There is no change in the area of agricultural land flooded with the Hard Defences option*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Economic Score	1141

Multi-Criteria Analysis Summary

Thomastown Option 1

3. Social Criteria

Objective 3.A (i)	Minimise risk to human health and life - Residents	
Assigned Weightings		
Global Weighting	27.0	*Nationally Constant Value*
Local Weighting	27.3	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.8	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	5	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**654**	*Global weighting x Local weighting x Total option score*

Objective 3.A (ii)	Minimise risk to human health and life - High vulnerability properties	
Assigned Weightings		
Global Weighting	17.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	1.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	0.0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 3.B (i)	Minimise risk to community - Social Infrastructure and Amenity	
Assigned Weightings		
Global Weighting	9.0	*Nationally Constant Value*
Local Weighting	114.0	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	2.7	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Enhancement or Creation of Social Amenity Sites	0.0	*Adjustment in relation to the Enhancement or creation of social amenity sites (Structural Option)*
Total Option Score	4.9	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**220**	*Global weighting x Local weighting x Total option score*

Objective 3.B (ii)	Minimise risk to community - Local Employment	
Assigned Weightings		
Global Weighting	7.0	*Nationally Constant Value*
Local Weighting	51.9	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	2.0	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	4.8	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**168**	*Global weighting x Local weighting x Total option score*

Social Score	1042

Multi-Criteria Analysis Summary

Thomastown Option 1

4. Environmental Criteria

Objective 4.A	Support the objectives of the WFD	
Assigned Weightings		
Global Weighting	16.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Total Option Score	-4	*Mainly construction phase impacts from creation and rehabilitation of walls and embankments, set back from sensitive waterbody. Excavation and restoration of banks. Reduced flood risk for 1% AEP events.*
Weighted Option Score	**-320**	*Global weighting x Local weighting x Total option score*

Objective 4.B	Support the objectives of the Habitats and Birds Directives	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	5.0	*The River Barrow and River Nore SAC and the River Nore SPA are within, downstream of and upstream of Thomastown. The Thomastown Quarry SAC is within the AFA.*
Option Scoring		
Total Option Score	-2	*Potential for direct construction phase disturbance impacts from construction of walls and embankments adjacent to the River Barrow and River Nore SAC and River Nore SPA. Potential for indirect impacts to SAC and SPA from sedimentation during construction. Impacts can be mainly mitigated for with good planning, appropriate timing of works and good construction practice. Embankments and walls should be set back from watercourse and designated sites as far as possible.*
Weighted Option Score	**-100**	*Global weighting x Local weighting x Total option score*

Objective 4.C	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	
Assigned Weightings		
Global Weighting	5.0	*Nationally Constant Value*
Local Weighting	4.0	*The AFA is within the Nore Lower FPM sensitive area. The Thomastown pNHA is within the AFA. The Mount Juliet pNHA is over 4km upstream of the AFA. The Red Dog pNHA is over 7km upcatchment of the AFA to the north. The Inistioge pNHA and the Ice House pNHA are all over 7km downstream of the AFA.*
Option Scoring		
Total Option Score	-2.0	*Slight potential for indirect impacts within Nore Freshwater Pearl Mussel sensitive area from downstream sedimentation during construction. Direct localised loss and disturbance to flora and fauna in footprint of works. Unlikely to be impacts to national, regional or local designations. Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-40**	*Global weighting x Local weighting x Total option score*

Objective 4.D	Protect and where possible enhance fisheries resource within the catchment (Inland Fisheries Only)	
Assigned Weightings		
Global Weighting	13.0	*Nationally Constant Value*
Local Weighting	5.0	*River Nore is a designated salmonid river. Significant salmon and trout fishing in the area.*
Option Scoring		
Total Option Score	-4.0	*Mainly construction phase impacts from creation and rehabilitation of walls and embankments, set back from sensitive waterbody. Excavation and restoration of banks. Potential for indirect impacts to River Nore fisheries and local fishing within AFA from sedimentation during construction. Some impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-260**	*Global weighting x Local weighting x Total option score*

Objective 4.E	Protect, and where possible enhance, landscape character and visual amenity within the zone of influence	
Assigned Weightings		
Global Weighting	8.0	*Nationally Constant Value*
Local Weighting	4.0	*The Kilkenny CDP 2008-2014 LAP demonstrates that Thomastown is within the Nore Valley, which is an Area of High Amenity. The landscape in the area is considered sensitive.*
Option Scoring		
Total Option Score	-4.0	*Creation and rehabilitation of walls and embankments in sensitive river corridor landscape. Most of corridor however already modified.*
Weighted Option Score	**-128**	*Global weighting x Local weighting x Total option score*

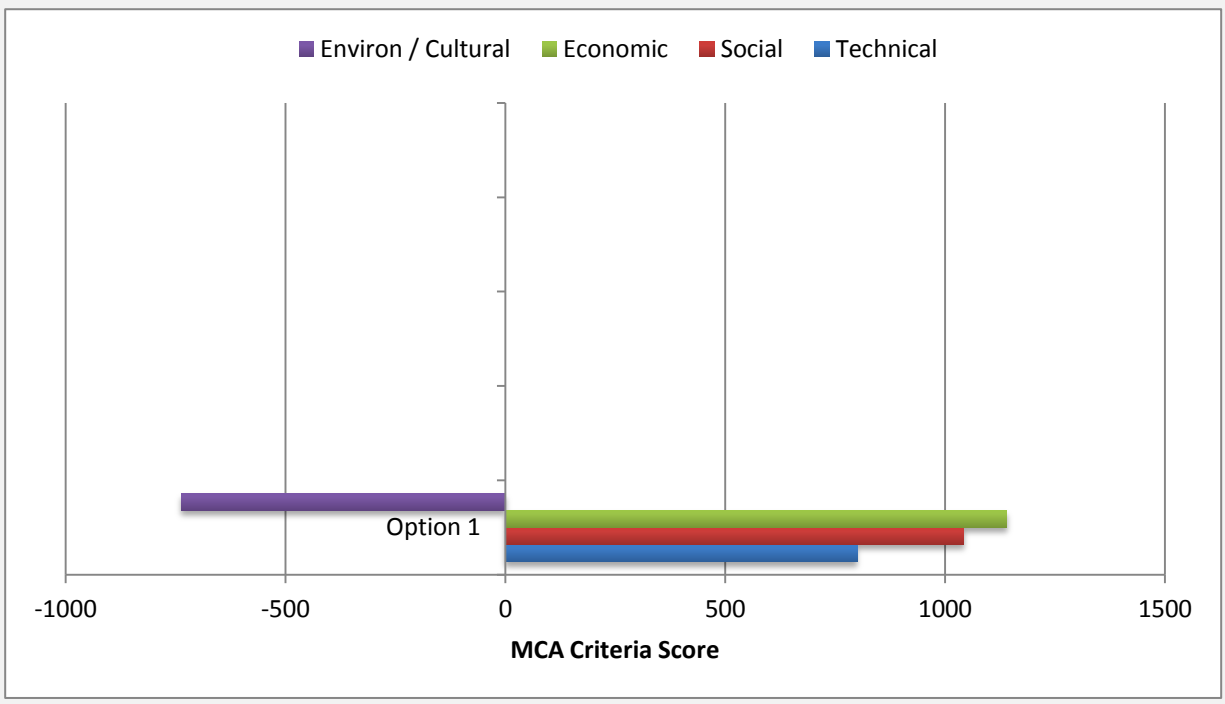
Objective 4.F (i)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	4.0	*There are 109 NIAH buildings within the AFA of national, regional and local importance. Many of these buildings are in close proximity to the River Nore. Thomastown is regarded as a historic town.*
Option Scoring		
Total Option Score	4.0	*Slight potential for impacts on the setting of several architectural features, with potential for physical impacts on Thomastown Bridge from tie in of defences, however many NIAH buildings to be protected from flooding events throughout the AFA. Increased protection to historic town.*
Weighted Option Score	**64**	*Global weighting x Local weighting x Total option score*

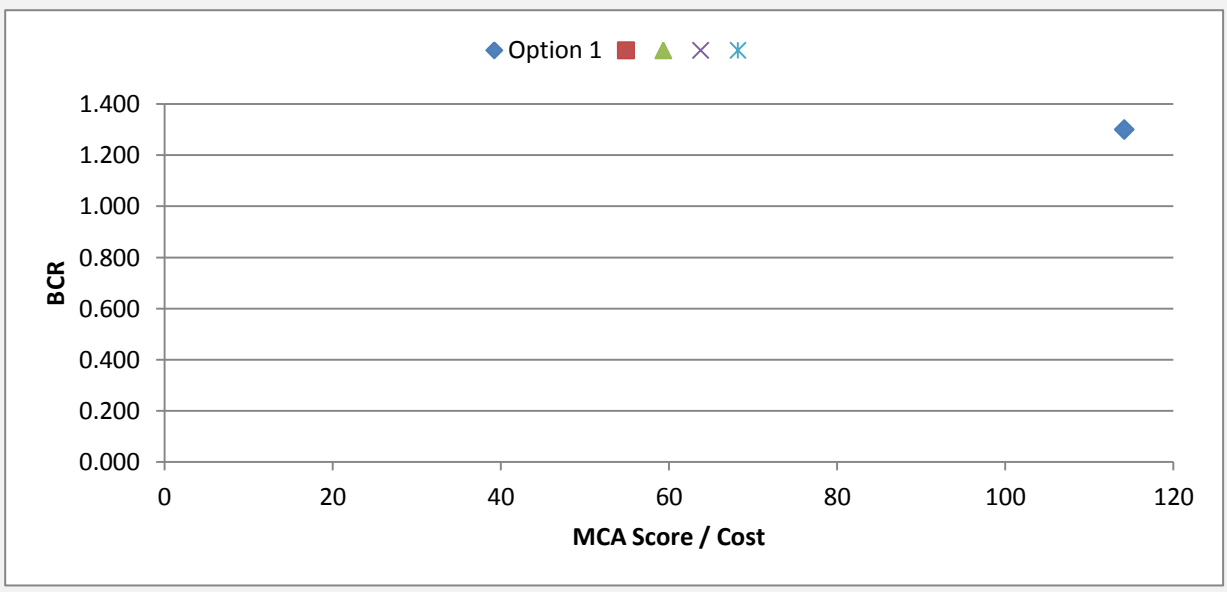
Objective 4.F (ii)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	4.0	*There is one monument in state care within the AFA which is of low vulnerability to flooding. There are also 35 monuments with no protection orders within the AFA, however are of low vulnerability to flooding. Thomastown is regarded as a historic town.*
Option Scoring		
Total Option Score	3.0	*Slight potential for impacts on the setting of several archaeological features, with potential for physical impacts on Thomastown Bridge monument from tie in of defences, however several monuments to be protected from flooding events throughout the AFA. Increased protection to historic town.*
Weighted Option Score	**48**	*Global weighting x Local weighting x Total option score*

Environmental Score	**-736**

Option Comparison
Thomastown

Option No.	MCA Appraisal Scores				TOTAL - MCA Benefit Score	Cost (€millions)	MCA Score / Cost	BCR
	Technical	Social	Economic	Environ / Cultural				
Option 1	800	1042	1141	-736	1447	12.678	114.151	1.300





Thomastown - Option 1

- River Centreline
- AFA Boundary
- Residual Risk
- Existing Risk
- Hard Defences

BURRELLSPARK
Páirc an Bhoireálaigh

0 0.075 0.15 0.3 Km

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Appendix H

Kilkenny (Breagagh) AFA Additional Information

List of background included:

1. Costings
    - Option 1 – Whole Life Costs – Hard Defences
    - Option 2 – Whole Life Costs – Hard Defences & Land Use Management
2. MCA
    - Option 1 – Whole Life Costs – Hard Defences
    - Option 2 – Whole Life Costs – Hard Defences & Land Use Management

3. Potential Option Drawings

    - Option 1 – Whole Life Costs – Hard Defences
    - Option 2 – Whole Life Costs – Hard Defences & Land Use Management

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	**Joanne Murdy**	**Date:**	**28/06/2017**
Checked by:	**Mark Wilson**	**Date:**	**28/06/2017**

Project reference	IBE0601

Project name:	SE CFRAM Study Breagagh,Option 1 (Hard Defences)

Base date for estimates (year 0)	Oct-2013
Scaling factor (e.g. €m, €k, €)	€

Construction Price Index (CPI)	**1.000**
Method Factor - to take into account particular site issues /constraints	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		-

Capital costs	**Cost (€)**	**Comment**
Total wall costs	€512,894.00	*418m of urban flood wall*
Total embankment costs	€14,395.00	*51m*
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€527,289	
Apply update to unit rate (CPI) if appropriate (cell N15)	€527,289	
Enter appropriate preliminaries estimate (%)	18%	
Enter other applicable costs (€)	€240,116	*Design, supervision, monitoring, land acquisition/compensation & art*
Total capital cost (€)	€862,318	
Consider amendments based on site issues/constraints (cell N16)	€862,318	
Total capital cost (€)	€862,318	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs	€167.00	-
Total embankment O&M costs	€162.00	-
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€329	

Other costs	**Cost (€)**	**Comment**
Other costs (consider the need for additional longer term or intermittent costs)		-

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€869,339	
Optimism bias rate (from external sheet)	41%	*out of bank but right at waters edge*
Total Cost including Optimism Bias	**€1,225,768**	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€862,317.5
Annual maintenance cost (€)	€329.0
Other cost (€)	€0.0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**	**Total PVc (€k):**		**869339**
	Cash sum	0	862318	16121	0	878439	**869339**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	862318			862317.5	862317.5
1	0.962			329		329.0	316.3
2	0.925			329		329.0	304.2
3	0.889			329		329.0	292.5
4	0.855			329		329.0	281.2
5	0.822			329		329.0	270.4
6	0.790			329		329.0	260.0
7	0.760			329		329.0	250.0
8	0.731			329		329.0	240.4
9	0.703			329		329.0	231.2
10	0.676			329		329.0	222.3
11	0.650			329		329.0	213.7
12	0.625			329		329.0	205.5
13	0.601			329		329.0	197.6
14	0.577			329		329.0	190.0
15	0.555			329		329.0	182.7
16	0.534			329		329.0	175.7
17	0.513			329		329.0	168.9
18	0.494			329		329.0	162.4
19	0.475			329		329.0	156.2
20	0.456			329		329.0	150.2
21	0.439			329		329.0	144.4
22	0.422			329		329.0	138.8
23	0.406			329		329.0	133.5
24	0.390			329		329.0	128.3
25	0.375			329		329.0	123.4
26	0.361			329		329.0	118.7
27	0.347			329		329.0	114.1
28	0.333			329		329.0	109.7
29	0.321			329		329.0	105.5
30	0.308			329		329.0	101.4
31	0.296			329		329.0	97.5
32	0.285			329		329.0	93.8
33	0.274			329		329.0	90.2
34	0.264			329		329.0	86.7
35	0.253			329		329.0	83.4
36	0.244			329		329.0	80.2
37	0.234			329		329.0	77.1
38	0.225			329		329.0	74.1
39	0.217			329		329.0	71.3
40	0.208			329		329.0	68.5
41	0.200			329		329.0	65.9
42	0.193			329		329.0	63.4
43	0.185			329		329.0	60.9
44	0.178			329		329.0	58.6
45	0.171			329		329.0	56.3
46	0.165			329		329.0	54.2
47	0.158			329		329.0	52.1
48	0.152			329		329.0	50.1
49	0.146			329		329.0	48.1

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	**Joanne Murdy**	**Date:**	**28/06/2017**
Checked by:	**Mark Wilson**	**Date:**	**28/06/2017**

Project reference	IBE0601

Project name:	SE CFRAM Study Breagagh, Option 2- Hard Defences & LUM

Base date for estimates (year 0)	Oct-2013
Scaling factor (e.g. €m, €k, €)	€

Construction Price Index (CPI)	**1.000**
Method Factor - to take into account particular site issues /constraints	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		-

Capital costs	**Cost (€)**	**Comment**
Total wall costs	€512,894.00	*418m of urban flood wall*
Total embankment costs	€14,395.00	*51m*
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€527,289	
Apply update to unit rate (CPI) if appropriate (cell N15)	€527,289	
Enter appropriate preliminaries estimate (%)	18%	
Enter other applicable costs (€)	€240,116	*Design, supervision, monitoring, land acquisition/compensation & art*
Total capital cost (€)	€862,318	
Consider amendments based on site issues/constraints (cell N16)	€862,318	
Total capital cost (€)	€862,318	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs	€334.00	*Total doubled for Land Use Management*
Total embankment O&M costs	€324.00	*Total doubled for Land Use Management*
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€658	

Other costs	**Cost (€)**	**Comment**
Other costs (consider the need for additional longer term or intermittent costs)		-

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€876,360	
Optimism bias rate (from external sheet)	41%	*out of bank but right at waters edge*
Total Cost including Optimism Bias	**€1,235,668**	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€862,317.5
Annual maintenance cost (€)	€658.0
Other cost (€)	€0.0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**	**Total PVc (€k):**		**876360**
	Cash sum	0	862318	32242	0	894560	**876360**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	862318			862317.5	862317.5
1	0.962			658		658.0	632.7
2	0.925			658		658.0	608.4
3	0.889			658		658.0	585.0
4	0.855			658		658.0	562.5
5	0.822			658		658.0	540.8
6	0.790			658		658.0	520.0
7	0.760			658		658.0	500.0
8	0.731			658		658.0	480.8
9	0.703			658		658.0	462.3
10	0.676			658		658.0	444.5
11	0.650			658		658.0	427.4
12	0.625			658		658.0	411.0
13	0.601			658		658.0	395.2
14	0.577			658		658.0	380.0
15	0.555			658		658.0	365.4
16	0.534			658		658.0	351.3
17	0.513			658		658.0	337.8
18	0.494			658		658.0	324.8
19	0.475			658		658.0	312.3
20	0.456			658		658.0	300.3
21	0.439			658		658.0	288.8
22	0.422			658		658.0	277.6
23	0.406			658		658.0	267.0
24	0.390			658		658.0	256.7
25	0.375			658		658.0	246.8
26	0.361			658		658.0	237.3
27	0.347			658		658.0	228.2
28	0.333			658		658.0	219.4
29	0.321			658		658.0	211.0
30	0.308			658		658.0	202.9
31	0.296			658		658.0	195.1
32	0.285			658		658.0	187.6
33	0.274			658		658.0	180.4
34	0.264			658		658.0	173.4
35	0.253			658		658.0	166.7
36	0.244			658		658.0	160.3
37	0.234			658		658.0	154.2
38	0.225			658		658.0	148.2
39	0.217			658		658.0	142.5
40	0.208			658		658.0	137.1
41	0.200			658		658.0	131.8
42	0.193			658		658.0	126.7
43	0.185			658		658.0	121.8
44	0.178			658		658.0	117.2
45	0.171			658		658.0	112.6
46	0.165			658		658.0	108.3
47	0.158			658		658.0	104.1
48	0.152			658		658.0	100.1
49	0.146			658		658.0	96.3

Option Appraisal and the Multi-Criteria Analysis

Name of modeller	Various
Name of assessor	Joanne Murdy
Date of Assessment	04/07/2017
Option ID	Option 1
Option Type	Structural Option
Option Location	Kilkenny (Breagagh)
Option Details	Hard Defences
AEP	1.0%
Option Cost	€1,225,768.00
Economic Benefit	€677,302.00

Multi-Criteria Analysis Summary
Kilkenny (Breagagh) Option 1

1. Technical Criteria

Objective 1.A	Ensure flood risk management options are operationally robust	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Level of risk score	3	*There is a requirement for simple systems or interventions for the option to operate, with regular monitoring and maintenance required, but a very low likelihood of system / operation failure*
Adjustment	No adjustment	*The level of risk score has not been adjusted*
Total Option Score	3.0	*Option score + adjustment*
Weighted Option Score	**300**	*Global weighting x Local weighting x Total option score*

Objective 1.B	Minimise health and safety risk in construction, maintenance and operation of the flood risk management option	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Option Score	1.0	*The following hazards have been identified: Risk of burial from earthfall, working near water (construction), work with heavy plant and components, working near water (O&M)*
Adjustment	0.0	*There have been no adjustments made to the option score*
Total Option Score	1.0	*Option score + adjustment*
Weighted Option Score	**100**	*Global weighting x Local weighting x Total option score*

Objective 1.C	Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Adaptability Score	1	*Option is adaptable only at significant cost*
Adjustment	No adjustment	*The adaptability score has not been adjusted*
Total Option Score	1.0	*Option score + adjustment*
Weighted Option Score	**100**	*Global weighting x Local weighting x Total option score*

Technical Score	500

Multi-Criteria Analysis Summary

Kilkenny (Breagagh) Option 1

2. Economic Criteria

Objective 2.A	Reduce economic damages	
Assigned Weightings		
Global Weighting	24.0	*Nationally Constant Value*
Local Weighting	1.0	*AAD for the SSA / €75,000*
AAD for the SSA	€ 23,329.39	*Baseline Scenario*
Option Scoring		
Reduced AAD	€ 12,564.68	*Defended Scenario*
Total Option Score	2.3	*0.05 X Percentage Reduction in AAD*
Weighted Option Score	**55**	*Global weighting x Local weighting x Total option score*

Objective 2.B	Minimise risk to transport infrastructure	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	14.8	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	0.6	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.8	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the option score*
Total Option Score	4.8	*Option score + adjustment*
Weighted Option Score	**240**	*Global weighting x Local weighting x Total option score*

Objective 2.C	Minimise risk to utility infrastructure	
Assigned Weightings		
Global Weighting	14.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	1.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	0.0	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	0.0	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the total option score*
Total Option Score	0.0	*Option score + adjustment*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 2.D	Manage risk to agriculture	
Assigned Weightings		
Global Weighting	12.0	*Nationally Constant Value*
Local Weighting	3.0	*The AFA is predominately urban with areas of pasture and arable land mainly located towards the boundary of the AFA. The Breagagh River Basin is located to the west and south-west of the AFA, pasture and arable land dominate this surrounding area.*
Option Scoring		
Total Option Score	0	*The outer extent of the AFA and the surrounding area is dominated by pasture land and areas of arable land. Much of the AFA is however taken up by urban fabric. There is no change in the area of agricultural land flooded with the Hard Defences option.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Economic Score	295

Multi-Criteria Analysis Summary
Kilkenny (Breagagh) Option 1
3. Social Criteria

Objective 3.A (i)	Minimise risk to human health and life - Residents	
Assigned Weightings		
Global Weighting	27.0	*Nationally Constant Value*
Local Weighting	2.4	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No adjustment*
Capped Local Weighting	2.4	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.1	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	5	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**312**	*Global weighting x Local weighting x Total option score*

Objective 3.A (ii)	Minimise risk to human health and life - High vulnerability properties	
Assigned Weightings		
Global Weighting	17.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	1.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	0.0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 3.B (i)	Minimise risk to community - Social Infrastructure and Amenity	
Assigned Weightings		
Global Weighting	9.0	*Nationally Constant Value*
Local Weighting	10.0	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Enhancement or Creation of Social Amenity Sites	0.0	*Adjustment in relation to the Enhancement or creation of social amenity sites (Structural Option)*
Total Option Score	5.0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**225**	*Global weighting x Local weighting x Total option score*

Objective 3.B (ii)	Minimise risk to community - Local Employment	
Assigned Weightings		
Global Weighting	7.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	1.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	0.0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Social Score	537

Multi-Criteria Analysis Summary
Kilkenny (Breagagh) Option 1

4. Environmental Criteria

Objective 4.A	Support the objectives of the WFD	
Assigned Weightings		
Global Weighting	16.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Total Option Score	-1	*Construction phase impacts from creation of walls and embankments set back from non-sensitive waterbody. Potential for some excavation and restoration of banks. Slight potential for indirect sedimentation impacts during construction. Reduced flooding in area with no significant polluting sources. Impacts can be mitigated for with good planning and good construction practice.*
Weighted Option Score	**-80**	*Global weighting x Local weighting x Total option score*

Objective 4.B	Support the objectives of the Habitats and Birds Directives	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	5.0	*The River Barrow and River Nore SAC and the River Nore SPA are within, downstream of and upstream of Kilkenny.*
Option Scoring		
Total Option Score	-1	*No direct impacts on existing SAC, SPA or Ramsar sites, however potential for indirect sedimentation impacts during construction works and increased sedimentation downstream from increased flows during flood events, which have the potential for impacts on the River Nore SAC and the River Nore SPA. Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-50**	*Global weighting x Local weighting x Total option score*

Objective 4.C	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	
Assigned Weightings		
Global Weighting	5.0	*Nationally Constant Value*
Local Weighting	5.0	*The AFA is within the Nore Lower FPM sensitive area. Known FPM habitats are located downstream of the AFA, on the River Nore. The Dunmore Complex pNHA, the Newpark Marsh pNHA, the Lough Macask pNHA and the Archersgrove are all within the AFA. Inchbeg pNHA and Ardaloo Fen pNHA are both over 4km upstream of the AFA. Esker Pits pNHA is over 9km upstream of the AFA. Mount Juliet pNHA is over 12km downstream of the AFA. Ballykeefe Wood pNHA and Nature Reserve is over 7km west of Kilkenny, however is not hydraulically linked to the AFA.*
Option Scoring		
Total Option Score	-1.0	*No direct impacts on existing designated sites, however very slight potential for indirect sedimentation impacts during construction works, which could impact on the Nore Freshwater Pearl Mussel catchment and the Nore Upper FPM sensitive area . Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-25**	*Global weighting x Local weighting x Total option score*

Objective 4.D	Protect and where possible enhance fisheries resource within the catchment (Inland Fisheries Only)	
Assigned Weightings		
Global Weighting	13.0	*Nationally Constant Value*
Local Weighting	5.0	*The River Breagagh is hydraulically linked to the River Nore. The River Nore is a designated salmonid river. Significant salmon and trout fishing in the area.*
Option Scoring		
Total Option Score	-1.0	*Slight potential for indirect impacts to downstream River Nore fisheries and local fishing from sedimentation during construction. Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-65**	*Global weighting x Local weighting x Total option score*

Objective 4.E	Protect, and where possible enhance, landscape character and visual amenity within the zone of influence	
Assigned Weightings		
Global Weighting	8.0	*Nationally Constant Value*
Local Weighting	3.0	*In the landscape appraisal for County Kilkenny, as part of Kilkenny County Development Plan 2008 - 2014, the Breagagh River Basin has no specific landscape protection.*
Option Scoring		
Total Option Score	-1.0	*Construction of local flood embankments and walls prior to the establishment of screening. Some local, permanent impacts on views from properties to be protected.*
Weighted Option Score	**-24**	*Global weighting x Local weighting x Total option score*

Objective 4.F (i)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	3.0	*There are 124 NIAH buildings within the AFA of national, regional and local importance.Kilkenny is considered a historic town. Some are located close to the Breagagh River. All recorded heritage features / monuments in the area are of low vulnerability to flooding.*
Option Scoring		
Total Option Score	5.0	*No negative effects on architectural features. Many NIAH buildings are located downstream of proposed line of Hard Defence.*
Weighted Option Score	**60**	*Global weighting x Local weighting x Total option score*

Objective 4.F (ii)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	4.0	*There is one monument in state care within the AFA which is of low vulnerability to flooding. Kilkenny is regarded as a historic town.*
Option Scoring		
Total Option Score	0.0	*No effects on archaeological features.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Environmental Score	**-184**

Option Appraisal and the Multi-Criteria Analysis

Name of modeller	Various
Name of assessor	Joanne Murdy
Date of Assessment	04/07/2017
Option ID	Option 2
Option Type	Structural Option
Option Location	Kilkenny (Breagagh)
Option Details	Hard Defences
AEP	1.0%
Option Cost	€1,235,668.00
Economic Benefit	€677,302.00

Multi-Criteria Analysis Summary
Kilkenny (Breagagh) Option 2

1. Technical Criteria

Objective 1.A	Ensure flood risk management options are operationally robust	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Level of risk score	3	*There is a requirement for simple systems or interventions for the option to operate, with regular monitoring and maintenance required, but a very low likelihood of system / operation failure*
Adjustment	No adjustment	*The level of risk score has not been adjusted*
Total Option Score	3.0	*Option score + adjustment*
Weighted Option Score	**300**	*Global weighting x Local weighting x Total option score*

Objective 1.B	Minimise health and safety risk in construction, maintenance and operation of the flood risk management option	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Option Score	1.0	*The following hazards have been identified: Risk of burial from earthfall, working near water (construction), work with heavy plant and components, working near water (O&M)*
Adjustment	0.0	*There have been no adjustments made to the option score*
Total Option Score	1.0	*Option score + adjustment*
Weighted Option Score	**100**	*Global weighting x Local weighting x Total option score*

Objective 1.C	Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Adaptability Score	1	*Option is adaptable only at significant cost*
Adjustment	No adjustment	*The adaptability score has not been adjusted*
Total Option Score	1.0	*Option score + adjustment*
Weighted Option Score	**100**	*Global weighting x Local weighting x Total option score*

Technical Score	500

Multi-Criteria Analysis Summary
Kilkenny (Breagagh) Option 2
2. Economic Criteria

Objective 2.A	Reduce economic damages	
Assigned Weightings		
Global Weighting	24.0	*Nationally Constant Value*
Local Weighting	1.0	*AAD for the SSA / €75,000*
AAD for the SSA	€ 23,329.39	*Baseline Scenario*
Option Scoring		
Reduced AAD	€ 12,564.68	*Defended Scenario*
Total Option Score	2.3	*0.05 X Percentage Reduction in AAD*
Weighted Option Score	**55**	*Global weighting x Local weighting x Total option score*

Objective 2.B	Minimise risk to transport infrastructure	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	14.8	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	0.6	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.8	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the option score*
Total Option Score	4.8	*Option score + adjustment*
Weighted Option Score	**240**	*Global weighting x Local weighting x Total option score*

Objective 2.C	Minimise risk to utility infrastructure	
Assigned Weightings		
Global Weighting	14.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	1.0	*1* ≤ capped local weight ≤ 5
Option Scoring		
Residual Risk Score	0.0	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	0.0	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the total option score*
Total Option Score	0.0	*Option score + adjustment*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 2.D	Manage risk to agriculture	
Assigned Weightings		
Global Weighting	12.0	*Nationally Constant Value*
Local Weighting	3.0	*The AFA is predominately urban with areas of pasture and arable land mainly located towards the boundary of the AFA. The Breagagh River Basin is located to the west and south-west of the AFA, pasture and arable land dominate this surrounding area.*
Option Scoring		
Total Option Score	0	*The outer extent of the AFA and the surrounding area is dominated by pasture land and areas of arable land. Much of the AFA is however taken up by urban fabric. There is no change in the area of agricultural land flooded with the Hard Defences option.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Economic Score	295

Multi-Criteria Analysis Summary
Kilkenny (Breagagh) Option 2
3. Social Criteria

Objective 3.A (i)	Minimise risk to human health and life - Residents	
Assigned Weightings		
Global Weighting	27.0	*Nationally Constant Value*
Local Weighting	2.4	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No adjustment*
Capped Local Weighting	2.4	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.1	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	5	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**312**	*Global weighting x Local weighting x Total option score*

Objective 3.A (ii)	Minimise risk to human health and life - High vulnerability properties	
Assigned Weightings		
Global Weighting	17.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	1.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	0.0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 3.B (i)	Minimise risk to community - Social Infrastructure and Amenity	
Assigned Weightings		
Global Weighting	9.0	*Nationally Constant Value*
Local Weighting	10.0	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Enhancement or Creation of Social Amenity Sites	0.0	*Adjustment in relation to the Enhancement or creation of social amenity sites (Structural Option)*
Total Option Score	5.0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**225**	*Global weighting x Local weighting x Total option score*

Objective 3.B (ii)	Minimise risk to community - Local Employment	
Assigned Weightings		
Global Weighting	7.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	1.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	0.0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Social Score	537

Multi-Criteria Analysis Summary
Kilkenny (Breagagh) Option 2

4. Environmental Criteria

Objective 4.A	Support the objectives of the WFD	
Assigned Weightings		
Global Weighting	16.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Total Option Score	0	*Construction phase impacts from creation of walls and embankments set back from sensitive waterbody. Potential for some excavation and restoration of banks. Slight potential for indirect sedimentation impacts during construction. Reduced flooding in area with no significant polluting sources.Impacts can be mitigated for with good planning and good construction practice. Effective upcatchment land use management has the potential for positive impacts on water body status through the reduction of pollutants and sediment entering rivers and the restoration of more natural hydrological and morphological regimes.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 4.B	Support the objectives of the Habitats and Birds Directives	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	5.0	*The River Barrow and River Nore SAC and the River Nore SPA are within, downstream of and upstream of Kilkenny.*
Option Scoring		
Total Option Score	-1	*No direct impacts on existing SAC, SPA or Ramsar sites, however potential for indirect sedimentation impacts during construction works and increased sedimentation downstream from increased flows during flood events, which have the potential for impacts on the River Nore SAC and the River Nore SPA. Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-50**	*Global weighting x Local weighting x Total option score*

Objective 4.C	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	
Assigned Weightings		
Global Weighting	5.0	*Nationally Constant Value*
Local Weighting	5.0	*The AFA is within the Nore Lower FPM sensitive area. Known FPM habitats are located downstream of the AFA, on the River Nore. The Dunmore Complex pNHA, the Newpark Marsh pNHA, the Lough Macask pNHA and the Archersgrove are all within the AFA. Inchbeg pNHA and Ardaloo Fen pNHA are both over 4km upstream of the AFA. Esker Pits pNHA is over 9km upstream of the AFA. Mount Juliet pNHA is over 12km downstream of the AFA. Ballykeefe Wood pNHA and Nature Reserve is over 7km west of Kilkenny, however is not hydraulically linked to the AFA.*
Option Scoring		
Total Option Score	0.0	*No direct impacts on existing designated sites, however very slight potential for indirect sedimentation impacts during construction works, which could impact on the Nore Freshwater Pearl Mussel catchment and the Nore Upper FPM sensitive area . Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice. Implementation of land use management may create potential for localised improvement of flora/fauna and biodiversity.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 4.D	Protect and where possible enhance fisheries resource within the catchment (Inland Fisheries Only)	
Assigned Weightings		
Global Weighting	13.0	*Nationally Constant Value*
Local Weighting	5.0	*The River Breagagh is hydraulically linked to the River Nore. The River Nore is a designated salmonid river. Significant salmon and trout fishing in the area.*
Option Scoring		
Total Option Score	-1.0	*Slight potential for indirect impacts to downstream River Nore fisheries and local fishing from sedimentation during construction. Impacts can be mitigated for with good planning, appropriate timing of works and good construction practice.*
Weighted Option Score	**-65**	*Global weighting x Local weighting x Total option score*

Objective 4.E	Protect, and where possible enhance, landscape character and visual amenity within the zone of influence	
Assigned Weightings		
Global Weighting	8.0	*Nationally Constant Value*
Local Weighting	3.0	*In the landscape appraisal for County Kilkenny, as part of Kilkenny County Development Plan 2008 - 2014, the Breagagh River Basin has no specific landscape protection.*
Option Scoring		
Total Option Score	-1.0	*Construction of local flood embankments and walls prior to the establishment of screening. Some local, permanent impacts on views from properties to be protected.*
Weighted Option Score	**-24**	*Global weighting x Local weighting x Total option score*

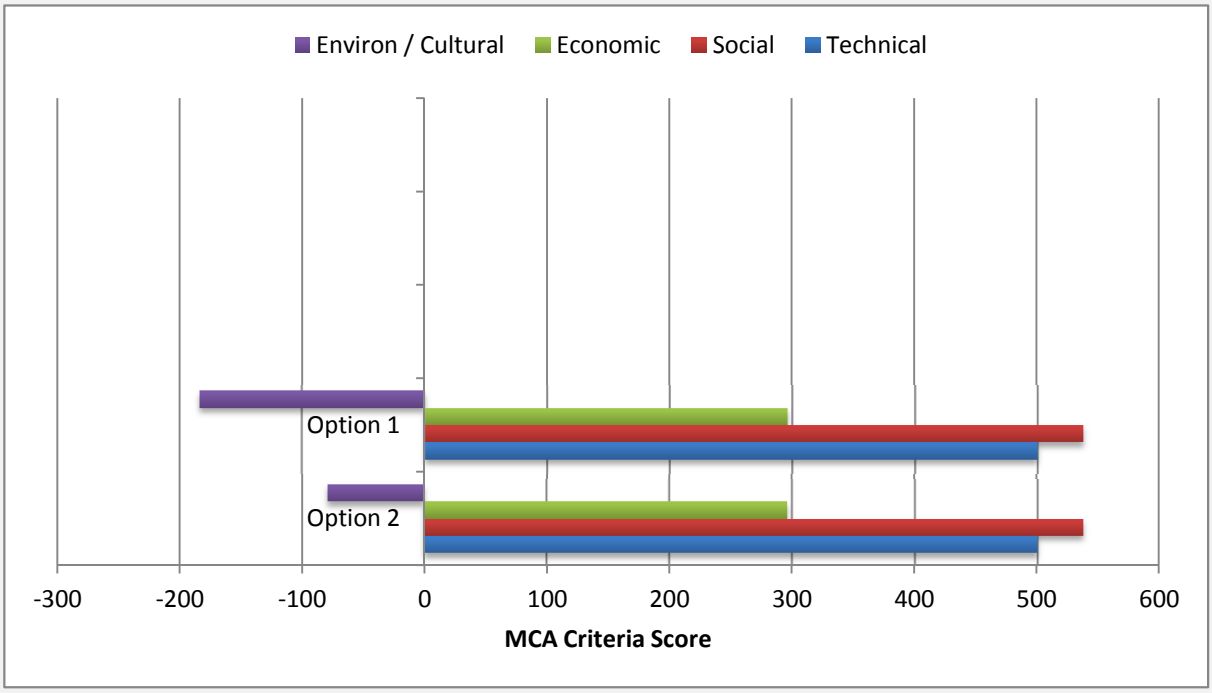
Objective 4.F (i)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	3.0	*There are 124 NIAH buildings within the AFA of national, regional and local importance.Kilkenny is considered a historic town. Some are located close to the Breagagh River. All recorded heritage features / monuments in the area are of low vulnerability to flooding.*
Option Scoring		
Total Option Score	5.0	*No negative effects on architectural features. Many NIAH buildings are located downstream of proposed line of Hard Defence.*
Weighted Option Score	**60**	*Global weighting x Local weighting x Total option score*

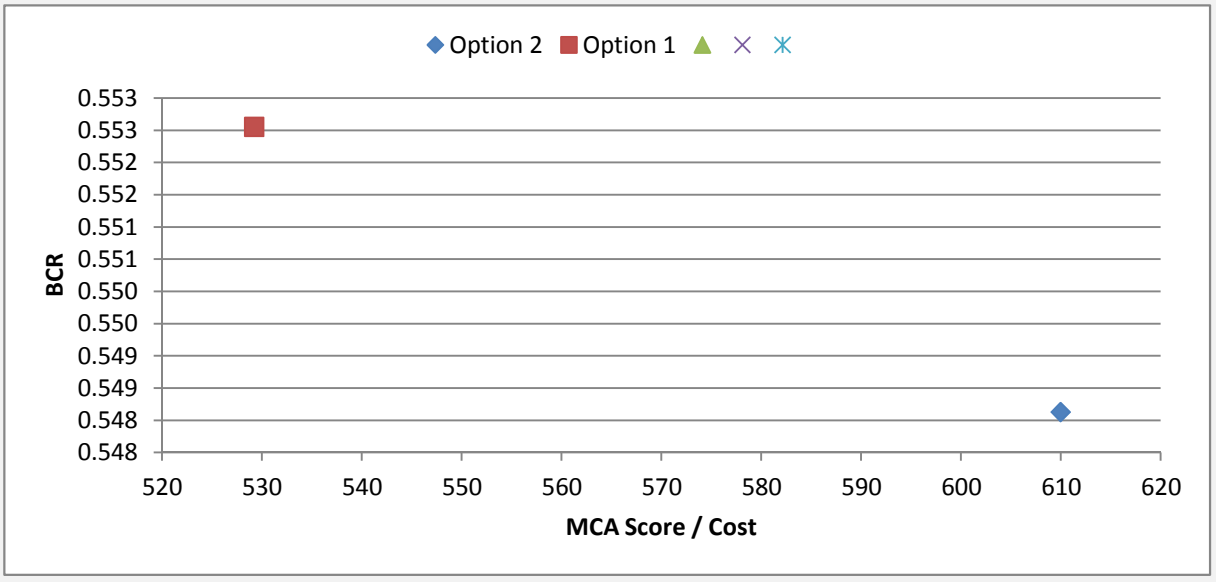
Objective 4.F (ii)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	4.0	*There is one monument in state care within the AFA which is of low vulnerability to flooding. Kilkenny is regarded as a historic town.*
Option Scoring		
Total Option Score	0.0	*No effects on archaeological features.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Environmental Score	**-79**

Option Comparison
Kilkenny (Breagagh)

Option No.	MCA Appraisal Scores				TOTAL - MCA Benefit Score	Cost (€millions)	MCA Score / Cost	BCR
	Technical	Social	Economic	Environ / Cultural				
Option 2	500	537	295	-79	816	1.236	660.137	0.548
Option 1	500	537	295	-184	883	1.226	720.37	0.553





ROBERTSHILL
Cnoc Riobaird

JAMESGR
Faiche Sha

LYONS
Pairceanna an Lionaigh

KILKENNY

MARNELLSMEADOWS
Móinéar an Mhairnéalaigh

WETLAND
An Baile Fliuch

POULGOUR
Poll Gabhair

LAND LOWER
luainte Íochtarach

Loch ar

SUGARLOAFHILL
Cnoc na Binn

KIL

0 0.1 0.2 0.4 Km

Kilkenny (Breagagh) - Option 1

- River Centreline
- Residual Risk
- Existing Risk
- Hard Defence

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DICKSBOROUGH
Baile Dic

DRAKELAND LOWER
Ráth Chluainte Íochtarach

DRAKELAND MIDDLE
Ráth Chluainte Láir

MORTGAGE FIELDS
Na Morgáistí

POULGOUR
Poll Gabhair

MARGARET'S FIELDS
Baile Mháiréide

WETLAND
An Baile Fliuch

LYONS
Páirceanna an Lionaigh

KILKENNY

MARNELLSMEADOWS
Móinéar an Mhairnéalaigh

Loch ar

SUGARLOAFHILL
Cnoc na Binne
KILKENNY

GARDENS (St. Patrick's Ph)

DUKESMEADO
Móinéar an Diú

BEARNSGROVE
Fearann an Dr

Lota Shraid

KILKENNY

ARCHE
Lota Shr

MAID
Cnoc

CASHEL
Caiseal

ARDSCREADAUN
Ard Screadain

SMITHSLAND NORTH
An Phairc Mhor Thuaidh

SMITHSLAND
An Phairc Mhor

LOUGHBOY
An Loch Bu

ARCHERSLEAS
Baile an Áirséaraigh

REVIEWFIE
An Bán Mór

CLONMORAN
Cluain Mérna

SHELLUMSRATH
Ráth an tSiolláma gh

SPRINGHILL
Cnoc Boi cín

BIRCHFIELD
Páirc an Bhirsigh

DONAGHMC
Domhnach M

DERDIMUS
Doire Dímais

GOSLINGSTOWN
Baile an Ghuaislínigh

FOULKS
Baile an Phucaigh

0 0.25 0.5 1 Km

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Kilkenny (Breagagh) - Option 2

- River Centreline
- Residual Risk
- Existing Risk
- Hard Defence
- Urban
- Agriculture