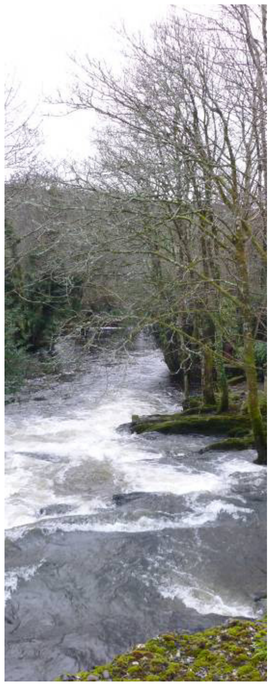

South Western CFRAM Study

Preliminary Options Report UoM 19

July 2016

The Office of Public Works

Oifig na nOibreacha Poiblí
The Office of Public Works

SOUTH WESTERN CFRAM STUDY
CATCHMENT FLOOD RISK ASSESSMENT AND MANAGEMENT

Mott MacDonald

South Western CFRAM Study

Preliminary Options Report UoM 19

July 2016

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Issue and Revision Record

Revision	Date	Originator	Checker	Approver	Description
A	February 2016	TD / RM / JD	B. O'Connor	F. McGivern	Draft Issue
B	May 2016	T. Donovan	B. O'Connor	F. McGivern	Draft Final
C	June 2016	T. Donovan	B. O'Connor	F. McGivern	Final
D	July 2016	J Desmond	T. Donovan	F. McGivern	Final

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Executive Summary

The Office of Public Works (OPW) is undertaking six catchment-based flood risk assessment and management (CFRAM) studies to identify and map areas across Ireland which are at existing and potential future risk of flooding. Mott MacDonald Ireland Ltd. has been appointed by the OPW to assess flood risk and develop flood risk management options in the South Western River Basin District. This Preliminary Options Report is one of a series of reports being produced as part of the South Western Catchment Flood Risk Assessment and Management Study (SW CFRAM Study). This report details the analysis undertaken to identify the preferred measures and options to manage flood risk in Unit of Management 19 (The Lee / Cork Harbour Catchment) which will form the basis for the Flood Risk Management Plan for this Unit of Management.

The preferred Flood Risk Management Options selected for inclusion in the Flood Risk Management Plan for UoM 19 are set out below:

- Planning Control
- Building Regulations
- SUDS
- Flood Forecasting and Warning Systems
  - Build on Lower Lee Flood Warning System
- Public Awareness
- Individual Property Flood Resilience
- Land Use Management

In addition to the options selected for the UoM, the preferred options selected for inclusion in the Flood Risk Management Plan for the Ballingeary / Inchigeelagh Sub-Catchment are set out below:

- Flood Forecasting and Warning Systems
  - River Level Gauges along with forecast rainfall to predict flooding from Lough Allua
  - Build on the Lower Lee Flood Warning System

The benefit of a flood forecasting and warning system may be reduced through the implementation of a measure / option at another SSA (i.e. AFA flood relief scheme). Therefore, the timing of other measures / options must be considered when implementing a flood forecasting and warning system.

The preferred Flood Risk Management Options selected for inclusion in the Flood Risk Management Plan for each of the AFAs in UoM 19 are set out below:

The preferred option for Ballingeary as identified in the MCA is Flood Defences.

The preferred option for Inchigeelagh as identified in the MCA is Flood Defences.

The preferred option for Castlemartyr as identified in the MCA is Flow Diversion and Flood Defences.

1 Introduction

1.1 Background

Flooding is a natural process that occurs throughout Ireland as a result of extreme rainfall, river flows, storm surges, waves, and high groundwater. Flooding can become an issue where the flood waters interact with people, property, farmland and protected habitats.

Flood risk in Ireland has historically been addressed through the use of structural or engineered solutions (arterial drainage schemes and / or flood relief schemes). In line with internationally changing perspectives, the Government adopted a new policy in 2004 that shifted the emphasis in addressing flood risk towards:

- A catchment-based context for managing risk;
- More pro-active flood hazard and risk assessment and management, with a view to avoiding or minimising future increases in risk, such as that which might arise from development in floodplains;
- Increased use of non-structural and flood impact mitigation measures.

A further influence on the management of flood risk in Ireland is the 'Floods' Directive [2007/60/EC]. The aim of this Directive is to reduce the adverse consequences of flooding on human health, the environment, cultural heritage and economic activity.

The Office of Public Works (OPW) is the lead agency in implementing flood management policy in Ireland. The OPW have commissioned a number of Catchment Flood Risk Assessment and Management Studies in order to assess and develop Flood Risk Management Plans (FRMPs) to manage the existing flood risk and also the potential for significant increases in this risk due to climate change, ongoing development and other pressures that may arise in the future.

Mott MacDonald Ireland Ltd. has been appointed by the OPW to undertake the Catchment-Based Flood Risk Assessment and Management Study (CFRAM Study) for the South Western River Basin District, henceforth referred to as the SW CFRAM Study. Under the project, Mott MacDonald Ireland Ltd. will produce FRMPs which will set out recommendations for the management of existing flood risk in the Study Area, and also assess the potential for significant increases in this risk due to climate change, ongoing development and other pressures that may arise in the future.

1.1 SW CFRAM Study Process

The overarching aims of the SW CFRAM Study are as follows:

- Identify and map the existing and potential future flood hazard;
- Assess and map the existing and potential future flood risk; and,
- Identify viable structural and non-structural options and measures for the effective and sustainable management of flood risk in the South Western River Basin District.

In order to achieve the overarching aims, the study is being undertaken in the following stages:

- Data collection;
- Hydrological analysis;
- Hydraulic analysis;
- Development of flood maps;
- Strategic Environmental Assessment and a Habitats Directive Appropriate Assessment;
- Flood risk assessment of people, economy and environment;
- Development and assessment of flood risk mitigation options; and,
- Development of the Flood Risk Management Plan (FRMP).

The resultant FRMP will set out recommendations for the management of existing flood risk and the potential for significant increases in this risk due to climate change, ongoing development and other pressures that may arise in the future.

The South Western River Basin District is split into five Units of Management (UoM). These Units follow watershed catchment boundaries and do not relate to political boundaries. The Units are as follows;

- The Blackwater Catchment (UoM 18)
- The Lee / Cork Harbour Catchment (UoM 19)
- The Bandon / Skibbereen Catchment (UoM 20)
- The Dunmanus / Bantry / Kenmare Bay Catchment (UoM 21)
- The Laune / Maine / Dingle Bay Catchment (UoM 22)

1.2 Report Structure

Table 1.1: Report Structure

Chapter	Key Contents of Chapter
1. Introduction	▪ Context of the Study ▪ The SW CFRAM process and aims ▪ Scope of Work
2. Description of the Unit of Management	▪ Description of study area ▪ Description of spatial scales of assessment
3. Screening of Possible Flood Risk Management Measures	▪ Description of the screening process ▪ Outcome of the screening process
4. Possible Flood Risk Management Measures	▪ Description of non-structural FRM measures ▪ Description of Structural measures
5. Development of Potential Flood Risk Management Options for AFAs	▪ Description of potential FRM options
6. Environmental Assessment	▪ Assessment of environmental impacts of potential FRM options
7. Stakeholder Input	▪ Summary of public consultations undertaken ▪ Summary of feedback received at public consultations
8. Flood Risk Assessment	▪ Description of the flood risk assessment process ▪ Description of receptors ▪ Description of flood risk maps
9. Estimate of Costs	▪ Estimate of costs of potential options
10. Appraisal of Options	▪ Description of the derivation of local weightings ▪ Description of the multi criteria analysis process
11. Selection of Preferred Options	▪ Description of preferred options

2 Description of the Unit of Management

2.1 Spatial Scales of Assessment

The South Western River Basin District covers an area of approximately 11,160 km^2. The Study Area includes most of County Cork, large parts of Counties Kerry and Waterford, along with small parts of the counties of Tipperary and Limerick. The Study Area contains over 1,800 km of coastline along the Atlantic Ocean and the Celtic Sea. There are five Units of Management within the South Western River Basin District, which are listed below:

- The Blackwater Catchment (UoM 18)
- The Lee / Cork Harbour Catchment (UoM 19)
- The Bandon / Skibbereen Catchment (UoM 20)
- The Dunmanus / Bantry / Kenmare Bay Catchment (UoM 21)
- The Laune / Maine / Dingle Bay Catchment (UoM 22)

Within the CFRAM Study, the screening, assessing and developing of Flood Risk Management (FRM) methods and options is to be considered on a range of Spatial Scales of Assessment (SSAs) that shall include:

- The Units of Management (UoM)
- Each Sub-Catchment within the Unit of Management
- Areas for Further Assessment (AFAs)
- Individual Risk Receptors (IRRs)

2.2 Spatial Scales of Assessment for Unit of Management 19

Within UoM 19 the River Lee from Ballingeary to Inchigeelagh forms a Sub-Catchment SSA where measures and options have potential to benefit both AFAs.

No IRRs have been identified within the South Western RBD and as such are not considered.

Based on the above, UoM 19 is split into 3 Spatial Scales of Assessment (SSAs). These are:

- The Unit of Management (UoM)
- Sub-Catchment
  - Ballingeary / Inchigeelagh
- Areas for Further Assessment (AFAs)
  - Ballingeary
  - Inchigeelagh
  - Castlemartyr
  - Killeagh

However, based on the Flood Risk Assessment and Mapping described in this report there is low risk in Killeagh and there are no structural flood risk management options proposed.

3 Screening of Possible Flood Risk Management Methods

3.1 General

A flood risk management option consists of one or, more commonly, a combination of flood risk management (FRM) methods or measures. The OPW have identified a range of possible FRM methods that could apply to areas at risk from flooding. The screening of possible FRM methods to determine their applicability and viability is carried out in this section.

3.2 Screening of Possible Flood Risk Management Methods

A preliminary assessment was carried out to identify which Flood Risk Management (FRM) methods were applicable to each of the SSAs within UoM 19.

The applicability and viability of each of the FRM methods was considered in terms of the following criteria:

- Applicability to the SSA
- Economic (potential benefits, impacts, likely costs etc.)
- Environmental (potential impacts and benefits)
- Social (impacts on people, society and the likely acceptability of the method) and
- Cultural (potential benefits and impacts upon heritage sites and resources)

The viability of each of the methods was assessed to a preliminary degree only. The purpose of the screening process was to identify the FRM methods that are clearly not applicable or viable within UoM 19. The FRM methods considered and the outcome of the screening process are shown in Table 3.1 below.

Table 3.1: Screening of Possible Flood Risk Management Methods

Measures / Methods	UoM	Sub-Catchment	AFA			
	19	Ballingeary / Inchigeelagh	Ballingeary	Inchigeelagh	Castlemartyr	Killeagh
Do Nothing	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable	Viable
Existing Regime	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable	Viable
Do Minimum	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable
Non-structural Measures						
• Planning Control	Viable	Viable	Viable	Viable	Viable	Viable
• Building Regulations	Viable	Viable	Viable	Viable	Viable	Viable
• SUDS	Viable	Viable	Viable	Viable	Viable	Viable
• Flood Forecasting	Viable	Viable	Viable	Viable	Viable	Viable
• Public Awareness	Viable	Viable	Viable	Viable	Viable	Viable
• Individual Property Flood Resilience	Viable	Viable	Viable	Viable	Viable	Viable
• Land Use Management	Viable	Viable	Viable	Viable	Viable	Viable
Structural Measures (Future Risk)						
• Strategic Development Management	Viable	Viable	Viable	Viable	Viable	Viable
Structural Measures (Current Risk)						
• Fluvial Storage	Viable	Viable	Viable	Not Viable	Not Viable	Not Viable
• Flow Diversion	Not Viable	Not Viable	Viable	Not Viable	Viable	Not Viable
• Increase Conveyance	Not Viable	Viable	Not Viable	Viable	Viable	Not Viable
• Flood Defences	Not Viable	Not Viable	Viable	Viable	Viable	Not Viable
• Improve existing defences	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable
• Relocate Properties	Viable	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable
• Localised protection works	Not Viable	Not Viable	Viable	Viable	Viable	Not Viable
Channel or Flood Defence Maintenance Works	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable
Other Works	-	-	-	-	-	-

3.3 Screening of UoM scale FRM Methods

3.3.1 Do Nothing / Existing Regime / Do Minimum

These measures are not viable due to the significant flood risk within UoM 19 to the economy and society for extreme events in the current and future scenarios.

3.3.2 Structural Measures (Current Risk)

Structural measures are typically not applicable to UoM scale SSAs due to cost and the likely significant social and environmental impacts of such works. Also, within UoM scale SSAs there are areas and receptors which are less vulnerable to flooding. Structural measures are more appropriate and applicable to AFA scale SSAs.

However, structural measures such as upstream storage and relocation of properties can be viable structural measures on a UoM scale.

3.4 Screening of Sub-Catchment scale FRM Methods

3.4.1 Do Nothing / Existing Regime / Do Minimum

These measures are not viable due to the significant flood risk within UoM 19 to the economy and society for extreme events in the current and future scenarios.

3.4.2 Structural Measures (Current Risk)

Structural measures are typically not applicable to Sub-catchment scale SSAs due to cost and the likely significant social and environmental impacts of such works. Also, within Sub-catchment scale SSAs there are areas and receptors which are less vulnerable to flooding. Structural measures are more appropriate and applicable to AFA scale SSAs.

However, structural measures such as upstream storage, increase conveyance and relocation of properties can be viable structural measures on a Sub-Catchment scale.

3.5 Screening of AFA scale FRM Methods

This section details each of the non-viable measures which have been screened out from further assessment. The remaining viable Flood Risk Management measures are assessed further in Chapter 4 and Chapter 5.

3.5.1 Do Nothing / Existing Regime

For the majority of the AFAs these measures are not viable due to the significant flood risk to the economy and society for extreme events in the current scenario and for future scenarios.

However, as part of the Flood Risk Assessment and Mapping, Killeagh was identified as having a low existing risk as there are no properties within the 1% AEP fluvial event. As a result, Killeagh has been excluded from the development of FRM Options on the basis that there is a low likelihood of achieving a cost-beneficial solution and/or the low priority that would be given to the AFA for any such works. Therefore, for Killeagh, the Do Nothing / Existing Regime are viable measures while all other structural measures are deemed to be not economically viable.

3.5.2 Do Minimum (e.g. Infilling of gaps etc.)

Within the AFAs considered there are no identifiable points or locations where minimum works such as infilling of gaps etc. would lead to a reduction in flood risk. Therefore, the do minimum approach is not applicable.

3.5.3 Ballingeary – Increase Conveyance

Ballingeary is located at the confluence of the River Lee and its tributary the Bunsheelin. The Bunsheelin is a steep flashy catchment and increasing conveyance along the watercourse or at structures will increase flooding in Ballingeary. Increasing conveyance along the River Lee will have limited impact as Lough Allua is located approximately 2.2km downstream of Ballingeary and the lake dictates the flood level in Ballingeary. For the 1% AEP event the level at Ballingeary is 85.94m OD Malin (Sule_52298), the upstream level at the Lough is 85.9m OD Malin (Sule_49937) and downstream level is 85.89m OD Malin (Sule_44100). The Lough is approximately 5.5km in length which results in only a 0.05m difference in level over 7.7km. The measure of improving the conveyance capacity of the River Lee at what is locally known as “The Ford” was considered. As this is located upstream of Lough Allua and the lake level dictates the flood level in Ballingeary this measure is not considered to be applicable. However, increasing conveyance at Inchigeelagh Bridge is considered under measures for Inchigeelagh.

3.5.4 Ballingeary – Improve Existing Defences

There are no existing flood defences in Ballingeary. This measure is not applicable.

3.5.5 Ballingeary – Relocate Properties

There are no isolated properties at risk within Ballingeary. This measure would require relocation of 21 Nr. residential and 25 Nr. non-residential properties. Relocating this number of properties from Ballingeary would not be socially viable as to do so would significantly alter the social fabric of this town.

3.5.6 Ballingeary – Channel or Flood Defence Maintenance Works

Ballingeary does not have an existing channel scheme or flood defence scheme to maintain. This measure is not applicable.

3.5.7 Inchigeelagh – Fluvial Storage

There are no suitable locations to store the required flow between Ballingeary and Inchigeelagh. Lough Allua is located between Ballingeary and Inchigeelagh and is a source of flooding due to backwater in the lake. Fluvial storage is not applicable.

3.5.8 Inchigeelagh – Flow Diversion

Due to the magnitude of flows in the River Lee (111m3/s for the 1% AEP event) and its location within a valley it is not feasible to divert flows. Flow diversion is not applicable.

3.5.9 Inchigeelagh – Improve Existing Defences

There are no existing flood defences in Inchigeelagh. This measure is not applicable.

3.5.10 Inchigeelagh – Relocate Properties

There are no isolated properties at risk within Inchigeelagh. This measure would require relocation of 14 Nr. residential and 14 Nr. non-residential properties. Relocating this number of properties from Inchigeelagh would not be socially viable as to do so would significantly alter the social fabric of this town.

3.5.11 Inchigeelagh – Channel or Flood Defence Maintenance Works

Inchigeelagh does not have an existing channel scheme or flood defence scheme to maintain. This measure is not applicable.

3.5.12 Castlemartyr – Fluvial Storage

There is no suitable location for storage upstream of Castlemartyr. In addition, the existing ground conditions are karst which include significant caves and swallow holes. The existing karst geology would require lining of the storage area which is not economically or environmentally viable. Fluvial storage is not applicable.

3.5.13 Castlemartyr – Improve Existing Defences

There are no existing flood defences in Castlemartyr. This measure is not applicable.

3.5.14 Castlemartyr – Relocate Properties

There are no isolated properties at risk within Castlemartyr. This measure would require relocation of 13 Nr. residential and 16 Nr. non-residential properties. The scheme benefit is approx. €3M. It is not economically viable to relocate a property at a cost of €103k per property. It would cost considerably more to relocate non-residential properties / businesses which may also suffer from moving away from the town centre. This measure is not economically viable.

3.5.15 Castlemartyr – Channel or Flood Defence Maintenance Works

Castlemartyr does not have an existing channel scheme or flood defence scheme to maintain. This measure is not applicable.

4 Possible Flood Risk Management Measures

4.1 General

A flood risk management option consists of one or, more commonly, a combination of flood risk management methods / measures. This section assesses the possible flood risk management measures as screened in Table 3.1.

4.2 Non-Structural Measures

Non-structural measures such as Land Use Management, Natural Flood Management, Green Infrastructure etc. are terms used to cover a suite of measures that are intended to reduce flood risk by working with natural systems and, where possible, provide environmental benefits. While in small catchments they can effectively manage flood risk to a certain degree in their own right, in larger catchments they can work in a complimentary way with other measures to achieve flood risk management targets.

Due to the time required to initiate, establish and prove the flood risk management targets of such measures, they are not deemed viable to mitigate the current flood risk and any potential reductions in flood risk should not be considered when developing other options based on structural measures.

Where there is existing flood risk, the implementation of non-structural measures such as Planning Control, SUDS etc. at any spatial scale of assessment will not mitigate flood risk, unless those measures are retrospectively applied. As this is unrealistic and not economically viable, such non-structural measures can only be applied to new development to maintain the status quo of the current flood risk scenario or mitigate future flood risk. The application of non-structural measures such as individual property resilience, public awareness and flood forecasting, to redevelopment or new development may reduce potential damage costs.

The non-structural measures described in this section are complimentary to structural measures and should be implemented as national policy to the SSAs where appropriate. However, at this stage they should not be considered in the development of options based on structural measures.

4.2.1 Planning Control

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.

4.2.2 Building Regulations / Planning Conditions

The risk of damage to properties from flooding can be mitigated by the use of appropriate construction techniques and materials. For example the damage caused to an internal wall of a property by flooding can depend on the materials and methods of its construction. A timber stud partition covered with plasterboard with low level electrical wiring would have to be completely replaced following immersion in flood water. However, a solid concrete block wall covered with tiles and high level electrical wiring on the other hand would only have to be washed down following a flood.

If for a particular town or high flood probability areas, certain building regulations or planning conditions were adopted that ensured structures were flood resilient through specified construction methods, building fabrics and uses, a decrease in the risk of damage could be achieved. The question of whether such regulations or planning conditions could be imposed upon developers, business owners or householders in flood prone areas would need to be addressed if this were to be brought forward as a flood risk management measure.

A link to a UK guidance document "Improving the Flood Performance of New Buildings" prepared by the Department for Communities and Local Government is provided below.

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/7730/flood_performance.pdf

4.2.3 Sustainable Urban Drainage Systems (SUDS)

Sustainable Urban Drainage (SUDS) involves the management of surface water run-off from developments in a manner which attempts to replicate the natural behaviour within catchments and watercourses, which is typically achieved through attenuation.

Within existing urban or developed areas there is typically little space available for the attenuation of storm water flows to a degree which would mitigate or reduce current flood risk. Therefore, it is not considered practical to implement SUDS for the mitigation of current risk at any SSA. However, within all SSAs every new development (and where possible redevelopment), should apply the principles of SUDS.

A separate Strategic SUDS report has been prepared for UoM 19 outlining potential SUDS measures in the AFAs. These measures focus on areas that are zoned for future development.

4.2.4 Flood Forecasting and Warning

Flood forecasting is a means of providing advanced warning of an impending flood event. A reliable advance warning system allows protective measures to be put in place and protective actions to be carried out in advance of a flood event. These actions and measures can reduce the damage caused in a flood event.

Flood forecasting is not a possible FRM measure at all SSAs. This is because the time between transmitting a flood forecast in which the authorities have reasonable confidence and the arrival of flood waters may not be long enough for people to take effective action to reduce flood damage. The minimum time to take effective action is deemed to be 6 hours. This time limit is set on the basis that once rainfall has been recorded it can take up to 2 hours to run a complex model and get meaningful forecasts. Following this forecast it is assumed that it can take people up to 3 hours to travel to their home or business and take the necessary measures to protect their property from flooding.

Flood forecasting and warning has been identified as a possible FRM measure for the SSAs highlighted in Table 4.1. Table 4.1 highlights the time to peak for the critical event (Fluvial = 1% AEP event / Tidal = 0.5% AEP event) and summarises the infrastructure required to implement a flood forecasting and warning system. The infrastructure required is based upon the layout of the catchment and the arrangement of watercourses that could contribute to flood flows. Gauges are located at critical locations in the catchment so that data on precipitation and rising river levels can be collected and analysed to feed into the forecasting system.

The accuracy of the forecasting system will depend on the number of river level and rain gauges collecting data. The more gauges there are the greater the accuracy of the system. The cost and complexity of the system will also increase with more gauges. This will give more accurate forecasts but it will take longer for the system to generate them.

Table 4.1: SSAs Suitable for Flood Forecasting

Spatial Scale of Assessment	Time to Peak of Event	Infrastructure
AFA		
Ballingeary	> 6 Hours	River level gauges (downstream at Lough Allua) Connect to Lower Lee Flood Warning System
Inchigeelagh	> 6 Hours	River level gauges (upstream at Lough Allua) Connect to Lower Lee Flood Warning System
Castlemartyr	> 6 Hours	Rain gauges River level gauges
Killeagh	> 6 Hours	Rain gauges River level gauges
Sub-Catchment		
Ballingeary / Inchigeelagh	> 6 Hours	River level gauges (Lough Allua) Connect to Lower Lee Flood Warning System
UoM		
River Lee / Cork Harbour	> 6 Hours	River level gauges (Lough Allua) Connect to Lower Lee Flood Warning System Use the existing OPW storm surge forecasting system to predict high tide levels.

Source: UoM 19 Hydraulics Report

An equation to estimate the impacts of flood warnings on flood damages has been developed by Green & Penning-Rowsell. This equation determines that the estimated actual flood damage avoided owing to flood warnings is approximately 13% of potential damages.

4.2.4.1 Ballingeary

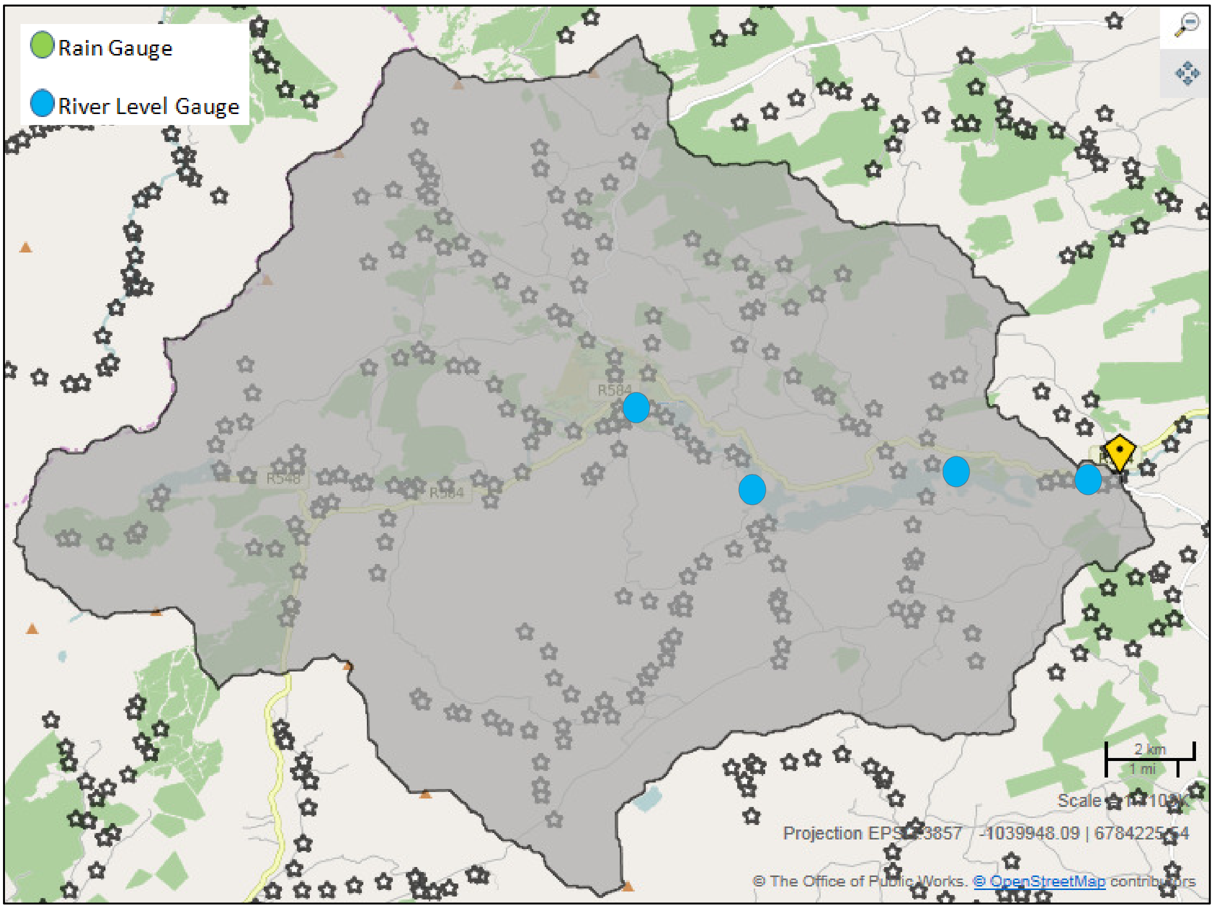
In Ballingeary flood warning would be ineffective for flooding caused by overland flow in the upper reaches of the Bunsheelin as this source of flood risk is driven by small flashy catchments. However, flood warning would be more effective for flooding arising from backwater in Lough Allua (River Lee) where forecast rainfall could be linked to the level in the Lough.

The infrastructure required for a flood forecasting and warning system in Ballingeary (AFA) is listed in Table 4.2 and the proposed locations are shown in Figure 4.1.

Table 4.2: Ballingeary – Flood Forecasting Infrastructure

Equipment	Quantity
Rain Gauges	0
River Level Gauge (Hydrometric Gauging Station)	4

Figure 4.1: Ballingeary – Lough Allua – Proposed Gauges



4.2.4.2 Inchigeelagh

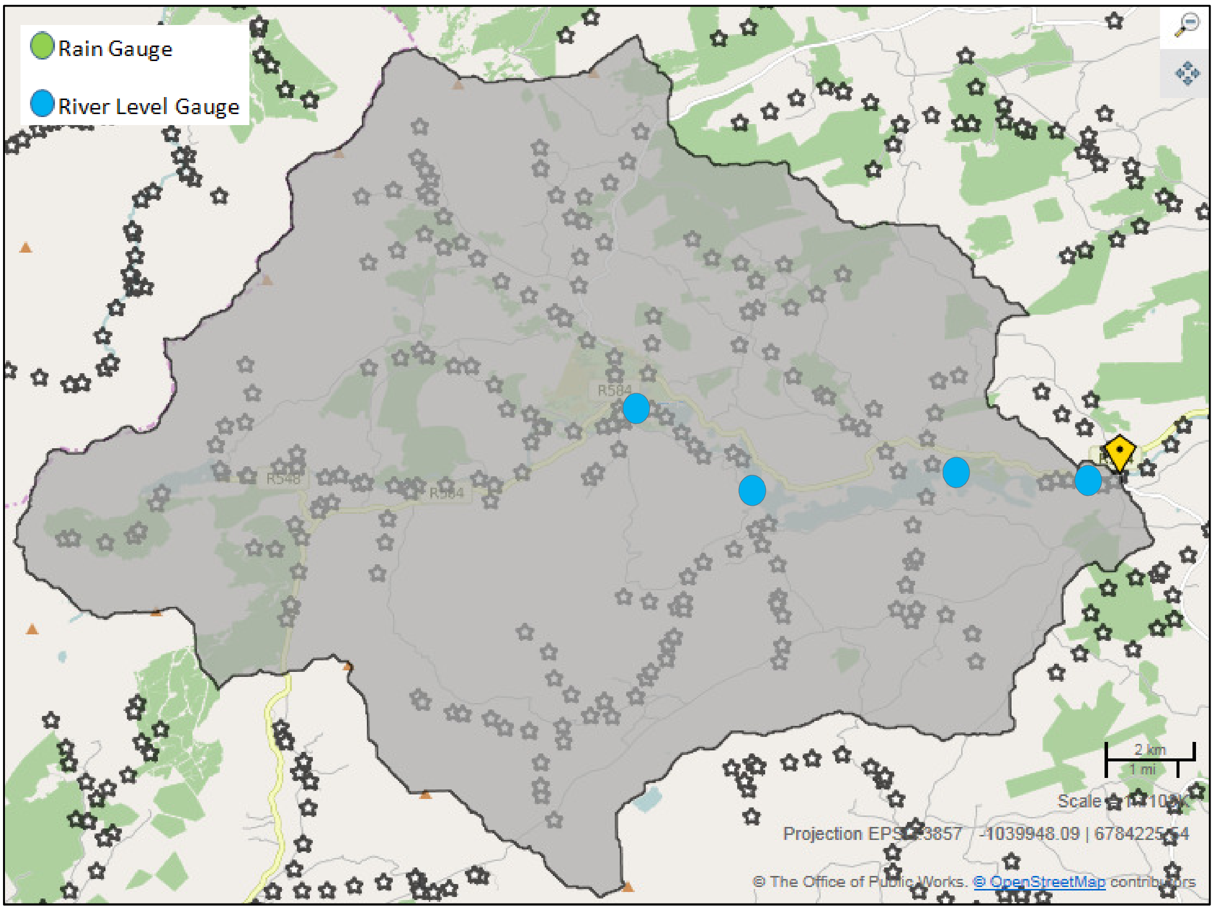
As is the case in Ballingeary, flood warning in Inchigeelagh would be more effective for flooding arising from Lough Allua (River Lee) where forecast rainfall could be linked to the level in the Lough.

The infrastructure required for a flood forecasting and warning system in Inchigeelagh (AFA) is listed in Table 4.3 and the proposed locations are shown in Figures 4.2.

Table 4.3: Inchigeelagh – Flood Forecasting Infrastructure

Equipment	Quantity
Rain Gauges	0
River Level Gauge (Hydrometric Gauging Station)	4

Figure 4.2: Inchigeelagh – Lough Allua – Proposed Gauges



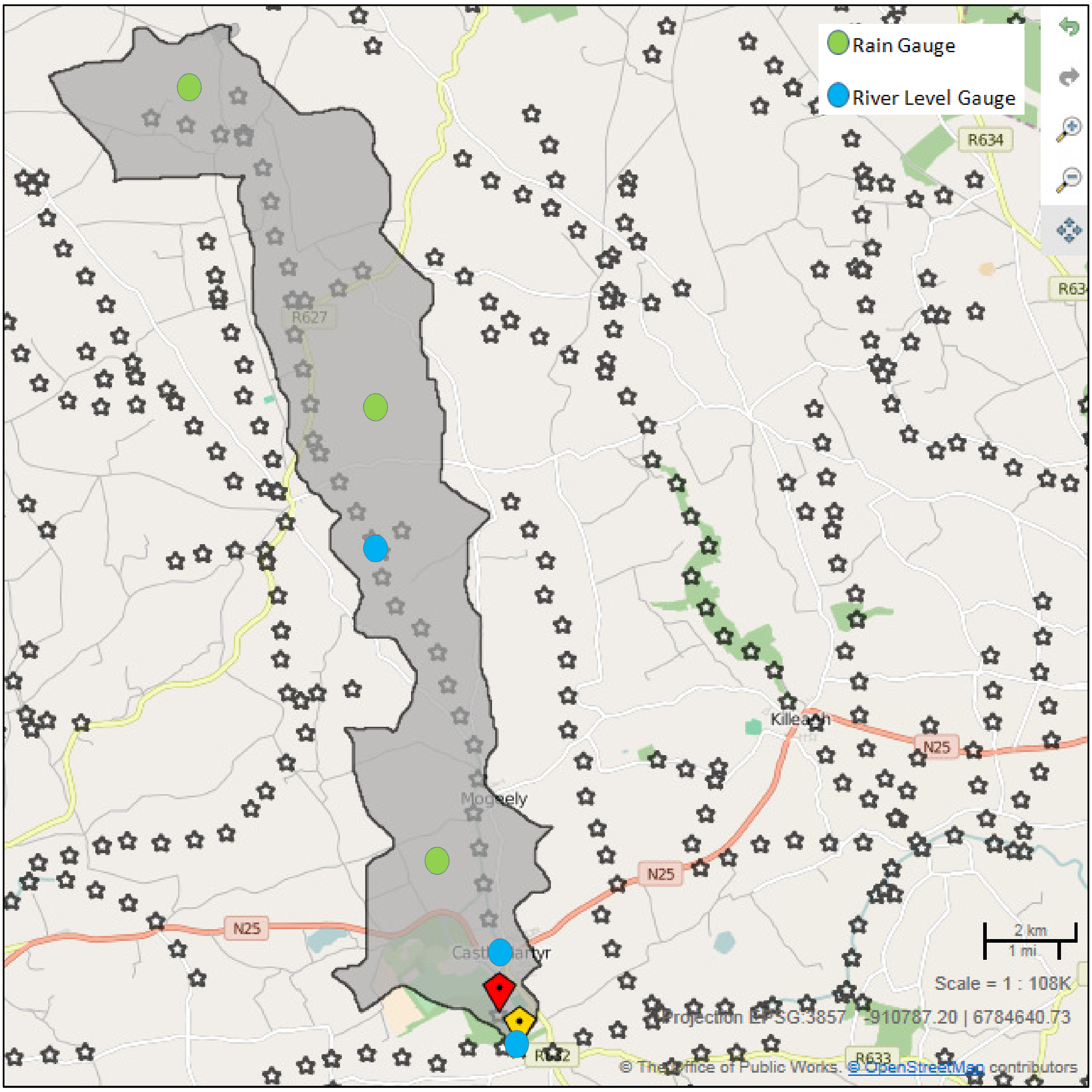
4.2.4.3 Castlemartyr

The infrastructure required for a flood forecasting and warning system in Castlemartyr (AFA) is listed in Table 4.4 and the proposed locations are shown in Figures 4.3.

Table 4.4: Castlemartyr – Flood Forecasting Infrastructure

Equipment	Quantity
Rain Gauges	3
River Level Gauge (Hydrometric Gauging Station)	3

Figure 4.3: Castlemartyr – Proposed Gauges



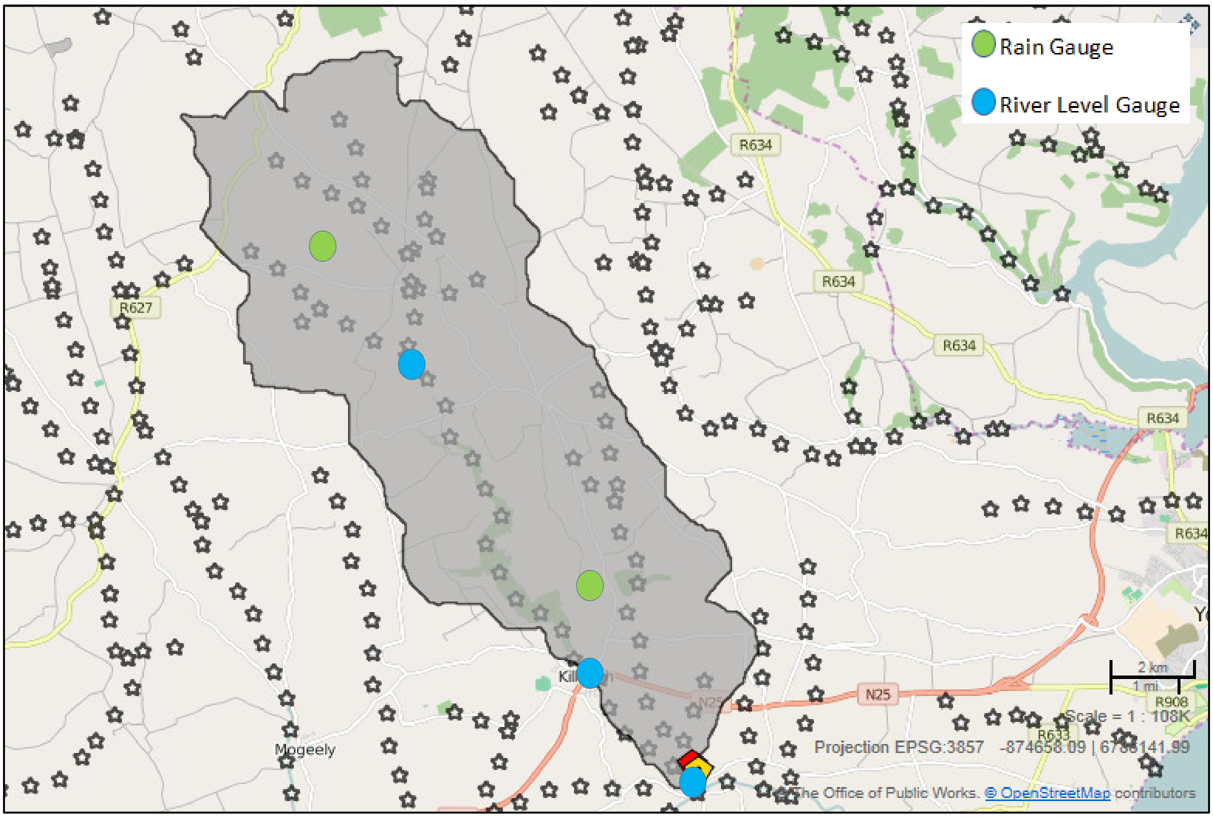
4.2.4.4 Killeagh

The infrastructure required for a flood forecasting and warning system in Killeagh (AFA) is listed in Table 4.5 and the proposed locations are shown in Figures 4.4.

Table 4.5: Killeagh – Flood Forecasting Infrastructure

Equipment	Quantity
Rain Gauges	2
River Level Gauge (Hydrometric Gauging Station)	3

Figure 4.4: Killeagh – Proposed Gauges



The infrastructure listed and shown above would also be required for a UoM / Sub-Catchment scale forecasting system which would build on the Lower Lee Flood Warning System.

Cost estimates for the proposed flood forecasting and warning systems are included in Section 9.0.

4.2.5 Public Awareness

Many of the measures to mitigate and manage flood risk and the potential consequences for flooding will involve the public at large. It is therefore important that the public is made aware of where to find information, what the information means and what actions the public and business owners can take to reduce the damage that would occur to their properties, possessions and interests in the event of a flood.

Public awareness measures will engender the public's recognition of the potential of the risk of flooding and the potential consequences thereof. Knowing in advance means that actions can be taken in a timely manner.

Measures to increase and promote public awareness include:

- Identifying the areas prone to flooding
- Information on measures to be implemented to reduce and / or manage the risk of flooding
- Measures in place to provide advance warning of flooding
- Establishment of methods to interface with the public and in particular the owners of vulnerable properties, i.e. workshops and meetings, Facebook, Twitter, text messaging, newsprint, websites, etc.

Flood risk maps and flood hazard maps have been produced for the UoM 19 AFAs. The dissemination of this information to the public will increase awareness.

4.2.6 Individual Property Flood Resilience

It is possible to reduce the damage caused by flooding to a property by carrying out works that make the property more flood resilient. Such works could include replacing porous floor and wall coverings with tiles or other non-porous finishes or raising electrical sockets to a level above the design flood level. Table 4.6 below shows the number of properties at risk from the 1% (or 0.5% for coastal flooding) AEP flood event in each AFA, the potential benefit achievable in each AFA and the total budget available for flood resilience works in each property. This budget is the benefit for the design event divided by the number of properties at risk. When account is taken of Optimism Bias (40%), preliminaries (32%) and design fees (13%) the total construction cost includes 85% of the available budget relates to non-construction costs. This means that only 15% of the total budget is available for the construction of flood resilience measures. This basic flood resilience budget indicates if individual property flood resilience is a viable option in each AFA. It is assumed that a basic budget of €7,500 is required for each property in order for it to be viable.

Table 4.6: Individual Property Flood Resilience

AFA	Residential Properties at Risk	Non-residential Properties at Risk	Capped Benefit €	Total IPFR budget €	Basic IPFP budget €	Viable Y/N
Ballingeary	21	25	14,882,358.26	323,529.53	48,529.43	Y
Inchigeelagh	14	14	4,681,767.44	167,205.98	25,080.90	Y
Castlemartyr	13	7	2,394,238.74	119,711.94	17,956.80	Y
Killeagh	0	0	0.00	0.00	0.00	N

This analysis indicates that Individual Property Flood Resilience is a viable option for Ballingeary, Inchigeelagh and Castlemartyr. This flood risk management measure should be explored further if no structural flood risk management measures are found to be viable for these AFAs.

4.2.7 Land Use Management

Land Use Management can be utilised as a non-structural measure to prevent or reduce the impact of flooding on properties, roads and other critical infrastructure. Land Use Management includes strategies to control overland flow, such as improving agricultural and forestry practices in key catchment areas. Local natural flood management measures such as the creation of wetlands or forestry to retain overland flow could also be adopted.

4.2.8 Emergency Response Planning

Well prepared and executed emergency response plans can significantly reduce the impact of flood events, particularly for human health and welfare.

The Framework for Major Emergency Management was developed in 2005 and was adopted by Government decision in 2006. Its purpose is to set out common arrangements and structures for front line public sector emergency management in Ireland. The Framework is based on the internationally recognized systems approach that, in essence, proposes an iterative cycle of continuous activity through five stages of emergency management:

– Hazard Identification
– Mitigation
– Preparedness
– Response
– Recovery

Under the Framework, Local Authorities are designated as the lead agency for co-ordinating the response to severe weather events, and each Local Authority should have, as a specific sub-plan of its Major Emergency Plan, a plan for responding to severe weather emergencies, whether a major emergency is declared or not. The other principal response agencies should include sub-plans for responding to notifications from the Local Authorities of severe weather warnings.

A Guide to Flood Emergencies (MEM Guidance Document 11, July 2013) has been published to assist the Principal Response Agencies in meeting their responsibilities, under the Framework for Major Emergency Management, and to deliver on the responsibilities of the OPW and the Local Authorities with respect to emergency planning as set out in the Report of the Flood Policy Review Group. The Guide provides advice on the development and implementation of consistently effective flood emergency response and short-term recovery planning by the Principal Response Agencies and others, and includes a template plan.

4.3 Structural Measures

4.3.1 General

As highlighted above, a flood risk management option consists of one or, more commonly, a combination of flood risk management methods / measures. Therefore, please note that some of the following structural measures may be required in combination to provide a potential flood risk management option that will mitigate both fluvial and tidal flood risk.

The possible flood risk management measures for each of the AFAs being considered are detailed in Table 4.7 below.

Table 4.7: Possible Structural Measures

AFA	Ballingeary	Inchigeelagh	Castlemartyr	Killeagh
Fluvial Storage	Y	N	Y	N
Flow Diversion	Y	N	Y	Y
Increase Conveyance	N	Y	Y	Y
Flood Defences	Y	Y	Y	Y
Improve Existing Defences	N	N	N	N
Relocate Properties	N	N	N	N
Localised Protection Works	Y	Y	Y	Y
Channel or Flood Defence Maintenance Works	N	N	N	N
Other works	N	N	N	N

Details of the possible flood risk management measures and how they can be combined into potential options are included in Section 5.

5 Development of Potential Flood Risk Management Options for AFAs

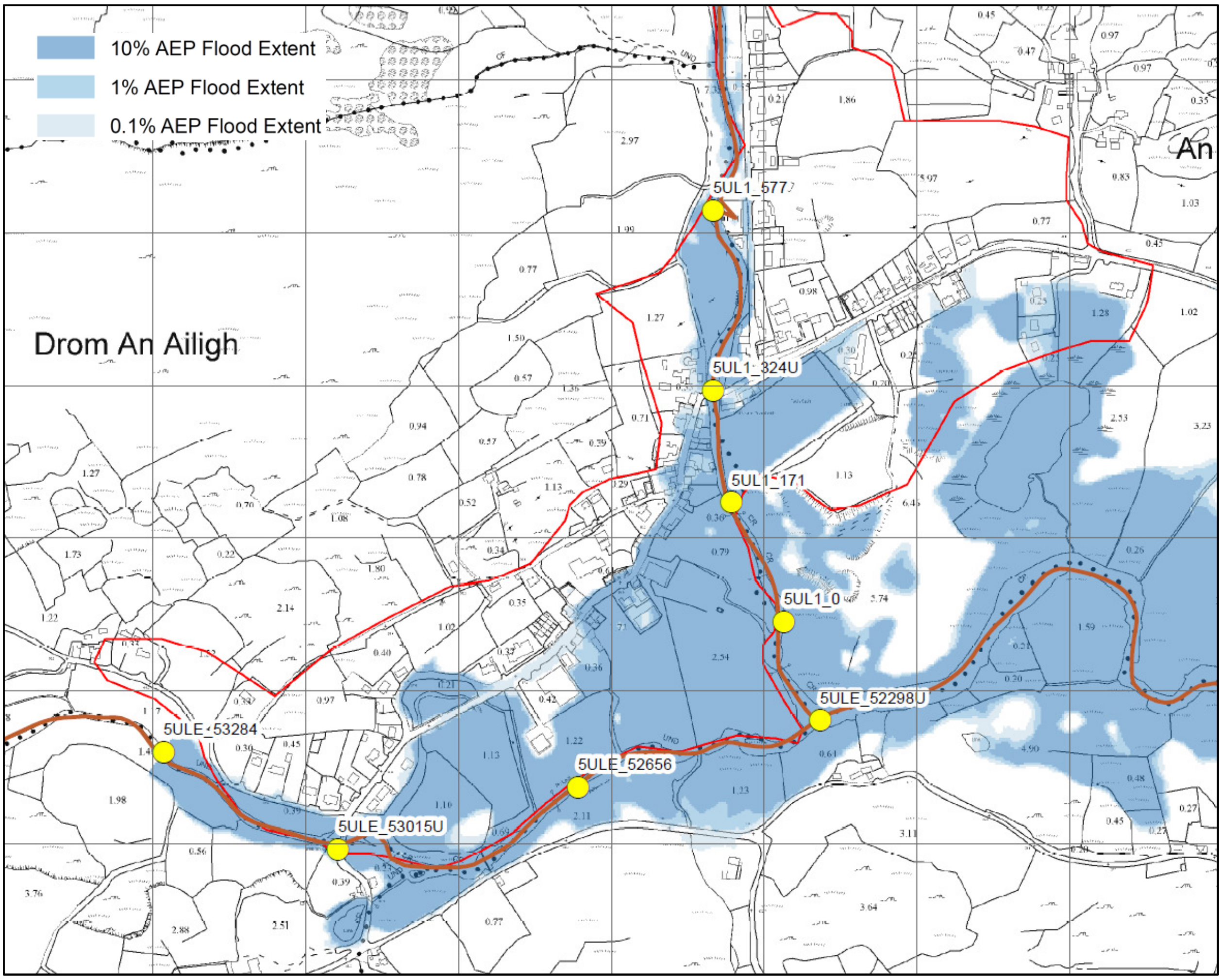
5.1 General

A Flood Risk Management (FRM) option consists of one, or more commonly a combination of FRM measures. This section outlines the development of the potential Flood Risk Management (FRM) options for each of the AFA's within UoM 19.

5.2 Ballingeary, Co. Cork

Ballingeary is located along the upper reach of the River Lee in County Cork. Ballingeary is at risk of fluvial flooding. The AFA and the existing fluvial flood risk are highlighted in Figure 5.1.

Figure 5.1: Ballingeary – Current Scenario Fluvial Flood Extents



5.2.1 Possible FRM Measures

As outlined in Section 3.0, the screening process identified the following potentially viable flood risk mitigation measures:

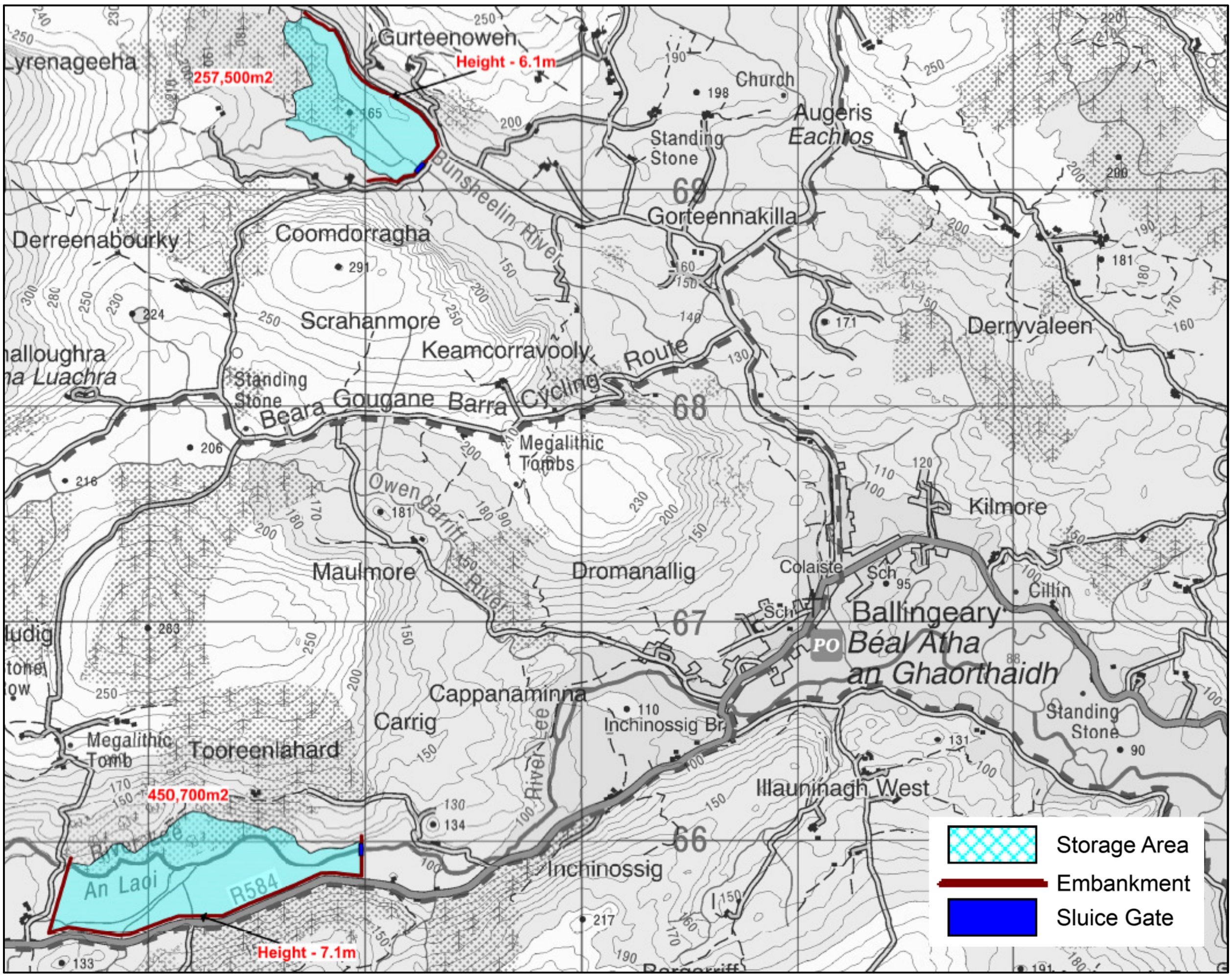
- Storage
- Flow Diversion
- Flood Defences

The possible measures were reviewed and assessed further to determine if they were applicable and viable. The measures were modelled individually to determine their effectiveness and impact.

5.2.1.1 Storage

Ballingeary is located at the confluence of the River Lee and its tributary, the Bunsheelin. Flooding occurs in Ballingeary for the 50% AEP fluvial event. Potential locations for the storage of fluvial flows were identified on both watercourses and an assessment of the available storage capacity was carried out. The locations of the potential storage areas are shown in Figure 5.2.

Figure 5.2: Ballingeary – Storage Measure



The required capacities of the storage areas are derived using the catchment hydrology as applied in the hydraulic modelling. No allowances for uncertainties in the estimate of the index flood flow or flood growth curve have been made.

Flooding occurs on the River Lee for the 50% AEP event (Qmed). The peak flow in the River Lee for the 1% AEP event is 83.5m3/s which results in significant flooding. The storage area on the River Lee is 450,700m2 and has a capacity of 2,953,595m3 which can limit the outflow to less than Qmed.

Flooding occurs on the Bunsheelin for the 50% AEP event (Qmed). The peak flow in the Bunsheelin for the 1% AEP event is 51m3/s which results in significant flooding. The storage area on the Bunsheelin is 257,500m2 and has a capacity of 1,439,021m3 which can limit the outflow to less than Qmed.

The proposed storage areas were modelled individually and in combination to determine the full extent of any benefit or impact.

The hydraulic modelling of storage on the River Lee alone shows a significant reduction in flood extent with an average reduction in water levels of approx. 0.4m. However, as shown in Figure 5.3, it does not achieive the required standard of protection with a number of properties along the Lee and Bunsheelin still flooding. Storage on the River Lee is not a viable measure individually.

The hydraulic modelling of storage on the Bunsheelin alone shows a significant reduction in flood extent with an average reduction in water levels of approx. 0.48m. As shown in Figure 5.4, this measure fully mitigates flooding along the Bunsheelin and reduces flooding through the town. However, there are a number of properties in the town still flooding. Storage on the Bunsheelin is not a viable measure individually.

The hydraulic modelling of storage on both the River Lee and the Bunsheelin together results in a significant reduction in flood extent with an average reduction in water levels of approx. 0.95m. As shown in Figure 5.5, this measure fully mitigates flooding along the River Lee and the Bunsheelin, achieving the required standard of protection. Storage on the River Lee and Bunsheelin is deemed to be a viable measure / option.

Figure 5.3: Ballingeary – River Lee Storage Measure Flood Extent

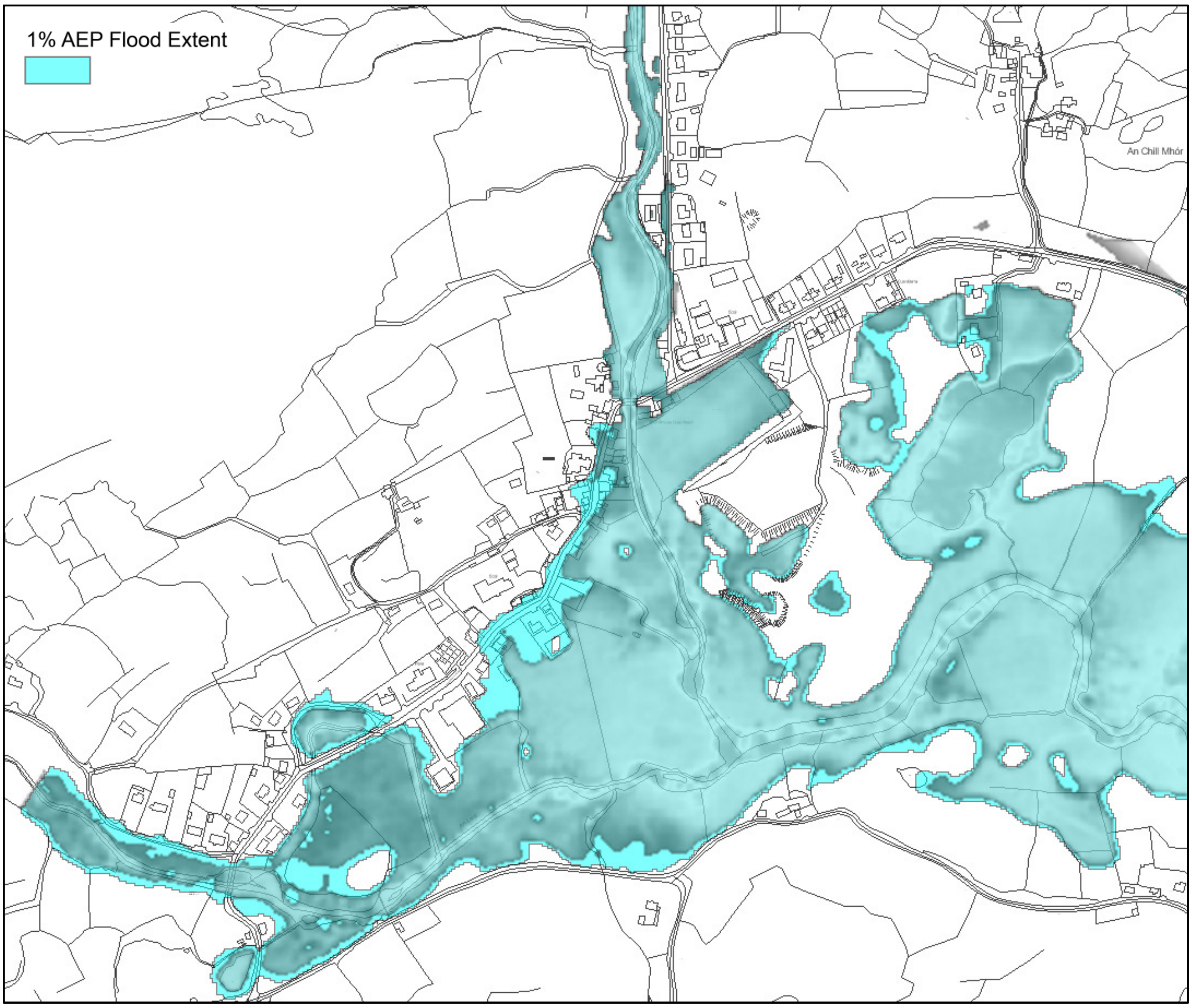


Figure 5.4: Ballingeary – Bunsheelin Storage Measure Flood Extent

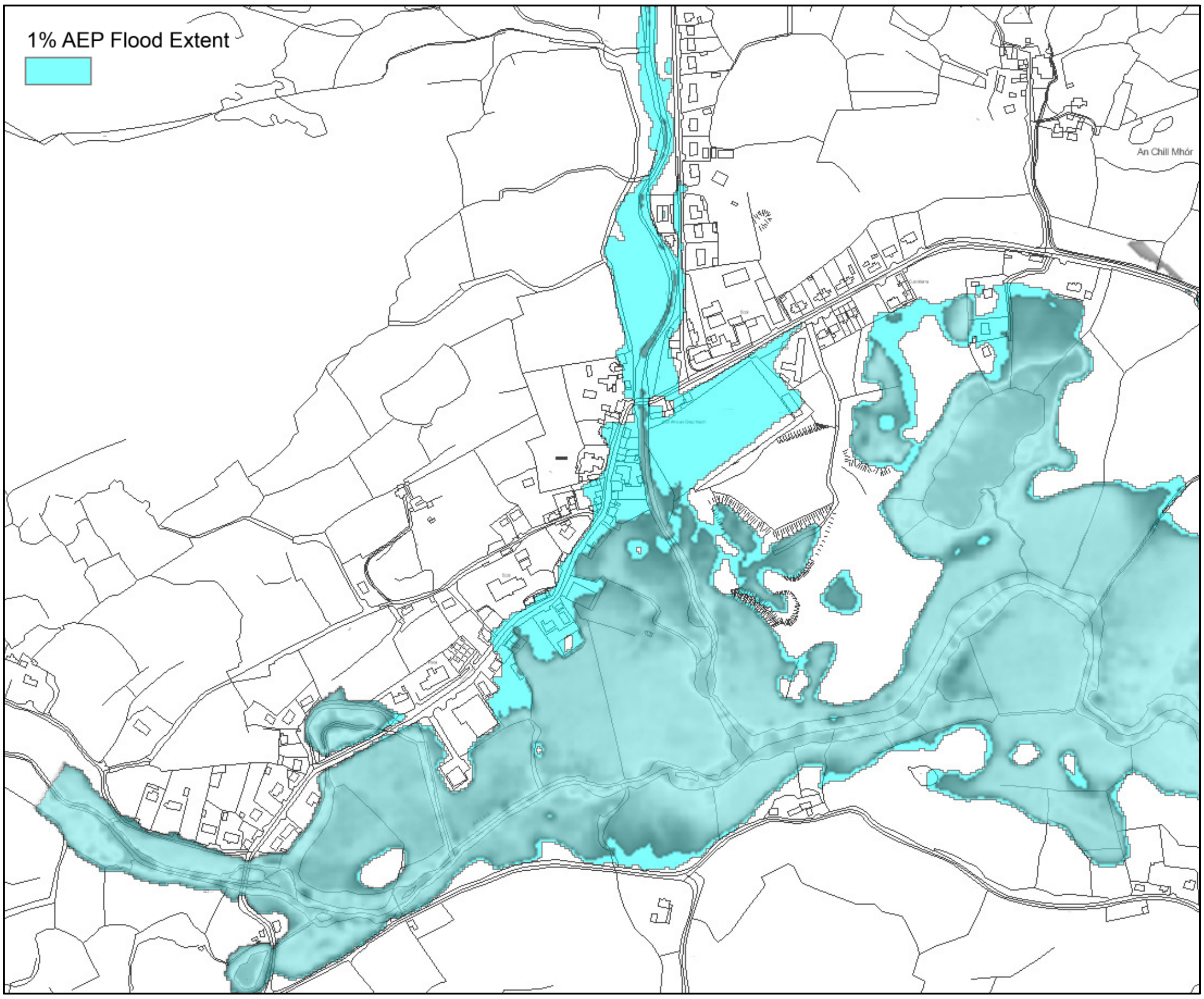
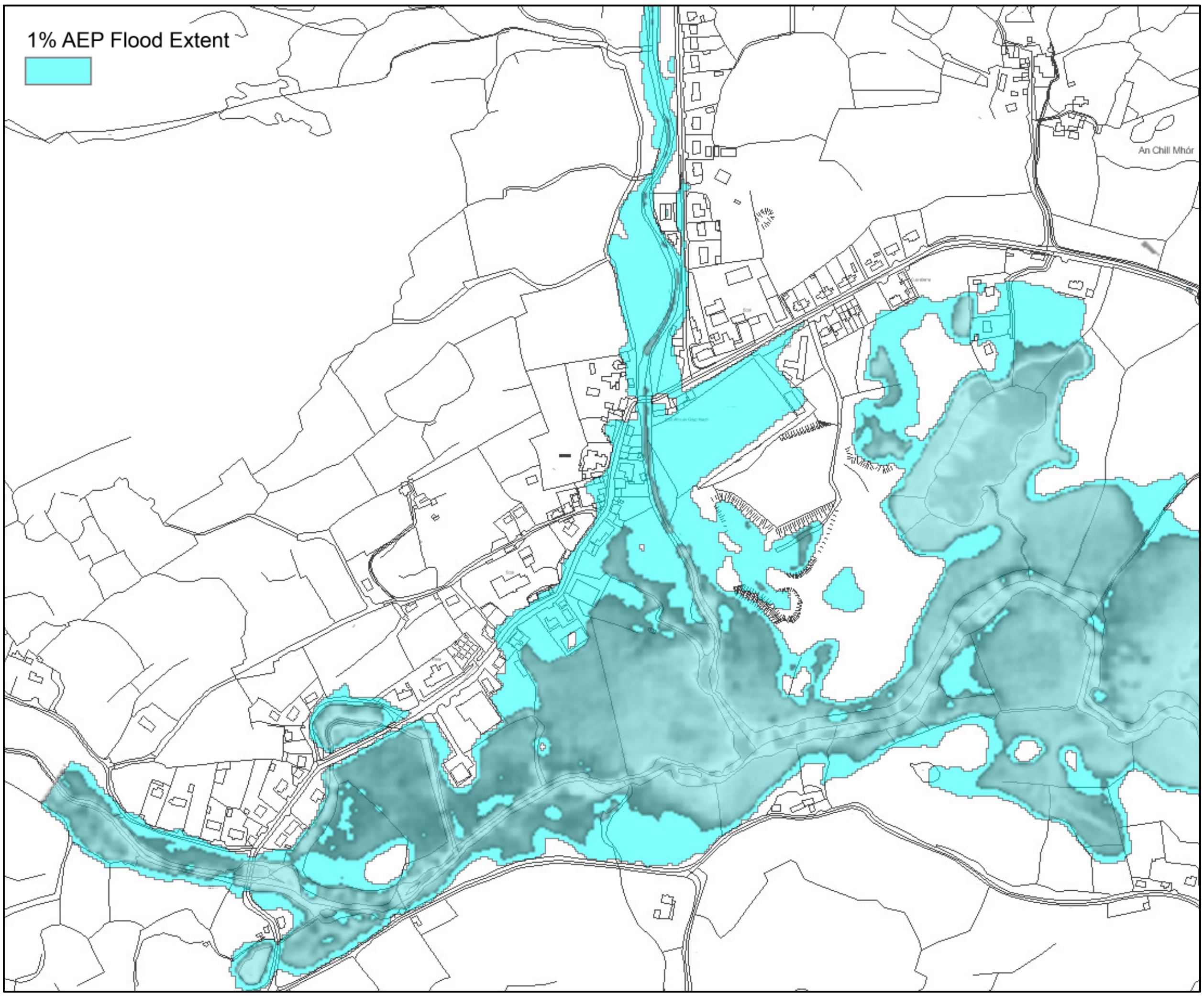


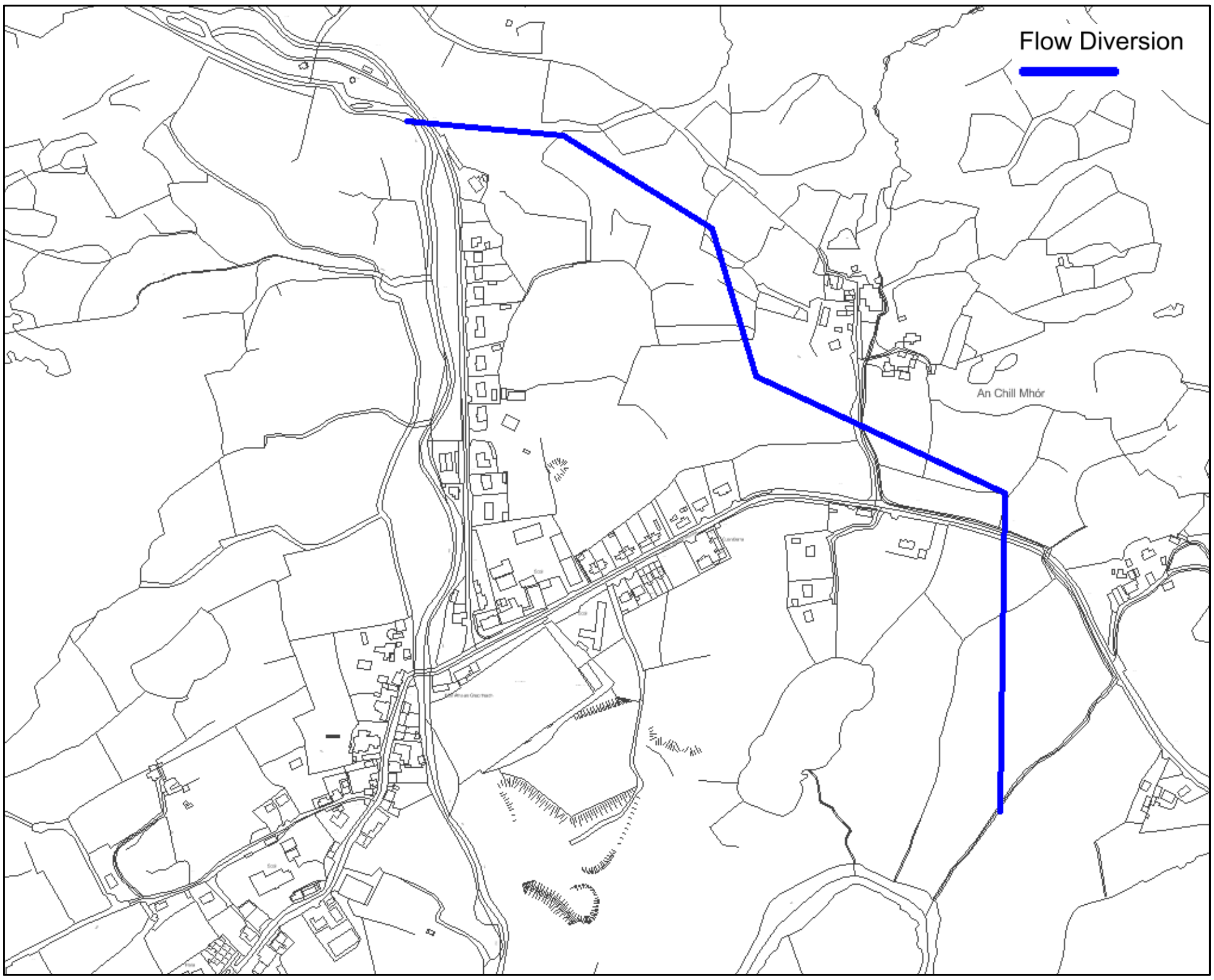
Figure 5.5: Ballingeary – River Lee & Bunsheelin Storage Measure Flood Extent



5.2.1.2 Flow Diversion

This measure aims to mitigate the flooding in Ballingeary by diverting flow from the Bunsheelin around the town and discharging to the River Lee downstream. The proposed route is shown in Figure 5.6.

Figure 5.6: Ballingeary – Flow Diversion Measure



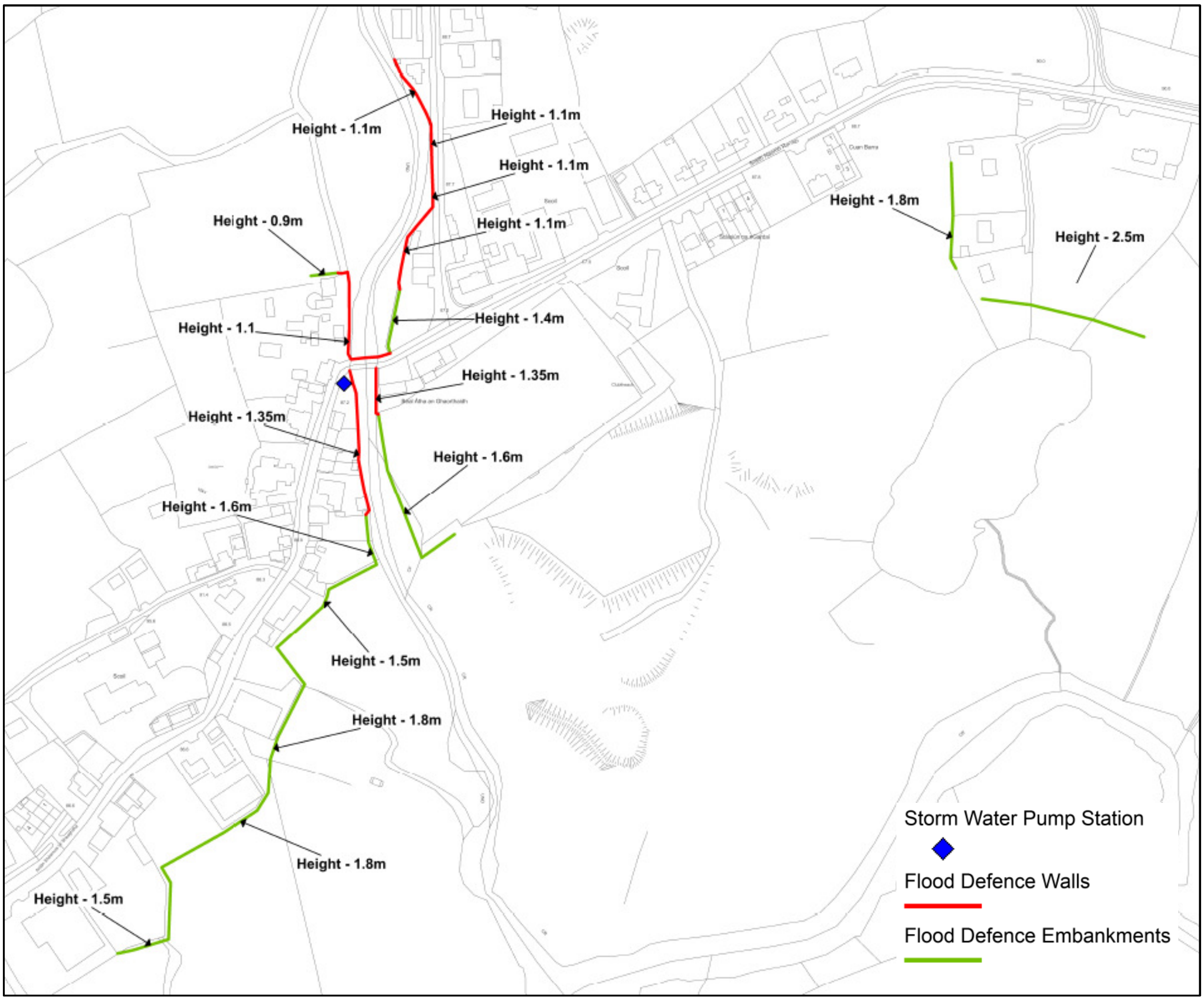
The peak flow in the Bunsheelin for the 1% AEP event is 51m3/s. Flooding occurs on the Bunsheelin and through the town for the 50% AEP event where the peak flow is 24m3/s. This measure aims to limit flow through the town to less than the 50% AEP event by diverting all excess flows through the flow diversion culvert. The proposed culvert is 2.4m wide by 2.1m high and approx. 1.2km long.

The hydraulic modelling of the proposed flow diversion indicates that the measure reduces the flood extent and depth of flooding along the Bunsheelin. However, some properties along the Bunsheelin still flood and this measure does not mitigate flood risk from the River Lee. This measure does not achieve the required standard of protection and is not deemed to be a viable measure as flood defences would still be required along the Bunsheelin and the Lee.

5.2.1.3 Flood Defences

This measure considers the mitigation of flood risk through the construction of flood defences. These defences include walls and embankments. The locations and heights of the defences are shown in Figure 5.7.

Figure 5.7: Ballingeary – Flood Defence Measure



The hydraulic modelling of the proposed flood defences as outlined in the above figure indicates that the measure fully achieves the required standard of protection for the 1% AEP fluvial event. The average increase in water level is 0.01m with the maximum increase of 0.09m occurring immediately upstream of the Bunsheelin bridge. This is deemed to be a viable measure / option.

5.2.2 Potential FRM Measures

Based on the review and hydraulic modelling the following are deemed to be potential FRM measures:

- Storage
- Flood Defences

5.2.3 Potential FRM Options

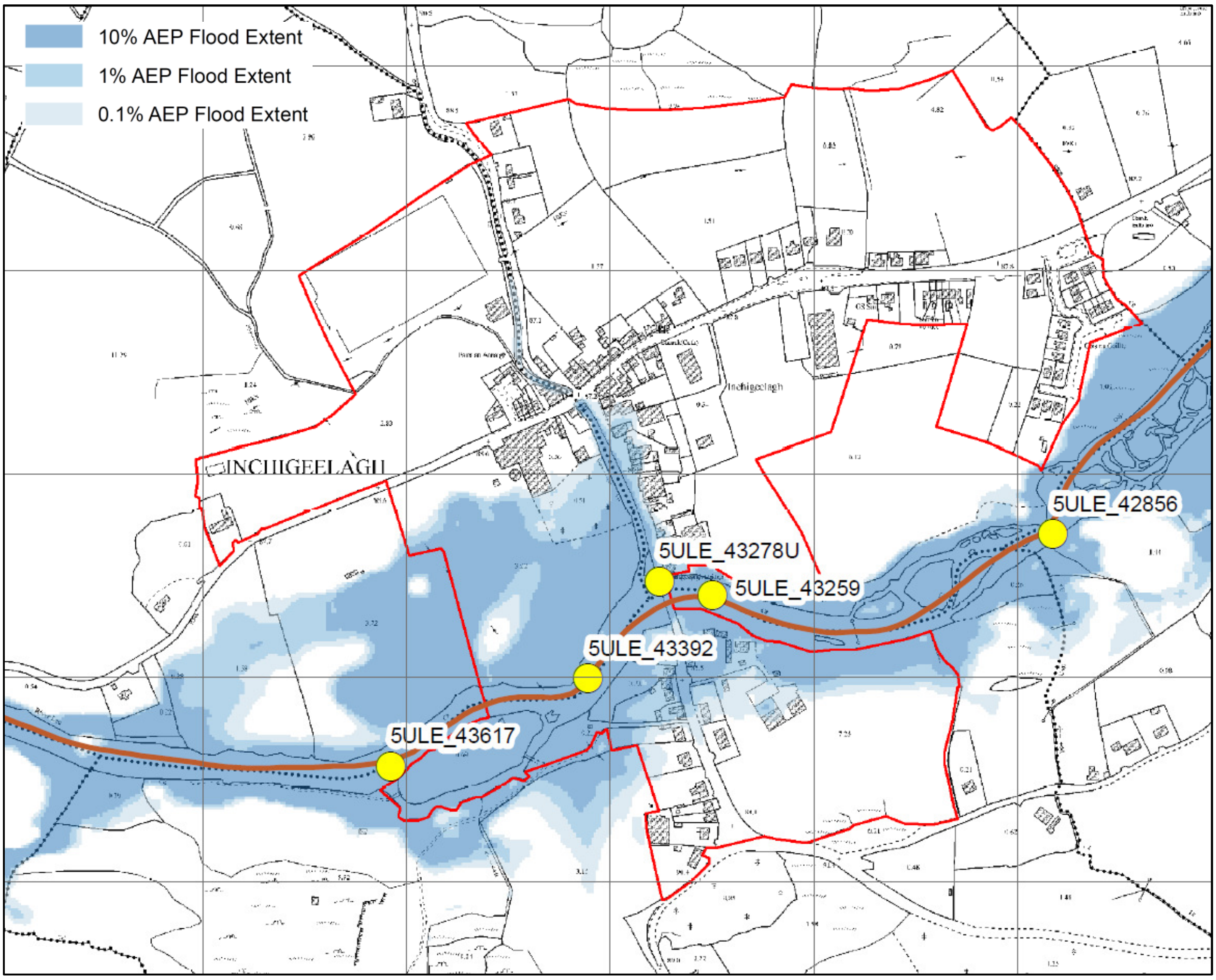
Based on the assessment of the potential (viable) FRM measures and detailed hydraulic modelling of the combined measures, the following are potential FRM options. Full outline drawings are included in Appendix B for each of the potential options.

- Option 1 – Flood Defences
- Option 2 – Storage

5.3 Inchigeelagh

Inchigeelagh is located along the River Lee in County Cork, approx. 8km downstream of Ballingeary. Inchigeelagh is at risk of fluvial flooding. The AFA and the existing fluvial flood risk are highlighted in Figure 5.8.

Figure 5.8: Inchigeelagh – Current Scenario Fluvial Flood Extents



5.3.1 Possible FRM Measures

As outlined in Section 3.0, the screening process identified the following possible flood risk mitigation measures:

- Increased Conveyance
- Flood Defences

The possible measures were reviewed and assessed further to determine if they were applicable and viable. The measures were modelled individually to determine their effectiveness and impact.

5.3.1.1 Increased Conveyance – Removal of Rock

Based on feedback received during the Public Information Day in Inchigeelagh, Inchigeelagh Bridge was identified as a critical structure which restricts the channel capacity. This measure aims to mitigate the flood risk by improving the conveyance of the bridge.

The existing bridge is an old arch bridge with seven arches and six piers restricting flow in the channel. There is an accumulation of stones and a high bedrock level at some of the arches. This measure aims to improve the conveyance of the bridge by removing the stones and other debris along with lowering the bed level under the bridge.

The hydraulic model indicated that there was an extremely minor reduction in water level of 0.02m upstream of the bridge during the 1% AEP event. There was no reduction in flood extent. This measure is not deemed to be a viable measure.

5.3.1.2 Increased Conveyance – Removal of Rock & Replacement of Bridge

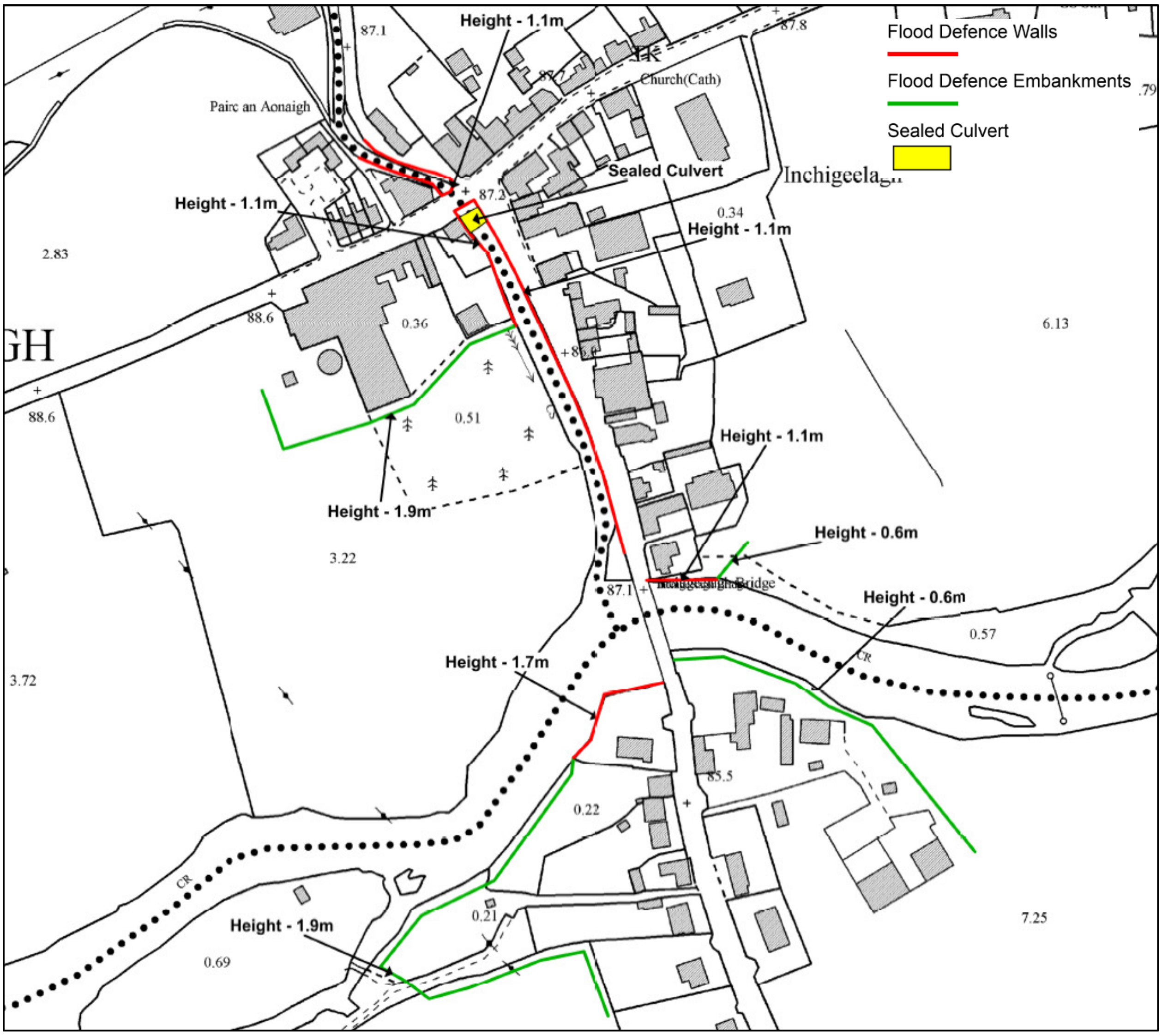
This measure aims to achieve the maximum improvement in conveyance by removing the debris, lowering the bedrock and replacing the arch bridge with a single span bridge with the soffit level set as high as possible. The removal of the bridge was not considered as it is significant regional route.

The hydraulic model indicated that there was an extremely minor reduction in water level of 0.09m upstream of the bridge during the 1% AEP event, with an increase of 0.05m downstream. There was no reduction in flood extent. This measure is not deemed to be a viable measure.

5.3.1.3 Flood Defences

This measure considers the mitigation of flood risk through the construction of flood defences. These defences include walls and embankments. The locations and heights of the defences are shown in Figure 5.9. It should be noted that where flood walls are proposed, these will replace any existing walls.

Figure 5.9: Inchigeelagh – Flood Defence Measure



The hydraulic modelling of the proposed flood defences as outlined in the above figure indicates that the measure fully achieves the required standard of protection for the 1% AEP fluvial event. The maximum increase in water level of 0.05m occurs immediately upstream of the bridge with water levels reducing by 0.03m immediately downstream. This is deemed to be a viable measure / option.

5.3.2 Potential FRM Measures

Based on the review and hydraulic modelling the following are deemed to be potential FRM measures:

- Flood Defences

5.3.3 Potential FRM Options

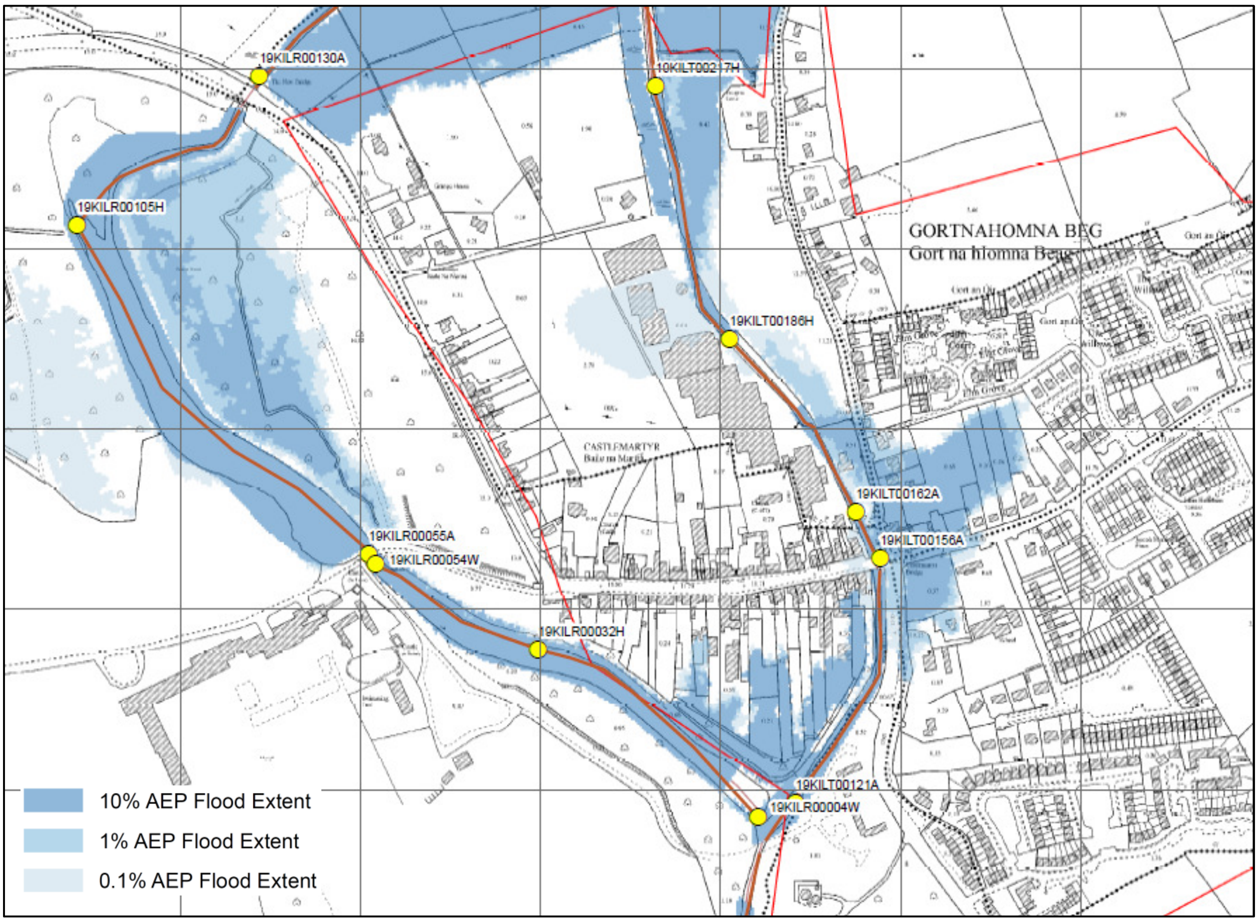
Based on the assessment of the potential (viable) FRM measures and detailed hydraulic modelling of the combined measures, the following are potential FRM options. Full outline drawings are included in Appendix B for each of the potential options.

- Option 1 – Flood Defences

5.4 Castlemartyr

Castlemartyr is located along the Kiltha River in County Cork. Castlemartyr is at risk of fluvial flooding. The AFA and the existing fluvial flood risk are highlighted in Figure 5.10.

Figure 5.10: Castlemartyr – Current Scenario Fluvial Flood Extents



5.4.1 Possible FRM Measures

As outlined in Section 3.0, the screening process identified the following possible flood risk mitigation measures:

- Increase Conveyance
- Flood Defences (Fluvial)
- Flow Diversion

The possible measures were reviewed and assessed further to determine if they were applicable and viable. The measures were modelled individually to determine their effectiveness and impact.

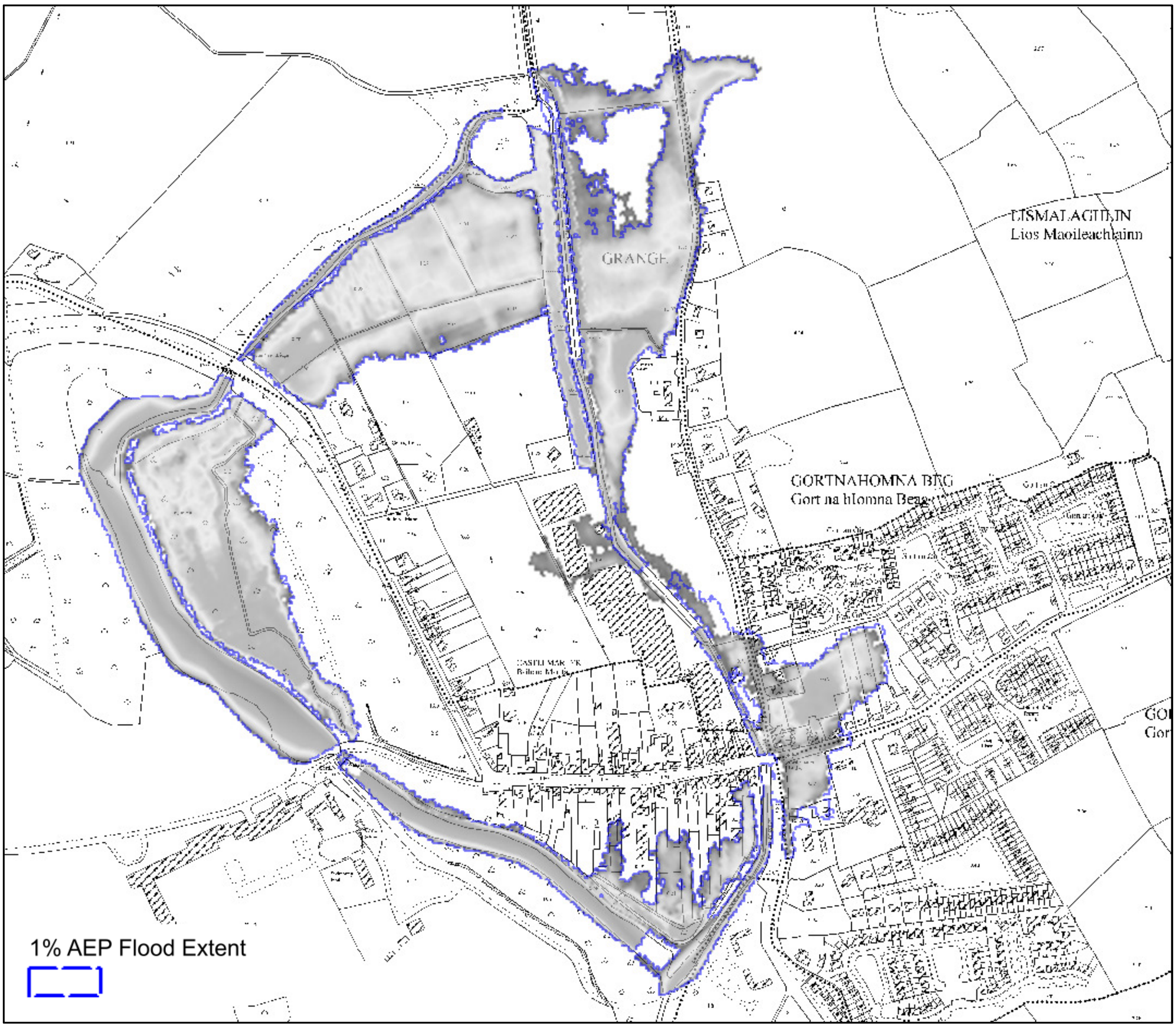
5.4.1.1 Increased Conveyance – Replace Bridges

As part of the hydraulic modelling for the flood risk mapping, Castlemartyr Bridge was identified as a critical structure which restricts the channel capacity. This measure aims to mitigate the flood risk by improving the conveyance of the bridge.

The existing bridge is an old arch bridge with piers restricting flow in the channel. This measure aims to achieve the maximum improvement in conveyance by replacing the arch bridges with a single span bridge with the soffit level set as high as possible.

The arch bridge in the hydraulic model was replaced with a single span bridge. The model indicated that there was an extremely minor reduction in the 1% AEP flood extent on the Kiltha with a maximum reduction in flood depth of 0.12m which occurred immediately upstream of the bridge. This measure is not deemed to be a viable measure individually or in combination as the reduction in flood extent / level / risk is minimal.

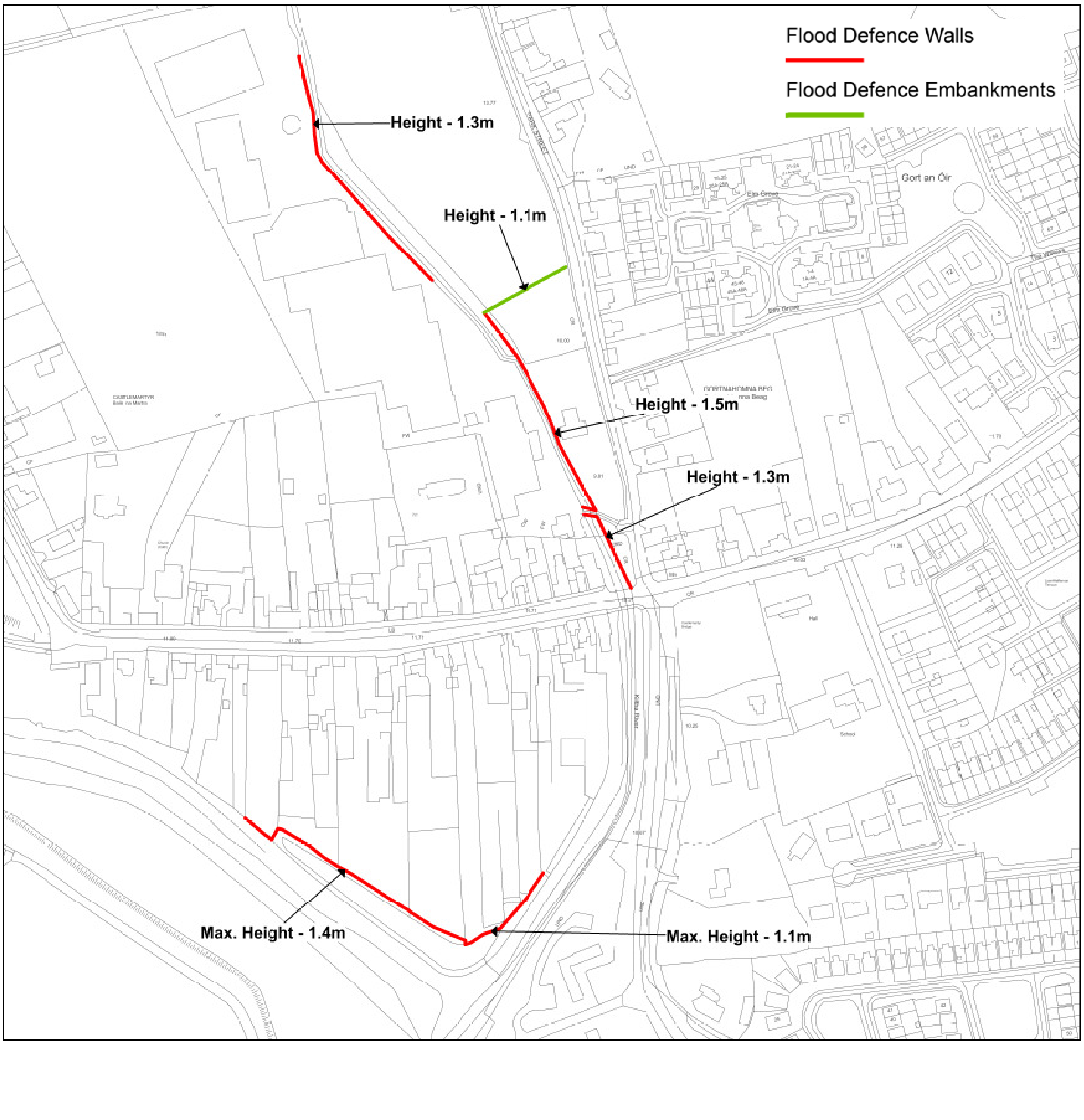
Figure 5.11: Castlemartyr – Conveyance Measure Flood Extent



5.4.1.2 Flood Defences

This measure considers the mitigation of flood risk through the construction of flood defences. These defences include walls and embankments. The locations and heights of the defences are shown in Figure 5.12.

Figure 5.12: Castlemartyr – Flood Defence Measure

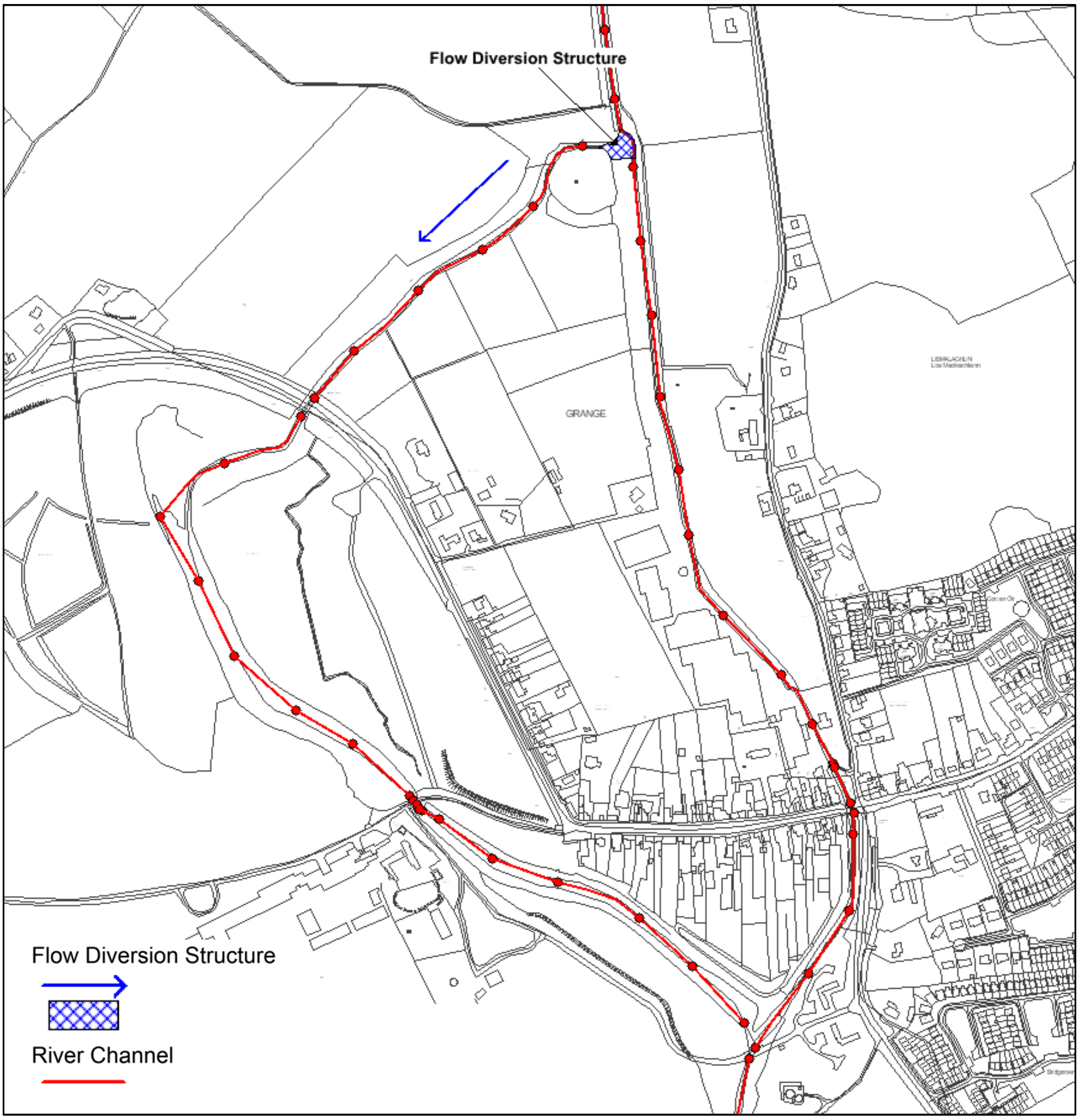


The hydraulic modelling of the proposed flood defences as outlined in the above figures indicates that the measure fully achieves the required standard of protection for the 1% AEP fluvial event. The average increase in water level is 0.01m with the maximum increase in water level of 0.34m occurring at the footbridge just upstream of Castlemartyr Bridge on the N25. This is deemed to be a viable measure / option.

5.4.1.3 Flow Diversion

This measure aims to mitigate the flood risk by diverting flow from the Kiltha River around the town through the existing bypass channel. The existing bypass channel is a historic feature which was created to bring flows into the grounds of the castle (now hotel).

Figure 5.13: Castlemartyr – Flow Diversion Measure



The flooding in Castlemartyr occurs due to the insufficient capacity of the channel and Castlemartyr Bridge. This measure aims to limit flow through the town to the 50% AEP (7m3/s approx.) by diverting all excess flows through the bypass channel.

The hydraulic modelling of the proposed flow diversion indicates that the measure is viable as it mitigates the flooding through the town for the 1% AEP fluvial event. However, there is still some flooding to properties at the downstream end of the town at the confluence of the bypass channel and the Kiltha River. This is deemed to be a viable measure.

5.4.2 Potential FRM Measures

Based on the review and hydraulic modelling the following are deemed to be potential FRM measures:

- Flood Defences
- Flow Diversion

5.4.3 Potential FRM Options

Based on the assessment of the potential (viable) FRM measures and detailed hydraulic modelling of the combined measures, the following are potential FRM options. Full outline drawings are included in Appendix B for each of the potential options.

- Option 1 – Flood Defences
- Option 2 – Flow Diversion & Flood Defences

6 Environmental Assessment

6.1 General

Refer to Appendix C for Draft SEA Options Appraisal Report and Appendix D for Draft Habitats Directive Screening (for Appropriate) Assessment.

7 Stakeholder Input

7.1 Draft Flood Mapping Public Consultation Days

Public Consultation Days (PCDs) were held in Unit of Management (UoM) 19 in January 2015. The purpose of the PCDs were to present the public with the Draft Flood Maps that have been prepared as part of the South Western CFRAM Study, to seek their feedback on those maps and on the Flood Risk management Objectives that apply to this area.

Details of the Public Consultation days held in the UoM 19 AFAs are shown in Table 7.1 below.

Table 7.1: Draft Flood Mapping PCDs

AFA	Date	Venue	Nr of Attendees
Ballingeary	27th of January 2015	Ballingeary GAA Club	25
Inchigeelagh	27th of January 2015	Iveleary GAA Club	23
Castlemartyr	23rd of January 2015	St. Joseph's National School	14
Killeagh	23rd of January 2015	Killeagh Community Hall	13

7.2 Flood Risk Management Measures

At the Draft Flood Mapping PCDs, attendees were asked to indicate what they thought should be done to manage flood risk in their AFAs. The responses are shown in Table 7.2 below.

Table 7.2: Flood Risk Management – Public Opinion

AFA	What needs to be done to manage flood risk?
Ballingeary	Clean the River Lee. Cut the trees stopping the water flowing. Additional Information In 1998, a group of farmers got together and hired a track machine. They clean the river 2km downstream in an area called The Ford. Trees were also cut. Work back then cost £200. The result was the village in Ballingeary did not flood for next 9 years. The farmers who own the land at The Ford are totally agreeable to cleaning the river again. This work has also got the all-clear from the Inland Fisheries Board and the Parks and Wildlife.
	High ground flood water arrives very quickly to Ballingeary now and it needs to flow to Lough Allua faster to remove threat of flooding
	Each flood seems to be different. - which river brings the most water - both rivers bog ? - wind direction Have heights of floods tracked with timer in different locations from Inchigeelagh up each river? I think it would show where the bottleneck is over a number of floods
	Deepen river channel
	Cut trees on the river bank
	Since they cleared Bunsheelin and Lee 3-4 years ago, things improved a lot.
	1. No more buildings to be erected 2. More widening of rivers 3. Maybe put up a wall on the riverside
	Education of landowners and residents, especially farmers, concerning dangers of altering waterways, i.e., straightening bends and unscientific dredging in rivers
Inchigeelagh	Put flood barriers in the island
	Yearly trees on river bank maintenance
	The overhanging trees and debris in the bed of the River Lee should be cleared, especially as it flows into the village by Inchigeelagh.
	Remove all blockages from river, small islands and trees
	Remove all obstacles along river, e.g., rocks, small islands, trees, etc.
	Rural maintenance
	Regulate Inniscarra Dam more carefully
	Continue annual river clearance works, including dredging; tree-cutting; treatment of cut tree "stumps" and continuous maintenance; village walls to be repaired also, i.e., an extension (2014) of satisfactory project needed.
Killeagh	Regular cleaning of the Womenagh River

7.3 Preliminary Options PCDs

On the 4th November 2019 and the 29th February 2016 stakeholder workshops were held with Local Authority Engineers to discuss the emerging preferred options. Feedback received at this workshop was used to revise the proposed options in advance of the Public Consultation Days.

Between November 2015 and February 2016 PCDs were held to display various Flood Risk Management Options in each of the UoM 19 AFAs under consideration. Details of the PCDS are shown in Table 7.3 below.

Table 7.3: Details of Public Consultation Days

AFA	Date	Venue	Nr of Attendees
Ballingeary	17th February 2016	Ballingeary GAA Club	31
Inchigeelagh	18th February 2016	Iveleary GAA Club	21
Castlemartyr	26th November 2015	St. Joseph's National School	4

At the Preliminary Options PCDs Attendees were asked to indicate their preference for the Flood Risk Management Options under consideration in each of the UoM 19 AFAs. Their responses are summarised in Table 7.4 below.

Table 7.4: Public Preference for Potential Options

AFA	Option	Nr of Rank 1 Received	Rank
Ballingeary	Flood Defences	3	1
	Storage	0	-
	Do Nothing	0	-
Inchigeelagh	Flood Defences	4	1
	Storage	0	2
	Do Nothing	0	3
Castlemartyr	Food Defences	1	2
	Flow Diversion & Flood Defences	2	1
	Do Nothing	0	3

8 Flood Risk Assessment

8.1 General

Flood risk mapping for the UoM 19 AFAs and Medium Priority Watercourses (MPWs) has been undertaken as part of this Study. The mapping includes the receptors that are at risk from flooding in the following categories:

- Society
- The Environment
- Cultural Heritage
- The Economy

The Flood Risk Maps for UoM 19 are included in an Annexe to the Preliminary Options Report: Annex I, Flood Risk Maps.

8.2 Receptors

Examples of the receptors in each of these categories are included in Table 8.1 below:

Table 8.1: Flood Risk Receptors

Category	Receptor
Society	People Homes Fire Stations Garda Stations Hospitals Care centres
The Environment	Protected Areas Pollution Sources
Cultural Heritage	Protected Archaeological Sites Protected Buildings
The Economy	Business Premises Roads Railway Ports Utilities

The numbers of receptors at risk from flooding in each AFA and each MPW are listed in tables 8.3 to 8.12 below. These tables indicate the receptors at risk from the current scenario, the Mid-Range Future Scenario (MRFS) and the High End Future Scenario (HEFS) and are split into the Annual Exceedance Probability of the flooding concerned.

Annual Exceedance Probability, henceforth referred to as AEP, is a term used throughout this report and the wider CFRAM studies to refer to the rarity of a flood event. The probability of a flood relates to the likelihood of an event of that size or larger occurring within any one year period. For example, a one in hundred year flood has a one chance in a hundred of occurring in any given year; 1:100 odds of occurring in any given year; or a 1% likelihood of occurring. This is described as a 1% annual exceedance probability (AEP) flood event.

Table 8.2 converts the 'return periods' to %AEP for key flood events as a reference to previous studies.

Table 8.2: Flood Probabilities

% Annual Exceedance Probability (%AEP)	Odds of a Flood Event in Any Given Year	Chance of a Flood Event in Any Given Year or Previous 'Return Period'
50%	1:2	1 in 2
20%	1:5	1 in 5
10%	1:10	1 in 10
5%	1:20	1 in 20
2%	1:50	1 in 50
1%	1:100	1 in 100
0.5%	1:200	1 in 200
0.1%	1:1000	1 in 1000

Table 8.3 below lists the number of Inhabitants at risk from fluvial flooding in each AFA.

Table 8.3: Risk to Society: Nr. of Inhabitants

	Current Scenario								Mid-Range Future Scenario								High End Future Scenario		
AFA	50%	20%	10%	5%	2%	1%	0.5%	0.1%	50%	20%	10%	5%	2%	1%	0.5%	0.1%	10%	1%	0.1%
Ballingeary	17	36	45	50	53	59	62	78	31	50	53	53	62	62	76	78	53	73	81
Castlemartyr	0	14	28	31	36	36	39	48	14	31	36	36	36	42	45	50	36	45	53
Inchigeelagh	6	20	25	34	36	39	42	62	20	28	36	39	39	39	56	62	36	50	62
Killeagh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	6

Table 8.4 below indicates the number of Residential Properties at risk from fluvial flooding in each AFA.

Table 8.4: Risk to Society: Nr. of residential properties

	Current Scenario								Mid-Range Future Scenario								High End Future Scenario		
AFA	50%	20%	10%	5%	2%	1%	0.5%	0.1%	50%	20%	10%	5%	2%	1%	0.5%	0.1%	10%	1%	0.1%
Ballingeary	6	13	16	18	19	21	22	28	11	18	19	19	22	22	27	28	19	26	29
Castlemartyr	0	5	10	11	13	13	14	17	5	11	13	13	13	15	16	18	13	16	19
Inchigeelagh	2	7	9	12	13	14	15	22	7	10	13	14	14	14	20	22	13	18	22
Killeagh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2

Table 8.5 below lists the number of high vulnerability properties at risk from fluvial flooding in each AFA. High vulnerability properties include Hospitals, Nursing Homes, Schools, Prisons, Camping / Halting sites.

Table 8.5: Risk to Society: Nr. of High Vulnerability Properties

	Current Scenario								Mid-Range Future Scenario								High End Future Scenario		
AFA	50%	20%	10%	5%	2%	1%	0.5%	0.1%	50%	20%	10%	5%	2%	1%	0.5%	0.1%	10%	1%	0.1%
Ballingeary	0	0	0	0	1	1	1	2	0	0	0	1	1	1	2	2	1	2	2
Castlemartyr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inchigeelagh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Killeagh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 8.6 below lists the number of Social Amenity Sites at risk from fluvial flooding in each AFA

Table 8.6: Risk to Society: Nr. of Social Amenity Sites

	Current Scenario								Mid-Range Future Scenario								High End Future Scenario		
AFA	50%	20%	10%	5%	2%	1%	0.5%	0.1%	50%	20%	10%	5%	2%	1%	0.5%	0.1%	10%	1%	0.1%
Ballingeary	1	2	2	2	2	2	2	3	2	2	2	2	2	2	2	3	2	2	1
Castlemartyr	0	0	0	0	1	1	1	1	0	0	0	1	1	1	1	1	1	1	0
Inchigeelagh	0	0	0	0	0	1	1	1	0	0	0	1	1	1	1	1	0	1	0
Killeagh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 8.7 below lists the number of properties on the National Inventory of Architectural Heritage at risk from fluvial flooding in each AFA

Table 8.7: Risk to Cultural Heritage: Nr. of NIAH Buildings

	Current Scenario								Mid-Range Future Scenario								High End Future Scenario		
AFA	50%	20%	10%	5%	2%	1%	0.5%	0.1%	50%	20%	10%	5%	2%	1%	0.5%	0.1%	10%	1%	0.1%
Ballingeary	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2
Castlemartyr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inchigeelagh	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1	1	2
Killeagh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 8.8 below lists the number of Archaeological Monuments at risk from fluvial flooding in each AFA.

Table 8.8: Risk to Cultural Heritage: Nr. of RMPs

	Current Scenario								Mid-Range Future Scenario								High End Future Scenario		
AFA	50%	20%	10%	5%	2%	1%	0.5%	0.1%	50%	20%	10%	5%	2%	1%	0.5%	0.1%	10%	1%	0.1%
Ballingeary	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Castlemartyr	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1
Inchigeelagh	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Killeagh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 8.9 below lists the number of Non-Residential Properties at risk from fluvial flooding in each AFA

Table 8.9: Risk to the Economy: Nr. of Non-Residential Properties

	Current Scenario								Mid-Range Future Scenario								High End Future Scenario		
AFA	50%	20%	10%	5%	2%	1%	0.5%	0.1%	50%	20%	10%	5%	2%	1%	0.5%	0.1%	10%	1%	0.1%
Ballingeary	9	18	22	22	24	25	26	30	16	22	22	24	26	26	27	30	24	27	30
Castlemartyr	0	4	5	5	7	9	12	16	4	5	6	7	11	13	15	18	7	15	19
Inchigeelagh	1	2	3	5	11	14	15	22	2	3	8	13	14	14	18	22	12	17	23
Killeagh	0	0	0	0	0	0	1	1	0	0	0	0	1	1	1	2	0	1	2

Table 8.10 below lists the number of Roads at risk from fluvial flooding in each AFA

Table 8.10: Risk to the Economy: Nr. of Roads

	Current Scenario								Mid-Range Future Scenario								High End Future Scenario		
AFA	50%	20%	10%	5%	2%	1%	0.5%	0.1%	50%	20%	10%	5%	2%	1%	0.5%	0.1%	10%	1%	0.1%
Ballingeary	1	2	2	2	3	3	3	3	2	2	3	3	3	3	3	3	3	3	3
Castlemartyr	0	1	2	3	3	3	3	3	1	3	3	3	3	3	3	3	3	3	3
Inchigeelagh	1	1	1	1	2	2	2	2	1	1	2	2	2	2	2	2	1	2	2
Killeagh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 8.11 below lists the number of Utilities at risk from fluvial flooding in each AFA

Table 8.11: Risk to the Economy: Nr. of Utilities

	Current Scenario								Mid-Range Future Scenario								High End Future Scenario		
AFA	50%	20%	10%	5%	2%	1%	0.5%	0.1%	50%	20%	10%	5%	2%	1%	0.5%	0.1%	10%	1%	0.1%
Ballingeary	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Castlemartyr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inchigeelagh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Killeagh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

8.3 Flood Risk Maps

Flood Risk Maps have been prepared to represent the various receptors at risk from flooding in each of the AFAs and MPWs. These maps are described in the following sections below.

8.3.1 Inhabitants Maps

Maps have been prepared to represent the number of people at risk from flooding of various frequencies. The numbers of people per house was taken from the CSO data. For UoM 19 the average occupancy rate is 2.8 people per house. For each AEP flood extent the number of residential properties at risk was counted and multiplied by that occupancy. The number of people at risk are represented as a density per hectare on the maps.

8.3.2 Economic Activity Maps

The types of economic activity at risk from flooding in UoM 19 are shown on the economic activity risk map. The types of activities considered are:

- Property
- Infrastructure
- Rural Land Use
- Economic

8.3.3 Economic Risk Density Maps

Maps have been prepared to represent the economic risk from flooding of various frequencies. The economic risk is represented on the maps as a density of the Annual Average Damage value per hectare.

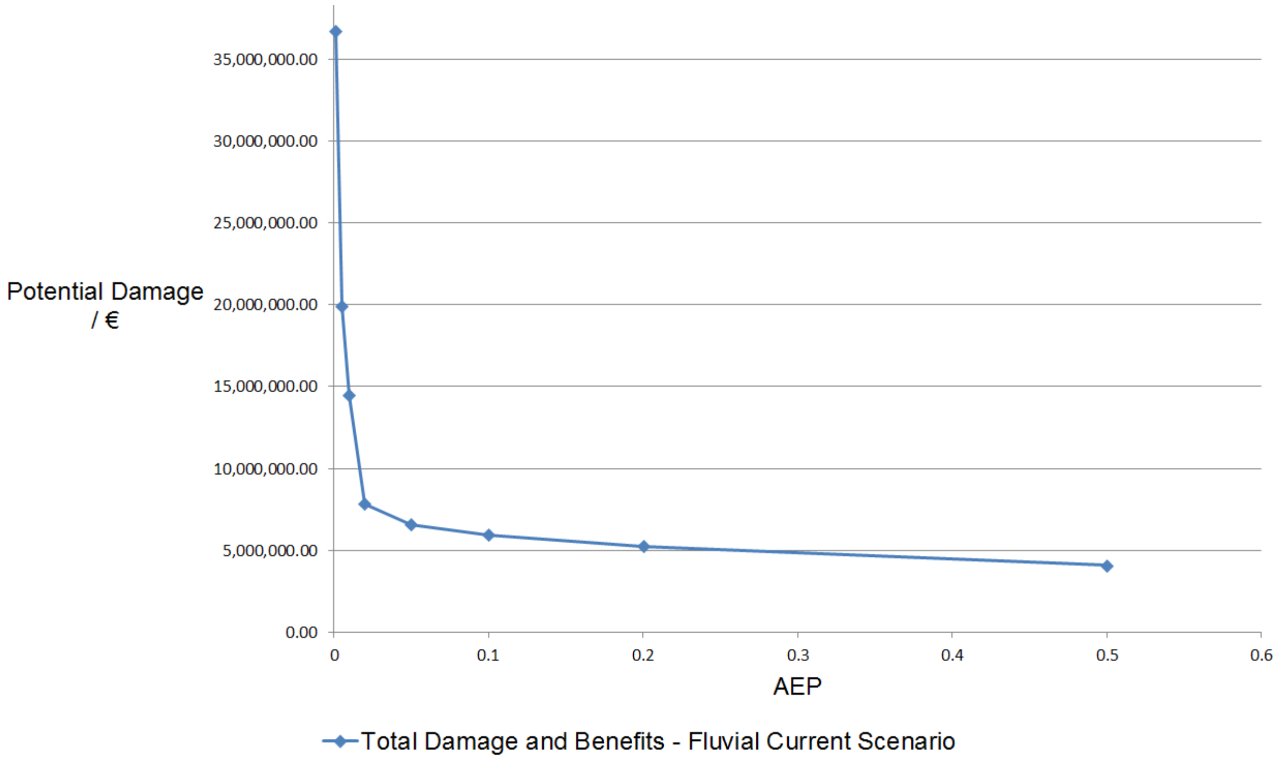
8.3.3.1 Annual Average Damage

The potential economic damage that could be caused by flooding was calculated for every property in each of the UoM 19 AFAs. The damage to a property is related to the type, use, area and the predicted depth of flooding within the property. It is possible to calculate the damage that could arise from a series of floods of different Annual Exceedance Probability (AEP). Using these damage values the Annual Average Damage for the AFA can be calculated by measuring the area under the Damage / Probability Curve.

For each property, the depth of flooding was extracted from the hydraulic model for the full range of design scenarios (i.e. 50% AEP to 0.01% AEP for both fluvial and tidal flooding). Using the research from the FHRC Multi-coloured Handbook, damage costs were calculated for each property for the range of scenarios.

The damage costs are based on property type and/or area. The total damages for each design scenario were summed and plotted on the annual average flood loss curve which is shown in Figure 8.1. The area under the curve is the Annual Average Damage (AAD).

Figure 8.1: Typical Damage / Probability Curve (Annual Average Flood Loss Curve)



The Annual Average Damage for each AFA is listed in Table 8.12 below.

Table 8.12: Annual Average Damage €

AFA	Current Scenario €	Mid-Range Future Scenario €	High End Future Scenario €
Ballingeary	1,103,883.41	1,456,523.65	1,680,751.90
Inchigeelagh	338,783.45	582,430.14	738,232.18
Castlemartyr	152,431.58	336,169.68	369,252.72
Killeagh	1,375.40	4,077.29	4,606.72

8.3.3.2 Present Value Damage (PVd)

The Present Value Damage (PVd), based on a scheme that will have to be renewed after 50 years and a discount rate of 4%, has also been calculated. The PVd is calculated for each individual property in order to allow capping of PVd values where the PVd exceeds the current market value of the property.

Where a property's estimated potential damage for an event of 0.1% AEP is equal to or exceeds €0.5M, a threshold survey was carried out as a spot check on the ground level as determined by the DTM. Where a discrepancy was noted, the damage assessment was updated and damages recalculated. Spot checks were also carried out on properties where the PVd of a property is 1% or more of the total PVd for the AFA.

Table 8.13 lists all properties with damages for the 0.1% AEP event exceeding €0.5M or with a PVd greater than 1% of the Total AFA PVd

Table 8.13: List of properties with damages exceeding €0.5M or a PVd greater than 1% of the Total AFA PVd

AFA	Property Type	Object ID	Fluvial Damages 0.1% AEP €	Tidal Damages 0.1% AEP €	PVd - % of Total
Ballingeary	Detached	2814	79,684.21	N/A	1.38%
	Detached	2873	108,716.44	N/A	3.12%
	Detached	1135002	79,684.21	N/A	1.28%
	Detached	1135134	91,046.94	N/A	2.65%
	Detached	1135281	77,369.21	N/A	2.10%
	Detached	1135303	77,369.21	N/A	1.45%
	Detached	1135343	78,526.71	N/A	2.24%
	Semi	1135035	71,186.62	N/A	2.39%
	Semi	1135121	64,188.67	N/A	2.32%
	Semi	1135237	55,651.13	N/A	1.92%
	Semi	1135248	58,391.94	N/A	2.18%
	Terrace	1135190	50,774.92	N/A	1.31%
	Terrace	1135191	51,325.38	N/A	1.44%
	Terrace	1135282	50,224.46	N/A	1.25%
	Cafe	1135078	107,489.35	N/A	1.79%
	ComCentre	1135252	69,798.79	N/A	1.51%
	Filling	1135243	67,710.28	N/A	1.35%
	Filling	1135053	154,956.66	N/A	9.20%
	Shop	1135184	384,163.80	N/A	4.25%
	Shop	1135209	427,602.05	N/A	15.07%
	Shop	1135227	175,802.64	N/A	2.94%
	Storage	1135054	32,691.72	N/A	1.75%
	Warehouse	1134992	173,621.47	N/A	13.48%
	Warehouse	1135146	224,888.72	N/A	14.34%
Inchigeelagh	Detached	981998	92,223.18	N/A	7.88%
	Detached	982026	91,046.94	N/A	7.46%

AFA	Property Type	Object ID	Fluvial Damages 0.1% AEP €	Tidal Damages 0.1% AEP €	PVd - % of Total
	Detached	982042	92,223.18	N/A	7.61%
	Detached	982051	87,246.87	N/A	7.11%
	Detached	982053	83,311.13	N/A	2.26%
	Detached	982077	110,948.64	N/A	9.28%
	Detached	982112	89,870.70	N/A	7.59%
	Detached	982127	85,934.96	N/A	4.58%
	Detached	982146	85,934.96	N/A	4.49%
	Detached	982147	89,870.70	N/A	7.29%
	Terrace	982048	50,774.92	N/A	1.22%
	Terrace	982181	50,774.92	N/A	1.22%
	Office	982063	107,430.77	N/A	1.54%
	Pub	982012	101,982.56	N/A	1.12%
	Shop	982097	103,806.20	N/A	1.17%
	Shop	982138	153,888.22	N/A	22.60%
	Warehouse	982136	353,273.21	N/A	2.00%
Castlemartyr	Bungalow	1604702	58,775.23	N/A	1.20%
	Bungalow	1604909	67,628.81	N/A	9.88%
	Detached	1604750	77,369.21	N/A	11.61%
	Detached	1604825	76,211.70	N/A	12.35%
	Detached	1604826	68,309.81	N/A	4.30%
	Detached	1604854	77,369.21	N/A	11.47%
	Detached	1604891	68,309.81	N/A	6.66%
	Detached	1604893	75,054.20	N/A	11.93%
	Detached	1605089	61,565.42	N/A	1.49%
	Semi	1605065	55,030.92	N/A	8.31%
	Semi	1605166	58,391.94	N/A	8.12%
	Terrace	1605024	20,248.44	N/A	3.82%
	Terrace	1605167	52,095.44	N/A	5.33%
	Storage	1604790	9,218.41	N/A	1.18%

Following the survey spot check, adjustments were made as required and property damages were capped. For Residential properties, the damages were capped at the market value of the property and non-residential properties were capped at ten times the rateable value of the property. The capping process was carried out in line with Guidance Note 27. Market values for residential properties were determined within each AFA. Typical capping values for residential properties are as follows:

- Detached = €250k - €300k
- Semi-detached = €150k - €250k
- Terrace = €100k - €150k

The annual average damage and present value damages for each of the AFAs is listed in Table 8.14. The benefit of a flood risk management option (Scheme) was also calculated which is the damage avoided by implementing a scheme to the required Standard of Protection (SOP).

Table 8.14: Summary of Damages & Benefit of Scheme Benefit

AFA	AAD €	PVd	Capped PVd	Benefit of Scheme (Damage Avoided) €
Ballingeary	1,103,883.41	23,713,827.31	15,956,640.50	14,882,358.26
Inchigeelagh	338,783.45	7,277,808.72	5,264,669.58	4,681,767.44
Castlemartyr	152,431.58	3,274,563.43	2,652,969.98	2,394,238.74
Killeagh	1,375.40	29,546.68	29,546.68	0.00

It is clear from Table 8.14 that there is low potential damage in Killeagh and that there is no benefit in implementing a scheme as damage only occurs for events greater than the standard of protection.

Table 8.15 lists the benefit or damage avoided by implementing a flood forecasting and warning system.

Table 8.15: Benefit of Implementing a Flood Forecasting & Warning System

Spatial Scale of Assessment	Infrastructure	Benefit € (13% of PVd)
AFA		
Ballingeary	River level gauges (downstream at Lough Allua) Connect to Lower Lee Flood Warning System	3,082,797.55
Inchigeelagh	River level gauges (upstream at Lough Allua) Connect to Lower Lee Flood Warning System	946,115.13
Castlemartyr	Rain gauges River level gauges	425,693.25
Killeagh	Rain gauges River level gauges	3,841.07
Sub-Catchment		
Ballingeary / Inchigeelagh	River level gauges (Lough Allua) Connect to Lower Lee Flood Warning System	€4M +
UoM		
River Lee / Cork Harbour	River level gauges (Lough Allua) Connect to Lower Lee Flood Warning System Use the existing OPW storm surge forecasting system to predict high tide levels.	€4M +

Source: UoM 19 Hydraulics Report

It is clear from Table 8.15 that a flood forecasting and warning system is not viable for Killeagh due to the low potential damages and benefits. The benefit of implementing a flood forecasting and warning system at the sub-catchment and UoM scale is likely to be greater than shown in Table 8.15 as it has the potential to reduce damages along MPWs and other watercourses not assessed as part of this study. However, there is a corresponding cost increase due to additional gauges etc.

8.3.4 General Risk Maps

General Risk Maps have been prepared for each of the watercourses modelled in UoM 19. These maps show the receptors at risk and the flood extents for three AEPs. The general risk maps are categorised by Flood Risk Receptor type. That is;

- Society
- The Environment
- Cultural Heritage
- The Economy

The AEPs of flooding shown on the general Risk Maps are the 10% AEP, the 1% AEP and the 0.1% AEP.

9 Estimates of Cost

9.1 Flood Forecasting and Warning Systems

The cost of the flood forecasting and warning systems were calculated using the rates and methods contained in the Unit Cost Database developed by the OPW for use in the CFRAM studies. The estimates in Table 9.1 include costs for specifications, site surveys, gauging and telemetry equipment, forecast model setup and development along with training, operation and maintenance. In addition, in order to take account of the high level nature of the estimate and include for unseen costs, optimism bias is included in these estimates. The costs are exclusive of VAT. Full details of the costs are included in Appendix A.

Table 9.1: Estimate of Costs – Flood Forecasting and Warning Systems

Spatial Scale of Assessment	Infrastructure	Benefit € (13% of PVd)	Estimated Cost / €
AFA			
Ballingeary	4 Nr. River Level Gauges (Hydrometric Station) Connect to Lower Lee Flood Warning System	3,082,797.55	560,195.00
Inchigeelagh	4 Nr. River Level Gauges (Hydrometric Station) Connect to Lower Lee Flood Warning System	467,510.84	560,195.00
Castlemartyr	3 Nr. Rain Gauges 3 Nr. River Level Gauges (Hydrometric Station)	425,693.25	621,659.00
Killeagh	2 Nr. Rain Gauges 3 Nr. River Level Gauges (Hydrometric Station)	3,841.07	617,339.00
Sub-Catchment			
Ballingeary / Inchigeelagh	4 Nr. River Level Gauges (Hydrometric Station) Connect to Lower Lee Flood Warning System	4M +	560,195.00
UoM			
River Lee / Cork Harbour	4 Nr. River Level Gauges (Hydrometric Station) Connect to Lower Lee Flood Warning System	4M +	< 800k

From Table 9.1 it can be seen that flood forecasting is not a viable measure for Castlemartyr or Killeagh.

Details of the Lower Lee Flood Warning System are not readily available to fully assess the additional infrastructure required to include the Ballingeary / Inchigeelagh Sub-Catchment. However, based on the damages avoided and economies of scale, building on the Lower Lee Flood Warning System is likely to be a viable measure.

It should be noted that the implementation of a measure / option at another SSA (i.e. AFA flood relief scheme) has the potential to reduce the benefit of a flood forecasting and warning system. Depending on the standard of protection this could be a significant reduction as the benefit would be reduced to less than 13% of the residual risk.

9.2 Structural Options

The cost of each viable option was calculated using the rates contained in the Unit Cost Database developed by the OPW for use in the CFRAM studies. This database contains rates for constructing various types of flood risk management measures depending on their height (depth), length and location.

The estimates in Table 9.2 below include costs for construction, maintenance, operation, land acquisition, and professional fees. In addition, in order to take account of the high level nature of the estimate and include for unseen costs, optimism bias is included in these estimates. The costs are exclusive of VAT. Full details of the costs are included in Appendix A.

Table 9.2: Estimate of Costs for Potential Options

SSA	Option	Estimated Cost / €	Benefit of Scheme €
AFA			
Ballingeary	Flood Defences	3,069,155.00	14,882,358.26
	Storage	18,785,087.24	
Inchigeelagh	Flood Defences	2,563,297.51	3,596,237.26
Castlemartyr	Flood Defences	1,443,787.19	2,394,238.74
	Flow Diversion & Flood Defences	3,539,582.25	
Sub-Catchment			
Ballingeary / Inchigeelagh	Storage	18,785,087.24	14,882,358.26 3,596,237.26 18,478,595.52

From Table 9.2 it can be seen that the storage option for Ballingeary AFA and the Ballingeary / Inchigeelagh Sub-catchment is not cost beneficial. Also, the flood defence option for Castlemartyr is not cost beneficial.

10 Appraisal of Options

The effectiveness and potential impacts of each of the potential options is assessed using a Multi Criteria Analysis, (MCA). This MCA process assigns a score for each option that relates to how effective that option is in terms of achieving set goals under a set of objectives. The MCA can then be used to guide the decision on which particular option is the preferred option to manage flood risk in a particular area.

10.1 Flood Risk Management Objectives

The effectiveness of each of the potential options is measured in terms of how it achieves a set of Flood Risk Management Objectives. These objectives are split into a number of categories. These are:

- Technical
- Economic
- Social
- Environmental

Some of these objectives are further split into sub-objectives, where this is not the case the sub objective is the same as the objective. The Objectives and Sub objectives are shown in Table 10.1 below.

Table 10.1: Flood Risk Management Objectives

Criteria		Objective		Sub-Objective
1 Technical	a	Ensure flood risk management options are operationally robust	i)	Ensure flood risk management options are operationally robust
	b	Minimise health and safety risks associated with the construction, operation and maintenance of flood risk management options	I)	Minimise health and safety risks associated with the construction, operation and maintenance of flood risk management options
	c	Ensure flood risk management options are adaptable to future flood risk, and the potential impacts of climate change	i)	Ensure flood risk management options are adaptable to future flood risk, and the potential impacts of climate change
2 Economic	a	Minimise economic risk	i)	Minimise economic risk
	d	Minimise risk to transport infrastructure	i)	Minimise risk to transport infrastructure
	c	Minimise risk to utility infrastructure	i)	Minimise risk to utility infrastructure
	d	Minimise risk to agriculture	i)	Minimise risk to agriculture
3 Social	a	Minimise risk to human health and life	i)	Minimise risk to human health and life of residents
			ii)	Minimise risk to high vulnerability properties
	b	Minimise risk to community	i)	Minimise risk to social infrastructure and amenity
			ii)	Minimise risk to local employment
4 Environmental	a	Support the objectives of the WFD	i)	Provide no impediment to the achievement of water body objectives and, if possible, contribute to the achievement of water body objectives.

Criteria		Objective		Sub-Objective
	B	Support the objectives of the Habitats Directive	i)	Avoid detrimental effects to, and where possible enhance, Natura 2000 network, protected species and their key habitats, recognising relevant landscape features and stepping stones.
	c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	i)	Avoid damage to or loss of, and where possible enhance, nature conservation sites and protected species or other know species of conservation concern.
	d	Protect, and where possible enhance, fisheries resource within the catchment	i)	Maintain existing, and where possible create new, fisheries habitat including the maintenance or improvement of conditions that allow upstream migration for fish species.
	e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	i)	Protect, and where possible enhance, visual amenity, landscape protection zones and views into / from designated scenic areas within the river corridor.
	f	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting	i)	Avoid damage to or loss of features, institutions and collections of architectural value and their setting.
			ii)	Avoid damage to or loss of features, institutions and collections of archaeological value and their setting.

:Source ; GN28

10.2 Global and Local Weightings

In order to take account of the relative importance of some objectives in comparison other objectives, each sub-objective is given a Global Weighting. These global weightings are set at a national level and are the same across all of the CFRAM Studies.

The Global Weightings for each sub objective are shown in Table 10.2 below.

Table 10.2: Global Weighting of Flood Risk management Objectives

Objective Ref	Sub Objective	Global Weighting
1(a)(i)	Ensure flood risk management options are operationally robust	20
1(b)(i)	Minimise health and safety risks associated with the construction, operation and maintenance of flood risk management options	20
1(c)(i)	Ensure flood risk management options are adaptable to future flood risk, and the potential impacts of climate change	20

Objective Ref	Sub Objective	Global Weighting
2(a)(i)	Minimise economic risk	24
2(b)(i)	Minimise risk to transport infrastructure	10
2(c)(i)	Minimise risk to utility infrastructure	14
2(d)(i)	Minimise risk to agriculture	12
3(a)(i)	Minimise risk to human health and life of residents	27
3(a)(ii)	Minimise risk to high vulnerability properties	17
3(b)(i)	Minimise risk to social infrastructure and amenity	9
3(b)(ii)	Minimise risk to local employment	7
4(a)(i)	Provide no impediment to the achievement of water body objectives and, if possible, contribute to the achievement of water body objectives.	16
4(b)(i)	Avoid detrimental effects to, and where possible enhance, Natura 2000 network, protected species and their key habitats, recognising relevant landscape features and stepping stones.	10
4(c)(i)	Avoid damage to or loss of, and where possible enhance, nature conservation sites and protected species or other know species of conservation concern.	5
4(d)(i)	Maintain existing, and where possible create new, fisheries habitat including the maintenance or improvement of conditions that allow upstream migration for fish species.	13
4(e)(i)	Protect, and where possible enhance, visual amenity, landscape protection zones and views into / from designated scenic areas within the river corridor.	8
4(f)(i)	Avoid damage to or loss of features, institutions and collections of architectural value and their setting.	4
4(f)(ii)	Avoid damage to or loss of features, institutions and collections of archaeological value and their setting.	4

Source: GN28

In order to take cognisance of the local perspective on the relative importance of objectives, each sub objective is also given a local weighting. Local weightings vary from 0 for not locally important to 5 for very important locally.

During the Draft Flood Mapping Public Consultation Day (PCD) the public were invited to consider each of the sub-objectives and provide a weighting on its importance. The local weightings listed below, which have been used in the MCA, are based on an assessment of the importance of these sub-objectives which has been informed by the input of the public at the PCD.

The Local Weighting for each FRM objective is shown in Table 10.3 below. The table also outlines the manner in which the Local weighting is derived. In some instances the Local Weighting is determined through local consultation. In other instances they are calculated based upon the number of receptors affected. The data used for calculating the local weighting are included in Appendix F1.

Table 10.3: Local Weighting

Sub Objective	Ballingeary	Inchigeelagh	Castlemartyr	Calculation Method
1(a)(i)	5	5	5	Constant
1(b)(i)	5	5	5	Constant
1(c)(i)	5	5	5	Constant
2(a)(i)	5	2.97	1.29	AAD / €75,000
2(b)(i)	5	5	5	Based on calculated assessment, adjusted by professional judgement
2(c)(i)	5	0	0	Based on calculated assessment, adjusted by professional judgement
2(d)(i)	0	4	0	By professional judgement assisted by local advice
3(a)(i)	5	4.78	3.2	Based on calculated assessment, adjusted by professional judgement
3(a)(ii)	1.05	0	0	Based on calculated assessment, adjusted by professional judgement
3(b)(i)	5	0.25	0.5	Based on calculated assessment, adjusted by professional judgement
3(b)(ii)	5	5	4.9	Based on calculated assessment, adjusted by professional judgement
4(a)(i)	5	5	5	Constant
4(b)(i)	0	0	1	By professional judgement assisted by local advice
4(c)(i)	2	2	4	By professional judgement assisted by local advice
4(d)(i)	4	4	2	By professional judgement assisted by local advice
4(e)(i)	3	3	3	By professional judgement assisted by local advice
4(f)(i)	0	0	3	By professional judgement assisted by local advice
4(f)(ii)	3	3	2	By professional judgement assisted by local advice

Source: GN 28

10.3 MCA Scoring

Each sub objective has a basic requirement and an aspirational target associated with it. The basic requirement for each sub objective equates to a no change scenario. That is the status quo before the FRM option is adopted. The aspirational target in most cases is set to the highest achievement that is reasonably possible against the sub-objective in implementing the FRM option. The performance of each FRM option is measured against the basic and aspirational targets for each sub objective and assigned a score in accordance with the principals in Table 10.4 below.

Table 10.4: MCA Scoring

Option Performance	Score
Meets Aspirational Target	5
Partially Achieving Aspirational Target	Score in proportion to performance
Meeting Basic Requirement (No Change)	0
Just Failing Basic Requirement	Score in proportion to performance
Fully Failing Basic Requirement	-5
Totally Failing Basic Requirement (Option Illegal or Totally Unacceptable)	-999

In the MCA the technical objectives measure if an option is robust in terms of operation. Higher scores are allocated to options that do not rely on mechanical, electrical or human intervention to operate effectively. Examples of such interventions include sluice gates, storm water over pumping, or erection of demountable barriers. The technical objectives also consider if the options can be constructed safely and if they can be adapted to future changes.

The adaptability of each option to the possible impacts of climate change is assessed through a qualitative decision tree. This involves identifying what flood risk management measures might be required in the future, what is required now and ensuring that decisions made now are adaptable to permit an effective and efficient transition to the management of potential future flood risk. The decision tree is a graphical representation of how the option can be adapted over time and of the scores given to each option. The decision trees are included in Appendix C.

The scoring for a given option reflects the cost and the degree of difficulty and potential impacts of future adaptions that would be necessary to maintain the Standard of Protection of the option under the MRFS and/or HEFS, whereby the greater the cost, difficulty and impact, the lower the score. The decision tree and scores for each SSA are included in Appendix E. The scores from the decision trees are used in the MCA.

The measurement of the performance of the options against the objective to avoid economic damage is measured in terms of the percentage of economic damage avoided by that option. Certain receptors in Coastal AFAs are at risk from fluvial and tidal flooding. On the basis of historical flood records it can be

said that these flooding mechanisms are independent of each other. For this reason when assessing the potential damage to properties in Coastal AFAs this report considers that the total potential damage is equal to the total potential fluvial damage added to the total potential tidal damage. Similarly when assessing the damage avoided by a particular option the total damage avoided is equal to the total fluvial damage plus the total tidal damage avoided. When calculating the percentage reduction in damage for a particular option this is calculated relative to the total potential damages in the town. The economic objectives also measure the performance of the option in terms of reducing the risk to transportation routes, utility infrastructure and agricultural land.

The social objectives in the MCA include the reduction of flood risk to people, high vulnerability properties such as hospitals and fire stations and to social infrastructure and amenities. Under social objectives the MCA also measures the performance of the option to reduce the risk to local employment in relation to the number of non-residential properties at risk.

Under the Environmental criteria the MCA measures the performance of the option under environmental headings such as:

- Promote achievement of good status in waterbodies
- Avoiding damage to protected habitats
- Minimising the risk of environmental pollution
- Avoid damage to the flora and fauna of the catchment
- Avoid damage to fisheries habitats
- Protect landscape character and visual amenity within the river corridor
- Avoid damage to features of architectural value
- Avoid damage to features of archaeological importance

Once all of the options have been analysed with reference to their performance against each of the sub-objectives the MCA score for each criteria can be calculated. This is done by multiplying the score for each sub objective by the Global and the local Weighting and then by summing the weighted scores for all the sub objectives under that criteria.

The **MCA Benefit Score** is calculated by adding the weighted score for the Economic, Social and Environmental Criteria together. This score represents the net benefits of the option.

The **Option Selection MCA Score** is calculated by adding the weighted scores of all the criteria together. This score includes the technical score and therefore includes all of the aspects that should be taken into account in considering the preferred option for a given location.

The **Total Construction Cost €** is the cost of the FRM option as outlined in Section 9.

The **MCA Benefit – Cost Ratio** is calculated by dividing the **MCA Benefit Score** by the cost of the option. This is a numerical but non monetised ratio that indicates the overall benefits that can be delivered per euro of investment.

The **Economic Benefit €** is the cost of the damage avoided for the FRM Option.

The **Economic Benefit – Cost Ratio** is calculated by dividing the cost of the damage avoided by adopting the FRM Option by the cost of the option. This is the traditional method used by OPW in assessing the economic case for proceeding with a flood relief scheme. In general terms a flood relief scheme would be considered economically viable if the benefit cost ratio is greater than 1.

10.4 Measures Being Undertaken under Other Policy Areas

Flood related measures being undertaken under other policy areas have the potential to have an impact on flood risk in the UoM. The relevant policy areas may relate to EU Directives 85/337/EEC (EIA Directive), 96/82/EC (Seveso II Directive), 2001/42/EC (SEA Directive) and 2000/60/EC (Water Framework Directive).

11 Selection of Preferred Options

11.1 Preferred Flood Risk Management Options – UoM

The preferred Flood Risk Management Options selected for inclusion in the Flood Risk Management Plan for UoM 19 are set out below:

- Planning Control
- Building Regulations
- SUDS
- Flood Forecasting and Warning Systems
  - Build on Lower Lee Flood Warning System
- Public Awareness
- Individual Property Flood Resilience
- Land Use Management

The non-structural measures highlighted above do not mitigate existing flood risk. However, they should be implemented as national policy to the SSAs to minimise future risk.

11.2 Preferred Flood Risk Management Options – Ballingeary / Inchigeelagh Sub-Catchment

In addition to the options selected for the UoM, the preferred options selected for inclusion in the Flood Risk Management Plan for the Ballingeary / Inchigeelagh Sub-Catchment are set out below:

- Flood Forecasting and Warning Systems
  - River Level Gauges along with forecast rainfall to predict flooding from Lough Allua
  - Build on Lower Lee Flood Warning System

As described in Section 9.1, the benefit of a flood forecasting and warning system may be reduced through the implementation of a measure / option at another SSA (i.e. AFA flood relief scheme). Therefore, the timing of other measures / options must be considered when implementing a flood forecasting and warning system.

As highlighted in Section 5.0, increase conveyance is not a viable measure for the Ballingeary / Inchigeelagh sub-catchment.

The potential storage option for the Ballingeary / Inchigeelagh Sub-Catchment is not cost beneficial as highlighted in Section 9.2.

11.3 Preferred Flood Risk Management Options – AFAs

11.3.1 MCA Scores

The Scores achieved by each potential option under consideration are listed in Table 11.1 below. Details of the MCA undertaken for each AFA are contained in Appendix F.

Table 11.1: MCA Scores for Potential Options

AFA / Option	Cost Estimate €	Capped Scheme Benefit €	MCA Benefit Score	Option Selection MCA Score	MCA Benefit Cost Ratio (Millions)	Economic Benefit Cost Ratio	Initial Rank
Ballingeary							
Do Nothing	-	-	-264.00	-264.00	0.00	0.00	3
Flood Defences	3,069,155.00	14,882,358.26	1692.30	2792.30	551.39	4.85	1
Storage	18,785,087.24	14,882,358.26	1418.30	2318.30	75.50	0.79	2
Inchigeelagh							
Do Nothing	-	-	-44.00	-44.00	0.00	0.00	2
Flood Defences	2,563,297.51	3,596,237.26	1424.97	2524.97	555.91	1.40	1
Castlemartyr							
Do Nothing	-	-	-36.00	-36.00	0.00	0.00	3
Flood Defences	3,539,582.25	2,394,238.74	624.98	1524.98	176.57	0.68	2
Flow Diversion & Flood Defences	1,443,787.19	2,394,238.74	704.98	1304.98	488.28	1.66	1

11.3.2 Feedback Provided on Options

At the public consultations for Preliminary Flood Risk Management Options the public were asked to rank the potential options in terms of their preference. The feedback received is included in Table 11.2 below.

Table 11.2: Public Preference for Potential Options

AFA	Option	Nr of Rank 1 Received	Rank
Ballingeary	Flood Defences	3	1
	Storage	0	-
	Do Nothing	0	-
Inchigeelagh	Flood Defences	4	1
	Storage	0	2
	Do Nothing	0	3
Castlemartyr	Food Defences	1	2
	Flow Diversion & Flood Defences	2	1
	Do Nothing	0	3

The selection of the preferred Flood Risk Management Option for each of the AFAs is based on the MCA and the feedback provided during the public consultation. The preferred options for each of the AFAs are listed below:

11.3.2.1 Ballingeary

The preferred option identified in the MCA is Flood Defences. The feedback provided at the Ballingeary PCD indicated that the public agreed with the preferred option indicated in the MCA.

11.3.2.2 Inchigeelagh

The preferred option identified in the MCA is Flood Defences. The feedback provided at the Inchigeelagh PCD indicated that the public agreed with the preferred option indicated in the MCA.

11.3.2.3 Castlemartyr

The preferred option identified in the MCA is Flow Diversion and Flood Defences. The feedback provided at the Castlemartyr PCD indicated that the public agreed with the preferred option indicated in the MCA.