Shannon Catchment-based Flood Risk Assessment and Management (CFRAM) Study

Preliminary Options Report
Unit of Management 23

Option Appraisal

Final Report

July 2016

Document Control Sheet

BPP 04 F8

Project: Shannon CFRAM Study
Client: Office of Public Works — Project No: 32103000
Document title: Preliminary Options Report - Unit of Management 23

	Originated by	Checked by	Reviewed by	
ORIGINAL	NAME KM/MC/OD	NAME Mairead Conlon	NAME Peter Smyth	
Approved by	NAME **Peter Smyth**	As Project Manager I confirm that the above document(s) have been subjected to Jacobs' Check and Review procedure and that I **approve them for issue**		INITIALS **PS**
DATE	27/2/15	**Initial DRAFT**		

REVISION	NAME KM/MC/OD	NAME Mairead Conlon	NAME Peter Smyth	
Approved by	NAME **Peter Smyth**	As Project Manager I confirm that the above document(s) have been subjected to Jacobs' Check and Review procedure and that I **approve them for issue**		INITIALS **PS**
DATE	23/7/15	**DRAFT**		

REVISION	NAME Jamie Reynolds	NAME Mairead Conlon	NAME Peter Smyth	
Approved by	NAME Peter Smyth	As Project Manager I confirm that the above document(s) have been subjected to Jacobs' Check and Review procedure and that I **approve them for issue**		INITIALS **PS**
DATE	**June 2016**	**DRAFT FINAL**		

REVISION	NAME Jessica Dale	NAME Mairead Conlon	NAME Peter Smyth	
Approved by	NAME Peter Smyth	As Project Manager I confirm that the above document(s) have been subjected to Jacobs' Check and Review procedure and that I **approve them for issue**		INITIALS **PS**
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Contents

Abbreviations

A full list of abbreviations frequently used in the CFRAM Programme and more widely in flood risk management is provided in Appendix A. Set out below are abbreviations used herein.

AEP	Annual Exceedance Probability (expressed as a percentage)
AFA	Area for Further Assessment
APMR	Areas of Potential Moderate Risk
CFRAM	Catchment Flood Risk Assessment and Management
EU	European Union
FRMP	Flood Risk Management Plan
GIS	Geographic Information System
IRR	Individual Risk Receptors
OPW	The Office of Public Works
RBD	River Basin District
SI	Statutory Instrument (SI No. 122 of 2010)
SOP	Standard of Protection
SSA	Spatial Scale of Assessment
UoM	Unit of Management
WFD	Water Framework Directive

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1 Introduction

1.1 Shannon CFRAM Study Area

The Shannon (the "Study Area") is the largest River Basin District (RBD) in Ireland, covering approximately 17,800km^2 and more than 20% of the island of Ireland. The RBD includes the entire catchment of the River Shannon and its estuary as well as some catchments in North Kerry and West Clare that discharge directly to the Atlantic.

The Shannon River rises in the Cuilcagh Mountains, at a location known as the Shannon Pot in the counties of Cavan and Fermanagh. The river flows in a southerly direction before turning west and discharging through the Shannon Estuary to the Atlantic Ocean between counties Clare and Limerick. Whilst the River Shannon is 260km long from its source to the head of the Shannon Estuary in Limerick City, over its course the river falls less than 200m in elevation. The Shannon RBD is characterised as an 'International RBD' as it extends into Northern Ireland. However, there are no areas identified as being at significant flood risk in the Shannon RBD within Northern Ireland, and no significant cross-border issues.

Significant tributaries of the Shannon include the Inny, Suck and Brosna. There are several lakes in the RBD, including Lough Ree, Lough Derg and Lough Allen.

Other important rivers within the RBD include the Maigue, Deel and Feale discharging into the Shannon Estuary from the south, and the Fergus, Owenogarney (or Ratty) and Cloon discharging into the estuary from the north.

The RBD includes parts of 17 counties: Limerick, Clare, Tipperary, Offaly, Westmeath, Longford, Roscommon, Kerry, Galway, Leitrim, Cavan, Sligo, Mayo, Cork, Laois, Meath and Fermanagh. While much of the settlement in the RBD is rural there are six significant urban centres within the RBD - Limerick City, Ennis, Tralee, Mullingar, Athlone and Tullamore.

The RBDs that were defined under the Water Framework Directive (WFD) were further divided into a number of Units of Management (UoM) for the purposes of the National CFRAM Programme.The UoM constitute major catchments or river basins (typically greater than 1000km2) and their associated coastal areas, or conglomerations of smaller river basins and their associated coastal areas. The Shannon RBD (and by definition the Shannon CFRAM Study Area) and the UoM within the Shannon RBD are shown in Figure 1.1. There are six hydrometric areas in total, these hydrometric areas have been grouped together to form four UoMs, as follows;

- Tralee Bay – Feale (Hydrometric Area 23 – 'HA23') – UoM 23;
- Shannon Estuary South - (Hydrometric Area 24 – 'HA24') – UoM 27;
- Shannon Upper and Lower (Hydrometric Area 25 & 26 – 'HA25 & 26') – UoM 25/26;
- Shannon Estuary North and Mal Bay (Hydrometric Area 27& 28 – 'HA27 & 28') – UoM 27/28

1.2 Preliminary Options Report Scope

The specification for the Preliminary Options Report is set out in Section 1 of the Catchment – based Flood Risk Assessment and Management (CFRAM) Studies Stage 1 Project Brief (June 2010) and elements of Sections 2.25 to 2.27 of the Shannon CFRAM Study Stage II Project Brief (October 2010). There are four Preliminary Options Reports for the Shannon CFRAM Study Area, one for each UoM in which at least one fluvial hydraulic model or coastal flooding model exists.

1.2.1 AFAs for different SSAs

The development of flood risk management options has been carried out at four Spatial Scales of Assessments (SSAs). The 4 SSAs are;

- The UoM
- Each sub-catchment or coastal area within the UoM
- AFAs
- IRRs

The Shannon CFRAM Study Area is comprised of six UoMs. Table 1.1 and figure 2.1 provides a summary of UoM 23, with a complete list of the associated SSA's considered.

Table 1.1 List of SSA by UoM

UoM	SSA level	AFA/IRR names	Fluvial (F) or Coastal (C) models
UoM 23	UoM	UoM 23	F / C
	Sub	Feale Sub Catchment	F
	AFA	Abbeyfeale	F
	AFA	Listowel	F
	AFA	Moneycashen	F / C
	AFA	Athea	F
	AFA	Abbeydorney	F
	AFA	Tralee	F / C
	AFA	Banna	F / C

1.3 Structure of this Report

1.3.1 Overview of Report Volumes

The Preliminary Options Report sets out the work and analysis undertaken in the development of flood risk management options for all the Spatial Scales of Assessment (SSA) within Unit of Management (UoM) 23.

1.3.2 Report Structure

This report, excluding appendices, is structured to reflect the specific reporting requirements of the CFRAM Studies Project Brief as follows:

Section 1 Provides an introduction to the Preliminary Options Report and sets the context and scope of this activity within the Shannon RBD.

Section 2 Provides an overview of the study area and the history of flooding.

Section 3 Describes, in general terms, the approach taken in to development of the flood risk management measures and the options assessment process.

Section 4 Describes the options appraisal results.

Section 5 Presents the preferred options, prioritisation and other recommendations for the flood risk management plan.

1.3.3 Report Appendices

A series of appendices to this POR Volume 1 'Option Assessment' report are relevant to summarising our adopted optioneering approach. These are:

Appendix A Glossary of Terms

Appendix B Flood Risk Management Definitions and the general methodology of how these measures are appraised.

Appendices C Detailed description of the work and analysis carried out in the development of the flood risk management options for each AFA.

Appendix D Detailed description the Economic Damage and Benefit Calculations and the Cost Benefit Analysis methodology

Appendix E Minutes from the option development meeting with the relevant Stakeholders

Appendix F MCA objectives and scoring methodology.

Appendix G This Appendix provides a detailed assessment of the freeboard allowances adopted in the outline design of embankments and flood walls for this study.

Appendix H CFRAM Unit Cost Development Project Final Report – Outlines the methodology used in determining the PV costs for the options.

Appendix I Left blank for UoM 23 report contains Flood Defence Asset Failure Maps for other UoM reports

Appendix J Relevant Guidance Notes produced by the OPW which are referenced in this process.

Appendices K Detailed description of the work and analysis carried out in the development of the flood risk management options for each sub-catchment.

Appendix M Economic Sensitivity Analysis

Appendices C provide specific information for each respective AFA. This enables different stakeholders to easily identify the AFAs that may be of interest, allowing

them to view the **relevant Appendix section**. Table 1.2 summarises the Appendix section reference for each AFA within UoM 23.

Table 1.2 Summary of Appendices C

Appendix Section	AFA	County
Appendix C1	Listowel	Kerry
Appendix C2	Abbeyfeale	Limerick
Appendix C3	Athea	Limerick
Appendix C4	Banna	Kerry
Appendix C5	Abbeydorney	Kerry
Appendix C6	Moneycashen	Kerry
Appendix C7	Tralee	Kerry

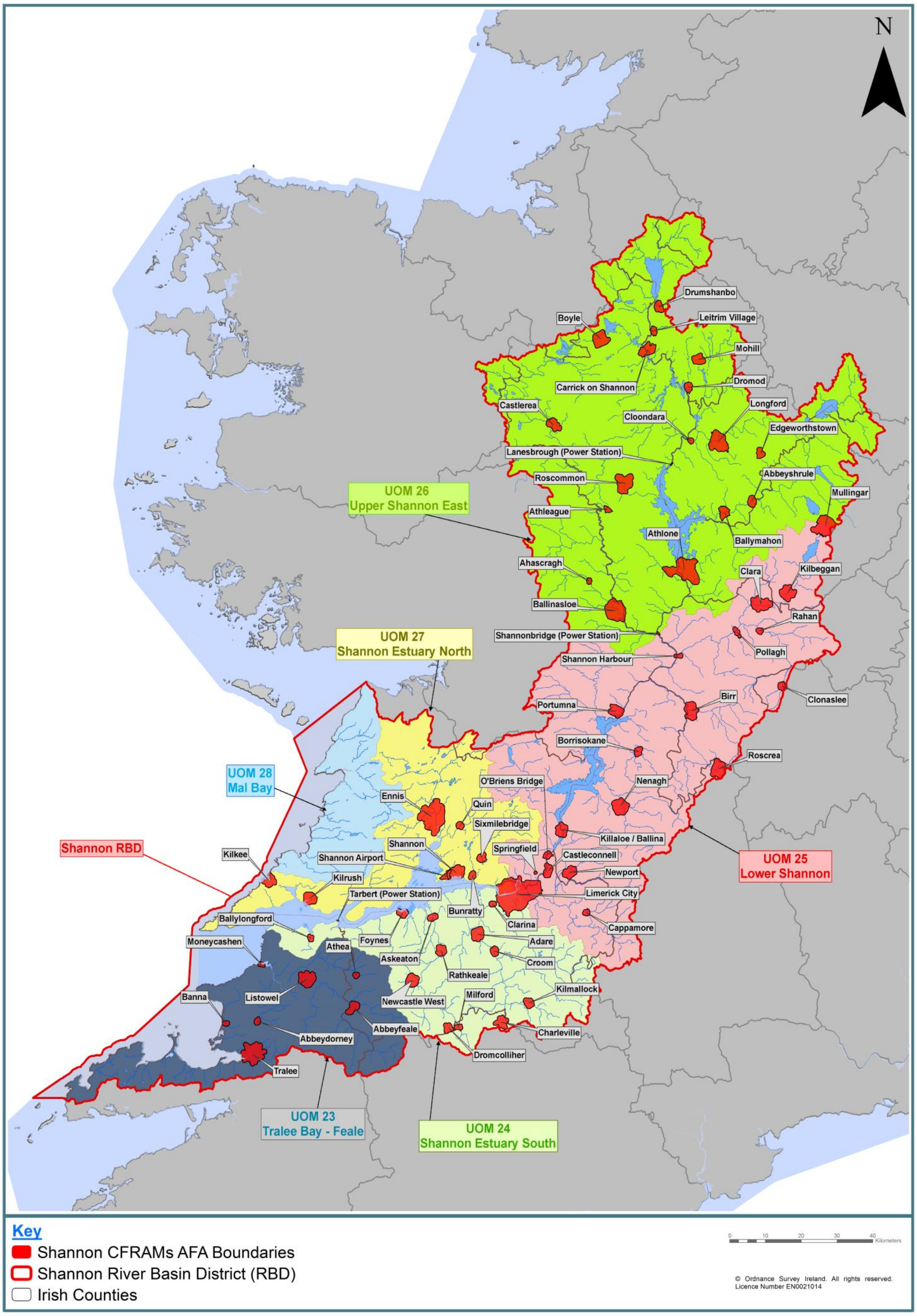


Figure 1.1 Shannon RBD and its Units of Management

2 Report Study Area and Data Collected

2.1 UoM Study Area

UoM 23 comprises the Feale and Tralee Bay catchments and is located within three counties; Kerry, Limerick and Cork. The total area of UoM 23 is approximately 1800 km^2. It is bounded on the northwest by the mouth of the Shannon Estuary and on the east and southeast by the Mulllaghareirk Mountains, forming the catchment boundary between UoM 23 and 24 (Figure 2.1). Along the southern boundary from east to west are the Glanaruddery Mountains and the Slieve Mish Mountains which extend into the Dingle Peninsula.

UoM 23 is dominated by the Feale catchment in the central and eastern area. The River Feale drains into Cashen Bay in its lower reaches where it becomes tidally influenced. This catchment, with a total area to the mouth of the Cashen of 1155 km^2 makes up around 65% of the total area of UoM 23. Major tributaries to the Feale catchment include the Shannow, Brick, Galey, Smearlagh, Allaghaun, and Oolagh rivers. These typically drain the upland areas to the east and south of the area, with the exception of the Brick which predominantly drains a lowland area towards the west.

The southern and south-western area is dominated by mountainous and upland areas with many steep and flashy watercourses, notably around the Dingle Peninsula and Tralee. The Slieve Mish Mountains are to the south and southwest of Tralee, with Stack's Mountains to the east and northeast of Tralee. The main rivers in this area are the River Lee and Big River, both flowing into Tralee.

The western area along the Atlantic coast (Ballyheige Bay) is a mainly low lying area with small catchments draining to the west coast. This area is protected by an extensive coastal dune system. There are important drainage schemes in this area behind the dune system, notably the Akeragh Drainage System which discharges to the Atlantic approximately 3km south of Ballyheige.

The northwest coast, with the exception of the Cashen which also discharges here, is characterised by small rivers and streams discharging to the Atlantic Ocean.

There are seven AFAs in UoM 23, with the relevant sub-catchment provided in Table 2.1.

Table 2.1 AFAs and Hydrological Catchments

AFA	Sub-catchment	County
Listowel	Feale	Kerry
Abbeyfeale	Feale	Limerick
Athea	Feale	Limerick
Banna	Tyshe	Kerry
Abbeydorney	Feale	Kerry
Moneycashen	Feale	Kerry
Tralee	Lee	Kerry

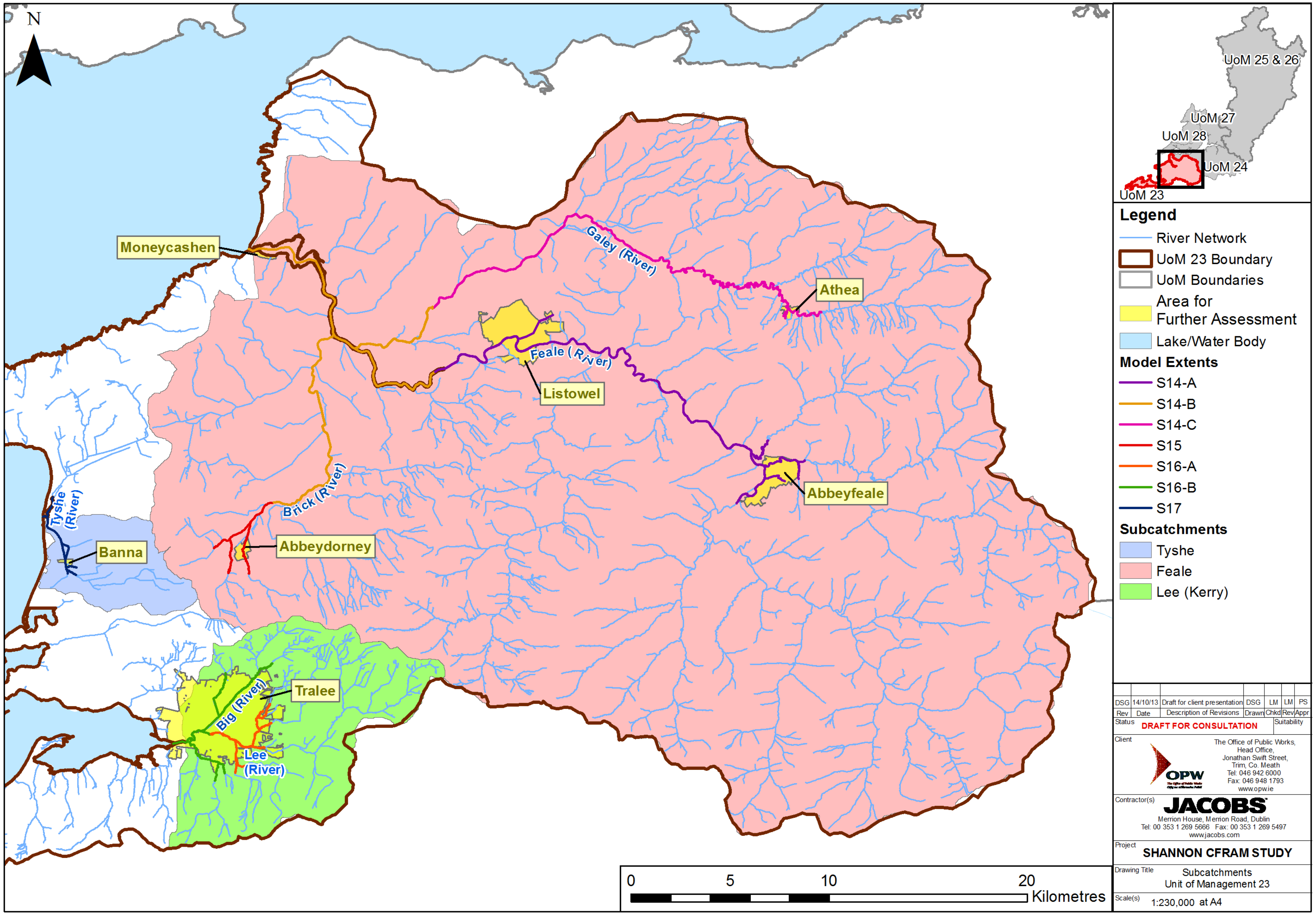


Figure 2.1 UoM 23 Sub-catchments

2.2 History of Flooding

Flood records were studied as part of the Inception Study to determine a flood history for the sub-catchments making up UoM 23. The findings are summarised below.

Listowel AFA

Major flood events that affected Listowel AFA were recorded in February 2001, July 2002, November 2002 and August 2003. The localised nature of the flood events and the fact that reported events do not appear to coincide with fluvial flood events recorded at the gauging station on the river (gauging station number 23002 - Listowel) suggest the potential source of the flooding being pluvial with the main mechanism of flood generation being a combination of localised storm events which may generate high surface runoff beyond the capacity of the drainage system.

Abbeyfeale AFA

The Abbeyfeale AFA located at the upper reach of the River Feale model extent was affected by the flood event of January 2005. As the 2005 flood event coincided with the high flow record at Station 23002 (Listowel), the cause of this flooding is considered to be fluvial.

Moneycashen

The Moneycashen AFA, located at the Feale Estuary, is susceptible to tidal/coastal flooding. This AFA was affected by a major tidal flood event in February 2002 (anecdotal evidence suggesting that tidal flood levels were at their highest in more than 80 years). The AFA recently suffered flooding in January and February 2014.

Athea AFA

The Athea AFA is located close to the upper boundary of the River Galey model (S14c). This AFA was affected by flooding in April 2005, in August 2008 and in September 2009. According to the Athea Flood Severity and Impact Report by JBA (October 2008), the main cause of the August 2008 flood in the Athea area was the extreme rainfall event, the AEP of which was estimated to be 0.16% (i.e. a return period of 650 years).

On examination of this flood event in was found that the main mechanism of flooding upstream of the bridge in the town was as a result of sediment blockage at the bridge. Considering this the flood risk in Athea has been determined with a blockage applied to the bridge.

Abbeydorney AFA

The Abbeydorney AFA is located on the River Brick, close to the upper boundary of the S15 model. The Abbeydorney area was affected by local surface water related flooding in October/November 1994.

Tralee AFA

The main sources of flooding in this AFA and surrounding area are the two tributaries of the River Lee: the Rivers Big and Balloonagh. These two tributaries drain the steeply sloping ground to the north of the town. Due to the underlying geology and steepness of the catchments, storm flows in the Big and Balloonagh are characterised by short durations and high peak flows resulting in flash flooding.

The Tralee area was flooded several times. The major recorded flood events were in November 1916, November/December 1924, January 1925, March 1955, May/December 1973, November 1980, August 1986, November 1996, August 1997, December 2005, August 2008, November 2009 and February 2011. According to the National Flood Hazard Mapping website www.floodmaps.ie, the recurrence of flood events in the town centre has improved after major drainage works following the severe flooding of August 1986. These drainage works include a major diversion channel which diverts flows from the Big River, which flows thought the main built up area of the town to the east of the town which was a rural area. However, areas outside the Tralee town centre appear to flood regularly. Most of the floods in Tralee are reported to have been caused by overgrowth in the banks of the river channels and inadequate capacity of culverts along the River Lee and its two tributaries the Big and Balloonagh. The area to which the flow from the Big River has been diverted is now a built up industrial area and is at risk of flooding.

Banna AFA

The Banna AFA is located in the Tyshe catchment. According to the records available on the website www.floodmaps.ie this AFA was affected by flooding in November 1980. In addition, recurring flooding has been reported on the R551 road through the village of Ardfert, which is located to the southeast of Banna AFA.

The main flood risk in Banna is due to tide locking of the fluvial flows. The outfall of the River Tyshe suffers from blockage as a result of coastal process. Without intervention it is likely a sand bar would form. Although weekly maintenance of the sediment build up has been carried out to reduce the flood risk the flood risk for Banna has been determined as the risk of flooding if no maintenance is carried out and a sand bar has formed.

3 Appraisal Methodology

3.1 Overview of the Option Appraisal methodology

The Option Appraisal methodology is a multi-staged approach to ensure the over-riding objectives for this phase of the project are achieved, namely:

- Identify appropriate flood risk management measures / options for the different SSAs;
- These measures / options should be robust and form the basis for any future planning stage associated with its implementation; and
- The rejection of any measure / option should be robust with clear and transparent reasoning.

To achieve these objectives, a five-stage Option Appraisal methodology has been developed which combines industry standard practices, specialist appraisal software, stakeholder engagement and professional judgement, to ensure a consistent approach to the decision making process.

Figure 3.1 provides the five-stage Option Appraisal process as a flow chart. Each stage comprises a number of sub-stages, with a summary of these provided in Table 3.1 below.

Table 3.1: Option Appraisal Stage and Sub-Stage

Stage	Description	
Stage 1	**Current Flood Risk**	
	Sub-stage 1.1	SSA / AFA and Watercourse Details
	Sub-stage 1.2	Summary of Flood Risk in 1% AEP Event
	Sub-stage 1.3	Existing Flood Risk Management Measures
	Sub-stage 1.4	Summary of PV Damages/Potential PV Benefits for 1%/0.5% AEP SOP
	Sub-stage 1.5	Summary of Social receptors at risk of flooding
	Sub-stage 1.6	Summary of Environmental receptors at risk of flooding
	Sub-stage 1.7	Summary of Cultural Heritage receptors at risk of flooding
	Sub-stage 1.8	Summary of Economic receptors at risk of flooding
Stage 2	**Screening of Measures**	
	Sub-stage 2.1	Baseline, Structural Measures and Non-Structural measures – Viability Assessment
	Sub-stage 2.2	Justification Screened Out Baseline, Structural and Non – Structural Measures
	Sub-stage 2.3	Summary of 'Screened In' Measures
Stage 3	**Selection of Options**	
	Sub-stage 3.1	Consideration of Options
Stage 4	**Appraisal of Options**	
	Sub-stage 4.1	Options Appraisal
Stage 5	**Multi-Criterial Assessment**	
	Sub-stage 5.1	Summary of MCA results for each option
	Sub-stage 5.2	Comparison of MCA Scores
	Sub-stage 5.3	Recommendation of Preferred Option

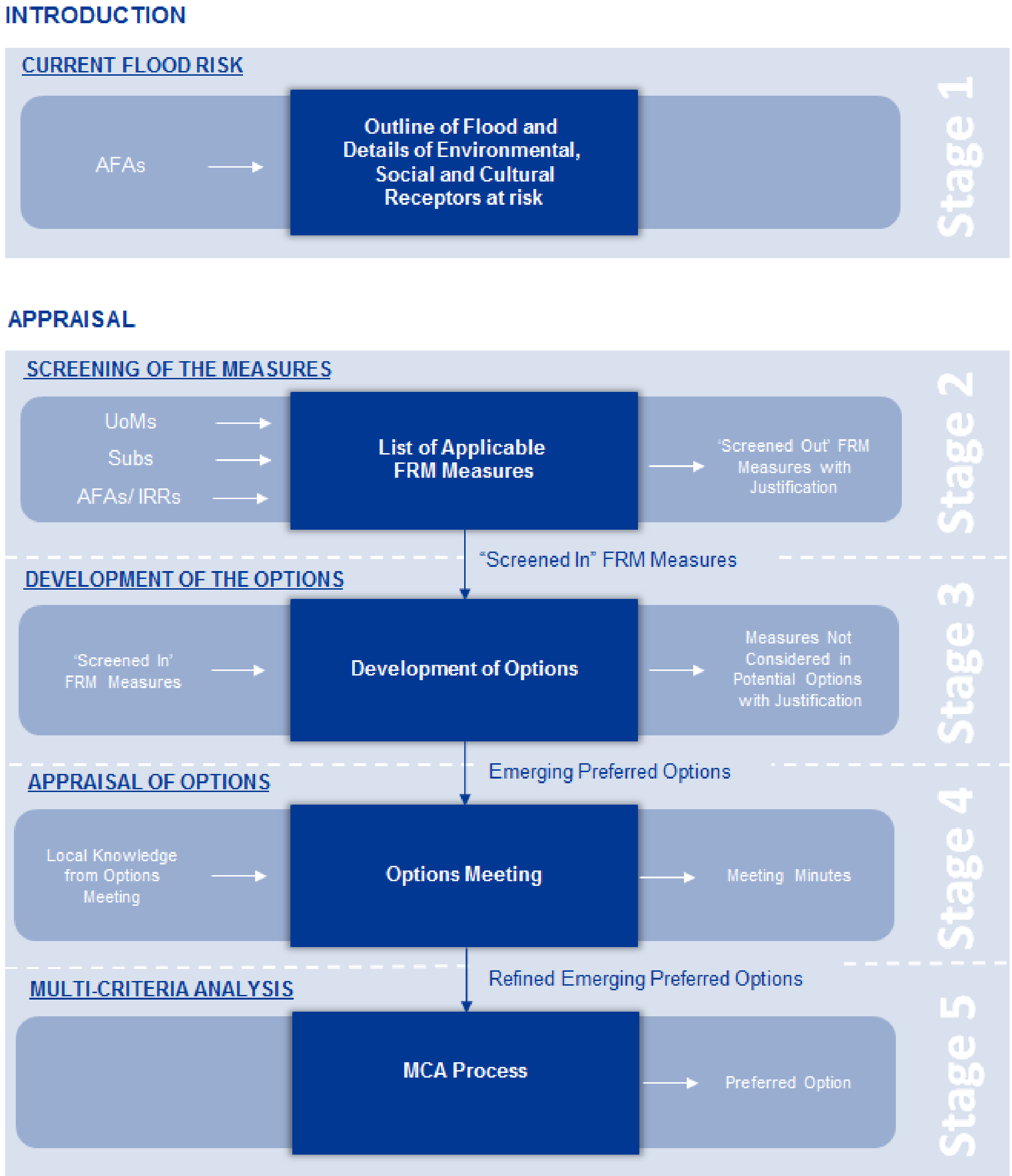


Figure 3.1: Option Appraisal Multi-Stage Process

To record the outcomes from each of these Option Appraisal stages / sub-stages, and ensure consistency in approach, we have developed a standard Option Appraisal Report format. The remainder of this Section 3 provides more information on the purpose, method and assumptions associated with each of the stages / sub-stages.

3.2 Stage 1: Summary of Current Flood Risk

Relevant Extract from Option Appraisal Flow Chart

The purpose of this Stage 1 is to determine the significance of the flood risk within the SSA, summarise the potential economic damage and the impacts to key receptors.

To achieve these objectives, Stage 1 has been divided into the eight sub-stages, which are summarised in Table 3.2.

Table 3.2: Summary of Sub-stages for Stage 1

Ref	Title
1.1	SSA / AFA and Watercourse Details
1.2	Summary of Flood Risk in 1% AEP Event
1.3	Existing Flood Risk Management Measures
1.4	Summary of PV Damages/Potential PV Benefits for 1% SOP
1.5	Summary of Social receptors at risk of flooding
1.6	Summary of Environmental receptors at risk of flooding
1.7	Summary of Cultural Heritage receptors at risk of flooding
1.8	Summary of Economic receptors at risk of flooding

A Stage 1 assessment has been undertaken for all AFAs. Following this, for those AFAs deemed to have an insignificant flood risk the choice not to proceed through Stages 2 to 5, was available. Appendix C provides information on the Option Appraisal Stages completed for each AFA.

The Option Appraisal Report records the information and decisions from each of these sub-stages; the following sections describe each of the sub-stages individually.

3.2.1 Sub-stage 1.1 SSA / AFA and Watercourse Details

Summary details of the SSA, the applicable AFAs and the associated watercourse details.

3.2.2 Sub-stage 1.2 Summary of Flood Risk

This stage determines the significance of the flood risk by appraising the number of properties at risk in the 1% AEP Fluvial and 0.5% AEP Tidal, along with the number of individual flood cells. Table 3.3 provides a relevant extract from the Option Appraisal Report, for a worked example.

Table 3.3: Option Appraisal Report – Report Section 1.2

1.2 Summary of Flood Risk in 1% Fluvial AEP Event				
Source of flood risk	Fluvial		Coastal	Both
Total Number of Properties at risk in AFA in 1% Fluvial AEP Event:		Residential	Non-Residential	Total
	Fluvial	136	24	160
AFA Flood Cells:	Total Number:	3		
	Flood Cell Titles:	LIL_A, LIL_B, LIL_C		
Breakdown of properties at risk per Flood Cell:	Flood Cell Ref	Residential	Non-Res	Total
	LIL_A	136	7	143
	LIL_B	0	1	1
	LIL_C	0	16	16

Only those properties whose centroid is within the 1% fluvial / 0.5% tidal AEP flood extent, has been counted as 'at risk' in this Option Appraisal Sub-stage 1.2. This is to ensure consistency with the approach to the calculation of the PV Damages.

3.2.3 Sub-stage 1.3 Summary of Existing Flood Risk Management Measures

This stage summarises our understanding of the existing flood management measures within the SSA. This information is available in the collect datasets, including the defence database and the arterial drainage maintenance schemes.

3.2.4 Sub-stage 1.4 Summary of PV Damages

This stage provides the economic, capped and uncapped, Present Value Damages (PVd), including a breakdown between residential and commercial across each flood cell.

The economic PVd is the discounted annual average damages sum. It is calculated using the Flood Hazard Research Centre Handbook of 2010 (FHRC, 2010) and the Multi-Coloured Manual" of 2005 (FHRC, 2005), based on the following:

- Direct damages based on flood depth, duration and property characteristics;
- Intangible damages, infrastructural utility damages and emergency services;
- The economic PVd does not include an allowance for Traffic disruption.

The following are important assumptions in our approach to the calculation of the PVd to ensure compliance with the project objectives:

- The property centroid must lie within the appropriate AEP flood extent to contribute a PVd;
- For residential properties, direct damages (PVd) commence at 0.3m below the property threshold level. This threshold is set at 0.15m above the LiDAR (bare earth) level at the property centroid;
- For non-residential properties, direct damages (PVd) commence at the property threshold level; This threshold is set at the LiDAR (bare earth) level at the property centroid;
- Site visits, including specific property inspections were carried out across all AFAs before adopting this approach to determining threshold level;

- Visual surveys have also been carried out of all non-residential properties contributing more than €500,000 PVd to ensure this property threshold assumption is appropriate. Where inappropriate, the property threshold has been adjusted and noted in the supplied datasets.

Appendix D of this Report provides more detail on the data used, tools developed and assumptions made in calculating the economic PVd.

The PVd is calculated as the discounted sum of the annual average damages over the project horizon, where:

- The discount rate to be applied is 4%, and
- The project horizon is 50 years

Sensitivity tests have been carried out on the PVd using higher and lower discount rates, 5% and 3% respectively. The results of these sensitivity tests are summarised in Appendix M of this Report.

3.2.5 Sub-stage 1.5 Summary of Social receptors at risk of flooding

This stage (Section 1.6) reports the social receptors at risk of flooding within the SSA/AFA. These features may provide constraints to the proposed measures and it is important the consequences of any recommendations are identified early in the appraisal process.

3.2.6 Sub-stage 1.6 Summary of Environmental receptors at risk of flooding

This stage (Section 1.6) reports the environmental receptors at risk of flooding within the SSA/AFA. These features may provide constraints to the proposed measures and it is important the consequence of any recommendations are identified early in the appraisal process.

3.2.7 Sub-stage 1.7 Summary of Cultural Heritage receptors at risk of flooding

This stage (Section 1.7) reports the cultural heritage receptors at risk of flooding within the SSA/AFA. These features may provide constraints to the proposed measures and it is important the consequences of any recommendations are identified early in the appraisal process.

3.2.8 Sub-stage 1.8 Summary of Economic receptors at risk of flooding

This stage (Section 1.8) reports the economic receptors at risk of flooding within the SSA/AFA These features may provide constraints to the proposed measures and it is important the consequence of any recommendations are identified early in the appraisal process.

3.3 Stage 2: Screening of the Measures

Relevant Extract from Option Appraisal Flow Chart

The purpose of this Stage 2 is twofold:

- Determine the viability of Baseline, Structural and Non-Structural Flood Risk Management Measures for each SSA / AFA; and
- Provide robust, transparent reasoning for those measures identified as unviable.

To achieve these objectives, Stage 2 has been divided into the three sub-stages, which are summarised in Table 3.4.

In the case where no measures are found to be viable, the MCA process will not be carried out and no further work will be carried out.

Table 3.4: Summary of Sub-stages for Stage 2

Ref	Title
2.1	Baseline, Structural Measures and Non-Structural measures – Viability Assessment
2.2	Justification Screened Out Baseline, Structural and Non – Structural Measures
2.3	Summary of ‘Screened In’ Measures

The ‘screening’ process essentially involves the identification of Flood Risk Management (FRM) measures which are deemed unviable. The FRM Measures which are ‘screened out’ will not provide applicable, acceptable or viable measures, either alone or in combination with other measures.

For the UoM and sub-catchment SSA’s FRM measures which provide benefits to multiple AFAs/IRRs within the UoM and other areas should be considered, along with the spatial and temporal coherence of methods being considered at AFA/IRR scales. Therefore certain measures such as “relocation of properties” are not applicable at the UoM and sub-catchment scale.

Table 3.5 is the list of the FRM measures considered for this study and the spatial scale for which they are applicable, are categorised into Baseline, Structural and Non-Structural measures. Appendix B provides a definition for each of the FRM measures and reasoning for their categorisation.

Table 3.5: FRM Measures and applicable SSA

Flood Risk Management Measure		Applicable SSA
Ref	**Title**	
Baseline		
A	Do Nothing	AFA/IRR
B	Existing Regime	AFA/IRR
C	Do Minimum	AFA/IRR
Structural		
D	Storage	All
E	Flow Diversion	All
F	Increase Conveyance	All
G	Construct Flood Defences	All
H	Relocation of Properties	AFA/IRR
I	Other Measures	All
Non Structural		
J	Flood Forecasting / Warning / Response	All
K	Public Awareness	All
L	Individual property resistance	AFA/IRR
M	Individual property resilience	AFA/IRR
N	Planning and development control measures	UoM
O	Building regulations	UoM
P	Sustainable urban drainage systems	AFA/IRR
Q	Land use management	All
R	Strategic development management	UoM
S	Additional Monitoring (rain and river level/flow gauges)	UoM

The FRM measures have been assessed for their potential viability (screening) against the following 5 assessment criteria:

i. Applicability to the Relevant Area (Appl.)
ii. Economic (Econ.)
iii. Environmental (Envir.)
iv. Social (Soc.)
v. Cultural (Cult.)

The 1% Annual Exceedance Probability (AEP) fluvial event and the 0.5% AEP tidal event are the preferred design standards for this screening assessment. However other design standards should be considered under certain circumstances and the screening appraisal processes should consider this potential flexibility.

It should be noted from Table 3.5 that whilst measures P and Q are included as measures to be considered, they specifically considered within Report III of the Preliminary Options Report. As such, these measures are excluded from the analysis within this Options Appraisal Report.

The Option Appraisal Report records the information and decisions from each of the Stage 2, sub-stages; the following sections describe each of the sub-stages individually.

3.3.1 Stage 2.1 Baseline, Structural and Non-Structural Measures – Viability Assessment

This stage determines the viability for each of the Baseline and Structural FRM measures, using the 5 assessment criteria

i. Appl.:
ii. Econ.:
iii. Envir.:
iv. Soc.:
v. Cult.;

If the determination for any of these three criteria is ‘unviable’, then the FRM measure is ‘Screened Out’. Only those FRM measures which are determined ‘viable’ for all five criteria are ‘Screened In’ for inclusion in the development of options in Stage 3. Table 3.6 provides a relevant extract from the Option Appraisal Report, for a worked example.

Table 3.6: Option Appraisal Report – Stage 2.1

2.1 Baseline, Structural and Non-Structural Measures							
Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.							
Measures		**Appl.**	**Econ.**	**Envir.**	**Soc.**	**Cult.**	**Overall Viability**
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
B	Existing Regime	Viable	Viable	Viable	Viable	Viable	**Screened In**
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
Structural							
D	Storage	Viable	Viable	Viable	Viable	Viable	**Screened In**
E	Flow Diversion	Viable	Viable	Viable	Viable	Viable	**Screened In**
F	Increase Conveyance	Viable	Viable	Viable	Viable	Viable	**Screened In**
G	Flood Defences	Viable	Viable	Viable	Viable	Viable	**Screened In**
H	Relocation of Properties	Unviable	Viable	Viable	Inviable	Viable	**Screened Out**
I	Other Measures	Unviable	Unviable	Unviable	Unviable	Unviable	**Screened Out**
Non-Structural							
J	Flood Forecasting / Warning / Response	Viable	Viable	Viable	Viable	Viable	**Screened In**
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	**Screened In**
L	Individual Property Resistance	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
M	Individual Property Resilience	Unviable	Viable	Viable	Viable	Viable	**Screened Out**

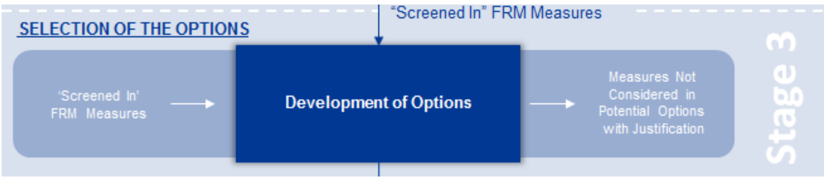
3.3.2 Stage 2.2 Justification for Screened Out Baseline, Structural and Non-Structural Measures

For those Baseline and Structural Measures 'screened out' in Stage 2.1, a robust and transparent reasoning for this conclusion is provided.

3.3.3 Stage 2.3 Summary of 'Screened In' Measures

This stage provides a summary of the Baseline, Structural and Non Structural FRAM Measures which have been 'Screened in' as viable and have therefore be taken forward and used in Stage 3 – Selection of Options.

3.4 Stage 3: Selection of the Options



Relevant Extract from Option Appraisal Flow Chart

The purpose of this Stage 3 is to develop the concept designs for the potential FRM Options from the 'screened in' FRM measures.

Structural, Non Structural and Baseline FRM measures are considered both independently and in combination with other measures to develop FRM Options.

For the development of FRM Options, certain structural FRM measures including Storage, Flow Diversion, Increase Conveyance and Construct Flood Defences, are considered with regard to different variations of these measures to ensure applicability to site conditions; refer to Table 3.7.

The concept design of all likely FRM Options are identified and taken forward to Stage 4 – Appraisal of Options.

Table 3.7: Specific Detailed FRM Measures considered at Stage 3

Ref	Title	Ref	Specific Detailed Description
D	Storage	Di	On-line Storage
		Dii	Off-line Storage
		Diii	Other Storage
E	Flow Diversion	Ei	Full Diversion
		Eii	Flood Relief Channel
		Eiii	Other Diversion/Channel
F	Increase Conveyance	Fi	Channel Dredging
		Fii	Channel Widening
		Fiii	Structure Enhancement
G	Construct Flood Defences	Gi	New Flood Defences
		Gii	Raise Existing Flood Defences
		Giii	Rehabilitate or improve Existing Flood Defences
		Giv	Demountable Defences
		Gv	Other Defences

At this concept design phase a general freeboard allowance has been applied to all structural defences. This general allowance is outlined in Table 3.8 below and has

been calculated using the Environment Agency's Fluvial Freeboard Guidance Note, R&D Technical Report W187 (2000). The freeboard calculation is based on two elements, the uncertainties relating to the physical processes that affect the defence and the uncertainty in the prediction of the existing flood risk in terms of the hydrology and hydraulic modelling. Details of how the freeboard has been calculated are contained in Appendix G.

Table 3.8: Freeboard Allowance

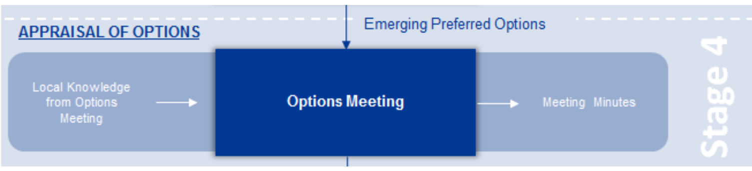
Defence Type	Fluvial	Coastal
Storage	210mm	n/a
Flow Diversion	210mm	n/a
Defences - Wall	210mm	210mm
Defences - Embankments	400mm	900mm

The following approach has been adopted when considering the replacement of existing formal effective flood defences as part of the option development:

- No existing flood defences are recommended for replacement, if their crest height currently provides the required design standard.
- If the crest height of an existing flood defence does not provide the required design standard, then the recommendation is for a new flood defence to be constructed as part of any option

Where existing defence form part of an option a geotechnical analysis of the existing defence should be carried out as part of the detailed design.

3.5 Stage 4: Appraisal of Options



Relevant Extract from Option Appraisal Flow Chart

The purpose of this Stage 4 is twofold:

- Develop each option and to consider its viability and applicability to site;
- Gain local knowledge that may influence the local weightings.

Stage 4.1 provides details of each option considered, including a breakdown of the measures included in the options and specification of any of the structural measures where appropriate.

Modelling of the option, if required, is also carried out at this stage to ascertain if the option is viable technically and gain an understanding of the impacts on the upstream or downstream water levels.

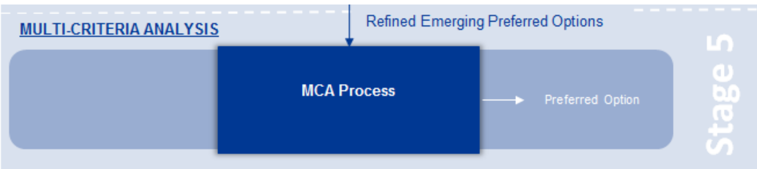
Table 3.9: Option Appraisal Report – Stage 4.1

<table>
<tr><th colspan="6">4. STAGE 4: Appraisal of Options</th></tr>
<tr><td colspan="6">4.1 Options Appraisal
Each option taken forward for Multi-Criteria Assessment (MCA) analysis is to be discussed at the Option Development Meeting. Below describes this concept design of each option and provides a summary of any significant comments/issues which were raised by LA staff at the Options Development Meetings. These comments will be considered in the local weightings and the MCA scores.</td></tr>
<tr><td colspan="2">Option Ref:</td><td colspan="4">LIL_01</td></tr>
<tr><td rowspan="3">Option Measures</td><td>Baseline</td><td>B</td><td colspan="3">Existing Regime</td></tr>
<tr><td>Structural</td><td>Gii</td><td colspan="3">Flood Defences: Raise Existing Flood Defences</td></tr>
<tr><td>Non Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="4">This option will provide a 1% Fluvial AEP Design standard to 143 of 160 properties within the AFA and reduce the impact of flood risk to the remaining 17 properties, identified as being at risk, and includes;
• Increase the height of existing embankments and locally raise the road in between the defences, to eliminate flood risk to the properties within flood cell LIL_A for the 1% AEP event.
• Individual flood resilience measures for the racecourse buildings in LIL_B and Kerry County Council stores and yard in LIL_C.
• Existing maintenance regime for the Feale along with a maintenance programme for the improved and existing defences.</td></tr>
<tr><td colspan="2" rowspan="2">Option Development Meeting:</td><td>Date:</td><td colspan="3">10th of June 2015</td></tr>
<tr><td>Summary:</td><td colspan="3">The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.</td></tr>
</table>

Detailed costing of the option is carried out at this stage using the unit cost database spreadsheets (version 1.1) created for the CFRAM project. This database provides unit costs for common method of flood risk management, for a range of conditions and scales. The whole life present value costs (PVc) is determined from the sum of the Present value costs over the project horizon of 50 years, with the future costs discounted by 4%. The Construction Price Index (CPI) is set at 0.987 for each option, as recommended in the CFRAM Unit Cost Development Project Final Report. This report has been included in Appendix H.

The whole life present value costs (PVc) are subject to sensitivity tests using higher and lower discount rates, 5% and 3% respectively. These are presented in Appendix M of this report.

3.6 Stage 5: Multi Criteria Assessment



Relevant Extract from Option Appraisal Flow Chart

Stage 5: Multi Criteria Assessment

The purpose of this Stage 5 is threefold:

- Obtain MCA and economic scores for each viable option;
- Provide a comparison of the options using the MCA and economic scores;
- Make a recommendation of the preferred option.

To achieve these objectives, Stage 5 has been divided into three sub-stages, which are summarised in Table 3.10.

Table 3.10: Summary of Sub-stages for Stage 5

Ref	Title
5.1	Options selected for the Multi Criteria Assessment
5.2	Comparison of Multi Criteria Assessment Scores
5.3	Recommendation of Preferred Option

The MCA scores the performance of each option in managing flood risk relative to the baseline under the 4 objectives:

- Technical;
- Economic;
- Social and
- Environmental.

Each objective has been weighted, globally and locally to reflect the objectives importance and to ensure that those objectives most relevant to the SSA were given priority in the decision making process.

Appendix F provides an outlines of the scoring system under the each objective. It also provides details of the global and local weightings applied to each score. The global weights are always set and are consistent with the other CFRAM studies. Some local weighting are set and constant whiles others are calculated or based on engineering judgement, this is outlined in further detail in Appendix F.

As outlined in Table 3.11, the Option Appraisal Report records the information and decisions from 3 sub-stages; the following sections describe each of the sub-stages individually.

3.6.1 Stage 5.1 Options selected for the Multi Criteria Assessment

This stage provides an overview of the options considered for MCA and provides specification details of the structural measures.

The outcome of the MCA includes:

- Criteria Scores for each objective
- Economic Scores
- MCA Scores

A brief outline for these scores is given in Table 3.11. Stage 5.1 of the Option Appraisal Report these scores are provided for each option.

Table 3.11 MCA and Economic Analysis outcome

		Ref
Criteria Score		
Technical	Sum of the Technical Sub Objectives Score Range (-299700 – 1500)	GN 28 App F
Economic	Sum of the Economic Sub Objectives Score Range (-299700 – 1500)	GN 28 App F
Social	Sum of the Social Sub Objectives Score Range (-299700 – 1500)	GN 28 App F
Environmental	Sum of the Environmental Sub Objectives Score Range (-299700– 1500)	GN 28 App F
Economic Score		
PV Cost	Present Value cost (PVc) of the option including ongoing maintenance and optimism bias.	GN 27 App D
Economic PV Benefits	The economic PV Benefits (PVb) are the reduction in the economic damages the option will provide.	GN 27 App D
Economic BCR	The capped PVb, divided by the PVc.	GN 27 App D
Net Present Value of Benefits	The capped PVb less the PVc.	GN 27 App D
MCA Scores		
MCA PV Benefits	The economic MCA PV Benefits are the reduction in the MCA economic damages the option will provide. These values are capped. For more detail refer to section in GN.	GN 27 App D
MCA Benefit Score	The sum of the economic, social, and environmental criteria scores. Range (-899100 to 4500)	GN 28
MCA BCR	The MCA Benefit Score per €1,000,000 PV Cost.	GN 28
Option Selection MCA	The sum of the technical, economic, social, and environmental criteria scores. Range (-1198800 to 6000)	GN 28

3.6.2 Stage 5.2 Comparison of Multi Criteria Assessment Scores

Stage 5.2 of the Option Appraisal Report provides a comparison of the option scores.

Table 3.12 provides a relevant extract from the Option Appraisal Report, for a worked example

Table 3.12: Option Appraisal Report – Stage 5.2

5.2 Comparison of Multi Criteria Assessment Scores Each option taken forward for further consideration through the Option Development Meeting has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).		
Categories	**Option Reference and Results**	
	LIL_01	LIL_02
Criteria Scores		
Technical	567	540
Economic	730	787
Social	728	772
Environmental	16	16
Economic Values		
Economic PV Benefits	€ 8,369,315	€ 8,369,315
PV Cost	€ 1,259,812	€ 1,212,109
NPV Benefits	€ 7,109,503	€ 7,157,206
Economic BCR	6.64	6.90
Outcome Scores		
MCA PV Benefits	€ 4,732,943	€ 4,732,943
MCA Benefit Score	1473	1575
MCA BCR	1169.36	1299.71
Option Selection MCA	2040	2115

3.6.3 Stage 5.3 Recommendation of the Preferred Option

The MCA scores provided by the MCA assessment are used to guide the decision making process for the preferred option. The MCA BCR has been given the greatest weight in determining the preferred option. The MCA BCR provides a measure of the overall benefits per euro investment.

Whilst the MCA BCR carries the greatest weight, and in general the preferred option is the option with the highest MCA BCR score, other factors are also taken into account. This is particularly the case when MCA BCR scores are similar, but a comparison of other scores shows a significant difference, for example, a lower capital cost or a higher technical score. These differences are difficult to predict and hence, if the preferred option is selected on criteria other than the MCA BCR score, a clear justification for the recommendation of the preferred option is provided.

4 Option Appraisal Results

Section 4 outlines how the five-stage option appraisal process has been applied in the Spatial Scales of Assessment (SSAs) within UoM 23. UoM 23 comprises the following 3no. SSAs, which are outlined in Table 4.1:

- Unit of Management (UoM);
- Sub-catchment; and
- Areas for Further Assessment (AFA).

Table 4.1 SSAs for UoM23.

Spatial Scale			
UoM	**Sub-catchment**	**AFA**	
UoM 23	Feale	Listowel	AFA
		Abbeyfeale	AFA
		Athea	AFA
		Abbeydorney	AFA
		Moneycashen	AFA
	Tyshe	Banna	AFA
	Lee	Tralee	AFA

As outlined in Section 3.3, for the UoM and sub-catchment SSAs, FRM measures which provide benefits to multiple AFAs/IRRs are only considered. Therefore, certain measures such as “relocation of properties” which are impractical to implement at this scale, are not considered at the UoM and sub-catchment SSAs.

FRM measures providing benefits to multiple AFAs/IRRs are considered at the sub-catchment SSA while, FRM measures providing benefits to multiple sub-catchments are considered at the UoM SSA.

Table 3.5 outlines the list of the FRM measures considered for this study and the spatial scale for which they are applicable, categorised into Baseline, Structural, and Non-Structural measures. Appendix B provides a definition for each of the FRM measures and reasoning for their categorisation.

The 1% AEP fluvial event and the 0.5% AEP tidal event are the preferred design standards for the development of the FRM options. However, other design standards have been considered where there is a clear technical, economic, social or environmental case as to why the preferred standards would not be appropriate.

4.1 Option Appraisal Results SSA: UoM 23

As outlined in Section 3.1 the option appraisal methodology is a multi-staged process. Stage 1, summary of the current flood risk for UoM 23, Stage 2, screening of the measures for UoM 23 and Stage 3: Development of Options for UoM 23 are outlined in Sections 4.2.1 to 4.2.3 below.

At the UoM SSA there are no FRM structural measures viable for UoM 23. Although there are viable non-structural FRM measures for UoM 23 at this SSA, Stage 4: Appraisal of Options for UoM 23 and Stage 5: Multi-Criteria Assessment has not been carried out as monetary or measurable benefits cannot be determined for such non-structural FRM measures at this SSA.

4.1.1 Stage 1: Summary of Current Flood Risk

The purpose of Stage 1 is to determine the significance of the flood risk within the UoM 23 and summarise the potential economic damage and the impacts to the key receptors. Stage 1 comprises 8 sub stages;

Stage 1.1: Sub-Catchment and Watercourse Details
Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal & AEP Event Sub-Catchments and Watercourses Details
Stage 1.3: Summary of Existing Flood Risk Management Measures Sub-Catchment and Watercourse Details
Stage 1.4: Summary of PV damages
Stage 1.5: Summary of Social Receptors at Risk of Flooding
Stage 1.6: Summary of Environmental Receptors at Risk of Flooding
Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding
Stage 1.8: Summary of Economic Receptors at Risk of Flooding

Tables 4.2 to 4.9 below outline the results of sub-stages 1.1 to 1.8 for UoM 23. All studied areas within the UoM but outside the AFAs/ IRRs are referred to as areas of potential moderate risk (APMRs). Details of the flood risk to the APMRs are provided at sub-catchment SSA along with summary details of flood risk within the AFAs. For further details of flood risk within each AFA, refer to the relevant Appendix C.

Table 4.2 Stage 1.1: Sub-Catchment and Watercourse Details

1. STAGE 1: Summary of Current Flood Risk	
1.1 UoM and Watercourses Details	
Unit of Management:	23
AFAs within UoM	Abbeydorney, Abbeyfeale, Athea, Banna, Listowel, Moneycashen, Tralee
Primary Watercourse(s):	River Allaghaun, River Ballybroman, River Big, River Boherroe, River Brick, River Chasen, River Feale, River Galey, River Lee, River Oolagh

Table 4.3 Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details

Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details					
	Sub-Catchments	**Event Type**	**Res**	**Non-Res**	**Total**
Properties at risk:	**APMR_Feale**	**Fluvial**	98	11	109
		Coastal	22	0	22
		Combined	169	36	205
	APMR_Tyshe	**Fluvial**	0	0	0
		Coastal	2	0	2
		Combined	0	0	0
	APMR_Lee	**Fluvial**	1	1	2
		Coastal	2	0	2
		Combined	2	1	3
	Within AFAs	**Fluvial**	713	371	1,084
		Coastal	124	13	137
		Combined	437	247	684
	Total for UoM	**Fluvial**	812	383	1,195
		Coastal	150	13	163
		Combined	608	284	892
Relevant Comments:	For AFA level breakdown see specific AFA reports.				

Table 4.4 Stage 1.3: Summary of Existing Flood Risk Management Measures

1.2 Summary of Existing Flood Risk Management Measures					
Arterial Drainage	**Storage**	**Flow Diversion**	**Flood Defences**	**Level Control**	**Other**
Yes	None	None	**Yes**	None	**Yes**
Relevant Comments	Other Measures is located in Banna and includes the routine works carried out to clear the outfall at Blackrock with the River Tyshe discharges to the Atlantic. Refer to the relevant Appendix C for more details.				

Table 4.5 Stage 1.4: Summary of PV damages

Stage 1.4: Summary of PV Damages

Fluvial and coastal damages calculated based on flood depths for all return periods up to the 0.1% AEP. Combined damages are a sum of the fluvial and coastal capped at value of the property.

Total PV Damages		Event Type	Capped Res	Capped Non-Res	Capped Total	Uncapped Res	Uncapped Non-Res	Uncapped Total
	APMR_Feale	Fluvial	€ 14,623,086	€ 1,525,386	€ 16,148,472	€ 34,430,582	€ 4,288,016	€ 38,718,598
		Coastal	€ 1,222,212	€ 1,607	€ 1,223,819	€ 2,562,743	€ 1,607	€ 2,564,350
		Combined	€ 15,036,204	€ 1,526,986	€ 16,563,190	€ 36,993,325	€ 4,289,623	€41,282,948
	APMR_Tyshe	Fluvial	€0	€ 0	€ 0	€ 0	€ 0	€0
		Coastal	€ 207,777	€ 0	€ 207,777	€ 207,777	€ 0	€ 207,777
		Combined	€ 207,777	€ 0	€ 207,777	€ 207,777	€ 0	€ 207,777
	APMR_Lee	Fluvial	€ 23,136	€ 96,667	€ 119,803	€ 27,227	€ 96,667	€ 123,894
		Coastal	€ 320,733	€ 0	€ 320,733	€ 600,002	€ 0	€ 600,002
		Combined	€ 417,913	€ 96,667	€ 514,580	€ 697,182	€ 96,667	€ 793,849
	Within AFAs	Fluvial	€ 24,889,682	€ 28,566,958	€ 53,456,640	€ 26,569,467	€ 34,711,440	€ 61,280,907
		Coastal	€ 3,961,692	€ 2,193,144	€ 6,155,288	€ 4,200,188	€ 2,928,851	€ 7,129,039
		Combined	€ 27,978,404	€ 28,671,627	€ 56,650,031	€ 29,926,715	€ 34,891,244	€ 64,817,959
	Total for UoM	Fluvial	€ 39,535,904	€ 30,189,011	€ 69,724,915	€ 61,027,276	€ 39,096,123	€ 100,123,399
		Coastal	€ 5,712,414	€ 2,194,751	€ 7,907,617	€ 7,570,710	€ 2,930,458	€ 10,501,168
		Combined	€ 43,640,298	€ 30,503,057	€ 73,935,578	€ 67,824,999	€ 39,277,534	€ 107,102,533

Table 4.6 Stage 1.5: Summary of Social Receptors at Risk of Flooding

Stage 1.5: Summary of Social Receptors at Risk of Flooding			
High Vulnerability Properties at risk :		**Type**	**Number**
	APMR_Feale	School	2
	APMR_Tyshe	N/A	0
	APMR_Lee	Nursing Home	1
	Within AFAs	School	2
		Hospital	1
		Nursing Home	1
	Total for UoM	School	4
		Hospital	1
		Nursing Home	2
Social Infrastructure Assets:		**Type**	**Number**
	APMR_Feale	N/A	None
	APMR_Tyshe	N/A	None
	APMR_Lee	N/A	None
	Within AFAs	Church	1
		Garda Station	1
		National Ambulance Station	1
		OPW Building Directory	3
	Total for UoM	Church	1
		Garda Station	1
		National Ambulance Station	1
		OPW Building Directory	3
Social Amenity Sites:		**Type**	**Number**
	APMR_Feale	N/A	0
	APMR_Tyshe	N/A	0
	APMR_Lee	N/A	0
	Within AFAs	N/A	0
	Total for UoM	N/A	0
Relevant Comments:	For AFA level breakdown see specific AFA reports.		

Table 4.7 Stage 1.6: Summary of Environmental Receptors at Risk of Flooding

Stage 1.6: Summary of Environmental Receptors at Risk of Flooding			
Risk to WFD Annex IV :		**Type**	**Number**
	APMR_Feale	WFD Drinking Water	2
	APMR_Tyshe	N/A	0
	APMR_Lee	N/A	0
	Within AFAs	Licenced IPPC Facility	1
		WFD Drinking Water	4
	Total for UoM	Licenced IPPC Facility	1
		WFD Drinking Water	6
Risk to cSACs,SPA's & SAC's :		**Type**	**Number**
	APMR_Feale	N/A	0
	APMR_Tyshe	SPA	1
	APMR_Lee	N/A	0
	Within AFAs	SPA	2
	Total for UoM	SPA	3
Relevant Comments:	For AFA level breakdown see specific AFA reports.		

Table 4.8 Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding

Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding			
Risk to Sites of Cultural Heritage:		**Type**	**Number**
	APMR_Feale	NIAH	2
		Recorded Monuments	24
	APMR_Tyshe	Proposed Natural Heritage Area	1
	APMR_Lee	Recorded Monuments	3
	Within AFAs	NIAH	115
		Recorded Monuments	14
		Proposed Natural Heritage Area	2
	Total for UoM	NIAH	117
		Recorded Monuments	41
		Proposed Natural Heritage Area	3
Relevant Comments:	For AFA level breakdown see specific AFA reports.		

Table 4.9 Stage 1.8: Summary of Economic Receptors at Risk of Flooding

Stage 1.8: Summary of Economic Receptors at Risk of Flooding			
Risk to Transport Infrastructure:		**Type**	**Number**
	APMR_Feale	Regional Road	16
		Local Road	57
	APMR_Tyshe	Regional Road	0
		Local Road	3
	APMR_Lee	Regional Road	0
		Local Road	1
	Within AFAs	National Road	1
		Regional Road	26
		Local Road	22
		Railway	1
	Total for UoM	National Road	1
		Regional Road	42
		Local Road	83
		Railway	1

		Type	Number
Risk to Utility Infrastructure:	**APMR_Feale**	Infrastructure	1
		Water Treatment Plants	1
	APMR_Tyshe	N/A	0
	APMR_Lee	N/A	0
	Within AFAs	Infrastructure	2
		Water Treatment Plants	1
	Total for UoM	Infrastructure	3
		Water Treatment Plants	2
Relevant Comments:	For AFA level breakdown see specific AFA reports.		

4.1.2 Stage 2: Screening of Measures UoM 23

The purpose of Stage 2 is to determine the viability of FRM measures for UoM 24 and to provide robust, transparent reasoning for those measures identified as unviable. The is achieved through 3 sub-stages;

Stage 2.1: Screening of the Measures Viability Assessment

Stage 2.2: Justification for Screened Out Baseline and Structural Measures

Stage 2.3: Summary of 'Screened In' Measures

Tables 4.10 to 4.12 below outline the results for each of these sub-stages.

Table 4.10 Stage 2.1: Screening of the Measures Viability Assessment

2. STAGE 2: Screening of the Measures							
2.1 Baseline, Structural and Non-Structural Measures Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.							
Measures		**Appl.**	**Econ.**	**Envir.**	**Soc.**	**Cult.**	**Overall Viability**
Baseline							
A	Do Nothing	Not considered at this SSA refer to Table 3.5					
B	Existing Regime	Not considered at this SSA refer to Table 3.5					
C	Do Minimum	Not considered at this SSA refer to Table 3.5					
Structural							
D	Storage	Unviable	N/A	N/A	N/A	N/A	**Screened Out**
E	Flow Diversion	Unviable	N/A	N/A	N/A	N/A	**Screened Out**
F	Increase Conveyance	Unviable	N/A	N/A	N/A	N/A	**Screened Out**
G	Flood Defences	Unviable	N/A	N/A	N/A	N/A	**Screened Out**
H	Relocation of Properties	Not considered at this SSA refer to Table 3.5					
I	Other Measures	Unviable	N/A	N/A	N/A	N/A	**Screened Out**

Non-Structural							
J	Flood Forecasting / Warning / Response	Unviable	N/A	N/A	N/A	N/A	**Screened Out**
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	**Screened In**
L	Individual property resistance	Not considered at this SSA refer to Table 3.5					
M	Individual property resilience	Not considered at this SSA refer to Table 3.5					
N	Planning and development control measures	Viable	Viable	Viable	Viable	Viable	**Screened In**
O	Building Regulations	Viable	Viable	Viable	Viable	Viable	**Screened In**
P	Sustainable Urban Drainage Systems	Not considered at this SSA refer to Table 3.5					
Q	Land use Management	Viable	Viable	Viable	Viable	Viable	**Screened In**
R	Strategic development management	Viable	Viable	Viable	Viable	Viable	**Screened In**
S	Additional Monitoring (rain and river level/flow gauges)	Viable	Viable	Viable	Viable	Viable	**Screened In**

Table 4.11 Stage 2.2: Justification for Screened Out Baseline and Structural Measures

Stage 2.2 Justification for Screened Out Baseline and Structural Measures			
The following provides justification on Measures with an overall viability 'Screened Out' categorisation. At this SSA, only measures that will reduce flood risk to multiple sub-catchments within the UoM are considered viable.			
D	Storage	Applicability Economic Environmental Social Cultural	At this SSA, only methods that can provide benefits to multiple sub-catchments within the UoMs should be considered. The sub-catchments within UoM23 are not hydraulically connected, therefore, the storage FRM method will not provide benefits to more than one sub-catchments.
E	Flow Diversion	Applicability Economic Environmental Social Cultural	At this SSA, only methods that can provide benefits to multiple sub-catchments within the UoMs should be considered. The sub-catchments within UoM24 are not hydraulically connected, therefore, the flow diversion FRM method will not provide benefits to more than one sub-catchments.
F	Increase Conveyance	Applicability Economic Environmental Social Cultural	At this SSA, only methods that can provide benefits to multiple sub-catchments within the UoMs should be considered. The sub-catchments within UoM23 are not hydraulically connected, therefore, the increase conveyance FRM method will not provide benefits to more than one sub-catchments.
G	Flood Defences	Applicability Economic Environmental Social Cultural	At this SSA, only methods that can provide benefits to multiple sub-catchments within the UoMs should be considered. The sub-catchments within UoM23 are not hydraulically connected,

			therefore, the flood defences FRM method will not provide benefits to more than one sub-catchments.
I	Other Measures	Applicability Economic Environmental Social Cultural	There were no other measures considered which would have benefits to all AFAs within the UoM.

Table 4.12 Stage 2.3: Summary of 'Screened In' Measures

Stage 2.3 Summary of 'Screened In' Measures			
The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.			
Non - Structural Measures			
J	Flood Forecasting / Warning / Response	N	Planning and development control measures
K	Public Awareness	O	Building Regulations
R	Strategic development management	S	Additional Monitoring (rain and river level/flow gauges)

4.1.3 Stage 3: Development of Options for UoM 23

The purpose of Stage 3 is to develop FRM options from the 'Screened In Measures'

As there were no viable structural measures for UoM 23 therefore this stage focuses on the development of the Non-Structural FRM measures into options, which is outlined in Table 4.13 below.

Table 4.13 Stage 3: Development of FRM measures to Options

Stage 3: Development of FRM measures to Options		
FRM Measure		Descriptions
J	Flood Forecasting / Warning / Response	A forecasting system combining rain gauge and water levels data could potentially be used to give warning of potential flood events for the UoM. Tidal flood forecasting systems could also be used to provide warning of any coastal flood risk to the areas at risk of flooding from tidal sources. More information about flood forecasting at an AFA level is available in the AFA Option Appraisal Reports in Appendix C
K	Public Awareness	Regional public awareness campaigns should be considered to provide information to the public of potential measures and actions local residents, business owners and landowners could take to reduce flood risk to their properties and allow them to prepare themselves, their properties, businesses, and land. However, awareness campaigns are better targeted at AFA level, rather than at UoM (or sub-catchment) SSAs.

N	Planning and development control measures	Considered in the Spatial Planning & Impacts to the Development report.
O	Building Regulations	Building Regulations could be applied in the construction of properties in areas of low or residual flood risk, to limit the damage to the properties in a flood event. These regulations would focus on the use of suitable materials and construction details. Guidelines on constructing in areas of flood risk are provided in the "Improving the Flood Performance of New Buildings" by the Department for Communities and Local Government, UK. Use of these measures would ensure the buildings are either flood resistant or flood resilient.
Q	Land use Management	Considered in separate report on SUDs and Land Use Management
R	Strategic development management	The proper application of the Guidelines on the Planning System and Flood Risk Management 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. Flood Zones Mapping for the MRFS future scenarios are provided as part of the FRMP and will facilitate the application of the Guidelines.
S	Additional Monitoring (rain and river level/flow gauges)	Across UoM 23, there is a varying degree of certainty on the flood risk assessment, due to the distribution of the catchment gauging stations. It is therefore a recommendation from this Study that additional gauging stations should be considered along watercourses where there is historical evidence of flood risk or properties are identified as being at risk in the 1% fluvial AEP event. Figures 4.1 and table 4.14 identify indicative locations where gauging stations are recommended. These include several locations across the UoM (and in this regard this is a UoM measure), one of which would also have a benefit at a sub-catchment level. It is important to note however that the primary benefit of each gauging station will be for the AFA in which it is located

Recommendations for all the above "Screened In" measures will be made in the Flood Risk Management Plan (FRMP).

As previously noted Stage 4: Appraisal of Options for UoM 23 and Stage 5: Multi-Criteria Assessment has not been carried out, as monetary or measurable benefits

cannot be determined for any of the ‘Screened In’ FRM non-structural measures at this SSA.

Table 5.14 Location of Recommended Gauging Stations

ID	Easting	Northing
GS01	112482	135215
GS02	111767	127337
GS03	85093	122557
GS04	856450	114336
GS05	841101	116380
GS06	760451	122155
GS09	876333	113059
GS07	833601	112301
GS08	846331	112451

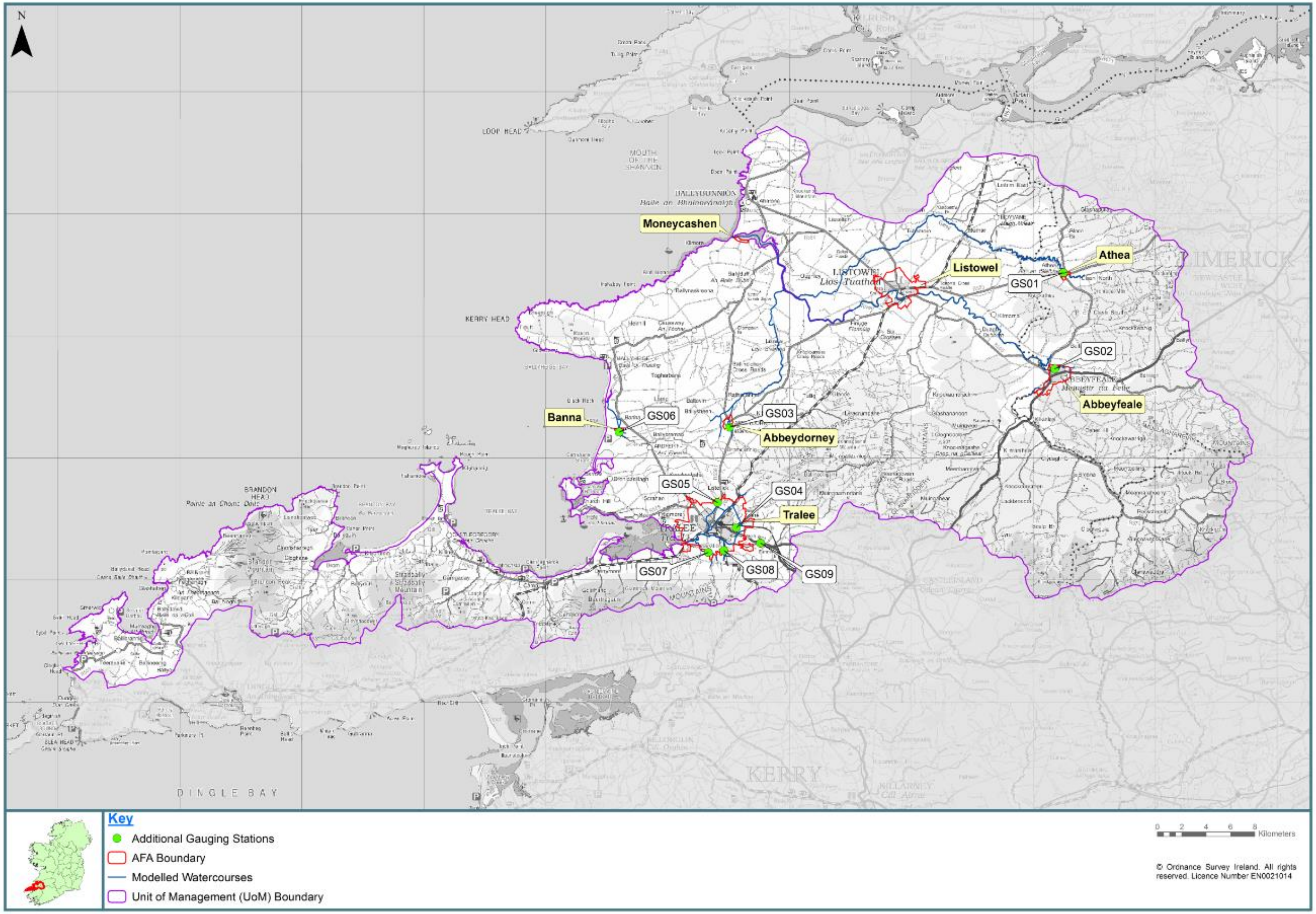


Figure 4.3 –Location of Recommended Gauging Stations

4.2 Option Appraisal Results SSA: Sub-Catchment

As outlined in Section 2.1, UoM 23 comprises 3 sub-catchments. The 3 sub-catchments represent key hydrological / hydraulic breakpoints within UoM 23 and naturally lend themselves to being split into these sub-catchments for the purposes of assessing FRM options.

The multi-stage option appraisal process, as outlined in Section 3.1, has been applied to each sub-catchment;

- Feale;
- Tyshe; and
- Lee

4.2.1 Feale Sub-Catchment

Tables 4.15 to 4.22 below outline the results of sub-stages 1.1 to 1.8 for the Feale Sub-catchment;

4.2.1.1 Stage 1: Summary of Current Flood Risk for the Feale Sub-Catchment

Table 4.15 Stage 1.1: Sub-Catchment and Watercourse Details

Stage 1.1: AFA and Watercourse Details	
Sub-catchment	Feale
AFAs	Listowel, Abbeyfeale, Athea, Abbeydorney, Moneycashen
Major Watercourses within the AFA:	River Cashen, River Feale, River Galey, River Brick

Table 4.16 Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details

Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details					
Properties at risk:		**Event Type**	**Res**	**Non-Res**	**Total**
	APMR_Feale	**Fluvial**	98	11	109
		Coastal	22	0	22
		Combined	169	36	205
	Within AFAs	**Fluvial**	160	33	193
		Coastal	5	0	5
		Combined	5	0	5
	Total for Sub-catchment	**Fluvial**	258	44	302
		Coastal	27	0	27
		Combined	174	36	210

Relevant Comments:	For AFA level breakdown see specific AFA reports.

Table 4.17 Stage 1.3: Summary of Existing Flood Risk Management Measures

Stage 1.3: Summary of Existing Flood Risk Management Measures					
Arterial Drainage	**Storage**	**Flow Diversion**	**Flood Defences**	**Level Control**	**Other**
Yes	None	None	**Yes**	None	None

Table 4.18 Stage 1.4: Summary of PV damages

Stage 1.4: Summary of PV Damages

Fluvial and coastal damages calculated based on flood depths for all return periods up to the 0.1% AEP. Combined damages are a sum of the fluvial and coastal capped at value of the property.

Total PV Damages		Event Type	Capped Residential	Capped Non-Res	Capped Total	Uncapped Residential	Uncapped Non-Res	Uncapped Total
	APMR_Feale	Fluvial	€ 14,623,086	€1,525,386	€16,148,472	€34,430,582	€4,288,016	€38,718,598
		Coastal	€ 1,222,212	€1,607	€1,223,819	€2,562,743	€1,607	€2,564,350
		Combined	€15,036,204	€1,526,986	€16,563,190	€36,993,325	€4,289,623	€41,282,948
	Within AFAs	Fluvial	€ 9,802,087	€ 3,666,693	€ 13,468,780	€ 9,976,468	€ 4,771,997	€ 14,748,465
		Coastal	€ 678,899	€ 0	€ 678,899	€ 686,095	€ 0	€ 686,095
		Combined	€ 10,467,470	€ 3,666,693	€ 14,134,163	€ 10,662,563	€ 4,771,997	€ 15,434,560
	Total for Sub-catchment	Fluvial	€ 24,425,173	€ 5,192,079	€ 29,617,252	€ 44,407,050	€ 9,060,013	€ 53,467,063
		Coastal	€ 1,901,111	€ 1,607	€ 1,902,718	€ 3,248,838	€ 1,607	€ 3,250,445
		Combined	€ 25,503,674	€ 5,193,679	€ 30,697,353	€ 47,655,888	€ 9,061,620	€ 56,717,508
Relevant Comments:	For AFA level breakdown see specific AFA reports.							

Table 4.19 Stage 1.5: Summary of Social Receptors at Risk of Flooding

Stage 1.5: Summary of Social Receptors at Risk of Flooding			
High Vulnerability Properties at risk :		**Type**	**Number**
	APMR_Feale	School	2
	Within AFAs	School	1
	Total for Sub-catchment	School	3
Social Infrastructure Assets:		**Type**	**Number**
	APMR_Feale	N/A	None
	Within AFAs	Racecourse	1
	Total for Sub-catchment	Racecourse	1
Social Amenity Sites:		**Type**	**Number**
	APMR_Feale	N/A	0
	Within AFAs	Community Centre	3
		Walkway	1
		Sports Facility	2
	Total for Sub-catchment	Community Centre	3
		Walkway	1
		Sports Facility	2
Relevant Comments:	For AFA level breakdown see specific AFA reports.		

Table 4.20 Stage 1.6: Summary of Environmental Receptors at Risk of Flooding

Stage 1.6: Summary of Environmental Receptors at Risk of Flooding			
Risk to WFD Annex IV :		**Type**	**Number**
	APMR_Feale	WFD Drinking Water	2
	Within AFAs	WFD Drinking Water	1
	Total for Sub-catchment	WFD Drinking Water	3
Risk to cSACs,SPA's & SAC's :		**Type**	**Number**
	APMR_Feale	N/A	0
	Within AFAs	cSAC	3
	Total for Sub-catchment	cSAC	3
Relevant Comments:	For AFA level breakdown see specific AFA reports.		

Table 4.21 Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding

Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding			
Risk to Sites of Cultural Heritage:		**Type**	**Number**
	APMR_Feale	NIAH	2
		Recorded Monuments	24
	Within AFAs	NIAH	6
	Total for Sub-catchment	NIAH	8
		Recorded Monuments	24
Relevant Comments:	For AFA level breakdown see specific AFA reports.		

Table 4.22 Stage 1.8: Summary of Economic Receptors at Risk of Flooding

Stage 1.8: Summary of Economic Receptors at Risk of Flooding			
Risk to Transport Infrastructure:		**Type**	**Number**
	APMR_Feale	Regional Road	16
		Local Road	57
	Within AFAs	National Road	1
		Regional Road	7
		Local Road	8
	Total for Sub-catchment	National Road	1
		Regional Road	23
		Local Road	65
Risk to Utility Infrastructure:		**Type**	**Number**
	APMR_Feale	Infrastructure	1
		Water Treatment Plant	1
	Within AFAs	Infrastructure	1
		Pumping Station	1
	Total for Sub-catchment	Infrastructure	2
		Water Treatment Plant	1
		Pumping Station	1
Relevant Comments:			

4.2.1.2 Stage 2: Screening of the Measures for Feale Sub-catchment

The purpose of Stage 2 is to determine the viability of FRM measures for this sub-catchment and to provide robust, transparent reasoning for those measures identified as unviable. The is achieved through 3 sub-stages;

Stage 2.1: Screening of the Measures Viability Assessment

Stage 2.2: Justification for Screened Out Baseline and Structural Measures

Stage 2.3: Summary of 'Screened In' Measures

Tables 4.23 to 4.25 below outline the results for each of these sub-stages.

Table 4.23 Stage 2.1: Screening of the Measures Viability Assessment

STAGE 2.1 Screening of the Measures Viability Assessment							
Baseline, Structural and Non-Structural Measures Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.							
Measures		**Appl.**	**Econ.**	**Envir.**	**Soc.**	**Cult.**	**Overall Viability**
Structural							
D	Storage	Unviable	Not Assessed	Not Assessed	Viable	Viable	**Screened Out**
E	Flow Diversion	Unviable	Not Assessed	Not Assessed	Viable	Viable	**Screened Out**
F	Increase Conveyance	Unviable	Not Assessed	Not Assessed	Viable	Viable	**Screened Out**
G	Flood Defences	Unviable	Not Assessed	Not Assessed	Viable	Viable	**Screened Out**
I	Other Measures	Unviable	Not Assessed	Not Assessed	Not Assessed	Not Assessed	**Screened Out**
Non-Structural							
J	Flood Forecasting / Warning / Response	Viable	Not Assessed	Viable	Viable	Viable	**Screened In**
K	Public Awareness	Viable	Not Assessed	Viable	Viable	Viable	**Screened In**

Table 4.24 Stage 2.2: Justification for Screened Out Baseline and Structural Measures

Stage 2.2 Justification for Screened Out Baseline and Structural Measures			
The following provides justification on Measures with an overall viability 'Screened Out' categorisation. At this SSA, only measures that will reduce flood risk multiple AFAs within the sub-catchment and other areas are considered viable.			
D	Storage	Applicability Economic Environmental Social Cultural	At this SSA, only methods that can provide benefits to multiple AFAs within the sub-catchment and other areas are considered. For each AFA within the sub-catchment storage has been found unviable and no offline storage area was identified that could provide protection to more than one AFA. Therefore, the storage FRM method will not provide benefits to multiple AFA's within the sub-catchment.

E	Flow Diversion	Applicability Economic Environmental Social Cultural	At this SSA, only methods that can provide benefits to multiple AFAs within the sub - catchment and other areas are considered. No suitable flow diversion route was found that would provide benefits to multiple AFA's within the sub-catchment.
F	Increase Conveyance	Applicability Economic Environmental Social Cultural	At this SSA, only methods that can provide benefits to multiple AFAs within the sub - catchment and other areas are considered. Increasing conveyance by means of removing a structure or localised dredging will not influence the flood extents of any other AFA. Therefore, the increase conveyance FRM method will not provide benefits to all AFA's within the sub-catchment.
G	Flood Defences	Applicability Economic Environmental Social Cultural	At this SSA, only methods that can provide benefits to multiple AFAs within the sub - catchment and other areas are considered. Flood Defences will not influence the flood extents of any other AFA. Therefore, the increase conveyance FRM method will not provide benefits to all AFA's within the sub-catchment.
I	Other Measures	Applicability Economic Environmental Social Cultural	No other measures were considered for UoM 23

Table 4.25 Stage 2.3: Summary of 'Screened In' Measures

Stage 2.3 Summary of 'Screened In' Measures	
The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.	
Non-Structural Measures	
J	Flood Forecasting / Warning / Response
K	Public Awareness

Non – structural measures such as; flood forecasting and public awareness have been considered for the sub-catchment and are addressed in the UoM spatial scale.

Recommendations for all the above "Screened In" measures will be made in the Flood Risk Management Plan (FRMP).

Stage 4: Appraisal of Options for the Feale sub-catchment and Stage 5: Multi-Criteria Assessment has not been carried out, as monetary or measurable benefits cannot be determined for any of the 'Screened In' FRM non-structural measures at this SSA.

4.2.2 Tyshe Sub-catchment

Tables 4.26 to 4.33 below outline the results of sub-stages 1.1 to 1.8 for the Tyshe Sub-catchment.

4.2.2.1 Stage 1: Summary of Current Flood Risk for Tyshe Sub-catchment

Table 4.26 Stage 1.1: AFA and Watercourse Details

Stage 1.1 AFA and Watercourse Details	
Sub-catchment	Tyshe
AFAs	Banna
Major Watercourses within the AFA:	River Tyshe

Table 4.27 Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details

Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details					
Properties at risk:		**Event Type**	**Res**	**Non-Res**	**Total**
	APMR_Tyshe	**Fluvial**	0	0	0
		Coastal	2	0	2
		Combined	0	0	0
	Within AFAs	**Fluvial**	19	0	19
		Coastal	18	0	18
		Combined	19	0	19
	Total for Sub-catchment	**Fluvial**	19	0	19
		Coastal	20	0	20
		Combined	19	0	19
Relevant Comments:	For AFA level breakdown see specific AFA reports.				

Table 4.28 Stage 1.3: Summary of Existing Flood Risk Management Measures

2.2 Summary of Existing Flood Risk Management Measures					
Arterial Drainage	**Storage**	**Flow Diversion**	**Flood Defences**	**Level Control**	**Other**
Yes	None	None	**Yes**	None	**Yes**
Relevant Comments	Other Measures is located in Banna and includes the routine works carried out to clear the outfall at Blackrock with the River Tyshe discharges to the Atlantic. Refer to the relevant Appendix C for more details				

Table 4.29 Stage 1.4: Summary of PV damages

Stage 1.4: Summary of PV Damages

Fluvial and coastal damages calculated based on flood depths for all return periods up to the 0.1% AEP. Combined damages are a sum of the fluvial and coastal capped at value of the property.

		Event Type	Capped Residential	Capped Non-Res	Capped Total	Uncapped Residential	Uncapped Non-Res	Uncapped Total
Total PV Damages	APMR_Tyshe	Fluvial	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
		Coastal	€ 207,777	€ 0	€ 207,777	€ 207,777	€ 0	€ 207,777
		Combined	€ 207,777	€ 0	€ 207,777	€ 207,777	€ 0	€ 207,777
	Within AFAs	Fluvial	€ 1,716,192	€ 0	€ 1,716,192	€ 1,720,700	€ 0	€ 1,720,700
		Coastal	€ 1,658,926	€ 0	€ 1,659,378	€ 1,658,926	€ 0	€ 1,658,926
		Combined	€ 2,674,804	€ 0	€ 2,674,804	€ 2,674,804	€ 0	€ 2,674,804
	Total for Sub-catchment	Fluvial	€ 1,716,192	€ 0	€ 1,716,192	€ 1,720,700	€ 0	€ 1,720,700
		Coastal	€ 1,866,703	€ 0	€ 1,867,155	€ 1,866,703	€ 0	€ 1,866,703
		Combined	€ 2,882,581	€ 0	€ 2,882,581	€ 2,882,581	€ 0	€ 2,882,581
Relevant Comments:	For AFA level breakdown see specific AFA reports.							

Table 4.30 Stage 1.5: Summary of Social Receptors at Risk of Flooding

Stage 1.5: Summary of Social Receptors at Risk of Flooding			
High Vulnerability Properties at risk :		**Type**	**Number**
	APMR_Tyshe	N/A	0
	Within AFAs	N/A	0
	Total for Sub-catchment	N/A	0
Social Infrastructure Assets:		**Type**	**Number**
	APMR_Tyshe	N/A	None
	Within AFAs	N/A	None
	Total for Sub-catchment	N/A	None
Social Amenity Sites:		**Type**	**Number**
	APMR_Tyshe	N/A	0
	Within AFAs	N/A	0
	Total for Sub-catchment	N/A	0
Relevant Comments:	For AFA level breakdown see specific AFA reports.		

Table 4.31 Stage 1.6: Summary of Environmental Receptors at Risk of Flooding

Stage 1.6: Summary of Environmental Receptors at Risk of Flooding			
Risk to WFD Annex IV :		**Type**	**Number**
	APMR_Tyshe	N/A	0
	Within AFAs	N/A	0
	Total for Sub-catchment	N/A	0
Risk to cSACs,SPA's & SAC's :		**Type**	**Number**
	APMR_Tyshe	SPA	1
	Within AFAs	SPA	1
		SAC	1
	Total for Sub-catchment	SPA	2
		SAC	1
Relevant Comments:	For AFA level breakdown see specific AFA reports.		

Table 4.32 Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding

Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding			
Risk to Sites of Cultural Heritage:		**Type**	**Number**
	APMR_Tyshe	Proposed Natural Heritage Area	1
	Within AFAs	N/A	0
	Total for Sub-catchment	Proposed Natural Heritage Area	1
Relevant Comments:	For AFA level breakdown see specific AFA reports.		

Table 4.33 Stage 1.8: Summary of Economic Receptors at Risk of Flooding

Stage 1.8: Summary of Economic Receptors at Risk of Flooding			
Risk to Transport Infrastructure:		**Type**	**Number**
	APMR_Tyshe	Local Road	3
	Within AFAs	N/A	0
	Total for Sub-catchment	Local Road	3
Risk to Utility Infrastructure:		**Type**	**Number**
	APMR_Tyshe	N/A	0
	Within AFAs	N/A	0
	Total for Sub-catchment	N/A	0
Relevant Comments:			

Conclusion:

As there is only one AFA within this sub catchment/coastal area there are no measures that will provide benefits to multiple AFA's therefore screening of the measures was not carried out. Non – structural measures such as; flood forecasting and public awareness have been considered for the sub-catchment and are addressed in the UoM spatial scale

4.2.3 Lee Sub-catchment

Tables 4.35 to 4.41 below outline the results of sub-stages 1.1 to 1.8 for the Tyshe Sub-catchment.

4.2.3.1 Stage 1: Summary of Current Flood Risk for Lee Sub-catchment

Table 4.34 Stage 1.1: Sub-catchment and Watercourse Details

Stage 1.1: AFA and Watercourse Details	
Sub-catchment	Lee
AFAs	Tralee
Major Watercourses within the AFA:	Lee (River), Big (River) Cloghers, Balyvelly, Hospital Tralee, Ballydunlea, Ratass, Tralee, Ballynabrennagh, Caherweesheen

Table 4.35 Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details

Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details					
Properties at risk:		**Event Type**	**Res**	**Non-Res**	**Total**
	APMR_Lee	**Fluvial**	1	1	2
		Coastal	2	0	2
		Combined	2	1	3
	Within AFAs	**Fluvial**	351	214	565
		Coastal	52	10	62
		Combined	403	224	627
	Total for Sub-catchment	**Fluvial**	352	215	567
		Coastal	54	10	64
		Combined	405	225	630
Relevant Comments:	For AFA level breakdown see specific AFA reports.				

Table 4.36 Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details

Summary of Existing Flood Risk Management Measures					
Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
Yes	None	None	Yes	None	None

Table 4.37 Stage 1.4: Summary of PV damages

Stage 1.4: Summary of PV Damages

Fluvial and coastal damages calculated based on flood depths for all return periods up to the 0.1% AEP. Combined damages are a sum of the fluvial and coastal capped at value of the property.

		Event Type	Capped Residential	Capped Non-Res	Capped Total	Uncapped Residential	Uncapped Non-Res	Uncapped Total
Total PV Damages	APMR_Lee	Fluvial	€ 23,136	€ 96,667	€ 119,803	€ 27,227	€ 96,667	€ 123,894
		Coastal	€ 320,733	€ 0	€ 320,733	€ 600,002	€ 0	€ 600,002
		Combined	€ 417,913	€ 96,667	€ 514,580	€ 697,182	€ 96,667	€ 793,849
	Within AFAs	Fluvial	€ 13,371,403	€ 24,900,265	€ 38,271,668	€ 14,872,299	€ 29,939,443	€ 44,811,742
		Coastal	€ 1,623,867	€ 2,193,144	€ 3,817,011	€ 1,855,167	€ 2,928,851	€ 4,784,018
		Combined	€ 14,836,130	€ 25,004,934	€ 39,841,064	€ 16,589,348	€ 30,119,247	€ 46,708,595
	Total for Sub-catchment	Fluvial	€ 13,394,539	€ 24,996,932	€ 38,391,471	€ 14,899,526	€ 30,036,110	€ 44,935,636
		Coastal	€ 1,944,600	€ 2,193,144	€ 4,137,744	€ 2,455,169	€ 2,928,851	€ 5,384,020
		Combined	€ 15,254,043	€ 25,101,601	€ 40,355,644	€ 17,286,530	€ 30,215,914	€ 47,502,444
Relevant Comments:		For AFA level breakdown see specific AFA reports.						

Table 4.38 Stage 1.5: Summary of Social Receptors at Risk of Flooding

Stage 1.5: Summary of Social Receptors at Risk of Flooding			
High Vulnerability Properties at risk :		**Type**	**Number**
	AMPR_Lee	Nursing Home	1
	Within AFAs	School	1
		Hospital	1
	Total for Sub-catchment	School	1
		Hospital	1
		Nursing Home	1
Social Infrastructure Assets:		**Type**	**Number**
	AMPR_Lee	N/A	None
	Within AFAs	Garda Station	1
		National Ambulance Station	1
	Total for Sub-catchment	Garda Station	1
		National Ambulance Station	1
Social Amenity Sites:		**Type**	**Number**
	APMR_Lee	N/A	0
	Within AFAs	N/A	0
	Total for Sub-catchment	N/A	0
Relevant Comments:	For AFA level breakdown see specific AFA reports.		

Table 4.39 Stage 1.6: Summary of Environmental Receptors at Risk of Flooding

Stage 1.6: Summary of Environmental Receptors at Risk of Flooding			
Risk to WFD Annex IV :		**Type**	**Number**
	APMR_Lee	N/A	None
	Within AFAs	Licenced IPPC Facility	1
	Total for Sub-catchment	Licenced IPPC Facility	1
Risk to cSACs,SPA's & SAC's :		**Type**	**Number**
	APMR_Lee	N/A	0
	Within AFAs	SPA	1
	Total for Sub-catchment	SPA	1
Relevant Comments:	For AFA level breakdown see specific AFA reports.		

Table 4.40 Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding

Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding			
Risk to Sites of Cultural Heritage:		**Type**	**Number**
	APMR_Lee	Recorded Monuments	3
	Within AFAs	NIAH	109
		Recorded Monuments	14
		Proposed Natural Heritage Area	1
	Total for Sub-catchment	NIAH	109
		Recorded Monuments	17
		Proposed Natural Heritage Area	1
Relevant Comments:	For AFA level breakdown see specific AFA reports.		

Table 4.41 Stage 1.8: Summary of Economic Receptors at Risk of Flooding

Stage 1.8: Summary of Economic Receptors at Risk of Flooding			
Risk to Transport Infrastructure:		**Type**	**Number**
	APMR_Lee	Local Road	1
	Within AFAs	National Road	2
		Regional Road	7
		Local Road	1
	Total for Sub-catchment	National Road	2
		Regional Road	7

		Local Road	2
Risk to Utility Infrastructure:		**Type**	**Number**
	APMR_Lee	N/A	0
	Within AFAs	Infrastructure – Eircom Depot	1
		Pumping Station	1
	Total for Sub-catchment	Infrastructure – Eircom Depot	1
		Pumping Station	1
Relevant Comments:			

Conclusion:
As there is only one AFA within this sub catchment/coastal area there are no measures that will provide benefits to multiple AFA's therefore screening of the measures was not carried out. Non – structural measures such as; flood forecasting and public awareness have been considered for the sub-catchment and are addressed in the UoM spatial scale.

4.3 Option Appraisal Results SSA: AFA

The AFA SSA's assessed and reported in this section, is as follows:

- Listowel;
- Abbeyfeale;
- Athea;
- Banna;
- Abbeydorney;
- Moneycashen;
- Tralee

Appendix C provides individual Option Appraisal Reports for each of the AFA's within this Unit of Management. Each Option Appraisal Report provides a clear and robust assessment of the Option Appraisal process.

The following sections provide an overview of the results for each AFA, at each of the six Option Appraisal Stages

4.3.1 Stage 1: Summary of Current Flood Risk - Results

Table 4.42 Results for Stage 1: Summary of Current Flood Risk

AFA/ IRR	Relevant Sub-Stage and Outcome[1]					
	Sub-Stage 1.2			Sub-Stage 1.4		
	No. Properties at Risk			Total Capped PV Damages		
	F	C	Comb.	F	C	Combined
Banna	19	18	19	€ 1,720,700	€ 1,663,874	€ 2,674,804
Listowel	160	0	0	€ 11,931,988	€ 0	€ 11,931,988
Abbeyfeale	4	0	0	€ 287,462	€ 0	€ 287,462
Athea	15	0	0	€ 809,096	€ 0	€ 809,096
Abbeydorney	9	0	0	€ 964,689	€ 0	€ 964,689
Moneycashen	5	5	5	€ 42,437	€ 678,899	€ 707,820
Tralee	565	62	627	€ 38,271,668	€ 3,817,011	€ 39,841,064

Note[1]: Only sub-stages with defined outcomes are summarised in this Table. Refer to Appendix C for a full report.

Table 4.43 Results for Stage 1: Summary of Current Flood Risk

AFA/ IRR	Relevant Sub-Stage and Outcome[1]			
	Sub-Stage 1.5	Sub-Stage 1.6	Sub-Stage 1.7	Sub-Stage 1.8
	Social Features	Environmental Features	Cultural Features	Economic Features
Banna	No	Yes	No	No
Listowel	Yes	Yes	Yes	Yes
Abbeyfeale	No	Yes	Yes	Yes
Athea	Yes	Yes	Yes	Yes
Abbeydorney	Yes	No	Yes	Yes
Moneycashen	No	Yes	No	Yes
Tralee	Yes	Yes	Yes	Yes

4.3.2 Stage 2: Screening of the measures - Results

Table 4.44 below outlines the screened in measures for all AFAs.

Table 4.44 Summary of Screened in Measures

Flood Risk Management Measure		AFAs						
Ref	Title	Listowel	Abbeyfeale	Athea	Banna	Abbeydorney	Moneycashen	Tralee
Baseline								
A	Do Nothing							
B	Existing Regime	✓						
C	Do Minimum							
Structural								
D	Storage							✓
E	Flow Diversion							✓
F	Increase Conveyance			✓		✓		✓
G	Construct Flood Defences	✓		✓	✓	✓		✓
H	Relocation of Properties							
I	Other Measures							
Non Structural								
J	Flood F'ing / Warning / Response	✓					✓	✓
K	Public Awareness	✓		✓	✓	✓	✓	✓
L	Individual property resistance	✓					✓	✓
M	Individual property resilience	✓	✓	✓	✓	✓	✓	✓

4.3.1 Stage 3 & 4: Selection of the Options and Appraisal - Results

Listowel

For Listowel a total of two options were considered, see Table 4.45. For more details of these options and the associated appraisal, refer to the Sections 3 and 4 of Appendix C1.

Table 4.45 Summary of Consideration of Options for Listowel

Measures		**Different composition of measures per option**						
Baseline Measures								
B	Existing Regime	✓	✓					
Structural Measures								
G	Flood Defences							
Gi	New Flood Defences							
Gii	Raise Existing Flood Defences	✓	✓					
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
J	Forecasting / Warning / Response		✓					
K	Public Awareness							
L	Individual property resistance		✓					
M	Individual property resilience	✓	✓					
Option Reference		LIL_01	LIL_02					

Measures not screened out but not included in options		
Measures		**Justification for not being included**
K	Public Awareness	Public Awareness was not considered as either an independent measure or in combination with other measures, as the option being appraised would provide the required 1% Fluvial AEP standard of protection. Public Awareness does not improve the viability of the options under consideration.

Abbeyfeale

For Abbeyfeale one option was considered, see Table 4.46. For more details of this option and the associated appraisal, refer to Sections 3 and 4 of Appendix C2.

Table 4.46 Summary of Consideration of Options for Abbeyfeale

Measures		**Different composition of measures per option**							
Non-Structural Measures									
K	Public Awareness								
M	Individual Property Resilience	✓							
Option Reference		AFE_01							
Measures not screened out but not included in options									
Measures		**Justification for not being included**							
K	Public Awareness	Public Awareness has not been included in this option as there is insufficient budget. When included with Individual Property Protection the Total Whole Life Cost of the option is €192,627. With an option comprising Individual Property Resilience PV benefits are limited to €154,034.							

Athea

For Athea a total of two options were considered, Table 4.47. For more details of these options and the associated appraisal, refer to the Sections 3 and 4 of Appendix C3.

Table 4.47 Summary of Consideration of Options for Athea

Measures		Different composition of measures per option						
Structural Measures								
F	Increase Conveyance							
Fi	Channel Dredging	✓						
Fii	Channel Widening							
Fiii	Structural Enhancement / Works							
G	Flood Defences							
Gi	New Flood Defences	✓	✓					
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
K	Public Awareness							
M	Individual Property Resilience							
Option Reference		ATA_01	ATA_02					

Measures not screened out but not included in options		
Measures		**Justification for not being included**
K	Public Awareness	Public Awareness was not considered as either an independent measure or in combination with other measures, as the option being appraised would provide the required 1% Fluvial AEP standard of protection. Public Public Awareness does not improve the viability of the option under consideration.
M	Individual Property Resilience	Individual Property Resilience was not considered as either an independent measure or in combination with other measures, as the option being appraised would provide the required 1% Fluvial / 0.5% Coastal AEP standard of protection. Individual Property Resilience does not improve the viability of the option under consideration.

Banna

For Banna one option was considered, see Table 4.48. For more details of this option and the associated appraisal, refer to the Sections 3 and 4 of Appendix C4.

Table 4.48 Summary of Consideration of Options for Banna

Measures		**Different composition of measures per option**						
Structural Measures								
G	Flood Defences							
Gi	New Flood Defences	✓						
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
K	Public Awareness							
M	Individual Property Resilience							
Option Reference		BAA_01						
Measures not screened out but not included in options								
Measures		**Justification**						
M	Public Awareness	Public Awareness was not considered as either an independent measure or in combination with other measures, as the option being appraised would provide the required 1% Fluvial AEP standard of protection. Public Awareness does not improve the viability of the options under consideration.						
M	Individual Property Resilience	Individual Property Resilience was not considered as either an independent measure or in combination with other measures, as the option being appraised would provide the required 1% Fluvial / 0.5% Coastal AEP standard of protection. Individual Property Resilience does not improve the viability of the option under consideration						

Abbeydorney

For Abbeydorney a total of two options were considered, see Table 4.49. For more details of these options and the associated appraisal, refer to the Sections 3 and 4 of Appendix C5.

Table 4.49 Summary of Consideration of Options for Abbeydorney

Measures		**Different composition of measures per option**						
Structural Measures								
F	Increase Conveyance							
Fi	Channel Dredging							
Fii	Channel Widening	✓	✓					
Fiii	Structure Enhancement / Works							
G	Flood Defences							
Gi	New Flood Defences		✓					
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
K	Public Awareness	✓						
M	Individual property resilience	✓						
Option Reference		ABY_01	ABY_02					

Moneycashen

In Moneycashen one option was considered at the options development meeting, see Table 4.50. For more details of this option and the associated appraisal, refer to the Sections 3 and 4 of Appendix C6.

Table 4.50 Summary of Consideration of Options for Moneycashen

Measures		Different composition of measures per option						
Non-Structural Measures								
J	Flood Forecasting / Warning / Response	✓						
K	Public Awareness	✓						
L	Individual property resistance	✓						
M	Individual property resilience							
Option Reference		MON_01						
Measures not screened out but not included in options								
Measures		**Justification for not being included**						
M	Individual Property Resilience	Individual Property Resilience was not considered as either an independent measure or in combination with other measures, as the option being appraised would provide the required 1% Fluvial / 0.5% Coastal AEP standard of protection. Individual Property Resilience does not improve the viability of the option under consideration.						

Tralee

In Tralee three options were considered at the options development meeting, see Table 4.51. For more details of these options and the associated appraisal, refer to the Sections 3 and 4 of Appendix C6.

Table 4.51 Summary of Consideration of Options for Tralee

Measures		**Different composition of measures per option**						
Structural Measures								
D	Storage							
Di	Online Storage	✓	✓					
Dii	Offline Storage							
Diii	Other Storage							
E	Flow Diversion							
Ei	Full Diversion							
Eii	Flood Relief Channel		✓	✓	✓			
Eiii	Other Diversion							
F	Increase Conveyance							
Fi	Channel Dredging	✓	✓	✓	✓			
Fii	Channel Widening	✓	✓	✓	✓			
Fiii	Structure Enhancement / Works		✓	✓	✓			
G	Flood Defences							
Gi	New Flood Defences	✓	✓	✓	✓			
Gii	Raise Existing Flood Defences	✓	✓	✓	✓			
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
J	Forecasting / Warning / Response	✓	✓	✓	✓			
K	Public Awareness	✓	✓	✓	✓			
L	Individual Property Resistance		✓	✓	✓			
M	Individual Property Resilience	✓	✓	✓	✓			
Option Reference		TRA_01	TRA_02	TRA_03	TRA_04			

4.3.2 Stage 5: Multi Criteria Assessment - Results

The MCA was carried out for all AFAs within UoM23**.** Further to this assessment the MCA and economic scores as outlined in Table 3.12 have been compared. Tables 4.52 to 4.58 below show summary results for the options for all AFAs.

Table 4.52 Comparison of Options for Listowel

5.2 Comparison of Multi Criteria Assessment Scores

Each option taken forward for further consideration through the Option Development Meeting has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).

Categories	**Option Reference and Results**	
	LIL_01	LIL_02
Criteria Scores		
Technical	567	540
Economic	668	728
Social	746	793
Environmental	-171	-171
Economic Values		
Economic PV Benefits	€ 8,369,315	€ 8,369,315
PV Cost	€ 1,259,812	€ 1,212,109
NPV Benefits	€ 7,109,503	€ 7,157,206
Economic BCR	6.64	6.90
Outcome Scores		
MCA PV Benefits	€ 4,732,943	€ 4,732,943
MCA Benefit Score	1243	1350
MCA BCR	986.58	1113.63
Option Selection MCA	1810	1890

Table 4.53 Comparison of Options for Abbeyfeale

5.2 Comparison of Multi Criteria Assessment Scores	
Each option taken forward for further consideration through the Option Development Meeting has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).	
Categories	**Option Reference and Results**
	AFE_01
Criteria Scores	
Technical	900
Economic	240
Social	20
Environmental	0
Economic Values	
Economic PV Benefits	€ 154,034
PV Cost	€ 152,357
NPV Benefits	€ 1,661
Economic BCR	1.29
Outcome Scores	
MCA PV Benefits	€ 154,034
MCA Benefit Score	260
MCA BCR	1709.38
Option Selection MCA	1160

Table 4.54 Comparison of Options for Athea

5.2 Comparison of Multi Criteria Assessment Scores Each option taken forward for further consideration through the Option Development Meeting has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).		
Categories	**Option Reference and Results**	
	ATA_01	ATA_02
Criteria Scores		
Technical	600	1000
Economic	265	265
Social	57	57
Environmental*	-50348	-419
Economic Values		
Economic PV Benefits	€ 543,552	€ 543,552
PV Cost	€ 533,035	€ 381,747
NPV Benefits	€ 10,517	€ 161,805
Economic BCR	1.02	1.42
Outcome Scores		
MCA PV Benefits	€ 274,266	€ 274,266
MCA Benefit Score	-50026	-97
MCA BCR	-93851.64	-254.71
Option Selection MCA	-49426	903

Table 4.55 Comparison of Options for Banna

5.2 Comparison of Multi Criteria Assessment Scores Each option taken forward for further consideration through the Option Development Meeting, has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).	
Categories	**Option Reference and Results**
	BAA_01
Criteria Scores	
Technical	800
Economic	-14
Social	672
Environmental	-179
Economic Values	
Economic PV Benefits	€2,424,244
PV Cost	€144,933
NPV Benefits	€2,279,311
Economic BCR	16.73
Outcome Scores	
MCA PV Benefits	€1,130,373
MCA Benefit Score	479
MCA BCR	3308.01
Option Selection MCA	1279

Table 4.56 Comparison of Options for Abbeydorney

5.2 Comparison of Multi Criteria Assessment Scores Each option taken forward for further consideration through the Option Decision Meeting has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Decision Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).		
Categories	**Option Reference and Results**	
	ABY_01	ABY_02
Criteria Scores		
Technical	950	1000
Economic	317	348
Social	81	529
Environmental	-120	-160
Economic Values		
Economic PV Benefits	€ 539,255	€ 884,657
PV Cost	€ 209,648	€278,059
NPV Benefits	€ 329,607	€ 606,598
Economic BCR	2.57	3.18
Outcome Scores		
MCA PV Benefits	€ 319,299	€ 420,144
MCA Benefit Score	279	718
MCA BCR	1331.42	2581.47
Option Selection MCA	1229	1718

Table 4.57 Comparison of Options for Moneycashen

2.3 Comparison of Multi Criteria Assessment Scores Each option taken forward for further consideration through the Option Development Meeting has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).	
Categories	**Option Reference and Results**
	MON_01
Criteria Scores	
Technical	650
Economic	67
Social	147
Environmental	0
Economic Values	
Economic PV Benefits	€ 633,752
PV Cost	€ 247,868
NPV Benefits	€ 385,884
Economic BCR	2.56
Outcome Scores	
MCA PV Benefits	€ 299,805
MCA Benefit Score	215
MCA BCR	865.85
Option Selection MCA	865

Table 4.58 Comparison of Options for Tralee

2.4 Comparison of Multi Criteria Assessment Scores Each option taken forward for further consideration through the Option Development Meeting has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).				
Categories	**Option Reference and Results**			
	TRA_01	TRA_02	TRA_03	TRA_04
Criteria Scores				
Technical	244	205	245	255
Economic	906	905	905	906
Social	741	741	741	741
Environmental	-231	-315	-201	-241
Economic Values				
Economic PV Benefits	€ 32,720,999	€ 32,657,428	€ 32,657,428	€ 32,657,428
PV Cost	€ 13,198,688	€ 14,064,878	€ 14,258,122	€ 19,012,090
NPV Benefits	€ 19,522,311	€ 18,592,550	€ 18,005,781	€ 13,645,338
Economic BCR	2.48	2.32	2.29	1.72
Outcome Scores				
MCA PV Benefits	€ 18,024,105	€ 18,005,781	€ 18,005,781	€ 18,005,781
MCA Benefit Score	1416	1332	1445	1406
MCA BCR	107.30	94.69	101.37	73.94
Option Selection MCA	1661	1536	1691	1660

5 Summary of Recommended Measures and Options

5.1 Recommendations at SSA: Unit of Management

The Flood Risk Management measures considered viable and therefore recommended for inclusion in the Flood Risk Management Plan at this Unit of Management SSA are:

- Flood Forecasting / Warning / Response
- Public Awareness;
- Planning and development control measures;
- Building Regulations;
- Land Use Management;
- Strategic development Management; and
- Additional Monitoring.

No Flood Risk Management options were considered viable at this Unit of Management SSA.

5.2 Recommendations at SSA: Sub-Catchment

The Flood Risk Management measures considered viable and therefore recommended for inclusion in the Flood Risk Management Plan at this sub-catchment SSA are:

- Flood Forecasting / Warning / Response
- Public Awareness;

No Flood Risk Management options were considered viable at this Sub-catchment SSA.

5.3 Recommendations at SSA: AFA

Different Flood Risk Management measures were considered viable and therefore recommended for inclusion in the Flood Risk Management Plan, for each of the AFAs. A summary of these recommendations with the outcomes of the MCA process for each AFA is presented in Table 5.1.

Consultation days were held in all AFAs. Any comments that were made at these consultation days have been considered in both the development of the options and the selection of the preferred option for each AFA.

Table 5.1 Summary of MCA Outcomes for each AFA

AFA	MCA outcomes				
	Summary of Existing Risk / MCA		Recommended Measure		
	Total PV Damages		Baseline	Structural	Non Structural
	Capped	Uncapped			
Listowel	€ 11,931,988	€ 13,037,292	✓	✓	✓
Abbeyfeale	€ 287,462	€ 287,462			✓
Athea	€ 809,096	€ 809,096		✓	
Banna	€ 2,674,804	€ 3,384,574		✓	
Abbeydorney	€ 964,689	€ 2,044,997		✓	
Moneycashen	€ 707,820	€ 728,532			✓
Tralee	€ 39,841,064	€ 46,708,595		✓	✓

The following sections summarise the preferred Flood Risk Management option being recommended for inclusion in the Flood Risk Management Plan, for each AFA respectively.

5.3.1 Listowel

The preferred option for Listowel with a MCA BCR of 1113.63 is LIL_02. A summary of the option is provided in Table 5.2 and Figure 5.1 below.

Table 5.2 Summary of the preferred option for Listowel

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**			
AFA	Listowel	Option Ref:	LIL_02
Option Measures			
Baseline	B	Existing Regime	
Structural	Gii	Flood Defences: Raising Existing Flood Defences	
Non-Structural	J	Flood Forecasting	
	L	Property Resistance	
	M	Property Resilience	
Criteria Scores			
Technical	540		
Economic	787		
Social	772		
Environmental	16		
Economic Values			
Economic PV Benefits	€ 8,369,315		
PV Cost	€ 1,212,109		
NPV Benefits	€ 7,157,206		
Economic BCR	6.90		
Outcome Scores			
MCA PV Benefits	€ 4,732,943		
MCA Benefit Score	1350		
MCA Benefit Score Ratio	1113.63		
Option Selection MCA	1890		
Relevant Figure	Figure 5.1		

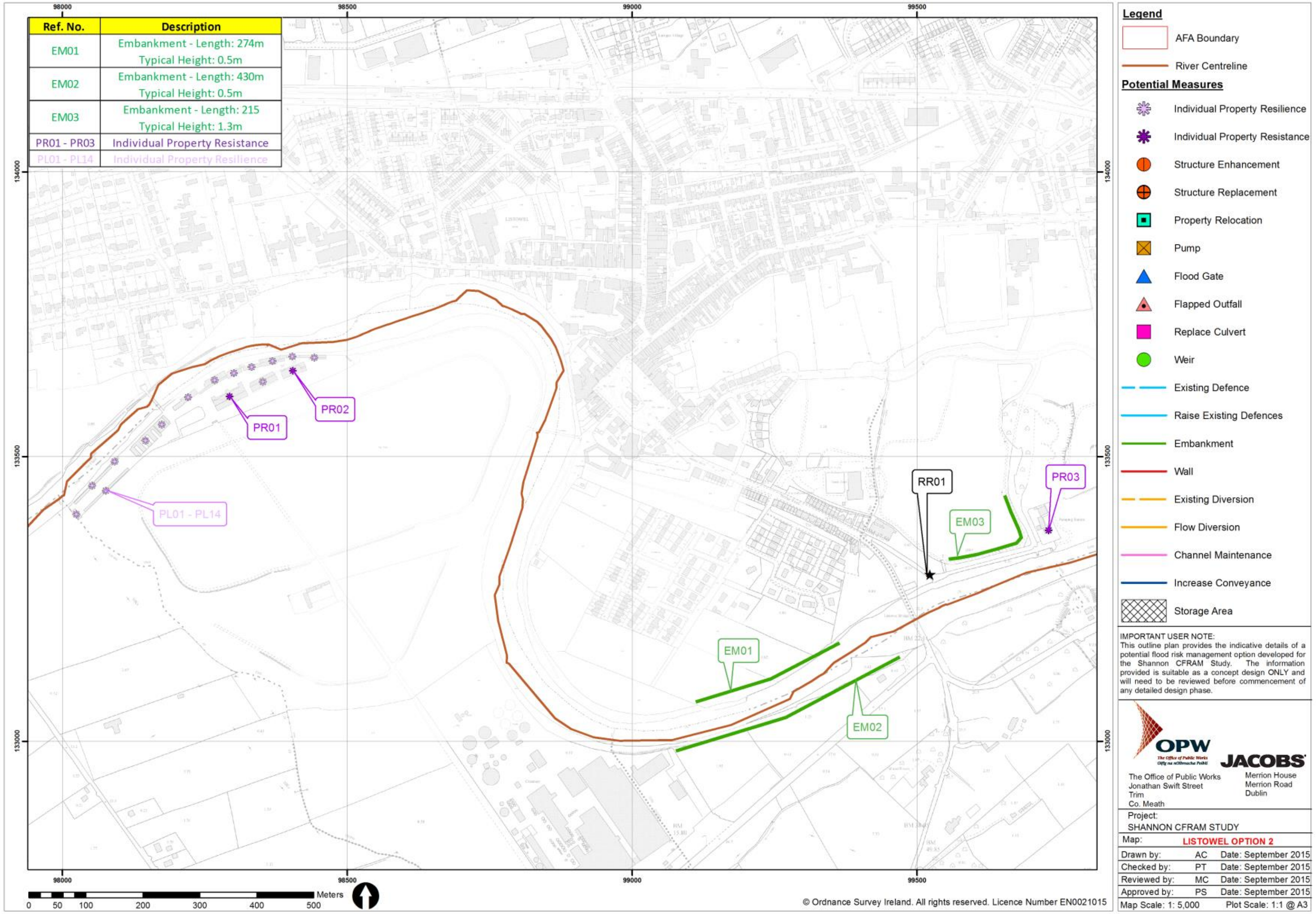


Figure 5.1 Summary of the preferred option for Listowel

5.3.2 Abbeyfeale

The preferred option for Abbeyfeale with a MCA BCR of 1709.38 is AFE_01. A summary of the option is provided in Table 5.3 and Figure 5.2 below

Table 5.3 Summary of the preferred option for Abbeyfeale

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**			
AFA	Abbeyfeale	Option Ref:	AFE_01
Option Measures			
Baseline	N/A	None	
Structural	N/A	None	
Non-Structural	M	Individual Property Resilience	
Criteria Scores			
Technical	900		
Economic	240		
Social	20		
Environmental	0		
Economic Values			
Economic PV Benefits	€ 154,034		
PV Cost	€ 152,373		
NPV Benefits	€ 1,661		
Economic BCR	1.01		
Outcome Scores			
MCA PV Benefits	€ 154,034		
MCA Benefit Score	260		
MCA Benefit Score Ratio	1709.38		
Option Selection MCA	1160		
Relevant Figure	Figure 5.2		

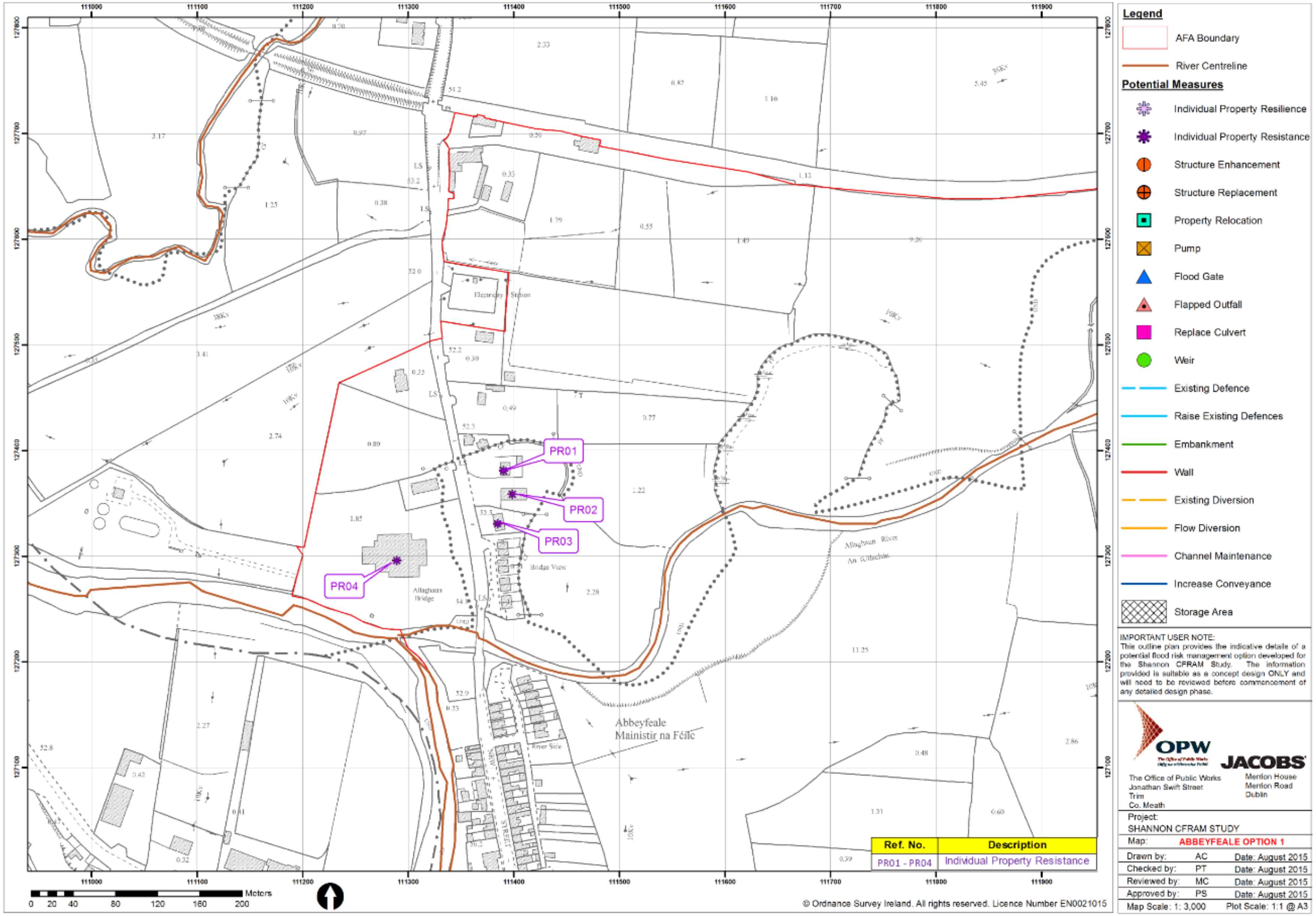


Figure 5.2 Summary of the preferred option for Abbeyfeale

5.3.3 Athea

The preferred option for Athea with a MCA BCR of -254.71 is ATA_02. A summary of the option is provided in Table 5.4 and Figure 5.3 below

Table 5.4 Summary of the preferred option for Athea

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**			
AFA	Athea	Option Ref:	ATA_02
Option Measures			
Baseline		N/A	
Structural	Gi	New Flood Defences	
Non-Structural		N/A	
Criteria Scores			
Technical	1000		
Economic	265		
Social	57		
Environmental	-419		
Economic Values			
Economic PV Benefits	€ 543,552		
PV Cost	€ 381,747		
NPV Benefits	€ 161,805		
Economic BCR	1.42		
Outcome Scores			
MCA PV Benefits	€ 274,266		
MCA Benefit Score	-97		
MCA Benefit Score Ratio	-254.71		
Option Selection MCA	903		
Relevant Figure	Figure 5.3		

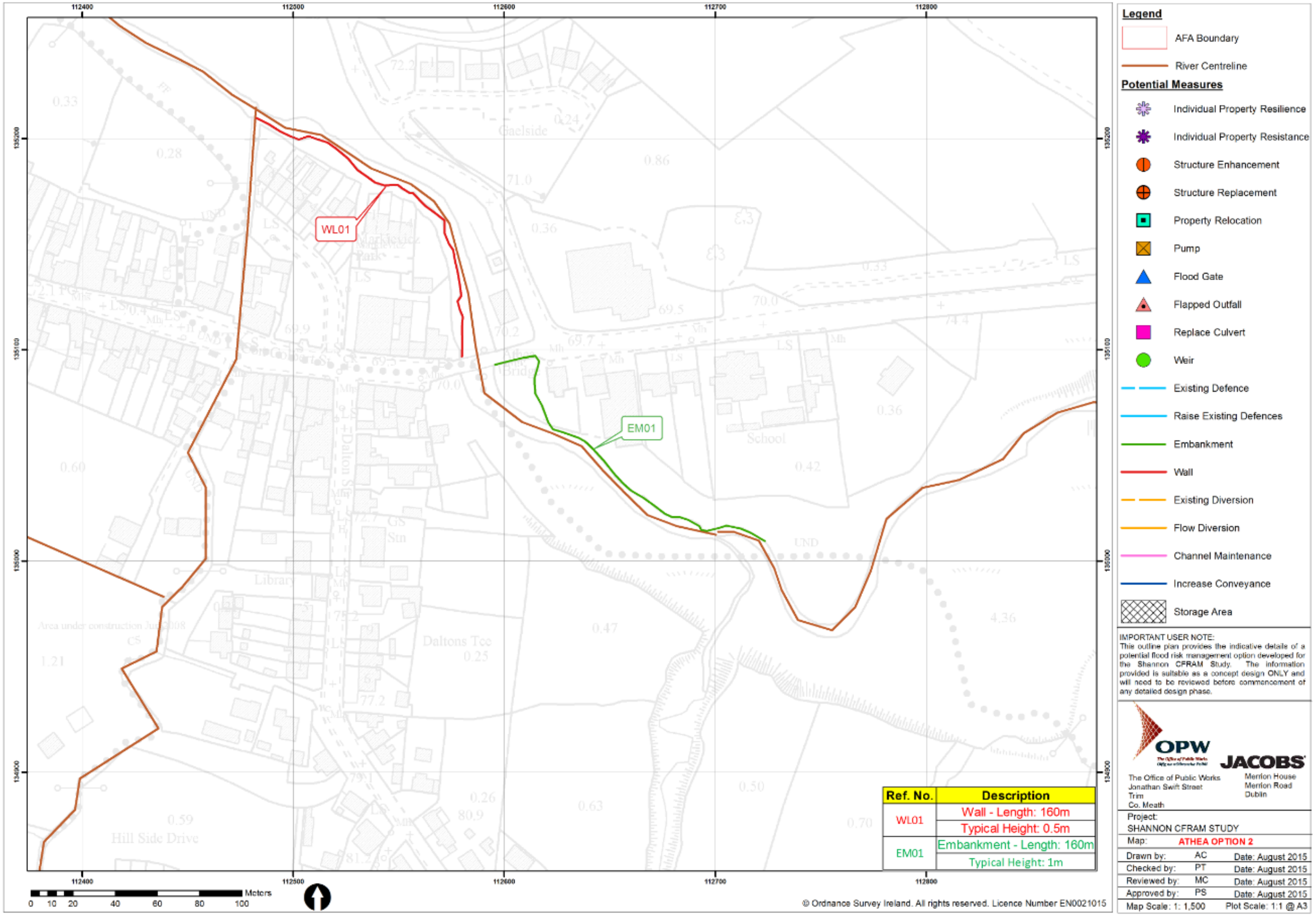


Figure 5.3 Summary of the preferred option for Athea

5.3.4 Banna

The preferred option for Banna with a MCA BCR of 3308.01 is BAA_01. A summary of the option is provided in Table 5.5 and Figure 5.4 below

Table 5.5 Summary of the preferred option for Banna

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**			
AFA	Banna	Option Ref:	BAA_01
Option Measures			
Structural	Gi	New Flood Defences	
Criteria Scores			
Technical	800		
Economic	-14		
Social	672		
Environmental	-179		
Economic Values			
Economic PV Benefits	€2,424,244		
PV Cost	€144,933		
NPV Benefits	€2,279,311		
Economic BCR	16.73		
Outcome Scores			
MCA PV Benefits	€1,130,373		
MCA Benefit Score	479		
MCA Benefit Score Ratio	3308.01		
Option Selection MCA	1279		
Relevant Figure	Figure 5.4		

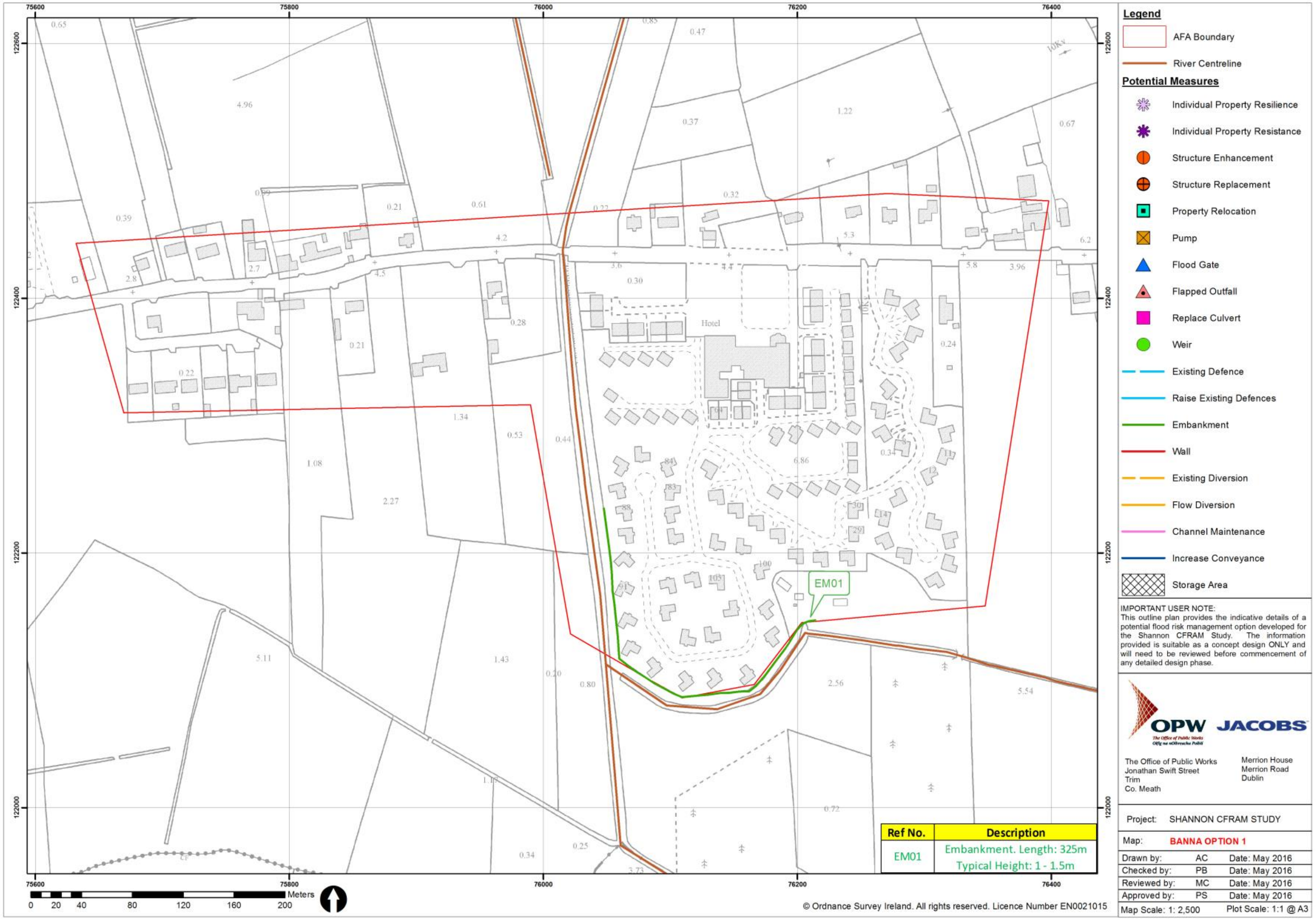


Figure 5.4 Summary of the preferred option for Banna

5.3.5 Abbeydorney

The preferred option for Abbeydorney with a MCA BCR of 2609.48 is ABY_02. A summary of the option is provided in Table 5.6 and Figure 5.5 below.

Table 5.6 Summary of the preferred option for Abbeydorney

<table>
<tr><td colspan="4">Multi Criteria Assessment
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.</td></tr>
<tr><td>AFA</td><td>Abbeydorney</td><td>Option Ref:</td><td>ABY_02</td></tr>
<tr><td colspan="4">Option Measures</td></tr>
<tr><td rowspan="2">Structural</td><td>Fii</td><td colspan="2">Channel Widening</td></tr>
<tr><td>Gi</td><td colspan="2">New Flood Defences</td></tr>
<tr><td>Non-Structural</td><td></td><td colspan="2">N/A</td></tr>
<tr><td colspan="4">Criteria Scores</td></tr>
<tr><td colspan="2">Technical</td><td colspan="2">1000</td></tr>
<tr><td colspan="2">Economic</td><td colspan="2">337</td></tr>
<tr><td colspan="2">Social</td><td colspan="2">529</td></tr>
<tr><td colspan="2">Environmental</td><td colspan="2">-140</td></tr>
<tr><td colspan="4">Economic Values</td></tr>
<tr><td colspan="2">Economic PV Benefits</td><td colspan="2">€ 884,657</td></tr>
<tr><td colspan="2">PV Cost</td><td colspan="2">€ 278,059</td></tr>
<tr><td colspan="2">NPV Benefits</td><td colspan="2">€ 606,598</td></tr>
<tr><td colspan="2">Economic BCR</td><td colspan="2">3.18</td></tr>
<tr><td colspan="4">Outcome Scores</td></tr>
<tr><td colspan="2">MCA PV Benefits</td><td colspan="2">€ 420,144</td></tr>
<tr><td colspan="2">MCA Benefit Score</td><td colspan="2">726</td></tr>
<tr><td colspan="2">MCA Benefit Score Ratio</td><td colspan="2">2609.48</td></tr>
<tr><td colspan="2">Option Selection MCA</td><td colspan="2">1726</td></tr>
<tr><td colspan="2">Relevant Figure</td><td colspan="2">Figure 5.2</td></tr>
</table>

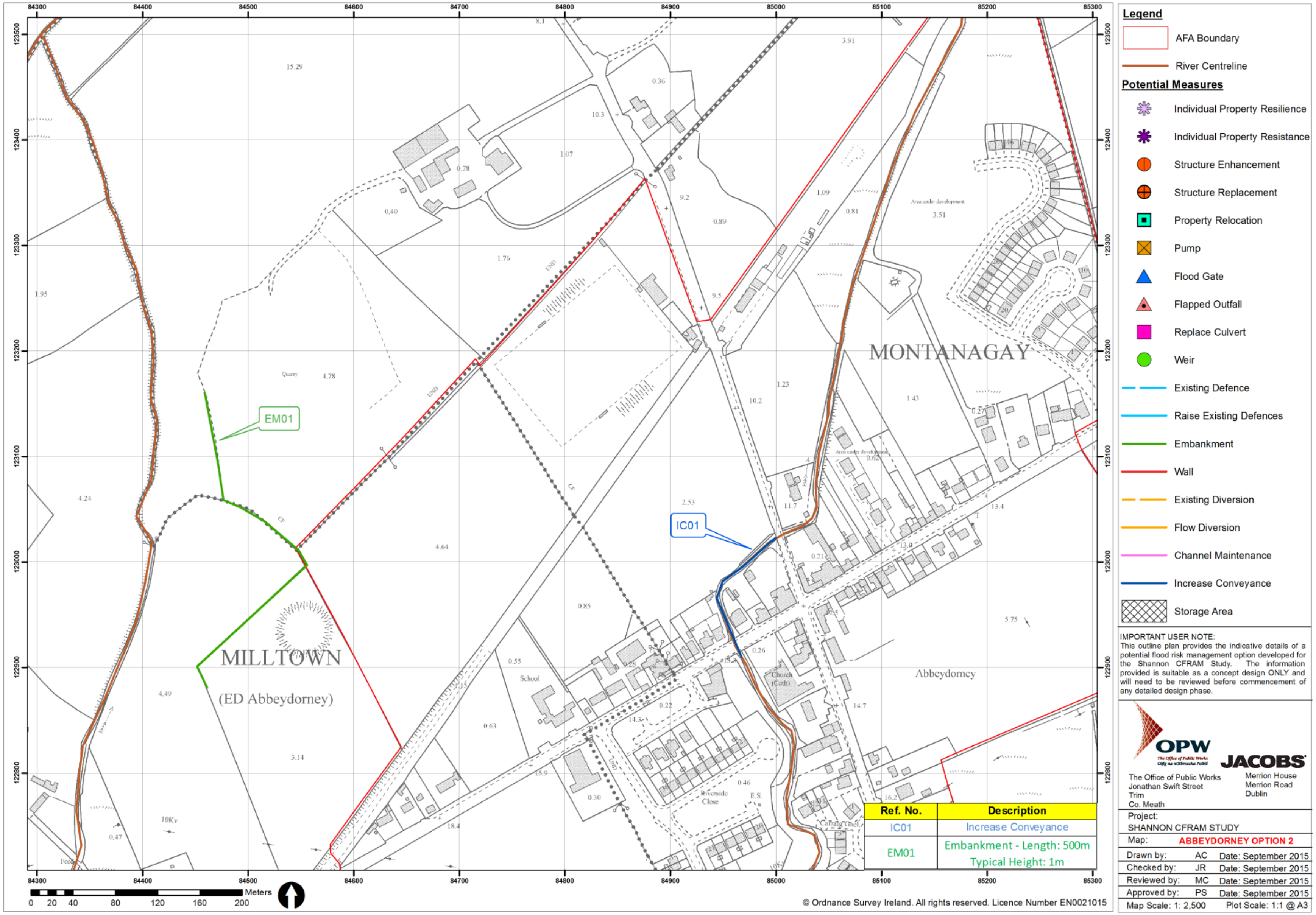


Figure 5.5 Summary of the preferred option for Abbeydorney

5.3.6 Moneycashen

The preferred option for Moneycashen with a MCA BCR of 865.85 is MON_01. A summary of the option is provided in Table 5.7 and Figure 5.6 below.

Table 5.7 Summary of the preferred option for Moneycashen

<table>
<tr><th colspan="4">Multi Criteria Assessment
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.</th></tr>
<tr><td>AFA</td><td>Moneycashen</td><td>Option Ref:</td><td>MON_01</td></tr>
<tr><th colspan="4">Option Measures</th></tr>
<tr><td>Baseline</td><td></td><td colspan="2">N/A</td></tr>
<tr><td>Structural</td><td></td><td colspan="2">N/A</td></tr>
<tr><td rowspan="3">Non-Structural</td><td>J</td><td colspan="2">Flood Forecasting</td></tr>
<tr><td>K</td><td colspan="2">Public Awareness</td></tr>
<tr><td>L</td><td colspan="2">Individual Property Resistance</td></tr>
<tr><th colspan="4">Criteria Scores</th></tr>
<tr><td colspan="2">Technical</td><td colspan="2">650</td></tr>
<tr><td colspan="2">Economic</td><td colspan="2">67</td></tr>
<tr><td colspan="2">Social</td><td colspan="2">147</td></tr>
<tr><td colspan="2">Environmental</td><td colspan="2">0</td></tr>
<tr><th colspan="4">Economic Values</th></tr>
<tr><td colspan="2">Economic PV Benefits</td><td colspan="2">€ 633,752</td></tr>
<tr><td colspan="2">PV Cost</td><td colspan="2">€ 247,868</td></tr>
<tr><td colspan="2">NPV Benefits</td><td colspan="2">€ 385,884</td></tr>
<tr><td colspan="2">Economic BCR</td><td colspan="2">2.56</td></tr>
<tr><th colspan="4">Outcome Scores</th></tr>
<tr><td colspan="2">MCA PV Benefits</td><td colspan="2">€ 299,805</td></tr>
<tr><td colspan="2">MCA Benefit Score</td><td colspan="2">215</td></tr>
<tr><td colspan="2">MCA Benefit Score Ratio</td><td colspan="2">865.85</td></tr>
<tr><td colspan="2">Option Selection MCA</td><td colspan="2">865</td></tr>
<tr><td colspan="2">Relevant Figure</td><td colspan="2">Figure 5.6</td></tr>
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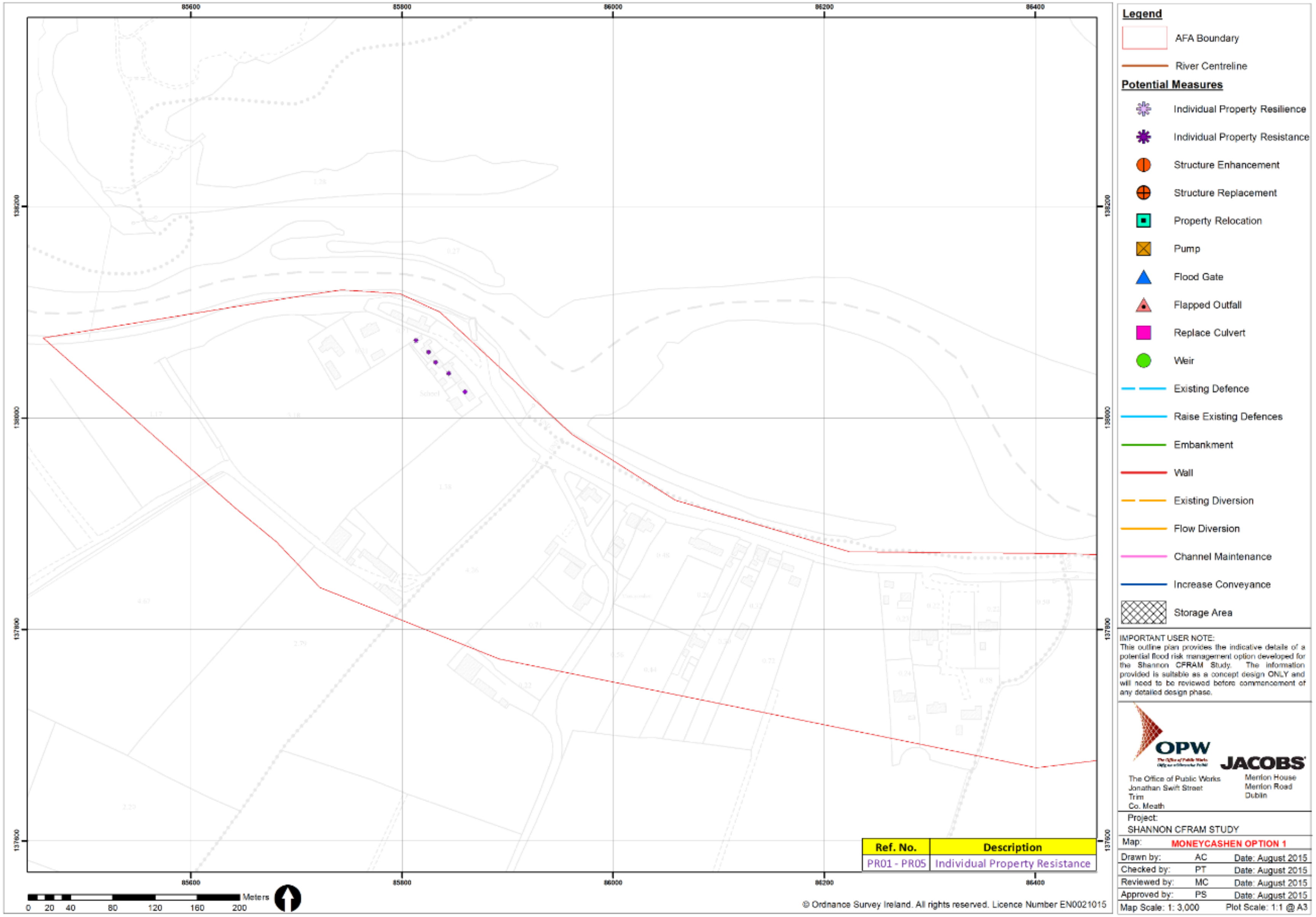

Figure 5.6 Summary of the preferred option for Moneycashen

5.3.7 Tralee

The preferred option for Tralee with a MCA BCR of 101.37 is TRA_03. A summary of the option is provided in Table 5.8 below.

Table 5.8 Summary of the preferred option for Tralee

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**			
AFA	Tralee	Option Ref:	TRA_03
Option Measures			
Baseline		NA	
Structural	Di	Storage: Online Storage	
	Eii	Flood Relief Channel	
	Fi	Channel Dredging	
	Fii	Channel Widening	
	Fiii	Structure Enhancement / Works	
	Gi	Flood Defences: New Flood Defences	
	Gii	Flood Defences: Raise Existing Flood Defences	
Non-Structural	J	Forecasting / Warning / Response	
	K	Public Awareness	
	L	Individual Property Resistance	
	M	Individual Property Resilience	
Criteria Scores			
Technical	245		
Economic	905		
Social	741		
Environmental	-201		
Economic Values			
Economic PV Benefits	€ 32,657,428		
PV Cost	€ 14,258,122		
NPV Benefits	€ 18,005,781		
Economic BCR	2.29		

Outcome Scores	
MCA PV Benefits	€ 18,005,781
MCA Benefit Score	1445
MCA Benefit Score Ratio	101.37
Option Selection MCA	1691
Relevant Figure	Figure 5.7

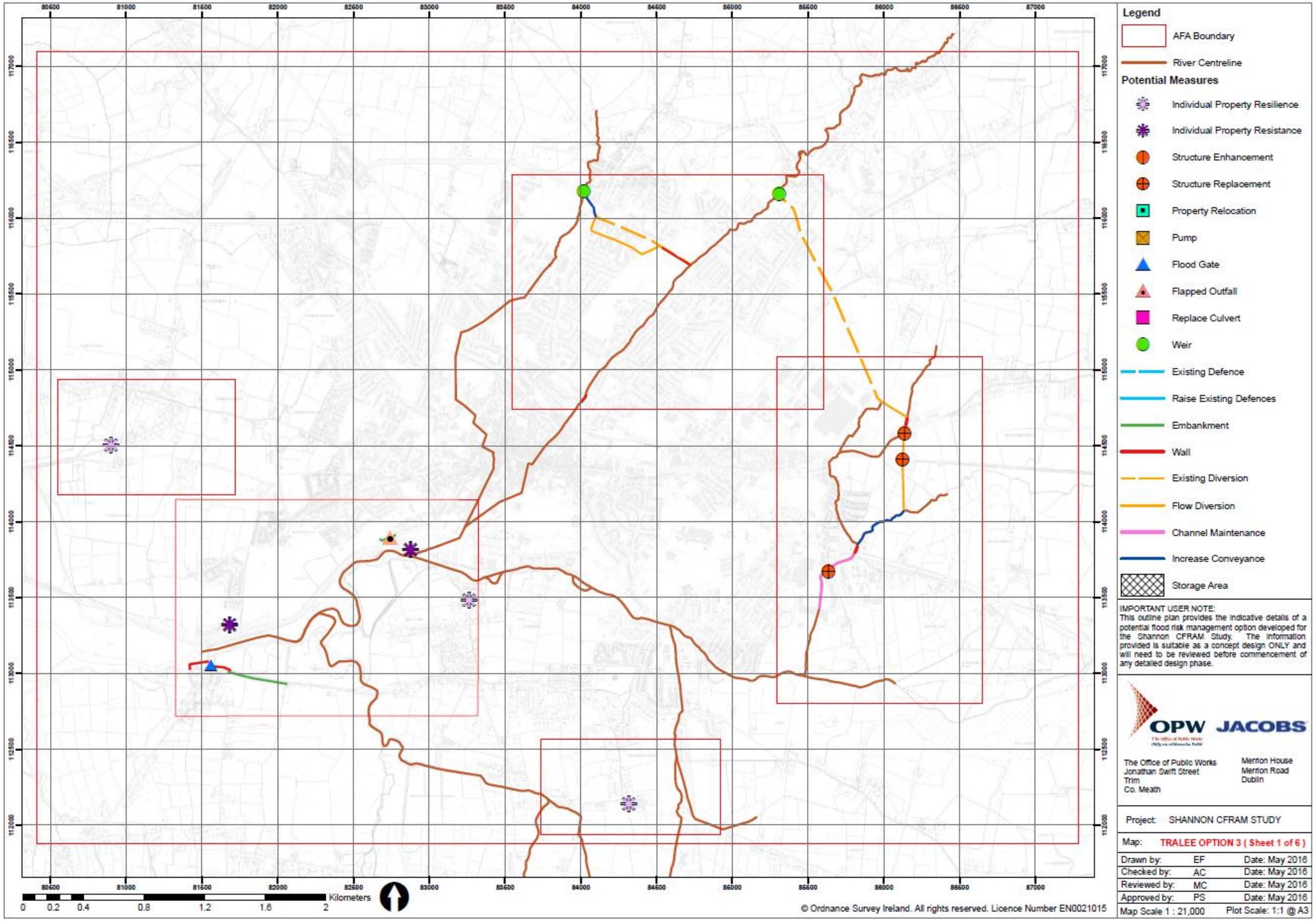

Figure 5.7 Summary of the preferred option for Tralee

Appendix A Glossary

Annual Exceedance Probability Or AEP	The probability that a certain flow value will be exceeded in any one year. For example the flow associated with the 1% AEP event at a particular location has a 1 in 100 chance of being exceeded in any year. A 5% AEP event has a 1 in 20 chance of being exceeded in any year. .
Area for Further Assessment Or AFA	An area that is considered to be at potentially significant risk, thereby justifying its inclusion for further assessment. Note that the term AFA is a replacement term for what was previously referred to as an APSR (Area of Potential Significant Risk). AFAs include cities, towns, villages, and individual risk receptors (IRR)
Areas of Potential Moderate Risk Or APMR	The areas to which the MPWs could give to rise existing or potential future fluvial and estuarine flooding are defined as the Fluvial Areas of Potential Moderate Risk (APMRs). Areas outside of APSRs that could be prone to coastal flooding are defined as Coastal APMRs.
Benefit – Cost Ratio	Benefit divided by the Costs
Catchment Flood Risk Assessment and Management Study Or CFRAM Study	The five year study covering the whole River Shannon catchment area which gives a picture of past flooding and areas at risk of future flooding, and sets out a prioritised set of specific measures for reducing and managing flood risk.
Flood Cell	Discrete areas of flood risk within a given AFA are referred to as ‘flood cells
Flood Risk Management Measure (FRM Measure)	A flood risk management strategy option (‘option’) consists of one or more flood risk management measures.
Habitats Directive	The Habitats Directive [92/43/EEC] aims at securing biodiversity through the provision of protection for animal and plant species and habitat types of European importance.
High – End Future Scenario Or HEFS	Potential future scenario representing climate change impacts not significantly outside the range of accepted predictions available, and with the allowances for increased flow, sea level rise etc. at the upper bounds of widely accepted projections
Individual Risk Receptor Or IRR	A single receptor (see below) that has been determined to represent a potentially significant flood risk (as opposed to a community or other area at potentially significant flood risk AFA).

Multi Criteria Assessment Or MCA	It is the framework which has been developed to assess the different range of potential impacts that the implementation of a measure/option will provide.
Mid – Range Future Scenario Or MRFS	Represent a 'likely' future scenario based on the wide range of predictions available and with the allowances for increased flow, sea level rise, etc. within the bounds of widely accepted projections
Present Value Damages Or PVd	The net present value of damages associated with the current flood risk.
Present Value Benefits Or PVb	The reduction of the PVd a flood risk management option will provide
River Basin District Or RBD	The natural geographical and hydrological units for water management, as defined during the implementation of the Water Framework Directive.
Special Scales Assessment Or SSA	The scale at which an assessment is to be undertaken. There are four principle SSAs for this study: - UoM - Sub-catchment - AFA - IRR
Unit of Management Or UoM	The division of the study area into major catchments and their associated coastal areas..

Appendix B Flood Risk Management Measures

The flood risk management (FRM) measures are set out in Table 3.7 of the main report, and presented again below in Table B.1 for clarity. These FRM measures will form the FRM option or options.

Table B.1: FRM Measures and applicable SSA

Flood Risk Management Measure		Applicable SSA
Ref	**Title**	
Baseline		
A	Do Nothing	AFA/IRR
B	Existing Regime	AFA/IRR
C	Do Minimum	AFA/IRR
Structural		
D	Storage	All
E	Flow Diversion	All
F	Increase Conveyance	All
G	Construct Flood Defences	All
H	Relocation of Properties	AFA/IRR
I	Other Measures	All
Non Structural		
J	Flood Forecasting / Warning / Response	All
K	Public Awareness	All
L	Individual property resistance	AFA/IRR
M	Individual property resilience	AFA/IRR
N	Planning and development control measures	UoM
O	Building regulations	UoM
P	Sustainable urban drainage systems	AFA/IRR
Q	Land use management	All
R	Strategic development management	UoM
S	Additional Monitoring (rain and river level/flow gauges)	UoM

This Appendix provides:

- Definition for each FRM measure;
- How each FRM measure is considered and specified; and
- Assumptions made on the viability of FRM measures at the screening stage of the measure phase.

Appendix B1: Baseline Measures

A - Do Nothing

Definition
Implement no new flood risk management measures and abandon any existing practices.
Screening of the Measure

The Do Nothing FRM measure can only be considered as an independent measure; it can not be considered in combination with another FRM measures.

The Do Nothing FRM measure has only been considered in the following scenarios;

- Where there is 'low' flood risk categorisation; and
- Abandoning any existing works (maintenance or capital) will not have a negative impact on the existing flood risk; and
- There are no location-specific reasons as to why measures need to be investigated; and
- There are no other viable measures, including the Existing Regime (Measure B) and Do minimum (Measure C) measures.

The Do Nothing FRM measure can not be screened out until all other FRM methods have been assessed.

B - Existing Regime

Definition
Continue with any existing flood risk management practices, such as reactive maintenance.

Screening of the Measure
The Existing Regime FRM measure has been considered as an independent viable measure in the following scenarios:

- Where there is 'low' flood risk categorisation; and
- There are no location-specific reasons as to why measures need to be investigated; and
- There are no other viable measures, including the Do minimum (Measure C) measures.

The Existing Regime FRM measure has also been considered in combination with other FRM measures and has generally been considered 'viable', as to discontinue with existing flood risk management practices is likely to have a negative impact to the existing flood risk.

Where the Existing Regime FRM measure has been considered 'unviable' in combination with other FRM measures, is:

- When the existing flood risk management practices have been found to be economically unsustainable; and
- There are other viable FRM measures which will mitigate any negative impact resulting from the abandonment of the existing flood risk management practices.

The Existing Regime FRM measure can not be screened out until all other FRM methods have been assessed.

C - Do Minimum

Definition
Implement additional minimal maintenance type works to reduce the flood risk in specific locations. This includes implementing reactive maintenance where it has not previously being implemented i.e. removal of debris at structures, cutting of grass/ clearing hedgerows/ low lying branches along the river bank, removal of loose debris and rubbish from the channel bed.

Screening of the Measure

The Do Minimum FRM measure has been considered as an independent viable measure in the following scenarios:

- Where there is 'low' flood risk categorisation; and
- There are no location-specific reasons as to why measures need to be investigated; and
- There are no other viable measures,

The Do Minimum FRM measure has also been considered in combination with other FRM measures.

Assessing the likely reduction in flood risk from the Do Minimum FRM measure has been based on the following factors:

- Engineering judgement using site photographs and survey data. If this dataset indicates no build-up of debris/rubbish in channel, the conclusion can be drawn that the introduction of a reactive maintenance is likely not to have a significant impact on flood risk; and
- Sensitivity tests have been carried out using the hydraulic models which indicates the reduction in channel water levels subject to a 20% reduction in Manning's n. While it has not been anticipated that the introduction of reactive maintenance will provide a 20% reduction to Manning's n, the results of this sensitivity tests have provided an indication of the watercourse's sensitivity to an improvement of in channel conveyance.

The Do Minimum FRM measure can not be screened out until all other FRM methods have been assessed.

Appendix B2: Structural Measures

D - Storage

Definition

Single or multiple site, online or offline flood water storage, flood retardation, etc. Detention basins and ponds are not considered as storage as these are considered as SuDS FRM measures.

There are different sub-types of Storage FRM Measures, which are summarised in Table B.2.

Table B-2 Types of Storage FRM measures

D – Storage	Di – On-line Storage
	Dii – Off-line Storage
	Diii – Other Storage

Concept Design

The concept design for any storage measure will be unique and dependant on the existing ground topography, location from watercourses, and volume of flood water to be stored.

Consideration has been given to all these parameters, along with health and safety, operation and maintenance issues, when determining the viability of this FRM Measure.

Freeboard Allowance

A freeboard allowance has been applied to the retaining structures needed as part of the concept design for any storage measure. This freeboard is to allow for model and construction uncertainty with these allowances summarised in Table B.3.

Table B-3 Freeboard applied to retaining structure for Storage

Defence Type	Freeboard – Fluvial (m)	Freeboard – Tidal (m)
Storage reservoir walls	0.220	N/A

Climate change

Where possible, an allowance has been made in the concept designs for adaptability to the HEFS. This has primarily used the sensitivity results from the hydraulic modelling exercise where allowances to account for Climate Change, have been included.

Screening of the Measure

The Storage FRM measure can be assessed as a viable FRM measure independently or in combination with other FRM measures.

The three key parameters when determining the viability of storage as a FRM measure are:

- Technically acceptable – Will the storing and attenuation of flood water significantly reduce flood risk.
- Suitable topography – Is the topography suitable to store the desired volume of flood water (either online of offline).
- Economics - What are the likely construction and maintenance costs for such a concept design.

Storage has not been considered viable where the source of flood risk is coastal.

The economic viability of the storage FRM measure has been estimated at the screening of measures phase (Stage 2 of the Optioneering Assessment). The PV benefits of the storage FRM measure have been calculated as the PV damages of the properties protected for all return periods up to the standard of protection of the storage unit.

Modelling of viable options

When a storage FRM measure has been considered a viable option independently or in combination with other measures, hydraulic modelling of the storage feature has been carried out:

- To confirm the required dimension of the storage area; and
- To confirm the dimensions of any weir structures required to divert flow; and
- To determine the standard of protection to be provided; and
- To understand the impact of water levels upstream and downstream of the storage area.

E - Flow Diversion

Definition

The diversion of flood waters to either increase conveyance or avoid area at risk.
There are different sub-types of the Flow Diversion FRM Measure, which are summarised in Table B.4.

Table B-4 Types of Flow Diversion FRM measures

E – Flow Diversion	Ei – Full Diversion
	Eii – Flood Relief Channel
	Eiii – Other Diversion/Channel

Concept Design
The parameters used for the concept designs of this FRM Measure are as follows:

- Flow diversion channels have been specified as inverted channels where the excavated fill is used to form embankments along the side of the channel to allow additional storage. The formed embankments are considered as flood defences.

Freeboard
A freeboard allowance has been applied to any associated flood defence to allow for model and construction uncertainty with these allowances summarised in Table B.5.

Table B-5 Freeboard applied to Defences

Defence Type	Freeboard – Fluvial (m)	Freeboard – Tidal (m)
Storage reservoir walls	0.220	N/A

Climate change
Where possible, the measure has been designed to be adaptable for the HEFS. This has taken the form of over-designing the channel capacity and considerations for any associated flood defences.

Screening of the Measure
The Flow Diversion FRM measure can be assessed as a viable FRM measure independently or in combination with other FRM measures.

The three key parameters when determining the viability of storage as a FRM measure are:

- Technically acceptable – Will a Flow Diversion measure reduce flood risk.
- Suitable topography – Is the topography suitable for a Flow Diversion measure i.e. is there an acceptable route.
- Economics - What are the likely construction and maintenance costs for such a concept design.

Flow Diversion Measure has not been considered viable where the source of flood risk is coastal.

The economic viability of this measure has been estimated at the screening of measures phase (Stage 2 of the Optioneering Assessment). The PV benefits of the measure have been calculated as the PV damages of the properties protected for all return periods up to the standard of protection of the flow diversion channel.

Modelling of viable options
When a Flow Diversion FRM measure has been considered viable either independently or in combination with other measures, modelling of the flow diversion channel has been carried;

- To confirm the flow diversion is technically feasible.
- To confirm the dimensions of the channel and any associated flood defences.
- To determine the standard of protection to be provided
- To understand the impact of waterlevels upstream and downstream of the diversion channel

F - Increase Conveyance

Definition

In-channel works, floodplain earthworks, removal of constraints / constrictions, increasing culvert/bridge openings, channel / floodplain clearance, etc. In-channel works included localised removal of bed material, localised widening of the channel or the construction of a two stage channel.

There are different sub-types of the Flow Diversion FRM Measure, *which are summarised in Table B.5.*

Table B-5 Types of Flow Diversion FRM measures

F – Increase Conveyance	Fi – Channel Dredging
	Fii – Channel Widening
	Fiii – Structure Enhancement / Works

Concept Design

As works associated with this Measure are 'local', the design concepts are typically unique, but could include:

- Additional bridge arches
- Localised removal of a known constraint – either in channel or on floodplain.
- Two stage channel.
- Underpinning of structures

Climate change

Due to the nature of this FRM measure, including an allowance or adaptability for climate change may be difficult.

Consideration will be given, where possible, for example if additional bridge arch is required it will be designed using the sensitivity results for climate change (HEFS). Also, if a two stage channel is required, the two stage channel will allow for the measure to be adaptable for the HEFS.

Screening of the Measure

The Increase Conveyance FRM measure can be assessed as a viable FRM measure independently or in combination with other FRM measures.

In-channel works is likely to have a significant negative environmental impact. Therefore such measures have only been considered viable in locations where it will eliminate / significantly reduce the flood risk and there are no other viable options.

The two key parameters when determining the viability of storage as a FRM measure are:

- Technically acceptable – Will Increasing Conveyance measure reduce flood risk.
- Economics - What are the likely construction and maintenance costs for such a concept design.

The economic viability of this measure has been estimated at the screening of measures phase (Stage 2 of the Optioneering Assessment). The PV benefits of the storage FRM measure have been calculated as the PV damages of the properties protected for all return periods up to the standard of protection of the in channel works.

Modelling of viable options

When an increase conveyance FRM measure has been considered a viable option independently or in combination with other measure modelling of the increased conveyance is carried out if required;

- To determine if the option is technically feasible.
- To determine the standard of protection to be provided.
- To understand the impact on waterlevels upstream and downstream of the works.

The requirement of modelling has been determined based on engineering judgement

G – Flood Defences: Construct flood defences/ Rehabilitate, improve existing defences/ Localised protection works (e.g., minor raising of existing defences / levels)

Definition

All forms of flood defence. This includes construction of new flood defences (wall and embankment) raising existing flood defences (wall and embankment), rehabilitate or improve existing flood defences or demountable defences. There are therefore different sub-types of Flood Defence Measures, which are summarised in Table B.6.

Table B-6 Types of Construct Flood Defence FRM measures

G – Construct Flood Defences	Gi – New Flood Defences
	Gii – Raise Existing Flood Defences
	Giii – Rehabilitate or improve Existing Flood Defences
	Giv – Demountable Defences
	Gv – Other Defences

Concept Design

The parameters used for the concept designs of this FRM Measure are as follows:

- Embankments: at least 1m wide on top to allow for the safe constructability and maintenance of the embankments. They will have a slope of 1:3 on the river side for stability and 1;5 on the landward side to allow for safe maintenance and cutting of grass. Modification of these dimensions has been considered on a site by site basis, using engineering judgement, if the above slope and dimensions cannot be maintained due to site space constraints.
- Raising existing. In locations where raise existing flood defences, the type of structure to be provided has been dictated by the existing structure.

Freeboard

Freeboard has been applied to design height of the defences to allow for model and construction uncertainty; the allowances are provided in Table B.7

Table B-7 Freeboard applied to Defences

Defence Type	Freeboard – Fluvial (m)	Freeboard – Tidal (m)
Walls	0.22	0.22
Embankment	0.4	0.9

Climate change
Where possible, defences have been specified to be adaptable for the HEFS.

Foundations for walls have been specified to provide a foundation that can be ad adaptable for the HEFS if economically viable.
The width of the top of the embankments have been specified to be wide enough to provide a sufficient foundation for the height of the embankments to be increased to the HEFS level and allow for the required slopes and embankment dimensions to be maintained.

Screening of the Measure
This FRM measure can be assessed as a viable FRM measure independently or in combination with other FRM measures.

The three key parameters when determining the viability of storage as a FRM measure are:

- Technically acceptable – Will a Flood Defence measure reduce flood risk.
- Suitable topography – Is the topography suitable for Flood Defences
- Economics - What are the likely construction and maintenance costs for such a concept design.

The type of flood defence selected is specified depended on site suitability and any existing defences. Demountable defences have only been considered viable in catchments where flood forecasting is a viable FRM measure. Similarly set back defences which require demountable gates or sections have only been considered viable in catchment where flood forecasting is viable.

The economic viability of this measure has been estimated at the screening of measures phase (Stage 2 of the Optioneering Assessment). The PV benefits of the Defences measure have been calculated as the PV damages of the properties protected for all return periods up to the standard of protection of the storage unit.

Modelling of viable options
When a Flood Defences FRM measure has been considered viable, either independently or in combination with other measure, modelling of the Flood Defence is carried out if required;

- To determine if the defence is technically feasible;
- To determine the required height of the defence;
- To determine the standard of protection to be provided; and
- To understand the impact of water levels upstream and downstream of the structures.

The requirement of whether modelling is needed has been determined based on engineering judgement.

H - Relocation of properties

Definition
The relocation of properties to outside the area at risk from the 1% AEP Fluvial and 0.5% Tidal flooding.

Concept Design
Will be the demolition of existing property and construction of new, on a ‘like for like’ basis.

Freeboard
Using the sensitivity results, the relocation of the property will be outside the area at risk from the HEFS assessment.

Screening of the Measure
This FRM measure can be assessed as a viable FRM measure independently or in combination with other FRM measures.
Relocation of properties is considered a less desirable measure, as it does not make any attempt to reduce the existing flood risk to the existing properties, and should only be considered a viable measure independently or in combination with other FRM measures when there is no other viable measure.

Appendix B3: Non-Structural Measures

Non-structural measures have only been considered as viable FRM measures in combination with either a baseline or structural measure. Non-structural FRM measures assist in dealing with the existing flood risk, but do not reduce this risk. In the circumstances where neither a baseline nor structural measure is viable, non–structural measures are considered independently and if viable are recommended in the Flood Risk Management Plan.

Table B.8 below is a summary of the Applicable SSA's for the Non Structural measures. The description of these Non Structural Measures are categorised in the different SSAs.

Flood Risk Management Measure		Applicable SSA
Ref	**Title**	
Non Structural		
J	Flood Forecasting / Warning / Response	All
K	Public Awareness	All
L	Individual property resistance	AFA/IRR
M	Individual property resilience	AFA/IRR
N	Planning and development control measures	UoM
O	Building regulations	UoM
P	Sustainable urban drainage systems	AFA/IRR
Q	Land use management	All
R	Strategic development management	UoM
S	Additional Monitoring (rain and river level/flow gauges)	UoM

Table B-8 Different SSAs for the Non Structural FRM Measures

J – Flood Forecasting/ Warning/ Response

Definition
Installation of a flood forecasting system to predict the onset of flooding, and an accompanying warning system. To support this, the development of emergency flood response procedures are included.

Applicable SSA
FRM Measure is applicable at all SSAs.

Concept Design
The flood forecasting and warning system FRM measure has only been considered viable in a catchment when the time between baseflow water levels and peak water levels, is greater or equal to 5 hours. This time is required to allow for the

evacuation of properties and the implementation of any temporary flood defences such as demountable defences and flood gates.

Screening of the Measure
This FRM measure has only be assessed as a viable FRM measure in combination with other FRM measures, particularly targeted public awareness and preparedness campaign, individual property protection and demountable defences.

K - Targeted public awareness and preparedness campaign

Definition
Raising awareness within the communities at risk through public campaigns; these would be targeted, regular and would involve meetings, workshops and information leaflets. The purpose of the campaign is to make residents aware of what they can do to stay safe in a flood event.

Applicable SSA
FRM Measure is applicable at all SSAs.

Concept Design
The targeted public awareness and preparedness campaign has been considered a viable measure in all AFAs where there is flood risk. The extent of the campaign depends on the level of flood risk within the AFA and the FRM measures considered along with the campaign. The aim of the campaign will be to make residents in the AFA aware of the existing flood risk and existing FRM measures and the operation protocol in the case of flood forecasting or demountable defences.

Screening of the Measure
This FRM measure can be assessed as a viable FRM measure independently or in combination with other FRM measures.

L - Individual property flood resistance

Definition
Individual property flood resistance is defined as a measure to prevent flood waters entering a property e.g. flood barriers, building skirts and non-return valves.

Applicable SSA
FRM Measure is applicable at all SSAs.

Concept Design
Individual property flood resistance has also only been considered suitable in areas where flood depths are less than 600mm. This assumption provides 400mm freeboard on a max permissible height of flood resistance of 1m. Flood resistance has not been provided in areas where flood risk in the 1% AEP event is greater than 1m due to the following factors;

- The risk of an ordinary masonry wall collapsing when the water pressure difference indoor and outdoor goes over 1m.
- An adult cannot easily step over an obstacle of greater than 1m in height.

Screening of the Measure
This FRM measure has only be assessed as a viable FRM measure in combination with the following FRM measures:

- J – Flood Forecasting/ Warning/ Response
- K - targeted public awareness and preparedness campaign,

M - Individual property flood resilience

Definition
Individual property flood resilience is defined as wet proofing a property by changing the materials use within the building and relocating vulnerable building services, in order to mitigate the flood vulnerability of a property and/or repair works. It does not prevent flood water from entering the property.

Applicable SSA
FRM Measure is applicable at all SSAs.

Concept Design
Flood resilience has only been considered suitable in areas where flood depths are less than 1m as it not considered feasible to relocate all building services such as sockets and household appliances at levels greater than 1.4m from ground level.

Screening of the Measure
The Increase Conveyance FRM measure can be assessed as a viable FRM measure independently or in combination with other FRM measures.
Individual property flood resilience does not require time to implement immediately prior to a flood. Therefore this FRM measure does not require Measure J – Flood Forecasting/ Warning/ Response.
Flood resilience has been considered a less desirable FRM measure, as it does not make any attempt to reduce the flood risk to the properties, and has only been considered a viable measure when there are no other viable measures.

N - Planning and development control measures

Definition
Zoning of land for flood risk appropriate development, prevention of inappropriate incremental development, review of existing Local Authority policies in relation to planning and development and of inter-jurisdictional co-operation within the catchment, etc.

Applicable SSA
FRM Measure is applicable at Sub-catchment and UoM Scale only. It has not been considered at AFA scale, as it is being recommended for implementation at Sub-catchment and UoM Scale.

O - Building regulations

Definition
Regulations relating to floor levels, flood-proofing, flood - resilience, sustainable drainage systems, prevention of reconstruction or redevelopment in flood-risk areas, etc

Applicable SSA
FRM Measure is applicable at Sub-catchment and UoM Scale only. It has not been considered at AFA scale, as it is being recommended for implementation at Sub-catchment and UoM Scale.

P - Sustainable urban drainage systems

Definition
Potential sustainable urban drainage systems, which will alleviate fluvial flood risk, at a strategic level.

Applicable SSA
FRM Measure is applicable at AFA/IRR Scale only.

Q - Land use management, including creation of wetlands, riparian buffer zones, etc.

Definition
Potential management practices within the catchment to attenuate existing runoff.

Applicable SSA
FRM Measure is applicable at all SSAs.

R - Strategic development management for necessary floodplain development

Definition
Proactive integration of structural measures into development designs and zoning, regulation on developer-funded communal retention, drainage and / or protection systems, etc.

Applicable SSA
FRM Measure is applicable at Sub-catchment and UoM Scale only. It has not been considered at AFA scale, as it is being recommended for implementation at Sub-catchment and UoM Scale.

Appendix C Option Appraisal Reports - AFA Spatial Scale

Appendix C1 Option Appraisal Report - Listowel

1. STAGE 1: Summary of Current Flood Risk

1.1 AFA and Watercourse Details

AFA	Listowel
Unit of Management:	23
Primary Watercourse(s):	River Feale

1.2 Summary of Flood Risk in 1% Fluvial AEP Event

Source of flood risk	**Fluvial**	Coastal	Both	
Total Number of Properties at risk in AFA in 1% Fluvial AEP Event:		**Residential**	**Non-Residential**	**Total**
	Fluvial	137	23	160
AFA Flood Cells:	**Total Number:**	3		
	Flood Cell Titles:	LIL_A, LIL_B, LIL_C		
Breakdown of properties at risk per Flood Cell:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	LIL_A	137	6	143
	LIL_B	0	16	16
	LIL_C	0	1	1
Relevant Figure Ref:	Figure 1.1 & 1.2			

1.3 Summary of Existing Flood Risk Management Measures

Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
Yes	None	None	**Yes**	None	None

Relevant Figure Ref:	Figure 1.1

1.4 Summary of PV Damages/Potential PV Benefits

Total PV Damage:		**Uncapped**	**Capped**	
	Fluvial	€ 13,037,292	€ 11,931,988	
Max Capped PV Benefits 1% Fluvial SOP:	€ 8,813,377			
Breakdown of Capped Max PV benefits 1% Fluvial SOP per Flood Cell*:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	LIL_A	€ 6,426,793	€ 1,467,544	€ 7,894,337
	LIL_B	€ 0	€ 866,710	€ 866,710
	LIL_C	€ 0	€ 52,330	€ 52,330
Relevant Figure Ref:	Figure 1.2			

*These are the maximum benefits available if a FRM option with a 1% Fluvial AEP SOP is provided to all properties within the AFA.

1.5 Social Risk		
High Vulnerability Properties at risk :	**Type**	**Description**
	None	N/A
Social Infrastructure Assets:	Community Centre	**5% AEP Fluvial Flood Extent.**
		Listowel Community Centre
	Sports Club	**5% AEP Fluvial Flood Extent.**
		Sports Club, Off Bridge road
	Racecourse	**5% AEP Fluvial Flood Extent.**
		Listowel Racecourse
Social Amenity Sites:	Walkway	**50% AEP Fluvial Flood Extent.**
		Walkway along River Feale
Relevant Figure Ref:	General Risk - Social	
1.6 Risk to the Environment		
	Type	**Description**
Risk to WFD Annex IV:	None	N/A
Risk to SACs:	Candidate Special Area of Conservation	The River Feale itself and lands to the right and left of the watercourse are designated candidate Special Area of Conservation (the Lower Shannon cSAC).
Relevant Figure Ref:	General Risk - Environment	
1.7 Risk to Cultural Heritage		
Risk to Sites of Cultural Heritage:	**Type**	**Description**
	NIAH	**10% AEP Fluvial Flood Extent.**
		Listowel Bridge, a regionally important structure
		1% AEP Fluvial Flood Extent.
		Dandy Lodge, a regionally important gate lodge
Relevant Figure Ref:	General Risk – Cultural Heritage	
1.8 Risk to the Economy		
Risk to Transport Infrastructure:	**Type**	**Description**
	National Road	**20% AEP Fluvial Flood Extent.**
		N69 to the south of Listowel
	Regional Road	**5% AEP Fluvial Flood Extent.**
		R555
	Local Road	**5% AEP Fluvial Flood Extent**
		Bridge Road
		0.5% AEP Fluvial Flood Extent
		The Lodge
		The Meadows
		0.1% AEP Fluvial Flood Extent
		Greenville Road

Risk to Utility Infrastructure:	Type	Description
	Water Pumping Station	**5% AEP Fluvial Flood Extent.**
		Water pumping station and abstraction point to the east of Listowel. This abstraction point and pumps are no longer in use but remain in working order and are used as a backup in the event of any difficulties with the main abstraction point further downstream.
Relevant Figure Ref:	General Risk - Economy	

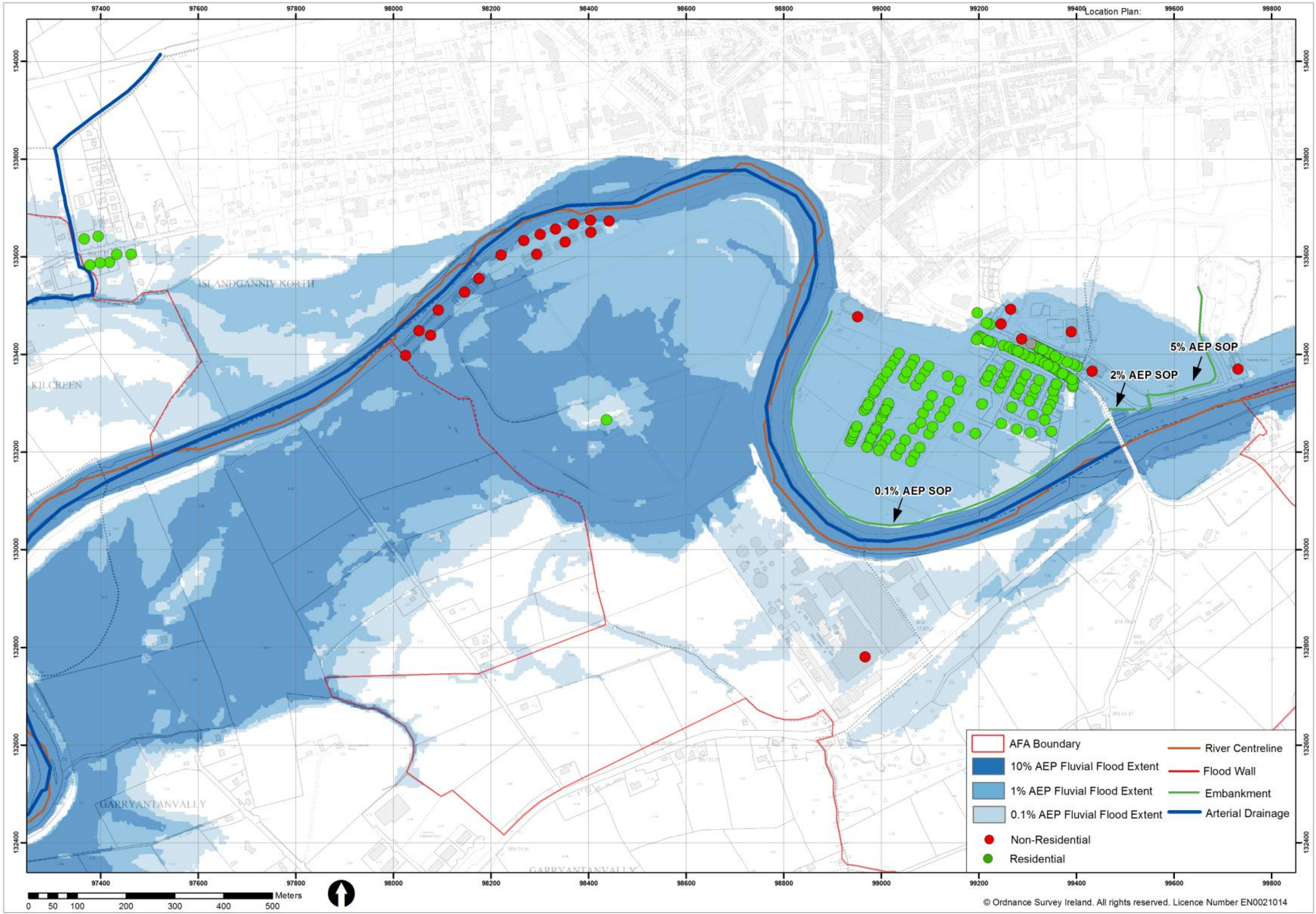

Figure 1.1 – Listowel Fluvial Flood Risk to Properties

Figure 1.2 – Listowel Total PV Damages for Properties within the 1% AEP Fluvial Flood Event and Flood Cells
Flood Cells are groupings of properties that are likely to be hydraulically linked

2. STAGE 2: Screening of the Measures

2.1 Baseline, Structural and Non-Structural Measures

Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.

Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
B	Existing Regime	Viable	Viable	Viable	Viable	Viable	**Screened In**
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
Structural							
D	Storage	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
E	Flow Diversion	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
F	Increase Conveyance	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
G	Flood Defences	Viable	Viable	Viable	Viable	Viable	**Screened In**
H	Relocation of Properties	Unviable	Viable	Viable	Unviable	Viable	**Screened Out**
I	Other Measures	Unviable	Unviable	Unviable	Unviable	Unviable	**Screened Out**
Non-Structural							
J	Flood Forecasting / Warning / Response	Viable	Viable	Viable	Viable	Viable	**Screened In**
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	**Screened In**
L	Individual property resistance	Viable	Viable	Viable	Viable	Viable	**Screened In**
M	Individual property resilience	Viable	Viable	Viable	Viable	Viable	**Screened In**

2.2 Justification for Screened Out Baseline and Structural Measures

The following provides justification on Measures with an overall viability 'Screened Out' categorisation.

A	Do Nothing	Applicability Economic Environmental Social Cultural	Screened out due to the number of properties currently at risk of flooding
C	Do Minimum	Applicability Economic Environmental Social Cultural	Screened out, as the do minimum FRM measure would have a negligible impact to the existing flood risk.
D	Storage	Applicability Economic Environmental Social Cultural	To provide protection to the AFA of Listowel it was calculated that a total storage volume of 6million m^3 would be required. From an examination of the local topography, no suitable area for storage was found. Consideration was also given to increasing the waterlevels in the River Feale as it flow through the agricultural land upstream of the AFA, by indroducing a series of reservoirs. This would reduce flood flows through the town, as more flow would be stored in the floodplains upstream. This measure was unviable as the gradient of the River Feale meant the influence on the waterlevels

			upstream of the weirs was only for a short distance and this had no significant impact on the flood risk in Listowel, see Figure 2.1.
E	Flow Diversion	Applicability Economic Environmental Social Cultural	To provide protection to the AFA of Listowel it was calculated for the 1% AEP event that a flow of 250m^3/s would have to be diverted around the AFA. This would require a channel of 27m in width by 3.5m in depth. The only feasible routes due to the local topography are illustrated in Figure 2.2. One route would require the relocation of two properties, which were not previously at risk from flooding. This option was considered socially unviable. The other route required going through the Kerry Group's plant, which was found to be economically unviable.
F	Increase Conveyance	Applicability Economic Environmental Social Cultural	To provide protection to the AFA of Listowel it was calculated for the 1% AEP event the River Feale would have to be dredged by 1.2m for a length of 2.5km. As the River Feale is a designated cSAC and there are other viable options this measure was not considered. Replacing the N69 bridge was also considered. However, it was found that replacing the existing structure to remove the existing afflux did not alleviate the flood risk to the AFA and this measure was not considered applicable to the area.
H	Relocation of Properties	Applicability Economic Environmental Social Cultural	The relocation of 160 properties is not applicable to the area and is socially unviable.
I	Other Measures	Applicability Economic Environmental Social Cultural	No other Measures have been identified.

2.3 Summary of 'Screened In' Measures

The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.

Baseline Measures		**Non-Structural Measures**	
B	Existing Regime	J	Flood Forecasting / Warning / Response
Structural Measures		K	Public Awareness
G	Flood Defences	L	Individual property resistance
		M	Individual property resilience

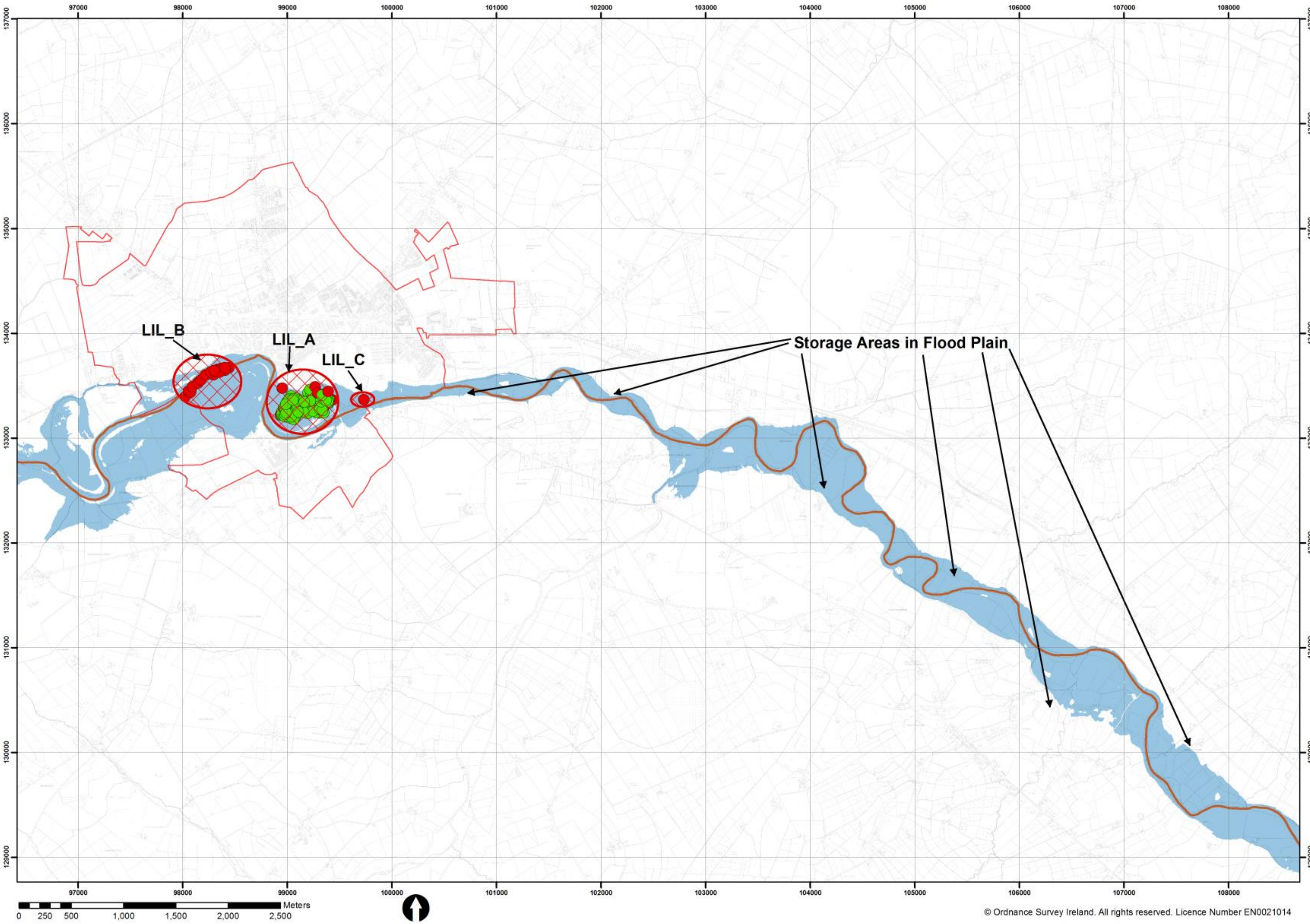

Figure 2.1 – Listowel Screened Out Storage Flood Measure

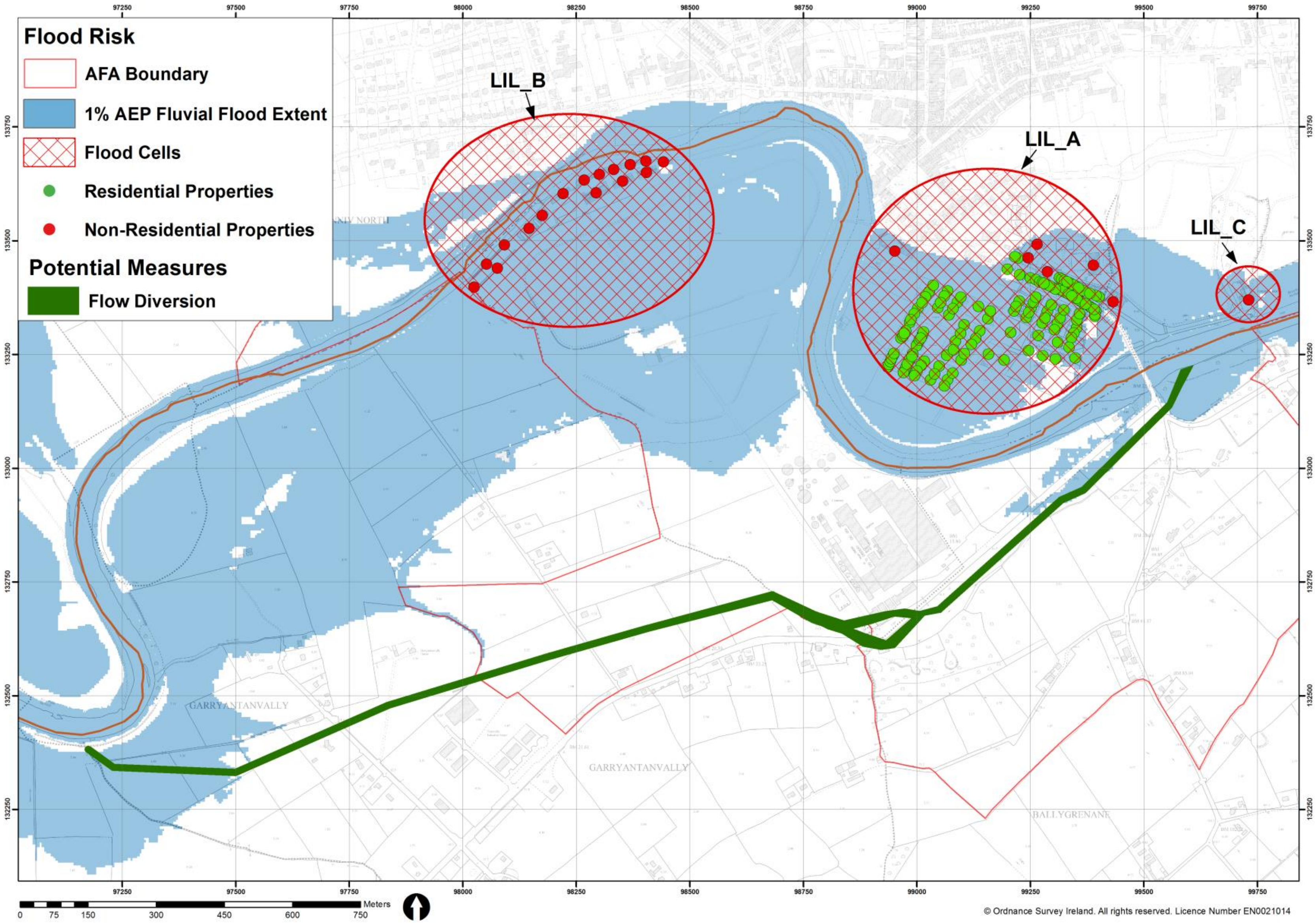

Figure 2.2 – Listowel Screened Out Flow Diversion Flood Measure

3. STAGE 3: Selection of Options

3.1 Consideration of Options

The following are the agreed combination of ‘Screened In’ measures that comprise each of the Options being taken forward for further consideration.

Where appropriate, the ‘Screened In’ measures have been sub-divided into separate specific measures to ensure applicability to site conditions.

Measures		Different composition of measures per option						
Baseline Measures								
B	Existing Regime	✓	✓					
Structural Measures								
G	Flood Defences							
Gi	New Flood Defences							
Gii	Raise Existing Flood Defences	✓	✓					
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
J	Forecasting / Warning / Response		✓					
K	Public Awareness							
L	Individual property resistance		✓					
M	Individual property resilience	✓	✓					
Option Reference		LIL_01	LIL_02					

Measures not screened out but not included in options		
Measures		**Justification for not being included**
K	Public Awareness	Public Awareness was not considered as either an independent measure or in combination with other measures, as the option being appraised would provide the required 1% Fluvial AEP standard of protection. Public Awareness does not improve the viability of the options under consideration.

4. STAGE 4: Appraisal of Options

4.1 Options Appraisal

Each option taken forward for Multi-Criteria Assessment (MCA) analysis is to be discussed at the Option Development Meeting. Below describes this concept design of each option and provides a summary of any significant comments/issues which were raised by LA staff at the Options Development Meetings. These comments will be considered in the local weightings and the MCA scores.

<table>
<tr><td colspan="2">Option Ref:</td><td colspan="4">LIL_01</td></tr>
<tr><td rowspan="3">Option Measures</td><td>Baseline</td><td>B</td><td colspan="3">Existing Regime</td></tr>
<tr><td>Structural</td><td>Gii</td><td colspan="3">Flood Defences: Raise Existing Flood Defences</td></tr>
<tr><td>Non Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="4">This option will provide a 1% Fluvial AEP Design standard to 143 of 160 properties within the AFA and reduce the impact of flood risk to the remaining 17 properties, identified as being at risk, and includes;
Increase the height of existing embankments and locally raise the road in between the defences, to eliminate flood risk to the properties within flood cell LIL_A for the 1% AEP event.
Individual flood resilience measures for the racecourse buildings in LIL_B and Kerry County Council stores and yard in LIL_C.
Existing maintenance regime for the Feale along with a maintenance programme for the improved and existing defences.</td></tr>
<tr><td colspan="2" rowspan="2">Option Development Meeting:</td><td>Date:</td><td colspan="3">10th of June 2015</td></tr>
<tr><td>Summary:</td><td colspan="3">The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.</td></tr>
</table>

<table>
<tr><td colspan="2">Option Ref:</td><td colspan="4">LIL_02</td></tr>
<tr><td rowspan="3">Option Measures</td><td>Baseline</td><td>B</td><td colspan="3">Existing Regime</td></tr>
<tr><td>Structural</td><td>Gii</td><td colspan="3">Flood Defences: Raise Existing Flood Defences</td></tr>
<tr><td>Non Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="4">This option will provide a 1% Fluvial AEP Design standard to 143 of 160 properties within the AFA and reduce the impact of flood risk to the remaining 17 properties, identified as being at risk, and includes;
Increase the height of existing embankments and locally raise the road in between the defences, to eliminate flood risk to the properties within flood cell LIL_A for the 1% AEP event.
Individual flood resilience measures for the racecourse stable buildings at LIL_B.
Individual flood resistance measures for the office and grandstand buildings at the racecourse in LIL_B, and the County Council stores and yard in LIL_C.
Flood forecasting to allow racecourse buildings and pumping station to prepare flood resistance measures, and for the community/council to ensure that the amenity walkway along the river is cleared and appropriate pedestrian diversions are in place.
Existing maintenance regime for the Feale along with a maintenance</td></tr>
</table>

	programme for the improved and existing defences.	
Option Development Meeting:	Date:	The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.
	Summary:	Further to the Options Development Meeting Kerry Co. Co. made us aware of that a Kerry Council Councils stores and yard for Listowel Town and North Kerry is located within the flood extent adjacent the standby pump station.

5. STAGE 5: Multi Criteria Assessment

5.1 Options selected for the Multi Criteria Assessment

Following the Option Development Meeting, the following options are the refined options for the Multi-Criteria Assessment (MCA) stage. This is the final of a five stage MCA process.

Option Reference		LIL_01	LIL_02
Baseline Measures			
B	Existing Regime	Existing River Feale arterial drainage scheme continued throughout AFA from downstream of N69 bridge.	Existing River Feale arterial drainage scheme continued throughout AFA from downstream of N69 bridge.
Structural Measures			
G	Flood Defences		
Gi	New Flood Defences		
Gii	Raise Existing Flood Defences	Existing earth embankments on both left and right banks, over 0.75km, raised by (on average) 1m. Approximately 30m of road is required to be raised to tie into flood defences.	Existing earth embankments on both left and right banks, over 0.75km, raised by (on average) 1m. Approximately 30m of road is required to be raised to tie into flood defences.
Giii	Demountable Defences		
Giv	Other Defences		
Non-Structural Measures			
J	Forecasting / Warning / Response		Simple stage based flood forecasting.
L	Individual property resistance		Individual flood resistance measures for the office and grandstand buildings at the racecourse in LIL_B, and the County Council stores and yard in LIL_C.
M	Individual property resilience	Individual flood resilience measures for the racecourse buildings in LIL_B and Kerry County Council stores and yard in LIL_C.	Individual flood resilience measures for the racecourse stable buildings at LIL_B.
Table reference A summary of the outcome from the MCA is presented in the following table		Table 5.1	Table 5.2

Table 5.1: Multi Criteria Assessment Outcome for Option LIL_01

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**			
AFA	Listowel	Option Ref:	LIL_01
Option Measures			
Baseline	B	Existing Regime	
Structural	Gii	Flood Defences: Raising Existing Flood Defences	
Non-Structural	M	Property Resilience	
Criteria Scores			
Technical	567		
Economic	668		
Social	746		
Environmental	-171		
Economic Values			
Economic PV Benefits	€ 8,369,315		
PV Cost	€ 1,259,812		
NPV Benefits	€ 7,109,503		
Economic BCR	6.64		
Outcome Scores			
MCA PV Benefits	€ 4,732,943		
MCA Benefit Score	1243		
MCA Benefit Score Ratio	986.58		
Option Selection MCA	1810		
Relevant Figure	Figure 5.1		

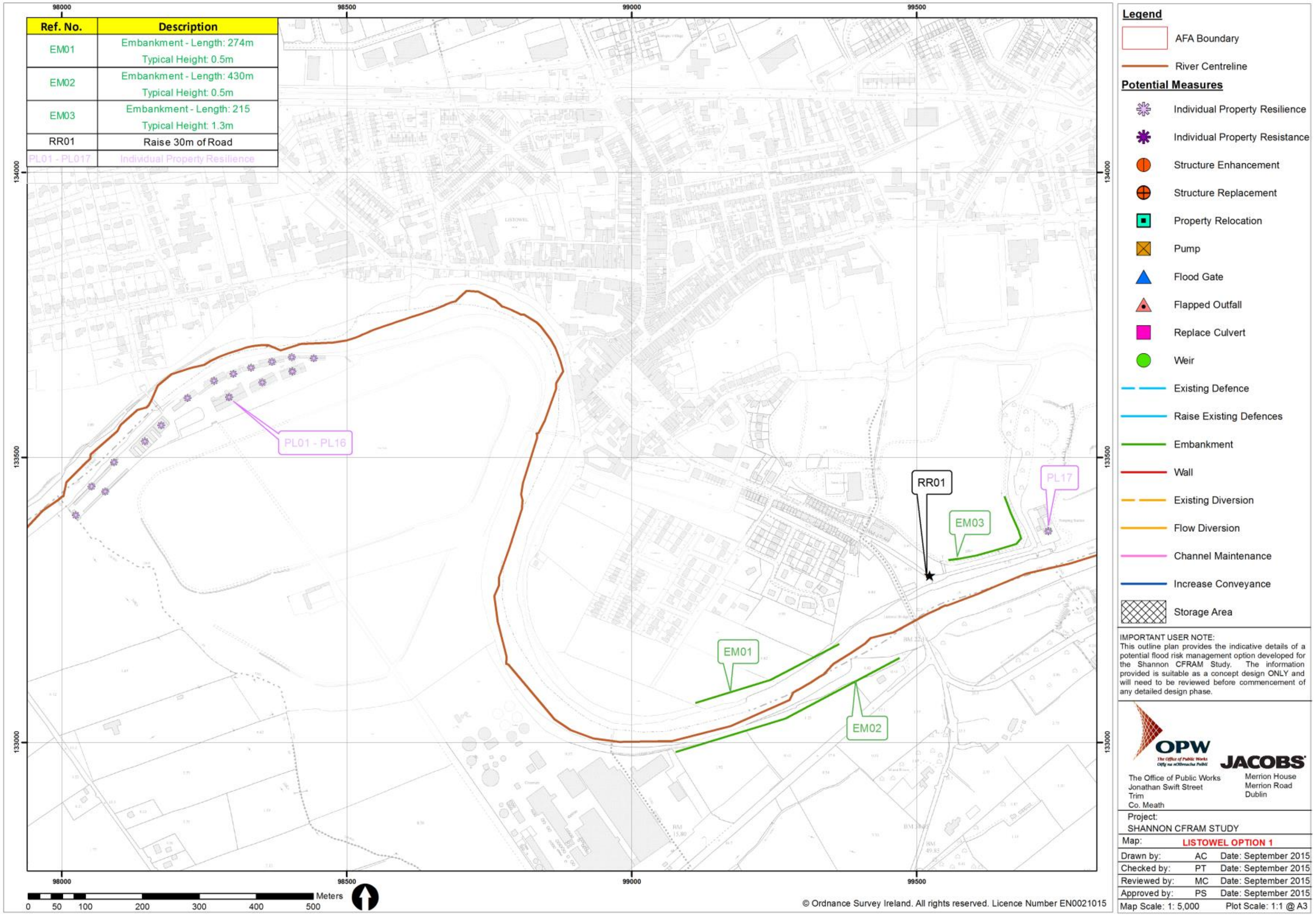

Figure 5.1 Option LIL_01

Table 5.2: Multi Criteria Assessment Outcome for Option LIL_02

<table>
<tr><td colspan="6">Multi Criteria Assessment
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.</td></tr>
<tr><td>AFA</td><td colspan="2">Listowel</td><td>Option Ref:</td><td colspan="2">LIL_02</td></tr>
<tr><td colspan="6">Option Measures</td></tr>
<tr><td>Baseline</td><td>B</td><td colspan="4">Existing Regime</td></tr>
<tr><td>Structural</td><td>Gii</td><td colspan="4">Flood Defences: Raising Existing Flood Defences</td></tr>
<tr><td rowspan="3">Non-Structural</td><td>J</td><td colspan="4">Flood Forecasting</td></tr>
<tr><td>L</td><td colspan="4">Property Resistance</td></tr>
<tr><td>M</td><td colspan="4">Property Resilience</td></tr>
<tr><td colspan="6">Criteria Scores</td></tr>
<tr><td colspan="3">Technical</td><td colspan="3">540</td></tr>
<tr><td colspan="3">Economic</td><td colspan="3">787</td></tr>
<tr><td colspan="3">Social</td><td colspan="3">772</td></tr>
<tr><td colspan="3">Environmental</td><td colspan="3">16</td></tr>
<tr><td colspan="6">Economic Values</td></tr>
<tr><td colspan="3">Economic PV Benefits</td><td colspan="3">€ 8,369,315</td></tr>
<tr><td colspan="3">PV Cost</td><td colspan="3">€ 1,212,109</td></tr>
<tr><td colspan="3">NPV Benefits</td><td colspan="3">€ 7,157,206</td></tr>
<tr><td colspan="3">Economic BCR</td><td colspan="3">6.90</td></tr>
<tr><td colspan="6">Outcome Scores</td></tr>
<tr><td colspan="3">MCA PV Benefits</td><td colspan="3">€ 4,732,943</td></tr>
<tr><td colspan="3">MCA Benefit Score</td><td colspan="3">1350</td></tr>
<tr><td colspan="3">MCA Benefit Score Ratio</td><td colspan="3">1113.63</td></tr>
<tr><td colspan="3">Option Selection MCA</td><td colspan="3">1890</td></tr>
<tr><td colspan="3">Relevant Figure</td><td colspan="3">Figure 5.1</td></tr>
</table>

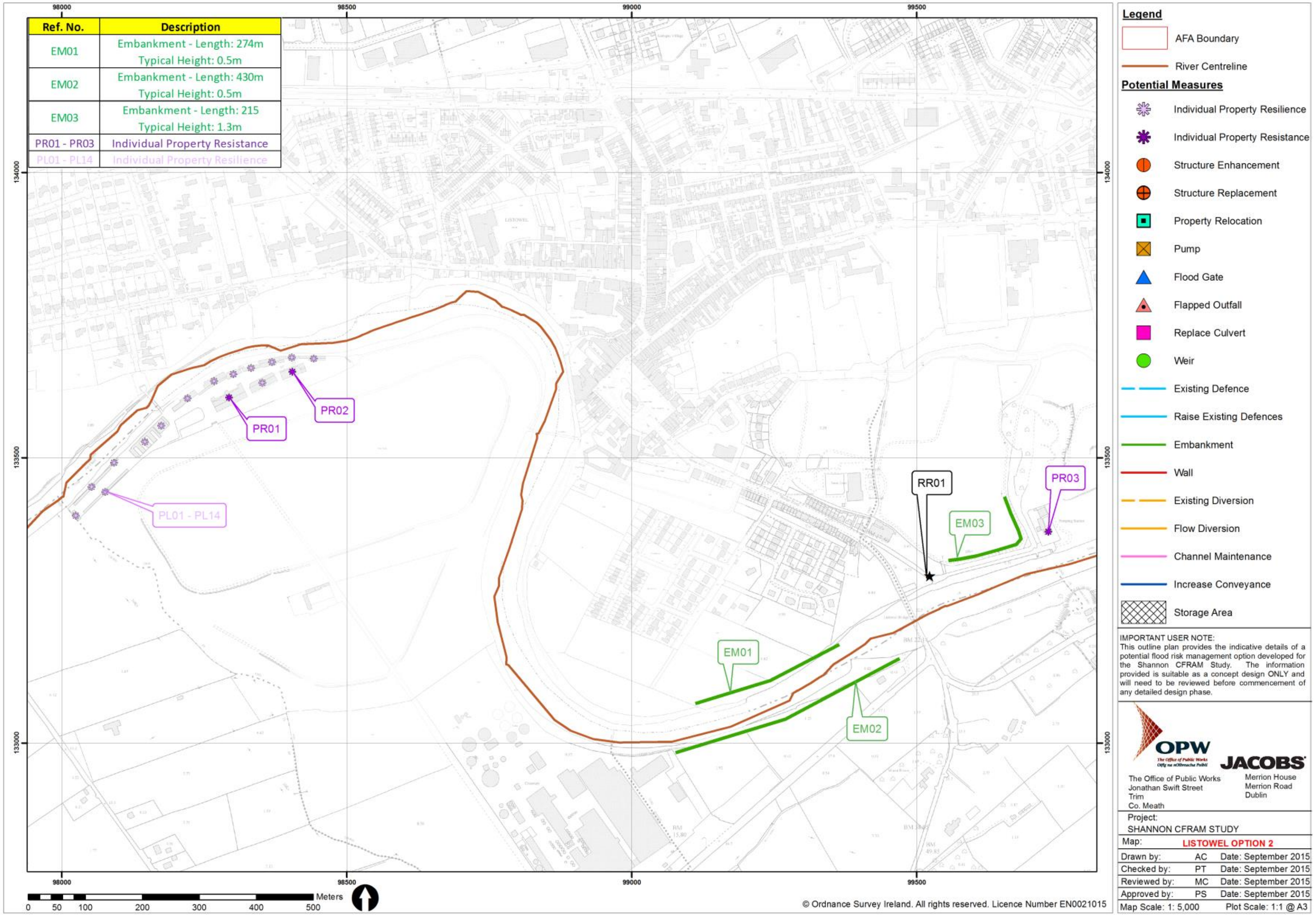

Figure 5.2 Option LIL_02

5.2 Comparison of Multi Criteria Assessment Scores

Each option taken forward for further consideration through the Option Development Meeting has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).

Categories	Option Reference and Results	
	LIL_01	LIL_02
Criteria Scores		
Technical	567	540
Economic	668	728
Social	746	793
Environmental	-171	-171
Economic Values		
Economic PV Benefits	€ 8,369,315	€ 8,369,315
PV Cost	€ 1,259,812	€ 1,212,109
NPV Benefits	€ 7,109,503	€ 7,157,206
Economic BCR	6.64	6.90
Outcome Scores		
MCA PV Benefits	€ 4,732,943	€ 4,732,943
MCA Benefit Score	1243	1350
MCA BCR	986.58	1113.63
Option Selection MCA	1810	1890

5.3 Recommendation of Preferred Option					
It forms part of the CFRAM process for the recommendation of a preferred option for each AFA. The prioritised selection criteria used in this recommendation process is detailed in Section 3.7.3 of the Main Report. Therefore, following the five stage Multi Criteria Assessment process, the preferred option is as outlined below					
Option Ref:		LIL_02			
Option Measures	**Baseline**	**B**	**Existing Regime**		
	Structural	**Gii**	**Flood Defences: Raise Existing Flood Defences**		
	Non Structural	**J** Flood Forecasting	**K** Public Awareness	**L** Property Resistance	**M** Property Resilience
Comments		This option will provide a 1% Fluvial AEP Design standard to 143 of 160 properties within the AFA and reduce the impact of flood risk to the remaining 17 properties, identified as being at risk, and includes; With the higher MCA BCR of 1113.63 LIL_02 is the emerging preferred option.			

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

<table>
<tr><th colspan="5">Fluvial Flood Forecasting Potential</th></tr>
<tr><td rowspan="3">Catchment Information</td><td colspan="2">Gauging Station</td><td rowspan="2">Catchment size (km ^{2})</td><td rowspan="2">Potential available forecast accuracy and reliability period</td></tr>
<tr><td>Fluvial</td><td>Rainfall</td></tr>
<tr><td>23006
23010
23007
23024 (Inactive)
23017
23002</td><td>N*</td><td>653</td><td>3 hours</td></tr>
<tr><td>Relevant Information:</td><td colspan="4">Neodata (GS 23006) 15km upstream of Abbeyfeale
Abbeyfeale (GS 23010) 14km upstream of Abbeyfeale
Oolagh Rly. Bridge (GS 23007) 14km upstream of Abbeyfeale
Knockaunbrack (GS 23008 - Inactive) 13km upstream of Abbeyfeale
Duagh (GS 23024 - Inactive) 8.5km upstream of Abbeyfeale
Trienearagh (GS 23017) 5km upstream of Abbeyfeale
Listowel (GS 23002) lies within the AFA</td></tr>
<tr><td rowspan="3">Additional Infrastructure Recommended</td><td colspan="2">Gauging Station</td><td colspan="2" rowspan="2">Other</td></tr>
<tr><td>Fluvial</td><td>Rainfall</td></tr>
<tr><td>No</td><td>No</td><td colspan="2">No</td></tr>
<tr><td>Relevant Comments:</td><td colspan="4">The existing fluvial gauging stations 23010 and 23017 could provide reasonably accurate and reliable predictions for flooding from the River Feale based on level/level relationships. GS 24010 and 23017 combined represents 82% of the total catchment area. There is no requirement for additional fluvial or rainfall gauges to provide flood forecasting for this AFA.</td></tr>
</table>

Annex A - Multi-Criteria Analysis Summary and Whole Life Cost Summaries for FRM Option(s)

CRITERIA		OBJECTIVE		Global Weighting	Local Weighting	Comments	LIL_01	Option Score	Weighted Score	LIL_02	Option Score	Weighted Score
							B – Existing Regime Gii – Raise Existing Flood Defences M – Individual Property Resilience			B – Existing Regime Gii – Raise Existing Flood Defences J – Flood Forecasting / Warning / Response M – Individual Property Resilience L – Individual Property Resistance		
1	Technical	a	Ensure flood risk management options are operationally robust	20	5.00	The option scores are determined based on the level of operational risk to operate or perform successfully. Each measure is scored independently and the average of the measure scores is used as the score for the option.	No risks / Manageable Negligible / Moderate / high Very low / High Low / Failure likely Low / moderate / Unacceptable B 3.00 Gii 4.00 M 2.00	3.00	300	No risks / Manageable Negligible / Moderate / high Very low / High Low / Failure likely Low / moderate / Unacceptable B 3.00 Gii 4.00 J 1.00 M 2.00 L 0.00	2.00	200
		b	Minimise health and safety risks associated with the construction and operation of flood risk management options	20	5.00	H&S risks are considered for construction and maintenance of flood risk management measures. The indicative aspirational score is set at five, with a point then deducted for each specific H&S risk in either construction or maintenance.	No risks / Moderate Negligible / Moderate / high Very low / High Low / Very High Low / moderate / Unacceptable Work near/in water Work near/in water	2.00	200	No risks / Moderate Negligible / Moderate / high Very low / High Low / Very High Low / moderate / Unacceptable Work near/in water Work near/in water	2.00	200
		c	Ensure flood risk management options are adaptable to future flood risk	20	5.00	The options scores are determined based on the sustainability and adaptability of the flood risk management measures in the face of potential future changes, including the potential impact of climate change. Each measure is scored independently and the average of the measure scores is used as the score for the option.	Option can be adapted at no to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. B 1.00 Gii 1.00 M 0.00	0.67	67	Option can be adapted at no to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. B 1.00 Gii 1.00 J 5.00 M 0.00 L 0.00	1.40	140
			TECHNICAL CRITERIA SCORE						567			540
2	Economic	a	Minimise economic risk	24	4.63		The score is calculated based on the reduction in AAD, following the full implementation of option.	3.56	395	The score is calculated based on the reduction in AAD, following the full implementation of option.	3.62	402
		b	Minimise risk to transport infrastructure	10	5.00		The score is calculated based on the reduction in flood risk to transport routes, following the full implementation of option.	0.00	0	The score is calculated based on the reduction in flood risk to transport routes, following the full implementation of option.	0.20	10
		c	Minimise risk to utility infrastructure	14	5.00		The score is calculated based on a reduction in flood risk to utility infrastructure, following the full implementation of option.	4.50	315	The score is calculated based on a reduction in flood risk to utility infrastructure, following the full implementation of option.	4.52	316
		d	Minimise risk to agriculture	12	3.50	Source of Flooding: Fresh Water Percentage of AFA that is rural land: 6.40%	Area of Agricultural Land Flooded: Increased Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: No Change Flood Warning: Not Applicable Agricultural Production Enhanced: No Change Other (Please Specify): Not Applicable	-1.00	-42	Area of Agricultural Land Flooded: Increased Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: No Change Flood Warning: Applicable Agricultural Production Enhanced: No Change Other (Please Specify): Not Applicable	0.00	0
			ECONOMIC CRITERIA SCORE						668			728
3	Social	a i)	Minimise risk to human health and life - Residents	27	5.00	Flood Depths & Velocities: Medium to high risk to life Known Areas of Highly Vulnerable People: Reasonable Cross Section of Society	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	4.00	539	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	4.20	566
		a ii)	Minimise risk to human health and life - High vulnerability properties	17	0.00	Rate of Onset of flooding: Assumed 1-2 hours for evacuation	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	0.00	0	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	1.00	0
		b i)	Minimise risk to community - Social Infrastructure & Amenity	9	5.00	Assets of Particular Social Value: Yes	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	1.04	47	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	1.14	51
		b ii)	Minimise risk to community - Local employment	7	5.00	Asset of Particular Employment Value: Yes	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	4.56	160	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	5.00	175
			SOCIAL CRITERIA SCORE						746			793
4	Environmental	a	Support the objectives of the WFD	16	5.00	The River Feale is of good status. The River is part of the lower Shannon cSAC. There is one drinking water abstraction point within the AFA and downstream of Listowel Town there is an area designated for drinking water. Local weighting to be applied for this objective is constant, and should always be set equal to 5 as WFD objectives must be achieved and are relevant to all waterbodies.	Potential short term construction impacts that can be mitigated. Therefore a potential for short-term impediment to the achievement of WB objectives.	-1.00	-80	Potential short term construction impacts that can be mitigated. Therefore a potential for short-term impediment to the achievement of WB objectives.	-1.00	-80
		b	Support the objectives of the Habitats Directive	10	5.00	There is 1 cSAC within AFA the Lower River Shannon cSAC 002165. Qualifying interests potentially within the AFA include otter, river, brook and sea lamprey, Atlantic salmon, floating river vegetation and FWPM. The status of the River Feale in Listowel is "Good". Local weighting by professional judgement set to 5 where an internationally important site (e.g. SAC/SPA/Ramsar) is present (within AFA) and potentially affected.	Potentially significant effects are: - Pollution risks to the River Feale (in particular siltation risks to Freshwater Pearl Mussel) - Risk of disturbance to otter or their resting sites during proposed works - Risk of invasive species spread during proposed works Therefore, potential detrimental impact upon existing cSAC site, including a delay in recovery of the site, but excluding impacts on the conservations objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	-1.00	-50	Potentially significant effects are: - Pollution risks to the River Feale (in particular siltation risks to Freshwater Pearl Mussel) - Risk of disturbance to otter or their resting sites during proposed works - Risk of invasive species spread during proposed works Therefore, potential detrimental impact upon existing cSAC site, including a delay in recovery of the site, but excluding impacts on the conservations objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	-1.00	-50
		c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	5	2.00	There are no nationally designated sites within the AFA, but there is potential for significant habitats and populations of European and nationally protected species, particularly associated with the River Feale. The River Feale is within a FWPM Catchments with extant populations (not SAC populations listed in S.I. 296 of 2009). Local weighting by professional judgement set to 2 where there are no designated sites but habitats/species are likely to be present that could be affected.	There are no nationally designated sites within the AFA, therefore no potential impact these however , there is potential for habitats and populations of European and nationally protected species, particularly associated with the River Feale to be effected. Potentially significant effects are due to: - Increases in suspended sediment - Pollution risks to the River Felae - Risk of disturbance to protected species or their resting sites - Risk of invasive species spread during proposed works - Loss of riparian habitat - Impact to fish species includes salmon and lamprey - Loss of life to FWPM due to siltation Therefore, potential localised loss of or disturbance to flora/fauna.	-1.00	-10	There are no nationally designated sites within the AFA, therefore no potential impact these however , there is potential for habitats and populations of European and nationally protected species, particularly associated with the River Feale to be effected. Potentially significant effects are due to: - Increases in suspended sediment - Pollution risks to the River Felae - Risk of disturbance to protected species or their resting sites - Risk of invasive species spread during proposed works - Loss of riparian habitat - Impact to fish species includes salmon and lamprey - Loss of life to FWPM due to siltation Therefore, potential localised loss of or disturbance to flora/fauna.	-1.00	-10
		d	Protect, and where possible enhance, fisheries resource within the catchment	13	3.00	The River Feale is designated as a Salmonid River (under the Salmonid Regulations) and is considered a high activity angling area. Local weighting of 3 set by professional judgement. Weighting of 3 applied where a waterbody supports substantial fisheries and is of regional value for fishing/angling.	Potential short term construction impacts that can be mitigated. Therefore, potential short-term minor impacts to fisheries habitat	-1.00	-39	Potential short term construction impacts that can be mitigated. Therefore, potential short-term minor impacts to fisheries habitat.	-1.00	-39
		e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	8	1.00	The AFA (Listowel) is a small heritage town however, there are no landscape designations within the AFA. The Sive walk along the River Feale is a local walking trail. Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected.	There will be construction related impacts to the Sive walk. The option will require the raising of the embankment on the landside of the Sive walk. The Sive walk will continue to flood during the 1 %AEP. Therefore, a potential long term impact to a low sensitivity landscape character/feature in the zone of visibility of the selected measure.	-1.00	-8	There will be construction related impacts to the Sive walk. The option will require the raising of the embankment on the landside of the Sive walk. The Sive walk will continue to flood during the 1 %AEP. Therefore, a potential long term impact to a low sensitivity landscape character/feature in the zone of visibility of the selected measure.	-1.00	-8
		f i)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of architectural value	4	2.00	The AFA (Listowel) is a small heritage town. The ACA within the AFA falls within the 1% AEP. One RPS/NIAH falls within the 1%AEP. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a moderate to low vulnerability.	The option will reduce the potential for flooding in the 1% AEP for 1 RPS/NIAH and 400m2 of ACA. Therefore, there is a potential increase in the level of protection for architectural features (RPS, NIAH and ACA) from flooding, such that it is less vulnerable to flood damage.	1.00	8	The option will reduce the potential for flooding in the 1% AEP for 1 RPS/NIAH and 400m2 of ACA. Therefore, there is a potential increase in the level of protection for architectural features (RPS, NIAH and ACA) from flooding, such that it is less vulnerable to flood damage.	1.00	8
		f ii)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of archaeological value	4	2.00	The AFA (Listowel) is a heritage town with one National Monument in State care which falls just outside the 1%AEP. There is one RMP that falls within the 1% AEP. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are a number of sites listed on the RMP/RPS present and potentially affected (moderate to low vulnerability).	The option will reduce the potential for flooding in the 1% AEP in the vicinity of a National Monument in State care. There will be no change to the potential flooding of the RMP. Therefore, there is the removal of negative elements from the setting of archaeological features (Recorded Monuments) so that it's setting is enhanced.	1.00	8	The option will reduce the potential for flooding in the 1% AEP in the vicinity of a National Monument in State care. There will be no change to the potential flooding of the RMP. Therefore, there is the removal of negative elements from the setting of archaeological features (Recorded Monuments) so that it's setting is enhanced.	1.00	8
			ENVIRONMENTAL CRITERIA SCORE						-171			-171
Economic Values			Economic PV Benefits					€8,369,315			€8,369,315	
			Cost					€1,259,812			€1,212,109	
			NPV Benefits					€7,109,503			€7,157,206	
			Economic BCR					**6.64**			**6.90**	
Outcome Scores			MCA PV Benefits					€4,732,943			€4,732,943	
			MCA Benefit Score					1243			1350	
			MCA BCR					**986.58**			**1113.63**	
			Option Selection MCA					1810			1890	

Objective	Global Weightings (fixed)	Local Weightings		Baseline / Local Weighting Comments	Option 1 Comments	Option 2 Comments
1.A	20	5.00	fixed	Local weighting is fixed	This score is determined for this option as it has very low operational risks to operate or perform successfully.	This score is determined for this option as it has low operational risks to operate or perform successfully.
1.B	20	5.00	fixed	Local weighting is fixed	This score is determined for this option as it has low health and safety risks associated with the construction and operation of flood risk management option.	This score is determined for this option as it has low health and safety risks associated with the construction and operation of flood risk management option.
1.C	20	5.00	fixed	Local weighting is fixed	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.
2.A	24	4.63	calculated	Local weighting is calculated based on the baseline AAD.	This score is calculated based on the reduction in AAD, following the full implementation of option.	This score is calculated based on the reduction in AAD, following the full implementation of option.
2.B	10	5.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to transport infrastructure. Significant delays have been noted but the calculated local weighting has not been increased as it is already at the maximum value permissible.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.
2.C	14	5.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to utility infrastructure. Calculated local weighting is at maximum permissible value. Althought the utility is a back up it does flood in low return period, therefore this score has not been adjusted.	This score is calculated based on a reduction in flood risk to utility infrastructure, following full implementation of option.	This score is calculated based on a reduction in flood risk to utility infrastructure, following full implementation of option.
2.D	12	3.50	Professional judgement	Local weighting has been set at 3.5 which considers the following - there is limitied agricultural land within the AFA at risk of flooding. - there is significant agricultural land downstream of the AFA at risk of flooding - The loss of Kerry Group to a flood event would have a significant impact to the farming community.	This score is determined based on the increased area of agricultural land flooded following full implementation of the option.	This score is determined based on the increased area of agricultural land flooded and the presence of flood forecasting, following full implementation of the option.
3.A (i)	27	5.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to residential properties. Although the depth of flooding are greater than 600mm and could pose a risk to life, the calculated local weighting has not been increased as it is at the maximum value permissible.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option. The option score has ben increased by 5% due to presence of flood forecasting.
3.A (ii)	17	0.00	calculated but adjusted by professional judgement if necessary	There are no high vulnerability properties at risk.	There is no risk to high vulnerability properties within the AFA.	There is no risk to high vulnerability properties within the AFA.
3.B (i)	9	5.00	calculated but adjusted by professional judgement if necessary	The calculated local weighting is at the maximum permissible value of 5, which is representative of the number of receptors at risk of flooding. Therefore no adjustment was made to the weighting.	Local weighting is calculated based on the baseline risk to social infrastructure.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option. This option includes flood forecasting allowing the walkway along the river to be evacuated, therefore the option score is improved by 10%.
3.B (ii)	7	5.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to local employment. Preliminary Local Weighting has been increased by 20% to account for Kerry Group as an significant local employer (but capped at a maximum weighting of 5).	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option. The Option Score has been increased by 10% to account for the presence of flood forecasting (capped at a maximum score of 5).
4.A	16	5.00	fixed	One European site within AFA and hydrologically connected to it. Lower River Shannon cSAC Qualifying interests likely to occur within the AFA include otter, river, brook and sea lamprey, Atlantic salmon, and floating river vegetation. The biological water quality of the River Feale in Listowel is of "Good Status", according to the EPA. However the sensitivity of Freshwater Pearl Mussel to siltation means the cSAC remains vulnerable to localised pollution incidents.	Potential short term construction impacts that can be mitigated	Potential short term construction impacts that can be mitigated
4.B	10	5.00	Professional judgement	One European site within AFA and hydrologically connected to it. Lower River Shannon cSAC Qualifying interests likely to occur within the AFA include otter, river, brook and sea lamprey, Atlantic salmon, and floating river vegetation. The biological water quality of the River Feale in Listowel is of "Good Status", according to the EPA. However the sensitivity of Freshwater Pearl Mussel to siltation means the cSAC remains vulnerable to localised pollution incidents.	No likely significant effects subject to mitigation implementation in full. Which include otter and invasive species surveys, and development of pollution control measures for freshwater pearl mussel, lamprey, and aquatic habitats.	No likely significant effects subject to mitigation implementation in full. Which include otter and invasive species surveys, and development of pollution control measures for freshwater pearl mussel, lamprey, and aquatic habitats.
4.C	5	1.00	Professional judgement	There are no nationally designated sites within the AFA, but there is potential for significant habitats and populations of European and nationally protected species, particularly associated with wetland habitats. Features of particular vulnerability are potential Annex 1-qualiy oak woodlands and marsh fritillary, as both are at unfavourable conservation status nationally, and both could be significantly affected by flooding.	Neutral . Potential for positive impact to local flora and fauna if species-rich planting mix used in proposed flood embankment.	Neutral . Potential for positive impact to local flora and fauna if species-rich planting mix used in proposed flood embankment.
4.D	13	3.00	Professional judgement	The River Feale is designated as a Salmonid River which is a high activity angling area	Potential short term construction impacts that can be mitigated.	Potential short term construction impacts that can be mitigated.
4.E	8	1.00	Professional judgement	Listowel is a small heritage town however there are no landscape planning designations within the AFA. The Sive walk along the River Feale is a local walking trail.	Three will be construction related impact to the Sive walk. The option will require the raising of the embankment on the landside of the Sive walk. There Sive walk will continue to flood during the 1 AEP.	Three will be construction related impact to the Sive walk. The option will require the raising of the embankment on the landside of the Sive walk. There Sive walk will continue to flood during the 1 AEP.
4.F(i)	4	3.00	Professional judgement	Listowel is a heritage town. The Market Square ACA fall within the 1% AEP. One RPS/NIAH fall within the 1%AEP flood extent.	The option will reduce the potential for flooding in the 1% AEP for 1 RPS/NIAH and 400m2 of ACA.	The option will reduce the potential for flooding in the 1% AEP for 1 RPS/NIAH and 400m2 of ACA.
4.F(ii)	4	3.00	Professional judgement	Listowel is a heritage town with one National Monument in State care. This falls just outside the 1%AEP flood extent. There is one RMP that fall within the 1% AEP.	The option will reduce the potential for flooding in the 1% AEP in the vicinity of a National Monument in State care. There will be no change to the potential flooding of the RMP.	The option will reduce the potential for flooding in the 1% AEP in the vicinity of a National Monument in State care. There will be no change to the potential flooding of the RMP.

Option 1 Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis					Notes to CFRAM Consultants
		€	€	€	
(1) Basic Construction Costs (Estimate)				**481,004**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2) Preliminaries	21.4%			**102,952**	Refer to UCD for selecting Preliminaries. %
Sub-Total:				**583,956**	
(3) Optimism Bias	40.0%			**233,582**	Refer to UCD for selecting OB %
(4) Construction Costs (Excl VAT)				**817,538**	
(5) Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)	13.0%			**106,280**	Set at 13%
Construction Costs and Fees				**923,818**	
(6) Other Items					
(a) Allowance for Archaeology & Environmental Mitigation Measures	10.0%		81,754		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b) Allowance for compensation and land acquisition	15.0%		122,631		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c) Site investigation	4% assumed		19,240		Professional judgement to be applied in estimating a suitable sum.
(d) Art Allowance			25,500		See “Guidance E – Per Cent for Art Note”
(e) Est. NPV Operation & Maintenance		62,050			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
Optimism Bias	40.0%	24,820	86,869	**335,994**	Refer to UCD for selecting OB %
Option Cost for Cost Benefit Analysis				**1,259,812**	

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	**J. Reynolds**	**Date:**	25/05/2015
Checked by:	**M. Conlon**	**Date:**	25/05/2015

Project reference	S14a	**Project name:**	Listowel - LIL_01
Base date for estimates (year 0)	Oct-2013	**Construction Price Index (CPI)**	**0.987**
Scaling factor (e.g. €m, €k, €)	€	**Method Factor - to take into account particular site issues /constraints**	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	**Cost (€)**	**Comment**
Total wall costs		
Total embankment costs	€151,179	*assuming imported fill, no piles*
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs	€23,352	*~30m of road raised to tie into existing defences.*
Total individual property protection costs	€313,032	*resilience costs for all properties still at risk after instalation of*
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€487,563	
Apply update to unit rate (CPI) if appropriate (cell N15)	€481,004	
Enter appropriate preliminaries estimate (%)	21%	*ref: Preliminaries and other costs v1.0*
Enter other applicable costs (€)		
Total capital cost (€)	€583,956	
Consider amendments based on site issues/constraints (cell N16)	€583,956	
Total capital cost (€)	€583,956	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs		
Total embankment O&M costs	€2,907	*average O&M costs assumed*
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs	€0	*assumed maintained under current regime.*
Total individual property protection O&M costs	€0	*Resilience assumed to have negligible O&M*
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€2,907	

Other costs	**Cost (€)**	**Comment**
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€646,006	
Optimism bias rate (from external sheet)	40%	*ref: S14a Optimism Bias Tool v2.0*
Total Cost including Optimism Bias	€904,408	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€583,956
Annual maintenance cost (€)	€2,907
Other cost (€)	€0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**	**22.341**			**Total PVc (€k):**	**646006**
	Cash sum	0	583956	142466	0	726422	**646006**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	583956			583956.0	583956.0
1	0.962			2907		2907.5	2795.6
2	0.925			2907		2907.5	2688.1
3	0.889			2907		2907.5	2584.7
4	0.855			2907		2907.5	2485.3
5	0.822			2907		2907.5	2389.7
6	0.790			2907		2907.5	2297.8
7	0.760			2907		2907.5	2209.4
8	0.731			2907		2907.5	2124.5
9	0.703			2907		2907.5	2042.7
10	0.676			2907		2907.5	1964.2
11	0.650			2907		2907.5	1888.6
12	0.625			2907		2907.5	1816.0
13	0.601			2907		2907.5	1746.1
14	0.577			2907		2907.5	1679.0
15	0.555			2907		2907.5	1614.4
16	0.534			2907		2907.5	1552.3
17	0.513			2907		2907.5	1492.6
18	0.494			2907		2907.5	1435.2
19	0.475			2907		2907.5	1380.0
20	0.456			2907		2907.5	1326.9
21	0.439			2907		2907.5	1275.9
22	0.422			2907		2907.5	1226.8
23	0.406			2907		2907.5	1179.6
24	0.390			2907		2907.5	1134.3
25	0.375			2907		2907.5	1090.6
26	0.361			2907		2907.5	1048.7
27	0.347			2907		2907.5	1008.4
28	0.333			2907		2907.5	969.6
29	0.321			2907		2907.5	932.3
30	0.308			2907		2907.5	896.4
31	0.296			2907		2907.5	861.9
32	0.285			2907		2907.5	828.8
33	0.274			2907		2907.5	796.9
34	0.264			2907		2907.5	766.3
35	0.253			2907		2907.5	736.8
36	0.244			2907		2907.5	708.5
37	0.234			2907		2907.5	681.2
38	0.225			2907		2907.5	655.0
39	0.217			2907		2907.5	629.8
40	0.208			2907		2907.5	605.6
41	0.200			2907		2907.5	582.3
42	0.193			2907		2907.5	559.9
43	0.185			2907		2907.5	538.4
44	0.178			2907		2907.5	517.7
45	0.171			2907		2907.5	497.8
46	0.165			2907		2907.5	478.6
47	0.158			2907		2907.5	460.2
48	0.152			2907		2907.5	442.5
49	0.146			2907		2907.5	425.5

Option 2 Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis			€	€	€	Notes to CFRAM Consultants
(1)	**Basic Construction Costs (Estimate)**				**447,764**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2)	**Preliminaries**	21.7%			**97,281**	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				**545,045**	
(3)	**Optimism Bias**	40.0%			**218,018**	Refer to UCD for selecting OB %
(4)	**Construction Costs (Excl VAT)**				**763,062**	
(5)	**Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)**	13.0%			**99,198**	Set at 13%
	Construction Costs and Fees				**862,261**	
(6)	**Other Items**					
(a)	Allowance for Archaeology & Environmental Mitigation Measures	10.0%		76,306		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b)	Allowance for compensation and land acquisition	15.0%		114,459		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c)	Site investigation	4% assumed		17,911		Professional judgement to be applied in estimating a suitable sum.
(d)	Art Allowance			25,500		See “Guidance E – Per Cent for Art Note”
(e)	Est. NPV Operation & Maintenance		82,623			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	40.0%	33,049	115,672	**349,848**	Refer to UCD for selecting OB %
	Option Cost for Cost Benefit Analysis				**1,212,109**	

JBA consulting

DONNACHADH O'BRIEN & ASSOCIATES CONSULTING ENGINEERS

OPW The Office of Public Works / Oifig na nOibreacha Poiblí

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	**J. Reynolds**	**Date:**	**25/05/2015**
Checked by:	**M. Conlon**	**Date:**	**25/05/2015**

Project reference	S14a	**Project name:**	Listowel - LIL_02
Base date for estimates (year 0)	Oct-2013	**Construction Price Index (CPI)**	**0.987**
Scaling factor (e.g. €m, €k, €)	€	**Method Factor - to take into account particular site issues /constraints**	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	**Cost (€)**	**Comment**
Total wall costs		
Total embankment costs	€151,179	*assuming imported fill, no piles*
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs	€23,352	*~30m of road raised to tie into existing defences.*
Total individual property protection costs	€262,560	*resistance for racecourse grandstand and office, and council depot. Resilience for stables.*
Total hydrometric gauging station costs		
Total flood forecasting costs	€16,779	*assuming 2no. single site alarms forecast*
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€453,870	
Apply update to unit rate (CPI) if appropriate (cell N15)	€447,764	
Enter appropriate preliminaries estimate (%)	22%	*ref: Preliminaries and other costs v1.0*
Enter other applicable costs (€)		
Total capital cost (€)	€545,045	
Consider amendments based on site issues/constraints (cell N16)	€545,045	
Total capital cost (€)	€545,045	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs		
Total embankment O&M costs	€2,907	*average O&M costs assumed*
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs	€0	*assumed maintained under current regime.*
Total individual property protection O&M costs	€564	*O&M for resistance at office, grandstand, and depot*
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs	€400	*assuming 2no. single site alarms forecast*
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€3,871	

Other costs	**Cost (€)**	**Comment**
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€627,667	
Optimism bias rate (from external sheet)	40%	*ref: S14a Optimism Bias Tool v2.0*
Total Cost including Optimism Bias	€878,734	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€545,045
Annual maintenance cost (€)	€3,871
Other cost (€)	€0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**		**Total PVc (€k):**	**627667**
	Cash sum	0	545045	189702	0	734746	**627667**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	545045			545044.6	545044.6
1	0.962			3871		3871.5	3722.6
2	0.925			3871		3871.5	3579.4
3	0.889			3871		3871.5	3441.7
4	0.855			3871		3871.5	3309.3
5	0.822			3871		3871.5	3182.1
6	0.790			3871		3871.5	3059.7
7	0.760			3871		3871.5	2942.0
8	0.731			3871		3871.5	2828.8
9	0.703			3871		3871.5	2720.0
10	0.676			3871		3871.5	2615.4
11	0.650			3871		3871.5	2514.8
12	0.625			3871		3871.5	2418.1
13	0.601			3871		3871.5	2325.1
14	0.577			3871		3871.5	2235.7
15	0.555			3871		3871.5	2149.7
16	0.534			3871		3871.5	2067.0
17	0.513			3871		3871.5	1987.5
18	0.494			3871		3871.5	1911.1
19	0.475			3871		3871.5	1837.6
20	0.456			3871		3871.5	1766.9
21	0.439			3871		3871.5	1698.9
22	0.422			3871		3871.5	1633.6
23	0.406			3871		3871.5	1570.8
24	0.390			3871		3871.5	1510.3
25	0.375			3871		3871.5	1452.3
26	0.361			3871		3871.5	1396.4
27	0.347			3871		3871.5	1342.7
28	0.333			3871		3871.5	1291.0
29	0.321			3871		3871.5	1241.4
30	0.308			3871		3871.5	1193.6
31	0.296			3871		3871.5	1147.7
32	0.285			3871		3871.5	1103.6
33	0.274			3871		3871.5	1061.1
34	0.264			3871		3871.5	1020.3
35	0.253			3871		3871.5	981.1
36	0.244			3871		3871.5	943.4
37	0.234			3871		3871.5	907.1
38	0.225			3871		3871.5	872.2
39	0.217			3871		3871.5	838.6
40	0.208			3871		3871.5	806.4
41	0.200			3871		3871.5	775.4
42	0.193			3871		3871.5	745.5
43	0.185			3871		3871.5	716.9
44	0.178			3871		3871.5	689.3
45	0.171			3871		3871.5	662.8
46	0.165			3871		3871.5	637.3
47	0.158			3871		3871.5	612.8
48	0.152			3871		3871.5	589.2
49	0.146			3871		3871.5	566.6

Appendix C2 Option Appraisal Report - Abbeyfeale

1. Preliminary Report: Summary of Current Flood Risk

1.1 AFA and Watercourse Details

AFA	Abbeyfeale
Unit of Management:	23
Primary Watercourse(s):	River Feale River Allaghaun River Oolagh

1.2 Summary of Flood Risk in 1% Fluvial AEP Event

Source of flood risk	**Fluvial**	Coastal	Both	
Total Number of Properties at risk in AFA in 1% Fluvial AEP Event:		**Residential**	**Non-Residential**	**Total**
	Fluvial	2	2	4
AFA Flood Cells:	**Total Number:**	1		
	Flood Cell Titles:	ABB_A		
Breakdown of properties at risk per Flood Cell:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	ABB_A	2	2	4
Relevant Comments:	Although there is only one flood cell in Abbeyfeale, the source of the flood risk is from both the River Feale and the River Allaghaun.			
Relevant Figure Ref:	Figure 1.1 to 1.2			

1.3 Summary of Existing Flood Risk Management Measures

Arterial Drainage	**Storage**	**Flow Diversion**	**Flood Defences**	**Level Control**	**Other**
None	None	None	None	None	**Yes**

Relevant Comments:	The OPW have carried out emergency works to the River Allaghaun upstream of the railway road bridge. These works were required to stop subsidence of the property on the right bank. Apart from these works, there is no existing maintenance regime on the River Allaghaun, the River Feale, or the River Oolagh in Abbeyfeale.

1.4 Summary of PV Damages/Potential PV Benefits

Total PV Damages:		**Uncapped**	**Capped**	
	Fluvial	€ 287,462	€ 287,462	
Max Capped Benefits 1% Fluvial AEP Event*:	€ 203,644			
Breakdown of Max Capped PV benefits per Flood Cell for 1% AEP Event:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	ABB_A	€ 11,820	€ 191,824	€ 203,644
Relevant Figure Ref:	Figure 1.2			

*These are the maximum benefits available if a FRM option with a 1% Fluvial AEP SOP is provided to all properties within the AFA.

1.5 Social Risk		
	Type	**Description**
High Vulnerability Properties at risk:	None	N/A
Social Infrastructure Assets:	None	N/A
Social Amenity Sites:	None	N/A
Relevant Figure Ref:	General Risk - Social	
1.6 Risk to the Environment		
	Type	**Description**
Risk to WFD Annex IV:	Drinking Water	The section of the River Feale adjacent to Abbeyfeale is designated as drinking water under the WFD.
Risk to SACs:	cSAC	The River Feale itself and lands to the right and left of the watercourse are designated candidate Special Area of Conservation (the Lower Shannon cSAC).
Relevant Figure Ref:	General Risk - Environment	
1.7 Risk to Cultural Heritage		
	Type	**Description**
Risk to Sites of Cultural Heritage:	NIAH	**50% AEP Flood Extent**
		R524 bridge on River Allaghaun is a structure of significant structural importance as it has been listed an NIAH structure.
Relevant Figure Ref:	General Risk – Cultural Heritage	
1.8 Risk to the Economy		
	Type	**Description**
Risk to Transport Infrastructure:	Regional Route	**50% AEP Flood Extent**
		R524
		R555
Risk to Utility Infrastructure:	None	N/A
Relevant Figure Ref:	General Risk - Economy	

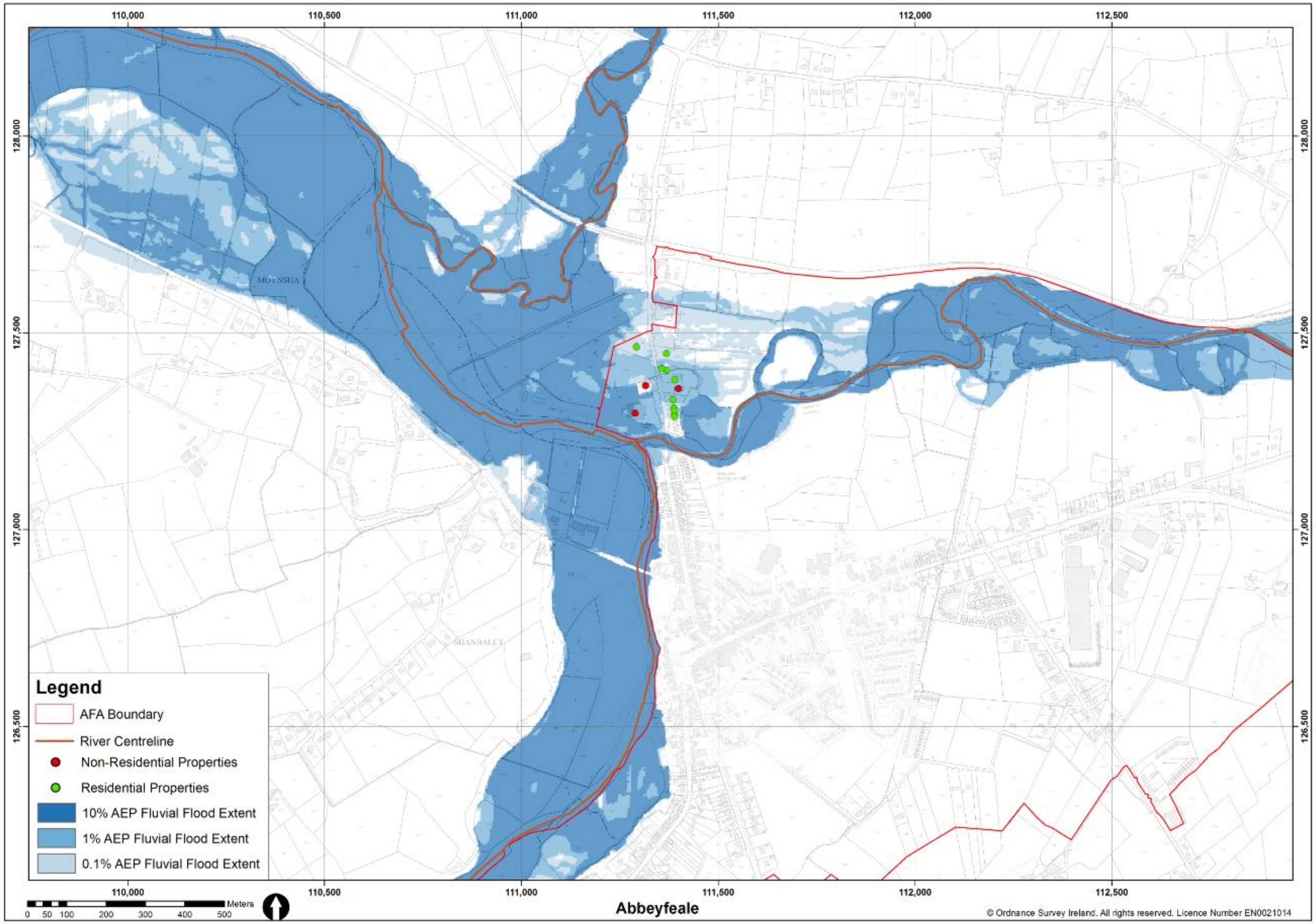

Figure 1.1 – Abbeyfeale Fluvial Flood Risk to Properties

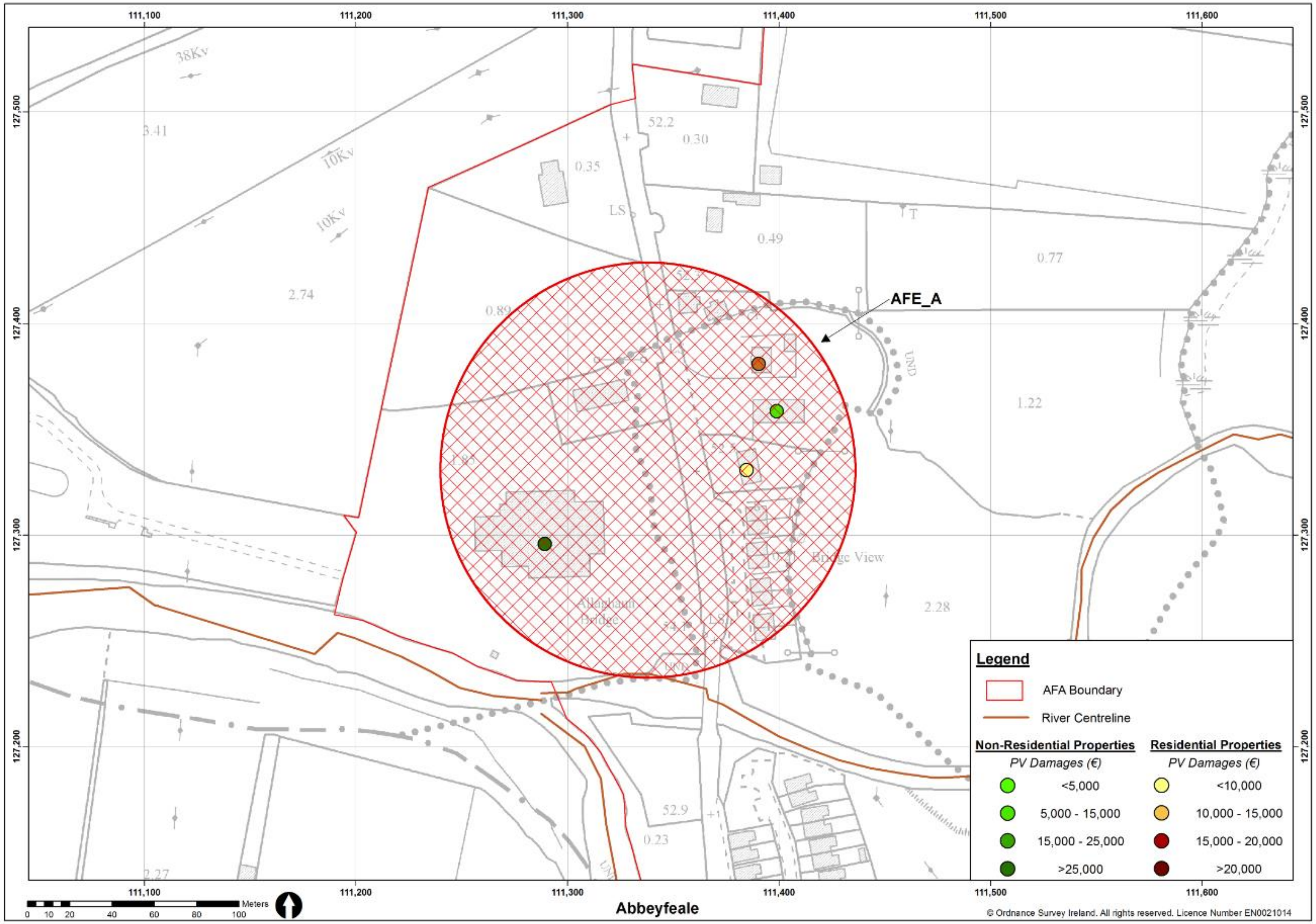

Figure 1.2 – Abbeyfeale Total PV Damages for Properties within the 1% AEP Fluvial Flood Event and Flood Cells Flood Cells are groupings of properties that are likely to be hydraulically linked

2. STAGE 2: Screening of the Measures

2.1 Baseline and Structural Measures

Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.

Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
B	Existing Regime	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
Structural							
D	Storage	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
E	Flow Diversion	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
F	Increase Conveyance	Unviable	Unviable	Viable	Viable	Viable	**Screened Out**
G	Flood Defences	Viable	Unviable	Viable	Viable	Viable	**Screened Out**
H	Relocation of Properties	Viable	Unviable	Viable	Viable	Viable	**Screened Out**
I	Other Measures	Unviable	Unviable	Unviable	Unviable	Unviable	**Screened Out**
Non-Structural							
J	Flood Forecasting / Warning / Response	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
K	Public Awareness	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
L	Individual Property Resistance	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
M	Individual Property Resilience	Viable	Viable	Viable	Viable	Viable	**Screened In**

2.2 Justification for Screened Out Baseline and Structural Measures

The following provides justification on Measures with an overall viability 'Screened Out' categorisation.

A	Do Nothing	Applicability Economic Environmental Social Cultural	Screened out as there are other viable measures.
B	Existing Regime	Applicability Economic Environmental Social Cultural	Although emergency maintenance works have been carried out in this area there is no existing maintenance regime in place.
C	Do Minimum	Applicability Economic Environmental Social Cultural	The Do Minimum FRM method is not a viable measure for Abbeyfeale as reactive and /or localised works will not reduce the flood risk from the River Feale or the River Allaghaun.
D	Storage	Applicability Economic Environmental Social Cultural	Flood risk to the properties in Abbeyfeale is from both the River Feale and the River Allaghaun. The River Allaghaun is too steep for Storage to be a viable FRM measure.

E	Flow Diversion	Applicability Economic Environmental Social Cultural	Not viable as this FRM method as due to the topography there is no available diversion routes.
F	Increase Conveyance	Applicability Economic Environmental Social Cultural	There is some head loss at the River Allaghaun bridge and underpinning of the bridge was considered. However, this option was economically unviable with preliminary costs of underpinning the bridge at approximately €200,000. Both the River Feale and River Allaghaun are designated SAC watercourses therefore dredging of the watercourses was not considered, as there are other viable options.
G	Flood Defences	Applicability Economic Environmental Social Cultural	To protect all properties 380 metres of embankment would be required. With the cost of the embankment at over €200,000, construction of embankments is economically unviable.
H	Relocation of Properties	Applicability Economic Environmental Social Cultural	The relocation of the 2 non - residential properties is unviable economically as the average cost of constructing a new property is €160,000 therefore to replace the 2 properties would cost €320,000, which is greater than the economic benefits available.
J	Flood Forecasting / Warning / Response	Applicability Economic Environmental Social Cultural	In the absence of any gauge data for the River Allaghaun a flood forecasting cannot be recommended as a viable FRM measure for Abbeyfeale.
L	Individual Property Resistance	Applicability Economic Environmental Social Cultural	Individual property resistance is not a viable FRM measure in the absence of a flood forecasting system.
I	Other Measures	Applicability Economic Environmental Social Cultural	No other Measures have been identified.

2.3 Summary of 'Screened In' Measures

The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.

Structural Measures		**Non-Structural Measures**	
		K	Public Awareness
		M	Individual Property Resilience

3. STAGE 3: Selection of Options

3.1 Consideration of Options

The following are the agreed combination of 'Screened In' measures that comprise each of the Options being taken forward for further consideration.

Where appropriate, the 'Screened In' measures have been sub-divided into separate specific measures to ensure applicability to site conditions.

Measures		Different composition of measures per option						
Non-Structural Measures								
K	Public Awareness							
M	Individual Property Resilience	✓						
Option Reference		AFE_01						

Measures not screened out but not included in options

Measures		Justification for not being included
K	Public Awareness	Public Awareness has not been included in this option as there is insufficient budget. When included with Individual Property Protection the Total Whole Life Cost of the option is €192,627. With an option comprising Individual Property Resilience PV benefits are limited to €154,034.

<table>
<tr><td colspan="7">4. STAGE 4: Appraisal of Options</td></tr>
<tr><td colspan="7">4.1 Options Appraisal
Each option taken forward for Multi-Criteria Assessment (MCA) analysis is to be discussed at the Option Meeting. Below describes this concept design of each option and provides a summary of any significant comments/issues which were raised by LA staff at the Options Meetings. These comments will be considered in the local weightings and the MCA scores.</td></tr>
<tr><td colspan="2">Option Ref:</td><td colspan="5">AFE_01</td></tr>
<tr><td>Option Measures</td><td>Non Structural</td><td>J
Flood Forecasting</td><td colspan="2">K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="5">This option will reduce the risk to the 4 properties identified as being at risk of flooding and includes;
• Individual property resilience for all properties.</td></tr>
<tr><td colspan="2" rowspan="2">Options Development Meeting:</td><td>Date:</td><td colspan="4">10th June 2015</td></tr>
<tr><td>Summary:</td><td colspan="4">The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.</td></tr>
</table>

5. STAGE 5: Multi Criteria Assessment		
5.1 Options selected for the Multi Criteria Assessment Following the Option Meeting, the following options are the refined options for the Multi-Criteria Assessment (MCA) stage. This is the final of a five-stage MCA process.		
Option Reference		AFE_01
Non-Structural Measures		
M	Individual Property Resilience	Individual flood resilience for all properties.
Table reference A summary of the outcome from the MCA is presented in the following table		Table 5.1

Table 5.1 – Multi Criteria Assessment Outcome for Option AFE_01

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**			
AFA	Abbeyfeale	Option Ref:	AFE_01
Option Measures			
Baseline	N/A	None	
Structural	N/A	None	
Non-Structural	M	Individual Property Resilience	
Criteria Scores			
Technical	900		
Economic	240		
Social	20		
Environmental	0		
Economic Values			
Economic PV Benefits	€ 154,034		
PV Cost	€ 152,373		
NPV Benefits	€ 1,661		
Economic BCR	**1.01**		
Outcome Scores			
MCA PV Benefits	€ 154,034		
MCA Benefit Score	**260**		
MCA Benefit Score Ratio	1709.38		
Option Selection MCA	**1160**		
Relevant Figure	Figure 5.1		

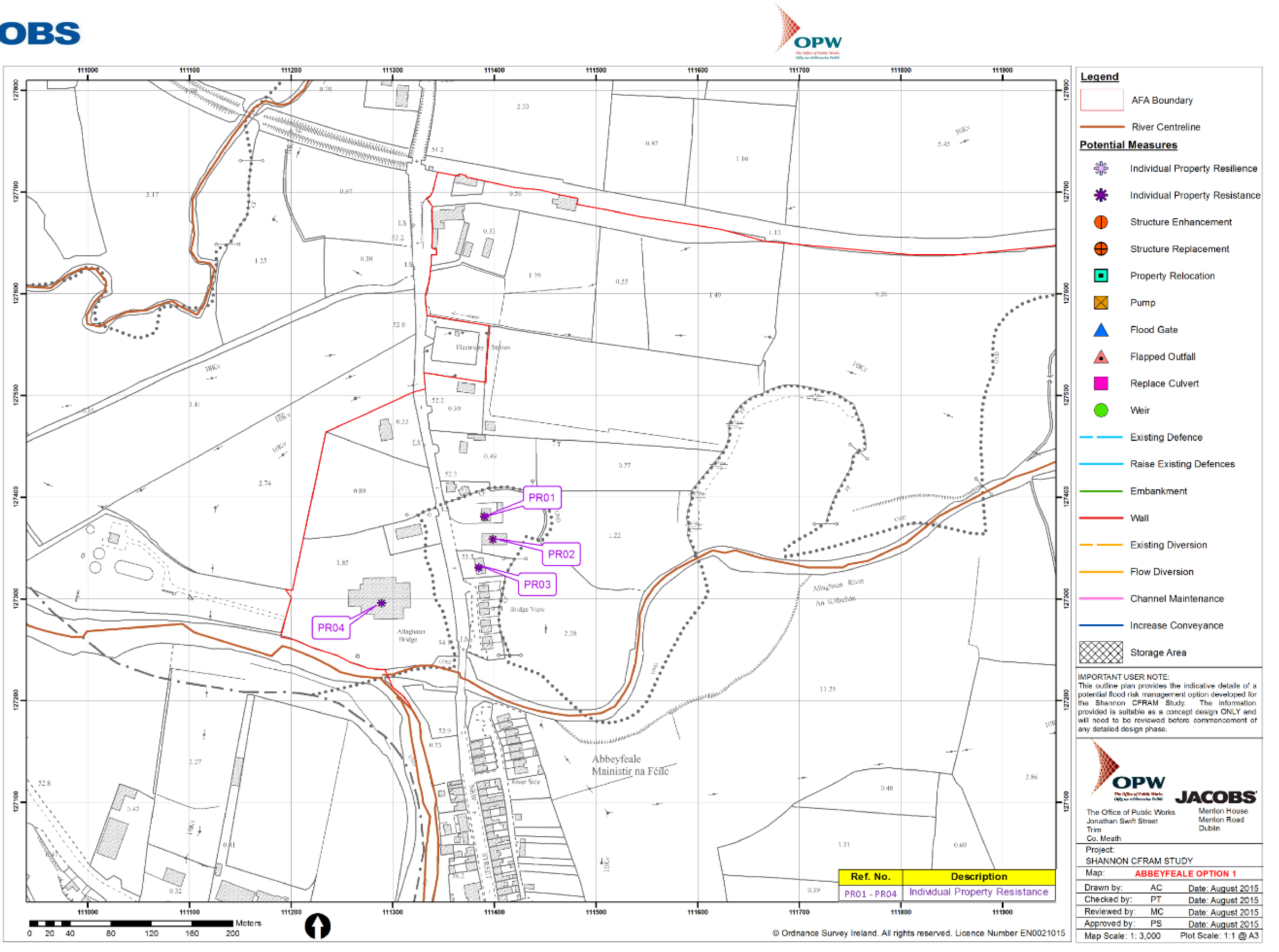

Figure 5.1 – Option AFE_01

5.2 Comparison of Multi Criteria Assessment Scores

Each option taken forward for further consideration through the Option Development Meeting has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).

Categories	**Option Reference and Results**
	AFE_01
Criteria Scores	
Technical	900
Economic	240
Social	20
Environmental	0
Economic Values	
Economic PV Benefits	€ 154,034
PV Cost	€ 152,357
NPV Benefits	€ 1,661
Economic BCR	**1.01**
Outcome Scores	
MCA PV Benefits	€ 154,034
MCA Benefit Score	260
MCA BCR	**1709.38**
Option Selection MCA	**1160**

5.3 Recommendation of Preferred Option				
It forms part of the CFRAM process for the recommendation of a preferred option for each AFA. The prioritised selection criteria used in this recommendation process is detailed in Section 3.7.3 of the Main Report. Therefore, following the five stage Multi Criteria Assessment process, the preferred option is as outlined below				
Option Ref:	AFE_01			
Option Measures – Baseline	N/A			
Option Measures – Structural	N/A			
Option Measures – Non Structural	J Flood Forecasting	K Public Awareness	L Property Resistance	**M Property Resilience**
Comments	This option will reduce the flood risk to all properties within the AFA, identified as being at risk.			

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

<table>
<tr><th colspan="5">Fluvial Flood Forecasting Potential</th></tr>
<tr><td rowspan="3">Catchment Information</td><td colspan="2">Gauging Station</td><td rowspan="2">Catchment size (km^2)</td><td rowspan="2">Potential available forecast accuracy and reliability period</td></tr>
<tr><td>Fluvial</td><td>Rainfall</td></tr>
<tr><td>23019 (Inactive)
23016 (Inactive)
23018
23005 (Inactive)
23029 (Inactive)
23015 (Inactive)</td><td>No*</td><td>417</td><td>Unknown</td></tr>
<tr><td>Relevant Information:</td><td colspan="4">Beheenagh (GS 23019 - Inactive) 5km upstream of Abbeyfeale
Mountcollins (GS 23016 - Inactive) 12km upstream of Abbeyfeale
Brosna (GS 23018) 11.5km upstream of Abbeyfeale
Goulburn (GS 23005 - Inactive) 5km upstream of Abbeyfeale
Temple Glentan (GS 23029 - Inactive) 8km upstream of Abbeyfeale
Tour Bridge (GS 23015 - Inactive) 12km upstream of Abbeyfeale</td></tr>
<tr><td rowspan="3">Additional Infrastructure Recommended</td><td colspan="2">Gauging Station</td><td colspan="2" rowspan="2">Other</td></tr>
<tr><td>Fluvial</td><td>Rainfall</td></tr>
<tr><td>Yes</td><td>Yes</td><td colspan="2">No</td></tr>
<tr><td>Relevant Comments:</td><td colspan="4">The key existing fluvial gauging stations upstream of this AFA are currently inactive. As no MPW is modelled upstream of Abbeyfeale it is not possible to accurately predict the potential available forecast period.

Due to the number of equal sized tributaries, which confluence upstream and within the AFA, an accurate and reliable flood forecasting warning system would require a series of rainfall gauges feeding into a rainfall-runoff model and river gauges. Any flood forecasting system for this AFA would also have potential to benefit Listowel AFA downstream.</td></tr>
</table>

*For this assessment only 15 minute tipping bucket gauge were considered.

Annex A - Multi-Criteria Analysis Summary and Whole Life Cost Summaries for FRM Option(s)

CRITERIA		OBJECTIVE		Global Weighting	Local Weighting	Comments	AFE_01 M – Individual Property Resilience	Option Score	Weighted Score
1	Technical	a	Ensure flood risk management options are operationally robust	20	5.00	The option scores are determined based on the level of operational risk to operate or perform successfully. Each measure is scored independently and the average of the measure scores is used as the score for the option.	No risks / Manageable Negligible / Moderate / high Very low / High Low / Failure likely Low / moderate / Unacceptable M: 3.00	3.00	300
		b	Minimise health and safety risks associated with the construction and operation of flood risk management options	20	5.00	H&S risks are considered for construction and maintenance of flood risk management measures. The indicative aspirational score is set at five, with a point then deducted for each specific H&S risk in either construction or maintenance.	No risks / Moderate Negligible / Moderate / high Very low / High Low / Very High Low / moderate / Unacceptable Work near services or buildings	3.00	300
		c	Ensure flood risk management options are adaptable to future flood risk	20	5.00	The options scores are determined based on the sustainability and adaptability of the flood risk management measures in the face of potential future changes, including the potential impact of climate change. Each measure is scored independently and the average of the measure scores is used as the score for the option.	Option can be adapted at no to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. M: 3.00	3.00	300
TECHNICAL CRITERIA SCORE									900
2	Economic	a	Minimise economic risk	24	0.14		The score is calculated based on the reduction in AAD, following the full implementation of option.	3.37	11
		b	Minimise risk to transport infrastructure	10	5.00		Scoring is based on the reduction in flood risk to transport routes, following the full implementation of option.	4.00	200
		c	Minimise risk to utility infrastructure	14	0.00		Scoring is calculate based on a reduction in flood risk to utility infrastructure, following the full implementation of option.	0.00	0
		d	Minimise risk to agriculture	12	2.43	Source of Flooding: Fresh Water Percentage of AFA that is rural land: 48.69%	Area of Agricultural Land Flooded: No Change Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: Decreased Flood Warning: Not Applicable Agricultural Production Enhanced: No Change Other (Please Specify): Not Applicable	1.00	29
ECONOMIC CRITERIA SCORE									240
3	Social	a i)	Minimise risk to human health and life - Residents	27.00	0.12	Flood Depths & Velocities: Assumed low risk to life Known Areas of Highly Vulnerable People: Reasonable Cross Section of Society	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	2.88	10
		a ii)	Minimise risk to human health and life - High vulnerability properties	17.00	0.00	Rate of Onset of flooding: Unknown	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	0.00	0
		b i)	Minimise risk to community - Social Infrastructure & Amenity	9.00	0.00	Assets of Particular Social Value: No	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	0.00	0
		b ii)	Minimise risk to community - Local employment	7.00	0.35	Asset of Particular Employment Value: No	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	4.29	11
SOCIAL CRITERIA SCORE									20
4	Environmental	a	Support the objectives of the WFD	16	5.00	The River Feale and the River Allaghaun are of good status. A stretch of the River Feale within the AFA is used for Drinking water (Water Framework Directive Register of Protected Areas). There is one WWTP in the 1%AEP but this is outside the AFA boundary and will be considered at sub catchment scale. There is one WTP pump/plant	The implementation of flood forecasting is unlikely to impact the achievement of water body objectives.	0.00	0
		b	Support the objectives of the Habitats Directive	10	5.00	The River Feale and River Allaghaun are part of the Lower Shannon cSAC. The nearest SPA is the Stack's to Mullaghareirk Mountains some 2km away. Local weighting of 5 set by professional judgement. Weighting of 5	The implementation of flood forecasting is unlikely to increase or reduce pollution risk to sensitive water bodies.	0.00	0
		c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	5	1.00	There are no nationally designated sites within the AFA, but there is potential for significant habitats and populations of European and nationally protected species. Local weighting of 1 set by professional judgement. Weighting of 1	The implementation of flood forecasting is unlikely to significantly impact or enhance the flora and fauna of the catchment.	0.00	0
		d	Protect, and where possible enhance, fisheries resource within the catchment	13	3.00	The River Feale is a salmonid waterbody. The River Allaghaun is considered to be of salmonid interest. The area would be used for amenity fishing. Local weighting of 3 applied by professional judgement, a score of 3	The implementation of flood forecasting is unlikely to significantly impact or enhance fisheries resource within the catchment.	0.00	0
		e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	8	0.00	No known designated landscape features are within the 1% AEP or the AFA. A small portion of the Great Southern Trail is within the 1%AEP to the north of the AFA. Local weighting of 0 applied by professional judgement, which relates	The implementation of flood forecasting is unlikely to result in a change to the existing landscape character/features.	0.00	0
		f i)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of architectural value	4	1.00	No RPS or ACAs fall within the 1% AEP. Part of Abbeyfeale is designated as an ACA and a number of RPS which are in close proximity to the River Feale and the 1%AEP. Local weighting of 1 applied by professional judgement, which relates	The implementation of flood forecasting is unlikely to result in a change to the architectural features.	0.00	0
		f ii)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of archaeological value	4	0.00	There are no RMPs within the 1% AEP. There are 2 RMP which are in close proximity to the River Feale and the 1%AEP. Local weighting of 0 applied by professional judgement, which relates to no archaeological features at risk.	The implementation of flood forecasting is unlikely to result in a change to the archaeological features.	0.00	0
ENVIRONMENTAL CRITERIA SCORE									0

Economic Values	**Economic PV Benefits**	€154,034
	Cost	€152,373
	NPV Benefits	€1,661
	Economic BCR	**1.01**
Outcome Scores	**MCA PV Benefits**	€154,034
	MCA Benefit Score	260
	MCA BCR	**1709.38**
	Option Selection MCA	1160

Objective	Global Weightings (fixed)	Local Weightings		Baseline Comments	Option 1 Comments
1.A	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has very low operational risks to operate or perform successfully.
1.B	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has very low health and safety risks associated with the construction and operation of flood risk management option.
1.C	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.
2.A	24	0.14	calculated	Local weighting is calculated based on the baseline AAD.	This score is calculated based on the reduction in AAD, following the full implementation of option.
2.B	10	5.00	calculated but adjusted by professional judgement if necessary	No change made to the calculated local weighting currently at maximum permissible in line with the number of transport routes at risk of flooding.	No amendment to POS deemed necessary.
2.C	14	0.00	calculated but adjusted by professional judgement if necessary	No receptors at risk of flooding	No amendment to option score as there is no risk under this objective.
2.D	12	0.00	Professional judgement	Although there is not a significant amount of agricultural land within or near the AFA ar risk of flooding, the Mart building is at risk and closure of the building for a period of time may impact the agrigultural business in the area.	This score is determined based on a reduction in the area of agricultural land flooded, following full implementation of the option.
3.A (i)	27	0.12	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to residential properties. Local Weighting has been increased by 20% as the rate of onset is unknown.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option.
3.A (ii)	17	0.00	calculated but adjusted by professional judgement if necessary	There is no risk to high vulnerability properties within the AFA.	There is no risk to high vulnerability properties within the AFA.
3.B (i)	9	5.00	calculated but adjusted by professional judgement if necessary	There is no risk to Social Infrastructure or Amenities within this AFA.	There is no risk to Social Infrastructure or Amenities within this AFA.
3.B (ii)	7	5.00	calculated but adjusted by professional judgement if necessary	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option.
4.A	16	5.00	fixed	The River Feale and River Allaghaun are part of the Lower Shannon cSAC. The nearest SPA is the Stack's to Mullaghareirk Mountains some 2km away. Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SCA/SPA/Ramsar) is present (within AFA) and potentially affected.	The implementation of flood forecasting is unlikely to impact the achievement of water body objectives.
4.B	10	5.00	Professional judgement	The River Feale and River Allaghaun are part of the Lower Shannon cSAC. The nearest SPA is the Stack's to Mullaghareirk Mountains some 2km away. Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SCA/SPA/Ramsar) is present (within AFA) and potentially affected.	The implementation of flood forecasting is unlikely to increase or reduce pollution risk to sensitive water bodies.
4.C	5	1.00	Professional judgement	There are no nationally designated sites within the AFA, but there is potential for significant habitats and populations of European and nationally protected species. Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no designated sites but habitats/species are likely to be present that could be affected	The implementation of flood forecasting is unlikely to significantly impact or enhance the flora and fauna of the catchment.
4.D	13	3.00	Professional judgement	The River Feale is a salmonid waterbody. The River Allaghaun is considered to be of salmonid interest. The area would be used for amenity fishing. Local weighting of 3 applied by professional judgement, a score of 3 indicates that the waterbody supports substaintial fisheries/shellfisheries and is of regional value for fishing/angling.	The implementation of flood forecasting is unlikely to significantly impact or enhance fisheries resource within the catchment.
4.E	8	0.00	Professional judgement	No known designated landscape features are within the 1% AEP or the AFA. A small portion of the Great Southern Trail is within the 1%AEP to the north of the AFA. Local weighting of 0 applied by professional judgement, which relates to no specific landscape designation, and no landscape value/sensitivity.	The implementation of flood forecasting is unlikely to result in a change to the existing landscape character/features.
4.F(i)	4	1.00	Professional judgement	No RPS or ACAs fall within the 1% AEP. Part of Abbeyfeale is designated as an ACA and a number of RPS which are in close proximity to the River Feale and the 1%AEP. Local weighting of 1 applied by professional judgement, which relates to no architectural features are at risk from flooding but potential effects on the settings of designated architectural features.	The implementation of flood forecasting is unlikely to result in a change to the architectural features.
4.F(ii)	4	0.00	Professional judgement	There are no RMPs within the 1% AEP. There are 2 RMP which are in close proximity to the River Feale and the 1%AEP. Local weighting of 0 applied by professional judgement, which relates to no archaeological features at risk.	The implementation of flood forecasting is unlikely to result in a change to the archaeological features.

Option 1 Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis					**Notes to CFRAM Consultants**
		€	**€**	**€**	
(1) Basic Construction Costs (Estimate)				**61,701**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2) Preliminaries	30.8%			**19,027**	Refer to UCD for selecting Preliminaries. %
Sub-Total:				**80,727**	
(3) Optimism Bias	33.0%			**26,640**	Refer to UCD for selecting OB %
(4) Construction Costs (Excl VAT)				**107,368**	
(5) Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)	13.0%			**13,958**	Set at 13%
Construction Costs and Fees				**121,325**	
(6) Other Items					
(a) Allowance for Archaeology & Environmental Mitigation Measures	10.0%		10,737		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b) Allowance for compensation and land acquisition	10.0%		10,737		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c) Site investigation			0	Only Resielience	Professional judgement to be applied in estimating a suitable sum.
(d) Art Allowance			0	Only Resielience	See “Guidance E – Per Cent for Art Note”
(e) Est. NPV Operation & Maintenance		7,199			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
Optimism Bias	33.0%	2,376	9,574	**31,048**	Refer to UCD for selecting OB %
Option Cost for Cost Benefit Analysis				**152,373**	

JBA consulting

DONNACHADH O'BRIEN & ASSOCIATES CONSULTING ENGINEERS

OPW The Office of Public Works Oifig na nOibreacha Poiblí

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	PT	Date:	26/05/2016
Checked by:		Date:	

Project reference		Project name:	ABB_01

Base date for estimates (year 0)	Oct-2013	Construction Price Index (CPI)	1.000
Scaling factor (e.g. €m, €k, €)	€	Method Factor - to take into account particular site issues /constraints	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	Cost (€)	Comment
Total wall costs		
Total embankment costs		
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs	€59,123	*Resielience*
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€59,123	
Apply update to unit rate (CPI) if appropriate (cell N15)	€59,123	
Enter appropriate preliminaries estimate (%)	31%	
Enter other applicable costs (€)	3373	
Total capital cost (€)	€80,727	
Consider amendments based on site issues/constraints (cell N16)	€80,727	
Total capital cost (€)	€80,727	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs		
Total embankment O&M costs		
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		*Property resilience assumed to have negligible O&M.*
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs	€337	*Public Awareness*
Total Operation and Maintenance costs	€337	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€87,926	
Optimism bias rate (from external sheet)	33%	
Total Cost including Optimism Bias	€116,942	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€80,727.5
Annual maintenance cost (€)	€337.3
Other cost (€)	€0.0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	4.0%	Present Value Factor:		22.341		Total PVc (€k):	87926
	Cash sum	0	80727	16528	0	97256	**87926**
	Discount	Cost Elements				TOTALS:	
year	Factor	Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	0	80727			80727.5	80727.5
1	0.962			337		337.3	324.3
2	0.925			337		337.3	311.9
3	0.889			337		337.3	299.9
4	0.855			337		337.3	288.3
5	0.822			337		337.3	277.2
6	0.790			337		337.3	266.6
7	0.760			337		337.3	256.3
8	0.731			337		337.3	246.5
9	0.703			337		337.3	237.0
10	0.676			337		337.3	227.9
11	0.650			337		337.3	219.1
12	0.625			337		337.3	210.7
13	0.601			337		337.3	202.6
14	0.577			337		337.3	194.8
15	0.555			337		337.3	187.3
16	0.534			337		337.3	180.1
17	0.513			337		337.3	173.2
18	0.494			337		337.3	166.5
19	0.475			337		337.3	160.1
20	0.456			337		337.3	153.9
21	0.439			337		337.3	148.0
22	0.422			337		337.3	142.3
23	0.406			337		337.3	136.9
24	0.390			337		337.3	131.6
25	0.375			337		337.3	126.5
26	0.361			337		337.3	121.7
27	0.347			337		337.3	117.0
28	0.333			337		337.3	112.5
29	0.321			337		337.3	108.2
30	0.308			337		337.3	104.0
31	0.296			337		337.3	100.0
32	0.285			337		337.3	96.2
33	0.274			337		337.3	92.5
34	0.264			337		337.3	88.9
35	0.253			337		337.3	85.5
36	0.244			337		337.3	82.2
37	0.234			337		337.3	79.0
38	0.225			337		337.3	76.0
39	0.217			337		337.3	73.1
40	0.208			337		337.3	70.3
41	0.200			337		337.3	67.6
42	0.193			337		337.3	65.0
43	0.185			337		337.3	62.5
44	0.178			337		337.3	60.1
45	0.171			337		337.3	57.7
46	0.165			337		337.3	55.5
47	0.158			337		337.3	53.4
48	0.152			337		337.3	51.3
49	0.146			337		337.3	49.4

Appendix C3 Option Appraisal Report - Athea

1. STAGE 1: Summary of Current Flood Risk

1.1 AFA and Watercourse Details

AFA	Athea
Unit of Management:	23
Primary Watercourses:	River Galey

1.2 Summary of Flood Risk in 1% AEP Event

<table>
<tr><td>Source of flood risk</td><td colspan="2">Fluvial</td><td colspan="2">Coastal</td><td>Both</td></tr>
<tr><td rowspan="2">Total Number of Properties at risk in AFA in 1% Fluvial AEP Event:</td><td colspan="2"></td><td>Residential</td><td>Non-Residential</td><td>Total</td></tr>
<tr><td colspan="2">Fluvial</td><td>12</td><td>3</td><td>15</td></tr>
<tr><td rowspan="2">AFA Flood Cells:</td><td colspan="2">Total Number:</td><td colspan="3">2</td></tr>
<tr><td colspan="2">Flood Cell Titles:</td><td colspan="3">ATA_A, ATA_B</td></tr>
<tr><td rowspan="3">Breakdown of properties at risk per Flood Cell:</td><td>Flood Cell Ref</td><td>Residential</td><td>Non-Res</td><td colspan="2">Total</td></tr>
<tr><td>ATA_A</td><td>9</td><td>0</td><td colspan="2">9</td></tr>
<tr><td>ATA_B</td><td>3</td><td>3</td><td colspan="2">6</td></tr>
<tr><td>Relevant Comments:</td><td colspan="5">The current flood risk assumes blockage at the main bridge in Athea as witnessed in the 2008 event.</td></tr>
<tr><td>Relevant Figure Ref:</td><td colspan="5">Figure 1.1 and 1.2.</td></tr>
</table>

1.3 Summary of Existing Flood Risk Management Measures

Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
No	No	No	No	No	No

Relevant Comments:	Although emergency maintenance works were carried out on the River Galey after the flood events in 2008 there is no existing maintenance regime in place.
Relevant Figure Ref:	Figure C3.1

1.4 Summary of PV Damages

<table>
<tr><td rowspan="2">Total PV Damage:</td><td></td><td colspan="2">Uncapped</td><td colspan="2">Capped</td></tr>
<tr><td>Fluvial</td><td colspan="2">€ 809,096</td><td colspan="2">€ 809,096</td></tr>
<tr><td>Max Capped Benefits for 1% Fluvial AEP Event*:</td><td colspan="5">€ 543,552</td></tr>
<tr><td rowspan="3">Breakdown of Max Capped PV Benefits per Flood Cell for 1% Fluvial AEP Event:</td><td>Flood Cell Ref</td><td>Residential</td><td>Non-Res</td><td colspan="2">Total</td></tr>
<tr><td>ATA_A</td><td>€ 390,244</td><td>€ 0</td><td colspan="2">€ 390,244</td></tr>
<tr><td>ATA_B</td><td>€ 106,707</td><td>€ 46,601</td><td colspan="2">€ 153,308</td></tr>
<tr><td>Relevant Figure Ref:</td><td colspan="5">Figure 1.2</td></tr>
</table>

*These are the maximum benefits available if a FRM option with a 1% Fluvial AEP SOP is provided to all properties within the AFA.

<table>
<tr><th colspan="3">1.5 Social Risk</th></tr>
<tr><td></td><td>Type</td><td>Description</td></tr>
<tr><td rowspan="2">High Vulnerability Properties at risk:</td><td rowspan="2">School</td><td>0.1% AEP Flood Extent</td></tr>
<tr><td>Athea National School</td></tr>
<tr><td rowspan="2">Social Infrastructure Assets:</td><td rowspan="2">Community Centre</td><td>1% AEP Flood Extent</td></tr>
<tr><td>Con Colbert Memorial Hall</td></tr>
<tr><td>Social Amenity Sites:</td><td>None</td><td>N/A</td></tr>
<tr><td>Relevant Figure Ref:</td><td colspan="2">General Risk – Social</td></tr>
</table>

<table>
<tr><th colspan="3">1.6 Risk to the Environment</th></tr>
<tr><td></td><td>Type</td><td>Description</td></tr>
<tr><td>Risk to WFD Annex IV:</td><td>None</td><td>N/A</td></tr>
<tr><td>Risk to SACs:</td><td>Candidate Special Area of Conservation</td><td>The Lower River Shannon is classified as a cSAC.</td></tr>
<tr><td>Relevant Figure Ref:</td><td colspan="2">General Risk - Environment</td></tr>
</table>

<table>
<tr><th colspan="3">1.7 Risk to Cultural Heritage</th></tr>
<tr><td></td><td>Type</td><td>Description</td></tr>
<tr><td rowspan="5">Risk to Sites of Cultural Heritage:</td><td rowspan="5">NIAH Buildings</td><td>50% AEP Flood Extent</td></tr>
<tr><td>Athea Bridge</td></tr>
<tr><td>20% AEP Flood Extent</td></tr>
<tr><td>Handball alley</td></tr>
<tr><td></td></tr>
<tr><td>Relevant Figure Ref:</td><td colspan="2">General Risk – Cultural Heritage</td></tr>
</table>

<table>
<tr><th colspan="3">1.8 Risk to the Economy</th></tr>
<tr><td></td><td>Type</td><td>Description</td></tr>
<tr><td rowspan="7">Risk to Transport Infrastructure:</td><td rowspan="4">Regional Road</td><td>50% AEP Flood Extent</td></tr>
<tr><td>R523</td></tr>
<tr><td>1% AEP Flood Extent</td></tr>
<tr><td>R524</td></tr>
<tr><td rowspan="3">Local Road</td><td>50% AEP Flood Extent</td></tr>
<tr><td>Markievicz Park</td></tr>
<tr><td>Barrack Street</td></tr>
<tr><td>Risk to Utility Infrastructure:</td><td>None</td><td>N/A</td></tr>
<tr><td>Relevant Figure Ref:</td><td colspan="2">General Risk - Economy</td></tr>
</table>

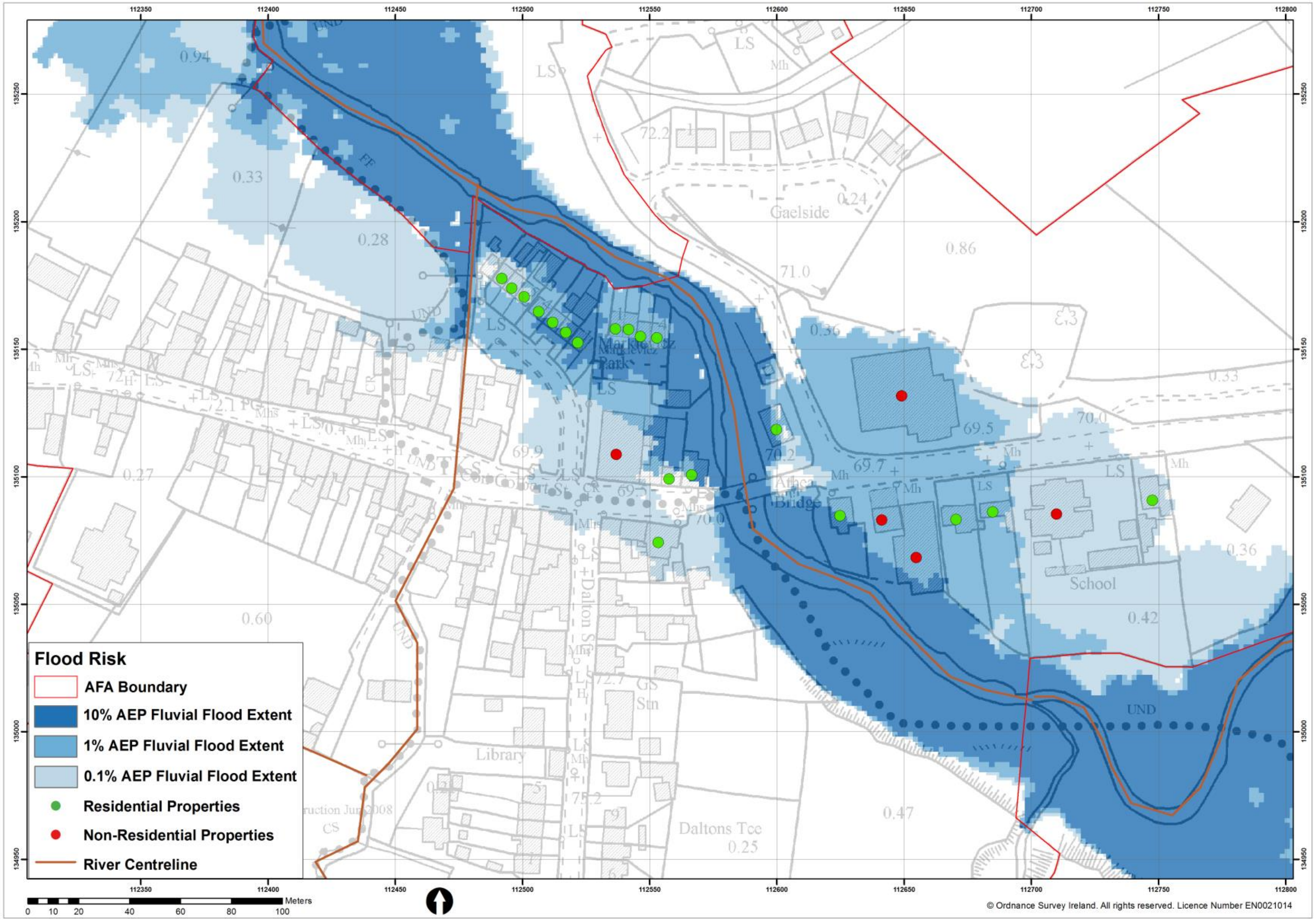

Figure 1.1– Athea Fluvial Flood Risk to Properties

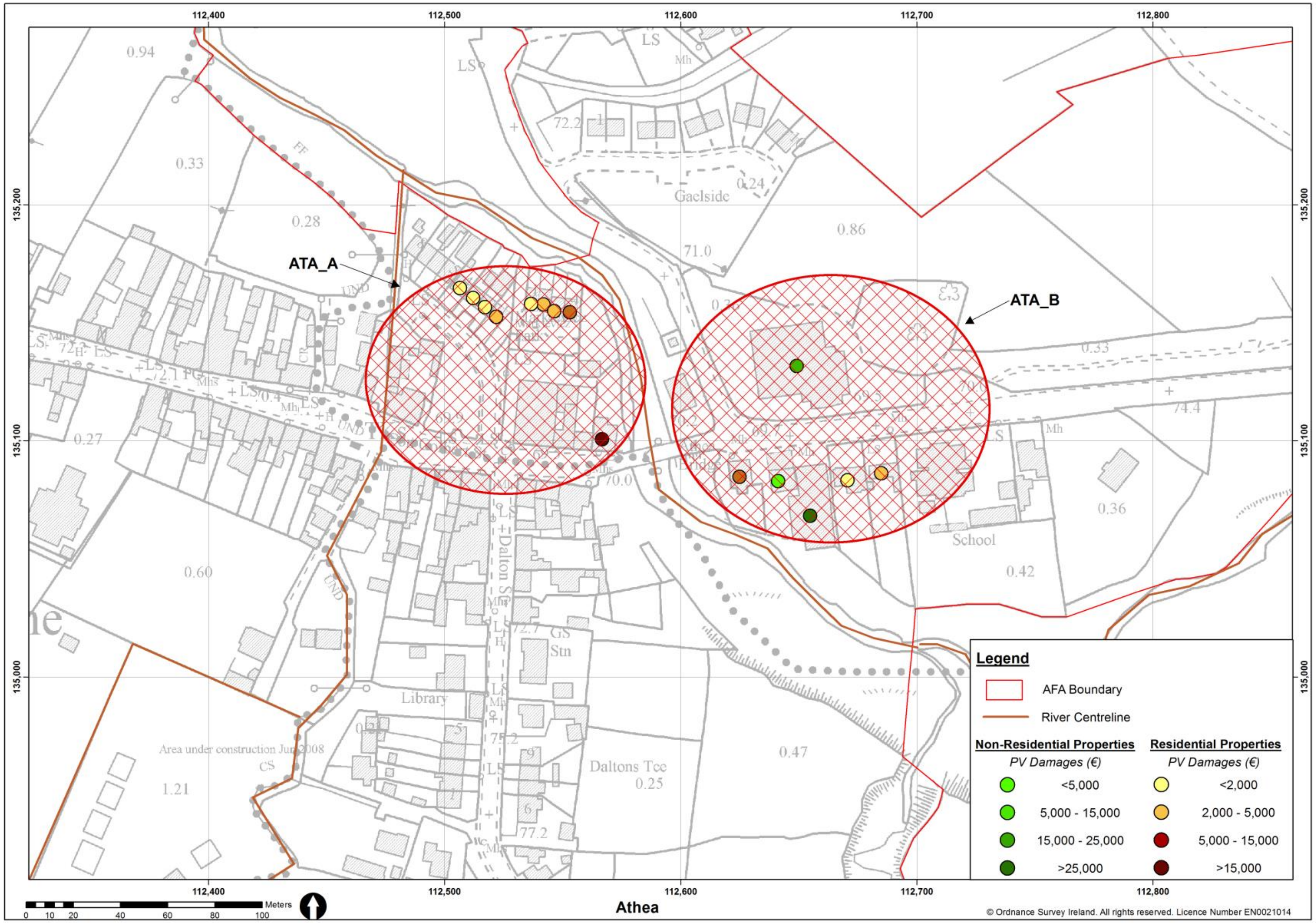

Figure 1.2 – Athea Total PV Damages for Properties within the 1% AEP Fluvial Flood Event and Flood Cells
Flood Cells are groupings of properties that are likely to be hydraulically linked

2. STAGE 2: Screening of the Measures

2.1 Baseline and Structural Measures

Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.

Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	Screened Out
B	Existing Regime	Unviable	Viable	Viable	Viable	Viable	Screened Out
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	Screened Out
Structural							
D	Storage	Unviable	Viable	Viable	Viable	Viable	Screened Out
E	Flow Diversion	Unviable	Viable	Viable	Viable	Viable	Screened Out
F	Increase Conveyance	Viable	Viable	Viable	Viable	Viable	Screened In
G	Flood Defences	Viable	Viable	Viable	Viable	Viable	Screened In
H	Relocation of Properties	Viable	Unviable	Viable	Unviable	Viable	Screened Out
I	Other Measures	Unviable	Unviable	Unviable	Unviable	Unviable	Screened Out
Non-Structural							
J	Flood Forecasting / Warning / Response	Unviable	Viable	Viable	Viable	Viable	Screened Out
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	Screened In
L	Individual property resistance	Unviable	Viable	Viable	Viable	Viable	Screened Out
M	Individual property resilience	Viable	Viable	Viable	Viable	Viable	Screened In

2.2 Justification for Screened Out Baseline and Structural Measures

The following provides justification on Measures with an overall viability 'Screened Out' categorisation.

A	Do Nothing	Applicability Economic Environmental Social Cultural	Screened out as there are other viable measures.
B	Existing Regime	Applicability Economic Environmental Social Cultural	Exisiting Regime is screened out as there is no maintenance scheme in place.
C	Do Minimum	Applicability Economic Environmental Social Cultural	The Do Minimum FRM method is not a viable measure for Athea as localisied cleaning of the channel will not reduce the flood risk.
D	Storage	Applicability Economic Environmental Social Cultural	Not viable as this FRM method is not applicable to the area and the source of flood risk.

E	Flow Diversion	Applicability Economic Environmental Social Cultural	Not viable as this FRM method is not applicable to the area and the source of flood risk.
H	Relocation of Properties	Applicability Economic Environmental Social Cultural	The relocation of 11 properties is not applicable to the area and is socially unviable. The average cost of constructing a new property is €160,000 therefore to replace the 11 properties would cost €1,760,000, which is greater than the economic benefits available.
I	Other Measures	Applicability Economic Environmental Social Cultural	No other Measures have been identified.
J	Flood Forecasting / Warning / Response	Applicability Economic Environmental Social Cultural	In the absence of any gauged data upstream of the Athea, the shape of the design flow hydrograph adopted was that from a gauging station approx. 20 km downstream. Although the shape of this hydrograph indicates an acceptable onset rate for flood forecasting, reports from the 2008 event in the town of Athea indicate the flood event had a rapid rate of onset. Based on the reports from the 2008 event flood forecasting cannot be recommended for Athea. A gauging station in Athea will be recommended in the FRMP to determine if a flood forecasting system could be viable in the future.
L	Individual property resistance	Applicability Economic Environmental Social Cultural	Individual property resistance is not viable without a forecasting system in place.

2.3 Summary of 'Screened In' Measures

The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.

Structural Measures		**Non-Structural Measures**	
F	Increase Conveyance	K	Public Awareness
G	Flood Defences	M	Individual property resilience

3. STAGE 3: Selection of Options

3.1 Consideration of Options

The following are the agreed combination of 'Screened In' measures that comprise each of the Options being taken forward for further consideration.

Where appropriate, the 'Screened In' measures have been sub-divided into separate specific measures to ensure applicability to site conditions.

Measures		**Different composition of measures per option**						
Structural Measures								
F	Increase Conveyance							
Fi	Channel Dredging	✓						
Fii	Channel Widening							
Fiii	Structural Enhancement / Works							
G	Flood Defences							
Gi	New Flood Defences	✓	✓					
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
K	Public Awareness							
M	Individual Property Resilience							
Option Reference		ATA_01	ATA_02					

Measures not screened out but not included in options		
Measures		**Justification for not being included**
K	Public Awareness	Public Awareness was not considered as either an independent measure or in combination with other measures, as the option being appraised would provide the required 1% Fluvial AEP standard of protection. Public Public Awareness does not improve the viability of the option under consideration.
M	Individual Property Resilience	Individual Property Resilience was not considered as either an independent measure or in combination with other measures, as the option being appraised would provide the required 1% Fluvial / 0.5% Coastal AEP standard of protection. Individual Property Resilience does not improve the viability of the option under consideration.

4. STAGE 4: Appraisal of Options

4.1 Options Appraisal

Each option taken forward for Multi-Criteria Assessment (MCA) analysis is to be discussed at the Option Development Meeting. Below describes this concept design of each option and provides a summary of any significant comments/issues which were raised by LA staff at the Options Development Meetings. These comments will be considered in the local weightings and the MCA scores.

Option Ref:		ATA_01			
Option Measures	**Structural**	**Fi**	**Increase Conveyance: Channel Dredging**		
		Gi	**Flood Defences: New Flood Defences**		
	Non Structural	J Flood Forecasting	K Public Awareness	L Property Resistance	M Property Resilience
Option Description:		This option will provide a 1% Fluvial AEP Design standard to all properties within the AFA, identified as being at risk and includes; • Walls constructed on the left bank downstream of the bridge. • Dredging of the the river channel upstream of the bridge to remove sediment build up, during off season for Salmon Spawning, followed by resedimentation of the channel under the supervision of an ecologist. • Montoring of sediment build up after in channel works to determine the frequency of required dredging works.			
Option Development Meeting:		Date:	10th June 2015		
		Summary:	The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.		

Option Ref:		ATA_02			
Option Measures	**Structural**	**Gi**	**Flood Defences: New Flood Defences**		
	Non Structural	J Flood Forecasting	K Public Awareness	L Property Resistance	M Property Resilience
Option Description:		This option will provide a 1% Fluvial AEP Design standard to all properties within the AFA, identified as being at risk and includes; • Walls constructed on the left bank downstream of the bridge. • Embankment/ wall on the right bank upstream of the bridge.			
Option Development Meeting:		Date:	10th June 2015		
		Summary:	The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.		

5. STAGE 5: Multi Criteria Assessment			
5.1 Options selected for the Multi Criteria Assessment Following the Option Development Meeting, the following options have been selected for the Multi-Criteria Assessment (MCA) stage. This is the final of a five stage MCA process.			
Option Reference		ATA_01	ATA_02
Structural Measures			
Fi	Increase Conveyance: Channel Dredging	Dredging of the the river channel upstream of the bridge to remove sediment build up, during off season for Salmon Spawning, followed by resedimentation of the channel under the supervision of an ecologist. Montoring of sediment build up after in channel works to determine the frequency of required dredging works.	
Gi	Flood Defences: New Flood Defences	Walls constructed on the left bank downstream of the bridge.	Walls constructed on the left bank downstream of the bridge. Embankment/ wall on the right bank upstream of the bridge.
	Table reference A summary of the outcome from the MCA is presented in the following table	Table 5.1	Table 5.2

Table 5.1 – Multi Criteria Assessment Outcome for Option ATA_01

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**			
AFA	Athea	Option Ref:	ATA_01

Option Measures		
Baseline		N/A
Structural	Gi	Flood Defences: New Flood Defences
	Fi	Increase Conveyance: Channel Dredging
Non-Structural		N/A

Criteria Scores	
Technical	600
Economic	265
Social	57
Environmental	-50348
Economic Values	
Economic PV Benefits	€ 543,552
PV Cost	€ 533,035
NPV Benefits	€ 10,517
Economic BCR	**1.02**
Outcome Scores	
MCA PV Benefits	€ 274,266
MCA Benefit Score	-50026
MCA Benefit Score Ratio	-93851.64
Option Selection MCA	-50348
Relevant Figure	Figure 5.1

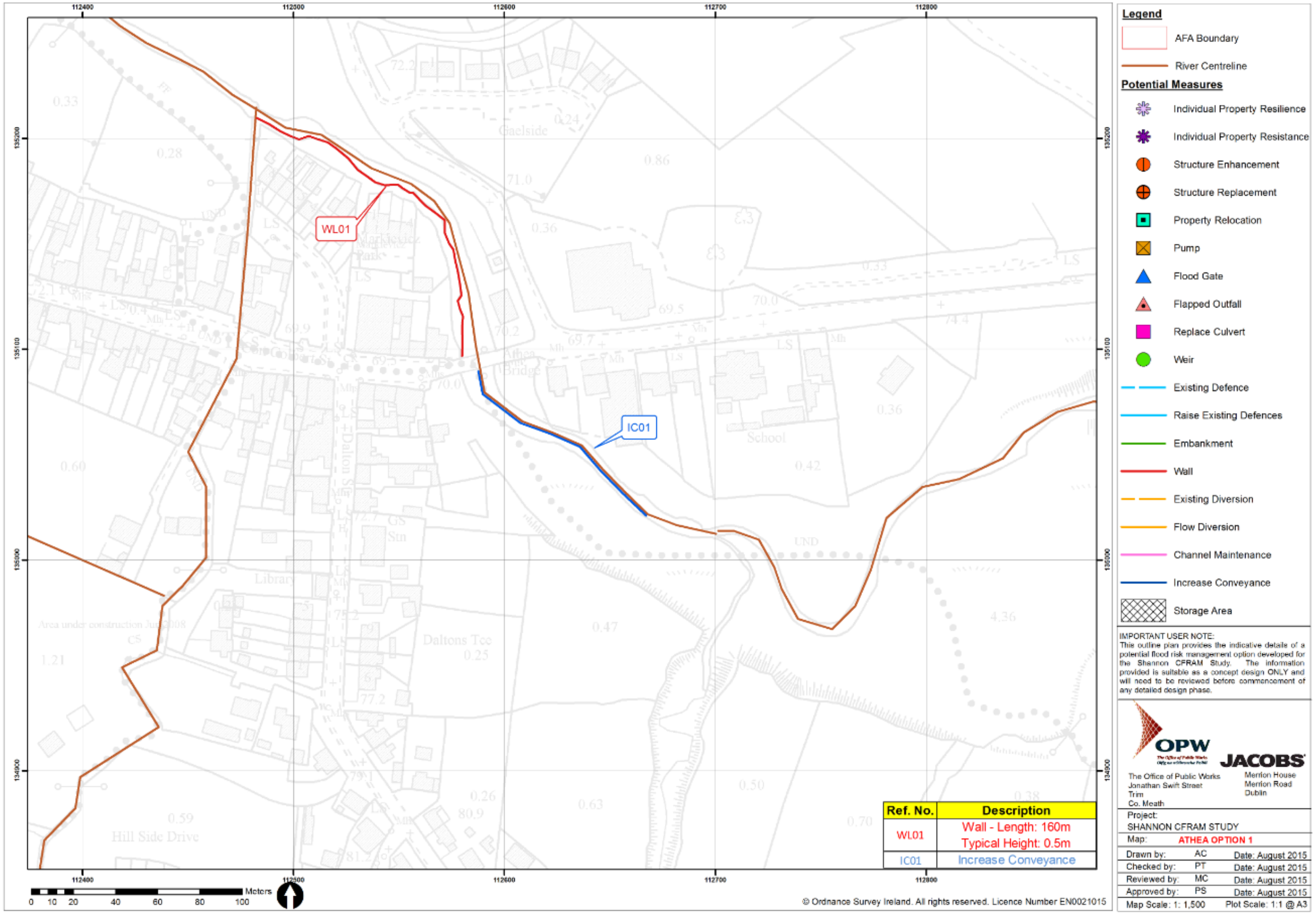

Figure 5.1 – Option ATA_01

Table 5.2 – Multi Criteria Assessment Outcome for Option ATA_02

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**			
AFA	Athea	Option Ref:	ATA_02
Option Measures			
Baseline		N/A	
Structural	Gi	New Flood Defences	
Non-Structural		N/A	
Criteria Scores			
Technical	1000		
Economic	265		
Social	57		
Environmental	-419		
Economic Values			
Economic PV Benefits	€ 543,552		
PV Cost	€ 381,747		
NPV Benefits	€ 161,805		
Economic BCR	**1.42**		
Outcome Scores			
MCA PV Benefits	€ 274,266		
MCA Benefit Score	-97		
MCA Benefit Score Ratio	-254.71		
Option Selection MCA	903		
Relevant Figure	Figure 5.1		

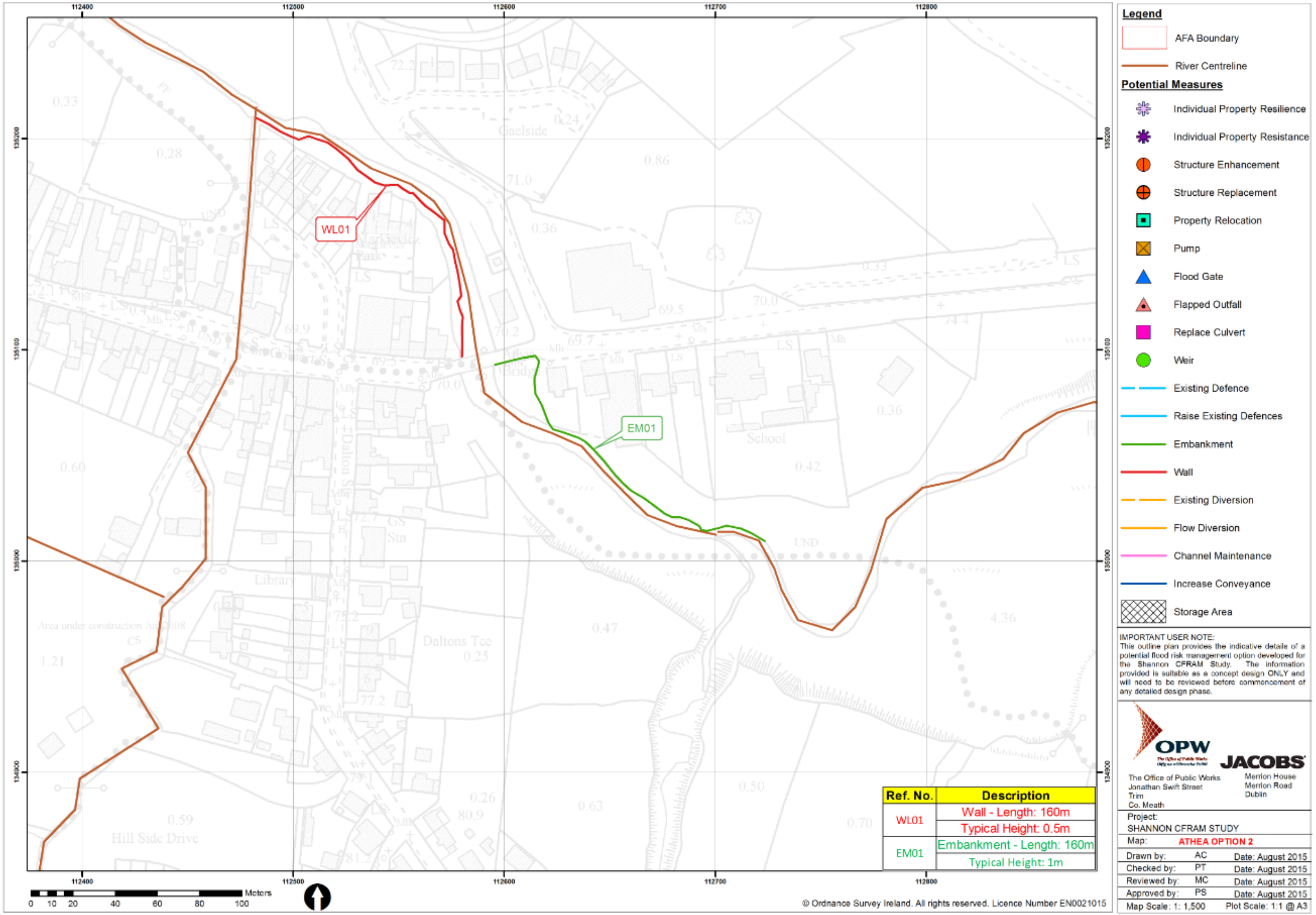

Figure 5.2 – Option ATA_02

5.2 Comparison of Multi Criteria Assessment Scores

Each option taken forward for further consideration through the Option Development Meeting has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).

Categories	Option Reference and Results	
	ATA_01	ATA_02
Criteria Scores		
Technical	600	1000
Economic	265	265
Social	57	57
Environmental*	-50348	-419
Economic Values		
Economic PV Benefits	€ 543,552	€ 543,552
PV Cost	€ 533,035	€ 381,747
NPV Benefits	€ 10,517	€ 161,805
Economic BCR	**1.02**	**1.42**
Outcome Scores		
MCA PV Benefits	€ 274,266	€ 274,266
MCA Benefit Score	-50026	-97
MCA BCR	-93851.64	-254.71
Option Selection MCA	-49426	903

<table>
<tr><td colspan="7">5.3 Recommendation of Preferred Option
It forms part of the CFRAM process for the recommendation of a preferred option for each AFA. The prioritised selection criteria used in this recommendation process is detailed in Section 3.7.3 of the Main Report.
Therefore, following the five stage Multi Criteria Assessment process, the preferred option is as outlined below</td></tr>
<tr><td colspan="2">Option Ref:</td><td colspan="5">ATA_02</td></tr>
<tr><td rowspan="2">Option Measures</td><td>Structural</td><td>Gi</td><td colspan="4">Flood Defences: New Flood Defences</td></tr>
<tr><td>Non-Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td colspan="2">M
Property Resilience</td></tr>
<tr><td colspan="2">Comment</td><td colspan="5">This option will provide a 1% Fluvial and 0.5% Coastal AEP Design standard to all properties within the AFA, identified as being at risk.

The MCA BCR is highest for ATA_02 and therefore this is the recommended emerging preferred option.</td></tr>
</table>

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

<table>
<tr><th colspan="5">Fluvial Flood Forecasting Potential</th></tr>
<tr><td rowspan="3">Catchment Information</td><td colspan="2">Gauging Station</td><td rowspan="2">Catchment size (km ^{2})</td><td rowspan="2">Potential available forecast accuracy and reliability period</td></tr>
<tr><td>Fluvial</td><td>Rainfall</td></tr>
<tr><td>No</td><td>No*</td><td>36.6</td><td>Unknown</td></tr>
<tr><td>Relevant Information:</td><td colspan="4">This is determined unknown for the following reasons;
• No suitable rain gauge
• No suitable gauging station</td></tr>
<tr><td rowspan="3">Additional Infrastructure Recommended</td><td colspan="2">Gauging Station</td><td colspan="2" rowspan="2">Other</td></tr>
<tr><td>Fluvial</td><td>Rainfall</td></tr>
<tr><td>Yes</td><td>No</td><td colspan="2">No</td></tr>
<tr><td>Relevant Comments:</td><td colspan="4">Due to the number of small tributaries which confluence upstream of the AFA, an accurate and reliable flood forecasting warning system would require a series of rainfall gauges feeding into a rainfall-runoff model and river gauges. However, it is unlikely that the catchment size of these tributaries and the forecast period would justify the introduction of such a system.

A simple flood forecasting system on the River Galey downstream of the confluence of these tributaries, upstream of the AFA, could potentially provide a small flood forecasting period based on a level trigger however as no MPW is modelled in this area it is not possible to accurately predict the potential available forecast period.

A gauging station in Athea will be recommended in the FRMP to determine if a flood forecasting system could be viable in the future.</td></tr>
</table>

*For this assessment only 15 minute tipping bucket gauge were considered.

Annex A - Multi-Criteria Analysis Summary and Whole Life Cost Summaries for FRM Option(s)

CRITERIA			OBJECTIVE	Global Weighting	Local Weighting	Comments	ATA_01 Fi: Channel Dredging Gi: New Flood Defences	Option Score	Weighted Score	ATA_02 Gi: New Flood Defences	Option Score	Weighted Score
1	Technical	a	Ensure flood risk management options are operationally robust	20	5.00	The option scores are determined based on the level of operational risk to operate or perform successfully. Each measure is scored independently and the average of the measure scores is used as the score for the option.	No risks / Manageable Negligible / Moderate / high Very low / High Low / Failure likely Low / moderate / Unacceptable Fi 0.00 Gi 5.00	2.50	250	No risks / Manageable Negligible / Moderate / high Very low / High Low / Failure likely Low / moderate / Unacceptable Gi 5.00	5.00	500
		b	Minimise health and safety risks associated with the construction and operation of flood risk management options	20	5.00	H&S risks are considered for construction and maintenance of flood risk management measures. The indicative aspirational score is set at five, with a point then deducted for each specific H&S risk in either construction or maintenance.	No risks / Moderate / Work near/in water Negligible / Moderate / high / Other (please specify) Very low / High Low / Very High Low / moderate / Unacceptable	2.00	200	No risks / Moderate / Work near/in water Negligible / Moderate / high / Other (please specify) Very low / High Low / Very High Low / moderate / Unacceptable	2.00	200
		c	Ensure flood risk management options are adaptable to future flood risk	20	5.00	The options scores are determined based on the sustainability and adaptability of the flood risk management measures in the face of potential future changes, including the potential impact of climate change. Each measure is scored independently and the average of the measure scores is used as the score for the option.	Option can be adapted at no to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. Fi 0.00 Gi 3.00	1.50	150	Option can be adapted at no to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. Gi 3.00	3.00	300
			TECHNICAL CRITERIA SCORE						600			1000
2	Economic	a	Minimise economic risk	24	0.25		The score is calculated based on the reduction in AAD, following the full implementation of option.	3.23	20	The score is calculated based on the reduction in AAD, following the full implementation of option.	3.23	20
		b	Minimise risk to transport infrastructure	10	5.00		The score is calculated based on the reduction in flood risk to transport routes, following the full implementation of option.	4.90	245	The score is calculated based on the reduction in flood risk to transport routes, following the full implementation of option.	4.90	245
		c	Minimise risk to utility infrastructure	14	0.00		The score is calculated based on a reduction in flood risk to utility infrastructure, following the full implementation of option.			The score is calculated based on a reduction in flood risk to utility infrastructure, following the full implementation of option.		
		d	Minimise risk to agriculture	12	4.00	Source of Flooding: Fresh Water Percentage of AFA that is rural land: 23.42%	Area of Agricultural Land Flooded: No Change Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: No Change Flood Warning: Not Applicable Agricultural Production Enhanced: No Change Other (Please Specify): Not Applicable	0.00	0	Area of Agricultural Land Flooded: No Change Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: No Change Flood Warning: Not Applicable Agricultural Production Enhanced: No Change Other (Please Specify): Not Applicable	0.00	0
			ECONOMIC CRITERIA SCORE						265			265
3	Social	a i)	Minimise risk to human health and life - Residents	27	0.41	Flood Depths & Velocities: Medium to high risk to life Known Areas of Highly Vulnerable People: Reasonable Cross Section of Society	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	4.14	46	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	4.14	46
		a ii)	Minimise risk to human health and life - High vulnerability properties	17	0.05	Rate of Onset of flooding: Significantly Greater Rate of Onset	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	0.00	0	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	0.00	0
		b i)	Minimise risk to community - Social Infrastructure & Amenity	9	0.33	Assets of Particular Social Value: Yes	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	2.27	7	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	2.27	7
		b ii)	Minimise risk to community - Local employment	7	0.21	Asset of Particular Employment Value: No	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	2.98	4	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	2.98	4
			SOCIAL CRITERIA SCORE						57			57
4	Environmental	a	Support the objectives of the WFD	16	5.00	The River Galey flows within the AFA and is of moderate status. There are no potentially polluting sources within the 1%AEP. There are a number of Annex IV areas within the AFA and in proximity to the AFA: The Galey River is a Salmonid Waterbody (that intersects an SAC) and forms part the Lower Shannon cSAC 002165. Local weighting to be applied for this objective is constant, and should always be set equal to 5 as WFD objectives must be achieved and are relevant to all waterbodies.	Construction related impacts due to significant construction works in and adjacent to the Galey River due to the construction of the flood defence wall, and dredging works in the waterbody (PC). The proposed wall will permanently replace the natural bank for approx. 150 m. Improvement of channel conveyance (dredging every 5 years) is proposed along the Galey River. Both these measures could cause potential changes to the hydrological and morphological regime of the waterbody, HM and PC impacts due to sediment release. There will be reduced flooding in area with no significant polluting sources in 1% AEP extent. Therefore, a potential for medium-term or recurring impediment to the achievement of wb objectives.	-3.00	-240	Construction related impacts due to significant construction works in and adjacent to the Galey River due to the construction of the flood defence wall and embankment, PC. The proposed wall will permanently replace the natural bank for approx. 150 m. This measures could cause potential changes to the hydrological and morphological regime of the watercourses, HM. The embankment will be set back from the watercourse as far a reasonably practical therefore impacts to the hydrological and morphological regime of the watercourses as a result of the embankment are unlikely. There will be reduced flooding in area with no significant polluting sources in 1% AEP. Therefore a potential for medium-term or recurring impediment to the achievement of wb objectives.	-2.50	-200
		b	Support the objectives of the Habitats Directive	10	5.00	There is 1 cSAC within AFA the Lower River Shannon cSAC. Qualifying interests likely to occur within the AFA include otter, river, brook and sea lamprey, Atlantic salmon, and floating river vegetation. The status of the water quality of the Galey River is "Moderate". The River Galey is within a FWPM catchment with pre-1970 live records only (extant populations unlikely, but information in insufficient to list as 'extinct). Therefore, the presence of FWPM cannot be ruled out. The Stacks to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA also falls within the AFA. Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (within AFA) and potentially affected.	Potentially significant effects are: - Increases in suspended sediment due to in stream works and dredging - Pollution risks to the Galey River - Risk of disturbance to otter or their resting sites during proposed works - Risk of invasive species spread during proposed works. - Loss of riparian habitat within the cSAC - Impact to fish species includes salmon and lamprey. - Loss of fisheries habitat - Loss of life to FWPM (the River Galey is within a catchment with pre-1970 live records where extant populations are unlikely, but information is insufficient to list as 'extinct'. Their presence is therefore presumed. Therefore, any detrimental impact upon existing conservation objectives of SAC, SPA or Ramsar site, as a result of flood risk management measures, where there are no suitable mitigation measures.	-999.00	-49950	Potentially significant effects are: - Increases in suspended sediment - Pollution risks to the Galey Feale - Risk of disturbance to otter or their resting sites during proposed works - Risk of invasive species spread during proposed works. - Loss of riparian habitat within the cSAC - Impact to fish species includes salmon and lamprey - Loss of fisheries habitat - Loss of life to FWPM (the River Galey is within a catchment with pre-1970 live records (extant populations unlikely, but information in insufficient to list as 'extinct') surveys by qualified ecologist to inform the Appropriate Assessment will be undertaken during the detailed design phase in order to identify if this species is occurring within the waterbody (River Galey). Therefore, a potential detrimental impact upon existing cSAC site, including a delay in recovery of the site, but excluding impacts on the conservations objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	-1.50	-75
		c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	5	2.00	There are no nationally designated sites within the AFA, but there is potential for significant habitats and populations of European and nationally protected species. The River Galey is within a catchments with pre-1970 live records therefore extant populations unlikely, but information in insufficient to list as 'extinct'. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are no designated sites but habitats/species are likely to be present that could be affected.	Potentially significant effects are: - Increases in suspended sediment - Pollution risks to the Galey River - Risk of disturbance to otter or their resting sites during proposed works - Risk of invasive species spread during proposed works - Loss of riparian habitat - Impact to fish species includes salmon and lamprey - Loss of fisheries habitat - Loss of life to FWPM (unlikely) Therefore, potential localised loss of or disturbance to flora/fauna.	-2.00	-20	Potentially significant effects are: - Increases in suspended sediment - Pollution risks to the Galey River - Risk of disturbance to otter or their resting sites during proposed works - Risk of invasive species spread during proposed works - Loss of riparian habitat - Impact to fish species includes salmon and lamprey - Loss of fisheries habitat - Loss of life to FWPM (unlikely) Therefore a potential localised loss of or disturbance to flora/fauna.	-1.50	-15
		d	Protect, and where possible enhance, fisheries resource within the catchment	13	2.00	The Galey River is a Salmonid Waterbody (that intersects an SAC) and is considered a medium activity angling area. Local weighting of 2 set by professional judgement. Weighting of 2 applied where a waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.	Potential short term construction impacts that can be mitigated. There is long term impacts associated with increased conveyance (dredging) along the Galey River the ongoing associated maintenance works in this area. Impact to the hydrological and morphological regimes and also an indirect negative /effect to ecological receptors (including fisheries) due to loss of the natural bank and dredging works. Therefore, a potential medium to long-term alternation of fisheries habitat.	-5.00	-130	Potential short term construction impacts that can be mitigated. Impact to the hydrological and morphological regimes and also an indirect negative /effect to ecological receptors (including fisheries) due to loss of the natural bank and dredging works. Therefore, a potential medium to long-term alternation of fisheries habitat.	-4.50	-117
		e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	8	1.00	There are no designated landscape features within the AFA. There is a small amenity area in the centre of Athea at the River Galey Bridge. Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected.	There is no impact on designated landscape features. The permanent wall and embankment within the AFA adjacent to watercourse within the Town will alter the visual amenity in the area. Therefore, a potential for long term impact to a low sensitivity landscape character/feature in the zone of visibility of the selected measure.	-2.00	-16	There is no impact on designated landscape features. The permanent wall and embankment within the AFA adjacent to watercourse within the Town will alter the visual amenity in the area. Therefore, a potential for long term impact to a low sensitivity landscape character/feature in the zone of visibility of the selected measure.	-2.50	-20
		f i)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of architectural value	4	2.00	There are no ACAs in the AFA. Athea Bridge is a RPS/NIAH and it within the 1%AEP but also within the River Galey. There is one other NIAH in the vicinity of the 1%AEP. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a moderate to low vulnerability.	The setting of the Athea Bridge (RPS/NIAH) could be affected by the proposed flood defence wall. There is a existing risk to 2 architectural Heritage features in the AFA (one is the Athea Bridge). The Athea Bridge will be afforded some protection in the 1%AEP with this option. Therefore, there is a potential increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.	1.00	8	The setting of the Athea Bridge (RPS/NIAH) could be affected by the proposed flood defence wall. There is a existing risk to 2 architectural Heritage features in the AFA (one is the Athea Bridge). The Athea Bridge will be afforded some protection in the 1%AEP with this option. Therefore, there is a potential increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.	1.00	8
		f ii)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of archaeological value	4	0.00	There area no RMP within the 1% AEP or within the AFA. Local weighting of 0 set by professional judgement. Weighting of 0 applied where there are no archaeological features at risk.	There are no RMPs in the AFA therefore, no significant impacts are predicted . There is a potential for unknown archaeological features to be impacted but these are not known. Therefore, no effects on archaeological features are predicted.	0.00	0	There are no RMPs in the AFA therefore, no significant impacts are predicted . There is a potential for unknown archaeological features to be impacted but these are not known. Therefore, no effects on archaeological features are predicted.	0.00	0
			ENVIRONMENTAL CRITERIA SCORE						-50348			-419
	Economic Values		Economic PV Benefits					€543,552			€543,552	
			Cost					€533,035			€381,747	
			NPV Benefits					€10,517			€161,805	
			Economic BCR					**1.02**			**1.42**	
	Outcome Scores		MCA PV Benefits					€274,266			€274,266	
			MCA Benefit Score					-50026			-97	
			MCA BCR					**-93851.64**			**-254.71**	
			Option Selection MCA					-49426			903	

Objective	Global Weightings (fixed)	Local Weightings		Baseline / Local Weighting Comments	Option 1 Comments	Option 2 Comments
1.A	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has low operational risks to operate or perform successfully.	This score is determined for this option as it has no operational risks to operate or perform successfully.
1.B	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has low health and safety risks associated with the construction and operation of flood risk management option.	This score is determined for this option as it has low health and safety risks associated with the construction and operation of flood risk management option.
1.C	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.
2.A	24	0.25	calculated	Local weighting is calculated based on the baseline AAD.	This score is calculated based on the reduction in AAD, following the full implementation of option.	This score is calculated based on the reduction in AAD, following the full implementation of option.
2.B	10	5.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to transport infrastructure. Local weighting already at maximum. Maximum local weighting is representative of receptors at risk - no change made to local weighting.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.
2.C	14	0.00	calculated but adjusted by professional judgement if necessary	There are no Utilitiy receptors at risk of flooding within the AFA.	There are no Utilitiy receptors at risk of flooding within the AFA.	There are no Utilitiy receptors at risk of flooding within the AFA.
2.D	12	4.00	Professional judgement	Local weighting is calculated based on the percentage of rural land within the AFA. As there is a lot of flooding of farmland within the AFA the local weighting has been increased to 4.	This option has no effect on agriculture.	This option has no effect on agriculture.
3.A (i)	27	0.41	calculated but adjusted by professional judgement if necessary	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option.	Local weighting is calculated based on the baseline risk to residential properties. Calculated local weighting increased by 50% as during historical events a rapid rate of onset was reported.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option.
3.A (ii)	17	0.05	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to high vulnerability properties.	This score is calculated based on a reduction in flooding to high vulnerability properties, following full implementation of the option.	This score is calculated based on a reduction in flooding to high vulnerability properties, following full implementation of the option.
3.B (i)	9	0.33	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to social infrastructure but adjusted by professional judgement. Local Weighting increased by 20% to account for presence of school and community centre.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option.
3.B (ii)	7	0.21	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to local employment.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option.
4.A	16	5.00	fixed	There is 1 cSAC within AFA the Lower River Shannon cSAC. Qualifying interests likely to occur within the AFA include otter, river, brook and sea lamprey, Atlantic salmon, and floating river vegetation. The status of the water quality of the Galey River is "Moderate". The River Galey is within a FWPM catchment with pre-1970 live records only (extant populations unlikely, but information in insufficient to list as 'extinct). Therefore, the presence of FWPM cannot be ruled out. The Stacks to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA also falls within the AFA. Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (within AFA) and potentially affected.	Construction related impacts due to significant construction works in and adjacent to the Galey River due to the construction of the flood defence wall, and dredging works in the waterbody (PC). The proposed wall will permanently replace the natural bank for approx. 150 m. Improvement of channel conveyance (dredging every 5 years) is proposed along the Galey River. Both these measures could cause potential changes to the hydrological and morphological regime of the waterbody, HM and PC impacts due to sediment release. There will be reduced flooding in area with no significant polluting sources in 1% AEP extent. Therefore, a potential for medium-term or recurring impediment to the achievement of wb objectives.	Construction related impacts due to significant construction works in and adjacent to the Galey River due to the construction of the flood defence wall and embankment, PC. The proposed wall will permanently replace the natural bank for approx. 150 m. This measures could cause potential changes to the hydrological and morphological regime of the watercourses, HM. The embankment will be set back from the watercourse as far a reasonably practical therefore impacts to the hydrological and morphological regime of the watercourses as a result of the embankment are unlikely. There will be reduced flooding in area with no significant polluting sources in 1% AEP. Therefore a potential for medium-term or recurring impediment to the achievement of wb objectives.
4.B	10	5.00	Professional judgement	There is 1 cSAC within AFA the Lower River Shannon cSAC. Qualifying interests likely to occur within the AFA include otter, river, brook and sea lamprey, Atlantic salmon, and floating river vegetation. The status of the water quality of the Galey River is "Moderate". The River Galey is within a FWPM catchment with pre-1970 live records only (extant populations unlikely, but information in insufficient to list as 'extinct). Therefore, the presence of FWPM cannot be ruled out. The Stacks to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA also falls within the AFA. Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (within AFA) and potentially affected.	Potentially significant effects are: - Increases in suspended sediment due to in stream works and dredging - Pollution risks to the Galey River - Risk of disturbance to otter or their resting sites during proposed works - Risk of invasive species spread during proposed works. - Loss of riparian habitat within the cSAC - Impact to fish species includes salmon and lamprey. - Loss of fisheries habitat - Loss of life to FWPM (the River Galey is within a catchment with pre-1970 live records where extant populations are unlikely, but information is insufficient to list as 'extinct'. Their presence is therefore presumed. Therefore, any detrimental impact upon existing conservation objectives of SAC, SPA or Ramsar site, as a result of flood risk management measures, where there are no suitable mitigation measures.	Potentially significant effects are: - Increases in suspended sediment - Pollution risks to the Galey Feale - Risk of disturbance to otter or their resting sites during proposed works - Risk of invasive species spread during proposed works. - Loss of riparian habitat within the cSAC - Impact to fish species includes salmon and lamprey - Loss of fisheries habitat - Loss of life to FWPM (the River Galey is within a catchment with pre-1970 live records (extant populations unlikely, but information in insufficient to list as 'extinct') surveys by qualified ecologist to inform the Appropriate Assessment will be undertaken during the detailed design phase in order to identify if this species is occurring within the waterbody (River Galey). Therefore, a potential detrimental impact upon existing cSAC site, including a delay in recovery of the site, but excluding impacts on the conservations objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.
4.C	5	2.00	Professional judgement	There are no nationally designated sites within the AFA, but there is potential for significant habitats and populations of European and nationally protected species. The River Galey is within a catchments with pre-1970 live records therefore extant populations unlikely, but information in insufficient to list as 'extinct'. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are no designated sites but habitats/species are likely to be present that could be affected.	Potentially significant effects are: - Increases in suspended sediment - Pollution risks to the Galey River - Risk of disturbance to otter or their resting sites during proposed works - Risk of invasive species spread during proposed works - Loss of riparian habitat - Impact to fish species includes salmon and lamprey - Loss of fisheries habitat - Loss of life to FWPM (unlikely) Therefore, potential localised loss of or disturbance to flora/fauna.	Potentially significant effects are: - Increases in suspended sediment - Pollution risks to the Galey River - Risk of disturbance to otter or their resting sites during proposed works - Risk of invasive species spread during proposed works - Loss of riparian habitat - Impact to fish species includes salmon and lamprey - Loss of fisheries habitat - Loss of life to FWPM (unlikely) Therefore a potential localised loss of or disturbance to flora/fauna.
4.D	13	2.00	Professional judgement	The Galey River is a Salmonid Waterbody (that intersects an SAC) and is considered a medium activity angling area. Local weighting of 2 set by professional judgement. Weighting of 2 applied where a waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.	Potential short term construction impacts that can be mitigated. There is long term impacts associated with increased conveyance (dredging) along the Galey River the ongoing associated maintenance works in this area. Impact to the hydrological and morphological regimes and also an indirect negative /effect to ecological receptors (including fisheries) due to loss of the natural bank and dredging works. Therefore, a potential medium to long-term alternation of fisheries habitat.	Potential short term construction impacts that can be mitigated. Impact to the hydrological and morphological regimes and also an indirect negative /effect to ecological receptors (including fisheries) due to loss of the natural bank and dredging works. Therefore, a potential medium to long-term alternation of fisheries habitat.
4.E	8	1.00	Professional judgement	There are no designated landscape features within the AFA. There is a small amenity area in the centre of Athea at the River Galey Bridge. Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected.	There is no impact on designated landscape features. The permanent wall and embankment within the AFA adjacent to watercourse within the Town will alter the visual amenity in the area. Therefore, a potential for long term impact to a low sensitivity landscape character/feature in the zone of visibility of the selected measure.	There is no impact on designated landscape features. The permanent wall and embankment within the AFA adjacent to watercourse within the Town will alter the visual amenity in the area. Therefore, a potential for long term impact to a low sensitivity landscape character/feature in the zone of visibility of the selected measure.
4.F(i)	4	2.00	Professional judgement	There are no ACAs in the AFA. Athea Bridge is a RPS/NIAH and it within the 1%AEP but also within the River Galey. There is one other NIAH in the vicinity of the 1%AEP. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a moderate to low vulnerability.	The setting of the Athea Bridge (RPS/NIAH) could be affected by the proposed flood defence wall. There is a existing risk to 2 architectural Heritage features in the AFA (one is the Athea Bridge). The Athea Bridge will be afforded some protection in the 1%AEP with this option. Therefore, there is a potential increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.	The setting of the Athea Bridge (RPS/NIAH) could be affected by the proposed flood defence wall. There is a existing risk to 2 architectural Heritage features in the AFA (one is the Athea Bridge). The Athea Bridge will be afforded some protection in the 1%AEP with this option. Therefore, there is a potential increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.
4.F(ii)	4	0.00	Professional judgement	There area no RMP within the 1% AEP or within the AFA. Local weighting of 0 set by professional judgement. Weighting of 0 applied where there are no archaeological features at risk.	There are no RMPs in the AFA therefore, no significant impacts are predicted . There is a potential for unknown archaeological features to be impacted but these are not known. Therefore, no effects on archaeological features are predicted.	There are no RMPs in the AFA therefore, no significant impacts are predicted . There is a potential for unknown archaeological features to be impacted but these are not known. Therefore, no effects on archaeological features are predicted.

CFRAM Programme – Option Costs for Cost Benefit Analysis			€	€	€	Notes to CFRAM Consultants
(1)	**Basic Construction Costs (Estimate)**				**187,100**	Construction Cost of each measure <u>including</u> Method Factor and CPI Adjustment but <u>excluding</u> Preliminaries
(2)	**Preliminaries**	25.7%			**47,996**	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				**235,096**	
(3)	**Optimism Bias**	25.0%			**58,774**	Refer to UCD for selecting OB %
(4)	**Construction Costs (Excl VAT)**				**293,870**	
(5)	**Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)**	13.0%			**38,203**	Set at 13%
	Construction Costs and Fees				**332,073**	
(6)	**Other Items**					
(a)	Allowance for Archaeology & Environmental Mitigation Measures	10.0%		29,387		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b)	Allowance for compensation and land acquisition	5.0%		14,693		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c)	Site investigation	3% assumed		8,816		Professional judgement to be applied in estimating a suitable sum.
(d)	Art Allowance					See “Guidance E – Per Cent for Art Note”
(e)	Est. NPV Operation & Maintenance		118,453			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	25.0%	29,613	148,066	**200,963**	Refer to UCD for selecting OB %
	Option Cost for Cost Benefit Analysis				**533,035**	

JBA consulting

DONNACHADH O'BRIEN & ASSOCIATES CONSULTING ENGINEERS

OPW The Office of Public Works Oifig na nOibreacha Poiblí

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	J. Reynolds	Date:	18/09/2015
Checked by:		Date:	

Project reference	S14c	Project name:	ATA_01

Base date for estimates (year 0)	Oct-2013	Construction Price Index (CPI)	0.987
Scaling factor (e.g. €m, €k, €)	€	Method Factor - to take into account particular site issues /constraints	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Capital costs	Cost (€)	Comment
Total wall costs	€159,024	*stone clad wall, piled*
Total embankment costs		
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs	€30,627	*Dredging (0.75m) and refill (0.25m), supervised by a*
Total Construction costs	€189,651	
Apply update to unit rate (CPI) if appropriate (cell N15)	€187,100	
Enter appropriate preliminaries estimate (%)	25.7%	
Enter other applicable costs (€)		
Total capital cost (€)	€235,096	
Consider amendments based on site issues/constraints (cell N16)	€235,096	
Total capital cost (€)	€235,096	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs	€60	*average o&m assumed*
Total embankment O&M costs		
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€60	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)	€30,627	*Dredging (0.75m) and refill (0.25m) every 5 years, supervised by a geomorphologist/ecologist.*

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€353,549	
Optimism bias rate (from external sheet)	25%	
Total Cost including Optimism Bias	€441,936	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€235,096
Annual maintenance cost (€)	€60
Other cost (€)	€30,627
Other works frequency (years)	5

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	4.0%	Present Value Factor:		22.341		Total PVc (€k):	353549
	Cash sum	0	235096	2958	275646	513700	353549
	Discount	Cost Elements				TOTALS:	
year	Factor	Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	0.00	235095.69			235095.69	235095.69
1	0.962			60.37		60.37	58.05
2	0.925			60.37		60.37	55.82
3	0.889			60.37		60.37	53.67
4	0.855			60.37		60.37	51.61
5	0.822			60.37	30627.37	30687.74	25223.09
6	0.790			60.37		60.37	47.71
7	0.760			60.37		60.37	45.88
8	0.731			60.37		60.37	44.11
9	0.703			60.37		60.37	42.42
10	0.676			60.37	30627.37	30687.74	20731.54
11	0.650			60.37		60.37	39.22
12	0.625			60.37		60.37	37.71
13	0.601			60.37		60.37	36.26
14	0.577			60.37		60.37	34.86
15	0.555			60.37	30627.37	30687.74	17039.81
16	0.534			60.37		60.37	32.23
17	0.513			60.37		60.37	30.99
18	0.494			60.37		60.37	29.80
19	0.475			60.37		60.37	28.66
20	0.456			60.37	30627.37	30687.74	14005.49
21	0.439			60.37		60.37	26.49
22	0.422			60.37		60.37	25.47
23	0.406			60.37		60.37	24.49
24	0.390			60.37		60.37	23.55
25	0.375			60.37	30627.37	30687.74	11511.49
26	0.361			60.37		60.37	21.78
27	0.347			60.37		60.37	20.94
28	0.333			60.37		60.37	20.13
29	0.321			60.37		60.37	19.36
30	0.308			60.37	30627.37	30687.74	9461.60
31	0.296			60.37		60.37	17.90
32	0.285			60.37		60.37	17.21
33	0.274			60.37		60.37	16.55
34	0.264			60.37		60.37	15.91
35	0.253			60.37	30627.37	30687.74	7776.75
36	0.244			60.37		60.37	14.71
37	0.234			60.37		60.37	14.14
38	0.225			60.37		60.37	13.60
39	0.217			60.37		60.37	13.08
40	0.208			60.37	30627.37	30687.74	6391.92
41	0.200			60.37		60.37	12.09
42	0.193			60.37		60.37	11.63
43	0.185			60.37		60.37	11.18
44	0.178			60.37		60.37	10.75
45	0.171			60.37	30627.37	30687.74	5253.69
46	0.165			60.37		60.37	9.94
47	0.158			60.37		60.37	9.56
48	0.152			60.37		60.37	9.19
49	0.146			60.37		60.37	8.83

Option 2 Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis					Notes to CFRAM Consultants
		€	€	€	
(1) Basic Construction Costs (Estimate)				**178,201**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2) Preliminaries	25.9%			**46,213**	Refer to UCD for selecting Preliminaries. %
Sub-Total:				**224,413**	
(3) Optimism Bias	25.0%			**56,103**	Refer to UCD for selecting OB %
(4) Construction Costs (Excl VAT)				**280,517**	
(5) Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)	13.0%			**36,467**	Set at 13%
Construction Costs and Fees				**316,984**	
(6) Other Items					
(a) Allowance for Archaeology & Environmental Mitigation Measures	10.0%		28,052		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b) Allowance for compensation and land acquisition	5.0%		14,026		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c) Site investigation	3% assumed		8,415		Professional judgement to be applied in estimating a suitable sum.
(d) Art Allowance					See "Guidance E – Per Cent for Art Note"
(e) Est. NPV Operation & Maintenance		11,416			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
Optimism Bias	25.0%	2,854	14,270	**64,763**	Refer to UCD for selecting OB %
Option Cost for Cost Benefit Analysis				**381,747**	

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	**J. Reynolds**	**Date:**	**14/07/2015**
Checked by:	**M. Conlon**	**Date:**	**14/07/2015**

Project reference	S14c	**Project name:**	Athea - ATA_02
Base date for estimates (year 0)	Oct-2013	**Construction Price Index (CPI)**	**0.987**
Scaling factor (e.g. €m, €k, €)	€	**Method Factor - to take into account particular site issues /constraints**	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	**Cost (€)**	**Comment**
Total wall costs	€159,024	*urban piled.*
Total embankment costs	€19,177	*no piles, imported material*
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€178,201	
Apply update to unit rate (CPI) if appropriate (cell N15)	€175,803	
Enter appropriate preliminaries estimate (%)	26%	
Enter other applicable costs (€)		
Total capital cost (€)	€224,413	
Consider amendments based on site issues/constraints (cell N16)	€224,413	
Total capital cost (€)	€224,413	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs	€60	*average O&M assumed*
Total embankment O&M costs	€475	*average O&M assumed*
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€535	

Other costs	**Cost (€)**	**Comment**
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€235,830	
Optimism bias rate (from external sheet)	25%	*default CFRAMS optimism bias*
Total Cost including Optimism Bias	€294,787	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€224,413.3
Annual maintenance cost (€)	€534.9
Other cost (€)	€0.0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**		**Total PVc (€k):**	**235830**
	Cash sum	0	224413	26212	0	250625	**235830**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	224413			224413.3	224413.3
1	0.962			535		534.9	514.4
2	0.925			535		534.9	494.6
3	0.889			535		534.9	475.6
4	0.855			535		534.9	457.3
5	0.822			535		534.9	439.7
6	0.790			535		534.9	422.8
7	0.760			535		534.9	406.5
8	0.731			535		534.9	390.9
9	0.703			535		534.9	375.8
10	0.676			535		534.9	361.4
11	0.650			535		534.9	347.5
12	0.625			535		534.9	334.1
13	0.601			535		534.9	321.3
14	0.577			535		534.9	308.9
15	0.555			535		534.9	297.0
16	0.534			535		534.9	285.6
17	0.513			535		534.9	274.6
18	0.494			535		534.9	264.1
19	0.475			535		534.9	253.9
20	0.456			535		534.9	244.1
21	0.439			535		534.9	234.7
22	0.422			535		534.9	225.7
23	0.406			535		534.9	217.0
24	0.390			535		534.9	208.7
25	0.375			535		534.9	200.7
26	0.361			535		534.9	192.9
27	0.347			535		534.9	185.5
28	0.333			535		534.9	178.4
29	0.321			535		534.9	171.5
30	0.308			535		534.9	164.9
31	0.296			535		534.9	158.6
32	0.285			535		534.9	152.5
33	0.274			535		534.9	146.6
34	0.264			535		534.9	141.0
35	0.253			535		534.9	135.6
36	0.244			535		534.9	130.3
37	0.234			535		534.9	125.3
38	0.225			535		534.9	120.5
39	0.217			535		534.9	115.9
40	0.208			535		534.9	111.4
41	0.200			535		534.9	107.1
42	0.193			535		534.9	103.0
43	0.185			535		534.9	99.1
44	0.178			535		534.9	95.2
45	0.171			535		534.9	91.6
46	0.165			535		534.9	88.1
47	0.158			535		534.9	84.7
48	0.152			535		534.9	81.4
49	0.146			535		534.9	78.3

Appendix C4 Option Appraisal Report - Banna

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STAGE 1: Summary of Current Flood Risk

1.1 AFA and Watercourse Details

AFA	Banna
Unit of Management:	23
Primary Watercourses:	Dinneens (Stream), North Commons (River), Tyshe (River), Ballynoe (River)

1.2 Summary of Flood Risk in 1% AEP Fluvial Event/ 0.5% Coastal Event

Source of flood risk	Fluvial	Coastal	**Both**

		Residential	Non-Residential	Total
Total Number of Properties at risk in AFA in 1% Fluvial / 0.5% Coastal AEP Event:	**Fluvial**	19	0	19
	Coastal	18	0	18
	Combined	19	0	19

AFA Flood Cells:	**Total Number:**	1
	Flood Cell Titles:	BAA_A

	Flood Cell Ref	Residential	Non-Res	Total
Breakdown of properties at (combined) risk per Flood Cell:	BAA_A	19	0	19

Relevant Comments:	Banna is at risk from both a 1% AEP fluvial and 0.5% coastal flood source.
Relevant Figure Ref:	Figure 1.1 to 1.3

1.3 Summary of Existing Flood Risk Management Measures

Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
No	No	No	No	No	**Yes**

Relevant Comments:	The River Tyshe flows to the sea at Black Rock. The outfall at Black Rock is vulnerable to blockage from build-up of sand. Sand and seaweed are excavated out of the channel opening. These works take place at least every two weeks, but this can be daily in the winter months. Maintenance work is also carried out to keep tidal flaps, approx. 600m upstream of the outfall, functioning. Sluice gates are manually operated to close on high tides to prevent tide backing up on Tyshe River, typically closed once every few weeks. A blockage analysis was carried out to determine the flood risk to the Banna AFA if the the excavation of sand and seaweed from the channel entrance was to cease. The flood extents resulting from this blockage analysis are provided as the current flood risk.
Relevant Figure Ref:	Figure 1.1 and 1.2

1.4 Summary of PV Damages/Potential PV

		Uncapped	Capped
Total PV Damages:	**Fluvial**	€ 1,720,700	€ 1,720,700
	Coastal	€ 1,663,874	€ 1,663,874
	Combined	€ 3,384,574	€ 2,674,804

Max Combined Capped Benefits for 1% Fluvial and 0.5% Coastal AEP Event:	€ 2,424,244			
Breakdown of Max Combined Capped PV Benefits per Flood Cell for 1% Fluvial and 0.5% Coastal AEP Event:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	BAA_A	€ 2,424,244	€ 0	€ 2,424,244
Relevant Figure Ref:	Figure 1.3			

1.5 Social Risk		
	Type	**Description**
High Vulnerability Properties at risk:	None	N/A
Social Infrastructure Assets:	None	N/A
Social Amenity Sites:	None	N/A
Relevant Figure Ref:	General Risk - Social	
1.6 Risk to the Environment		
	Type	**Description**
Risk to WFD Annex IV:	None	N/A
Risk to SACs:	SACs & SPAs	There are no designated sites within the AFA the closest is the Akeragh, Banna And Barrow Harbour SAC, Tralee Bay Complex SPA less than 500m west.
Relevant Figure Ref:	General Risk - Environment	
1.7 Risk to Cultural Heritage		
	Type	**Description**
Risk to Sites of Cultural Heritage:	None	N/A
Relevant Figure Ref:	General Risk – Cultural Heritage	
1.8 Risk to the Economy		
	Type	**Description**
Risk to Transport Infrastructure:	None	N/A
Risk to Utility Infrastructure:	None	N/A
Relevant Figure Ref:	General Risk - Economy	

Figure 1.1 – Banna Coastal Flood Risk to Properties with Blockage

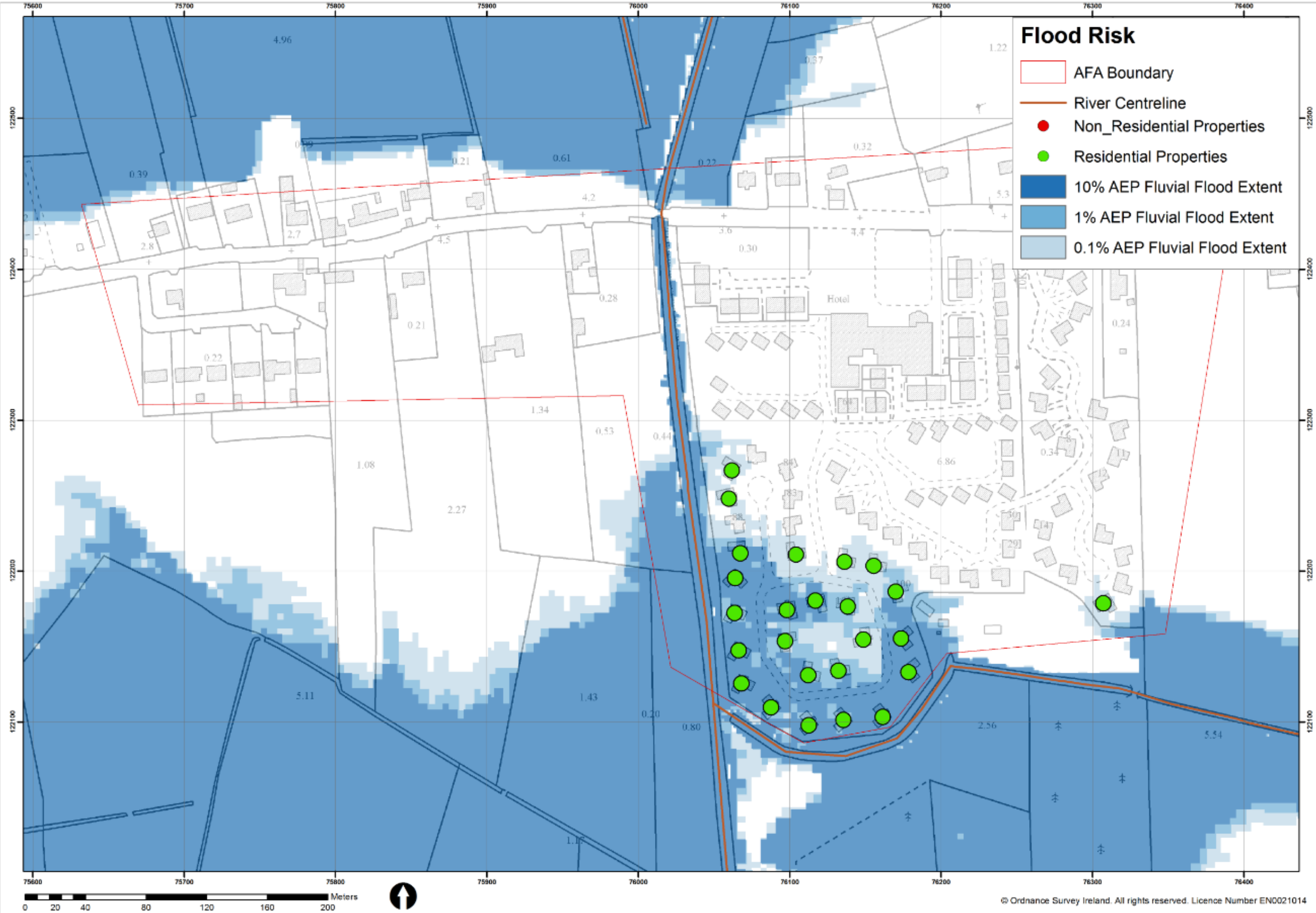

Figure 1.2 – Banna Fluvial Flood Risk to Properties with Blockage

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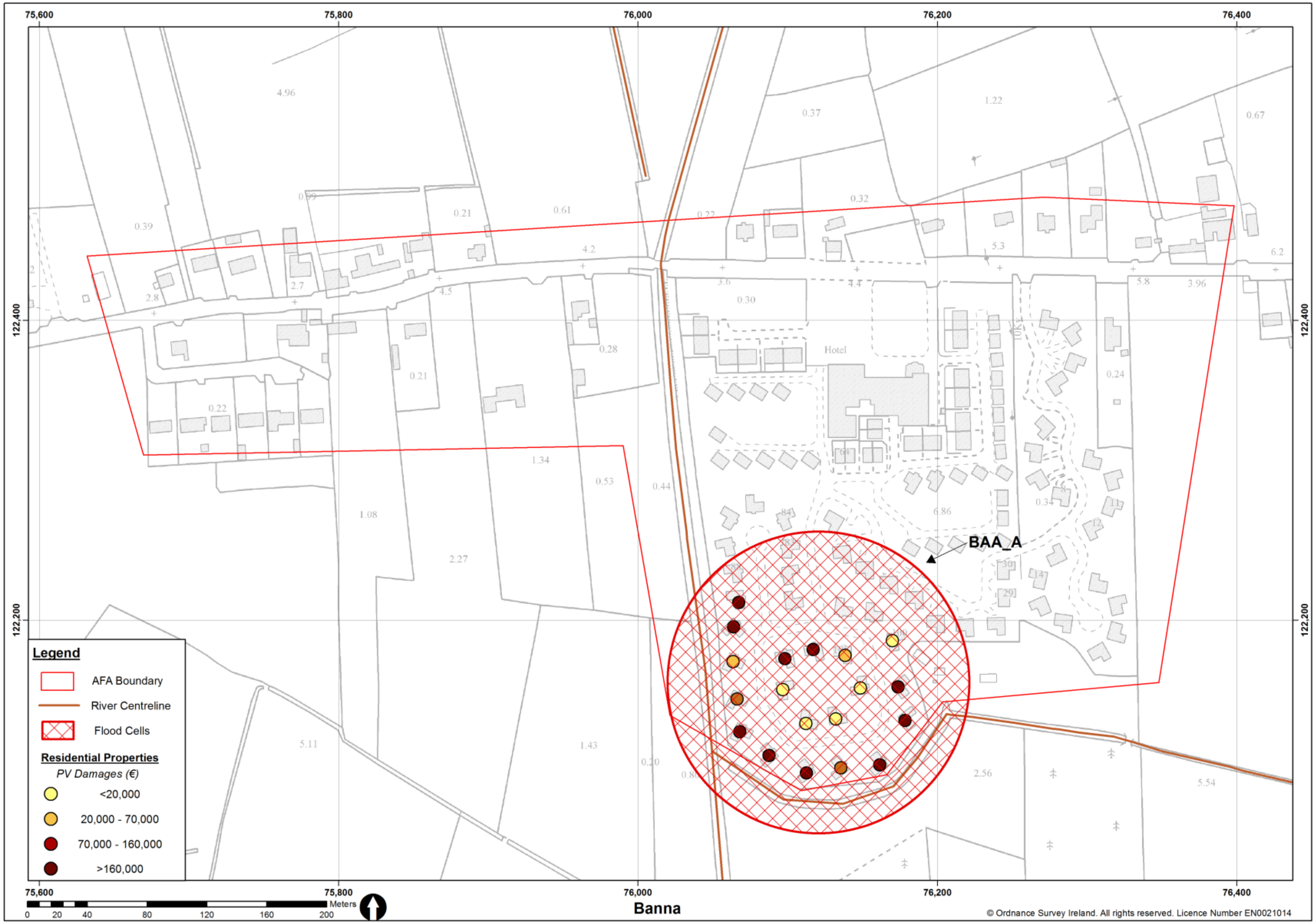

Figure 1.3 – Banna Total Combined PV Damages for Properties in the 1% Fluvial & 0.5% Coastal AEP Flood Event and Flood Cells. Flood Cells are groupings of properties that are likely to be hydraulically linked.

STAGE 2: Screening of the Measures

2.1 Baseline, Structural and Non-Structural Measures

Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.

Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
B	Existing Regime	Viable	Unviable	Viable	Viable	Viable	**Screened Out**
C	Do Minimum	Unviable	Unviable	Viable	Unviable	Viable	**Screened Out**
Structural							
D	Storage	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
E	Flow Diversion	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
F	Increase Conveyance	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
G	Flood Defences	Viable	Viable	Viable	Viable	Viable	**Screened In**
H	Relocation of Properties	Unviable	Unviable	Viable	Unviable	Viable	**Screened Out**
I	Other Measures	Unviable	Unviable	Unviable	Unviable	Unviable	**Screened Out**
Non-Structural							
J	Flood Forecasting / Warning / Response	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	**Screened In**
L	Individual Property Resistance	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
M	Individual Property Resilience	Viable	Viable	Viable	Viable	Viable	**Screened In**

2.2 Justification for Screened Out Baseline and Structural Measures

The following provides justification on Measures with an overall viability 'Screened Out' categorisation.

A	Do Nothing	Applicability Economic Environmental Social Cultural	"Screened Out" as there are other viable options
B	Existing Regime	Applicability Economic Environmental Social Cultural	The PV cost of the existing regime is estimated at approx. €3.2m, considering the annual costs are estimated at €150,000. With the maximum PV cost of approx. €2.4m this option is economically unviable.
C	Do Minimum	Applicability Economic Environmental Social Cultural	Screened out as the do minimum FRM measure would have no impact in alleviating the flood risk.
D	Storage	Applicability Economic Environmental Social Cultural	Storage is not applicable to this AFA as there is significant coastal flood risk.

H	Relocation of Properties	Applicability Economic Environmental Social Cultural	The relocation of 20 properties is not applicable to the area as it would be economically and socially unviable.
E	Flow Diversion	Applicability Economic Environmental Social Cultural	Flow Diversion is not applicable to this AFA as there is significant coastal flood risk.
F	Increased Conveyance	Applicability Economic Environmental Social Cultural	Increase conveyance is not applicable to this AFA as there is significant coastal flood risk.
I	Other Measures	Applicability Economic Environmental Social Cultural	No other Measures have been identified.
J	Flood Forecasting / Warning / Response	Applicability Economic Environmental Social Cultural	The source of flood risk within the AFA is due to the tide locking of fluvial flow. While flood-forecasting system is viable for the coastal element of the flood risk a warning system indicating the threat of fluvial flooding would also be required. In the absence of any flow/stage gauges in the area flood forecasting cannot be recommended.
L	Individual Property Resistance	Applicability Economic Environmental Social Cultural	Individual property resistance is not a viable FRM measure in the absence of a flood forecasting system.

2.3 Summary of 'Screened In' Measures

The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.

Structural Measures		**Non- Structural Measures**	
G	Flood Defences	K	Public Awareness
		M	Individual Property Resilience

STAGE 3: Selection of Options

3.1 Consideration of Options

The following are the agreed combination of 'Screened In' measures that comprise each of the Options being taken forward for further consideration.

Where appropriate, the 'Screened In' measures have been sub-divided into separate specific measures to ensure applicability to site conditions.

Measures		**Different composition of measures per option**						
Structural Measures								
G	Flood Defences							
Gi	New Flood Defences	✓						
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
K	Public Awareness							
M	Individual Property Resilience							
Option Reference		BAA_01						

Measures not screened out but not included in options

Measures		**Justification**
M	Public Awareness	Public Awareness was not considered as either an independent measure or in combination with other measures, as the option being appraised would provide the required 1% Fluvial AEP standard of protection. Public Awareness does not improve the viability of the options under consideration.
M	Individual Property Resilience	Individual Property Resilience was not considered as either an independent measure or in combination with other measures, as the option being appraised would provide the required 1% Fluvial / 0.5% Coastal AEP standard of protection. Individual Property Resilience does not improve the viability of the option under consideration

STAGE 4: Appraisal of Options

4.1 Options Appraisal

Each option taken forward for Multi-Criteria Assessment (MCA) analysis is to be discussed at the Option Development Meeting. Below describes this concept design of each options and provides a summary of any significant comments/issues which were raised by LA staff at the Options Development Meetings. These comments will be considered in the local weightings and the MCA scores.

Option Ref:		BAA_01				
Option Measures	**Baseline**		**None**			
	Structural	**Gi**	**Flood Defences: New Flood Defences**			
	Non Structural	J Flood Forecasting	K Public Awareness	L Property Resistance	M Property Resilience	
Option Description:		This option will provide a 1% Fluvial and 0.5% Coastal AEP Design standard to properties within the AFA identified as being at risk and includes; • Construction of embankment average height 1-1.5m above ground level, and 325m long. • Discontinuing the existing regime of removing silt and debris from the outfall at Blackrock.				
Option Development Meeting:		Date:	10th of June 2015			
		Summary:	The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.			

STAGE 5: Multi Criteria Assessment		
5.1 Options selected for the Multi Criteria Assessment Following the Option Development Meeting, the following options are the refined options for the Multi-Criteria Assessment (MCA) stage. This is the final of a five stage MCA process.		
Option Reference		BAA_01
Structural Measures		
Gi	New Flood Defences	Construction of new flood defence as shown in Figure 5.1.
Table reference A summary of the outcome from the MCA is presented in the following table		Table 5.1

Table 5.1: Multi Criteria Assessment Outcome for Option BAA_01

<table>
<tr><td colspan="5">Multi Criteria Assessment
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.</td></tr>
<tr><td>AFA</td><td colspan="2">Banna</td><td>Option Ref:</td><td>BAA_01</td></tr>
<tr><td colspan="5">Option Measures</td></tr>
<tr><td>Structural</td><td>Gi</td><td colspan="3">New Flood Defences</td></tr>
<tr><td colspan="5">Criteria Scores</td></tr>
<tr><td colspan="3">Technical</td><td colspan="2">800</td></tr>
<tr><td colspan="3">Economic</td><td colspan="2">-14</td></tr>
<tr><td colspan="3">Social</td><td colspan="2">672</td></tr>
<tr><td colspan="3">Environmental</td><td colspan="2">-179</td></tr>
<tr><td colspan="5">Economic Values</td></tr>
<tr><td colspan="3">Economic PV Benefits</td><td colspan="2">€2,424,244</td></tr>
<tr><td colspan="3">PV Cost</td><td colspan="2">€144,933</td></tr>
<tr><td colspan="3">NPV Benefits</td><td colspan="2">€2,279,311</td></tr>
<tr><td colspan="3">Economic BCR</td><td colspan="2">16.73</td></tr>
<tr><td colspan="5">Outcome Scores</td></tr>
<tr><td colspan="3">MCA PV Benefits</td><td colspan="2">€1,130,373</td></tr>
<tr><td colspan="3">MCA Benefit Score</td><td colspan="2">479</td></tr>
<tr><td colspan="3">MCA Benefit Score Ratio</td><td colspan="2">3308.01</td></tr>
<tr><td colspan="3">Option Selection MCA</td><td colspan="2">1279</td></tr>
<tr><td colspan="3">Relevant Figure</td><td colspan="2">Figure 5.1</td></tr>
</table>

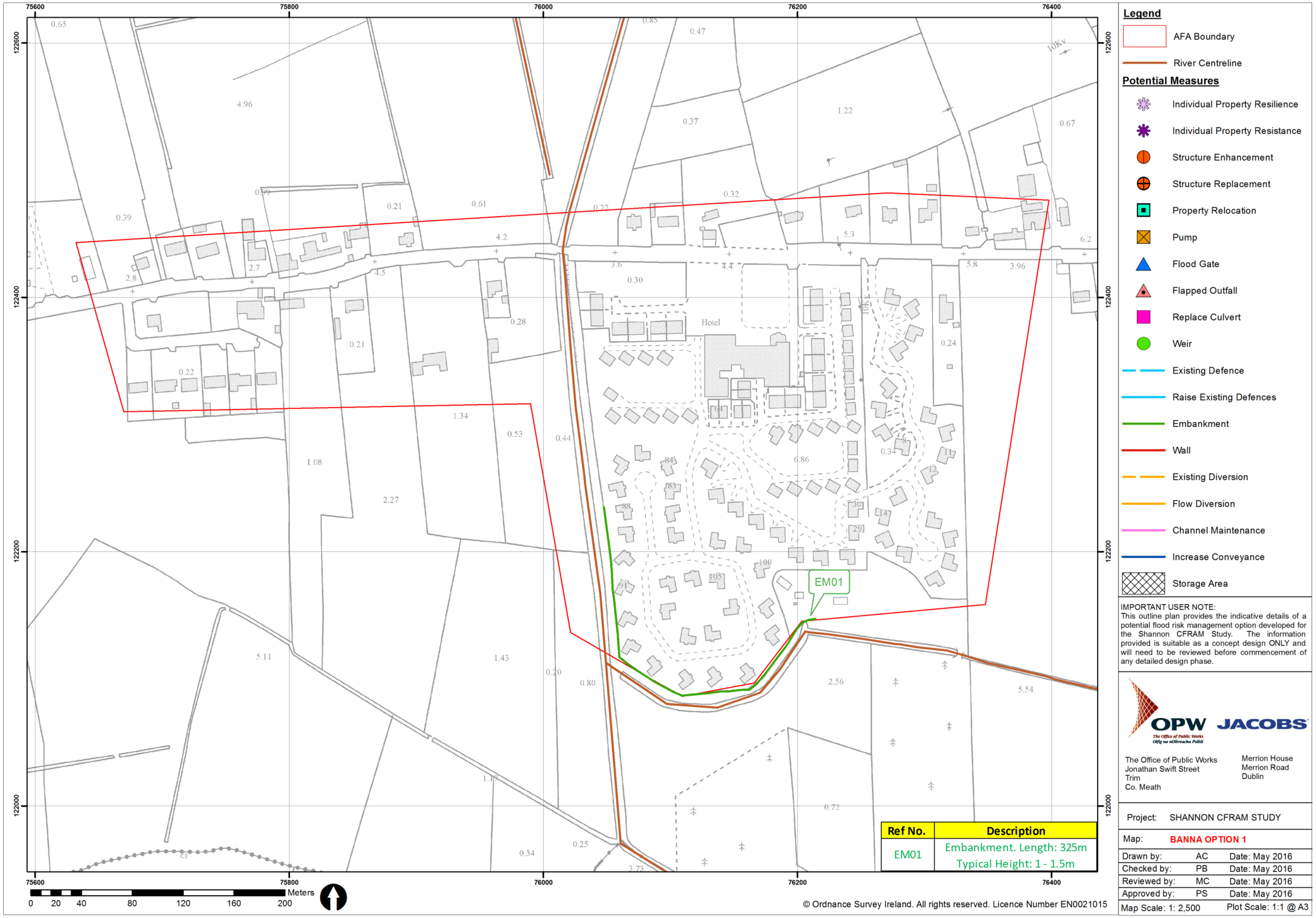

Figure 5.1 Option BAA_01

5.2 Comparison of Multi Criteria Assessment Scores

Each option taken forward for further consideration through the Option Development Meeting, has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).

Categories	**Option Reference and Results**
	BAA_01
Criteria Scores	
Technical	800
Economic	-14
Social	672
Environmental	-179
Economic Values	
Economic PV Benefits	€2,424,244
PV Cost	€144,933
NPV Benefits	€2,279,311
Economic BCR	**16.73**
Outcome Scores	
MCA PV Benefits	€1,130,373
MCA Benefit Score	479
MCA BCR	**3308.01**
Option Selection MCA	1279

5.3 Recommendation of Preferred Option

It forms part of the CFRAM process for the recommendation of a preferred option for each AFA. The prioritised selection criteria used in this recommendation process is detailed in Section 3.7.3 of the Main Report.

Therefore, following the five stage Multi Criteria Assessment process, the preferred option is as outlined below

Option Ref:		BAA_01				
Option Measures	**Structural**	Gi	New Flood Defences			
	Non Structural	J Flood Forecasting	K Public Awareness	L Property Resistance	M Property Resilience	
Comments		This option has been designed to protect all properties at risk of flooding in both the 1% AEP fluvial event and the 0.5% AEP coastal event. It is the only viable option for this AFA. Prior to discontinuing the removal of sand at the outfall at Blackrock a study of the impact this will have on Ballyheige will need to be carried. The watercourse in this area has not been modelled as part of the CFRAM.				

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

Fluvial Flood Forecasting Potential

Fluvial Flood Forecasting Potential				
Catchment Information	**Gauging Station**		**Catchment size (km ^{2})**	**Potential available forecast accuracy and reliability period**
	Fluvial	**Rainfall**		
	No	No*	21.5	Unknown
Relevant Information:	This is determined unknown for the following reasons; • No suitable rain gauge • No suitable gauging station			
Additional Infrastructure Recommended	**Gauging Station**		**Other**	
	Fluvial	**Rainfall**		
	No	No	No	
Relevant Comments:	As the catchment is small any potential flood forecasting early warning system would be unlikely to provide accurate and reliable predictions. Moreover, it is unlikely to provide significant warning time. There is little to no potential for the development of an effective fluvial flood forecasting system for Banna. Tidal flooding could be predicted by a simple forecasting system.			

*For this assessment only 15 minute tipping bucket gauge were considered.

Fluvial

Rainfall

No

No*

21.5

Unknown

Relevant Information:

This is determined unknown for the following reasons;

- No suitable rain gauge
- No suitable gauging station

Additional Infrastructure Recommended

Gauging Station

Other

Fluvial

Rainfall

No

No

No

Relevant Comments:

As the catchment is small any potential flood forecasting early warning system would be unlikely to provide accurate and reliable predictions. Moreover, it is unlikely to provide significant warning time.

There is little to no potential for the development of an effective fluvial flood forecasting system for Banna.

Tidal flooding could be predicted by a simple forecasting system.

Annex A - Multi-Criteria Analysis Summary and Whole Life Cost Summaries for FRM Option(s)

Appendix C5 Option Appraisal Report - Abbeydorney

1. STAGE 1: Summary of Current Flood Risk

1.1 AFA and Watercourse Details

AFA	Abbeydorney
Unit of Management:	23
Primary Watercourses:	Milltown House (Stream), Boherroe (River),Ballybroman (River), Cahermead (Stream)

1.2 Summary of Flood Risk in 1% AEP Event

Source of flood risk	**Fluvial**	Coastal	Both

Total Number of Properties at risk in AFA in 1% Fluvial AEP Event:		**Residential**	**Non-Residential**	**Total**
	Fluvial	4	5	9
AFA Flood Cells:	**Total Number:**	2		
	Flood Cell Titles:	ABY_A, ABY_B		
Breakdown of properties at risk per Flood Cell:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	ABY_A	3	4	7
	ABY_B	1	1	2
Relevant Figure Ref:	Figure 1.1 and 1.2			

1.3 Summary of Existing Flood Risk Management Measures

Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
Yes	None	None	**Yes**	None	None

Relevant Figure Ref:	Figure 1.1

1.4 Summary of PV Damages/Potential PV Benefits for 1% Fluvial SOP

Total PV Damages:		**Uncapped**		**Capped**
	Fluvial	€ 2,044,997		€ 964,689
Max Capped Benefits for 1% Fluvial AEP Event*:	€ 882,835			
Breakdown of Max Capped PV Benefits per Flood Cell for 1% Fluvial AEP Event:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	ABY_A	€ 148,464	€ 40,389	€ 188,853
	ABY_B	€ 300,073	€ 393,909	€ 693,982
Relevant Figure Ref:	Figure 1.2			

*These are the maximum benefits available if a FRM option with a 1% Fluvial AEP SOP is provided to all properties within the AFA.

1.5 Social Risk		
	Type	**Description**
High Vulnerability Properties at risk:	None	N/A
Social Infrastructure Assets:	Sports Facility	**50% AEP Flood Extent**
		GAA Pitch
	Community Centre	**50% AEP Flood Extent**
		GAA Clubhouse
Social Amenity Sites:	None	N/A
Relevant Figure Ref:	General Risk - Social	
1.6 Risk to the Environment		
	Type	**Description**
Risk to WFD Annex IV:	None	N/A
Risk to SACs:	None	N/A
Relevant Figure Ref:	General Risk - Environment	
1.7 Risk to Cultural Heritage		
	Type	**Description**
Risk to Sites of Cultural Heritage:	NIAH Buildings	**0.1% AEP Flood Extent**
		Saint Bernard's Catholic Church, regionally important
Relevant Figure Ref:	General Risk – Cultural Heritage	
1.8 Risk to the Economy		
	Type	**Description**
Risk to Transport Infrastructure:	Regional Road	**50% AEP Flood Extent**
		R556
		R557
	Local Road	**0.5% AEP Flood Extent**
		The Cloisters
Risk to Utility Infrastructure:	Low vulnerability infrastructure	**0.1% AEP Flood Extent**
		Hand water pump
Relevant Figure Ref:	General Risk - Economy	

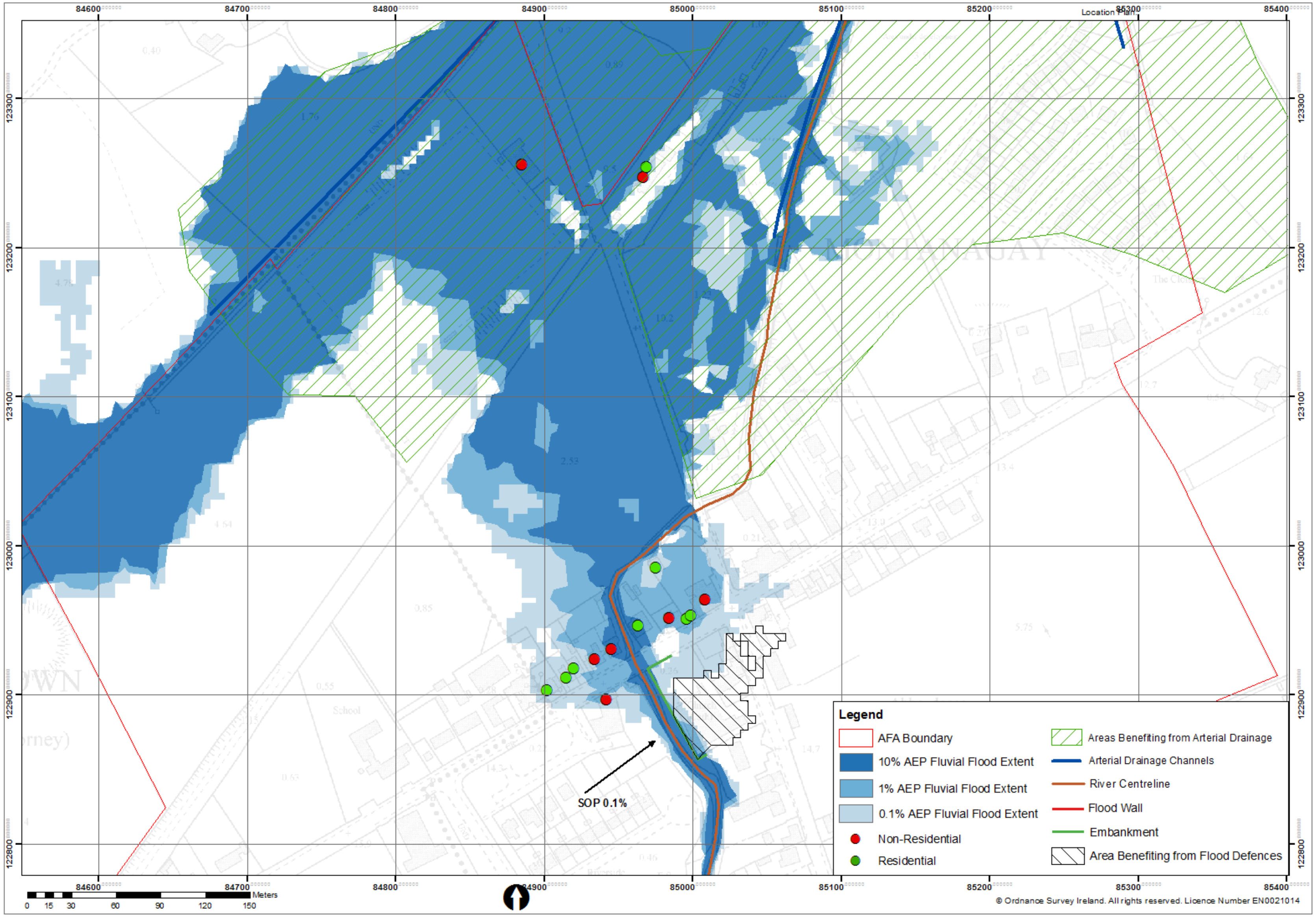

Figure 1.1– Abbeydorney Fluvial Flood Risk to Properties

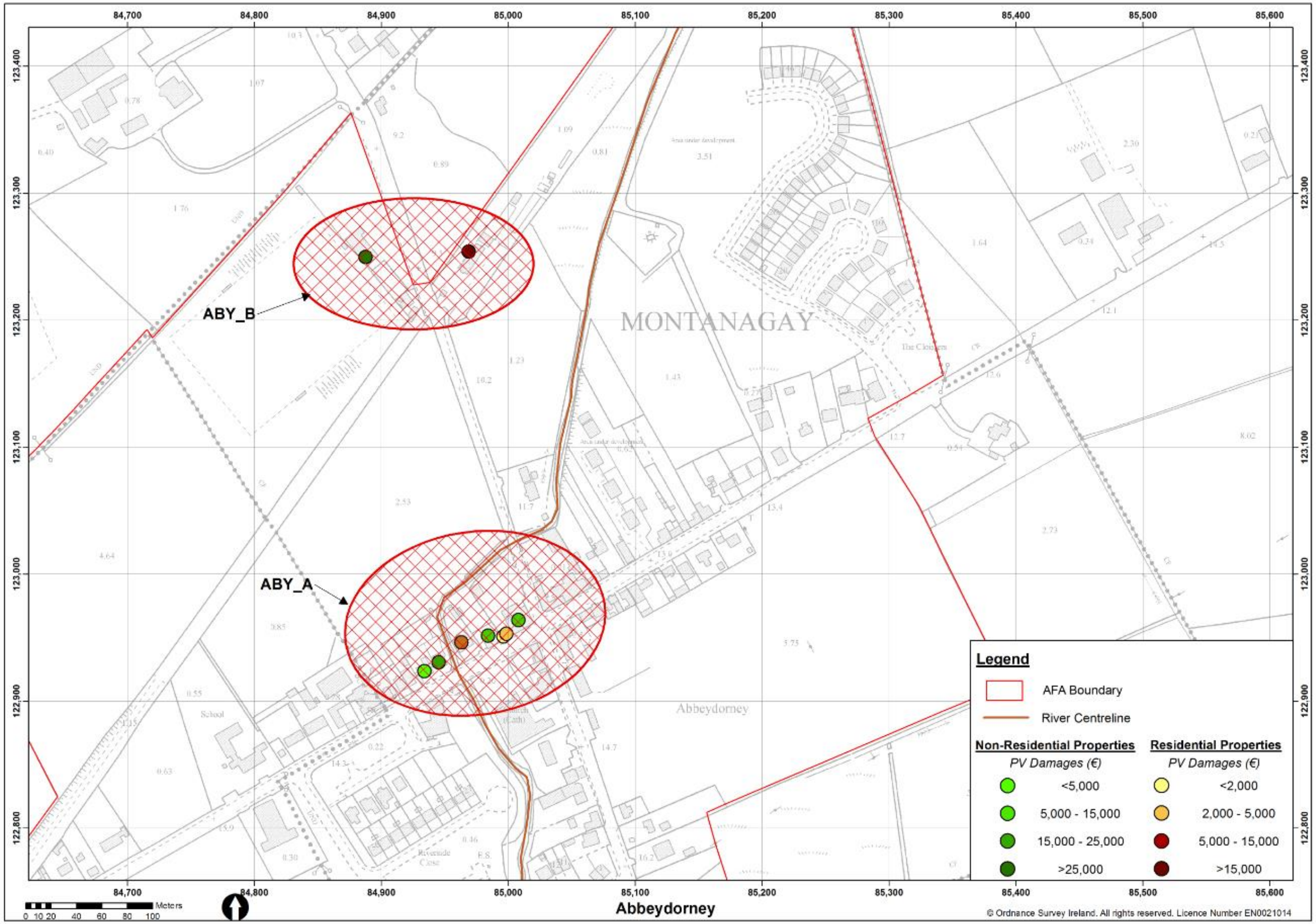

Figure 1.2 – Abbeydorney PV Damages for Properties in the 1% Fluvial AEP Events and Flood Cells
Flood Cells are groupings of properties that are likely to be hydraulically linked

2. STAGE 2: Screening of the Measures

2.1 Baseline, Structural and Non-Structural Measures

Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.

Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
B	Existing Regime	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
Structural							
D	Storage	Unviable	Unviable	Viable	Viable	Viable	**Screened Out**
E	Flow Diversion	Viable	Unviable	Viable	Viable	Viable	**Screened Out**
F	Increase Conveyance	Viable	Viable	Viable	Viable	Viable	**Screened In**
G	Flood Defences	Viable	Viable	Viable	Viable	Viable	**Screened In**
H	Relocation of Properties	Unviable	Viable	Viable	Unviable	Viable	**Screened Out**
I	Other Measures	Unviable	Unviable	Unviable	Unviable	Unviable	**Screened Out**
Non-Structural							
J	Flood Forecasting / Warning / Response	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	**Screened In**
L	Individual Property Resistance	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
M	Individual Property Resilience	Viable	Viable	Viable	Viable	Viable	**Screened In**

2.2 Justification for Screened Out Baseline and Structural Measures

The following provides justification on Measures with an overall viability 'Screened Out' categorisation.

A	Do Nothing	Applicability Economic Environmental Social Cultural	The Do Nothing FRM method is not a viable measure for Abbeydorney as there is flood risk in the AFA and other viable options are available.
B	Existing Regime	Applicability Economic Environmental Social Cultural	The Existing Regime FRM method is not a viable option for Abbeydorney as there is no official existing regime in place for the watercourses as they flow through the town.
C	Do Minimum	Applicability Economic Environmental Social Cultural	The Do Minimum FRM measure was screened as channel cleaning and localised improvement works would have no significant impact to the overall flood risk.
D	Storage	Applicability Economic Environmental Social Cultural	There is no location for natural storage in the catchment. Creation of an artificial storage area will not be viable economically based on the potential PV benefits; the estimated cost of storage is greater than €900,000. Figure 2.1

E	Flow Diversion	Applicability Economic Environmental Social Cultural	Flow diversion downstream of the Bridge street bridge was considered to remove the two 90 degree angles in the River Boherroe. This flow diversion route was found to be not viable economically. The approximate economic cost would be €950,000 due to the need for a new bridge. Figure 2.2
H	Relocation of Properties	Applicability Economic Environmental Social Cultural	As the majority of the properties at risk of flooding are located in the town centre, relocation of these properties would result in relocation of the majority of the town. Therefore, this measure is considered not applicable to the area or socially viable.
I	Other Measures	Applicability Economic Environmental Social Cultural	No other measures identified.
J	Flood Forecasting / Warning / Response	Applicability Economic Environmental Social Cultural	Flood forecasting is not a viable FRM method in Abbeydorney as the time to peak in the River Boherroe is less than 3 hours.
L	Individual Property Resistance	Applicability Economic Environmental Social Cultural	Individual property flood resistance requires time to implement and is only effective where a flood forecasting and warning system is viable. As flood forecasting is not viable in Abbeydorney, individual property flood resistance cannot be considered a viable measure.

2.3 Summary of 'Screened In' Measures

The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.

Structural Measures		**Non-Structural Measures**	
F	Increase Conveyance	K	Public Awareness
G	Flood Defences	M	Individual Property Resilience

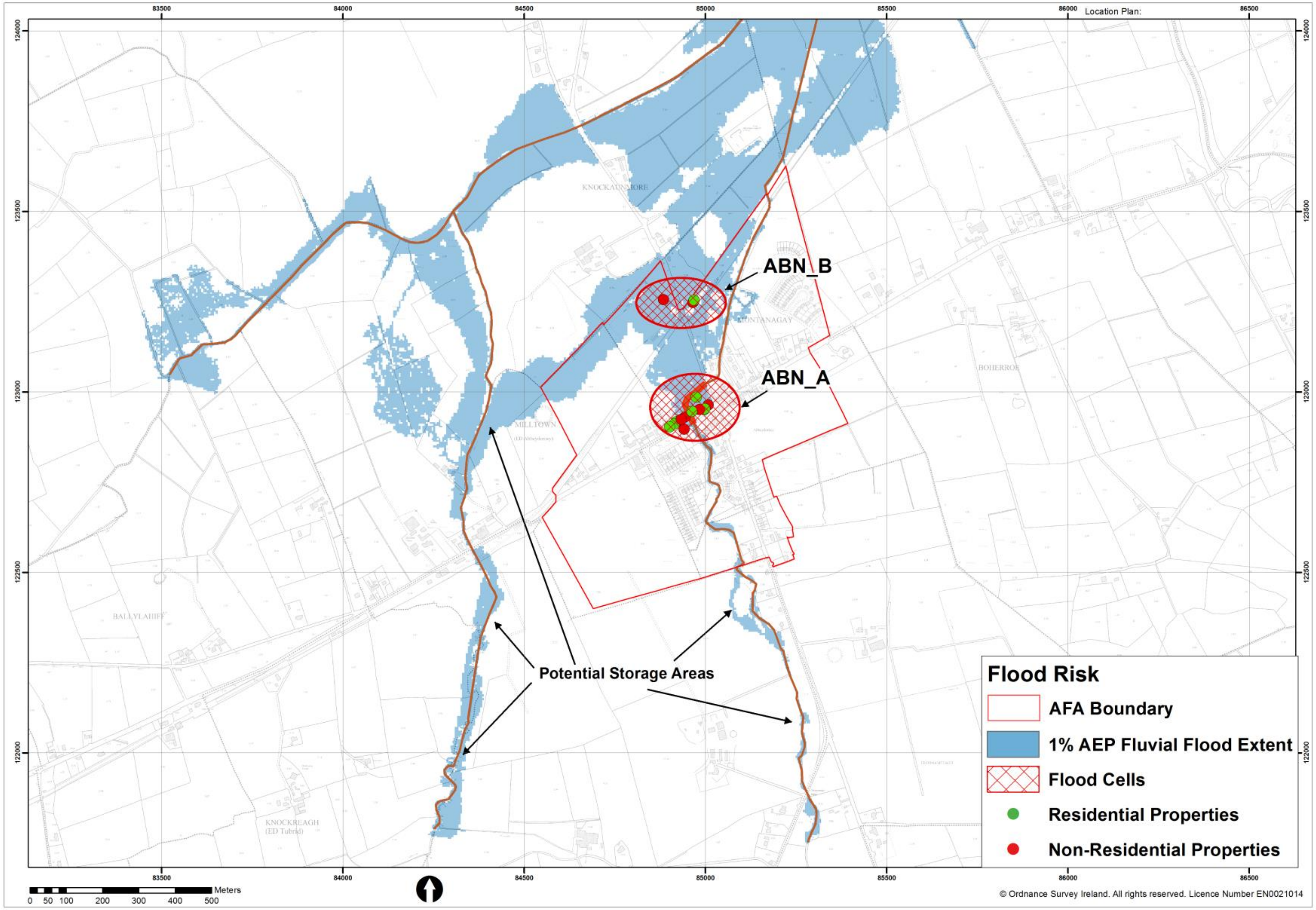

Figure 2.1 – Abbeydorney Screened Out Storage Flood Measures

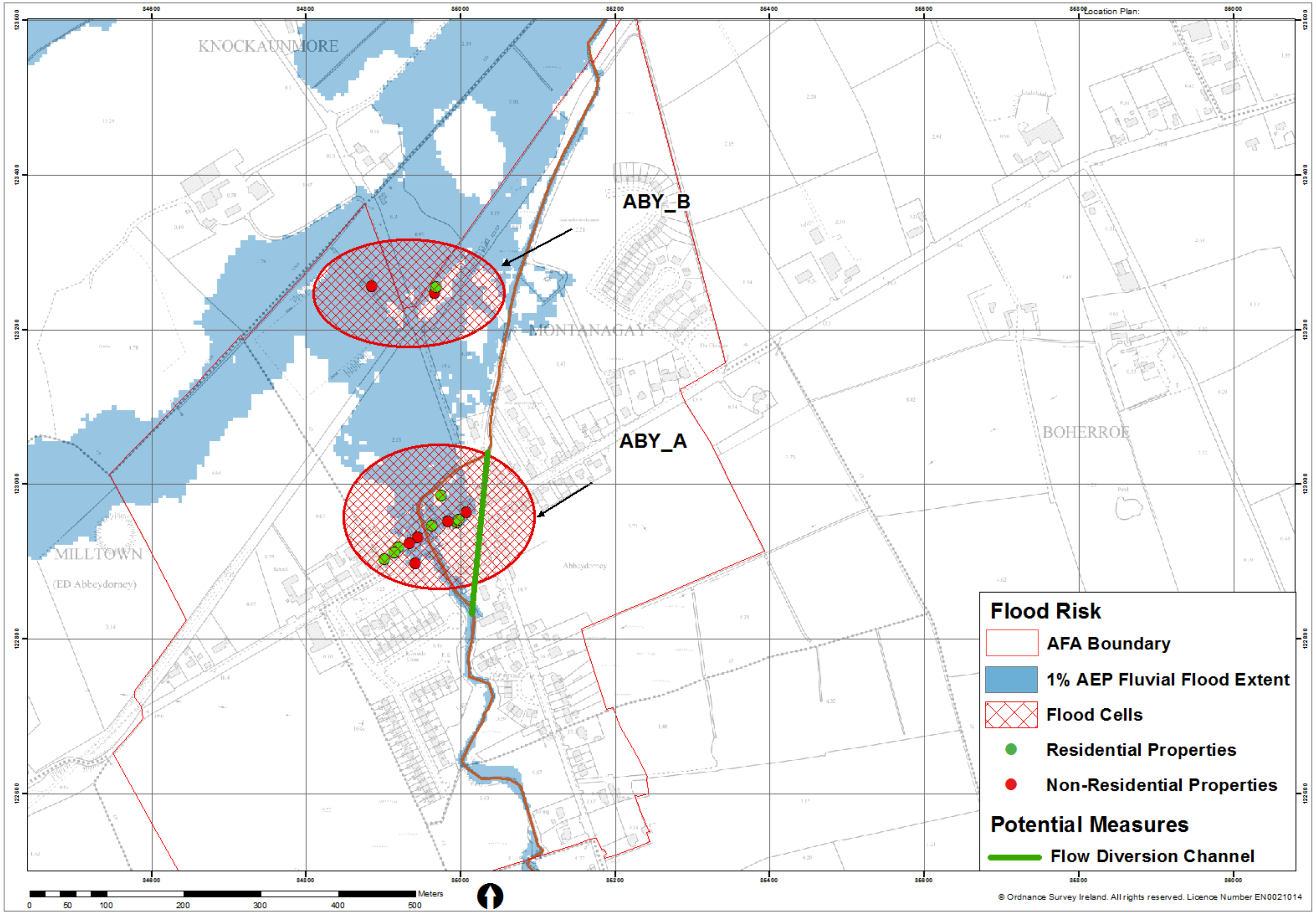

Figure 2.2 – Abbeydorney Screened Out Flow Diversion Flood Measure

3. STAGE 3: Selection of Options

3.1 Consideration of Options

The following are the agreed combination of 'Screened In' measures that comprise each of the Options being taken forward for further consideration.

Where appropriate, the 'Screened In' measures have been sub-divided into separate specific measures to ensure applicability to site conditions.

Measures		**Different composition of measures per option**						
Structural Measures								
F	Increase Conveyance							
Fi	Channel Dredging							
Fii	Channel Widening	✓	✓					
Fiii	Structure Enhancement / Works							
G	Flood Defences							
Gi	New Flood Defences		✓					
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
K	Public Awareness	✓						
M	Individual property resilience	✓						
Option Reference		ABY_01	ABY_02					

4. STAGE 4: Appraisal of Options

4.1 Options Appraisal

Each option taken forward for further consideration through the Option Decision Meeting has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Decision Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).

<table>
<tr><td colspan="2">Option Ref:</td><td colspan="4">ABY_01</td></tr>
<tr><td rowspan="2">Option Measures</td><td>Structural</td><td>Fii</td><td colspan="3">Increased conveyance: Channel Widening</td></tr>
<tr><td>Non Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="4">This option will provide a 1% Fluvial AEP Design standard to 6 of the 9 properties within the AFA and reduce the impact of flood risk to the remaining 3 properties, identified as being at risk, and includes;
• Localised widening of the River Boherroe along the 150m reach between the Bridge road bridge and R556 road bridge.
• Introduction of a maintenance programme for the new channel and other watercourses within the AFA.
• Targeted Public Awareness and preparedness campaign.
• Individual Property Resilience for the properties at risk of flooding in area ABY_B</td></tr>
<tr><td colspan="2" rowspan="2">Decision Development Meeting:</td><td>Date:</td><td colspan="3">10th of June 2015</td></tr>
<tr><td>Summary:</td><td colspan="3">The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.</td></tr>
</table>

<table>
<tr><td colspan="2">Option Ref:</td><td colspan="4">ABY_02</td></tr>
<tr><td rowspan="3">Option Measures</td><td rowspan="2">Structural</td><td>Gi</td><td colspan="3">Construct Flood Defences: New Flood Defences</td></tr>
<tr><td>Fii</td><td colspan="3">Increased conveyance: Channel Widening</td></tr>
<tr><td>Non Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="4">This option will provide a 1% Fluvial AEP Design standard to all properties within the AFA identified as being at risk, and includes;
• Localised widening of the River Boherroe along the 150m metre reach between the Bridge road bridge and R556 road bridge. It is intended that the works will provide protection to the properties at risk of flooding in the 1% AEP in area ABY_A and a reduction in flood depths to properties in area ABY_B.
• An earth embankment across the floodplain to prevent the flow route from the Milltown House Stream to provide complete protection to the properties in ABY_B for the 1% AEP event.
• Introduction of maintenance programme for the defences and other watercourses within the AFA.</td></tr>
</table>

Decision Development Meeting:	Date:	10^{th} of June 2015
	Summary:	The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.

5. STAGE 5: Multi Criteria Assessment

5.1 Options selected for the Multi Criteria Assessment

Following the Option Decision Meeting, the following options have been selected for the Multi-Criteria Assessment (MCA) stage. This is the final of a five-stage MCA process.

Option Reference		ABY_01	ABY_02
Structural Measures			
Fii	Channel Widening	Localised widening for 150m of the River Boherroe between Bridge road, and the R556. On average, the river is to be widened from a 4m wide channel to a 5.5m wide channel.	Localised widening for 150m of the River Boherroe between Bridge road, and the R556. On average, the river is to be widened from a 4m wide channel to a 5.5m wide channel.
Gi	New Flood Defences		Earth embankment of a maximum height 1.8 metre in height across the floodplain to prevent the flow route from the Milltown house Stream
Non-Structural Measures			
K	Public Awareness	Public awareness campaign to be completed annually.	
M	Individual Property Resilience	For properties at risk of flooding in area ABY_B	
	Table reference A summary of the outcome from the MCA is presented in the following table	Table 5.1	Table 5.2

Table 5.1 – Multi Criteria Assessment Outcome for Option ABY_01

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**			
AFA	Abbeydorney	Option Ref:	ABY_01
Option Measures			
Structural	Fii	Channel Widening	
Non-Structural	K	Public Awareness	
	M	Individual Property Resilience	
Criteria Scores			
Technical		700	
Economic		213	
Social		81	
Environmental		-100	
Economic Values			
Economic PV Benefits		€ 539,255	
PV Cost		€ 209,648	
NPV Benefits		€ 329,607	
Economic BCR		**2.57**	
Outcome Scores			
MCA PV Benefits		€ 319,299	
MCA Benefit Score		**194**	
MCA Benefit Score Ratio		926.31	
Option Selection MCA		**894**	
Relevant Figure		Figure 5.1	

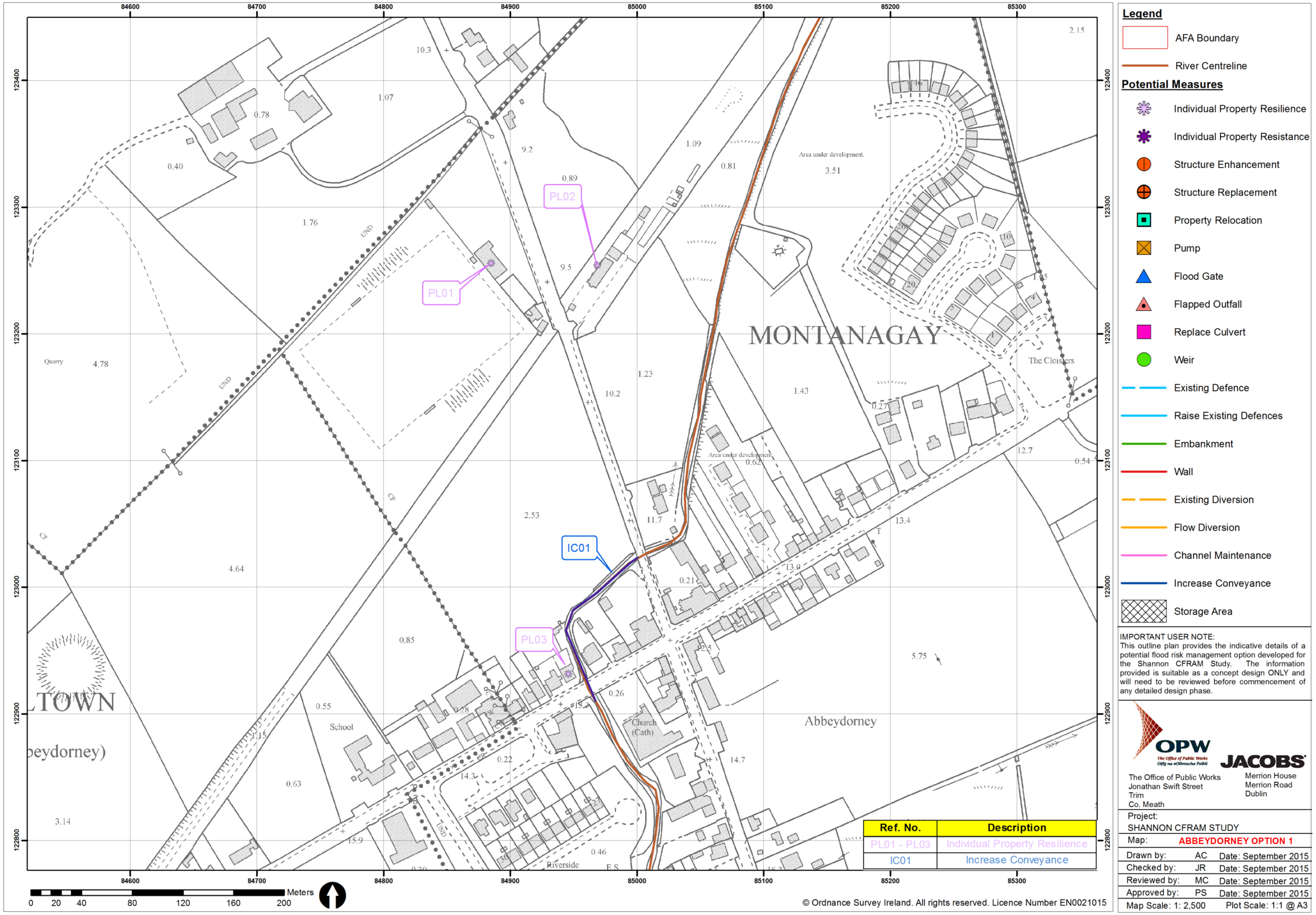

Figure 5.1 – Option ABY_01

Table 5.2 – Multi Criteria Assessment Outcome for Option ABY_02

Multi Criteria Assessment			
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.			
AFA	Abbeydorney	Option Ref:	ABY_02

Option Measures		
Structural	Fii	Channel Widening
	Gi	New Flood Defences
Non-Structural		N/A

Criteria Scores	
Technical	1000
Economic	337
Social	529
Environmental	-140
Economic Values	
Economic PV Benefits	€ 884,657
PV Cost	€ 278,059
NPV Benefits	€ 606,598
Economic BCR	**3.18**
Outcome Scores	
MCA PV Benefits	€ 420,144
MCA Benefit Score	**726**
MCA Benefit Score Ratio	2609.48
Option Selection MCA	**1726**
Relevant Figure	Figure 5.2

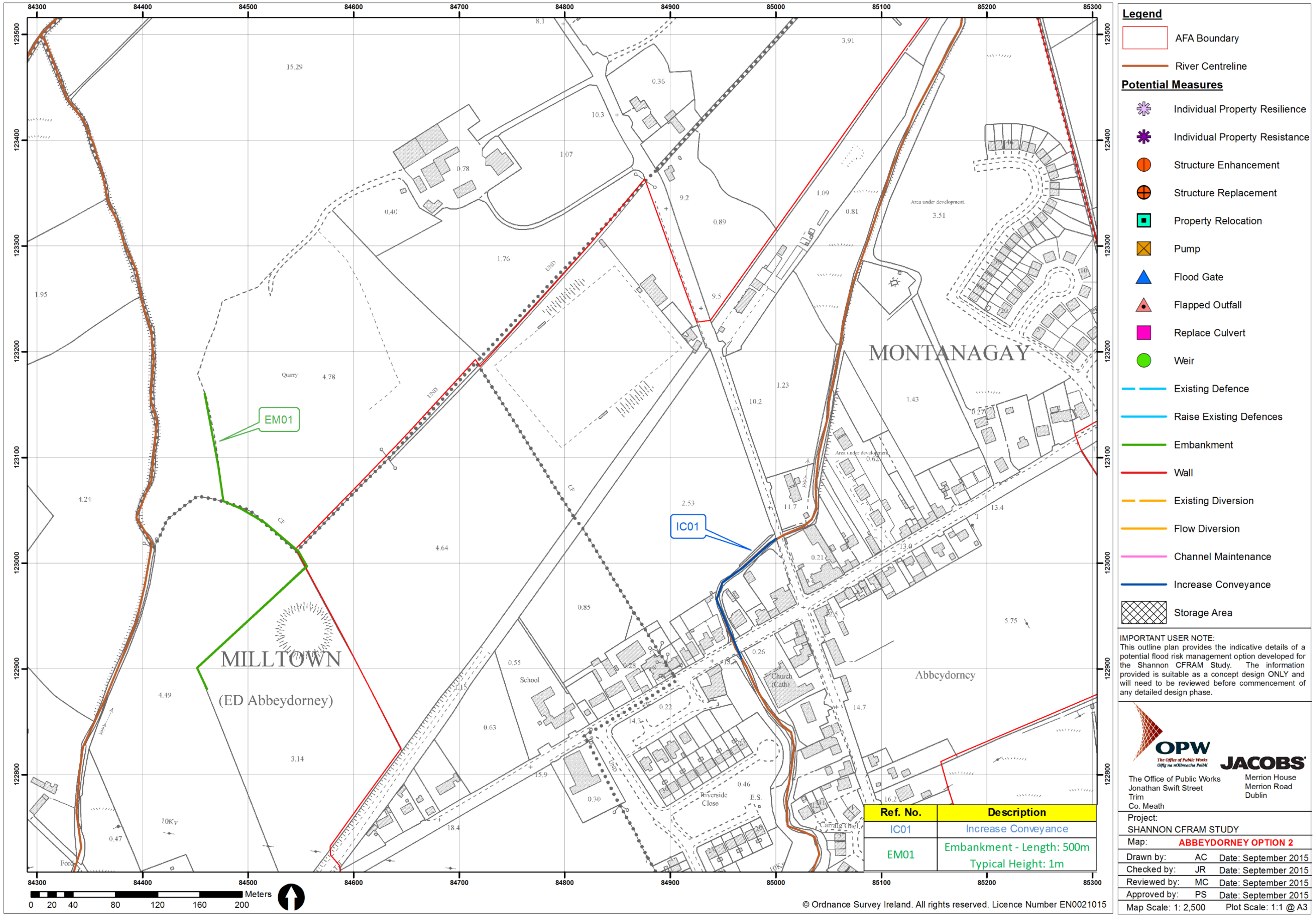

Figure 5.2 - ABY_02

5.2 Comparison of Multi Criteria Assessment Scores Each option taken forward for further consideration through the Option Decision Meeting has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Decision Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).		
Categories	**Option Reference and Results**	
	ABY_01	ABY_02
Criteria Scores		
Technical	950	1000
Economic	317	348
Social	81	529
Environmental	-120	-160
Economic Values		
Economic PV Benefits	€ 539,255	€ 884,657
PV Cost	€ 209,648	€278,059
NPV Benefits	€ 329,607	€ 606,598
Economic BCR	**2.57**	**3.18**
Outcome Scores		
MCA PV Benefits	€ 319,299	€ 420,144
MCA Benefit Score	**279**	**718**
MCA BCR	1331.42	2581.47
Option Selection MCA	**1229**	**1718**

<table>
<tr><td colspan="6">5.3 Recommendation of Preferred Option
It forms part of the CFRAM process for the recommendation of a preferred option for each AFA. The prioritised selection criteria used in this recommendation process is detailed in Section 3.7.3 of the Main Report.
Therefore, following the five stage Multi Criteria Assessment process, the preferred option is as outlined below</td></tr>
<tr><td colspan="2">Option Ref:</td><td colspan="4">ABY_02</td></tr>
<tr><td rowspan="4">Option Measures</td><td>Baseline</td><td colspan="4">N/A</td></tr>
<tr><td rowspan="2">Structural</td><td>Fi</td><td colspan="3">Channel Dredging</td></tr>
<tr><td>Gi</td><td colspan="3">New Flood Defences</td></tr>
<tr><td>Non-Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Comment</td><td colspan="4">This option will provide a 1% Fluvial AEP Design standard to all properties within the AFA identified as being at risk and with a MCA BCR score of 2581.47, this is the highest-ranking option.</td></tr>
</table>

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

<table>
<tr><th colspan="5">Fluvial Flood Forecasting Potential</th></tr>
<tr><td rowspan="3">Catchment Information</td><td colspan="2">Gauging Station</td><td rowspan="2">Catchment size (km ^{2})</td><td rowspan="2">Potential available forecast accuracy and reliability period</td></tr>
<tr><td>Fluvial</td><td>Rainfall</td></tr>
<tr><td>No</td><td>No*</td><td>6</td><td>Unknown</td></tr>
<tr><td>Relevant Information:</td><td colspan="4">This is determined unknown for the following reasons;
• No suitable rain gauge
• No suitable gauging station</td></tr>
<tr><td rowspan="3">Additional Infrastructure Recommended</td><td colspan="2">Gauging Station</td><td colspan="2" rowspan="2">Other</td></tr>
<tr><td>Fluvial</td><td>Rainfall</td></tr>
<tr><td>No</td><td>No</td><td colspan="2">No</td></tr>
<tr><td>Relevant Comments:</td><td colspan="4">As the catchment is small any potential flood forecasting early warning system would be unlikely to provide accurate and reliable predictions. Moreover, the potential forecast period is small.

There is little to no potential for the development of an effective fluvial flood forecasting system for Abbeydorney.</td></tr>
</table>

*For this assessment only 15 minute tipping bucket gauge were considered.

Annex A - Multi-Criteria Analysis Summary and Whole Life Cost Summaries for FRM Option(s)

CRITERIA		OBJECTIVE		Global Weighting	Local Weighting	Comments	ABY_01 Fi – Channel Dredging K – Public Awareness M – Individual Property Resilience	Option Score	Weighted Score	ABY_02 Gi – New Flood Defences Fi – Channel Dredging	Option Score	Weighted Score
1	Technical	a	Ensure flood risk management options are operationally robust	20	5.00	The option scores are determined based on the level of operational risk to operate or perform successfully. Each measure is scored independently and the average of the measure scores is used as the score for the option.	None / Manageable; Negligible / Moderate / high; Very low / High; Low / Failure likely; Low / moderate / Unacceptable Fi 4.00 K M 4.00	4.00	400	None / Manageable; Negligible / Moderate / high; Very low / High; Low / Failure likely; Low / moderate / Unacceptable Gi 5.00 Fi 5.00	5.00	500
		b	Minimise health and safety risks associated with the construction and operation of flood risk management options	20	5.00	H&S risks are considered for construction and maintenance of flood risk management measures. The indicative aspirational score is set at five, with a point then deducted for each specific H&S risk in either construction or maintenance.	None / Manageable; Negligible / Moderate / high; Very low / High; Low / Very High; Low / moderate / Unacceptable Work near/in water	3.00	300	None / Manageable; Negligible / Moderate / high; Very low / High; Low / Very High; Low / moderate / Unacceptable Work near/in water	3.00	300
		c	Ensure flood risk management options are adaptable to future flood risk	20	5.00	The options scores are determined based on the sustainability and adaptability of the flood risk management measures in the face of potential future changes, including the potential impact of climate change. Each measure is scored independently and the average of the measure scores is used as the score for the option.	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. Fi 3.00 K M 2.00	2.50	250	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. Gi 3.00 Fi 1.00	2.00	200
TECHNICAL CRITERIA SCORE									950			1000
2	Economic	a	Minimise economic risk	24	0.87		The score is calculated based on the reduction in AAD, following the full implementation of option.	4.50	94	The score is calculated based on the reduction in AAD, following the full implementation of option.	4.84	101
		b	Minimise risk to transport infrastructure	10	5.00		Scoring is based on the reduction in flood risk to transport routes, following the full implementation of option.	4.47	223	Scoring is based on the reduction in flood risk to transport routes , following the full implementation of option.	4.94	247
		c	Minimise risk to utility infrastructure	14	0.25		Scoring is calculate based on a reduction in flood risk to utility infrastructure, following the full implementation of option.	0.00	0	Scoring is calculate based on a reduction in flood risk to utility infrastructure, following the full implementation of option.	0.00	0
		d	Minimise risk to agriculture	12	0.00	Source of Flooding: Fresh Water Percentage of AFA that is rural land: 53.97%	Area of Agricultural Land Flooded: No Change Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: No Change Flood Warning: Not Applicable Agricultural Production Enhanced: No Change Other (Please Specify): Not Applicable	0.00	0	Area of Agricultural Land Flooded: No Change Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: No Change Flood Warning: Not Applicable Agricultural Production Enhanced: No Change Other (Please Specify): Not Applicable	0.00	0
ECONOMIC CRITERIA SCORE									317			348
3	Social	a i)	Minimise risk to human health and life - Residents	27.00	1.48	Flood Depths & Velocities: Assumed low risk to life Known Areas of Highly Vulnerable People: Reasonable Cross Section of Society	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	4.81	192	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	4.81	192
		a ii)	Minimise risk to human health and life - High vulnerability properties	17.00	0.00	Rate of Onset of flooding: Assumed 1-2 hours for evacuation	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	0.00	0	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	0.00	0
		b i)	Minimise risk to community - Social Infrastructure & Amenity	9.00	5.00	Assets of Particular Social Value: Yes	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	-5.00	-225	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	4.95	223
		b ii)	Minimise risk to community - Local employment	7.00	3.43	Asset of Particular Employment Value: No	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	4.78	115	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	4.78	115
SOCIAL CRITERIA SCORE									81			529
4	Environmental	a	Support the objectives of the WFD	16	5.00	The Milltown House (stream), Boherroe River, Ballybroman River and Cahermead (stream) watercourses within the AFA enter the Brick River north of the AFA and this is at as good status. There is one WwTP within the AFA which is within close proximity to the 1%AEP.	Construction - Related impacts due to construction works in and adjacent to the River Boherroe. Operational - The proposed localised widening of the River Boherroe and the maintenance programme for the new	-1.00	-80	Construction - Related impacts due to construction works in and adjacent to the River Boherroe during the localised widening of the river over 150m. Operational - The proposed localised widening of the River	-1.50	-120
		b	Support the objectives of the Habitats Directive	10	1.00	There are no Natura 2000 sites within the AFA. The nearest SAC/SPA is the Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA and the Lower Shannon cSAC. The Brick River flows into the Lower Shannon cSAC.	Potentially significant effects are: - Increases in suspended sediment due to in stream works and maintenance dredging. - Pollution risk to the River Boherroe, and the Brick River and Lower River Shannon downstream	-1.00	-10	Potentially significant effects are: - Increases in suspended sediment due to in stream works, works adjacent to the watercourse and maintenance dredging. - Pollution risk to the River Boherroe and Milltown House	-1.00	-10
		c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	5	1.00	There are no nationally designated sites within the AFA, but there is potential for significant habitats and populations of European and nationally protected species. Features of particular vulnerability are potential otters which could be significantly affected by flooding.	Potentially significant effects are: - Increases in suspended sediment due to in stream works and dredging. - Pollution risk to the River Boherroe, and the Brick River and Lower River Shannon downstream	-1.00	-5	Potentially significant effects are: - Increases in suspended sediment due to in stream works and dredging. - Pollution risk to the Milltown House Stream, Boherroe River, and the Brick River and Lower River Shannon downstream	-1.00	-5
		d	Protect, and where possible enhance, fisheries resource within the catchment	13	1.00	The Brick River is a salmonid waterbody. However, the watercourses within the AFA are not salmonid. Local weighting of 1 set by professional judgement. Weighting of 1 applied where fisheries could be present but unlikely given the	Potential short term construction impacts that can be mitigated. There are long term impacts associated with increased conveyance along the Boherroe River associated with the	-2.50	-32.5	Potential short term construction impacts that can be mitigated. There are long term impacts associated with increased conveyance along the Boherroe River associated with the	-2.50	-33
		e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	8	0.00	No designated landscape features are within the 1% AEP or within the AFA. Local weighting of 0 set by professional judgement. Weighting of 0 applied where no specific landscape designation, and no landscape	There are no locally sensitive landscape features and there are no anticipated impacts on designated landscape features.	0.00	0	There are no locally sensitive landscape features and there are no anticipated impacts on designated landscape features. There will be short term construction related visual impacts and long term impacts from the earth embankment.	0.00	0
		f i)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of architectural value	4	2.00	1 RPS fall within the 1% AEP. 2 other is in close proximity. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present	The option will reduce the potential for flooding in the 1% AEP for 1 RPS. Therefore, there is a potential increase in the level of protection for architectural features from flooding, such that	1.00	8	The option will reduce the potential for flooding in the 1% AEP for 1 RPS. Therefore, there is a potential increase in the level of protection for architectural features from flooding, such that	1.00	8
		f ii)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of archaeological value	4	0.00	There are no RMPs within the 1% or the AFA. There are a number of RMPs in close proximity to the 1%AEP but this is outside the AFA boundary and will be considered at sub catchment scale. Local weighting of 0 set by professional judgement. Weighting of 0	There are no RMPs within the 1% or the AFA. There are a number of RMPs in close proximity to the 1%AEP but this is outside the AFA boundary and will be considered at sub catchment scale.	0.00	0	There are no RMPs within the 1% or the AFA. There are a number of RMPs in close proximity to the 1%AEP but this is outside the AFA boundary and will be considered at sub catchment scale.	0.00	0
ENVIRONMENTAL CRITERIA SCORE									-120			-160

		ABY_01	ABY_02
Economic Values	Economic PV Benefits	€539,255	€884,657
	Cost	€209,648	€278,059
	NPV Benefits	€329,607	€606,598
	Economic BCR	**2.57**	**3.18**
Outcome Scores	MCA PV Benefits	€319,299	€420,144
	MCA Benefit Score	279	718
	MCA BCR	**1331.42**	**2581.47**
	Option Selection MCA	1229	1718

Objective	Global Weightings (fixed)	Local Weightings		Baseline Comments	Option 1 Comments	Option 2 Comments
1.A	20	5.00	fixed	Local weighting is fixed	This score is determined for this option as it has negligible operational risks to operate or perform successfully.	This score is determined for this option as it has no operational risks to operate or perform successfully.
1.B	20	5.00	fixed	Local weighting is fixed	This score is determined for this option as it has very low health and safety risks associated with the construction and operation of flood risk management option.	This score is determined for this option as it has very low health and safety risks associated with the construction and operation of flood risk management option.
1.C	20	5.00	fixed	Local weighting is fixed	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.
2.A	24	0.87	calculated	Local weighting is calculated based on the baseline AAD.	This score is calculated based on the reduction in AAD, following the full implementation of option.	This score is calculated based on the reduction in AAD, following the full implementation of option.
2.B	10	5.00	calculated but adjusted by professional judgement	Local weighting is calculated based on the baseline risk to transport infrastructure. Local weighting already at maximum.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.
2.C	14	0.25	calculated but adjusted by professional judgement	Local weighting is calculated based on the baseline risk to utility infrastructure.	This score is calculated based on a reduction in flood risk to utility infrastructure, following full implementation of option.	This score is calculated based on a reduction in flood risk to utility infrastructure, following full implementation of option.
2.D	12	0.00	Professional judgement	Local weighting is calculated based on the percentage of rural land within the AFA.	This score is determined based on no change to the area of agricultural land flooded, following full implementation of the option.	This score is determined based on no change to the area of agricultural land flooded, following full implementation of the option.
3.A (i)	27	1.48	calculated but adjusted by professional judgement	It was noted at the options meeting that a general cross section of population at risk of flooding. Therefore, no ajustment was made to the calculated local weighting.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option.
3.A (ii)	17	0.00	calculated but adjusted by professional judgement	There are no high vulnerability properties at risk.	There is no risk to high vulnerability properties within the AFA.	There is no risk to high vulnerability properties within the AFA.
3.B (i)	9	5.00	calculated but adjusted by professional judgement	Local weighting is calculated based on the baseline risk to social infrastructure. The significant importance of the GAA clubhouse to the town was noted. The calculated local weighting of 5 was not changed as this is the maximum value permissible.	GAA pitch and clubhouse not protected so option score revised down to -5.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option.
3.B (ii)	7	5.00	calculated but adjusted by professional judgement	Local weighting is calculated based on the baseline risk to local employment. Local weighting capped at maximum value of 5.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option.
4.A	16	5.00	fixed	There are no Natura 2000 sites within the AFA. The nearest SAC/SPA is the Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA and the Lower Shannon cSAC. The Brick River flows into the Lower Shannon cSAC.	Construction - Related impacts due to construction works in and adjacent to the River Boherroe. Operational - The proposed localised widening of the River Boherroe and the maintenance programme for the new channel and other watercourses within the	Construction - Related impacts due to construction works in and adjacent to the River Boherroe during the localised widening of the river over 150m. Operational - The proposed localised widening of the River Boherroe and the maintenance programme for
4.B	10	1.00	Professional judgement	There are no Natura 2000 sites within the AFA. The nearest SAC/SPA is the Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA and the Lower Shannon cSAC. The Brick River flows into the Lower Shannon cSAC. Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no designated sites but habitats/species are likely to be present that could be affected	Potentially significant effects are: - Increases in suspended sediment due to in stream works and maintenance dredging. - Pollution risk to the River Boherroe, and the Brick River and Lower River Shannon downstream - Risk of disturbance to otter or their resting sites during proposed works - Risk of invasive species spread during proposed works - Impact to fish species	Potentially significant effects are: - Increases in suspended sediment due to in stream works, works adjacent to the watercourse and maintenance dredging. - Pollution risk to the River Boherroe and Milltown House Stream, and the Brick River and Lower River Shannon downstream - Risk of disturbance to otter or their resting sites during proposed works - Risk of invasive species spread during proposed works
4.C	5	1.00	Professional judgement	There are no nationally designated sites within the AFA, but there is potential for significant habitats and populations of European and nationally protected species. Features of particular vulnerability are potential otters which could be significantly affected by flooding. Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no designated sites but habitats/species are likely to be present that could be affected	Potentially significant effects are: - Increases in suspended sediment due to in stream works and dredging. - Pollution risk to the River Boherroe, and the Brick River and Lower River Shannon downstream - Risk of disturbance to otter or their resting sites during proposed works - Risk of invasive species spread during proposed works - Impact to fish species Therefore, potential for localised loss of or disturbance to flora/fauna.	Potentially significant effects are: - Increases in suspended sediment due to in stream works and dredging. - Pollution risk to the Milltown House Stream, Boherroe River, and the Brick River and Lower River Shannon downstream - Risk of disturbance to otter or their resting sites during proposed works - Risk of invasive species spread during proposed works - Impact to fish species Therefore, potential for localised loss of or disturbance to flora/fauna.
4.D	13	1.00	Professional judgement	The Brick River is a salmonid waterbody. However, the watercourses within the AFA are not salmonid. Local weighting of 1 set by professional judgement. Weighting of 1 applied where fisheries could be	Potential short term construction impacts that can be mitigated. There are long term impacts associated with increased conveyance along the Boherroe River	Potential short term construction impacts that can be mitigated. There are long term impacts associated with increased conveyance along the Boherroe River
4.E	8	0.00	Professional judgement	No designated landscape features are within the 1% AEP or within the AFA. Local weighting of 0 set by professional judgement. Weighting of 0 applied where no specific landscape designation, and no landscape value/sensitivity are present.	There are no locally sensitive landscape features and there are no anticipated impacts on designated landscape features.	There are no locally sensitive landscape features and there are no anticipated impacts on designated landscape features. There will be short term construction related visual impacts and long term impacts from the earth embankment.
4.F(i)	4	2.00	Professional judgement	1 RPS fall within the 1% AEP. 2 other is in close proximity. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a moderate to low vulnerability.	The option will reduce the potential for flooding in the 1% AEP for 1 RPS. Therefore, there is a potential increase in the level of protection for architectural features from flooding, such that it is less vulnerable to flood damage.	The option will reduce the potential for flooding in the 1% AEP for 1 RPS. Therefore, there is a potential increase in the level of protection for architectural features from flooding, such that it is less vulnerable to flood damage.
4.F(ii)	4	0.00	Professional judgement	There are no RMPs within the 1% or the AFA. There are a number of RMPs in close proximity to the 1%AEP but this is outside the AFA boundary and will be considered at sub catchment scale. Local weighting of 0 set by professional judgement. Weighting of 0 applied where there are no archaeological features at risk.	There are no RMPs within the 1% or the AFA. There are a number of RMPs in close proximity to the 1%AEP but this is outside the AFA boundary and will be considered at sub catchment scale.	There are no RMPs within the 1% or the AFA. There are a number of RMPs in close proximity to the 1%AEP but this is outside the AFA boundary and will be considered at sub catchment scale.

Option 1 Costs for CBA

	CFRAM Programme – Option Costs for Cost Benefit Analysis					Notes to CFRAM Consultants
			€	€	€	
(1)	**Basic Construction Costs (Estimate)**				**74,657**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2)	**Preliminaries**	28.7%			**21,392**	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				**96,049**	
(3)	**Optimism Bias**	33.5%			**32,148**	Refer to UCD for selecting OB %
(4)	**Construction Costs (Excl VAT)**				**128,197**	
(5)	**Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)**	13.0%			**16,666**	Set at 13%
	Construction Costs and Fees				**144,863**	
(6)	**Other Items**					
(a)	Allowance for Archaeology & Environmental Mitigation Measures	10.0%		12,820		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b)	Allowance for compensation and land acquisition	13.0%		16,666		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c)	Site investigation			5,128		Professional judgement to be applied in estimating a suitable sum.
(d)	Art Allowance			0		See "Guidance E – Per Cent for Art Note"
(e)	Est. NPV Operation & Maintenance		22,606			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	33.5%	7,566	30,172	**64,785**	Refer to UCD for selecting OB %
	Option Cost for Cost Benefit Analysis				**209,648**	

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:		Date:	
Checked by:		Date:	

Project reference		Project name:	
Base date for estimates (year 0)	Oct-2013	Construction Price Index (CPI)	1.000
Scaling factor (e.g. €m, €k, €)	€	Method Factor - to take into account particular site issues /constraints	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	Cost (€)	Comment
Total wall costs		
Total embankment costs		
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs	€27,303	
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs	€63,450	*Individual property Resielience for Hair studio, Gaa Club house and Station Hous*
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total user specified method costs	€5,296	*Assumed 3.5 weeks work in year one (Entered as Capital cost)*
Total Construction costs	€96,049	
Apply update to unit rate (CPI) if appropriate (cell N15)	€96,049	
Enter appropriate preliminaries estimate (%)	29%	*ref: Preliminaries and other costs v1.0*
	0	
Enter other applicable costs (€)	0	
Total capital cost (€)	€96,049	
Consider amendments based on site issues/constraints (cell N16)	€96,049	
Total capital cost (€)	€96,049	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs		
Total embankment O&M costs		
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs	€1,059	
Total Operation and Maintenance costs	€1,059	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€118,655	
Optimism bias rate (from external sheet)	33%	
Total Cost including Optimism Bias	€158,369	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€96,049.2
Annual maintenance cost (€)	€1,059.2
Other cost (€)	€0.0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	4.0%	Present Value Factor:		22.341	Total PVc (€k):		118655
	Cash sum	0	96049	51902	0	147951	118655
	Discount	Cost Elements				TOTALS:	
year	Factor	Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	0	96049			96049.2	96049.2
1	0.962			1059		1059.2	1018.5
2	0.925			1059		1059.2	979.3
3	0.889			1059		1059.2	941.7
4	0.855			1059		1059.2	905.4
5	0.822			1059		1059.2	870.6
6	0.790			1059		1059.2	837.1
7	0.760			1059		1059.2	804.9
8	0.731			1059		1059.2	774.0
9	0.703			1059		1059.2	744.2
10	0.676			1059		1059.2	715.6
11	0.650			1059		1059.2	688.1
12	0.625			1059		1059.2	661.6
13	0.601			1059		1059.2	636.1
14	0.577			1059		1059.2	611.7
15	0.555			1059		1059.2	588.2
16	0.534			1059		1059.2	565.5
17	0.513			1059		1059.2	543.8
18	0.494			1059		1059.2	522.9
19	0.475			1059		1059.2	502.8
20	0.456			1059		1059.2	483.4
21	0.439			1059		1059.2	464.8
22	0.422			1059		1059.2	446.9
23	0.406			1059		1059.2	429.8
24	0.390			1059		1059.2	413.2
25	0.375			1059		1059.2	397.3
26	0.361			1059		1059.2	382.1
27	0.347			1059		1059.2	367.4
28	0.333			1059		1059.2	353.2
29	0.321			1059		1059.2	339.6
30	0.308			1059		1059.2	326.6
31	0.296			1059		1059.2	314.0
32	0.285			1059		1059.2	301.9
33	0.274			1059		1059.2	290.3
34	0.264			1059		1059.2	279.2
35	0.253			1059		1059.2	268.4
36	0.244			1059		1059.2	258.1
37	0.234			1059		1059.2	248.2
38	0.225			1059		1059.2	238.6
39	0.217			1059		1059.2	229.5
40	0.208			1059		1059.2	220.6
41	0.200			1059		1059.2	212.1
42	0.193			1059		1059.2	204.0
43	0.185			1059		1059.2	196.1
44	0.178			1059		1059.2	188.6
45	0.171			1059		1059.2	181.3
46	0.165			1059		1059.2	174.4
47	0.158			1059		1059.2	167.7
48	0.152			1059		1059.2	161.2
49	0.146			1059		1059.2	155.0

Option 2 Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis			€	€	€	Notes to CFRAM Consultants
(1)	**Basic Construction Costs (Estimate)**				**96,637**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2)	**Preliminaries**	28.6%			**27,663**	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				**124,301**	
(3)	**Optimism Bias**	33.8%			**42,043**	Refer to UCD for selecting OB %
(4)	**Construction Costs (Excl VAT)**				**166,344**	
(5)	**Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)**	13.0%			**21,625**	Set at 13%
	Construction Costs and Fees				**187,968**	
(6)	**Other Items**					
(a)	Allowance for Archaeology & Environmental Mitigation Measures	10.0%		16,634		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b)	Allowance for compensation and land acquisition	13.0%		21,625		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c)	Site investigation			6,654		Professional judgement to be applied in estimating a suitable sum.
(d)	Art Allowance					See "Guidance E – Per Cent for Art Note"
(e)	Est. NPV Operation & Maintenance		33,759			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	33.8%	11,419	45,178	**90,091**	Refer to UCD for selecting OB %
	Option Cost for Cost Benefit Analysis				**278,059**	

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	PT	**Date:**	
Checked by:		**Date:**	

Project reference		**Project name:**	ABY_02
Base date for estimates (year 0)	Oct-2013	**Construction Price Index (CPI)**	1.000
Scaling factor (e.g. €m, €k, €)	€	**Method Factor - to take into account particular site issues /constraints**	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	**Cost (€)**	**Comment**
Total wall costs		
Total embankment costs	€69,335	*Rural clay emb formed from imported material.*
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs	€27,303	
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€96,637	
Apply update to unit rate (CPI) if appropriate (cell N15)	€96,637	
Enter appropriate preliminaries estimate (%)	29%	
Enter other applicable costs (€)	0	
Total capital cost (€)	€124,301	
Consider amendments based on site issues/constraints (cell N16)	€124,301	
Total capital cost (€)	€124,301	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs		
Total embankment O&M costs	€1,582	
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€1,582	

Other costs	**Cost (€)**	**Comment**
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€158,060	
Optimism bias rate (from external sheet)	33%	
Total Cost including Optimism Bias	€210,964	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€124,300.7
Annual maintenance cost (€)	€1,581.9
Other cost (€)	€0.0
Other works frequency (years)	

Key

- Information
- Calculation
- Cost input
- User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**	**Total PVc (€k):**		**158060**
	Cash sum	0	124301	77511	0	201812	**158060**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	124301			124300.7	124300.7
1	0.962			1582		1581.9	1521.0
2	0.925			1582		1581.9	1462.5
3	0.889			1582		1581.9	1406.3
4	0.855			1582		1581.9	1352.2
5	0.822			1582		1581.9	1300.2
6	0.790			1582		1581.9	1250.2
7	0.760			1582		1581.9	1202.1
8	0.731			1582		1581.9	1155.9
9	0.703			1582		1581.9	1111.4
10	0.676			1582		1581.9	1068.6
11	0.650			1582		1581.9	1027.5
12	0.625			1582		1581.9	988.0
13	0.601			1582		1581.9	950.0
14	0.577			1582		1581.9	913.5
15	0.555			1582		1581.9	878.4
16	0.534			1582		1581.9	844.6
17	0.513			1582		1581.9	812.1
18	0.494			1582		1581.9	780.9
19	0.475			1582		1581.9	750.8
20	0.456			1582		1581.9	721.9
21	0.439			1582		1581.9	694.2
22	0.422			1582		1581.9	667.5
23	0.406			1582		1581.9	641.8
24	0.390			1582		1581.9	617.1
25	0.375			1582		1581.9	593.4
26	0.361			1582		1581.9	570.6
27	0.347			1582		1581.9	548.6
28	0.333			1582		1581.9	527.5
29	0.321			1582		1581.9	507.2
30	0.308			1582		1581.9	487.7
31	0.296			1582		1581.9	469.0
32	0.285			1582		1581.9	450.9
33	0.274			1582		1581.9	433.6
34	0.264			1582		1581.9	416.9
35	0.253			1582		1581.9	400.9
36	0.244			1582		1581.9	385.5
37	0.234			1582		1581.9	370.6
38	0.225			1582		1581.9	356.4
39	0.217			1582		1581.9	342.7
40	0.208			1582		1581.9	329.5
41	0.200			1582		1581.9	316.8
42	0.193			1582		1581.9	304.6
43	0.185			1582		1581.9	292.9
44	0.178			1582		1581.9	281.6
45	0.171			1582		1581.9	270.8
46	0.165			1582		1581.9	260.4
47	0.158			1582		1581.9	250.4
48	0.152			1582		1581.9	240.8
49	0.146			1582		1581.9	231.5

Appendix C6 Option Appraisal Report – Moneycashen

1. Preliminary Report: Summary of Current Flood Risk

1.1 AFA and Watercourse Details	
AFA	Moneycashen
Unit of Management:	23
Primary Watercourse(s):	River Chasen, River Feale, River Galey, River Brick

1.2 Summary of Flood Risk in 1% Fluvial/0.5% Coastal AEP Event				
Source of flood risk	Fluvial	Coastal		**Both**
Total Number of Properties at risk in AFA in 1% Fluvial / 0.5% Coastal AEP Event:		**Residential**	**Non-Residential**	**Total**
	Fluvial	5	0	5
	Coastal	5	0	5
	Combined	5	0	5
AFA Flood Cells:	**Total Number:**	1		
	Flood Cell Titles:	MON_A		
Breakdown of properties at risk per Flood Cell:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	MON_A	5	0	5
Relevant Comments:	Moneycashen is at risk from both a 1% AEP fluvial and 0.5% coastal flood source.			
Relevant Figure Ref:	Figure 1.1 and 1.2.			

1.3 Summary of Existing Flood Risk Management Measures					
Arterial Drainage	**Storage**	**Flow Diversion**	**Flood Defences**	**Level Control**	**Other**
Yes	No	No	**Yes**	No	No
Relevant Comments:	There is an existing informal flood defence, which has been included in the model and provides some protection. The condition of the defence is poor.				
Relevant Figure Ref:	Figure 1.1 and 1.2				

1.4 Summary of PV Damages/Potential PV Benefits			
Total PV Damages:		**Uncapped**	**Capped**
	Fluvial	€ 42,437	€ 42,437
	Coastal	€ 686,095	€ 678,899
	Combined	€728,532	€ 707,820
Max Combined Capped Benefits for 1% Fluvial and 0.5% Coastal AEP Event*:	€ 633,752		

Breakdown of Combined Capped Max PV benefits 1% Fluvial (0.5% Coastal) SOP per Flood Cell:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	MON_A	€ 633,752	€ 0	€ 633,752
Relevant Figure Ref:	Figure 1.2			

*These are the maximum benefits available if a FRM option with a 1% Fluvial / 0.5% Coastal AEP SOP is provided to all properties within the AFA.

1.5 Social Risk		
High Vulnerability Properties at risk :	**Type**	**Description**
	None	N/A
Social Infrastructure Assets:	None	N/A
Social Amenity Sites:	None	N/A
Relevant Figure Ref:	General Risk - Social	
1.6 Risk to the Environment		
	Type	**Description**
Risk to WFD Annex IV	None	N/A
Risk to SACs	Candidate Special Area of Conservation	The Cashen Estuary is part of the Lower Shannon cSAC, part of which falls within this AFA.
Relevant Figure Ref:	General Risk - Environment	
1.7 Risk to Cultural Heritage		
Risk to Sites of Cultural Heritage:	**Type**	**Description**
	None	N/A
Relevant Figure Ref:	General Risk – Cultural Heritage	
1.8 Risk to the Economy		
Risk to Transport Infrastructure	**Type**	**Description**
	Local Rural Road	**20% AEP Flood Extent.**
		Unnamed Local Road
Risk to Utility Infrastructure	**Type**	**Description**
	None	N/A
Relevant Figure Ref:	General Risk - Economy	

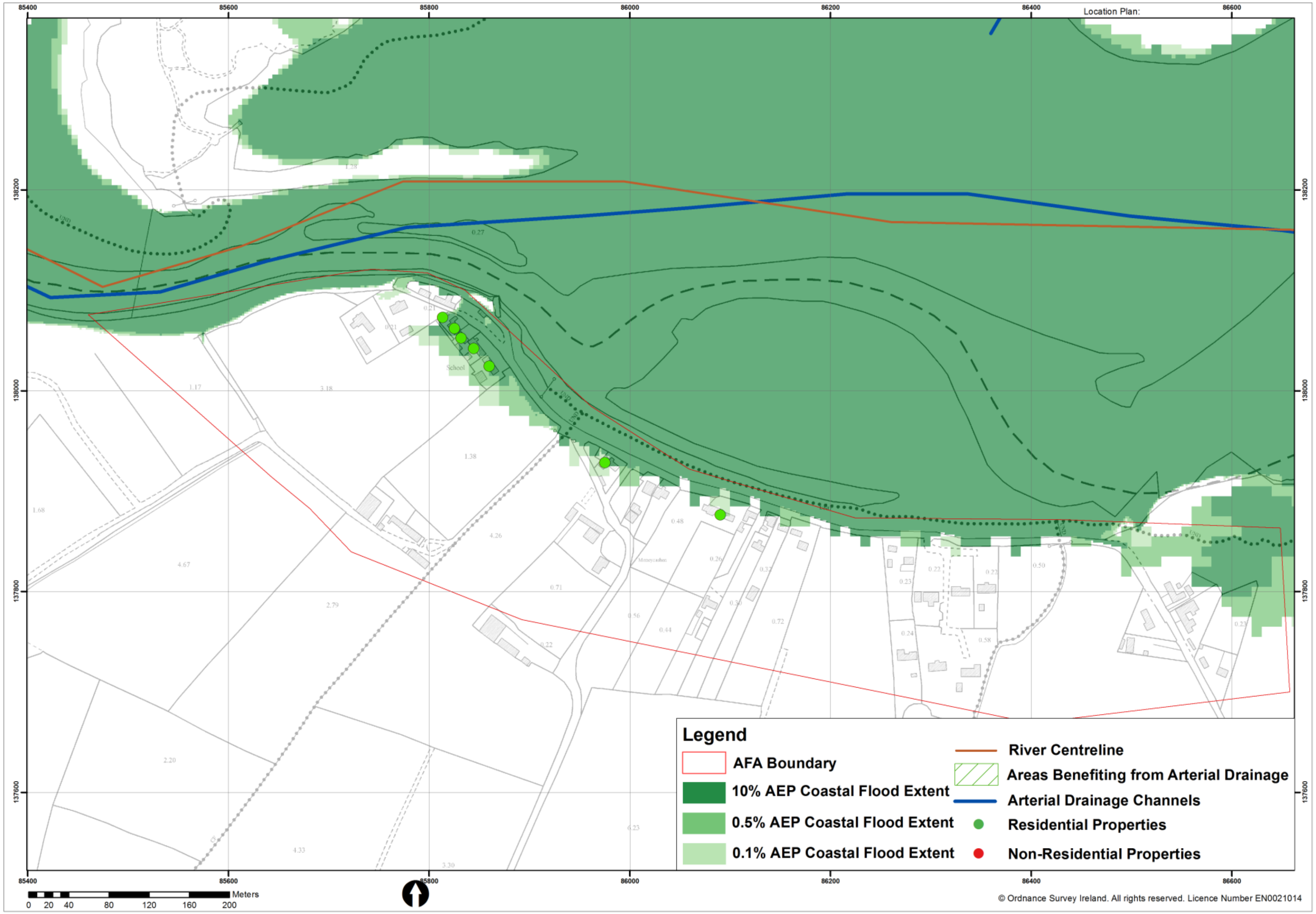

Figure 1.1 – Moneycashen Coastal Flooded Properties

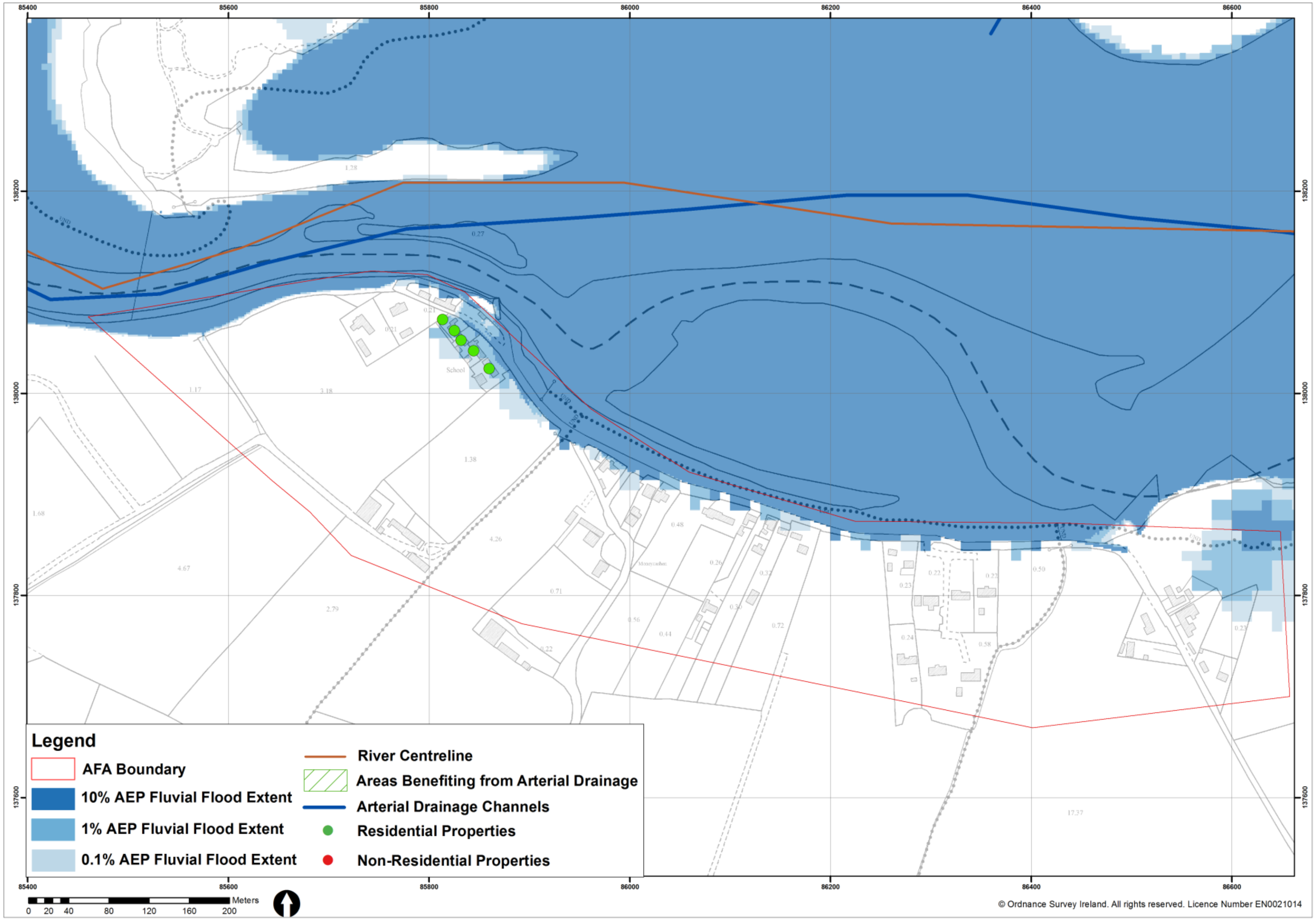

Figure 1.2 – Moneycashen Fluvial Flooded Properties

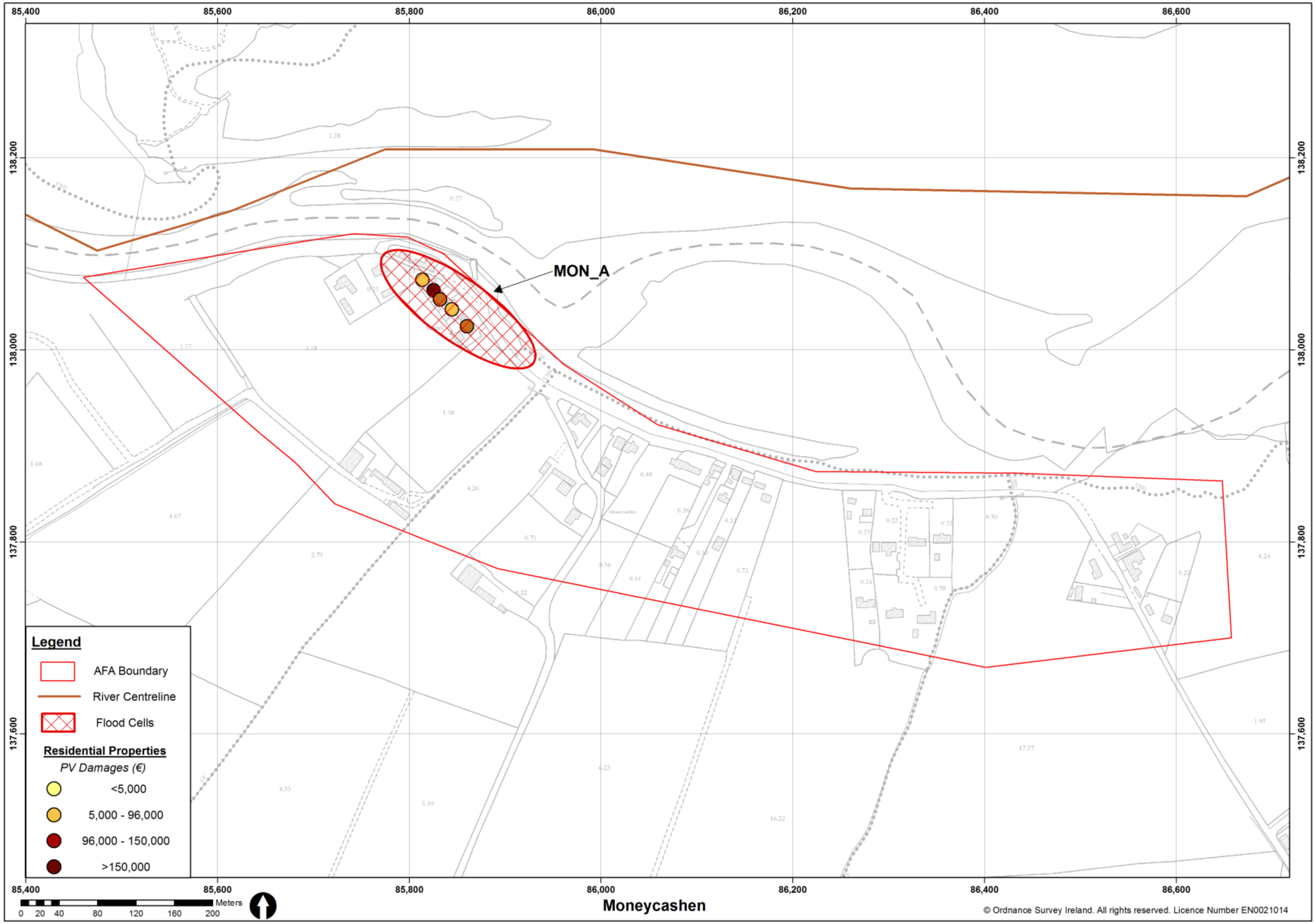

Figure 1.3 – Moneycashen Total Combined PV Damages for Properties in the 1% Fluvial & 0.5% Coastal AEP Flood Event and Flood Cells. Flood Cells are groupings of properties that are likely to be hydraulically linked

2. STAGE 2: Screening of the Measures

2.1 Baseline and Structural Measures

Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.

Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	Screened Out
B	Existing Regime	Unviable	Viable	Viable	Viable	Viable	Screened Out
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	Screened Out
Structural							
D	Storage	Unviable	Viable	Viable	Viable	Viable	Screened Out
E	Flow Diversion	Unviable	Viable	Viable	Viable	Viable	Screened Out
F	Increase Conveyance	Unviable	Viable	Viable	Viable	Viable	Screened Out
G	Flood Defences	Viable	Unviable	Viable	Viable	Viable	Screened Out
H	Relocation of Properties	Viable	Unviable	Viable	Unviable	Viable	Screened Out
I	Other Measures	Unviable	Unviable	Unviable	Unviable	Unviable	Screened Out
Non-Structural							
J	Flood Forecasting / Warning / Response	Viable	Viable	Viable	Viable	Viable	Screened In
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	Screened In
L	Individual property resistance	Viable	Viable	Viable	Viable	Viable	Screened In
M	Individual property resilience	Viable	Viable	Viable	Viable	Viable	Screened In

2.2 Justification for Screened Out Baseline and Structural Measures

The following provides justification on Measures with an overall viability 'Screened Out' categorisation.

A	Do Nothing	Applicability Economic Environmental Social Cultural	Screened out as there are other viable measures.
B	Existing Regime	Applicability Economic Environmental Social Cultural	Although there is an existing arterial drainage scheme in place. This work has no impact of the level of flood risk to the properties as the source of flood risk is coastal.
C	Do Minimum	Applicability Economic Environmental Social Cultural	The Do Minimum FRM method is not a viable measure for Moneycashen as reactive maintenance will not reduce the coastal flood risk.
D	Storage	Applicability Economic Environmental Social Cultural	Not viable as this FRM method is not applicable to the area and the source of flood risk.
E	Flow Diversion	Applicability Economic Environmental Social Cultural	Not viable as this FRM method is not applicable to the area and the source of flood risk.

F	Increase Conveyance	Applicability Economic Environmental Social Cultural	Not viable as this FRM method is not applicable to the area and the source of flood risk.
G	Flood Defences	Applicability Economic Environmental Social Cultural	There is an existing informal flood defence, which has been included in the model and provides some protection. The condition of the defence is poor. To provide protection to the 0.5% AEP coastal event, this wall would need to be replaced, as it is not suitable to be modified to the height required. The proposed flood defence would be required to replace the existing defence for over 350 m in length. The height of the required wall is in order of 1.6 m. The cost of the above option (sea wall only) is estimated at €4,500,000. With max potential benefits of €633,752 the flood defence is economically unviable.
H	Relocation of Properties	Applicability Economic Environmental Social Cultural	The relocation of 5 properties is not applicable to the area and is socially unviable. The average cost of constructing a new property is €160,000 therefore to replace the 5 properties would cost €800,000, which is greater than the economic benefits available.
I	Other Measures	Applicability Economic Environmental Social Cultural	No other Measures have been identified.

2.3 Summary of 'Screened In' Measures

The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.

Structural Measures		**Non-Structural Measures**	
		J	Flood Forecasting / Warning / Response
		K	Public Awareness
		L	Individual property resistance
		M	Individual property resilience

Figure C6.5 – Moneycashen Screened Out Measures

3. STAGE 3: Selection of Options

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3.1 Consideration of Options

The following are the agreed combination of 'Screened In' measures that comprise each of the Options being taken forward for further consideration.

Where appropriate, the 'Screened In' measures have been sub-divided into separate specific measures to ensure applicability to site conditions.

Measures		Different composition of measures per option						
Non-Structural Measures								
J	Flood Forecasting / Warning / Response	✓						
K	Public Awareness	✓						
L	Individual property resistance	✓						
M	Individual property resilience							
Option Reference		MON_01						

Measures not screened out but not included in options		
Measures		**Justification for not being included**
M	Individual Property Resilience	Individual Property Resilience was not considered as either an independent measure or in combination with other measures, as the option being appraised would provide the required 1% Fluvial / 0.5% Coastal AEP standard of protection. Individual Property Resilience does not improve the viability of the option under consideration.

4. STAGE 4: Appraisal of Options

4.1 Options Appraisal

Each option taken forward for Multi-Criteria Assessment (MCA) analysis is to be discussed at the Option Development Meeting. Below describes this concept design of each option and provides a summary of any significant comments/issues which were raised by LA staff at the Options Development Meetings. These comments will be considered in the local weightings and the MCA scores.

Option Ref:		MON_01			
Option Measures	**Non Structural**	**J** Flood Forecasting	**K** Public Awareness	**L** Property Resistance	M Property Resilience
Option Description:		This option will provide a reduce the impact of flood risk to all properties predicted at risk in the 1% Fluvial and 0.5% Coastal AEP event and includes; • Simple Flood Forecasting system to alert residents of high tides. • Individual flood resistance measures for all properties. • Yearly public awareness campaigns to constantly remind residents of flood risk in the area.			
Option Development Meeting:		Date:	10th of June 2015		
		Summary:	The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.		

5. STAGE 5: Multi Criteria Assessment

5.1 Options selected for the Multi Criteria Assessment

Following the Option Development Meeting, the following options are the refined options for the Multi-Criteria Assessment (MCA) stage. This is the final of a five stage MCA process.

Option Reference		MON_01
Non-Structural Measures		
J	Forecasting / Warning / Response	Simple Flood Forecasting system to alert residents of high tides.
K	Public Awareness	Yearly public awareness campaigns to constantly remind residents of flood risk in the area.
L	Individual property resistance	Individual flood resistance measures for all properties.
Table reference A summary of the outcome from the MCA is presented in the following table		Table 5.1

Table 5.1: Multi Criteria Assessment Outcome for Option MON_01

<table>
<tr><td colspan="4">Multi Criteria Assessment
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.</td></tr>
<tr><td>AFA</td><td>Moneycashen</td><td>Option Ref:</td><td>MON_01</td></tr>
<tr><td colspan="4">Option Measures</td></tr>
<tr><td>Baseline</td><td></td><td colspan="2">N/A</td></tr>
<tr><td>Structural</td><td></td><td colspan="2">N/A</td></tr>
<tr><td rowspan="3">Non-Structural</td><td>J</td><td colspan="2">Flood Forecasting</td></tr>
<tr><td>K</td><td colspan="2">Public Awareness</td></tr>
<tr><td>L</td><td colspan="2">Individual Property Resistance</td></tr>
<tr><td colspan="4">Criteria Scores</td></tr>
<tr><td colspan="2">Technical</td><td colspan="2">650</td></tr>
<tr><td colspan="2">Economic</td><td colspan="2">67</td></tr>
<tr><td colspan="2">Social</td><td colspan="2">147</td></tr>
<tr><td colspan="2">Environmental</td><td colspan="2">0</td></tr>
<tr><td colspan="4">Economic Values</td></tr>
<tr><td colspan="2">Economic PV Benefits</td><td colspan="2">€ 633,752</td></tr>
<tr><td colspan="2">PV Cost</td><td colspan="2">€ 247,868</td></tr>
<tr><td colspan="2">NPV Benefits</td><td colspan="2">€ 385,884</td></tr>
<tr><td colspan="2">Economic BCR</td><td colspan="2">2.56</td></tr>
<tr><td colspan="4">Outcome Scores</td></tr>
<tr><td colspan="2">MCA PV Benefits</td><td colspan="2">€ 299,805</td></tr>
<tr><td colspan="2">MCA Benefit Score</td><td colspan="2">215</td></tr>
<tr><td colspan="2">MCA Benefit Score Ratio</td><td colspan="2">865.85</td></tr>
<tr><td colspan="2">Option Selection MCA</td><td colspan="2">865</td></tr>
<tr><td colspan="2">Relevant Figure</td><td colspan="2">Figure 5.1</td></tr>
</table>

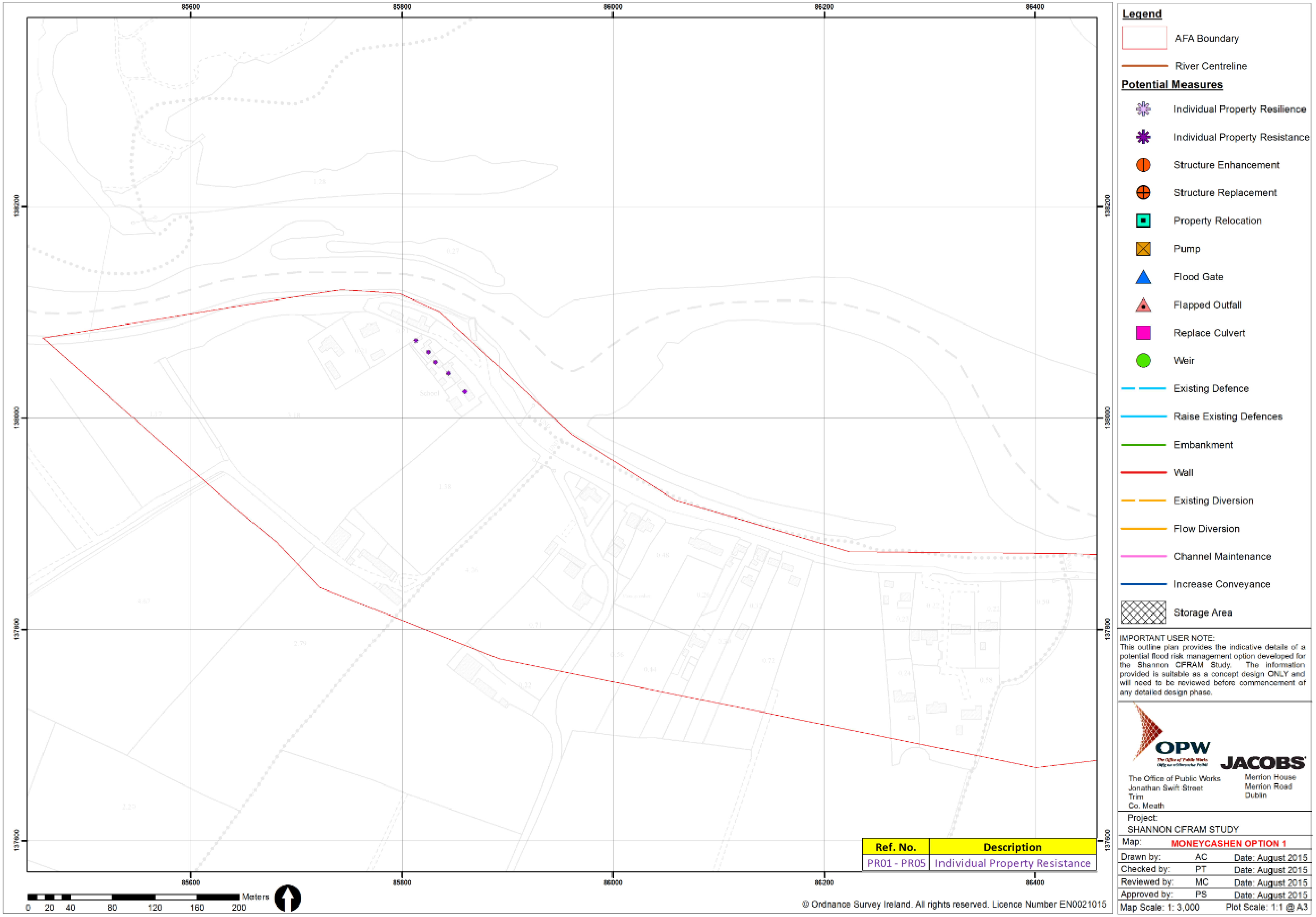


Figure 5.1 Option MON_01

5.2 Comparison of Multi Criteria Assessment Scores

Each option taken forward for further consideration through the Option Development Meeting has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).

Categories	Option Reference and Results
	MON_01
Criteria Scores	
Technical	650
Economic	67
Social	147
Environmental	0
Economic Values	
Economic PV Benefits	€ 633,752
PV Cost	€ 247,868
NPV Benefits	€ 385,884
Economic BCR	2.56
Outcome Scores	
MCA PV Benefits	€ 299,805
MCA Benefit Score	215
MCA BCR	865.85
Option Selection MCA	865

5.3 Recommendation of Preferred Option

It forms part of the CFRAM process for the recommendation of a preferred option for each AFA. The prioritised selection criteria used in this recommendation process is detailed in Section 3.7.3 of the Main Report.

Therefore, following the five stage Multi Criteria Assessment process, the preferred option is as outlined below

Option Ref:		MON_01			
Option Measures	**Baseline**	N/A			
	Structural	N/A			
	Non Structural	**J** Flood Forecasting	**K** Public Awareness	**L** Property Resistance	M Property Resilience
Comments		This option will reduce the flood risk to all properties within the AFA, identified as being at risk.			

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

<table>
<tr><th colspan="5">Fluvial Flood Forecasting Potential</th></tr>
<tr><th rowspan="3">Catchment Information</th><th colspan="2">Gauging Station</th><th rowspan="2">Catchment size (km ^{2})</th><th rowspan="2">Potential available forecast accuracy and reliability period</th></tr>
<tr><th>Fluvial</th><th>Rainfall</th></tr>
<tr><td>Yes</td><td>No*</td><td>1155</td><td>6 -12 hours</td></tr>
<tr><th>Relevant Information:</th><td colspan="4">Moneycashen (GS 23068) lies within the AFA
Feale Bridge (GS 23061) lies within the AFA
Sleveen Main Channel (GS 23030) 15km upstream of Moneycashen
Listowel (GS 23002) 33km upstream of Moneycashen
Inch Bridge Galey (GS 23001) 25km upstream of Moneycashen</td></tr>
<tr><th rowspan="3">Additional Infrastructure Recommended</th><th colspan="2">Gauging Station</th><th colspan="2" rowspan="2">Other</th></tr>
<tr><th>Fluvial</th><th>Rainfall</th></tr>
<tr><td>No</td><td>No</td><td colspan="2">No</td></tr>
<tr><th>Relevant Comments:</th><td colspan="4">The existing fluvial gauging stations 23030, 23002 and 23001 could provide reasonably accurate and reliable predictions for flooding from the River Feale. The three gaging stations together represent 88% of the total catchment area at Moneycashen. There is no requirement for additional fluvial or rainfall gauges to provide flood forecasting for this AFA.

It must be noted that Moneycashen is tidally influenced and an understanding of the coincidence of peak tide level would have to be included in the fluvial flood forecasting system.

Tidal flooding could be predicted by a simple forecasting system.</td></tr>
</table>

*For this assessment only 15 minute tipping bucket gauge were considered.

Annex A - Multi-Criteria Analysis Summary and Whole Life Cost Summaries for FRM Option

CRITERIA		OBJECTIVE		Global Weighting	Local Weighting	Comments	MON_01 J – Flood Forecasting / Warning / Response K – Public Awareness L – Individual Property Resistance		Option Score	Weighted Score
1	Technical	a	Ensure flood risk management options are operationally robust	20	5.00	The option scores are determined based on the level of operational risk to operate or perform successfully. Each measure is scored independently and the average of the measure scores is used as the score for the option.	No risks / Manageable Negligible / Moderate / high Very low / High Low / Failure likely Low / moderate / Unacceptable	J 1.00 K L 1.00	1.00	100
		b	Minimise health and safety risks associated with the construction and operation of flood risk management options	20	5.00	H&S risks are considered for construction and maintenance of flood risk management measures. The indicative aspirational score is set at five, with a point then deducted for each specific H&S risk in either construction or maintenance.	No risks / Moderate Negligible / Moderate / high Very low / High Low / Very High Low / moderate / Unacceptable	Work near services or buildings	3.00	300
		c	Ensure flood risk management options are adaptable to future flood risk	20	5.00	The options scores are determined based on the sustainability and adaptability of the flood risk management measures in the face of potential future changes, including the potential impact of climate change. Each measure is scored independently and the average of the measure scores is used as the score for the option.	Option can be adapted at no to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions.	J 5.00 K L 0.00	2.50	250
			TECHNICAL CRITERIA SCORE							650
2	Economic	a	Minimise economic risk	24	0.21		The score is calculated based on the reduction in AAD, following the full implementation of option.		4.54	22
		b	Minimise risk to transport infrastructure	10	3.00		The score is calculated based on the reduction in flood risk to transport routes, following the full implementation of option.		0.50	15
		c	Minimise risk to utility infrastructure	14	0.00		The score is calculated based on a reduction in flood risk to utility infrastructure, following the full implementation of option.		0.00	0
		d	Minimise risk to agriculture	12	2.50	Source of Flooding: Salt Water Percentage of AFA that is rural land: 100.00%	Area of Agricultural Land Flooded: No Change Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: No Change Flood Warning: Applicable Agricultural Production Enhanced: No Change Other (Please Specify): Not Applicable		1.00	30
			ECONOMIC CRITERIA SCORE							67
3	Social	a i)	Minimise risk to human health and life - Residents	27	1.10	Flood Depths & Velocities: Medium to high risk to life Known Areas of Highly Vulnerable People: Reasonable Cross Section of Society	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.		4.94	147
		a ii)	Minimise risk to human health and life - High vulnerability properties	17	0.00	Rate of Onset of flooding: Significantly Greater Rate of Onset	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.		4.00	0
		b i)	Minimise risk to community - Social Infrastructure & Amenity	9	0.00	Assets of Particular Social Value: No	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.		0.00	0
		b ii)	Minimise risk to community - Local employment	7	0.00	Asset of Particular Employment Value: No	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.		0.00	0
			SOCIAL CRITERIA SCORE							147
4	Environmental	a	Support the objectives of the WFD	16	5.00	The Cashen Estuary is of moderate status. There are no significant pollution sourced in the 1%AEP or in the AFA. There are no drinking water features. The Cashen Estuary is nutrient sensitive. There is a small shellfish area within the Cashen Estuary just outside the AFA boundary. Local weighting to be applied for this objective is constant, and should always be set equal to 5 as WFD objectives must be achieved and are relevant to all waterbodies.	The implementation of flood forecasting is unlikely to impact the achievement of water body objectives.		0.00	0
		b	Support the objectives of the Habitats Directive	10	5.00	The Cashen Estuary is part of the Lower Shannon cSAC part of which falls within the AFA. Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (within AFA) and potentially affected.	The implementation of flood forecasting is unlikely to increase or reduce pollution risk to sensitive water bodies.		0.00	0
		c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	5	1.00	The Cashen Estuary is a pNHA part of which falls within the AFA. Local weighting of 5 set by professional judgement. Weighting of 5 applied where a nationally important site (pNHA, NHA etc) is present (within AFA) and potentially affected	The implementation of flood forecasting is unlikely to significantly impact or enhance the flora and fauna of the catchment.		0.00	0
		d	Protect, and where possible enhance, fisheries resource within the catchment	13	3.00	The Cashen River within the AFA is not a salmonid waterbody. There are some shellfish areas that are protected outside the AFA. Local weighting of 2 applied by professional judgement, a score of 2 indicates that the waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.	The implementation of flood forecasting is unlikely to significantly impact or enhance fisheries resource within the catchment.		0.00	0
		e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	8	0.00	No designated landscape features are within the 1% Fluvial AEP or 0.5% AEP coastal within the AFA. The Ballybunnion walk is located in the vicinity of the AFA but across the estuary. There are also a number of special amenity areas and a view/prospect outside of the AFA. Local weighting of 2 applied by professional judgement, which relates to landscape character type designated at a county level as low sensitivity and/or low value and potentially affected.	The implementation of flood forecasting is unlikely to result in a change to the existing landscape character/features.		0.00	0
		f i)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of architectural value	4	1.00	1 RPS fall within the 1% fluvial and 0.5% coastal AEP. Local weighting of 2 applied by professional judgement, which relates to a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a moderate to low vulnerability.	The implementation of flood forecasting is unlikely to result in a change to the architectural features.		0.00	0
		f ii)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of archaeological value	4	0.00	There are no RMP within the 1% fluvial and 0.5% coastal AEP. Local weighting of 0 applied by professional judgement, which relates to no archaeological features at risk.	The implementation of flood forecasting is unlikely to result in a change to the archaeological features.		0.00	0
			ENVIRONMENTAL CRITERIA SCORE							0
	Economic Values		**Economic PV Benefits**						€633,752	
			Cost						€247,868	
			NPV Benefits						€385,884	
			Economic BCR						**2.56**	
	Outcome Scores		**MCA PV Benefits**						€299,805	
			MCA Benefit Score						215	
			MCA BCR						**865.85**	
			Option Selection MCA						865	

Objective	Global Weightings (fixed)	Local Weightings		Baseline Comments	Option 1 Comments
1.A	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has low/moderate operational risks to operate or perform successfully.
1.B	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has very low health and safety risks associated with the construction and operation of flood risk management option.
1.C	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.
2.A	24	0.21	calculated	Local weighting is calculated based on the baseline AAD.	This score is calculated based on the reduction in AAD, following the full implementation of option.
2.B	10	3.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to transport infrastructure. Significant transport delays due to flooding. Therefore local weighting has been increased by 50%.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.
2.C	14	0.00	calculated but adjusted by professional judgement if necessary	There are no utility infrastructure receptors at risk within this AFA.	There are no utility infrastructure receptors at risk within this AFA.
2.D	12	2.50	Professional judgement	Although there is minimal amount of Agricultural land within the AFA there is a significant amount of land upstream flooded. Therefore this local weighting has been set to 2.5.	This score is determined based on the presence of flood forecasting, following full implementation of the option.
3.A (i)	27	1.10	calculated but adjusted by professional judgement if necessary	Calculated local weighting left unchanged as although there is medium to high risk to life there was a significantly greater rate of onset than 1-2 hours.	Caclulation for including flood forecasting overwrites score to 4.00. This has been removed so that the percentage risk reduction is represented.
3.A (ii)	17	0.00	calculated but adjusted by professional judgement if necessary	There are no high vulnerability properties at risk of flooding within this AFA.	There are no high vulnerability properties at risk of flooding within this AFA.
3.B (i)	9	0.00	calculated but adjusted by professional judgement if necessary	There are no Social Infrastructure or Amenities at risk of flooding within this AFA.	There are no Social Infrastructure or Amenities at risk of flooding within this AFA.
3.B (ii)	7	0.00	calculated but adjusted by professional judgement if necessary	There is no risk to local employment within this AFA.	There is no risk to local employment within this AFA.
4.A	16	5.00	fixed	The Cashen Estuary is part of the Lower Shannon cSAC part of which falls within the AFA. Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (within AFA) and potentially affected.	The implementation of flood forecasting is unlikely to impact the achievement of water body objectives.
4.B	10	5.00	Professional judgement	The Cashen Estuary is part of the Lower Shannon cSAC part of which falls within the AFA. Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (within AFA) and potentially affected.	The implementation of flood forecasting is unlikely to increase or reduce pollution risk to sensitive water bodies.
4.C	5	1.00	Professional judgement	The Cashen Estuary is a pNHA part of which falls within the AFA. Local weighting of 5 set by professional judgement. Weighting of 5 applied where a nationally important site (pNHA, NHA etc) is present (within AFA) and potentially affected	The implementation of flood forecasting is unlikely to significantly impact or enhance the flora and fauna of the catchment.
4.D	13	3.00	Professional judgement	The Cashen River within the AFA is not a salmonid waterbody. There are some shellfish areas that are protected outside the AFA. Local weighting of 2 applied by professional judgement, a score of 2 indicates that the waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.	The implementation of flood forecasting is unlikely to significantly impact or enhance fisheries resource within the catchment.
4.E	8	0.00	Professional judgement	No designated landscape features are within the 1% Fluvial AEP or 0.5% AEP coastal within the AFA. The Ballybunnion walk is located in the vicinity of the AFA but across the estuary. There are also a number of special amenity areas and a view/prospect outside of the AFA. Local weighting of 2 applied by professional judgement, which relates to landscape character	The implementation of flood forecasting is unlikely to result in a change to the existing landscape character/features.
4.F(i)	4	1.00	Professional judgement	1 RPS fall within the 1% fluvial and 0.5% coastal AEP. Local weighting of 2 applied by professional judgement, which relates to a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a moderate to low vulnerability.	The implementation of flood forecasting is unlikely to result in a change to the architectural features.
4.F(ii)	4	0.00	Professional judgement	There are no RMP within the 1% fluvial and 0.5% coastal AEP. Local weighting of 0 applied by professional judgement, which relates to no archaeological features at risk.	The implementation of flood forecasting is unlikely to result in a change to the archaeological features.

Option Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis			€	€	€	Notes to CFRAM Consultants
(1)	**Basic Construction Costs (Estimate)**				**52,180**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2)	**Preliminaries**	31.5%			**16,416**	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				**68,596**	
(3)	**Optimism Bias**	24.0%			**16,463**	Refer to UCD for selecting OB %
(4)	**Construction Costs (Excl VAT)**				**85,059**	
(5)	**Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)**	13.0%			**11,058**	Set at 13%
	Construction Costs and Fees				**96,116**	
(6)	**Other Items**					
(a)	Allowance for Archaeology & Environmental Mitigation Measures	10.0%		8,506		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b)	Allowance for compensation and land acquisition	10.0%		8,506		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c)	Site investigation	4.0%		3,402		Professional judgement to be applied in estimating a suitable sum.
(d)	Art Allowance			N/A		See "Guidance E – Per Cent for Art Note"
(e)	Est. NPV Operation & Maintenance		105,918			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	24.0%	25,420	131,338	**151,752**	Refer to UCD for selecting OB %
	Option Cost for Cost Benefit Analysis				**247,868**	

JBA consulting

DONNACHADH O'BRIEN & ASSOCIATES CONSULTING ENGINEERS

OPW The Office of Public Works Oifig na nOibreacha Poiblí

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	J. Reynolds	Date:	13/07/2015
Checked by:	M.Conlon	Date:	13/07/2015

Project reference	S14b	Project name:	Moneycashen - Option 1
Base date for estimates (year 0)	Oct-2013	Construction Price Index (CPI)	0.987
Scaling factor (e.g. €m, €k, €)	€	Method Factor - to take into account particular site issues /constraints	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	Cost (€)	Comment
Total wall costs		
Total embankment costs		
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs	€ 28,000	*4 residential semi-dethatched properties*
Total hydrometric gauging station costs		
Total flood forecasting costs	€ 16,000	*assuming 2 single site alarms forecast, equiv. to tidal buoy*
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs	€ 8,180	*Public Awareness: assumed extra work in first year, followed by maintenance.*
Total Construction costs	€52,180	
Apply update to unit rate (CPI) if appropriate (cell N15)	€51,478	
Enter appropriate preliminaries estimate (%)	31%	
Enter other applicable costs (€)		
Total capital cost (€)	€68,596	
Consider amendments based on site issues/constraints (cell N16)	€68,596	
Total capital cost (€)	€68,596	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs		
Total embankment O&M costs		
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs	€ 560	
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs	€ 2,358	
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs	€ 2,045	
Total Operation and Maintenance costs	€4,963	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€174,514	
Optimism bias rate (from external sheet)	24%	
Total Cost including Optimism Bias	€216,397	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€68,595.8
Annual maintenance cost (€)	€4,963.0
Other cost (€)	€0.0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	4.0%	Present Value Factor:		22.341		Total PVc (€k):	174514
	Cash sum	0	68596	243187	0	311783	174514
	Discount	Cost Elements				TOTALS:	
year	Factor	Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	0	68596			68595.8	68595.8
1	0.962			4963		4963.0	4772.1
2	0.925			4963		4963.0	4588.6
3	0.889			4963		4963.0	4412.1
4	0.855			4963		4963.0	4242.4
5	0.822			4963		4963.0	4079.2
6	0.790			4963		4963.0	3922.3
7	0.760			4963		4963.0	3771.5
8	0.731			4963		4963.0	3626.4
9	0.703			4963		4963.0	3486.9
10	0.676			4963		4963.0	3352.8
11	0.650			4963		4963.0	3223.9
12	0.625			4963		4963.0	3099.9
13	0.601			4963		4963.0	2980.6
14	0.577			4963		4963.0	2866.0
15	0.555			4963		4963.0	2755.8
16	0.534			4963		4963.0	2649.8
17	0.513			4963		4963.0	2547.9
18	0.494			4963		4963.0	2449.9
19	0.475			4963		4963.0	2355.7
20	0.456			4963		4963.0	2265.0
21	0.439			4963		4963.0	2177.9
22	0.422			4963		4963.0	2094.2
23	0.406			4963		4963.0	2013.6
24	0.390			4963		4963.0	1936.2
25	0.375			4963		4963.0	1861.7
26	0.361			4963		4963.0	1790.1
27	0.347			4963		4963.0	1721.3
28	0.333			4963		4963.0	1655.0
29	0.321			4963		4963.0	1591.4
30	0.308			4963		4963.0	1530.2
31	0.296			4963		4963.0	1471.3
32	0.285			4963		4963.0	1414.7
33	0.274			4963		4963.0	1360.3
34	0.264			4963		4963.0	1308.0
35	0.253			4963		4963.0	1257.7
36	0.244			4963		4963.0	1209.3
37	0.234			4963		4963.0	1162.8
38	0.225			4963		4963.0	1118.1
39	0.217			4963		4963.0	1075.1
40	0.208			4963		4963.0	1033.7
41	0.200			4963		4963.0	994.0
42	0.193			4963		4963.0	955.7
43	0.185			4963		4963.0	919.0
44	0.178			4963		4963.0	883.6
45	0.171			4963		4963.0	849.7
46	0.165			4963		4963.0	817.0
47	0.158			4963		4963.0	785.6
48	0.152			4963		4963.0	755.3
49	0.146			4963		4963.0	726.3

Appendix C7 Option Appraisal Report - Tralee

1. Preliminary Report: Summary of Current Flood Risk

1.1 AFA and Watercourse Details

AFA	Tralee
Unit of Management:	23
Primary Watercourse(s):	Lee (River), Big (River) Cloghers, Balyvelly, Hospital Tralee, Ballydunlea, Ratass, Tralee, Ballynabrennagh, Caherweesheen

1.2 Summary of Flood Risk in 1% Fluvial / 0.5% Coastal AEP Event

Source of flood risk	Fluvial	Coastal	**Both**

Total Number of Properties at risk in AFA in 1% Fluvial / 0.5% Coastal AEP Event:		**Residential**	**Non-Residential**	**Total**
	Fluvial	351	214	565
	Coastal	52	10	62
	Combined	403	224	627

AFA Flood Cells:	**Total Number:**	4
	Flood Cell Titles:	TRA_A, TRA_B, TRA_C, TRA_D

Breakdown of properties at (combined) risk per Flood Cell:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	TRA_A	52	10	62
	TRA_B	118	186	304
	TRA_C	233	27	260
	TRA_D	0	1	1

Relevant Figure Ref: Figure 1.1 to 1.3

1.3 Summary of Existing Flood Risk Management Measures

Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
None	None	None	**Yes**	None	None

Relevant Figure Ref: Figure 1.1 and 1.2

1.4 Summary of PV Damages/Potential PV Benefits

Total PV Damages:		**Capped**	**Uncapped**
	Fluvial	€ 38,271,668	€ 44,811,742
	Coastal	€ 3,817,011	€ 4,784,018
	Combined	€ 39,841,064	€ 46,708,595

Max Combined Capped Benefits for 1% Fluvial and 0.5% Coastal AEP Event*:	€ 32,726,816

Breakdown of Max Combined Capped PV Benefits per Flood Cell for 1% Fluvial and 0.5% Coastal AEP Event:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	TRA_A	€ 1,261,871	€ 1,960,548	€ 3,222,419
	TRA_B	€ 1,603,362	€ 12,848,182	€ 14,451,544
	TRA_C	€ 9,712,452	€ 5,320,986	€ 15,033,438

	TRA_D	€ 0	€ 19,415	€ 19,415
Relevant Figure Ref:	Figure 1.3			

*These are the maximum benefits available if a FRM option with a 1% Fluvial / 0.5% Coastal AEP SOP is provided to all properties within the AFA.

1.5 Social Risk		
	Type	**Description**
High Vulnerability Properties at risk:	School	**0.1% AEP Fluvial Flood Extent**
		Scoil Mhuire na Mbraithre on Brewery Road / Edward Street
	Hospital	**10% AEP Fluvial Flood Extent**
		Kerry General Hospital
	Nursing Home	**1% AEP Fluvial Flood Extent**
		OUTSIDE AFA: Cuil Didin Residential Care Facility to the south of Tralee
Social Infrastructure Assets:	Garda Station	**5% AEP Fluvial Flood Extent**
		Tralee Garda Station, New Road
Social Amenity Sites:	None	N/A
Relevant Figure Ref:	General Risk - Social	
1.6 Risk to the Environment		
	Type	**Description**
Risk to WFD Annex IV:	Special Protection Area	Tralee Bay Complex SPA
	Licensed IPPC Facility	**1% AEP Fluvial Flood Extent**
		Henry Denny & Sons ltd. Factory (Racket Lane)
Risk to SACs:	Special Area of Conservation	Tralee Bay and Magharees Peninsula (west to Cloghane)
Relevant Figure Ref:	General Risk - Environment	
1.7 Risk to Cultural Heritage		
	Type	**Description**
Risk to Sites of Cultural Heritage:	Kerry National Monument	**10% AEP Fluvial Flood Extent**
		Enclosure, Manor West
		1% AEP Flood Extent
		Unknown, west of Blennerville
		Cross-inscribed stone, Ashe Memorial Hall, Denny Street
		Ogham stone, Ashe Memorial Hall, Denny Street
		0.1% AEP Flood Extent
		Mound, south of Blennerville
		Balloonagh Castle, North Circular Road
		St. John’s COI Church, Ashe Street
		Ring barrow, Manor East
	Proposed Natural Heritage Area	**50% AEP Flood Extent**
		The Proposed Natural Heritage Area of Tralee Bay and Magharees Peninsula (west to Cloghane)
	NIAH Buildings	**20% AEP Coastal Flood Extent**
		Ballyard Bridge, south of Tralee
		10% AEP Flood Extent
		The Station House bar and grill, N86/Kearney’s Road

		1% AEP Flood Extent
		Blennerville Windmill
		No.1-9 Green View Terrace
		12 houses along Prince's Quay including No.1-6 & 15
		No.1-3 Godfrey Place
		Two houses along Ivy Terrace
		No.1-3 Stoughton Row
		Three properties along Abbey Street
		Kerry School of Music, High Street
		"Val O Shea's" House, Bridge Street
		No.11-13, 17, & 20-21 Bridge Street
		No.2, 25-26, 29, 34 and Supermacs, The Mall
		No.2-4, 10-11, 14-15, 105, 109-112, & 120 Rock Street
		Russell Street Arch
		Pembroke Street - Godley's Bar, Tralee Laundry, St. Anthony's
		No.7-9, 11, 13-15, & Warehouse on Milk Market Lane
		No. 20-21, 37, 42, & 49 Ashe Street
		No. 3 Church Street
		Three houses on Ballymullen Road
		Parts of the Military Barracks, Ballymullen Road
		Holy Cross Roman Catholic Church, Day Place
		0.1% AEP Flood Extent
		Blennerville House and outbuildings
		No.1 Day Place
		No.9 Bridge Street
		No.5 & 11 The Square
		No.1-1a, 7, 9-13, 30, 32-33, The Mall
		No.18, Brat's Place Restaurant, and Unnamed House on Milk Market Lane.
		No. 4, 7, 36, & 39/40 Ashe Street
		No.2, & 8 Church Street
		Keliher's Mills, North Circular Road
		No.4-7, 9-10, & 33-34 Lower Castle Street
		Denny Street - No. 33, Grand Hotel (partially)
		Ashe Street - Tralee Court House, and St. John's COI Church
Relevant Figure Ref:	General Risk – Cultural Heritage	

1.8 Risk to the Economy		
	Type	**Description**
Risk to Transport Infrastructure:	National Secondary Road	**50% AEP Coastal & Fluvial Flood Extent**
		N86
		N70
	Regional Road	**10% AEP Fluvial Flood Extent**
		R919
		5% AEP Fluvial Flood Extent
		R556
		R551
		1% AEP Fluvial Flood Extent
		R875
		R874
		R878
		Ashe Street
	Local Road	**50% AEP Fluvial Flood Extent**
		Kearney's Road
Risk to Utility Infrastructure:	High Vulnerability Utility	**10% AEP Fluvial Flood Extent**
		Eircom Depot at Castlewood Park / Kilerisk Road
	Low Vulnerability Utility	**0.1% AEP Flood Extent**
		Pumping station for the Tralee sewerage scheme, to the south of Tralee.
Relevant Figure Ref:	General Risk - Economy	

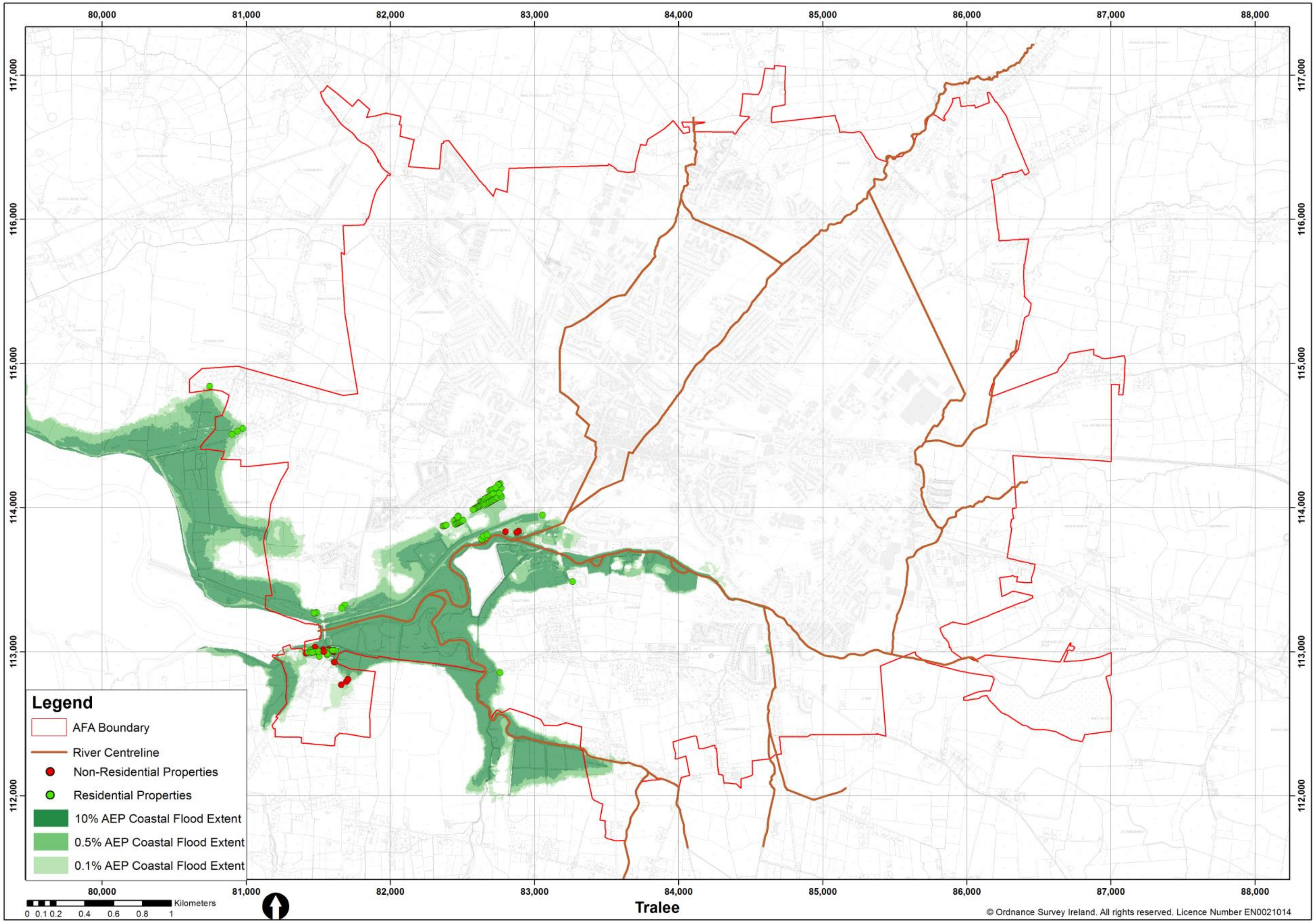


Figure 1.1 – Tralee Coastal Flood Risk to Properties

JACOBS

OPW
The Office of Public Works
Oifig na nOibreacha Poiblí

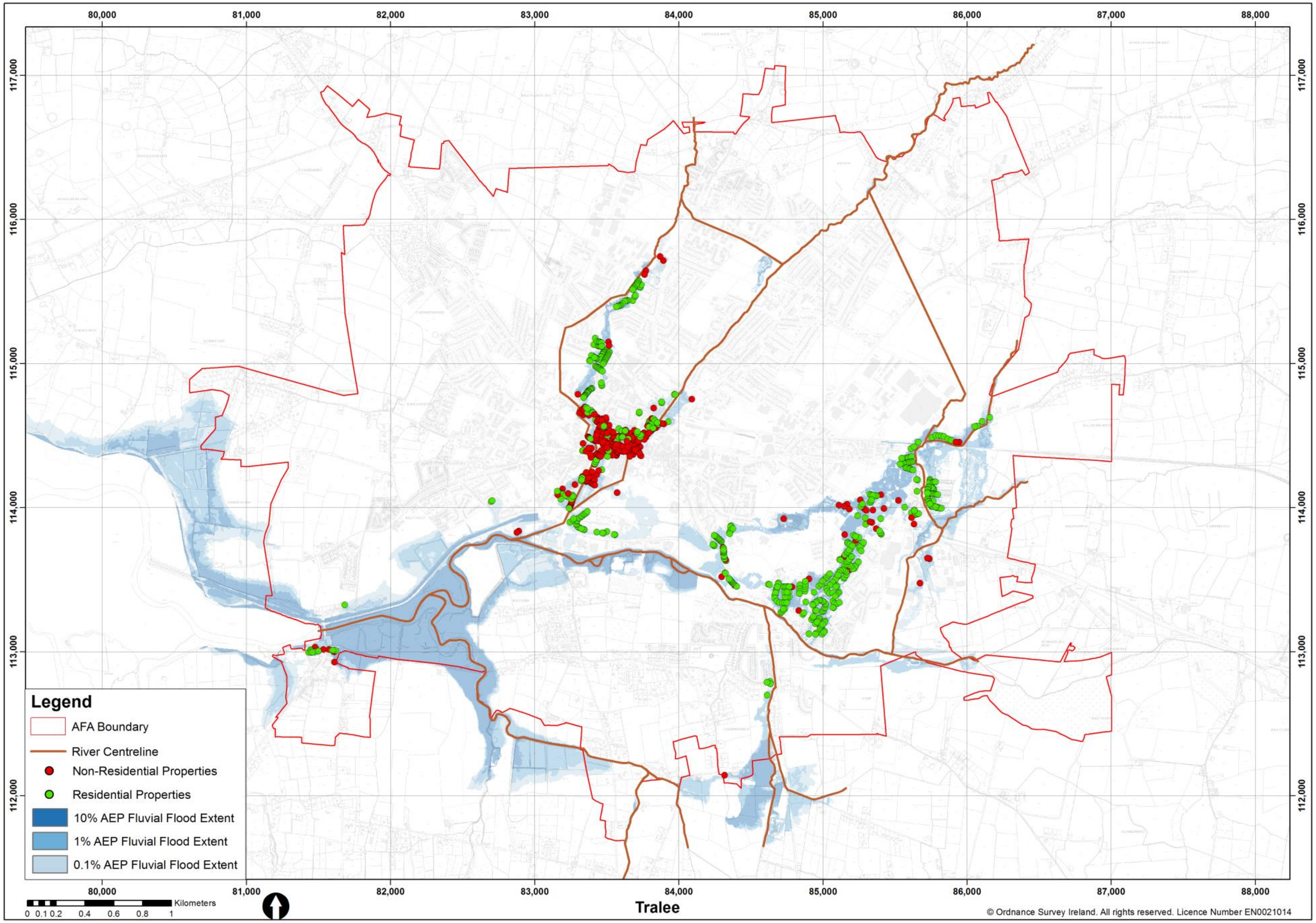


Figure 1.2 – Tralee Fluvial Flood Risk to Properties

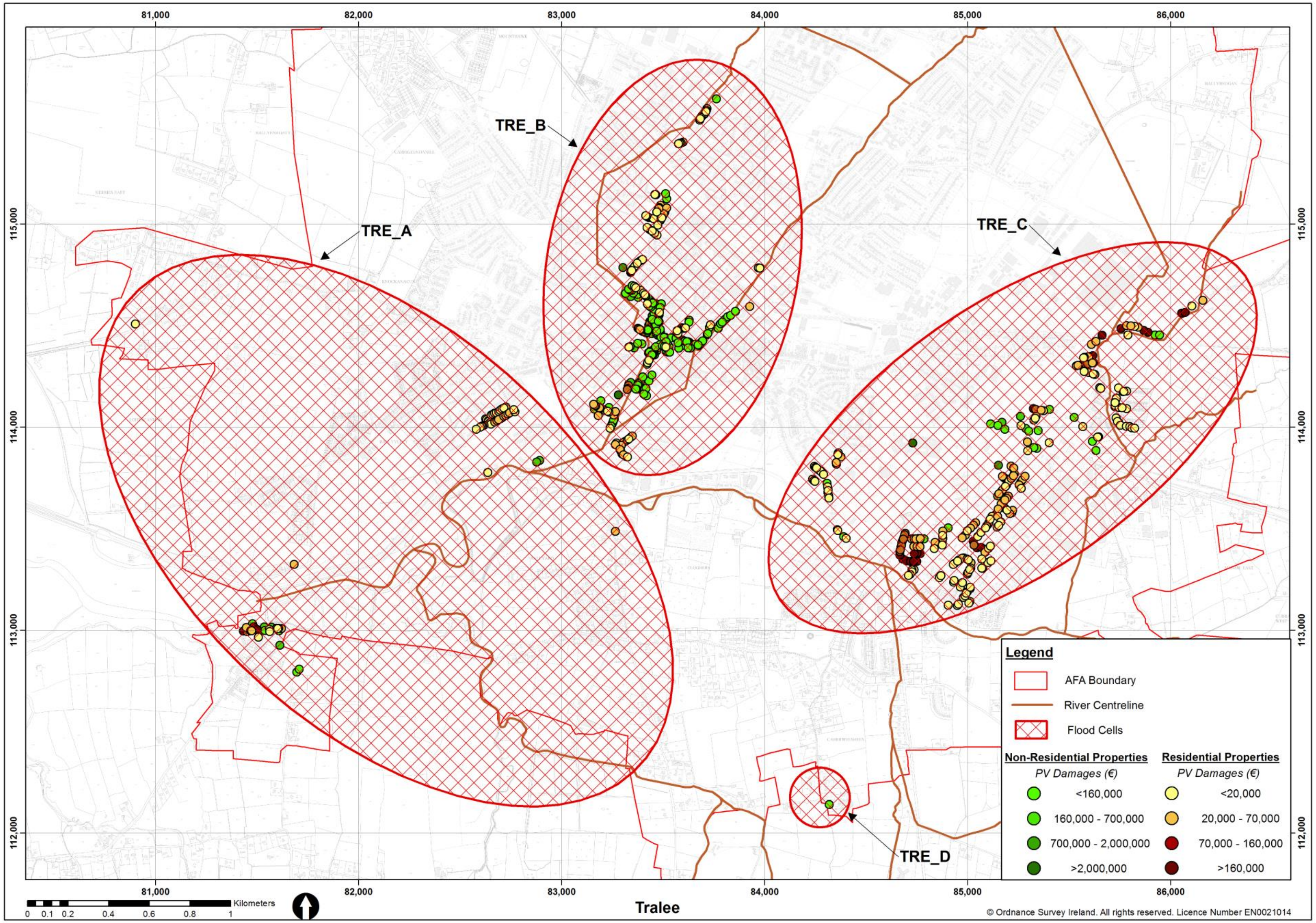


Figure 1.3 –Tralee Total Combined PV Damages for Properties in the 1% Fluvial & 0.5% Coastal AEP Flood Event and Flood Cells. Flood Cells are groupings of properties that are likely to be hydraulically linked

2. STAGE 2: Screening of the Measures

2.1 Baseline, Structural and Non-Structural Measures

Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.

Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Unviable	Viable	Screened Out
B	Existing Regime	Unviable	Viable	Viable	Viable	Viable	Screened Out
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	Screened Out
Structural							
D	Storage	Viable	Viable	Viable	Viable	Viable	Screened In
E	Flow Diversion	Viable	Viable	Viable	Viable	Viable	Screened In
F	Increase Conveyance	Viable	Viable	Viable	Viable	Viable	Screened In
G	Flood Defences	Viable	Viable	Viable	Viable	Viable	Screened In
H	Relocation of Properties	Unviable	Viable	Viable	Viable	Viable	Screened Out
I	Other: Flood Gate in the Canal	Viable	Unviable	Viable	Viable	Viable	Screened Out
Non-Structural							
J	Flood Forecasting / Warning / Response	Viable	Viable	Viable	Viable	Viable	Screened In
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	Screened In
L	Individual Property Resistance	Viable	Viable	Viable	Viable	Viable	Screened In
M	Individual Property Resilience	Viable	Viable	Viable	Viable	Viable	Screened In

2.2 Justification for Screened Out Baseline and Structural Measures

The following provides justification on Measures with an overall viability 'Screened Out' categorisation.

A	Do Nothing	Applicability Economic Environmental Social Cultural	Due to the high level of flood risk within the AFA the Do Nothing FRM measure is not applicable to the area and is not socially viable.
B	Existing Regime	Applicability Economic Environmental Social Cultural	Screened out as there is no existing regime currently in place.
C	Do Minimum	Applicability Economic Environmental Social Cultural	Screened out as the Do Minimum FRM measure will have negligible impact to the existing flood risk.
H	Relocation of Properties	Applicability Economic Environmental Social Cultural	The relocation of 627 properties is not applicable to the area and is socially unviable.

I	Other: Flood Gate in the Canal	Applicability Economic Environmental Social Cultural	Installation of a floodgate in the Canal, upstream of the Blennerville bridge was considered. The purpose of the floodgate will be to hold back tidal flows coming up the canal into the Marina area. A flood gate in this area can only offer flood protection for flood events of a magnitude less than the 2% AEP event, as for any greater magnitude events the impact of the gate is negated due to bypassing flow between the River Lee and the Canal further upstream. As this measure will only reduce the flood risk to one property, it is not economically viable.

2.3 Summary of 'Screened In' Measures

The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.

Structural Measures		Non-Structural Measures	
D	Storage	J	Flood Forecasting / Warning / Response
E	Flow Diversion	K	Public Awareness
F	Increase Conveyance	L	Individual Property Resistance
G	Flood Defences	M	Individual Property Resilience

3. STAGE 3: Selection of Options

3.1 Consideration of Options

The following are the agreed combination of 'Screened In' measures that comprise each of the Options being taken forward for further consideration.

Where appropriate, the 'Screened In' measures have been sub-divided into separate specific measures to ensure applicability to site conditions.

Measures		**Different composition of measures per option**						
Structural Measures								
D	Storage							
Di	Online Storage	✓	✓					
Dii	Offline Storage							
Diii	Other Storage							
E	Flow Diversion							
Ei	Full Diversion							
Eii	Flood Relief Channel		✓	✓	✓			
Eiii	Other Diversion							
F	Increase Conveyance							
Fi	Channel Dredging	✓	✓	✓	✓			
Fii	Channel Widening	✓	✓	✓	✓			
Fiii	Structure Enhancement / Works		✓	✓	✓			
G	Flood Defences							
Gi	New Flood Defences	✓	✓	✓	✓			
Gii	Raise Existing Flood Defences	✓	✓	✓	✓			
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
J	Forecasting / Warning / Response	✓	✓	✓	✓			
K	Public Awareness	✓	✓	✓	✓			
L	Individual Property Resistance		✓	✓	✓			
M	Individual Property Resilience	✓	✓	✓	✓			
Option Reference		TRA_01	TRA_02	TRA_03	TRA_04			

4. STAGE 4: Appraisal of Options

4.1 Options Appraisal

Each option taken forward for Multi-Criteria Assessment (MCA) analysis is to be discussed at the Option Development Meeting. Below describes this concept design of each option and provides a summary of any significant comments/issues which were raised by LA staff at the Options Development Meetings. These comments will be considered in the local weightings and the MCA scores.

<table>
<tr><td colspan="2">Option Ref:</td><td colspan="4">TRA_01</td></tr>
<tr><td rowspan="7">Option Measures</td><td>Baseline</td><td colspan="4">N/A</td></tr>
<tr><td rowspan="5">Structural</td><td>Di</td><td colspan="3">Storage: Online Storage</td></tr>
<tr><td>Fi</td><td colspan="3">Increase Conveyance: Channel Dredging</td></tr>
<tr><td>Fii</td><td colspan="3">Increase Conveyance: Channel Widening</td></tr>
<tr><td>Gi</td><td colspan="3">Flood Defences: New Flood Defences</td></tr>
<tr><td>Gii</td><td colspan="3">Flood Defences: Raise Existing Flood Defences</td></tr>
<tr><td>Non Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="4">This option will provide a 1% Fluvial and 0.5% Coastal AEP Design standard to 624 of the 627 properties within the AFA and reduce the risk to 3 properties, identified as being at risk from both these sources, and includes;
• Provide storages areas at River Big, River Mackies, and the River Ratass.
• Construct wall on the left bank of the River Ratass and the River Tralee adjacent the storage area.
• Clean the Ratass watercourse as it flows through the industrial estate of Manor West.
• Construct walls along the River Big downstream of Brewery Road.
• Walls to protect the Pier 17 business centre.
• Embankment to protect properties at Knockmoyle and Caheranne Village.
• Upgrade of walls adjacent Windmill lane including the provision of floodgates at the carpark entrance.
• Construct wall to protect properties adjacent the canal at Blennerville.
• Construct wall along Kearney's Road.
• Improve the capacity of the River Ballingowan.
• Individual property resistance to protect 2 properties as shown on figure 5.1.
• Individual property resilience to protect the property off the Dingle Rd. as shown on figure 5.1.</td></tr>
<tr><td colspan="2" rowspan="2">Option Development Meeting:</td><td>Date:</td><td colspan="3">10th of June 2015</td></tr>
<tr><td>Summary:</td><td colspan="3">The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.</td></tr>
</table>

<table>
<tr><td colspan="2">Option Ref:</td><td colspan="4">TRA_02</td></tr>
<tr><td rowspan="9">Option Measures</td><td>Baseline</td><td colspan="4">N/A</td></tr>
<tr><td rowspan="7">Structural</td><td>Di</td><td colspan="3">Storage: Online Storage</td></tr>
<tr><td>Eii</td><td colspan="3">Flow Diversion: Flood Relief Channel</td></tr>
<tr><td>Fi</td><td colspan="3">Increase Conveyance: Channel Dredging</td></tr>
<tr><td>Fii</td><td colspan="3">Increase Conveyance: Channel Widening</td></tr>
<tr><td>Fiii</td><td colspan="3">Increase Conveyance: Structure Enhancement / Works</td></tr>
<tr><td>Gi</td><td colspan="3">Flood Defences: New Flood Defences</td></tr>
<tr><td>Gii</td><td colspan="3">Flood Defences: Raise Existing Flood Defences</td></tr>
<tr><td>Non Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="4">This option will provide a 1% Fluvial and 0.5% Coastal AEP Design standard to 622 of the 627 properties within the AFA and reduce the risk to 5 properties, identified as being at risk from both these sources, and includes;
• Provide storages areas at River Big and the River Mackies
• Construct wall on the left bank of the River Mackies adjacent the storage area.
• Construct walls along the River Big downstream of Brewery Road.
• Diversion channel to divert flow from the Tralee River to the Ratass River.
• Increase size of culvert at the downstream of the Ratass River and the culvert under the railway line at the Tralee River.
• Clean the Ratass watercourse as it flows through the industrial estate of Manor West.
• Improve the capacity of the River Ballingowan.
• Replace the bridge at the Renault garage and the local access road behind the Nissan garage.
• Individual property resistance to protect the Pier 17 business centre.
• Individual property resistance to protect properties adjacent the canal at Blennerville.
• Flood Forecasting for coastal events
• Embankment to protect properties at Knockmoyle and Caheranne Village.
• Upgrade of walls adjacent Windmill lane including the provision of floodgates at the carpark entrance.
• Construct wall and embankment along Kearney's Road.
• Individual property resistance to other protect 2 properties as shown on figure 5.2.
• Individual property resilience to protect the property off the Dingle Rd. as shown on figure 5.2.</td></tr>
<tr><td colspan="2" rowspan="2">Option Development Meeting:</td><td>Date:</td><td colspan="3">10th of June 2015</td></tr>
<tr><td>Summary:</td><td colspan="3">The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.</td></tr>
<tr><td colspan="6"></td></tr>
</table>

<table>
<tr><td colspan="2">Option Ref:</td><td colspan="5">TRA_03</td></tr>
<tr><td rowspan="8">Option Measures</td><td>Baseline</td><td colspan="5">N/A</td></tr>
<tr><td rowspan="6">Structural</td><td>Eii</td><td colspan="4">Flow Diversion: Flood Relief Channel</td></tr>
<tr><td>Fi</td><td colspan="4">Increase Conveyance: Channel Dredging</td></tr>
<tr><td>Fii</td><td colspan="4">Increase Conveyance: Channel Widening</td></tr>
<tr><td>Fiii</td><td colspan="4">Increase Conveyance: Structure Enhancement / Works</td></tr>
<tr><td>Gi</td><td colspan="4">Flood Defences: New Flood Defences</td></tr>
<tr><td>Giii</td><td colspan="4">Flood Defences: Raise Existing Flood Defences</td></tr>
<tr><td>Non Structural</td><td colspan="2">J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="5">This option will provide a 1% Fluvial and 0.5% Coastal AEP Design standard to 622 of the 627 properties within the AFA and reduce the risk to 5 properties, identified as being at risk from both these sources, and includes;
• Increase capacity of the diversion channel between Mackies River and the River Big.
• Provide a wall on the right bank of the open channel of the flood diversion between the Mackies River and the River Big.
• Improve inlet arrangement at the diversion channel diverting flow from the River Big to the River Ratass.
• Individual property resistance to protect properties adjacent the canal at Blennerville.
• Construct diversion channel from the River Ratass to the River Tralee.
• Construct diversion channel from the River Tralee to the River Ballynabrennagh replacing the River Tralee culvert.
• Clean the Ratass watercourse as it flows through the industrial estate of Manor West.
• Improve the capacity of the River Ballynabrennagh and provide embankments on the left bank.
• Construct walls along the River Big downstream of Brewery Road.
• Individual property resistance to protect the Pier 17 business centre.
• Flood Forecasting for coastal events
• Embankment to protect properties at Knockmoyle and Caheranne Village.
• Upgrade of walls adjacent Windmill lane including the provision of flood gates at the carpark entrance,
• Construct wall along Kearney’s Road.
• Individual property resistance to other protect 2 properties as shown on figure 5.3.
• Individual property resilience to protect the property off the Dingle Rd. as shown on figure 5.3.</td></tr>
<tr><td colspan="2" rowspan="2">Option Development Meeting:</td><td>Date:</td><td colspan="4">10th of June 2015</td></tr>
<tr><td>Summary:</td><td colspan="4">The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.</td></tr>
</table>

<table>
<tr><td colspan="2">Option Ref:</td><td colspan="4">TRA_04</td></tr>
<tr><td rowspan="8">Option Measures</td><td>Baseline</td><td colspan="4">N/A</td></tr>
<tr><td rowspan="6">Structural</td><td>Eii</td><td colspan="3">Flow Diversion: Flood Relief Channel</td></tr>
<tr><td>Fi</td><td colspan="3">Increase Conveyance: Channel Dredging</td></tr>
<tr><td>Fii</td><td colspan="3">Increase Conveyance: Channel Widening</td></tr>
<tr><td>Fiii</td><td colspan="3">Increase Conveyance: Structure Enhancement / Works</td></tr>
<tr><td>Gi</td><td colspan="3">Flood Defences: New Flood Defences</td></tr>
<tr><td>Giii</td><td colspan="3">Flood Defences: Raise Existing Flood Defences</td></tr>
<tr><td>Non Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="4">This option will provide a 1% Fluvial and 0.5% Coastal AEP Design standard to 622 of the 627 properties within the AFA and reduce the risk to 5 properties, identified as being at risk from both these sources, and includes;
• New flood relief culvert between the Mackies River and the River Big. This is to allow excess flood flow be diverted from the Mackies into the Big River.
• Provide a wall on the right bank of the open channel of the flood diversion between the Mackies River and the River Big. Also clean this channel.
• Improve inlet arrangement at the diversion channel diverting flow from the River Big to the River Ratass.
• Construct diversion channel from the River Ratass to the River Tralee.
• Clean the Ratass watercourse as it flows through the industrial estate of Manor West.
• Construct diversion channel from the River Tralee to the River Ballynabrennagh replacing the River Tralee road culvert.
• Construct diversion channel from the Ballynabrennagh River to the River Lee.
• Improve the capacity of the River Ballynabrennagh and provide embankments on the left bank.
• Construct walls along the River Big downstream of Brewery Road.
• Individual property resistance to protect the Pier 17 business centre.
• Individual property resistance to protect properties adjacent the canal at Blennerville.
• Flood Forecasting for coastal events
• Embankment to protect properties at Knockmoyle and Caheranne Village.
• Upgrade of walls adjacent Windmill lane including the provision of flood gates at the carpark entrance,
• Construct wall along Kearney’s Road.
• Individual property resistance to other protect 2 properties as shown on figure 5.4.
• Individual property resilience to protect the property off the Dingle Rd. as shown on figure 5.4.</td></tr>
<tr><td colspan="2" rowspan="2">Option Development Meeting:</td><td>Date:</td><td colspan="3">10th of June 2015</td></tr>
<tr><td>Summary:</td><td colspan="3">Option added following the meeting with Kerry County Council.</td></tr>
</table>

5. STAGE 5: Multi Criteria Assessment

5.1 Options selected for the Multi Criteria Assessment

Following the Option Development Meeting, the following options have been selected for the Multi-Criteria Assessment (MCA) stage. This is the final of a five-stage MCA process.

Option Reference		TRA_01	TRA_02	TRA_03	TRA_04
Structural Measures					
Di	Online Storage	Provide storages areas at River Big, River Mackies, and the River Ratass.	Provide storages areas at River Big and River Mackies		
Eii	Flood Relief Channel		Diversion channel to divert flow from the Tralee River to the Ratass River	Construct diversion channel from the River Ratass to the River Tralee. Construct diversion channel from the River Tralee to the River Ballynabrennagh replacing the River Tralee culvert.	Construct diversion channel from the River Ratass to the River Tralee. Construct diversion channel from the River Tralee to the River Ballynabrennagh replacing the River Tralee culvert. Construct diversion channel from the Ballynabrennagh River to the River Lee.
Fi	Channel Dredging	Improve the capacity of the River Ballingowan.	Clean the Ratass watercourse as it flows through the industrial estate of Manor West. Improve the capacity of the River Ballingowan.	Increase capacity of the diversion channel between Mackies River and the River Big. Improve the capacity of the River Ballingowan and provide embankments on the left bank.	Increase capacity of the diversion channel between Mackies River and the River Big. Improve the capacity of the River Ballingowan and provide embankments on the left bank.
Fii	Channel Widening				
Fiii	Structure Enhancement / Works		Increase size of culvert at the downstream of the Ratass River and the culvert under the railway line at the Tralee River. Replace the bridge at the Renault garage and the local access road behind the Nissan garage.	Improve inlet arrangement at the diversion channel diverting flow from the River Big to the River Ratass.	Improve inlet arrangement at the diversion channel diverting flow from the River Big to the River Ratass.
Gi	New Flood Defences	Construct wall on the left bank of the River Ratass and the River Tralee adjacent the storage area. Construct walls along the River Big downstream of Brewery Road. Walls to protect the Pier 17 business centre. Embankment to protect properties at Knockmoyle and Caheranne Village. Construct wall to	Construct wall on the left bank of the River Mackies adjacent the storage area. Construct walls along the River Big downstream of Brewery Road. Embankment to protect properties at Knockmoyle and Caheranne Village. Construct wall and embankment along Kearney's Road.	Construct walls along the River Big downstream of Brewery Road. Embankment to protect properties at Knockmoyle and Caheranne Village. Construct wall along Kearney's Road.	Construct walls along the River Big downstream of Brewery Road. Embankment to protect properties at Knockmoyle and Caheranne Village. Construct wall along Kearney's Road.

		protect properties adjacent the canal at Blennerville. Construct wall along Kearney's Road.			
Gii	Raise Existing Flood Defences	Upgrade of walls adjacent Windmill lane including the provision of floodgates at the carpark entrance.	Upgrade of walls adjacent Windmill lane including the provision of floodgates at the carpark entrance.	Upgrade of walls adjacent Windmill lane including the provision of floodgates at the carpark entrance.	Upgrade of walls adjacent Windmill lane including the provision of floodgates at the carpark entrance.
Non-Structural Measures					
J	Flood Forecasting / Warning / Response	Flood Forecasting for coastal events	Flood Forecasting for coastal events	Flood Forecasting for coastal events	Flood Forecasting for coastal events
K	Public Awareness	This will apply to all properties receiving Individual Property Resistance or Resilience	This will apply to all properties receiving Individual Property Resistance or Resilience	This will apply to all properties receiving Individual Property Resistance or Resilience	This will apply to all properties receiving Individual Property Resistance or Resilience
L	Individual Property Resistance		Individual property resistance to protect the Pier 17 business centre. Individual property resistance to protect properties adjacent the canal at Blennerville. Individual property resistance to protect other 2 properties as shown on figure 5.2.	Individual property resistance to protect the Pier 17 business centre. Individual property resistance to protect properties adjacent the canal at Blennerville. Individual property resistance to protect other 2 properties as shown on figure 5.3.	Individual property resistance to protect the Pier 17 business centre. Individual property resistance to protect properties adjacent the canal at Blennerville. Individual property resistance to protect other 2 properties as shown on figure 5.4.
M	Individual Property Resilience	Individual property resilience to protect 3 properties as shown on figure 5.1.	Individual property resilience to protect 3 properties as shown on figure 5.2.	Individual property resilience to protect 3 properties as shown on figure 5.3.	Individual property resilience to protect 3 properties as shown on figure 5.4.
	Table reference A summary of the outcome from the MCA is presented in the following table	Table 5.1	Table 5.2	Table 5.3	Table 5.4

Table 5.1: Multi Criteria Assessment Outcome for Option TRA_01

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**			
AFA	Tralee	Option Ref:	TRA_01

Option Measures		
Baseline		NA
Structural	Di	Storage: Online Storage
	Fi	Channel Dredging
	Fii	Channel Widening
	Gi	Flood Defences: New Flood Defences
	Gii	Flood Defences: Raise Existing Flood Defences
Non-Structural	J	Forecasting / Warning / Response
	K	Public Awareness
	L	Individual Property Resistance
	M	Individual Property Resilience

Criteria Scores	
Technical	244
Economic	906
Social	741
Environmental	-231
Economic Values	
Economic PV Benefits	€ 32,720,999
PV Cost	€ 13,198,688
NPV Benefits	€ 19,522,311
Economic BCR	**2.48**
Outcome Scores	
MCA PV Benefits	€ 18,024,105
MCA Benefit Score	1416
MCA Benefit Score Ratio	107.301
Option Selection MCA	1661
Relevant Figure	Figure 5.1

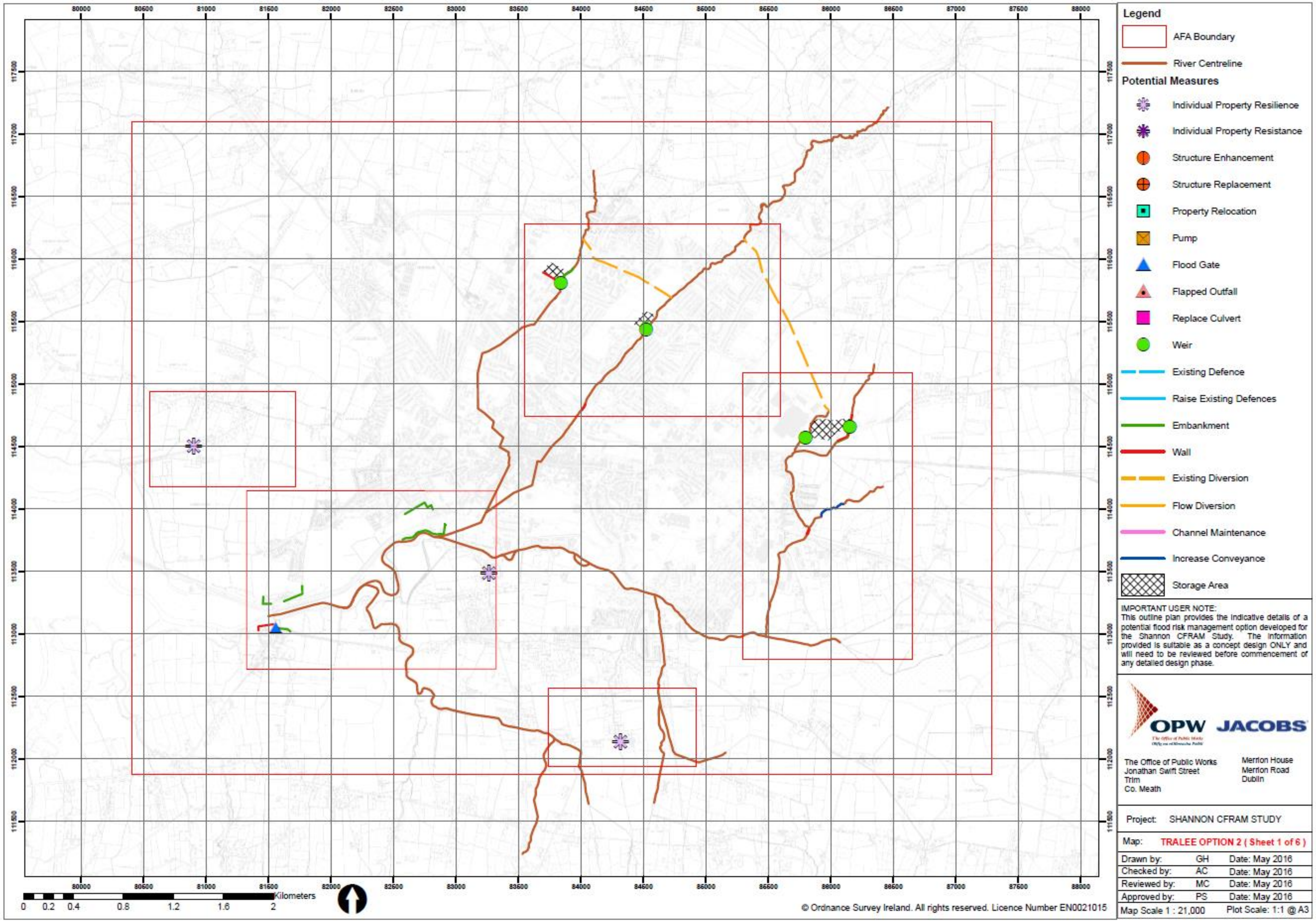
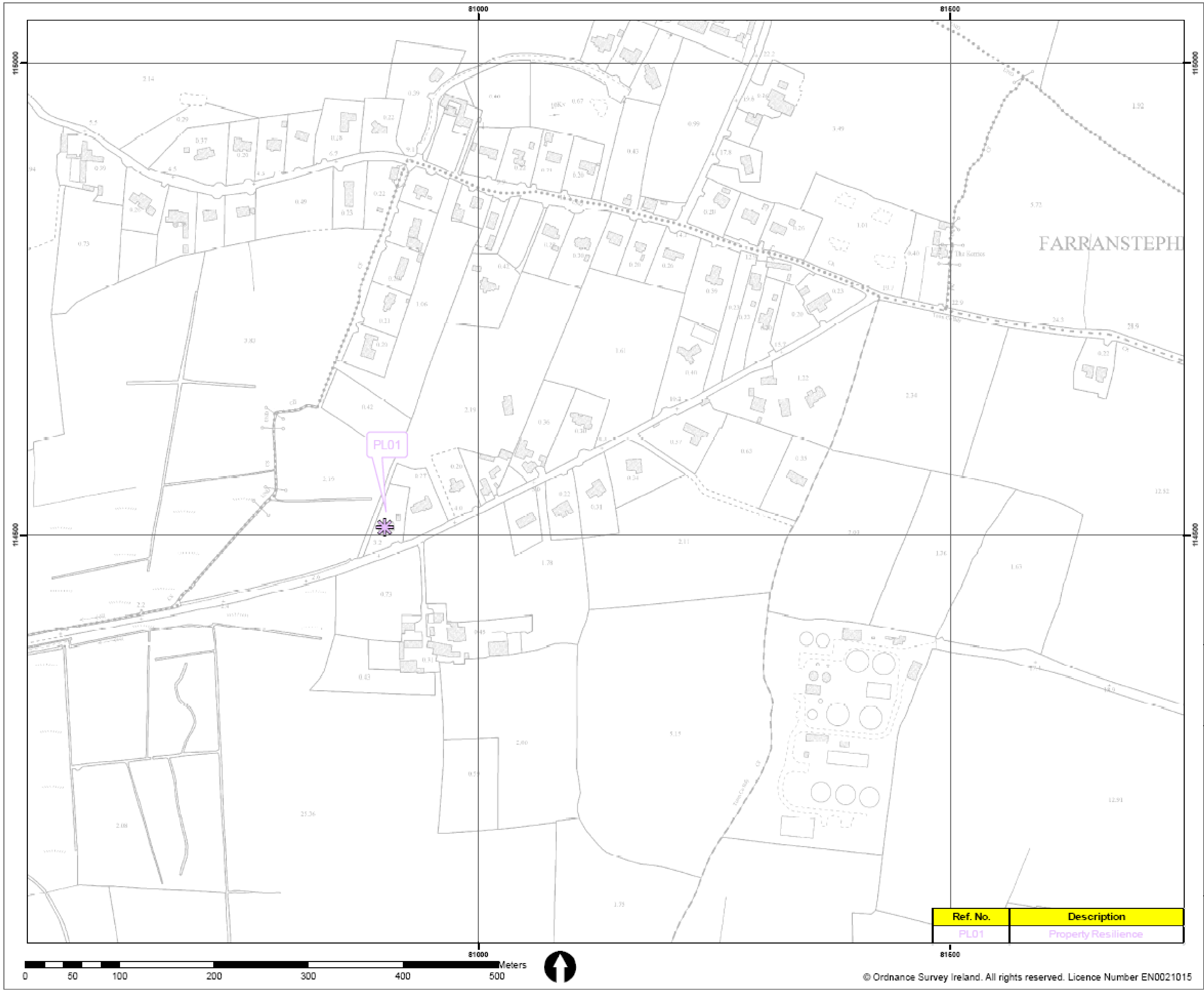


Figure 5.1 Option TRA_01 (Sheet 1 of 6)



Ref. No.	Description
PL01	Property Resilience

Legend

- AFA Boundary
- River Centreline

Potential Measures

- Individual Property Resilience
- Individual Property Resistance
- Structure Enhancement
- Structure Replacement
- Property Relocation
- Pump
- Flood Gate
- Flapped Outfall
- Replace Culvert
- Weir
- Existing Defence
- Raise Existing Defences
- Embankment
- Wall
- Existing Diversion
- Flow Diversion
- Channel Maintenance
- Increase Conveyance
- Storage Area

IMPORTANT USER NOTE:
This outline plan provides the indicative details of a potential flood risk management option developed for the Shannon CFRAM Study. The information provided is suitable as a concept design ONLY and will need to be reviewed before commencement of any detailed design phase.

OPW JACOBS

The Office of Public Works
Jonathan Swift Street
Trim
Co. Meath

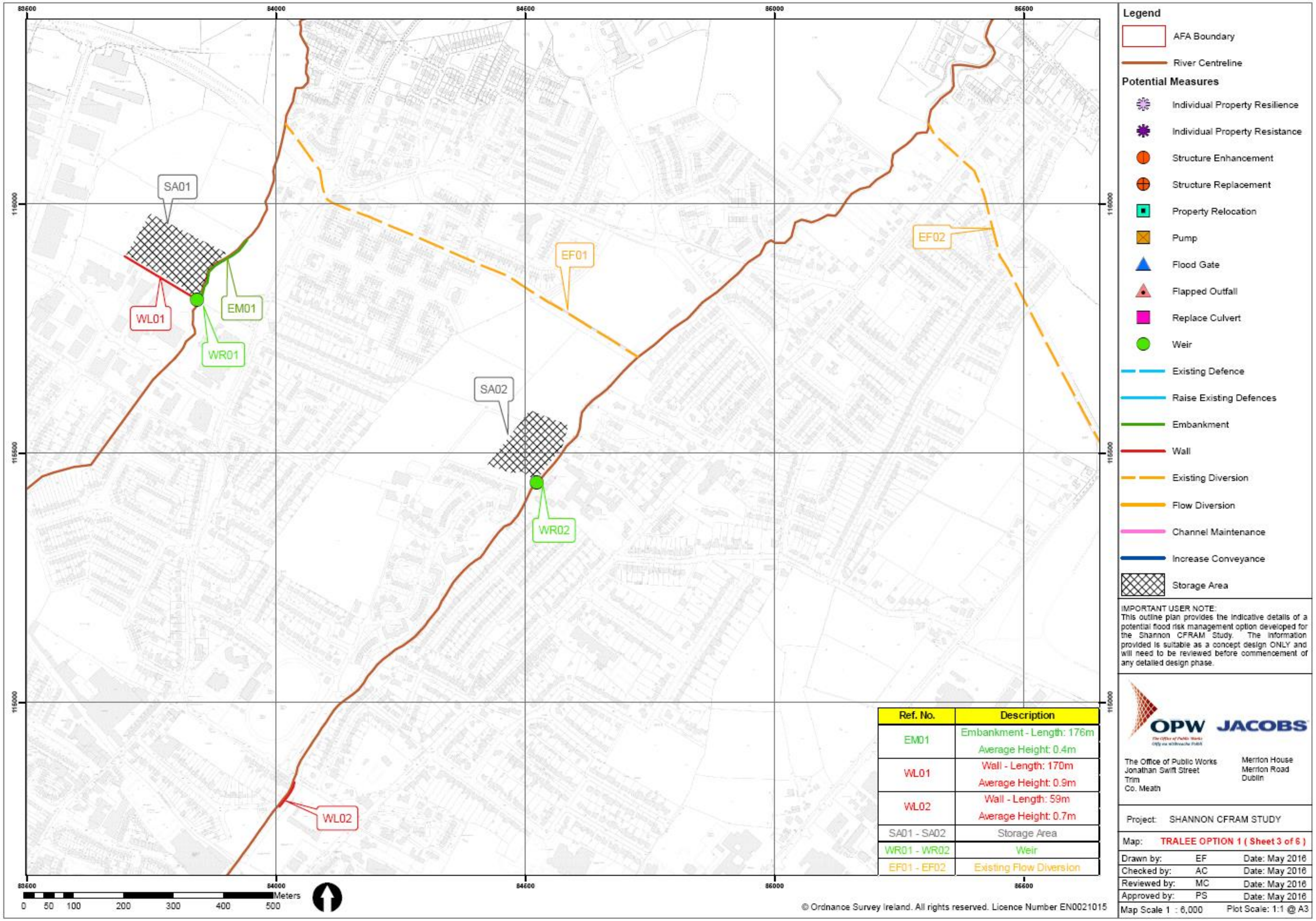
Merrion House
Merrion Road
Dublin

Project: SHANNON CFRAM STUDY

Map: TRALEE OPTION 1 (Sheet 2 of 6)

Drawn by:	EF	Date: May 2016
Checked by:	AC	Date: May 2016
Reviewed by:	MC	Date: May 2016
Approved by:	PS	Date: May 2016
Map Scale 1 : 4,000		Plot Scale: 1:1 @ A3

Figure 5.1 Option TRA_01 (Sheet 2 of 6)



Ref. No.	Description
EM01	Embankment - Length: 176m Average Height: 0.4m
WL01	Wall - Length: 170m Average Height: 0.9m
WL02	Wall - Length: 59m Average Height: 0.7m
SA01 - SA02	Storage Area
WR01 - WR02	Weir
EF01 - EF02	Existing Flow Diversion

Figure 5.1 Option TRA_01 (Sheet 3 of 6)

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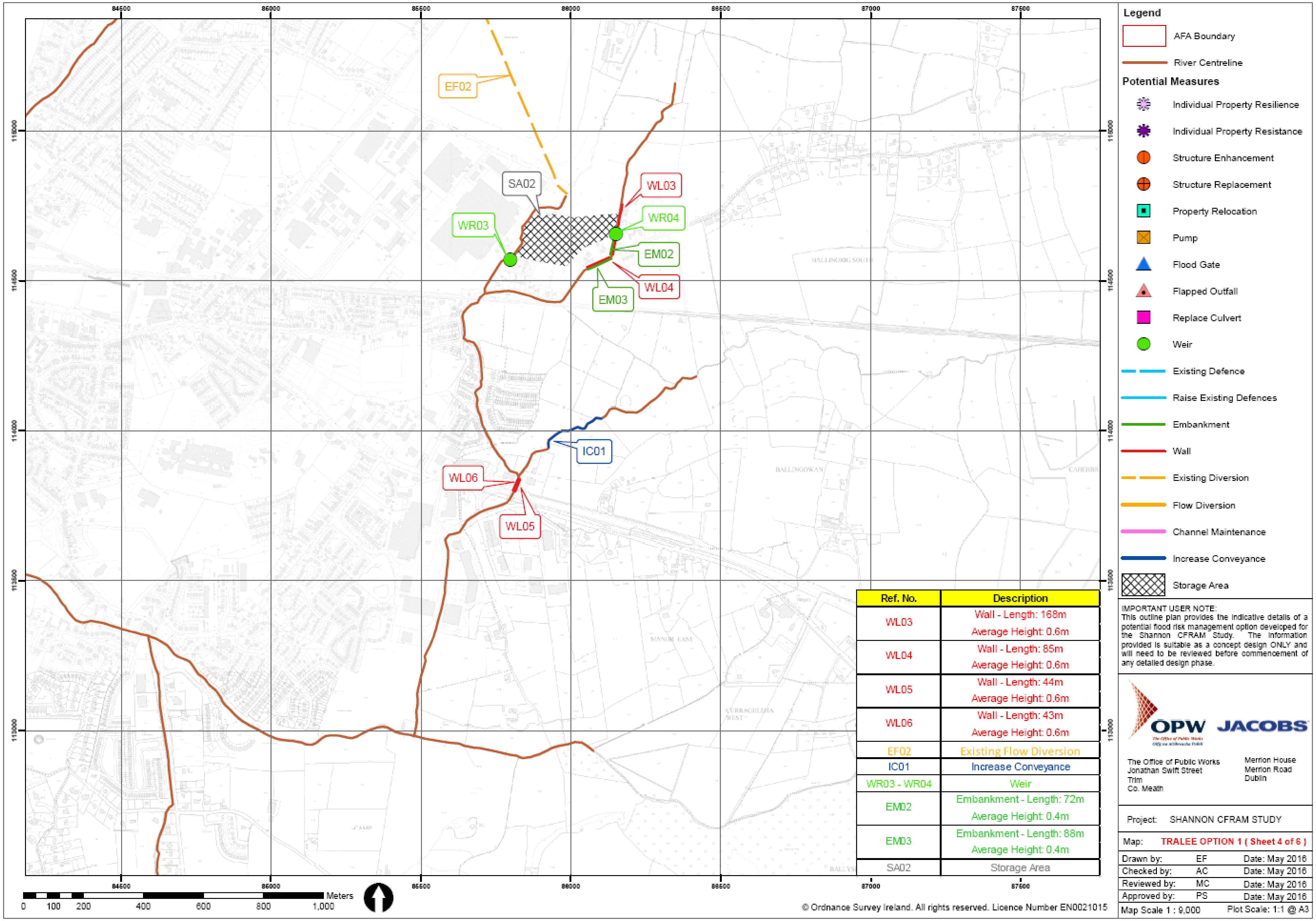
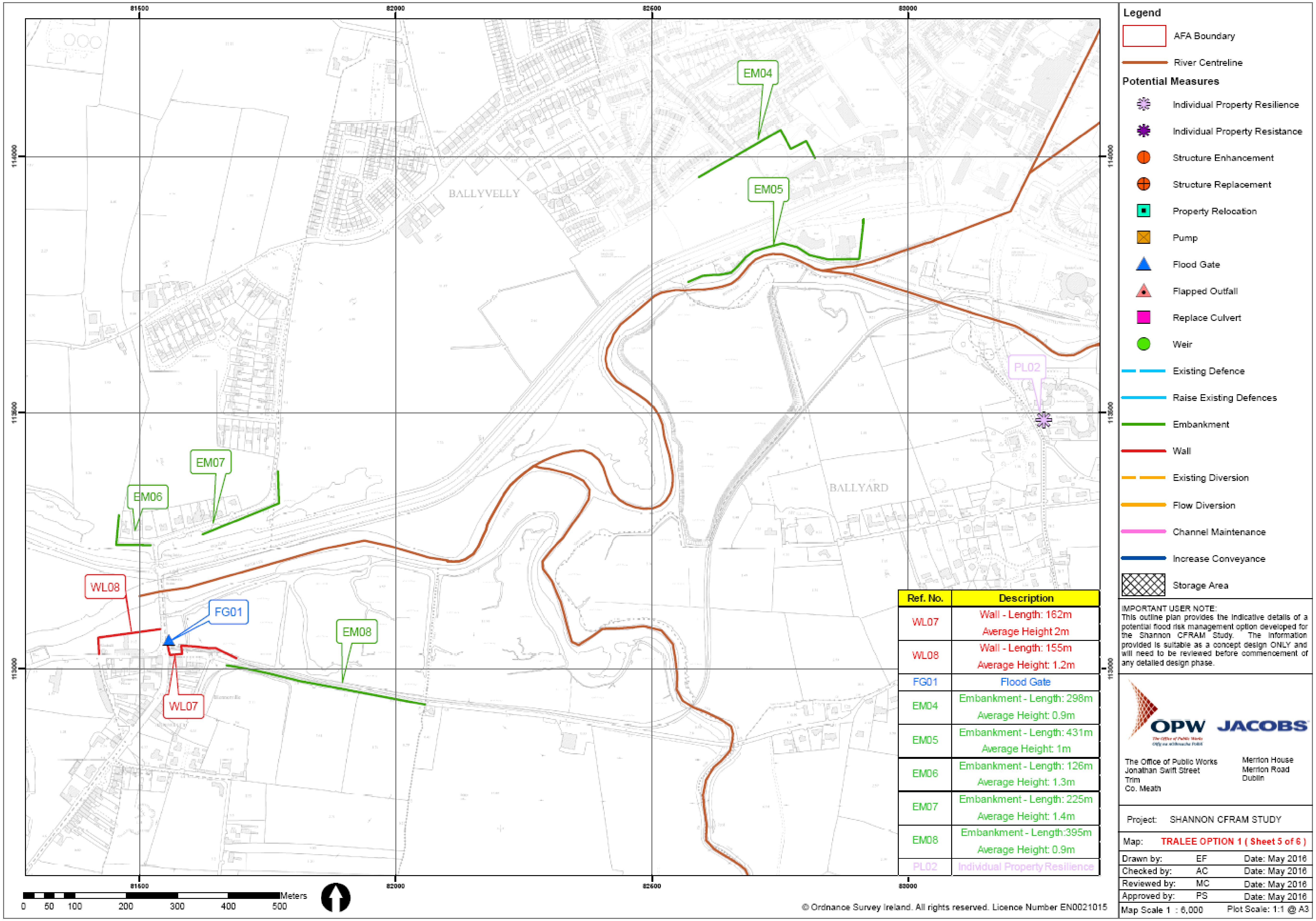


Ref. No.	Description
WL03	Wall - Length: 168m Average Height: 0.6m
WL04	Wall - Length: 85m Average Height: 0.6m
WL05	Wall - Length: 44m Average Height: 0.6m
WL06	Wall - Length: 43m Average Height: 0.6m
EF02	Existing Flow Diversion
IC01	Increase Conveyance
WR03 - WR04	Weir
EM02	Embankment - Length: 72m Average Height: 0.4m
EM03	Embankment - Length: 88m Average Height: 0.4m
SA02	Storage Area

Figure 5.1 Option TRA_01 (Sheet 4 of 6)



Ref. No.	Description
WL07	Wall - Length: 162m Average Height 2m
WL08	Wall - Length: 155m Average Height: 1.2m
FG01	Flood Gate
EM04	Embankment - Length: 298m Average Height: 0.9m
EM05	Embankment - Length: 431m Average Height: 1m
EM06	Embankment - Length: 126m Average Height: 1.3m
EM07	Embankment - Length: 225m Average Height: 1.4m
EM08	Embankment - Length:395m Average Height: 0.9m
PL02	Individual Property Resilience

Figure 5.1 Option TRA_01 (Sheet 5 of 6)

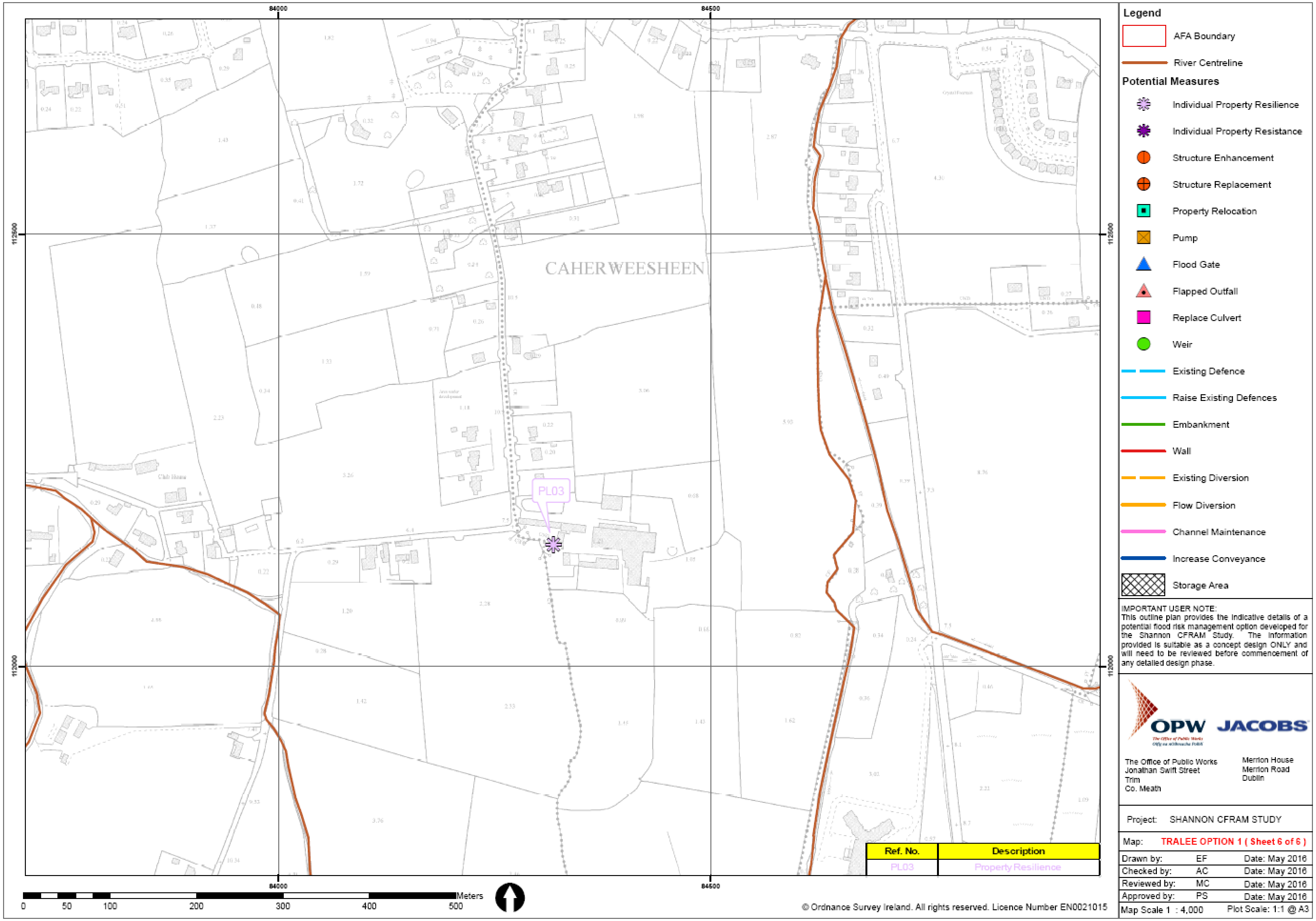


Figure 5.1 Option TRA_01 (Sheet 6 of 6)

Table 5.2: Multi Criteria Assessment Outcome for Option TRA_02

<table>
<tr><td colspan="4">Multi Criteria Assessment
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.</td></tr>
<tr><td>AFA</td><td>Tralee</td><td>Option Ref:</td><td>TRA_02</td></tr>
<tr><td colspan="4">Option Measures</td></tr>
<tr><td>Baseline</td><td></td><td colspan="2">NA</td></tr>
<tr><td rowspan="7">Structural</td><td>Di</td><td colspan="2">Storage: Online Storage</td></tr>
<tr><td>Eii</td><td colspan="2">Flood Relief Channel</td></tr>
<tr><td>Fi</td><td colspan="2">Channel Dredging</td></tr>
<tr><td>Fii</td><td colspan="2">Channel Widening</td></tr>
<tr><td>Fiii</td><td colspan="2">Structure Enhancement / Works</td></tr>
<tr><td>Gi</td><td colspan="2">Flood Defences: New Flood Defences</td></tr>
<tr><td>Gii</td><td colspan="2">Flood Defences: Raise Existing Flood Defences</td></tr>
<tr><td rowspan="4">Non-Structural</td><td>J</td><td colspan="2">Forecasting / Warning / Response</td></tr>
<tr><td>K</td><td colspan="2">Public Awareness</td></tr>
<tr><td>L</td><td colspan="2">Individual Property Resistance</td></tr>
<tr><td>M</td><td colspan="2">Individual Property Resilience</td></tr>
<tr><td colspan="4">Criteria Scores</td></tr>
<tr><td colspan="2">Technical</td><td colspan="2">205</td></tr>
<tr><td colspan="2">Economic</td><td colspan="2">905</td></tr>
<tr><td colspan="2">Social</td><td colspan="2">741</td></tr>
<tr><td colspan="2">Environmental</td><td colspan="2">-316</td></tr>
<tr><td colspan="4">Economic Values</td></tr>
<tr><td colspan="2">Economic PV Benefits</td><td colspan="2">€ 32,657,428</td></tr>
<tr><td colspan="2">PV Cost</td><td colspan="2">€ 14,064,878</td></tr>
<tr><td colspan="2">NPV Benefits</td><td colspan="2">€ 18,592,550</td></tr>
<tr><td colspan="2">Economic BCR</td><td colspan="2">2.32</td></tr>
<tr><td colspan="4">Outcome Scores</td></tr>
<tr><td colspan="2">MCA PV Benefits</td><td colspan="2">€ 18,005,781</td></tr>
<tr><td colspan="2">MCA Benefit Score</td><td colspan="2">1332</td></tr>
<tr><td colspan="2">MCA Benefit Score Ratio</td><td colspan="2">94.69</td></tr>
<tr><td colspan="2">Option Selection MCA</td><td colspan="2">1536</td></tr>
<tr><td colspan="2">Relevant Figure</td><td colspan="2">Figure 5.2</td></tr>
</table>

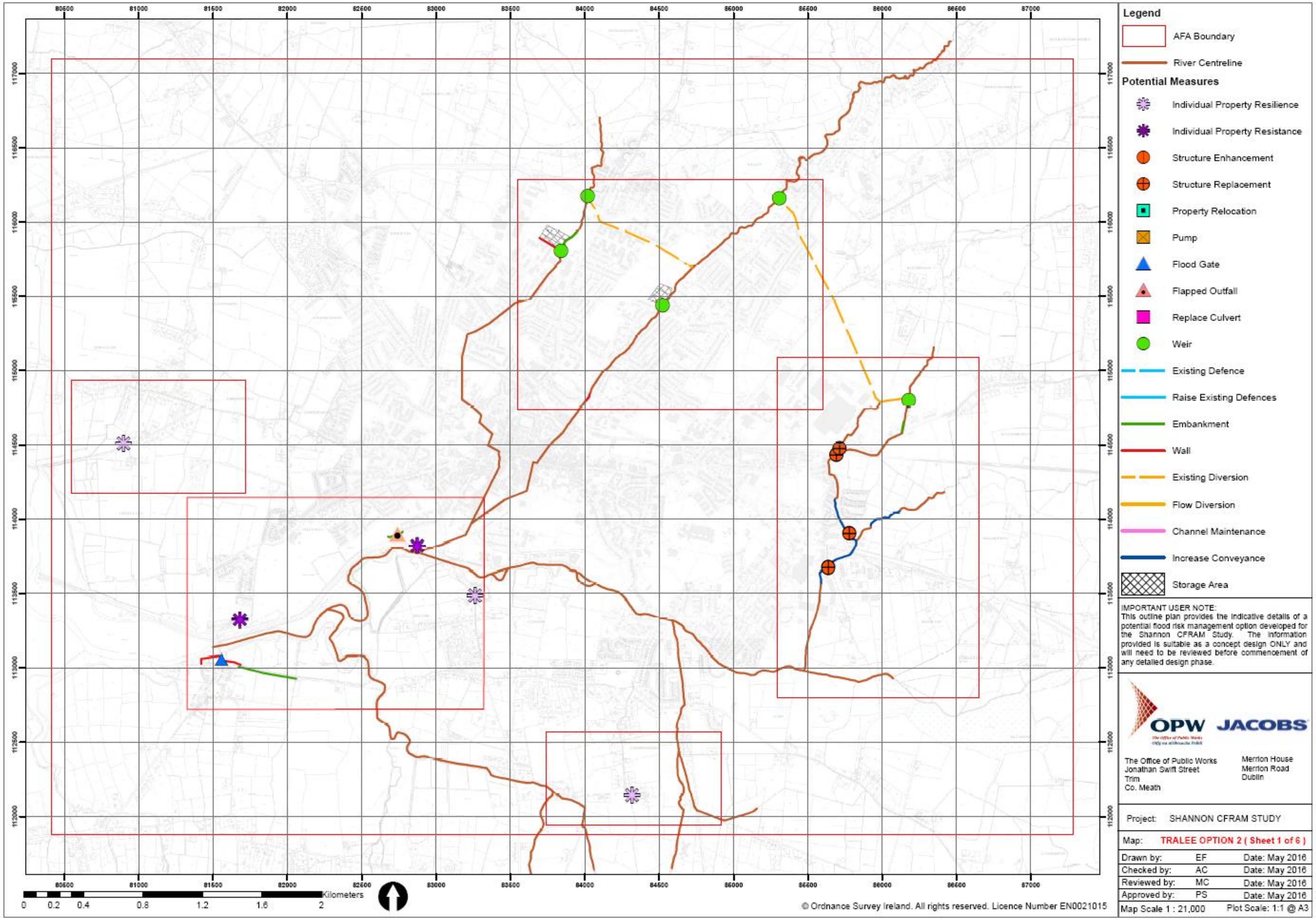
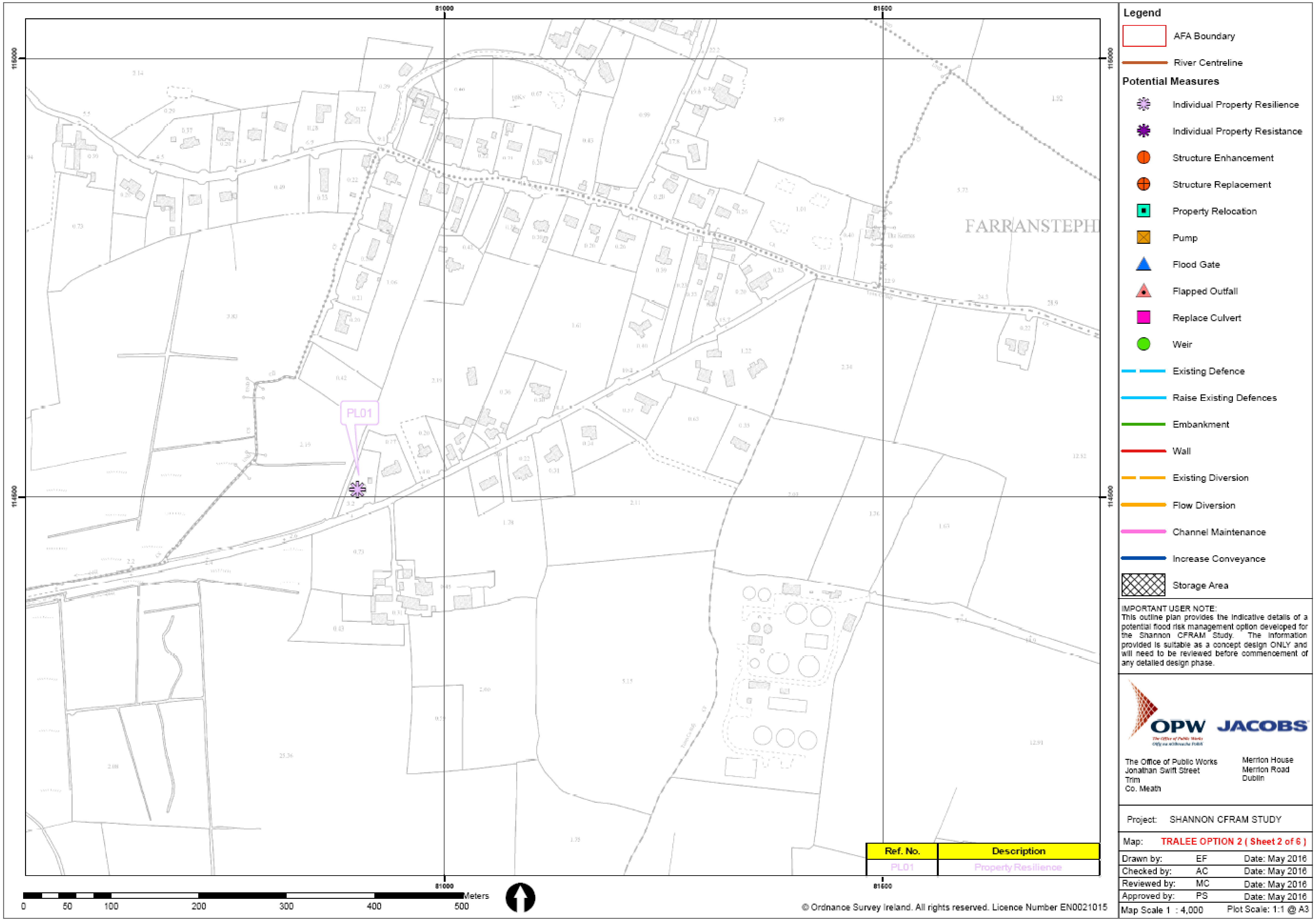


Figure 5.2 Option TRA_02 (Sheet 1 of 6)



Ref. No.	Description
PL01	Property Resilience

Figure 5.2 Option TRA_02 (Sheet 2 of 6)

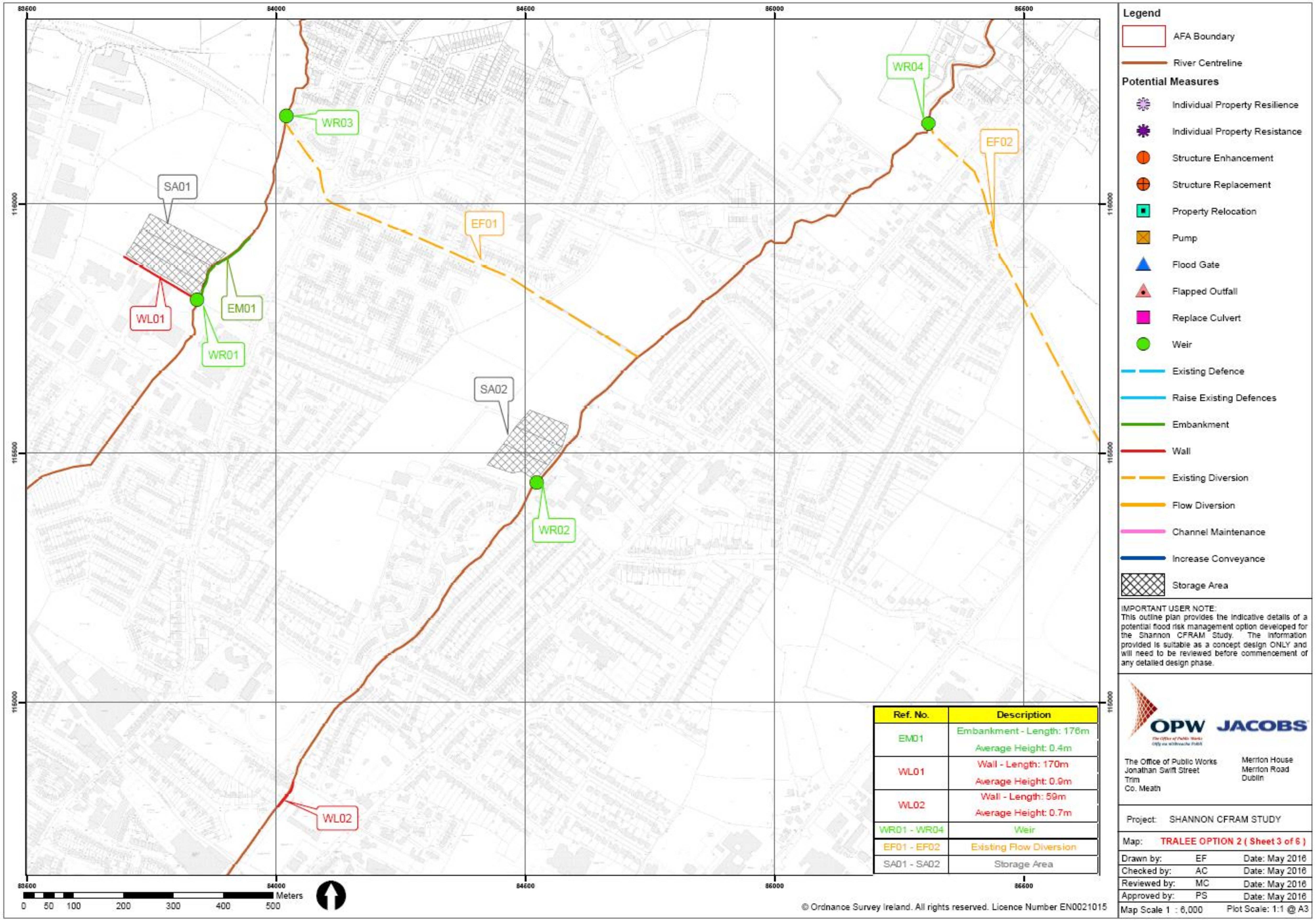
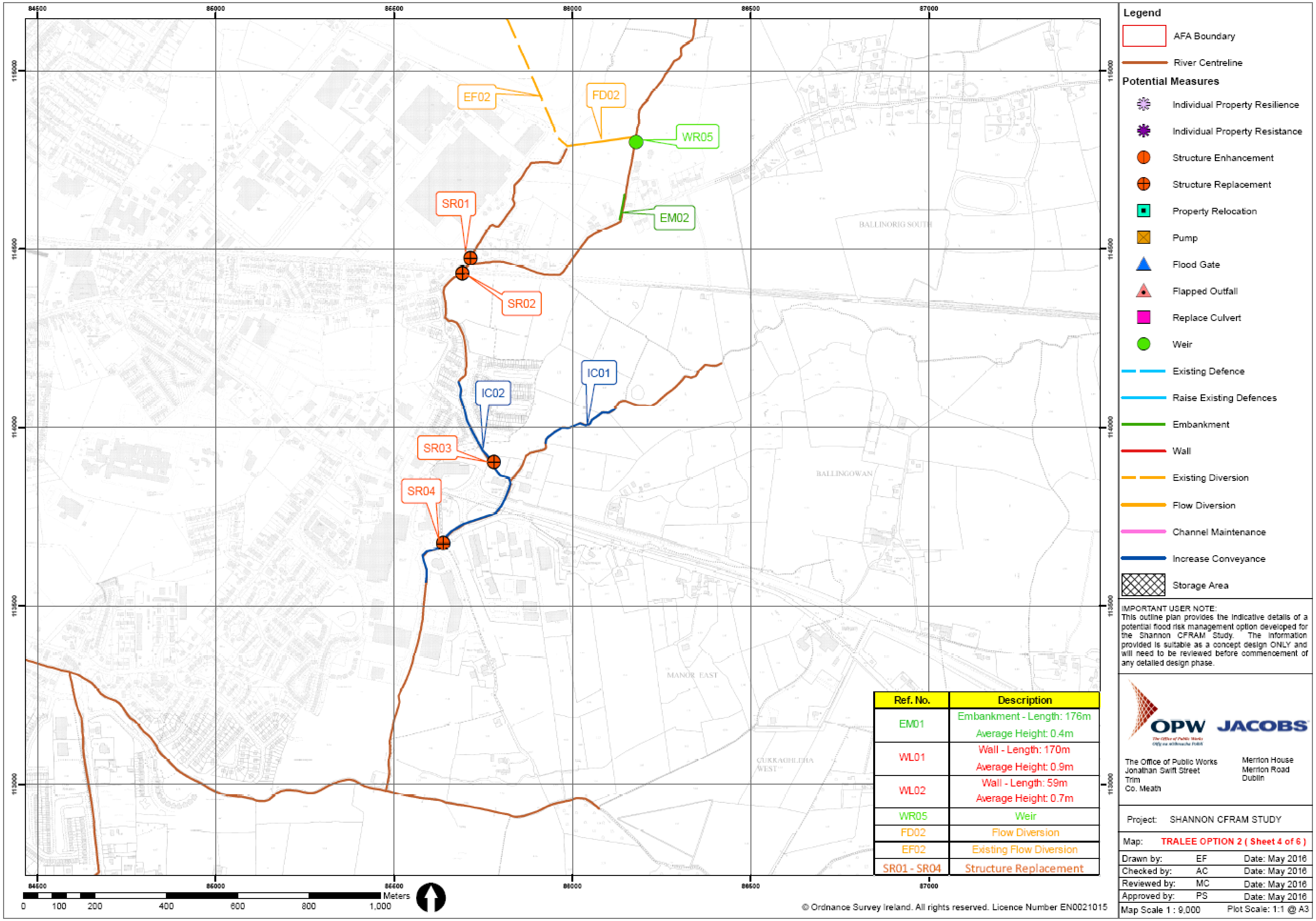
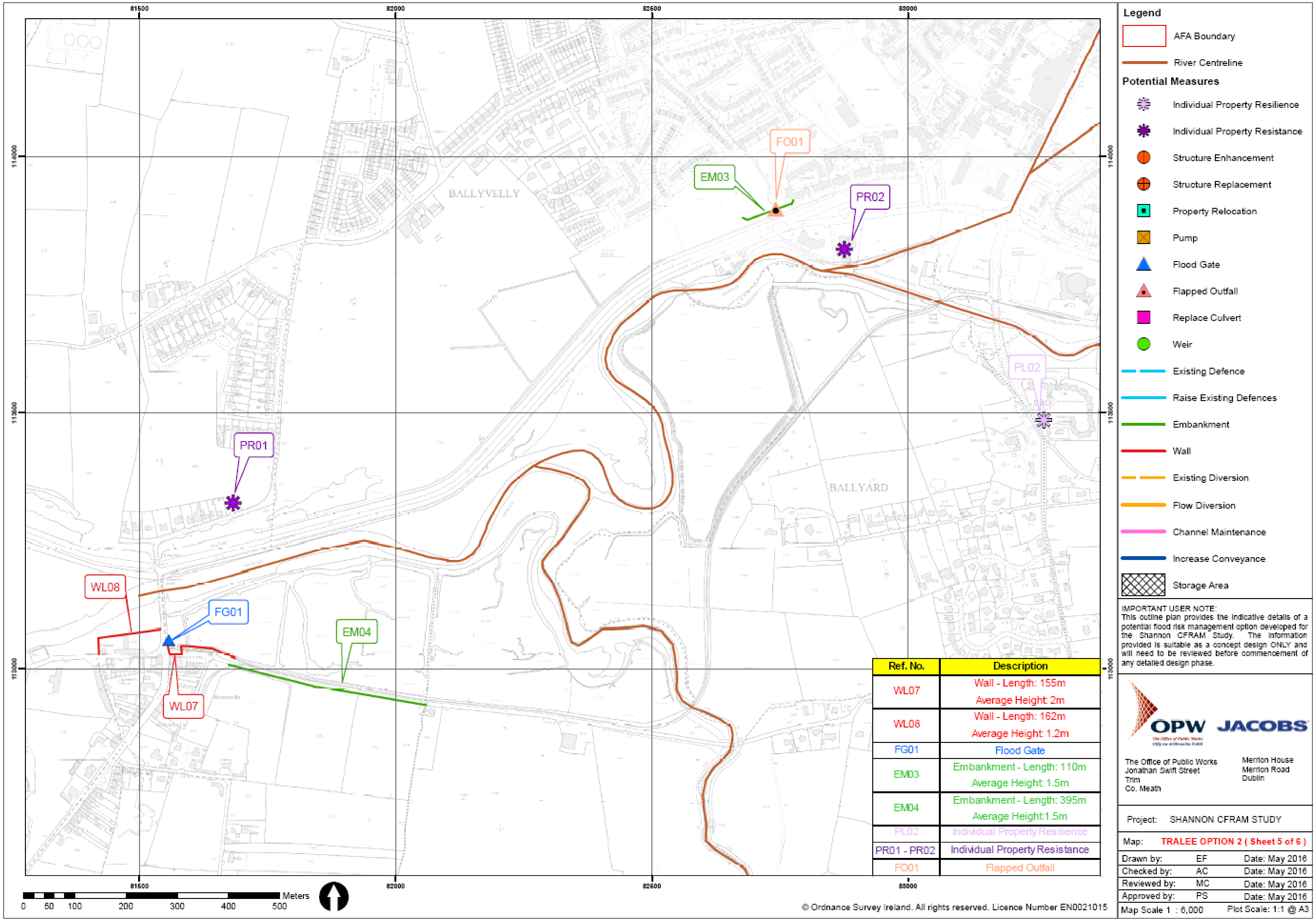


Figure 5.2 Option TRA_02 (Sheet 3 of 6)



Ref. No.	Description
EM01	Embankment - Length: 176m Average Height: 0.4m
WL01	Wall - Length: 170m Average Height: 0.9m
WL02	Wall - Length: 59m Average Height: 0.7m
WR05	Weir
FD02	Flow Diversion
EF02	Existing Flow Diversion
SR01 - SR04	Structure Replacement

Figure 5.2 Option TRA_02 (Sheet 4 of 6)



Ref. No.	Description
WL07	Wall - Length: 155m Average Height: 2m
WL08	Wall - Length: 162m Average Height: 1.2m
FG01	Flood Gate
EM03	Embankment - Length: 110m Average Height: 1.5m
EM04	Embankment - Length: 395m Average Height:1.5m
PL02	Individual Property Resilience
PR01 - PR02	Individual Property Resistance
FO01	Flapped Outfall

Figure 5.2 Option TRA_02 (Sheet 5 of 6)

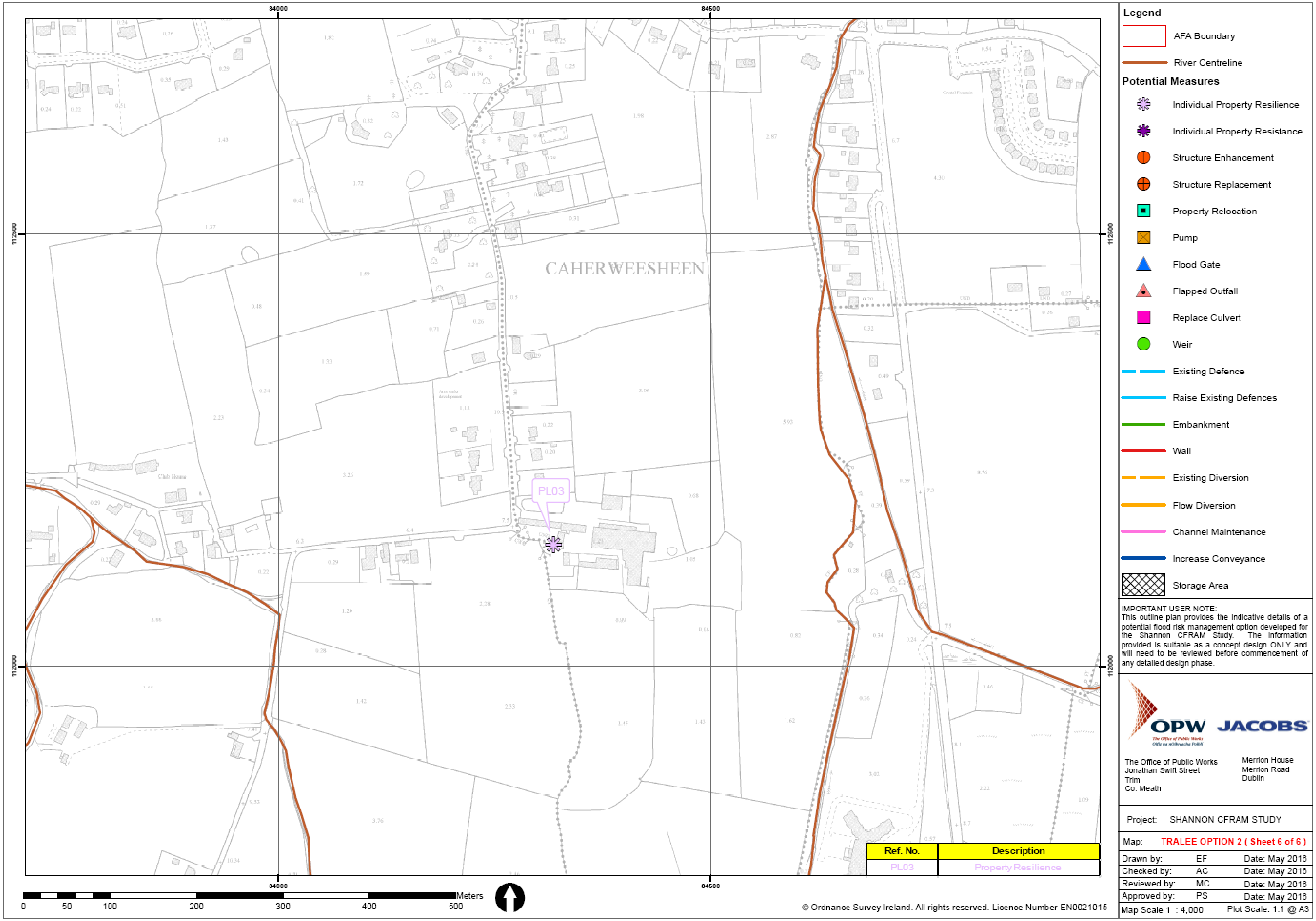


Figure 5.2 Option TRA_02 (Sheet 6 of 6)

Table 5.3: Multi Criteria Assessment Outcome for Option TRA_03

<table>
<tr><td colspan="4">Multi Criteria Assessment
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.</td></tr>
<tr><td>AFA</td><td>Tralee</td><td>Option Ref:</td><td>TRA_03</td></tr>
<tr><td colspan="4">Option Measures</td></tr>
<tr><td>Baseline</td><td></td><td colspan="2">NA</td></tr>
<tr><td rowspan="7">Structural</td><td>Di</td><td colspan="2">Storage: Online Storage</td></tr>
<tr><td>Eii</td><td colspan="2">Flood Relief Channel</td></tr>
<tr><td>Fi</td><td colspan="2">Channel Dredging</td></tr>
<tr><td>Fii</td><td colspan="2">Channel Widening</td></tr>
<tr><td>Fiii</td><td colspan="2">Structure Enhancement / Works</td></tr>
<tr><td>Gi</td><td colspan="2">Flood Defences: New Flood Defences</td></tr>
<tr><td>Gii</td><td colspan="2">Flood Defences: Raise Existing Flood Defences</td></tr>
<tr><td rowspan="4">Non-Structural</td><td>J</td><td colspan="2">Forecasting / Warning / Response</td></tr>
<tr><td>K</td><td colspan="2">Public Awareness</td></tr>
<tr><td>L</td><td colspan="2">Individual Property Resistance</td></tr>
<tr><td>M</td><td colspan="2">Individual Property Resilience</td></tr>
<tr><td colspan="4">Criteria Scores</td></tr>
<tr><td colspan="2">Technical</td><td colspan="2">245</td></tr>
<tr><td colspan="2">Economic</td><td colspan="2">905</td></tr>
<tr><td colspan="2">Social</td><td colspan="2">741</td></tr>
<tr><td colspan="2">Environmental</td><td colspan="2">-201</td></tr>
<tr><td colspan="4">Economic Values</td></tr>
<tr><td colspan="2">Economic PV Benefits</td><td colspan="2">€ 32,657,428</td></tr>
<tr><td colspan="2">PV Cost</td><td colspan="2">€ 14,258,122</td></tr>
<tr><td colspan="2">NPV Benefits</td><td colspan="2">€ 18,005,781</td></tr>
<tr><td colspan="2">Economic BCR</td><td colspan="2">2.29</td></tr>
<tr><td colspan="4">Outcome Scores</td></tr>
<tr><td colspan="2">MCA PV Benefits</td><td colspan="2">€ 18,005,781</td></tr>
<tr><td colspan="2">MCA Benefit Score</td><td colspan="2">1445</td></tr>
<tr><td colspan="2">MCA Benefit Score Ratio</td><td colspan="2">101.371</td></tr>
<tr><td colspan="2">Option Selection MCA</td><td colspan="2">1691</td></tr>
<tr><td colspan="2">Relevant Figure</td><td colspan="2">Figure 5.3</td></tr>
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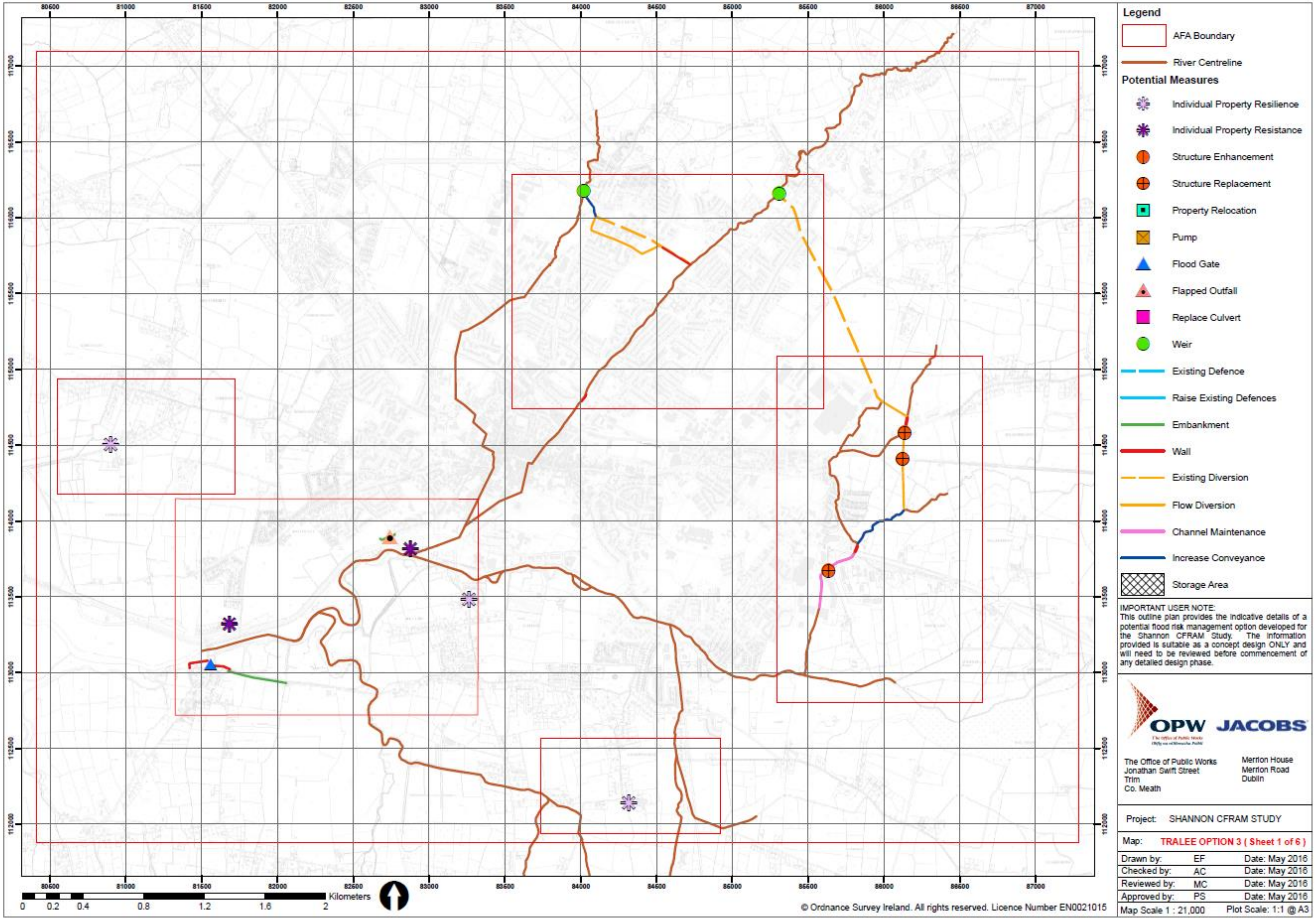


Figure 5.3 Option TRA_03 (Sheet 1 of 6)

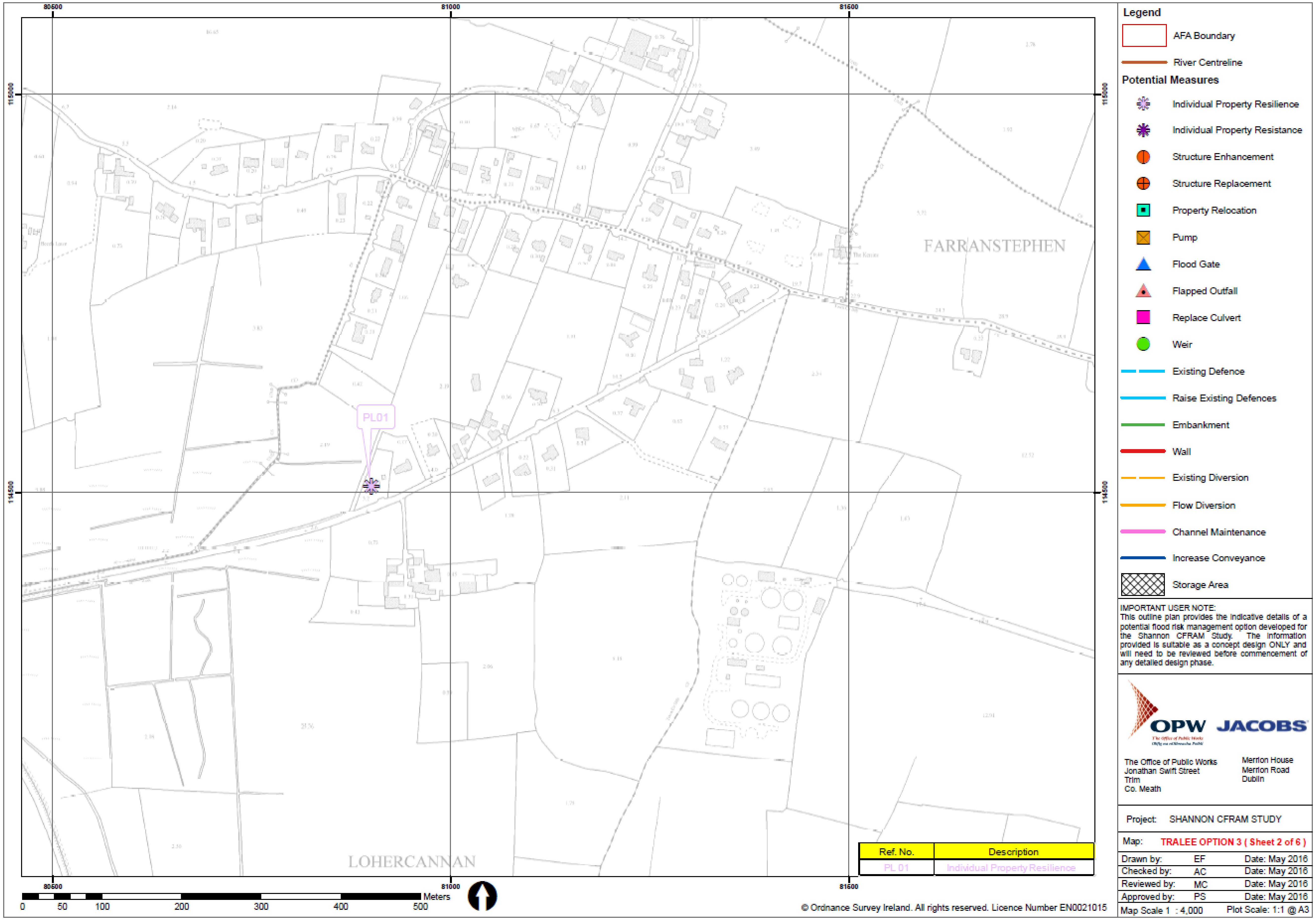
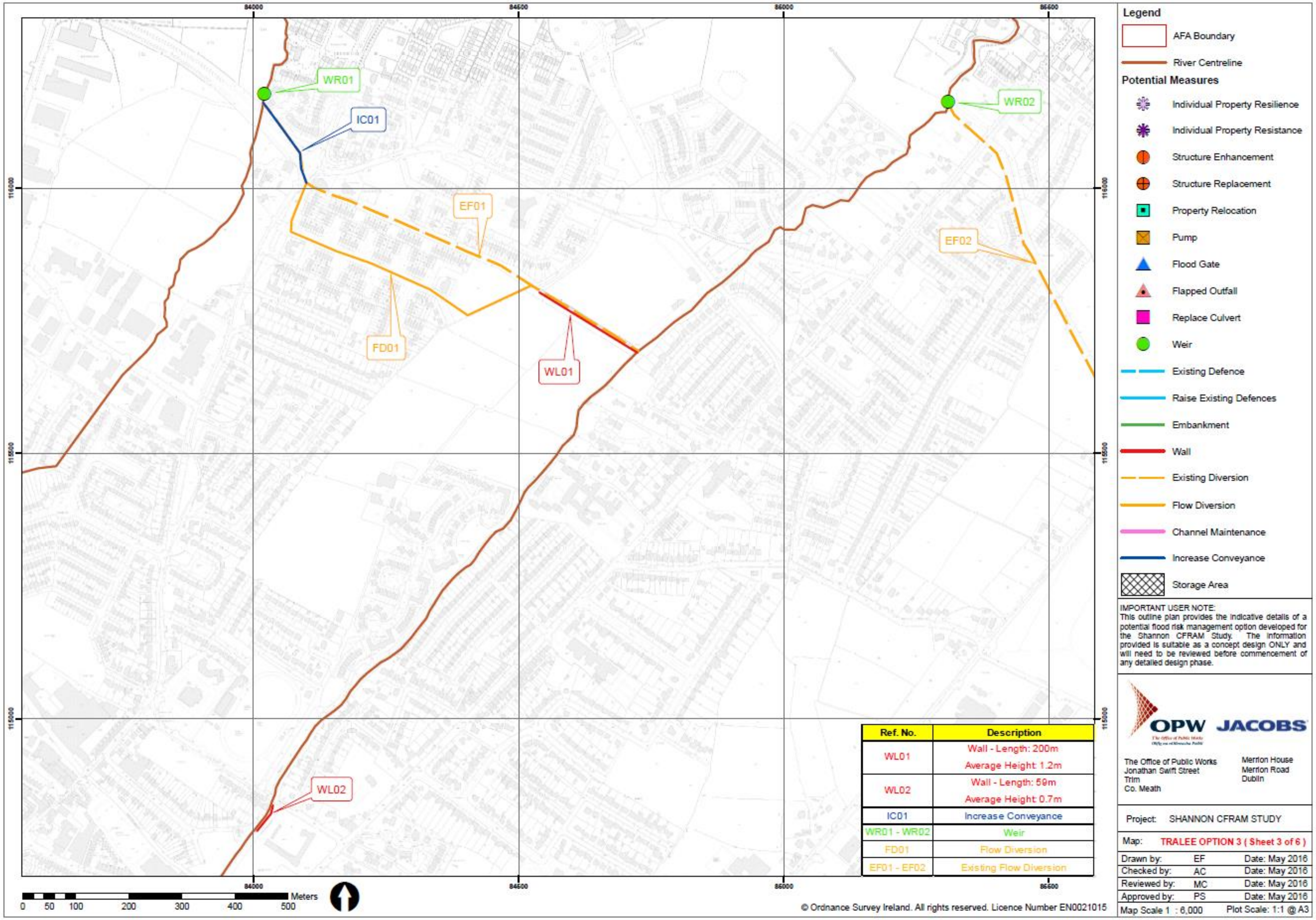


Figure 5.3 Option TRA_03 (Sheet 2 of 6)



Ref. No.	Description
WL01	Wall - Length: 200m Average Height: 1.2m
WL02	Wall - Length: 59m Average Height: 0.7m
IC01	Increase Conveyance
WR01 - WR02	Weir
FD01	Flow Diversion
EF01 - EF02	Existing Flow Diversion

Figure 5.3 Option TRA_03 (Sheet 3 of 6)

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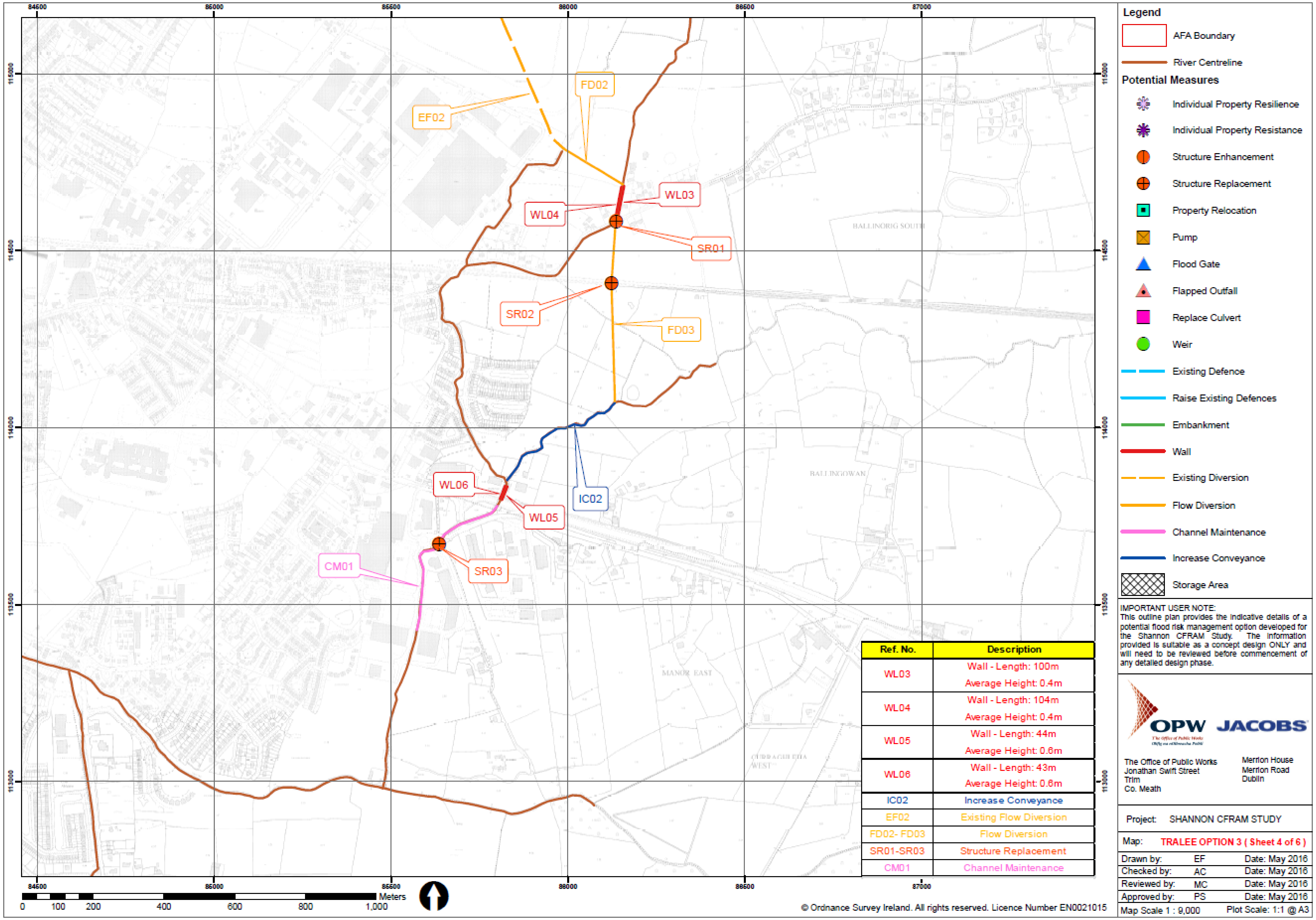
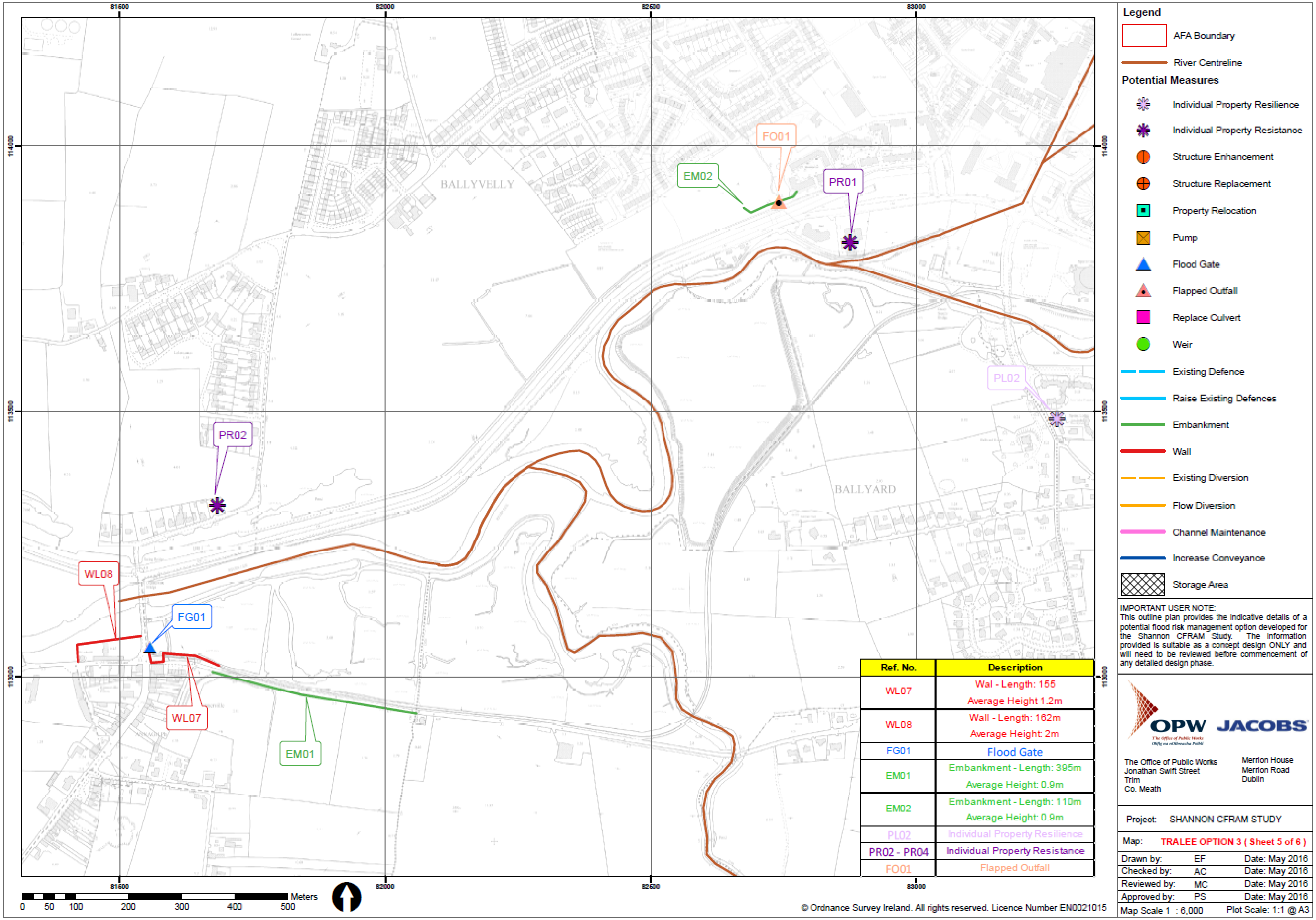


Ref. No.	Description
WL03	Wall - Length: 100m Average Height: 0.4m
WL04	Wall - Length: 104m Average Height: 0.4m
WL05	Wall - Length: 44m Average Height: 0.6m
WL06	Wall - Length: 43m Average Height: 0.6m
IC02	Increase Conveyance
EF02	Existing Flow Diversion
FD02- FD03	Flow Diversion
SR01-SR03	Structure Replacement
CM01	Channel Maintenance

Figure 5.3 Option TRA_03 (Sheet 4 of 6)

JACOBS

OPW



Ref. No.	Description
WL07	Wal - Length: 155 Average Height 1.2m
WL08	Wall - Length: 162m Average Height: 2m
FG01	Flood Gate
EM01	Embankment - Length: 395m Average Height: 0.9m
EM02	Embankment - Length: 110m Average Height: 0.9m
PL02	Individual Property Resilience
PR02 - PR04	Individual Property Resistance
FO01	Flapped Outfall

Figure 5.3 Option TRA_03 (Sheet 5 of 6)

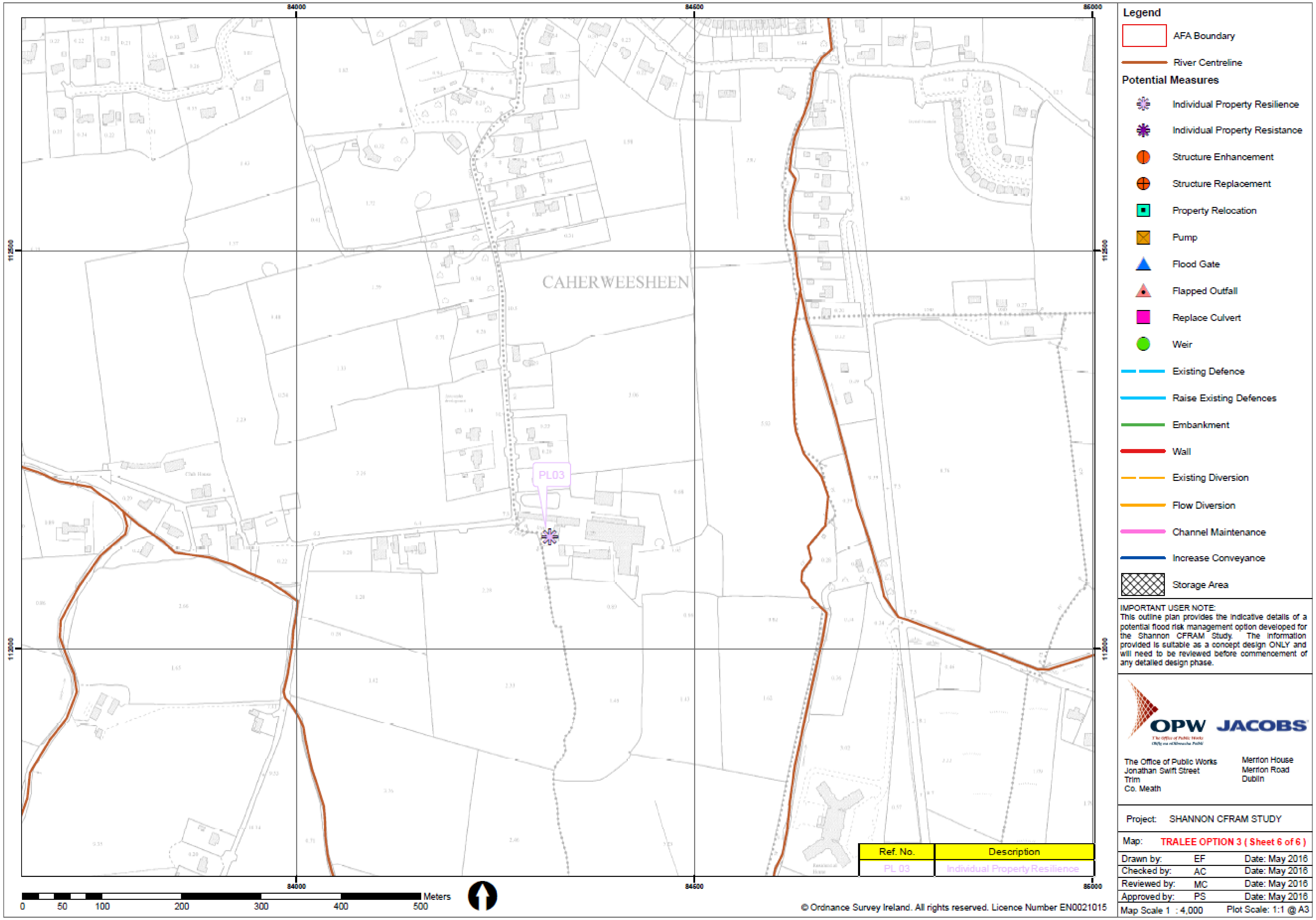


Figure 5.3 Option TRA_03 (Sheet 6 of 6)

Table 5.4: Multi Criteria Assessment Outcome for Option TRA_04

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**			
AFA	Tralee	Option Ref:	TRA_04
Option Measures			
Baseline		NA	
Structural	Di	Storage: Online Storage	
	Eii	Flood Relief Channel	
	Fi	Channel Dredging	
	Fii	Channel Widening	
	Fiii	Structure Enhancement / Works	
	Gi	Flood Defences: New Flood Defences	
	Gii	Flood Defences: Raise Existing Flood Defences	
Non-Structural	J	Forecasting / Warning / Response	
	K	Public Awareness	
	L	Individual Property Resistance	
	M	Individual Property Resilience	
Criteria Scores			
Technical	255		
Economic	906		
Social	741		
Environmental	-241		
Economic Values			
Economic PV Benefits	€ 32,657,428		
PV Cost	€ 19,012,090		
NPV Benefits	€ 13,645,338		
Economic BCR	**1.72**		
Outcome Scores			
MCA PV Benefits	€ 18,005,781		
MCA Benefit Score	1406		
MCA Benefit Score Ratio	73.94		
Option Selection MCA	1660		
Relevant Figure	Figure 5.4		

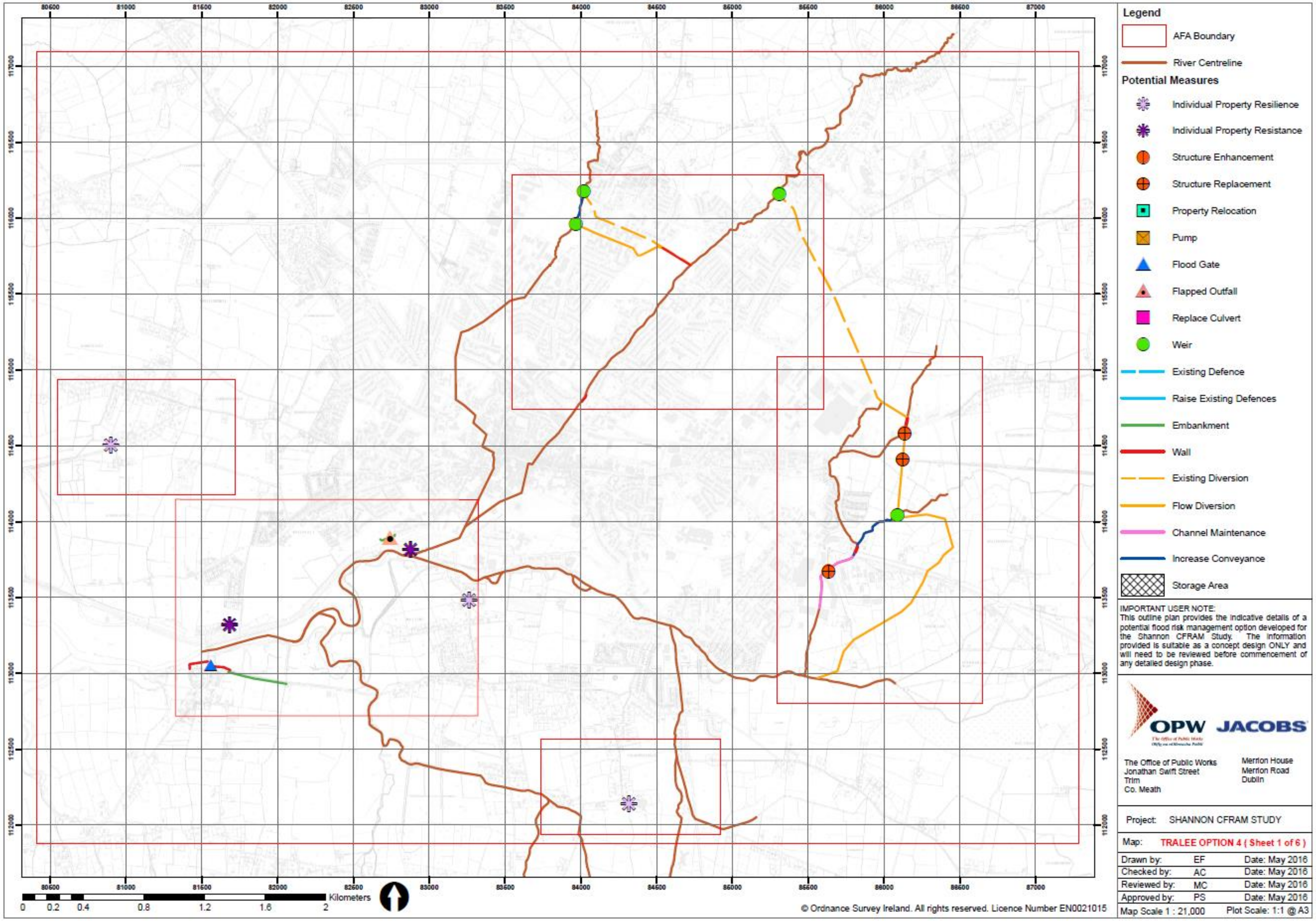


Figure 5.4 Option TRA_04 (Sheet 1 of 6)

JACOBS

OPW

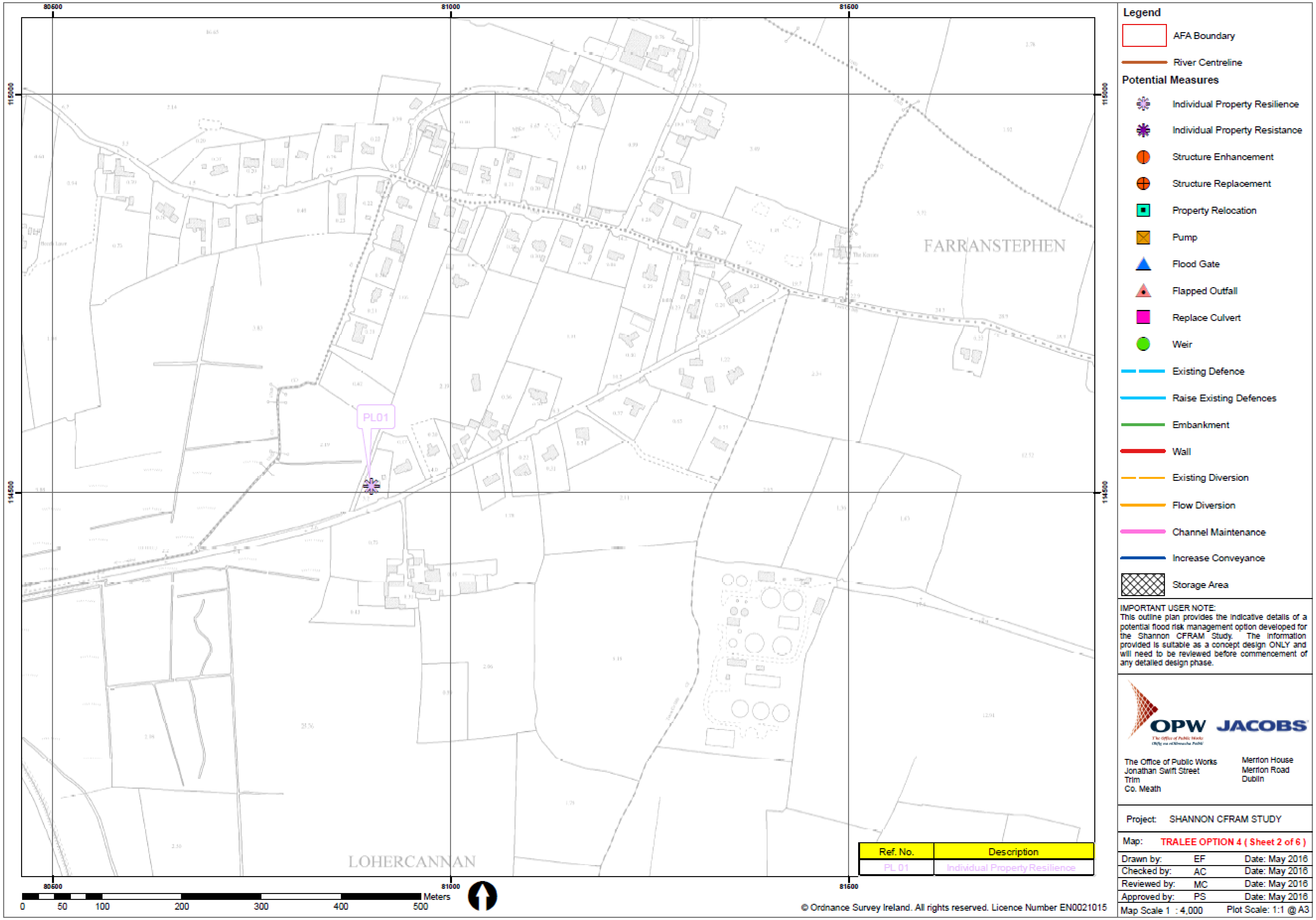


Figure 5.4 Option TRA_04 (Sheet 2 of 6)

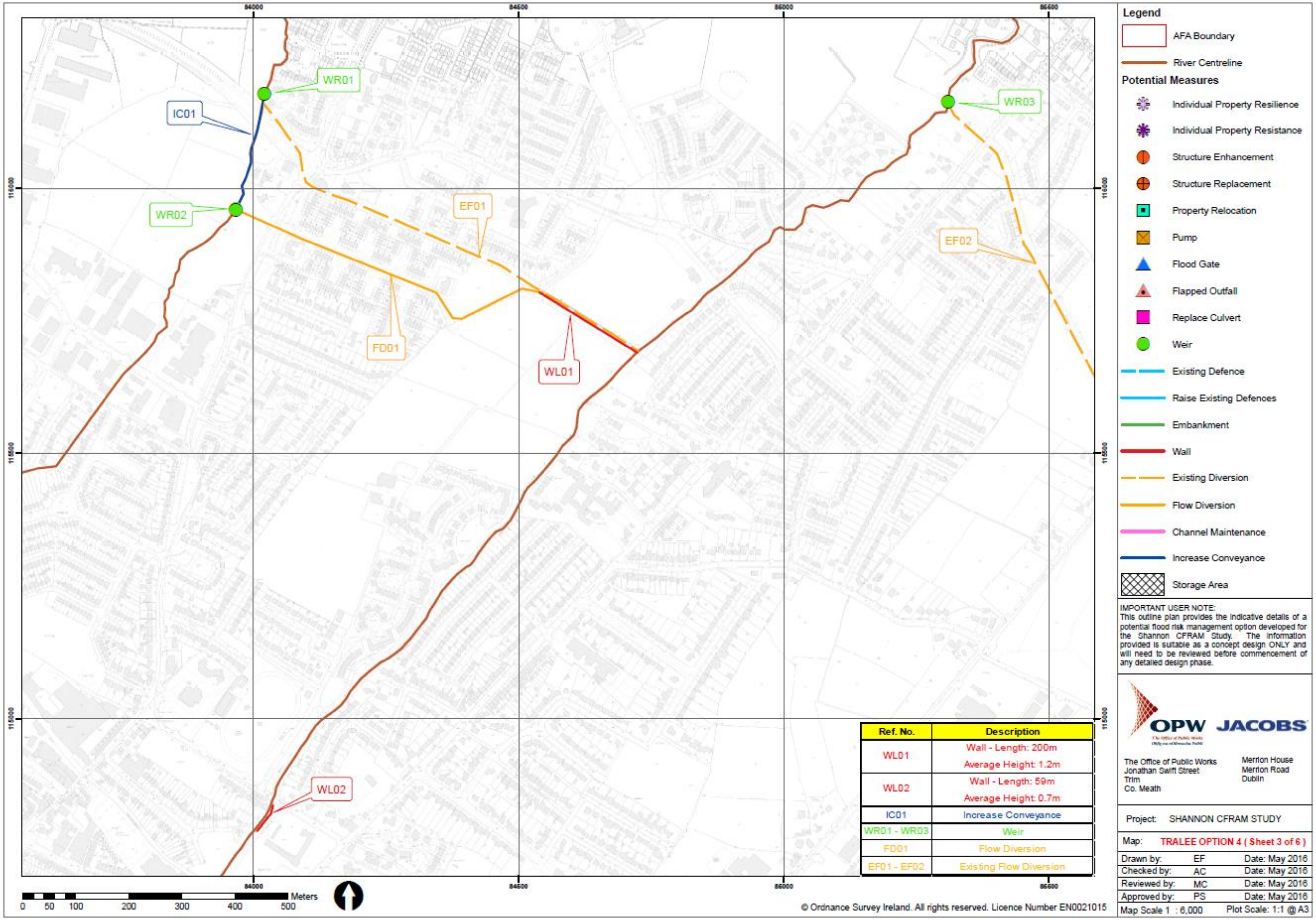
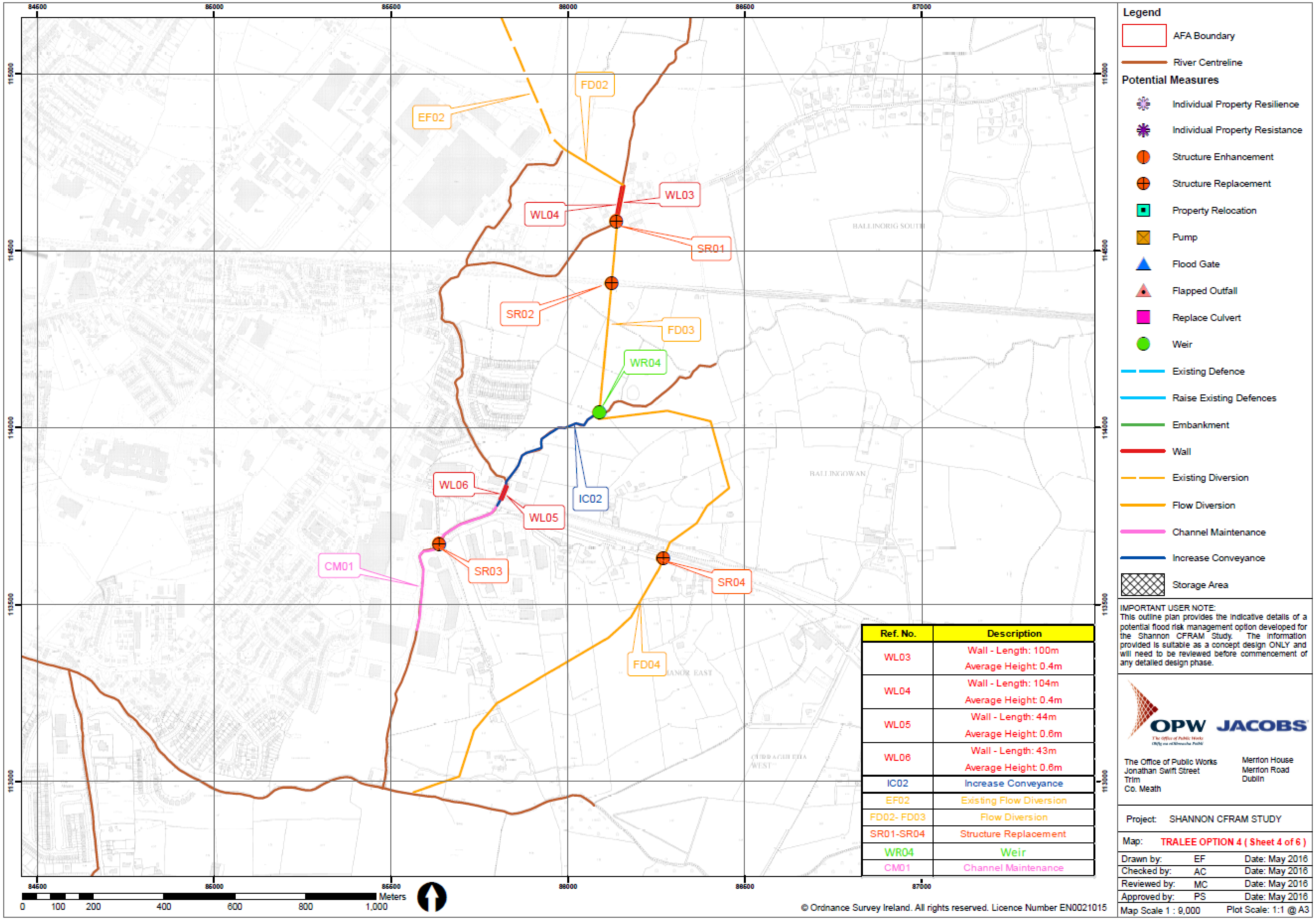


Figure 5.4 Option TRA_04 (Sheet 3 of 6)



Ref. No.	Description
WL03	Wall - Length: 100m Average Height: 0.4m
WL04	Wall - Length: 104m Average Height: 0.4m
WL05	Wall - Length: 44m Average Height: 0.6m
WL06	Wall - Length: 43m Average Height: 0.6m
IC02	Increase Conveyance
EF02	Existing Flow Diversion
FD02- FD03	Flow Diversion
SR01-SR04	Structure Replacement
WR04	Weir
CM01	Channel Maintenance

Figure 5.4 Option TRA_04 (Sheet 4 of 6)

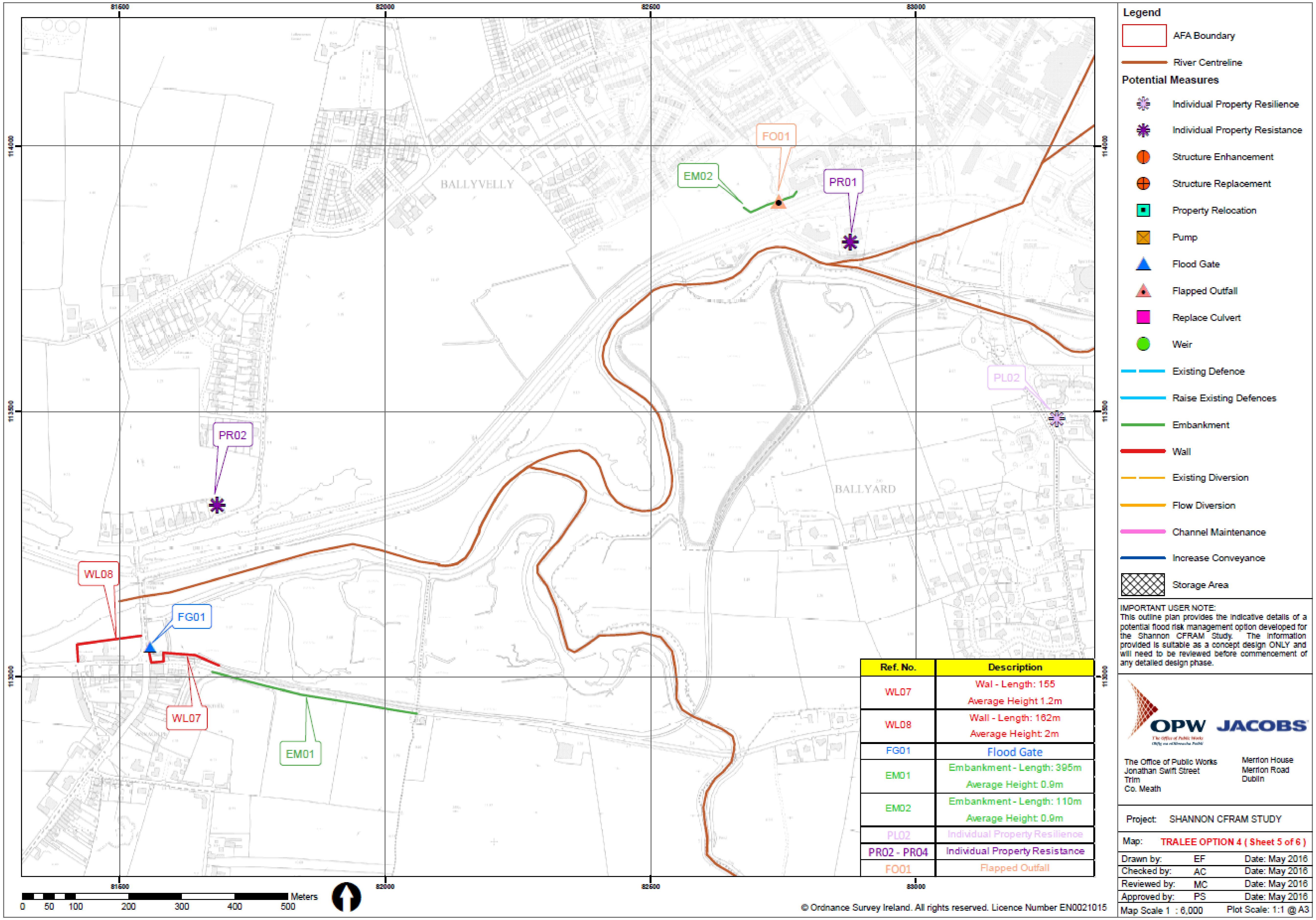


Figure 5.4 Option TRA_04 (Sheet 5 of 6)

JACOBS

OPW

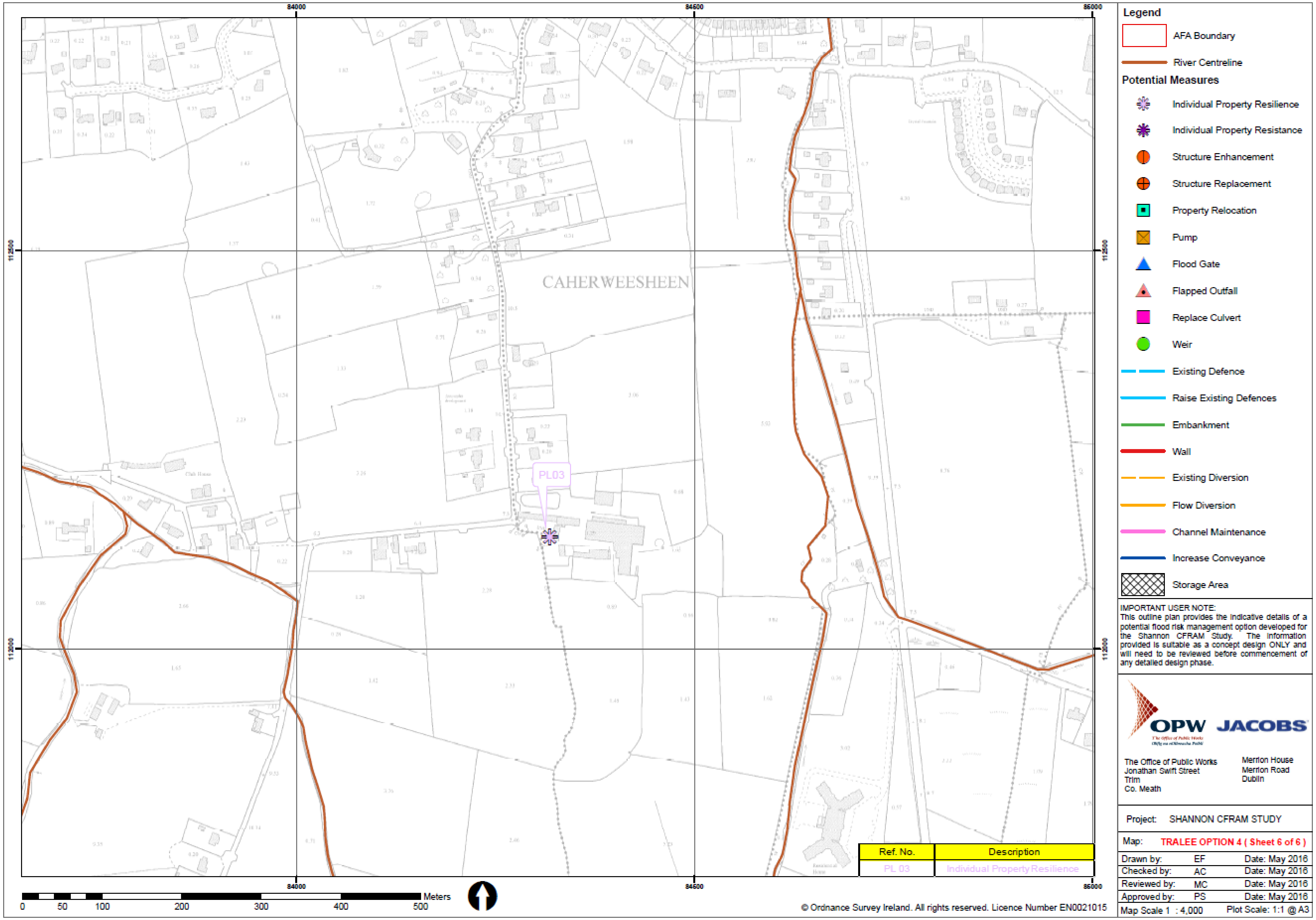


Figure 5.4 Option TRA_04 (Sheet 6 of 6)

5.2 Comparison of Multi Criteria Assessment Scores

Each option taken forward for further consideration through the Option Development Meeting has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).

Categories	Option Reference and Results			
	TRA_01	TRA_02	TRA_03	TRA_04
Criteria Scores				
Technical	244	205	245	255
Economic	906	905	905	906
Social	741	741	741	741
Environmental	-231	-315	-201	-241
Economic Values				
Economic PV Benefits	€ 32,720,999	€ 32,657,428	€ 32,657,428	€ 32,657,428
PV Cost	€ 13,198,688	€ 14,064,878	€ 14,258,122	€ 19,012,090
NPV Benefits	€ 19,522,311	€ 18,592,550	€ 18,005,781	€ 13,645,338
Economic BCR	**2.48**	**2.32**	**2.29**	**1.72**
Outcome Scores				
MCA PV Benefits	€ 18,024,105	€ 18,005,781	€ 18,005,781	€ 18,005,781
MCA Benefit Score	1416	1332	1445	1406
MCA BCR	107.30	94.69	101.37	73.94
Option Selection MCA	1661	1536	1691	1660

<table>
<tr><td colspan="7">5.3 Recommendation of Preferred Option
It forms part of the CFRAM process for the recommendation of a preferred option for each AFA. The prioritised selection criteria used in this recommendation process is detailed in Section 3.7.3 of the Main Report.
Therefore, following the five stage Multi Criteria Assessment process, the preferred option is as outlined below</td></tr>
<tr><td colspan="2">Option Ref:</td><td colspan="5">TRA_03</td></tr>
<tr><td rowspan="8">Option Measures</td><td>Baseline</td><td colspan="5">N/A</td></tr>
<tr><td rowspan="6">Structural</td><td>Eii</td><td colspan="4">Flood Relief Channel</td></tr>
<tr><td>Fi</td><td colspan="4">Channel Dredging</td></tr>
<tr><td>Fii</td><td colspan="4">Channel Widening</td></tr>
<tr><td>Fiii</td><td colspan="4">Structure Enhancement / Works</td></tr>
<tr><td>Gi</td><td colspan="4">New Flood Defences</td></tr>
<tr><td>Gii</td><td colspan="4">Raise Existing Flood Defences</td></tr>
<tr><td>Non Structural</td><td colspan="2">J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Comments</td><td colspan="5">This option will provide a 1% Fluvial and 0.5% Coastal AEP Design standard to 674 of the 679 properties within the AFA and reduce the risk to 5 properties, identified as being at risk from both these sources.

Though option TRA_03 has a lower Economic BCR and MCA BCR than option TRA_01, it scores higher overall with an Option Selection MCA of 1691 and is therefore chosen as the preferred option.

There is no suitable gauge data in the catchment available to determine the hydrology for Tralee and as such there is uncertainty associated with the predicted fluvial flood risk to the town. The Ballymullen gauge on the River Lee has a tidal influence and therefore could not be reliably used for determining the fluvial flows.

The flood risk management options considered are based on the predicted flood risk maps which were determined using all available survey and historical data up to Summer 2012.

Anecdotal evidence from flood events in September and November/December 2015 suggest there are areas of Tralee at risk of flooding that are not represented on the Shannon CFRAM predicted flood maps. At the CFRAMs hydrological study and flood maps are effectively ‘date stamped’ to Summer 2012, the reasons for the difference with the 2015 flood events has not been investigated. It is therefore a recommendation of this study that the 2015 flood events are appraised to determine the source of flooding, their annual exceedance probability and then, if necessary, updated calibration of the CFRAMs hydraulic model for Tralee to reflect this new information. It is also a recommendation of this study that reliable gauging stations are installed on all watercourses to reduce the uncertainty associated with the current predicted flood extents.

Tralee is a heavily urbanised town and there is interaction between the fluvial flows, coastal reaches and the drainage networks. There is historical evidence of flooding from the drainage network coinciding with tidal and fluvial events. Flood risk from the drainage network is not considered as part of the CFRAM process, nor is the potential detrimental impacts to this drainage network from the proposed CFRAM flood risk management options for example, proposed</td></tr>
</table>

	flood walls may prevent drainage outfalls freely discharging to the river network. Therefore, given the close interaction of the fluvial, coastal and drainage flood risks for Tralee, it is a recommendation of this study that a fully integrated catchment model is developed to understand all these sources of flood risk as part of the design for the Shannon CFRAM preferred flood risk management option. The Cuil Didin Residential Care Facility to the south of Tralee is not not included in the assessment as it is outside the AFA boundary. However, as an at risk/vulnerable property it should be considered for inclusion in a scheme at the detailed design stage of a proposed option.

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

<table>
<tr><th colspan="5">Fluvial Flood Forecasting Potential</th></tr>
<tr><td rowspan="3">Catchment Information</td><td colspan="2">Gauging Station</td><td rowspan="2">Catchment size (km ^{2})</td><td rowspan="2">Potential available forecast accuracy and reliability period</td></tr>
<tr><td>Fluvial</td><td>Rainfall</td></tr>
<tr><td>23011
23012
23022
23063
23013</td><td>No*</td><td>98.6</td><td>Unknown</td></tr>
<tr><td>Relevant Information:</td><td colspan="4">Ballycarty (GS 23011 Inactive) 2km upstream of Tralee AFA
Ballymullen (GS 23012 Inactive) lies within the AFA
Tralee Clonalour (GS 23022) lies within the AFA
Ballyard (GS 23063) lies within the AFA
Oakview (GS 23013 - Inactive) lies within the AFA</td></tr>
<tr><td rowspan="3">Additional Infrastructure Recommended</td><td colspan="2">Gauging Station</td><td colspan="2" rowspan="2">Other</td></tr>
<tr><td>Fluvial</td><td>Rainfall</td></tr>
<tr><td>No</td><td>No</td><td colspan="2">No</td></tr>
<tr><td>Relevant Comments:</td><td colspan="4">The gauges within the AFA are unsuitable for flood forecasting as the forecast period is too small.

Any accurate and reliable flood forecasting warning system would require installation of a series of rainfall and river gauges on the tributaries feeding into the AFA. However, it is unlikely that the forecast period and the catchment size of these tributaries would justify the introduction of such a system.

There is little to no potential for the development of an effective fluvial flood forecasting system for Tralee.

This AFA is also tidally influenced; tidal flooding could be predicted by a simple forecasting system.</td></tr>
</table>

*For this assessment only 15 minute tipping bucket gauge were considered.

Annex A - Multi-Criteria Analysis Summary and Whole Life Cost Summaries for FRM Option(s)

CRITERIA		OBJECTIVE		Global Weighting	Local Weighting	Comments	TRE_01	Option Score	Weighted Score	TRE_02	Option Score	Weighted Score	TRE_03	Option Score	Weighted Score
							Di Online Storage Fi Channel Dredging Fii Channel Widening Gi New Flood Defences Giii Demountable Defences M Individual Property Resilience L Individual Property Resistance J Flood Forecasting / Warning / Response K Public Awareness			Di Online Storage Fi Channel Dredging Fii Channel Widening Gi New Flood Defences Giii Demountable Defences Fiii Structure Enhancement / Works Eiii Other Diversion J Flood Forecasting / Warning / Response K Public Awareness L Individual Property Resistance M Individual Property Resilience			Di Online Storage Fi Channel Dredging Fii Channel Widening Gi New Flood Defences Giii Demountable Defences Fiii Structure Enhancement / Works Ei Full Diversion J Flood Forecasting / Warning / Response K Public Awareness L Individual Property Resistance M Individual Property Resilience		
1	Technical	a	Ensure flood risk management options are operationally robust	20	5.00	The option scores are determined based on the level of operational risk to operate or perform successfully. Each measure is scored independently and the average of the measure scores is used as the score for the option.	No risks / Manageable Negligible / Moderate / high Very low / High Low / Failure likely Low / moderate / Unacceptable Di 0.00 Fi 4.00 Fii 4.00 Gi 5.00 Giii 1.00 M 3.00 L 3.00 J 1.00 K 5.00	2.89	289	No risks / Manageable Negligible / Moderate / high Very low / High Low / Failure likely Low / moderate / Unacceptable Di -0.50 Fi 4.00 Fii 4.00 Gi 5.00 Giii 1.00 Fiii 4.00 Eiii 3.00 J 2.00 K 5.00 L 1.00 M 2.00	2.77	277	No risks / Manageable Negligible / Moderate / high Very low / High Low / Failure likely Low / moderate / Unacceptable Di 2.00 Fi 4.00 Fii 4.00 Gi 5.00 Giii 1.00 Fiii 4.00 Ei 4.00 J 3.00 K 5.00 L 1.00 M 2.00	3.18	318
		b	Minimise health and safety risks associated with the construction and operation of flood risk management options	20	5.00	H&S risks are considered for construction and maintenance of flood risk management measures. The indicative aspirational score is set at five, with a point then deducted for each specific H&S risk in either construction or maintenance.	No risks / Moderate / Work near/in water Negligible / Moderate / high / Work near services or buildings Very low / High / Other (please specify) Low / Very High / Work near traffic Low / moderate / Unacceptable	-3.00	-300	No risks / Moderate / Work near/in water Negligible / Moderate / high / Work near services or buildings Very low / High / Other (please specify) Low / Very High / Work near traffic Low / moderate / Unacceptable	-3.00	-300	No risks / Moderate / Work near/in water Negligible / Moderate / high / Work near services or buildings Very low / High / Other (please specify) Low / Very High / Work near traffic Low / moderate / Unacceptable	-3.00	-300
		c	Ensure flood risk management options are adaptable to future flood risk	20	5.00	The options scores are determined based on the sustainability and adaptability of the flood risk management measures in the face of potential future changes, including the potential impact of climate change. Each measure is scored independently and the average of the measure scores is used as the score for the option.	Option can be adapted at no to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. Di 0.00 Fi 3.00 Fii 3.00 Gi 3.00 Giii 4.00 M 3.00 L 1.00 J 1.00 K 5.00	2.56	256	Option can be adapted at no to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. Di 0.00 Fi 3.00 Fii 3.00 Gi 3.00 Giii 4.00 Fiii 1.00 Eiii 1.00 J 1.00 K 5.00 L 1.00 M 3.00	2.27	227	Option can be adapted at no to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. Di 0.00 Fi 3.00 Fii 3.00 Gi 3.00 Giii 4.00 Fiii 1.00 Ei 1.00 J 1.00 K 5.00 L 1.00 M 3.00	2.27	227
			TECHNICAL CRITERIA SCORE						244			205			245
2	Economic	a	Minimise economic risk	24	5.00		The score is calculated based on the reduction in AAD, following the full implementation of option.	4.08	490	The score is calculated based on the reduction in AAD, following the full implementation of option.	4.08	489	The score is calculated based on the reduction in AAD, following the full implementation of option.	4.08	489
		b	Minimise risk to transport infrastructure	10	5.00		The score is calculated based on the reduction in flood risk to transport routes, following the full implementation of option.	1.27	64	The score is calculated based on the reduction in flood risk to transport routes, following the full implementation of option.	1.27	64	The score is calculated based on the reduction in flood risk to transport routes, following the full implementation of option.	1.27	64
		c	Minimise risk to utility infrastructure	14	5.00		The score is calculated based on a reduction in flood risk to utility infrastructure, following the full implementation of option.	4.84	339	The score is calculated based on a reduction in flood risk to utility infrastructure, following the full implementation of option.	4.84	339	The score is calculated based on a reduction in flood risk to utility infrastructure, following the full implementation of option.	4.84	339
		d	Minimise risk to agriculture	12	1.16	Source of Flooding: Both Fresh & Salt Water Percentage of AFA that is rural land: 23.25%	Area of Agricultural Land Flooded: No Change Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: No Change Flood Warning: Applicable Agricultural Production Enhanced: No Change Other (Please Specify): Not Applicable	1.00	14	Area of Agricultural Land Flooded: No Change Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: No Change Flood Warning: Applicable Agricultural Production Enhanced: No Change Other (Please Specify): Not Applicable	1.00	14	Area of Agricultural Land Flooded: No Change Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: No Change Flood Warning: Applicable Agricultural Production Enhanced: No Change Other (Please Specify): Not Applicable	1.00	14
			ECONOMIC CRITERIA SCORE						906			905			905
3	Social	a i)	Minimise risk to human health and life - Residents	27	5.00	Flood Depths & Velocities: Medium to high risk to life Known Areas of Highly Vulnerable People: Reasonable Cross Section of Society	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	2.20	297	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	2.20	297	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	2.20	297
		a ii)	Minimise risk to human health and life - High vulnerability properties	17	5.00	Rate of Onset of flooding: Assumed 1-2 hours for evacuation	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	2.00	170	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	2.00	170	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	2.00	170
		b i)	Minimise risk to community - Social Infrastructure & Amenity	9	3.78	Assets of Particular Social Value: Yes	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	4.64	158	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	4.64	158	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	4.64	158
		b ii)	Minimise risk to community - Local employment	7	5.00	Asset of Particular Employment Value: No	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	3.33	116	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	3.33	116	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	3.33	116
			SOCIAL CRITERIA SCORE						741			741			741
4	Environmental	a	Support the objectives of the WFD	16	5.00	There are a number of WFD water bodies within the AFA associated with the Lee River and Estuary. The status of these water bodies ranges from bad to good. There are a number of potentially polluting sources within the 1%A	There will be 2 pollution sources potentially removed from the 1% AEP. Construction related impacts due to significant construction works in and adjacent to watercourses.	-1.00	-80	Construction related impacts due to significant construction works in and adjacent to watercourses. There are 3 off-line upstream storage areas proposed on the River Lee and tributaries of the River Lee and 4 new weirs	-1.50	-120	There will be 2 pollution sources potentially removed from the 1% AEP. Construction related impacts due to significant construction works in and adjacent to watercourses.	-1.50	-120
		b	Support the objectives of the Habitats Directive	10	3.00	This AFA contains the Tralee Bay And Magharees Peninsula, West To Cloghane cSAC (002070) and Ballyseedy SAC (002112). It also contains the Tralee Bay Complex SPA (004188) and the Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA (004161) is located approx. 2.5 km to the north east.	Potential significant effects in relation to works within the boundary of the Tralee Bay And Magharees Peninsula, West To Cloghane SAC. However, it is noted in relation to the proposed wall that the boundary of the cSAC in this area falls on an existing access road which is highly unlikely to be	-1.50	-45	Potential significant effects in relation to works within the boundary of the Tralee Bay And Magharees Peninsula, West To Cloghane SAC. However, it is noted in relation to the proposed wall that the boundary of the cSAC in this area falls on an existing access road which is highly unlikely to be	-1.00	-30	Potential significant effects in relation to works within the boundary of the Tralee Bay And Magharees Peninsula, West To Cloghane SAC. However, it is noted in relation to the proposed wall that the boundary of the cSAC in this area falls on an existing access road which is highly unlikely to be	-1.00	-30
		c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	5	3.00	There is one nationally designated site within the AFA. There is potential for significant habitats and populations of European and nationally protected species, particularly associated with estuarine habitats.	Potential significant effects in relation to works within the boundary of the Tralee Bay And Magharees Peninsula, West To Cloghane pNHA. However, it is noted in relation to the proposed wall that the boundary of the pNHA in this area fall on an existing access road which is highly unlikely to be	-1.50	-23	Potential significant effect are related to works within the boundary of the Tralee Bay And Magharees Peninsula, West To Cloghane pNHA in relation to construction of a flood wall. However it is noted in relation to the proposed wall that the boundary of the pNHA in this area falls on an existing access	-1.00	-15	Potential significant effect are related to works within the boundary of the Tralee Bay And Magharees Peninsula, West To Cloghane pNHA in relation to construction of a flood wall. However it is noted in relation to the proposed wall that the boundary of the pNHA in this area falls on an existing access	-1.00	-15
		d	Protect, and where possible enhance, fisheries resource within the catchment	13	3.00	None of the waterbodies within the AFA are designated as salmonid. There are no shore angling areas within the AFA. There is a protected shellfish area within Tralee Bay but outside the AFA boundary. Fishing in the area is primarily related to sea angling.	Potential short term construction impacts on water quality and subsequent fish species. There are long term impacts associated with increased conveyance along a short section of the tributary of the Lee.	-3.00	-117	Potential short term construction impacts on water quality and subsequent fish species. There are long term impacts associated with increased conveyance along a short section of the tributary of the Lee.	-4.50	-175.5	There is an opportunity to improve arrangement for fish passage as there are a number of weirs proposed to be improved. Potential short term construction impacts on water quality	-2.00	-78
		e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	8	1.00	The AFA (Tralee) is an important tourist destination however, there are no designated landscape features within the AFA. The North Kerry Way runs along the western boundary of the AFA and also runs into the AFA along the canal.	There is no impact on designated landscape features from this option. Storage areas upstream and permanent embankment and walls within the AFA adjacent to watercourse within Tralee	-2.00	-16	There is no impact on designated landscape features with this option. Storage areas upstream and permanent embankment and walls within the AFA adjacent to watercourse within Tralee	-2.00	-16	There is no impact on designated landscape features with this option. Permanent embankments and walls within the AFA adjacent to watercourse within Tralee Town will alter the visual	-1.00	-8
		f i)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of architectural value	4	3.00	There is a significant existing risk to architectural heritage in the AFA with a large potion of the Tralee ACA and a number of NIAH and RPS (approx. 60) in the 1% AEP. No RPS data was made available. Local weighting of 3 set by professional judgement. Weighting of 3	The option comprises upstream storage which will not affect the setting of the ACA and the NIAH/RPS. The proposed wall in the vicinity of the ACA is unlikely effect the setting of any architectural features.	3.50	42	The option comprises upstream storage which will not affect the setting of the ACA and the NIAH/RPS. The proposed wall in the vicinity of the ACA is unlikely to effect the setting of any architectural features. There is a significant existing risk to architectural heritage in the AFA with a large portion of the	3.50	42	The option will not affect the setting of the ACA and the NIAH/RPS. The proposed wall in the vicinity of the ACA is unlikely to effect the setting of any architectural features. There is a significant existing risk to architectural heritage in the AFA with a large portion of the ACA and a number of	3.50	42
		f ii)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of archaeological value	4	2.00	There are 7 RMPs within the 1% AEP &/or 0.5% AEP. There is a national monument in close proximity to the 1% AEP. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are a number of sites listed on the RMP/RPS	There are no RMPs in the areas proposed for storage or the proposed wall and/or embankment. Therefore no significant impact are predicted to any RMPs. There is the potential for 6 RMPs of low vulnerability to be	1.00	8	There are no RMP in the areas proposed for storage or in the vicinity of the proposed wall and/or embankment. Therefore no significant impacts are predicted to any RMPs. There is the potential for 6 RMPs of low vulnerability to be	0.00	0	There are RMP in the vicinity of the proposed works. However no significant impact are predicted to any RMPs. There is the potential for 6 RMPs of low vulnerability to be removed from the 1% AEP.	1.00	8
			ENVIRONMENTAL CRITERIA SCORE						-231			-315			-201
	Economic Values		Economic PV Benefits					€32,720,999			€32,657,428			€32,657,428	
			Cost					€13,198,688			€14,064,878			€14,258,122	
			NPV Benefits					€19,522,311			€18,592,550			€18,399,306	
			Economic BCR					**2.48**			**2.32**			**2.29**	
	Outcome Scores		MCA PV Benefits					€18,024,105			€18,005,781			€18,005,781	
			MCA Benefit Score					1416			1332			1445	
			MCA BCR					**107.30**			**94.69**			**101.37**	
			Option Selection MCA					1661			1536			1691	

	TRE_04
Di	Online Storage
Fi	Channel Dredging
Fii	Channel Widening
Gi	New Flood Defences
Giii	Demountable Defences
Fiii	Structure Enhancement / Works
Ei	Full Diversion
J	Flood Forecasting / Warning / Response
K	Public Awareness
L	Individual Property Resistance
M	Individual Property Resilience

CRITERIA		OBJECTIVE		Global Weighting	Local Weighting	Comments	TRE_04	Option Score	Weighted Score
1	Technical	a	Ensure flood risk management options are operationally robust	20	5.00	The option scores are determined based on the level of operational risk to operate or perform successfully. Each measure is scored independently and the average of the measure scores is used as the score for the option.	No risks / Manageable Negligible / Moderate / high Very low / High Low / Failure likely Low / moderate / Unacceptable Di 2.00; Fi 4.00; Fii 4.00; Gi 5.00; Giii 1.00; Fiii 4.00; Ei 4.00; J 3.00; K 5.00; L 1.00; M 2.00	3.18	318
		b	Minimise health and safety risks associated with the construction and operation of flood risk management options	20	5.00	H&S risks are considered for construction and maintenance of flood risk management measures. The indicative aspirational score is set at five, with a point then deducted for each specific H&S risk in either construction or maintenance.	No risks / Moderate / Work near/in water Negligible / Moderate / high / Work near services or buildings Very low / High / Other (please specify) Low / Very High / Work near traffic Low / moderate / Unacceptable	-3.00	-300
		c	Ensure flood risk management options are adaptable to future flood risk	20	5.00	The options scores are determined based on the sustainability and adaptability of the flood risk management measures in the face of potential future changes, including the potential impact of climate change. Each measure is scored independently and the average of the measure scores is used as the score for the option.	Option can be adapted at no to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. Di 0.00; Fi 3.00; Fii 3.00; Gi 3.00; Giii 4.00; Fiii 1.00; Ei 2.00; J 1.00; K 5.00; L 1.00; M 3.00	2.36	236
			TECHNICAL CRITERIA SCORE						255
2	Economic	a	Minimise economic risk	24	5.00		The score is calculated based on the reduction in AAD, following the full implementation of option.	4.08	490
		b	Minimise risk to transport infrastructure	10	5.00		The score is calculated based on the reduction in flood risk to transport routes, following the full implementation of option.	1.27	64
		c	Minimise risk to utility infrastructure	14	5.00		The score is calculated based on a reduction in flood risk to utility infrastructure, following the full implementation of option.	4.84	339
		d	Minimise risk to agriculture	12	1.16	Source of Flooding: Both Fresh & Salt Water Percentage of AFA that is rural land: 23.25%	Area of Agricultural Land Flooded: No Change Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: No Change Flood Warning: Applicable Agricultural Production Enhanced: No Change Other (Please Specify): Not Applicable	1.00	14
			ECONOMIC CRITERIA SCORE						906
3	Social	a i)	Minimise risk to human health and life - Residents	27	5.00	Flood Depths & Velocities: Medium to high risk to life Known Areas of Highly Vulnerable People: Reasonable Cross Section of Society	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	2.20	297
		a ii)	Minimise risk to human health and life - High vulnerability properties	17	5.00	Rate of Onset of flooding: Assumed 1-2 hours for evacuation	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	2.00	170
		b i)	Minimise risk to community - Social Infrastructure & Amenity	9	3.78	Assets of Particular Social Value: Yes	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	4.64	158
		b ii)	Minimise risk to community - Local employment	7	5.00	Asset of Particular Employment Value: No	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	3.33	116
			SOCIAL CRITERIA SCORE						741
4	Environmental	a	Support the objectives of the WFD	16	5.00	There are a number of WFD water bodies within the AFA associated with the Lee River and Estuary. The status of these water bodies ranges from bad to good. There are a number of potentially polluting sources within the 1%A	There will be 2 pollution sources potentially removed from the 1% AEP. Construction related impacts due to significant construction works in and adjacent to watercourses.	-2.00	-160
		b	Support the objectives of the Habitats Directive	10	3.00	This AFA contains the Tralee Bay And Magharees Peninsula, West To Cloghane cSAC (002070) and Ballyseedy SAC (002112). It also contains the Tralee Bay Complex SPA (004188) and the Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA (004161) is located approx. 2.5 km to the north east.	Potential significant effects in relation to works within the boundary of the Tralee Bay And Magharees Peninsula, West To Cloghane SAC. However, it is noted in relation to the proposed wall that the boundary of the cSAC in this area falls on an existing access road which is highly unlikely to be	-1.00	-30
		c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	5	3.00	There is one nationally designated site within the AFA. There is potential for significant habitats and populations of European and nationally protected species, particularly associated with estuarine habitats.	Potential significant effect are related to works within the boundary of the Tralee Bay And Magharees Peninsula, West To Cloghane pNHA in relation to construction of a flood wall. However it is noted in relation to the proposed wall that the boundary of the pNHA in this area falls on an existing access	-1.00	-15
		d	Protect, and where possible enhance, fisheries resource within the catchment	13	3.00	None of the waterbodies within the AFA are designated as salmonid. There are no shore angling areas within the AFA. There is a protected shellfish area within Tralee Bay but outside the AFA boundary. Fishing in the area is primarily related to sea angling.	There is an opportunity to improve arrangement for fish passage as there are a number of weirs proposed to be improved. There is one new weir proposed. Potential short term construction impacts on water quality	-2.00	-78
		e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	8	1.00	The AFA (Tralee) is an important tourist destination however, there are no designated landscape features within the AFA. The North Kerry Way runs along the western boundary of the AFA and also runs into the AFA along the canal.	There is no impact on designated landscape features with this option. Permanent embankments and walls within the AFA adjacent to watercourse within Tralee Town will alter the visual	-1.00	-8
		f i)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of architectural value	4	3.00	There is a significant existing risk to architectural heritage in the AFA with a large potion of the Tralee ACA and a number of NIAH and RPS (approx. 60) in the 1% AEP. No RPS data was made available. Local weighting of 3 set by professional judgement. Weighting of 3	The option will not affect the setting of the ACA and the NIAH/RPS. The proposed wall in the vicinity of the ACA is unlikely to effect the setting of any architectural features. There is a significant existing risk to architectural heritage in the AFA with a large portion of the ACA and a number of	3.50	42
		f ii)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of archaeological value	4	2.00	There are 7 RMPs within the 1% AEP &/or 0.5% AEP. There is a national monument in close proximity to the 1% AEP. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are a number of sites listed on the RMP/RPS	There are RMP in the vicinity of the proposed works. However no significant impact are predicted to any RMPs. There is the potential for 6 RMPs of low vulnerability to be removed from the 1% AEP.	1.00	8
			ENVIRONMENTAL CRITERIA SCORE						-241

Economic Values	Economic PV Benefits	€32,657,428
	Cost	€19,012,090
	NPV Benefits	€13,645,338
	Economic BCR	**1.72**
Outcome Scores	MCA PV Benefits	€18,005,781
	MCA Benefit Score	1406
	MCA BCR	**73.94**
	Option Selection MCA	1660

Objective	Global Weightings (fixed)	Local Weightings		Baseline Comments	Option 1 Comments	Option 2 Comments	Option 3 Comments	Option 4 Comments
1.A	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has negligible operational risks to operate or perform successfully.	This score is determined for this option as it has negligible operational risks to operate or perform successfully.	This score is determined for this option as it has negligible operational risks to operate or perform successfully.	This score is determined for this option as it has negligible operational risks to operate or perform successfully.
1.B	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has low/moderate health and safety risks associated with the construction and operation of flood risk management option.	This score is determined for this option as it has low/moderate health and safety risks associated with the construction and operation of flood risk management option.	This score is determined for this option as it has low/moderate health and safety risks associated with the construction and operation of flood risk management option.	This score is determined for this option as it has low/moderate health and safety risks associated with the construction unknown operation of flood risk management option.
1.C	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.
2.A	24	5.00	calculated	Local weighting is calculated based on the baseline AAD.	This score is calculated based on the reduction in AAD, following the full implementation of option.	This score is calculated based on the reduction in AAD, following the full implementation of option.	This score is calculated based on the reduction in AAD, following the full implementation of option.	This score is calculated based on the reduction in AAD, following the full implementation of option.
2.B	10	5.00	calculated but adjusted by professional judgement if necessary	The calculated local weighting is at the maximum permissible value of 5, which is representative of the number of receptors at risk of flooding. Therefore no adjustment was made to the weighting.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.
2.C	14	5.00	calculated but adjusted by professional judgement if necessary	The calculated local weighting is at the maximum permissible value of 5, which is representative of the number of receptors at risk of flooding. Therefore no adjustment was made to the weighting.	This score is calculated based on a reduction in flood risk to utility infrastructure, following full implementation of option.	This score is calculated based on a reduction in flood risk to utility infrastructure, following full implementation of option.	This score is calculated based on a reduction in flood risk to utility infrastructure, following full implementation of option.	This score is calculated based on a reduction in flood risk to utility infrastructure, following full implementation of option.
2.D	12	1.16	Professional judgement	Local weighting is calculated based on the percentage of rural land within the AFA.	This score is determined based on application of flood forecasting, following full implementation of the option.	This score is determined based on application of flood forecasting, following full implementation of the option.	This score is determined based on application of flood forecasting, following full implementation of the option.	This score is determined based on application of flood forecasting, following full implementation of the option.
3.A (i)	27	5.00	calculated but adjusted by professional judgement if necessary	The calculated local weighting is at the maximum permissible value of 5, which is representative of the number of receptors at risk of flooding. Therefore no adjustment was made to the weighting.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option. The Preliminary Option Score has been increased by 10% to account for presence of flood forecasting.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option. The Preliminary Option Score has been increased by 10% to account for presence of flood forecasting.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option. The Preliminary Option Score has been increased by 10% to account for presence of flood forecasting.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option. The Preliminary Option Score has been increased by 10% to account for presence of flood forecasting.
3.A (ii)	17	5.00	calculated but adjusted by professional judgement if necessary	The calculated local weighting is at the maximum permissible value of 5, which is representative of the number of receptors at risk of flooding. Therefore no adjustment was made to the weighting.	Risk to high vulnerability properties reduced by option.	Risk to high vulnerability properties reduced by option.	Risk to high vulnerability properties reduced by option.	Risk to high vulnerability properties reduced by option.
3.B (i)	9	3.78	calculated but adjusted by professional judgement if necessary	Local weighting has been calculated as a maximum of 5, therefore no adjustment to the score is required.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option.
3.B (ii)	7	5.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to local employment. The local weighting is capped at the maximum value of 5.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option. Score reduced by 20% due to storage area in lands zoned for Industry.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option. Score reduced by 20% due to storage area in lands zoned for Industry.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option. Score reduced by 20% due to storage area in lands zoned for Industry.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option. Score reduced by 20% due to storage area in lands zoned for Industry.
4.A	16	5.00	fixed	This AFA contains the Tralee Bay And Magharees Peninsula, West To Cloghane cSAC (002070) and Ballyseedy SAC (002112). It also contains the Tralee Bay Complex SPA (004188) and the Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA (004161) is located approx. 2.5 km to the north east. The Tralee Bay SAC/SPA fall within the 1%/0.5% AEP also approx. 800m2 of Ballyseedy Woods cSAC is within the 1% AEP. Local weighting of 3 set by professional judgement. Weighting of 3 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (outside AFA) and potentially affected.	There will be 2 pollution sources potentially removed from the 1% AEP. Construction related impacts due to significant construction works in and adjacent to watercourses. There are 3 off-line upstream storage areas proposed on the River Lee and tributaries of the River Lee and 4 new weirs proposed at these locations. In addition improvement of channel conveyance are proposed along the tributary of the River Lee. All these measures could cause potential changes to the hydrological and morphological regime of the watercourses. Overall a potential short-term or intermittent impediment to the achievement of wb objectives.	Construction related impacts due to significant construction works in and adjacent to watercourses. There are 3 off-line upstream storage areas proposed on the River Lee and tributaries of the River Lee and 4 new weirs proposed at these location. In addition improvement of channel conveyance is proposed along 3 location on the tributary of the River Lee. All these measures could cause potential changes to the hydrological and morphological regime of the watercourses. Overall a potential short-term or intermittent impediment to the achievement of wb objectives.	There will be 2 pollution sources potentially removed from the 1% AEP. Construction related impacts due to significant construction works in and adjacent to watercourses. There are proposed improvement to existing weirs at 2 locations. In addition improvement of channel conveyance is proposed along the tribute of the River Lee. There is also 2 no. flow diversion channels proposed. All these measures could cause potential changes to the hydrological and morphological regime of the watercourses. Overall a potential short-term or intermittent impediment to the achievement of wb objectives.	There will be 2 pollution sources potentially removed from the 1%AEP. Construction related impacts due to significant construction works in and adjacent to watercourses, PC. There are proposed improvement to weirs at 2 locations. In addition improvement of channel conveyance is proposed along the tribute of the River Lee. There is also a flow diversion channel proposed. All these measures could cause potential changes to the hydrological and morphological regime of the watercourses, HM. Overall a potential short-term or intermittent impediment to the achievement of wb objectives.
4.B	10	3.00	Professional judgement	This AFA contains the Tralee Bay And Magharees Peninsula, West To Cloghane cSAC (002070) and Ballyseedy SAC (002112). It also contains the Tralee Bay Complex SPA (004188) and the Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA (004161) is located approx. 2.5 km to the north east. The Tralee Bay SAC/SPA fall within the 1%/0.5% AEP also approx. 800m2 of Ballyseedy Woods cSAC is within the 1% AEP. Local weighting of 3 set by professional judgement. Weighting of 3 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (outside AFA) and potentially affected.	Potential significant effects in relation to works within the boundary of the Tralee Bay And Magharees Peninsula, West To Cloghane SAC. However, it is noted in relation to the proposed wall that the boundary of the cSAC in this area falls on an existing access road which is highly unlikely to be qualifying habitat. There are also construction works proposed to improve/replace the wall adjacent to the Tralee Bay And Magharees Peninsula, West To Cloghane SAC. There are also embankments under this option to the north of the SAC, EM06 and EM07. Potentially significant effects during construction are: - Pollution risks to the Tralee Bay And Magharees Peninsula, West To Cloghane SAC - Disturbance to bird species within and outside the SPA - Disturbance to otter within and outside the cSAC Therefore, there is a potential detrimental impact upon existing cSAC site, including a delay in recovery of the site, but excluding impacts on the conservations objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	Potential significant effects in relation to works within the boundary of the Tralee Bay And Magharees Peninsula, West To Cloghane SAC. However, it is noted in relation to the proposed wall that the boundary of the cSAC in this area falls on an existing access road which is highly unlikely to be qualifying habitat. There is also construction works proposed to improve/replace the wall adjacent to the Tralee Bay And Magharees Peninsula, West To Cloghane SAC. Potentially significant effects during construction are: - Pollution risks to the Tralee Bay And Magharees Peninsula, West To Cloghane SAC - Loss of intertidal habitat adjacent to the Tralee Bay And Magharees Peninsula, West To Cloghane in relation to the proposed wall - Disturbance to bird species within and outside the SPA - Disturbance to otter within and outside the cSAC Therefore, there is a potential detrimental impact upon existing cSAC site, including a delay in recovery of the site, but excluding impacts on the conservations objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	Potential significant effects in relation to works within the boundary of the Tralee Bay And Magharees Peninsula, West To Cloghane SAC. However, it is noted in relation to the proposed wall that the boundary of the cSAC in this area falls on an existing access road which is highly unlikely to be qualifying habitat. There are also construction works proposed to improve/replace the wall adjacent to the Tralee Bay And Magharees Peninsula, West To Cloghane SAC. Potentially significant effects during construction are: - Pollution risks to the Tralee Bay And Magharees Peninsula, West To Cloghane SAC -Loss of intertidal habitat adjacent to the Tralee Bay And Magharees Peninsula, West To Cloghane in relation to the proposed wall - Disturbance to bird species within and outside the SPA - Disturbance to otter within and outside the cSAC Therefore, potential detrimental impact upon existing cSAC site, including a delay in recovery of the site, but excluding impacts on the conservations objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	There are no proposed works within the boundary of any of the European sites. However there are construction works proposed to improve/replace the wall adjacent to the Tralee Bay And Magharees Peninsula, West To Cloghane SAC. Due to the proximity to the SAC there are potential for significant effects. Potentially significant effects during construction are: - Pollution risks to the Tralee Bay And Magharees Peninsula, West To Cloghane SAC -Loss of intertidal habitat adjacent to the Tralee Bay And Magharees Peninsula, West To Cloghane in relation to the proposed wall - Disturbance to bird species within and outside the SPA - Disturbance to otter within and outside the cSAC Therefore, potential detrimental impact upon existing cSAC site, including a delay in recovery of the site, but excluding impacts on the conservations objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.
4.C	5	3.00	Professional judgement	There is one nationally designated site within the AFA. There is potential for significant habitats and populations of European and nationally protected species, particularly associated with estuarine habitats. Local weighting of 3 set by professional judgement. Weighting of 3 applied where a nationally important site (pNHA, NHA etc.) is present (outside AFA) and potentially affected	Potential significant effects in relation to works within the boundary of the Tralee Bay And Magharees Peninsula, West To Cloghane pNHA. However, it is noted in relation to the proposed wall that the boundary of the pNHA in this area fall on an existing access road which is highly unlikely to be qualifying habitat. There are also construction works proposed to improve/replace the wall adjacent to the Tralee Bay And Magharees Peninsula, West To Cloghane pNHA. There is also embankment under this option to the north of the pNHA, EM06 and EM07. Potentially significant effects during construction are: - Pollution risks to the Tralee Bay And Magharees Peninsula, West To Cloghane pNHA - Disturbance to bird species - Disturbance to otter Therefore, a potential localised loss of or disturbance to flora/fauna.	Potential significant effect are related to works within the boundary of the Tralee Bay And Magharees Peninsula, West To Cloghane pNHA in relation to construction of a flood wall. However it is noted in relation to the proposed wall that the boundary of the pNHA in this area falls on an existing access road which is highly unlikely to be qualifying habitat. There are also construction works proposed to improve/replace the wall adjacent to the Tralee Bay And Magharees Peninsula, West To Cloghane pNHA. Due to the proximity to the pNHA there is potential for significant effects. Potentially significant effects are: - Pollution risks to the Tralee Bay And Magharees Peninsula, West To Cloghane SAC - Loss of intertidal habitat adjacent to the Tralee Bay And Magharees Peninsula, West To Cloghane in relation to the proposed wall - Disturbance to bird species Therefore, a potential localised loss of or disturbance to	Potential significant effect are related to works within the boundary of the Tralee Bay And Magharees Peninsula, West To Cloghane pNHA in relation to construction of a flood wall. However it is noted in relation to the proposed wall that the boundary of the pNHA in this area falls on an existing access road which is highly unlikely to be qualifying habitat. There are also construction works proposed to improve/replace the wall adjacent to the Tralee Bay And Magharees Peninsula, West To Cloghane pNHA. Due to the proximity to the pNHA there is potential for significant effects. Potentially significant effects are: - Pollution risks to the Tralee Bay And Magharees Peninsula, West To Cloghane SAC - Loss of intertidal habitat adjacent to the Tralee Bay And Magharees Peninsula, West To Cloghane in relation to the proposed wall - Disturbance to bird species Therefore, a potential localised loss of or disturbance to	There are no proposed works within the boundary of any of the pNHA. However there are construction works proposed to improve/replace the wall adjacent to the Tralee Bay And Magharees Peninsula, West To Cloghane pNHA. Due to the proximity to the pNHA there are potential for significant effects Potentially significant effects are: - Pollution risks to the Tralee Bay And Magharees Peninsula, West To Cloghane SAC - Loss of intertidal habitat adjacent to the Tralee Bay And Magharees Peninsula, West To Cloghane in relation to the proposed wall - Disturbance to bird species Therefore, a potential localised loss of or disturbance to flora/fauna.
4.D	13	3.00	Professional judgement	None of the waterbodies within the AFA are designated as salmonid. There are no shore angling areas within the AFA. There is a protected shellfish area within Tralee Bay but outside the AFA boundary. Fishing in the area is primarily related to sea angling. Local weighting of 3 set by professional judgement. Weighting of 3 applied where a waterbody supports substantial fisheries/shellfisheries and is of regional value for fishing/angling.	Potential short term construction impacts on water quality and subsequent fish species. There are long term impacts associated with increased conveyance along a short section of the tributary of the Lee. In addition there are 4 no. new weirs proposed however there are a number of weirs already in existence upstream. Impact to the hydrological and morphological regimes and also an indirect negative effect to ecological receptors (including fisheries) due to offline storage areas. Therefore, a potential medium to long-term alteration of fisheries habitat.	Potential short term construction impacts on water quality and subsequent fish species. There are long term impacts associated with increased conveyance along a short section of the tributary of the Lee. In addition there are 4 no. new weirs proposed however there are a number of weirs already in existence upstream. Impact to the hydrological and morphological regimes and also an indirect negative effect to ecological receptors (including fisheries) due to offline storage areas and flow diversion. Therefore, a potential medium to long-term alteration of fisheries habitat.	There is an opportunity to improve arrangement for fish passage as there are a number of weirs proposed to be improved. Potential short term construction impacts on water quality and subsequent fish species. There are long term impacts associated with increased conveyance along 3 sections and channel cleaning along 1 section of tributaries of the River Lee and the on-going maintenance works in this areas. Impact to the hydrological and morphological regimes and also an indirect negative effect to ecological receptors (including fisheries) due to the above and flow diversion along a tributary of the Lee. Therefore, a potential medium to long-term alteration of fisheries habitat but with the potential for removal of existing barriers to movement.	There is opportunity to improve arrangement for fish passage as there are a number of weirs proposed to be improved. Potential short term construction impacts on water quality and subsequent fish species. There is long term impacts associated with increased conveyance along 3 sections and channel cleaning along 1 section along Tributaries of the River Lee and the ongoing maintenance works in this areas. Impact to the hydrological and morphological regimes and also an indirect negative /effect to ecological receptors (including fisheries) due to the above and flow diversion along a tributary of the Lee. Therefore, a potential medium to long-term alternation of fisheries habitat but with the potential for removal of existing barriers to movement.
4.E	8	1.00	Professional judgement	The AFA (Tralee) is an important tourist destination however, there are no designated landscape features within the AFA. The North Kerry Way runs along the western boundary of the AFA and also runs into the AFA along the canal. Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected.	There is no impact on designated landscape features from this option. Storage areas upstream and permanent embankment and walls within the AFA adjacent to watercourse within Tralee Town will alter the visual amenity in the area. The North Kerry Way will continue to flood in the 1% AEP. Therefore, a potential for long term impact to a low sensitivity landscape character/feature in the zone of visibility of the selected measure.	There is no impact on designated landscape features with this option. Storage areas upstream and permanent embankment and walls within the AFA adjacent to watercourse within Tralee Town will alter the visual amenity in the area. The North Kerry Way will continue to flood in the 1% AEP. Therefore, a potential for long term impact to a low sensitivity landscape character/feature in the zone of visibility of the selected measure.	There is no impact on designated landscape features with this option. Permanent embankments and walls within the AFA adjacent to watercourse within Tralee Town will alter the visual amenity in the area. The North Kerry Way will continue to flood in the 1% AEP. Therefore, a potential for long term impact to a low sensitivity landscape character/feature in the zone of visibility of the selected measure.	There is no impact on designated landscape features with this option. Storage areas up stream and permanent embankment and walls within the AFA adjacent to watercourse within Tralee Town will alter the visual amenity in the area. The north Kerry way will continue to flood in the 1%AEP. Therefore, a potential for long term impact to a low sensitivity landscape character/feature in the zone of visibility of the selected measure.
4.F(i)	4	3.00	Professional judgement	There is a significant existing risk to architectural heritage in the AFA with a large potion of the Tralee ACA and a number of NIAH and RPS (approx. 60) in the 1% AEP. No RPS data was made available. Local weighting of 3 set by professional judgement. Weighting of 3 applied where there are a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a high to moderate vulnerability.	The option comprises upstream storage which will not affect the setting of the ACA and the NIAH/RPS. The proposed wall in the vicinity of the ACA is unlikely effect the setting of any architectural features. There is a significant existing risk to architectural heritage in the AFA with a large portion of the ACA and a number of NIAH/RPS in the 1% AEP that will now be protected. Therefore, there is a potential to increase in the level of protection for a number of architectural features (RPS and NIAH) from flooding, such that they are substantially less vulnerable to flood damage.	The option comprises upstream storage which will not affect the setting of the ACA and the NIAH/RPS. The proposed wall in the vicinity of the ACA is unlikely to effect the setting of any architectural features. There is a significant existing risk to architectural heritage in the AFA with a large portion of the ACA and a number of NIAH/RPS in the 1% AEP that will now be protected. Therefore, there is a potential to increase in the level of protection for a number of architectural features (Record of Protected Structures and NIAH) from flooding, such that they are substantially less vulnerable to flood damage.	The option will not affect the setting of the ACA and the NIAH/RPS. The proposed wall in the vicinity of the ACA is unlikely to effect the setting of any architectural features. There is a significant existing risk to architectural heritage in the AFA with a large portion of the ACA and a number of NIAH/RPS in the 1% AEP that will now be protected. Therefore, there is a potential to increase in the level of protection for a number of architectural features (Record of Protected Structures and NIAH) from flooding, such that they are substantially less vulnerable to flood damage.	The option comprises upstream storage which will not affect the setting of the ACA and the NIAH/RPS. The proposed wall in the vicinity of the ACA is unlikely effect the setting of any architectural features. There is a significant existing risk to architectural Heritage in the AFA with a large portion of the ACA and a number of NIAH/RPS in the 1% AEP that will be now protected in the 1%AEP. Therefore, there is a potential to increase in the level of protection for a number of architectural features (Record of Protected Structures and NIAH) from flooding, such that they are substantially less vulnerable to flood damage.
4.F(ii)	4	2.00	Professional judgement	There are 7 RMPs within the 1% AEP &/or 0.5% AEP. There is a national monument in close proximity to the 1% AEP. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are a number of sites listed on the RMP/RPS present and potentially affected. (moderate to low vulnerability).	There are no RMPs in the areas proposed for storage or the proposed wall and/or embankment. Therefore no significant impact are predicted to any RMPs. There is the potential for 6 RMPs of low vulnerability to be removed from the 1% AEP. Therefore, there is a potential to increase the level of protection for archaeological features (Recorded Monuments) from flooding, such that it is less vulnerable to flood damage.	There are no RMP in the areas proposed for storage or in the vicinity of the proposed wall and/or embankment. Therefore no significant impacts are predicted to any RMPs. There is the potential for 6 RMPs of low vulnerability to be removed from the 1% AEP. Therefore, there is a potential to increase the level of protection for archaeological features (Recorded Monuments) from flooding, such that it is less vulnerable to flood damage.	There are RMP in the vicinity of the proposed works. However no significant impact are predicted to any RMPs. There is the potential for 6 RMPs of low vulnerability to be removed from the 1% AEP. Therefore, there is a potential to increase the level of protection for archaeological features (Recorded Monuments) from flooding, such that it is less vulnerable to flood damage.	There are no RMP in the areas proposed for storage or in the vicinity of the proposed wall and/or embankment. Therefore no significant impact are predicted to any RMPs. There is a potential for unknown archaeological feature to be impacted but there are not known. There is the potential for 6 RMPs of low vulnerability to be removed from the 1%AEP. Therefore, there is a potential to increase the level of protection for archaeological features (Recorded Monuments) from flooding, such that it is less vulnerable to flood damage.

Option 1 Costs for CBA

	CFRAM Programme – Option Costs for Cost Benefit Analysis		€	€	€	Notes to CFRAM Consultants
(1)	**Basic Construction Costs (Estimate)**				**5,302,843**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2)	**Preliminaries**	11%			**562,266**	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				**5,865,109**	
(3)	**Optimism Bias**	40%			**2,346,044**	Refer to UCD for selecting OB %
(4)	**Construction Costs (Excl VAT)**				**8,211,152**	
(5)	**Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)**	13%			**1,067,450**	Set at 13%
	Construction Costs and Fees				**9,278,602**	
(6)	**Other Items**					
(a)	Allowance for Archaeology & Environmental Mitigation Measures	15%		1,231,673		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b)	Allowance for compensation and land acquisition	15%		1,231,673		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c)	Site investigation	9% assumed		739,004		Professional judgement to be applied in estimating a suitable sum.
(d)	Art Allowance			51,000		See "Guidance E – Per Cent for Art Note"
(e)	Est. NPV Operation & Maintenance		476,240			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	40%	190,496	666,736	**3,920,086**	Refer to UCD for selecting OB %
	Option Cost for Cost Benefit Analysis				**13,198,688**	

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	**J. Reynolds**	**Date:**	**13/05/2015**
Checked by:	**M. Conlon**	**Date:**	

Project reference	S16
Project name:	Shannon CFRAMS - S16 Tralee

Base date for estimates (year 0)	Dec-2013
Scaling factor (e.g. €m, €k, €)	€
Construction Price Index (CPI)	**0.987**
Method Factor - to take into account particular site issues /constraints	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	**Cost (€)**	**Comment**
Total wall costs	€2,046,712	*ref: S16 Tralee - 01 Walls Option 1*
Total embankment costs	€322,368	*ref: S16 Tralee - 02 Embankments Option 1*
Total demountable barriers/gates costs	€17,000	*ref: S16 Tralee - 03 Demountable Walls & Gates Option 1*
Total in-channel excavation costs	€12,828	*ref: S16 Tralee - 04 Excavations (in channel) Option 1*
Total excavation on land costs	€2,828,811	*ref: S16 Tralee - 05 Excavations (on land) Option 1*
Total weir construction costs	€109,860	*ref: S16 Tralee - 06 Weir Option 1*
Total weir removal costs		
Total bridge removal costs		
Total bridge construction costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs	€26,824	
Total hydrometric gauging station costs		
Total flood forecasting costs	€10,752	
Total pumping station costs		
Total channel maintenance costs	€0	*ref: S16 Tralee - 17 Channel Maintenance Option 1*
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€5,375,154	
Apply update to unit rate (CPI) if appropriate (cell N15)	€5,302,843	
Enter appropriate preliminaries estimate (%)	10.60%	*ref: Preliminaries and other costs v1.0*
Enter other applicable costs (€)		
Total capital cost (€)	€5,865,109	
Consider amendments based on site issues/constraints (cell N16)	€5,865,109	
Total capital cost (€)	**€5,865,109**	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs	€334	*ref: S16 Tralee - 01 Walls Option 1*
Total embankment O&M costs	€5,726	*ref: S16 Tralee - 02 Embankments Option 1*
Total demountable barriers/gates O&M costs	€86	*ref: S16 Tralee - 03 Demountable Walls & Gates Option 1*
Total in-channel excavation O&M costs	€0	*ref: S16 Tralee - 04 Excavations (in channel) Option 1*
Total excavation on land O&M costs	€0	*ref: S16 Tralee - 05 Excavations (on land) Option 1*
Total weir O&M costs	€7,500	*ref: S16 Tralee - 06 Weir Option 1*
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs	€224	
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs	€2,420	
Total pumping station O&M costs		
Total channel maintenance O&M costs	€728	*ref: S16 Tralee - 17 Channel Maintenance Option 1*
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs	€5,296	*ref: S16 Tralee - TargetedPublicAwareness_Campaign*
Total Operation and Maintenance costs	€22,315	

Other costs	**Cost (€)**	**Comment**
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€6,341,349	
Optimism bias rate (from external sheet)	40%	
Total Cost including Optimism Bias	**€8,877,889**	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	€0
Year of capital works (year)	
Capital cost (€)	€5,865,109
Annual maintenance cost (€)	€22,315
Other cost (€)	€0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**		**Total PVc (€k):**	**6341349**
	Cash sum	0	5865109	1093447	0	6958556	**6341349**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	5865109			5865108.9	5865108.9
1	0.962			22315		22315.2	21457.0
2	0.925			22315		22315.2	20631.7
3	0.889			22315		22315.2	19838.2
4	0.855			22315		22315.2	19075.2
5	0.822			22315		22315.2	18341.5
6	0.790			22315		22315.2	17636.1
7	0.760			22315		22315.2	16957.8
8	0.731			22315		22315.2	16305.5
9	0.703			22315		22315.2	15678.4
10	0.676			22315		22315.2	15075.4
11	0.650			22315		22315.2	14495.6
12	0.625			22315		22315.2	13938.0
13	0.601			22315		22315.2	13402.0
14	0.577			22315		22315.2	12886.5
15	0.555			22315		22315.2	12390.9
16	0.534			22315		22315.2	11914.3
17	0.513			22315		22315.2	11456.0
18	0.494			22315		22315.2	11015.4
19	0.475			22315		22315.2	10591.8
20	0.456			22315		22315.2	10184.4
21	0.439			22315		22315.2	9792.7
22	0.422			22315		22315.2	9416.0
23	0.406			22315		22315.2	9053.9
24	0.390			22315		22315.2	8705.7
25	0.375			22315		22315.2	8370.8
26	0.361			22315		22315.2	8048.9
27	0.347			22315		22315.2	7739.3
28	0.333			22315		22315.2	7441.6
29	0.321			22315		22315.2	7155.4
30	0.308			22315		22315.2	6880.2
31	0.296			22315		22315.2	6615.6
32	0.285			22315		22315.2	6361.1
33	0.274			22315		22315.2	6116.5
34	0.264			22315		22315.2	5881.2
35	0.253			22315		22315.2	5655.0
36	0.244			22315		22315.2	5437.5
37	0.234			22315		22315.2	5228.4
38	0.225			22315		22315.2	5027.3
39	0.217			22315		22315.2	4833.9
40	0.208			22315		22315.2	4648.0
41	0.200			22315		22315.2	4469.3
42	0.193			22315		22315.2	4297.4
43	0.185			22315		22315.2	4132.1
44	0.178			22315		22315.2	3973.1
45	0.171			22315		22315.2	3820.3
46	0.165			22315		22315.2	3673.4
47	0.158			22315		22315.2	3532.1
48	0.152			22315		22315.2	3396.3
49	0.146			22315		22315.2	3265.6

Option 2 Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis						Notes to CFRAM Consultants
			€	€	€	
(1)	**Basic Construction Costs (Estimate)**				**4,795,862**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2)	**Preliminaries**	11.1%			**530,197**	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				**5,326,059**	
(3)	**Optimism Bias**	60.0%			**3,195,635**	Refer to UCD for selecting OB %
(4)	**Construction Costs (Excl VAT)**				**8,521,694**	
(5)	**Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)**	13.0%			**1,107,820**	Set at 13%
	Construction Costs and Fees				**9,629,515**	
(6)	**Other Items**					
(a)	Allowance for Archaeology & Environmental Mitigation Measures	15.0%		1,278,254		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b)	Allowance for compensation and land acquisition	15.0%		1,278,254		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c)	Site investigation			766,953		Professional judgement to be applied in estimating a suitable sum.
(d)	Art Allowance			51,000		See "Guidance E – Per Cent for Art Note"
(e)	Est. NPV Operation & Maintenance		663,064			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	60.0%	397,838	1,060,902	**4,435,363**	Refer to UCD for selecting OB %
	Option Cost for Cost Benefit Analysis				**14,064,878**	

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	J. Reynolds	Date:	13/05/2015
Checked by:	M. Conlon	Date:	

Project reference	S16	Project name:	Shannon CFRAMS - S16 Tralee
Base date for estimates (year 0)	Dec-2013	Construction Price Index (CPI)	0.987
Scaling factor (e.g. €m, €k, €)	€	Method Factor - to take into account particular site issues /constraints	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	Cost (€)	Comment
Total wall costs	€1,630,114	*ref: S16 Tralee - 01 Walls Option 2*
Total embankment costs	€175,992	*ref: S16 Tralee - 02 Embankments Option 2*
Total demountable barriers/gates costs	€17,000	*ref: S16 Tralee - 03 Demountable Walls & Gates Option 2*
Total in-channel excavation costs	€166,396	*ref: S16 Tralee - 04 Excavations (in channel) Option 2, method factor of 2*
Total excavation on land costs	€2,250,501	*ref: S16 Tralee - 05 Excavations (on land) Option 2*
Total weir construction costs	€82,395	*ref: S16 Tralee - 06 Weir Option 2*
Total weir removal costs		
Total bridge removal costs	€248,746	*ref: S16 Tralee - 08 Bridges Option 2*
Total bridge construction costs	inc. in above	*ref: S16 Tralee - 08 Bridges Option 2*
Total bridge underpinning costs		
Total culvert costs	€233,668	*ref: S16 Tralee - 10 Culverts Option 2*
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs	€48,048	*ref: S16 Tralee - 13 Individual Property Protection Option 2*
Total hydrometric gauging station costs		
Total flood forecasting costs	€8,400	
Total pumping station costs		
Total channel maintenance costs	N/A	*ref: S16 Tralee - 17 Channel Maintenance Option 2*
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€4,861,260	
Apply update to unit rate (CPI) if appropriate (cell N15)	€4,795,862	
Enter appropriate preliminaries estimate (%)	11.06%	*ref: Preliminaries and other costs v1.0*
Enter other applicable costs (€)		
Total capital cost (€)	€5,326,059	
Consider amendments based on site issues/constraints (cell N16)	€5,326,059	
Total capital cost (€)	**€5,326,059**	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs	€206	*ref: S16 Tralee - 01 Walls Option 2*
Total embankment O&M costs	€2,377	*ref: S16 Tralee - 02 Embankments Option 2*
Total demountable barriers/gates O&M costs	€86	*ref: S16 Tralee - 03 Demountable Walls & Gates Option 2*
Total in-channel excavation O&M costs	€1,889	*ref: S16 Tralee - 04 Excavations (in channel) Option 2*
Total excavation on land O&M costs	€0	*ref: S16 Tralee - 05 Excavations (on land) Option 2*
Total weir O&M costs	€5,625	*ref: S16 Tralee - 06 Weir Option 2*
Total weir removal O&M costs		
Total bridge O&M costs	€800	*ref: S16 Tralee - 08 Bridges Option 2*
Total bridge removal O&M costs	N/A	*ref: S16 Tralee - 08 Bridges Option 2*
Total bridge underpinning O&M costs		
Total culvert O&M costs	€7,393	*ref: S16 Tralee - 10 Culverts Option 2*
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs	€336	*ref: S16 Tralee - 13 Individual Property Protection Option 2*
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs	€2,420	
Total pumping station O&M costs		
Total channel maintenance O&M costs	€4,642	*ref: S16 Tralee - 17 Channel Maintenance Option 2*
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs	€5,296	*ref: S16 Tralee - TargetedPublicAwareness_Campaign*
Total Operation and Maintenance costs	€31,069	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€5,989,123	
Optimism bias rate (from external sheet)	60%	*ref: Optimism Bias Tool v.2.0 - medium risk assumed.*
Total Cost including Optimism Bias	**€9,582,597**	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	€0
Year of capital works (year)	
Capital cost (€)	€5,326,059
Annual maintenance cost (€)	€31,069
Other cost (€)	€0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	4.0%	Present Value Factor:		22.341	Total PVc (€k):		5989123
	Cash sum	0	5326059	1522394	0	6848453	5989123
	Discount	Cost Elements				TOTALS:	
year	Factor	Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	0	5326059			5326059.0	5326059.0
1	0.962			31069		31069.3	29874.3
2	0.925			31069		31069.3	28725.3
3	0.889			31069		31069.3	27620.5
4	0.855			31069		31069.3	26558.1
5	0.822			31069		31069.3	25536.7
6	0.790			31069		31069.3	24554.5
7	0.760			31069		31069.3	23610.1
8	0.731			31069		31069.3	22702.0
9	0.703			31069		31069.3	21828.9
10	0.676			31069		31069.3	20989.3
11	0.650			31069		31069.3	20182.0
12	0.625			31069		31069.3	19405.8
13	0.601			31069		31069.3	18659.4
14	0.577			31069		31069.3	17941.7
15	0.555			31069		31069.3	17251.7
16	0.534			31069		31069.3	16588.1
17	0.513			31069		31069.3	15950.1
18	0.494			31069		31069.3	15336.7
19	0.475			31069		31069.3	14746.8
20	0.456			31069		31069.3	14179.6
21	0.439			31069		31069.3	13634.2
22	0.422			31069		31069.3	13109.8
23	0.406			31069		31069.3	12605.6
24	0.390			31069		31069.3	12120.8
25	0.375			31069		31069.3	11654.6
26	0.361			31069		31069.3	11206.4
27	0.347			31069		31069.3	10775.3
28	0.333			31069		31069.3	10360.9
29	0.321			31069		31069.3	9962.4
30	0.308			31069		31069.3	9579.2
31	0.296			31069		31069.3	9210.8
32	0.285			31069		31069.3	8856.5
33	0.274			31069		31069.3	8515.9
34	0.264			31069		31069.3	8188.4
35	0.253			31069		31069.3	7873.4
36	0.244			31069		31069.3	7570.6
37	0.234			31069		31069.3	7279.4
38	0.225			31069		31069.3	6999.5
39	0.217			31069		31069.3	6730.2
40	0.208			31069		31069.3	6471.4
41	0.200			31069		31069.3	6222.5
42	0.193			31069		31069.3	5983.2
43	0.185			31069		31069.3	5753.0
44	0.178			31069		31069.3	5531.8
45	0.171			31069		31069.3	5319.0
46	0.165			31069		31069.3	5114.4
47	0.158			31069		31069.3	4917.7
48	0.152			31069		31069.3	4728.6
49	0.146			31069		31069.3	4546.7

Option 3 Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis					Notes to CFRAM Consultants
		€	€	€	
(1) Basic Construction Costs (Estimate)				**5,732,504**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2) Preliminaries	10.3%			**587,726**	Refer to UCD for selecting Preliminaries. %
Sub-Total:				**6,320,229**	
(3) Optimism Bias	40.0%			**2,528,092**	Refer to UCD for selecting OB %
(4) Construction Costs (Excl VAT)				**8,848,321**	
(5) Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)	13.0%			**1,150,282**	Set at 13%
Construction Costs and Fees				**9,998,603**	
(6) Other Items					
(a) Allowance for Archaeology & Environmental Mitigation Measures	15.0%		1,327,248		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b) Allowance for compensation and land acquisition	15.0%		1,327,248		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c) Site investigation	*9% assumed*		796,349		Professional judgement to be applied in estimating a suitable sum.
(d) Art Allowance			51,000		See “Guidance E – Per Cent for Art Note”
(e) Est. NPV Operation & Maintenance		541,196			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
Optimism Bias	40.0%	216,478	757,674	**4,259,519**	Refer to UCD for selecting OB %
Option Cost for Cost Benefit Analysis				**14,258,122**	

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	**J. Reynolds**	**Date:**	**13/05/2015**
Checked by:	**M. Conlon**	**Date:**	

Project reference	S16	**Project name:**	Shannon CFRAMS - S16 Tralee - Option 3
Base date for estimates (year 0)	Dec-2013	**Construction Price Index (CPI)**	**0.987**
Scaling factor (e.g. €m, €k, €)	€	**Method Factor - to take into account particular site issues /constraints**	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	**Cost (€)**	**Comment**
Total wall costs	€1,278,623	*ref: S16 Tralee - 01 Walls Option 3*
Total embankment costs	€64,569	*ref: S16 Tralee - 02 Embankments Option 3*
Total demountable barriers/gates costs	€17,000	*ref: S16 Tralee - 03 Demountable Walls & Gates Option 3*
Total in-channel excavation costs	€801,389	*ref: S16 Tralee - 04 Excavations (in channel) Option 3*
Total excavation on land costs	€171,846	*ref: S16 Tralee - 05 Excavations (on land) Option 3*
Total weir construction costs	€54,930	*ref: S16 Tralee - 06 Weir Option 3*
Total weir removal costs	inc. above	*ref: S16 Tralee - 06 Weir Option 3*
Total bridge removal costs	€49,301	*ref: S16 Tralee - 08 Bridges Option 3*
Total bridge construction costs	€1,908,391	*ref: S16 Tralee - 08 Bridges Option 3*
Total bridge underpinning costs		
Total culvert costs	€1,397,425	*ref: S16 Tralee - 10 Culverts Option 3*
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs	€48,048	*ref: S16 Tralee - 13 Individual Property Protection Option 3*
Total hydrometric gauging station costs	€8,400	
Total flood forecasting costs	€10,752	
Total pumping station costs		
Total channel maintenance costs	€0	*ref: S16 Tralee - 17 Channel Maintenance Option 3*
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€5,810,674	
Apply update to unit rate (CPI) if appropriate (cell N15)	€5,732,504	
Enter appropriate preliminaries estimate (%)	10.25%	*ref: Preliminaries and other costs v1.0*
Enter other applicable costs (€)		
Total capital cost (€)	€6,320,229	
Consider amendments based on site issues/constraints (cell N16)	€6,320,229	
Total capital cost (€)	**€6,320,229**	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs	€327	*ref: S16 Tralee - 01 Walls Option 3*
Total embankment O&M costs	€1,598	*ref: S16 Tralee - 02 Embankments Option 3*
Total demountable barriers/gates O&M costs	€86	*ref: S16 Tralee - 03 Demountable Walls & Gates Option 3*
Total in-channel excavation O&M costs	€0	*ref: S16 Tralee - 04 Excavations (in channel) Option 3*
Total excavation on land O&M costs	€0	*ref: S16 Tralee - 05 Excavations (on land) Option 3*
Total weir O&M costs	€3,750	*ref: S16 Tralee - 06 Weir Option 3*
Total weir removal O&M costs		
Total bridge O&M costs	€2,400	*ref: S16 Tralee - 08 Bridges Option 3*
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs	€4,928	*ref: S16 Tralee - 10 Culverts Option 3*
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs	€336	*ref: S16 Tralee - 13 Individual Property Protection Option 3*
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs	€2,420	
Total pumping station O&M costs		
Total channel maintenance O&M costs	€4,217	*ref: S16 Tralee - 17 Channel Maintenance Option 3*
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs	€5,296	*ref: S16 Tralee - TargetedPublicAwareness_Campaign*
Total Operation and Maintenance costs	€25,359	

Other costs	**Cost (€)**	**Comment**
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€6,861,425	
Optimism bias rate (from external sheet)	40%	*ref: Optimism Bias Tool v.2.0 - medium risk assumed.*
Total Cost including Optimism Bias	**€9,605,995**	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	€0
Year of capital works (year)	
Capital cost (€)	€6,320,229
Annual maintenance cost (€)	€25,359
Other cost (€)	€0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**		**Total PVc (€k):**	**6861425**
	Cash sum	0	6320229	1242584	0	7562814	**6861425**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	6320229			6320229.4	6320229.4
1	0.962			25359		25358.9	24383.5
2	0.925			25359		25358.9	23445.7
3	0.889			25359		25358.9	22543.9
4	0.855			25359		25358.9	21676.9
5	0.822			25359		25358.9	20843.1
6	0.790			25359		25358.9	20041.5
7	0.760			25359		25358.9	19270.7
8	0.731			25359		25358.9	18529.5
9	0.703			25359		25358.9	17816.8
10	0.676			25359		25358.9	17131.5
11	0.650			25359		25358.9	16472.6
12	0.625			25359		25358.9	15839.1
13	0.601			25359		25358.9	15229.9
14	0.577			25359		25358.9	14644.1
15	0.555			25359		25358.9	14080.9
16	0.534			25359		25358.9	13539.3
17	0.513			25359		25358.9	13018.6
18	0.494			25359		25358.9	12517.8
19	0.475			25359		25358.9	12036.4
20	0.456			25359		25358.9	11573.5
21	0.439			25359		25358.9	11128.3
22	0.422			25359		25358.9	10700.3
23	0.406			25359		25358.9	10288.8
24	0.390			25359		25358.9	9893.0
25	0.375			25359		25358.9	9512.5
26	0.361			25359		25358.9	9146.7
27	0.347			25359		25358.9	8794.9
28	0.333			25359		25358.9	8456.6
29	0.321			25359		25358.9	8131.4
30	0.308			25359		25358.9	7818.6
31	0.296			25359		25358.9	7517.9
32	0.285			25359		25358.9	7228.7
33	0.274			25359		25358.9	6950.7
34	0.264			25359		25358.9	6683.4
35	0.253			25359		25358.9	6426.3
36	0.244			25359		25358.9	6179.2
37	0.234			25359		25358.9	5941.5
38	0.225			25359		25358.9	5713.0
39	0.217			25359		25358.9	5493.3
40	0.208			25359		25358.9	5282.0
41	0.200			25359		25358.9	5078.8
42	0.193			25359		25358.9	4883.5
43	0.185			25359		25358.9	4695.7
44	0.178			25359		25358.9	4515.1
45	0.171			25359		25358.9	4341.4
46	0.165			25359		25358.9	4174.4
47	0.158			25359		25358.9	4013.9
48	0.152			25359		25358.9	3859.5
49	0.146			25359		25358.9	3711.0

Option 4 Costs for CBA

	CFRAM Programme – Option Costs for Cost Benefit Analysis		€	€	€	Notes to CFRAM Consultants
(1)	**Basic Construction Costs (Estimate)**				**7,849,262**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2)	**Preliminaries**	8.8%			**693,742**	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				**8,543,005**	
(3)	**Optimism Bias**	40.0%			**3,417,202**	Refer to UCD for selecting OB %
(4)	**Construction Costs (Excl VAT)**				**11,960,206**	
(5)	**Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)**	13.0%			**1,554,827**	Set at 13%
	Construction Costs and Fees				**13,515,033**	
(6)	**Other Items**					
(a)	Allowance for Archaeology & Environmental Mitigation Measures	15.0%		1,794,031		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b)	Allowance for compensation and land acquisition	15.0%		1,794,031		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c)	Site investigation	*9% assumed*		1,076,419		Professional judgement to be applied in estimating a suitable sum.
(d)	Art Allowance			51,000		See "Guidance E – Per Cent for Art Note"
(e)	Est. NPV Operation & Maintenance		558,269			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	40.0%	223,307	781,576	**5,497,057**	Refer to UCD for selecting OB %
	Option Cost for Cost Benefit Analysis				**19,012,090**	

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	J. Reynolds	**Date:**	13/05/2015
Checked by:	M. Conlon	**Date:**	

Project reference	S16	**Project name:**	Shannon CFRAMS - S16 Tralee - Option 4

Base date for estimates (year 0)	Dec-2013	**Construction Price Index (CPI)**	0.987
Scaling factor (e.g. €m, €k, €)	€	**Method Factor - to take into account particular site issues /constraints**	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	**Cost (€)**	**Comment**
Total wall costs	€1,278,623	*ref: S16 Tralee - 01 Walls Option 4*
Total embankment costs	€64,569	*ref: S16 Tralee - 02 Embankments Option 4*
Total demountable barriers/gates costs	€17,000	*ref: S16 Tralee - 03 Demountable Walls & Gates Option 4*
Total in-channel excavation costs	€801,389	*ref: S16 Tralee - 04 Excavations (in channel) Option 4*
Total excavation on land costs	€1,124,542	*ref: S16 Tralee - 05 Excavations (on land) Option 4*
Total weir construction costs	€54,930	*ref: S16 Tralee - 06 Weir Option 4*
Total weir removal costs	inc. above	*ref: S16 Tralee - 06 Weir Option 4*
Total bridge removal costs	€49,301	*ref: S16 Tralee - 08 Bridges Option 4*
Total bridge construction costs	€3,101,318	*ref: S16 Tralee - 08 Bridges Option 4*
Total bridge underpinning costs		
Total culvert costs	€1,397,425	*ref: S16 Tralee - 10 Culverts Option 4*
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs	€48,048	*ref: S16 Tralee - 13 Individual Property Protection Option 4*
Total hydrometric gauging station costs	€8,400	
Total flood forecasting costs	€10,752	
Total pumping station costs		
Total channel maintenance costs	€0	*ref: S16 Tralee - 17 Channel Maintenance Option 4*
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€7,956,297	
Apply update to unit rate (CPI) if appropriate (cell N15)	€7,849,262	
Enter appropriate preliminaries estimate (%)	8.84%	*ref: Preliminaries and other costs v1.0*
Enter other applicable costs (€)		
Total capital cost (€)	€8,543,005	
Consider amendments based on site issues/constraints (cell N16)	€8,543,005	
Total capital cost (€)	**€8,543,005**	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs	€327	*ref: S16 Tralee - 01 Walls Option 4*
Total embankment O&M costs	€1,598	*ref: S16 Tralee - 02 Embankments Option 4*
Total demountable barriers/gates O&M costs	€86	*ref: S16 Tralee - 03 Demountable Walls & Gates Option 4*
Total in-channel excavation O&M costs	€0	*ref: S16 Tralee - 04 Excavations (in channel) Option 4*
Total excavation on land O&M costs	€0	*ref: S16 Tralee - 05 Excavations (on land) Option 4*
Total weir O&M costs	€3,750	*ref: S16 Tralee - 06 Weir Option 4*
Total weir removal O&M costs		
Total bridge O&M costs	€3,200	*ref: S16 Tralee - 08 Bridges Option 4*
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs	€4,928	*ref: S16 Tralee - 10 Culverts Option 4*
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs	€336	*ref: S16 Tralee - 13 Individual Property Protection Option 4*
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs	€2,420	
Total pumping station O&M costs		
Total channel maintenance O&M costs	€4,217	*ref: S16 Tralee - 17 Channel Maintenance Option 4*
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs	€5,296	*ref: S16 Tralee - TargetedPublicAwareness_Campaign*
Total Operation and Maintenance costs	€26,159	

Other costs	**Cost (€)**	**Comment**
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€9,101,273	
Optimism bias rate (from external sheet)	40%	*ref: Optimism Bias Tool v.2.0 - medium risk assumed.*
Total Cost including Optimism Bias	**€12,741,783**	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	€0
Year of capital works (year)	
Capital cost (€)	€8,543,005
Annual maintenance cost (€)	€26,159
Other cost (€)	€0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**		**Total PVc (€k):**	**9101273**
	Cash sum	0	8543005	1281784	0	9824789	**9101273**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	8543005			8543004.6	8543004.6
1	0.962			26159		26158.9	25152.8
2	0.925			26159		26158.9	24185.3
3	0.889			26159		26158.9	23255.1
4	0.855			26159		26158.9	22360.7
5	0.822			26159		26158.9	21500.7
6	0.790			26159		26158.9	20673.7
7	0.760			26159		26158.9	19878.6
8	0.731			26159		26158.9	19114.0
9	0.703			26159		26158.9	18378.9
10	0.676			26159		26158.9	17672.0
11	0.650			26159		26158.9	16992.3
12	0.625			26159		26158.9	16338.8
13	0.601			26159		26158.9	15710.3
14	0.577			26159		26158.9	15106.1
15	0.555			26159		26158.9	14525.1
16	0.534			26159		26158.9	13966.4
17	0.513			26159		26158.9	13429.3
18	0.494			26159		26158.9	12912.8
19	0.475			26159		26158.9	12416.1
20	0.456			26159		26158.9	11938.6
21	0.439			26159		26158.9	11479.4
22	0.422			26159		26158.9	11037.9
23	0.406			26159		26158.9	10613.3
24	0.390			26159		26158.9	10205.1
25	0.375			26159		26158.9	9812.6
26	0.361			26159		26158.9	9435.2
27	0.347			26159		26158.9	9072.3
28	0.333			26159		26158.9	8723.4
29	0.321			26159		26158.9	8387.9
30	0.308			26159		26158.9	8065.3
31	0.296			26159		26158.9	7755.1
32	0.285			26159		26158.9	7456.8
33	0.274			26159		26158.9	7170.0
34	0.264			26159		26158.9	6894.2
35	0.253			26159		26158.9	6629.1
36	0.244			26159		26158.9	6374.1
37	0.234			26159		26158.9	6128.9
38	0.225			26159		26158.9	5893.2
39	0.217			26159		26158.9	5666.5
40	0.208			26159		26158.9	5448.6
41	0.200			26159		26158.9	5239.0
42	0.193			26159		26158.9	5037.5
43	0.185			26159		26158.9	4843.8
44	0.178			26159		26158.9	4657.5
45	0.171			26159		26158.9	4478.4
46	0.165			26159		26158.9	4306.1
47	0.158			26159		26158.9	4140.5
48	0.152			26159		26158.9	3981.2
49	0.146			26159		26158.9	3828.1

Appendix D: Economic Damage & Benefit Calculation and Cost Benefit Analysis

Contents

1 Introduction

This Appendix explains the process and methodology for the calculation of economic flood damages and the use of these economic damages for option benefit analysis. This methodology is based on OPW Guidance Note 27 (Rev.C).

The aim of OPW Guidance Note 27, and this Appendix, is to apply a common approach to the calculation of monetarised, economic flood damages, and the economic benefits of floor risk management options. These are then used for undertaking cost-benefit analysis, with a view to ensuring that damages, benefits, and benefit-cost calculations are determined in a nationally consistent manner, to enable inter-comparability of proposed measures across the country.

2 Economic Damage and Benefit Calculation

2.1 Introduction

The calculation of economic benefits is undertaken using standardised guidelines and figures, provided in the Flood Hazard Research Centre Handbook of 2010 (FHRC, 2010) and the 'Multi-Coloured Manual' of 2005 (FHRC, 2005) as referred to in FHRC, subject to caveats, amendment and clarification set out in the OPW Guidance Note 27 'Economic Damage and Benefit Calculation and Cost-Benefit Analysis' Rev. C.

The approach provides an economic, as opposed to financial assessment. For example, residential property damages take account of depreciation of the value of contents (e.g. replacing items like-for-like, as opposed to purchasing new items). Indirect damages to non-residential properties are included for some types (e.g. damage to small, individually, or family owned businesses) whereas loss of business is generally not included as this is assumed to be displaced to elsewhere within the economy.

2.2 Methodology

The assessment of the overall economic damages associated with flooding is composed of the following components:

- **Principal Direct Damages:** Direct property damage to residential and non-residential properties
- **Intangible and Intangible damage**
- **Emergency services**
- **Infrastructural Utility Assets**

2.2.1 Direct Property Damage – Residential and Non-Residential

(a) Residential Properties

Direct property damages to Residential Properties are calculated according to the depth-damage data presented in the 2010 Handbook for economic appraisal. The data is matched to each property based on the depth of flooding and the MCM code which categorises the property into various residential categories (e.g. detached, semi-detached, terraced, Bungalow). Details of the property types are provided in the GeoDirectory for Ireland.

Flood damages for residential properties begin at flood depths of -0.3 m relative to threshold levels. This only applies however, to properties whose footprint lies within the flooded area.

For properties with basements, the flood damages for the property assume a depth of 2.4m once the flood depth exceeds the threshold level for the basement. This damage is in addition to the normal depth-damage calculation for the ground floor of the property.

Different depth damage curves are used for the different property types dependant on the duration of flooding;

- >12 hours
- <12 hours

An additional 10% is applied to the damages for non –residential properties at risk of flooding from coastal sources.

The damages from the depth damage curve are converted to Euros using £1 = €1.279 conversion rate and an inflation multiplication factor of 1.051 has been applied. This is derived from inflation rates based on the CPI in Ireland for the period 2010 - 2013.

(b) Non Residential Properties

Direct property damages to Non - Residential Properties are calculated according to the indicative susceptibility depth-damage data presented in the 2010 Handbook for economic appraisal. The data is matched to each property based on the depth of flooding and the "MCM code" as referred to the FHRC 2005 and 2010 which categorises the property into various non- residential categories (e.g. high street shop, warehouse). There are different depth-damage curves for each MCM code.

Although, the GeoDirectory for Ireland does not provide a MCM code for each non-residential property type, it does provide a NACE code which has been used to determine the representative MCM code for each Non-Residential Property. In instances where the NACE code is not provided in the Geodirectory it is determined manually using professional judgement and a combination of site visits and remote data, such as 'Google Street Map'.

Direct flood damages for non-residential properties are calculated on a £/m^2 basis (converted to €/m^2).

Flood damages for non-residential properties begin at flood depths of 0m relative to threshold levels.

Depth damage curves for non-residential properties are only available for durations less than 12 hours in the FHRC 2010.

An additional 10% is applied to the damages for non –residential properties at risk of flooding from coastal sources.

Where the property type is mixed i.e. there is both residential and non-residential classification applied to the property, it has been assumed that the non-residential element of the property is located on the ground floor and damages associated with non-residential properties has been applied. Spot checks of this have been carried out using 'Google Street Map'.

As for residential properties the damages from the depth damage curve are converted to Euros using £1 = €1.279 conversion rate and an inflation multiplication factor of 1.051 has been applied. This is derived from inflation rates based on the CPI in Ireland for the period 2010 - 2013.

2.2.2 Principal Direct Damage

Principal Direct Damages are the sum of the residential and non-residential property damages.

The Average Annual Damages (AAD) are based on the modelled probability events occurring in any given year. A minimum of three events are required to generate a meaningful result, and a maximum of eight events can be considered. The total PV direct damages are then calculated by discounting the AAD over the specified appraisal period.

2.2.3 Intangible and Indirect Damages

Flood events can cause significant stress, anxiety, and ill health to potentially affected people, during and hen after a flood. Individuals generally incur some costs due to their properties flooding that are not directly related to damage, such as evacuation, temporary accommodation, loss of earnings, increased travel and shopping costs, etc.

While these negative impacts are difficult to monetarise or quantify, it is recognised that these impacts are significant, and professional opinion has indicated that they could well be greater than the direct damages to residential properties.

For residential properties, the intangible and indirect flood damages shall together be set equal to the total (direct) property damages.

Intangible damages may also be applied in the case of small, individually, or family-owned businesses where the intangible impact would be personal and similar in nature to that which might be experienced were the property residential.

2.2.4 Emergency Services

Costs to emergency services (which include evacuation costs) are included in the economic damages, and are calculated as 8.1% of the total Principal Direct Damage (PDD) Costs.

2.2.5 Infrastructural Utility Assets

Economic damages to infrastructural utility assets (e.g. electrical sub-stations, gas installations and pipe-work, telecommunications assets, etc.) are calculated as 20% of total PDD Costs.

2.2.6 Annual Average Damage

Damages are calculated for each property residential and non-residential for each of the following AEP events;

- 50%, 20%, 10%, 4%, 2%, 1%, 0.5% and 0.1%

The Annual Average Damage (AAD) is calculated using linear interpolation between damage values for each of these defined design events; i.e. with a damage value calculated for each ‘slice’ based on the average of the damages for the design event damages that form the probability boundaries for the ‘slice’, and the probability range of the ‘slice’.

The AAD is calculated as the sum of the damage values of each slice, up to and including the 'slice' with the 0.1% AEP event as the upper bounding event.

The AAD is also calculated for the MRFS and the HEFS scenarios. For The HEFS as the depth are only available for the 10%, 1% (0.5% for coastal flooding) and 0.1% AEP events the damages for these events are calculated these values are used to shift the MRFS damage curve to derive an indicative damage curve for the HEFS.

2.2.7 Present Value Damages

The PVd are calculated as the discounted sum of the annual average damages over the project horizon, where:

- The discount rate to be applied is 4%
- The project horizon is 50 years

2.2.8 Capped Present Value Damages

Capped PV Damages are the damages capped at the value of the properties contributing to the damages.

The capping value of the direct damages for a residential property is the value of that property. The value of the property has been based on the property price guide[1] see annex B1.

The capping value of the intangible and indirect damage for a residential property is also the value of the property.

The capping value of the direct damages for a non- residential property is 10 time the rateable value of the property multiplied by the floor area and the yield value, see annex B2.

2.3 ArcGIS Tool

An ArcGIS tool has been developed for this project that rapidly calculates the economic cost of flooding to properties, based on model predictions of flood depth. Compared with the alternative calculation methods based in Excel, the ArcGIS tool offers a number of benefits, including efficiency and robustness.

2.3.1 Parameters

The tool is set up to use hydraulic model predictions of flood depth at individual property locations that have already been incorporated into a property database (ArcGIS point layer). Each unique property point in the GeoDirectory is assigned a flood depth for each modelled probability event.

The following key information, used by the tool, is provided in the Geodirectory for each address point:

- Unique geo-database ID

[1] "Property Price Guide" - The Sunday Times 11/01/2015

- Building use type (residential, non-residential, or unknown)
- Residential property type
- Non-Residential property type
- Location coordinates (Easting and Northing)
- European industrial activity classification (NACE) code

In addition to the above parameters the floor area for non-residential properties are required.

Note that where any of the above data is not available, assumptions using professional judgement have been used in order to approximate the damages.

The following parameters must be specified as the tool is run:

- Region of Study – select from 14 regions in the Shannon RBD[2] to load approximate market values for each type of residential property (see Annex B). This is to allow damage estimates to be capped at market prices.
- Appraisal period – the default project horizon is 50 years and the default discount rate is specified as 4%. Additional discount rates of 3% and 5% can be selected. As specified in OPW GN27 Section 3.8.
- Emergency service costs – specified value of 8.1% is applied as a default (see Section 2.2.4).
- Property threshold – The default values are 0.15 m for residential and 0.0 m for non-residential. When surveyed thresholds are available then the tool will revert to that value.
- Duration of flooding – specify shorter or longer than 12 hours as there are different depth-damage datasets for residential property types depending on the duration (see Section 2.2.5).
- Coastal uplift – an uplift (10%) to account for increased property damages due to coastal (saltwater) inundation.

[2] Clare, Cork, Galway, Galway City, Kerry, Laois, Leitrim, Limerick, Limerick City, Longford, Offaly, Roscommon, Tipperary, and Westmeath

3 Cost Benefit Analysis

3.1 General Methodology

As detailed in OPW Guidance Note 27, the benefit-cost ratio (BCR) is produced as the output of the cost-benefit analysis. This is calculated by dividing the Present Value Benefits (PVb) for an option or measure, capped as appropriate, by the whole life costs (PVc) of that option or measure. Measures are only recommended as measures to be put forward in the Flood Risk Management Plan if their BCR is greater than unity.

In addition, the Net Present Value of the benefits (NPVb) of the option is calculated by deduction the PVc from the capped PVb.

Table C.1, below, taken from OPW Guidance Note 27 - Appendix B, and sets out which parameters are applicable for each use (Economic CBA, Economic Risk Mapping, and appraisal against MCA Objective 2.1), and how some of the parameters (e.g. Total damages for a given event, AAD) are calculated based on previous parameters.

As set out in the Generic CFRAM Project Brief, sensitivity tests are undertaken to determine the BCR using higher or lower discount rates, which are 5% and 3% respectively.

Further guidance on deriving costs for options or measures is provided in the OPW Guidance Note on the use of Unit Cost Database.

Table C.1 Cost Benefit Analysis Explanatory Table

Parameter		Application		
		Economic CBA	**Economic Risk Mapping**	**MCA Appraisal Objective 2.a**
1.	Residential Damages	Yes	Yes	Yes
2.	Non-Residential Damages	Yes	Yes	Yes
3.	Principal Direct Damages (PDD)	1 + 2	1 + 2	1 + 2
4.	Intangible Damages	Yes	Yes	No
5.	Infrastructural Utility Damages	Yes	Yes	No
6.	Emergency Services	Yes	Yes	Yes
7.	Traffic Disruption	Possibly	Possibly	No
8.	Event Damage	3 + 4 + 5 + 6 + 7	3 + 4 + 5 + 6 + 7	3 + 6
9.	Annual Average Damage (AAD)	Annualise 8	Annualise 8	Annualise 8
10.	Present Value of Damages (PVd)	Discounted sum of 9 over the Project Horizon	N/A	Discounted sum of 9 over the Project Horizon
11.	Un-capped PVb	Reduction in PVd (10) provided by option	N/A	Reduction in PVd (10) provided by option
12.	Capping Value	Double Residential Property Value, or, = Non-Residential Property Value	N/A	N/A
13.	Capped PVb	11, but not > 12	N/A	11
14.	PVc	Whole Life Scheme Cost	N/A	Whole Life Scheme Cost
15.	BCR	13 / 14	N/A	13 / 14
16.	NPVb	13 - 14	N/A	13 - 14

Annex A Direct Damage Values (2014-15 Price Base)

A.1 Residential Properties Short Duration Flooding (<12 Hours)

		MCM Damage Data - Direct Damage (€/m depth)														
MCM Code	**Property Type**	**-0.30**	**0.00**	**0.05**	**0.10**	**0.20**	**0.30**	**0.60**	**0.90**	**1.20**	**1.50**	**1.80**	**2.10**	**2.40**	**2.70**	**3.00**
110	DETACHED	1103	1103	13005	19238	32571	39371	47997	52439	57472	61986	69524	73807	77613	86219	90731
120	SEMI DETACHED	1476	1476	10851	14867	23799	27912	34399	36779	40156	42834	48214	51137	54220	60437	63476
130	TERRACE	1282	1282	9410	12949	21119	24786	30710	32823	35777	37968	42326	44515	46862	52628	54995
140	BUNGALOW	1030	1030	12888	18962	30643	36171	44664	48956	54063	58684	66296	70888	75340	84196	88899
150	FLAT	861	861	10824	14849	23924	27917	34748	37071	39797	41628	46074	47802	49213	54121	56054

A.2 Residential Properties Long Duration Flooding (<12 Hours)

		MCM Damage Data - Direct Damage (€/m depth)														
MCM Code	**Property Type**	**-0.30**	**0.00**	**0.05**	**0.10**	**0.20**	**0.30**	**0.60**	**0.90**	**1.20**	**1.50**	**1.80**	**2.10**	**2.40**	**2.70**	**3.00**
110	DETACHED	1690	5271	23909	34105	47730	57471	64134	68302	72318	79174	87493	97363	102668	108187	114594
120	SEMI DETACHED	1853	3891	17130	24836	34171	40770	45135	47766	50338	54547	60061	66876	70418	74255	78534
130	TERRACE	1655	3327	14721	21463	29974	35913	39799	42183	44369	47579	51967	58035	60317	62817	65677
140	BUNGALOW	1768	5043	22843	33627	46399	54661	61385	66185	70367	77501	85955	96665	102804	108436	115519
150	FLAT	1168	3086	16548	24169	33165	39272	43581	46087	48008	50290	54780	60141	62162	64256	66891

A.3 Non-Residential Properties Short Duration Flooding (<12 Hours)

		MCM Damage Data - Direct Damage (€/m^2/m depth)																
MCM Code	**Property Type**	**-1.00**	**-0.75**	**-0.5**	**-0.25**	**0.00**	**0.25**	**0.50**	**0.75**	**1.00**	**1.25**	**1.50**	**1.75**	**2.00**	**2.25**	**2.50**	**2.75**	**3.00**
210	Shop/Store (Weighted mean)	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
211	(High Street) Shop	0	0	0	0	0	249	540	811	1022	1167	1291	1384	1469	1534	1597	1640	1686
213	Superstore/Hypermarket	0	0	0	0	0	441	991	1421	1794	2210	2430	2525	2619	2659	2703	2729	2758
214	Retail Warehouse	0	0	0	0	0	600	804	997	1142	1267	1383	1457	1524	1578	1629	1677	1717
215	Showroom	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
216	Kiosk	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
217	Outdoor market	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
218	Indoor Market	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
220	Vehicle Services (Weighted mean)	0	0	0	0	0	111	255	374	456	514	571	607	640	666	693	715	741
221	Vehicle Repair Garage	0	0	0	0	0	75	209	315	385	437	489	520	548	572	596	615	638
222	Petrol Filling Station	0	0	0	0	0	190	352	481	586	644	701	731	758	779	801	818	839
223	Car Showroom	0	0	0	0	0	220	394	568	691	778	860	929	989	1036	1084	1125	1172
224	Plant Hire	0	0	0	0	0	71	147	246	320	723	1124	1509	1891	1930	1969	1989	2013
230	Retail Services (Weighted mean)	0	0	0	0	0	205	395	608	772	897	1009	1097	1169	1219	1271	1311	1361
231	Hairdressing Salon	0	0	0	0	0	56	141	199	274	364	420	461	485	511	541	568	605
232	Betting Shop	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
233	Laundrette	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
234	Pub/Social club/wine bar	0	0	0	0	0	202	371	582	732	836	939	1018	1087	1133	1182	1219	1264
235	Restaurant	0	0	0	0	0	210	433	712	928	1098	1236	1349	1450	1522	1596	1656	1728
236	Café/Food Court	0	0	0	0	0	379	713	985	1204	1366	1528	1663	1745	1793	1838	1872	1914
237	Post Office	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
238	Garden Centre	0	0	0	0	0	53	112	148	184	215	245	273	299	309	317	325	334
300	Office (Weighted mean)	0	0	0	0	0	197	378	585	738	830	915	978	1033	1077	1123	1159	1202
310	Offices (non-specific)	0	0	0	0	0	196	376	581	733	824	909	972	1027	1070	1116	1151	1194
311	Computer Centres (Hi-Tech)	0	0	0	0	0	1854	3482	4589	5410	6061	6364	6458	6543	6609	6679	6732	6796
320	Bank	0	0	0	0	0	172	340	546	683	782	875	943	1006	1060	1120	1169	1219
400	Distribution/Logistics (Mean-all 4 w/h codes)	0	0	0	0	0	198	394	614	796	950	1101	1237	1371	1489	1607	1720	1824
410	Warehouse (including store)	0	0	0	0	0	76	141	218	275	317	358	389	417	436	455	470	488
420	Land Used for Storage	0	0	0	0	0	1	9	86	137	189	239	269	294	311	327	340	353
430	Road Haulage	0	0	0	0	0	76	141	218	275	317	358	389	417	436	455	470	488
411	Warehouse	0	0	0	0	0	254	487	713	919	1109	1298	1486	1679	1856	2034	2210	2332
412	Warehouse	0	0	0	0	0	100	200	332	432	505	583	648	702	755	806	847	899
413	Warehouse	0	0	0	0	0	360	747	1195	1556	1868	2165	2426	2684	2909	3132	3354	3577
510	Leisure (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
511	Hotel	0	0	0	0	0	217	400	652	922	1034	1144	1222	1292	1346	1404	1448	1502
512	Boarding House	0	0	0	0	0	68	113	362	588	733	862	944	1010	1058	1104	1140	1174
513	Caravan Mobile	0	0	0	0	0	0	0	448	611	724	913	1042	1100	1147	1188	1224	1269

514	Caravan Static	0	0	0	0	0	53	95	178	229	296	359	422	464	487	502	524	537
515	Self-catering Unit	0	0	0	0	0	247	326	433	511	566	619	660	696	724	754	777	805
516	Hostel (including prisons)	0	0	0	0	0	247	326	433	511	566	619	660	696	724	754	777	805
517	Bingo hall	0	0	0	0	0	801	1597	2474	2622	2725	2826	2897	2962	3012	3065	3105	3154
518	Theatre/Cinema	0	0	0	0	0	416	736	1086	1345	1525	1656	1748	1833	1903	1971	2023	2078
519	Beach Hut	0	0	0	0	0	29	68	113	169	187	194	199	203	204	204	204	205
520	Sport (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
521	Sports Grounds and Playing Fields	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
522	Golf Courses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
523	Sports and Leisure centres	0	0	0	0	0	181	369	558	715	800	884	951	1013	1051	1088	1119	1156
524	Amusement Arcade/Park	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
525	Football Ground and Stadia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
526	Mooring/Wharf/Marina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
527	Swimming Pool	0	0	0	0	0	181	369	558	715	800	884	951	1013	1051	1088	1119	1156
600	Public Building (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
610	School/College/University/Nursery	0	0	0	0	0	432	786	1164	1440	1673	1838	1969	2085	2191	2295	2371	2458
620	Surgery/Health Centre	0	0	0	0	0	332	465	559	647	790	874	923	970	1015	1049	1093	1136
625	Residential Home	0	0	0	0	0	247	326	433	511	566	619	660	696	724	754	777	805
630	Community Centres/Halls	0	0	0	0	0	73	169	245	325	370	417	460	506	532	538	543	546
640	Library	0	0	0	0	0	244	490	889	1146	1346	1536	1697	1844	1889	1936	1972	2016
650	Fire/Ambulance station	0	0	0	0	0	120	255	419	552	668	791	868	983	1013	1044	1068	1098
651	Police Station	0	0	0	0	0	196	376	581	733	824	909	972	1027	1070	1116	1151	1194
660	Hospital	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
670	Museum	0	0	0	0	0	244	490	889	1146	1346	1536	1697	1844	1889	1936	1972	2016
680	Law court	0	0	0	0	0	196	376	581	733	824	909	972	1027	1070	1116	1151	1194
690	Church	0	0	0	0	0	70	144	205	266	298	332	364	398	419	424	428	431
800	Industry (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
810	Workshop	0	0	0	0	0	204	519	728	861	941	1006	1046	1082	1113	1140	1169	1203
820	Factory/Works/Mill	0	0	0	0	0	204	519	728	861	941	1006	1046	1082	1113	1140	1169	1203
830	Extractive/heavy Industry	0	0	0	0	0	3	45	146	201	271	335	386	425	455	486	545	581
840	Sewage treatment works	0	0	0	0	0	3	45	146	201	271	335	386	425	455	486	545	581
850	Laboratory	0	0	0	0	0	3456	3970	4544	5007	5513	6018	6440	6907	6957	7010	7050	7100
900	Miscellaneous (Weighted mean)	0	2	5	17	32	32	32	32	32	32	32	32	32	32	32	32	32
910	Car Park	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
920	Public Convenience	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
930	Cemetery/Crematorium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
940	Bus Station	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
950	Dock Hereditament	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
960	Electricity Hereditament	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

A.4 Non-Residential Properties Long Duration Flooding (>12 Hours)

		MCM Damage Data - Direct Damage (€/m^2/m depth)																
MCM Code	**Property Type**	**-1.00**	**-0.75**	**-0.5**	**-0.25**	**0.00**	**0.25**	**0.50**	**0.75**	**1.00**	**1.25**	**1.50**	**1.75**	**2.00**	**2.25**	**2.50**	**2.75**	**3.00**
210	Shop/Store (Weighted mean)	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
211	(High Street) Shop	0	0	0	0	0	328	702	1022	1246	1400	1536	1633	1733	1795	1869	1919	1972
213	Superstore/Hypermarket	0	0	0	0	0	582	1288	1790	2188	2652	2892	2979	3090	3111	3162	3193	3227
214	Retail Warehouse	0	0	0	0	0	793	1045	1256	1394	1520	1646	1720	1798	1846	1906	1962	2009
215	Showroom	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
216	Kiosk	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
217	Outdoor market	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
218	Indoor Market	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
220	Vehicle Services (Weighted mean)	0	0	0	0	0	147	332	471	557	617	679	716	755	779	811	836	867
221	Vehicle Repair Garage	0	0	0	0	0	99	272	397	469	524	581	613	647	669	697	719	746
222	Petrol Filling Station	0	0	0	0	0	251	458	606	715	773	834	863	894	912	938	958	982
223	Car Showroom	0	0	0	0	0	290	513	716	843	933	1023	1097	1167	1212	1268	1317	1371
224	Plant Hire	0	0	0	0	0	94	192	310	390	867	1338	1781	2231	2258	2304	2327	2355
230	Retail Services (Weighted mean)	0	0	0	0	0	270	513	766	942	1076	1200	1294	1379	1426	1487	1534	1593
231	Hairdressing Salon	0	0	0	0	0	75	183	250	334	436	499	544	573	598	633	665	707
232	Betting Shop	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
233	Laundrette	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
234	Pub/Social club/wine bar	0	0	0	0	0	266	482	733	893	1004	1118	1201	1282	1326	1383	1426	1479
235	Restaurant	0	0	0	0	0	277	563	897	1132	1318	1471	1592	1711	1781	1867	1938	2022
236	Café/Food Court	0	0	0	0	0	501	927	1241	1469	1639	1818	1962	2059	2098	2151	2190	2239
237	Post Office	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
238	Garden Centre	0	0	0	0	0	69	146	187	224	258	292	322	353	361	371	380	390
300	Office (Weighted mean)	0	0	0	0	0	260	492	737	900	995	1089	1154	1219	1260	1314	1356	1406
310	Offices (non-specific)	0	0	0	0	0	258	488	732	895	989	1082	1147	1212	1252	1305	1347	1396
311	Computer Centres (Hi-Tech)	0	0	0	0	0	2448	4526	5782	6600	7273	7574	7621	7720	7732	7814	7876	7952
320	Bank	0	0	0	0	0	227	441	688	833	939	1041	1112	1187	1240	1311	1368	1427
400	Distribution/Logistics (Mean-all 4 w/h codes)	0	0	0	0	0	261	512	774	971	1140	1310	1460	1617	1742	1880	2012	2134
410	Warehouse (including store)	0	0	0	0	0	101	183	274	336	380	426	459	492	510	532	549	571
420	Land Used for Storage	0	0	0	0	0	1	12	108	167	227	285	317	347	364	383	398	413
430	Road Haulage	0	0	0	0	0	101	183	274	336	380	426	459	492	510	532	549	571
411	Warehouse	0	0	0	0	0	336	633	898	1121	1331	1545	1754	1981	2172	2380	2585	2728
412	Warehouse	0	0	0	0	0	132	260	418	527	607	694	765	829	883	943	991	1052
413	Warehouse	0	0	0	0	0	475	972	1506	1898	2242	2576	2862	3167	3404	3665	3924	4185
510	Leisure (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
511	Hotel	0	0	0	0	0	286	520	822	1125	1241	1361	1442	1524	1575	1643	1694	1757
512	Boarding House	0	0	0	0	0	89	146	456	718	879	1026	1114	1192	1238	1291	1333	1374
513	Caravan Mobile	0	0	0	0	0	0	0	564	746	869	1087	1230	1298	1342	1390	1432	1484

514	Caravan Static	0	0	0	0	0	70	124	224	280	355	427	498	547	570	587	613	629
515	Self-catering Unit	0	0	0	0	0	326	424	546	623	679	737	779	821	848	882	909	942
516	Hostel (including prisons)	0	0	0	0	0	326	424	546	623	679	737	779	821	848	882	909	942
517	Bingo hall	0	0	0	0	0	1057	2077	3117	3199	3270	3363	3419	3495	3524	3586	3633	3691
518	Theatre/Cinema	0	0	0	0	0	550	957	1369	1640	1830	1971	2063	2163	2227	2306	2367	2431
519	Beach Hut	0	0	0	0	0	38	88	143	206	224	231	235	239	239	239	239	240
520	Sport (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
521	Sports Grounds and Playing Fields	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
522	Golf Courses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
523	Sports and Leisure centres	0	0	0	0	0	240	480	703	872	959	1052	1122	1195	1229	1273	1310	1353
524	Amusement Arcade/Park	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
525	Football Ground and Stadia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
526	Mooring/Wharf/Marina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
527	Swimming Pool	0	0	0	0	0	240	480	703	872	959	1052	1122	1195	1229	1273	1310	1353
600	Public Building (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
610	School/College/University/Nursery	0	0	0	0	0	570	1022	1466	1756	2008	2187	2324	2461	2563	2685	2774	2876
620	Surgery/Health Centre	0	0	0	0	0	439	604	705	789	948	1040	1089	1145	1187	1228	1279	1329
625	Residential Home	0	0	0	0	0	326	424	546	623	679	737	779	821	848	882	909	942
630	Community Centres/Halls	0	0	0	0	0	96	220	308	396	444	496	543	598	623	629	635	639
640	Library	0	0	0	0	0	322	637	1120	1399	1615	1828	2003	2175	2210	2265	2307	2359
650	Fire/Ambulance station	0	0	0	0	0	158	331	528	673	801	942	1024	1160	1185	1222	1250	1284
651	Police Station	0	0	0	0	0	258	488	732	895	989	1082	1147	1212	1252	1305	1347	1396
660	Hospital	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
670	Museum	0	0	0	0	0	322	637	1120	1399	1615	1828	2003	2175	2210	2265	2307	2359
680	Law court	0	0	0	0	0	258	488	732	895	989	1082	1147	1212	1252	1305	1347	1396
690	Church	0	0	0	0	0	92	188	258	325	358	395	429	469	490	496	501	505
800	Industry (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
810	Workshop	0	0	0	0	0	269	675	917	1051	1129	1197	1235	1276	1302	1333	1367	1407
820	Factory/Works/Mill	0	0	0	0	0	269	675	917	1051	1129	1197	1235	1276	1302	1333	1367	1407
830	Extractive/heavy Industry	0	0	0	0	0	4	58	184	245	325	399	456	501	533	569	637	679
840	Sewage treatment works	0	0	0	0	0	4	58	184	245	325	399	456	501	533	569	637	679
850	Laboratory	0	0	0	0	0	4562	5161	5725	6109	6616	7161	7599	8150	8140	8202	8249	8307
900	Miscellaneous (Weighted mean)	0	2	5	17	32	43	42	41	39	39	38	38	38	38	38	38	38
910	Car Park	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
920	Public Convenience	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
930	Cemetery/Crematorium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
940	Bus Station	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
950	Dock Hereditament	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
960	Electricity Hereditament	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Annex B Default Market Values

B.1 Residential Property Market Values

The value of residential properties has been based on the price guide from the "Property Price Guide" - The Sunday Times (11/01/2015).

Table B.1 Residential Property Market Values

Region	Bungalow	Detached	Semi-detached	Terrace	Duplex
Leitrim	€ 95,271	€ 112,308	€ 56,822	€ 49,521	€ 0
Roscommon	€ 68,667	€ 83,750	€ 76,800	€ 62,500	€ 0
Longford	€ 89,700	€ 103,400	€ 63,800	€ 27,500	€ 49,500
Westmeath	€ 111,700	€ 239,100	€ 107,325	€ 76,100	€ 82,475
Offaly	€ 122,500	€ 176,800	€ 137,700	€ 52,200	€ 56,000
Laois	€ 126,200	€ 107,300	€ 172,640	€ 64,000	€ 0
Tipperary	€ 90,100	€ 250,700	€ 103,500	€ 47,303	€ 0
Galway	€ 80,660	€ 171,000	€ 105,525	€ 99,800	€ 165,600
Galway City	€ 390,750	€ 313,829	€ 255,969	€ 212,300	€ 187,900
Clare	€ 117,226	€ 143,000	€ 98,300	€ 56,700	€ 83,500
Limerick	€ 77,980	€ 136,400	€ 120,700	€ 72,720	€ 146,450
Limerick City	€ 160,040	€ 225,300	€ 126,660	€ 69,300	€ 0
Kerry	€ 110,100	€ 93,200	€ 125,800	€ 78,400	€ 74,000
Cork (Charleville & Milford only)	€ 132,200	€ 102,110	€ 52,800	€ 38,000	€ 0

B.2 Non-Residential Property Values

Non-residential rateable values are taken from the 'Commercial and Industrial Floorspace and Rateable Value Statistics' - April 2008 values. (https://www.gov.uk/government/statistical-data-sets/live-tables-on-commercial-and-industrial-floorspace-and-rateable-value-statistics).

It has been determined that non-residential rateable values for the South West of England provide the most representative rates for Irish rates.

An inflation rate of 1.052 was applied to these rates to obtain the 2010 rateable values. Once the 2010 values were obtained a currency conversion of 1.279 and inflation rate of 1.051 was applied as for the direct property damages.

No rateable information is provided for property classes of Leisure or Public Buildings, therefore the assumption was made that Leisure and Public Building are set to be equal to the 'Other' category.

An EY factor is used to convert the rateable value into an estimated market value for non-residential properties. The market value is estimated by the following calculation:

Market Value (£/m2) = Rateable Value (£/m2) * 100/EY

For all non-residential property types the EY factor has been set at 10%.

Table B.2 Rateable Values

Region	Retail	Office	Warehouse	Leisure & Public	Industry
London	267	252	86	74	72
South East	195	146	74	47	57
Eastern	181	137	64	49	51
South West	161	115	51	37	41
East Midlands	148	99	49	42	38
West Midlands	158	120	51	47	37
Wales	139	96	40	31	31
North West	161	108	44	41	34
Yorkshire & Humberside	160	107	42	37	33
North East	157	96	37	28	31

Appendix E Option Development Meeting - Minutes

Appendix F MCA objectives and Scoring Methodology

MCA Objectives

The MCA objectives are outlined in GN 28. GN 28 has been provided for reference in Appendix G of this report. The FRM objectives reflect what the overall flood risk management programme is seeking to achieve, expanding on the requirements of the National Flood Policy Review and the European Unions (EUs) ‘Floods’ Directive.

At a local level, and for the purposes of the MCA, the objectives set out an aim that the each flood risk management option should be seeking to achieve, if possible. The degree to which an option achieves the objective is an indication of the ‘success’ of the option, and equally, the more an option achieves across all of the objectives, then the greater the preference that will be given to that option relative to others, taking account also of the cost of each of the options.

The flood risk management objects are split into four categories:

- Technical
- Economic
- Social
- Environmental

These objectives have been split into sub-objective. The sub-objective for each categories and the scoring mechanism used are outlined in Tables F.1 to Tables F.4 overleaf.

Table F.1 Technical Objective

Technical Objective				
Objective	**Description of Scoring**	**Global Weighting**	**Local Weighting**	**Scoring Range**
Technical 1A – Ensure flood risk management options are operationally robust	Scoring is to be by professional judgement, based on the guidance, taking into account the degree of reliance of the option on mechanical, electrical or electronic systems ('systems'), or on human intervention, action or decision ('intervention') to operate or perform successfully.	20	5 (Constant)	5 : No Operation Risk 4 to 5 : Negligible Operational Risk 3 to 4 : Very Low Operational Risk 2 to 3 : Low Operational Risk 1 to 2 : Low / Moderate Operational Risk 0 to 1 : Moderate but Manageable Operational Risk -1 to 0 : Moderate / High Operational Risk -3 to -1 : High Operational Risk -5 to -3 : Foreseeable likelihood of failure -999 to -5 : Unacceptable Risk
Technical 1B – Minimise health and safety risk in construction and operation of the flood risk management option	Scoring is to be by professional judgement, The indicative score under this objective should be set at five, and then have a point deducted for each specific risk (as defined under the Safety, Health and Welfare at work (Construction) Regulations) likely to be encountered in a) construction and then again in b) operation and maintenance.	20	5 (Constant)	5 : No H&S Risk 4 to 5 : Negligible H&S Risk 3 to 4 : Very Low H&S Risk 2 to 3 : Low H&S Risk 1 to 2 : Low / Moderate H&S Risk 0 to 1 : Moderate but Manageable H&S Risk -1 to 0 : Moderate / High H&S Risk -3 to -1 : High H&S Risk -5 to -3 : High H&S Risk -999 to -5 : Unacceptable Risk
Technical 1C – Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change	Scoring is to be by professional judgement, based on guidance.	20	5 (Constant)	>3 : Option can be adapted at no to limited cost and difficulty, and provides no impediment to future interventions. 0 to 3 : Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. -3 to 0 : Option cannot be adapted, but provides no to minor impediment to potential future interventions. -999 to -3 : Option cannot be adapted, and provides moderate to major impediment to potential future interventions.

Table F.2 Economic Objective

Economic Objective				
Objective	**Description of Scoring**	**Global Weighting**	**Local Weighting**	**Scoring Range**
Economic 2A – Reduce economic damages	Option Score = 0.05 X Percentage Reduction in AAD. The following values should apply as the percentage reduction in AAD for non-structural options (i.e. those that do no reduce hazard, but can reduce it) % Reduction in AAD 10 % : >12 hours warning 6% : 6-12 hours warning 4% : 2-6 hours warning 0% : < 2 hours warning	24	AAD for the SSA / € 75,000. Subject to a maximum local weighting of 5.	5 : 100 % reduction in AAD 0 : No change in AAD < 0 : A negative score indicates that AAD has increased
Economic 2B – Minimise risk to transport infrastructure	Scoring is based on degree of reduction of flood risk to transport receptors at risk from flooding. Each type of transport receptor is assigned a score and scoring is calculated based on a score derived from the number and type of transport infrastructure receptors potentially affected by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of that receptor. This score can be adjusted by professional judgement.	10	Based on calculated assessment, adjusted by professional judgement, subject to a maximum local weighting of 5.	N/A : No transport infrastructure at risk 5 : The risk to transport infrastructure is reduced to zero 0 : No change in risk to transport infrastructure < 0 : A negative score indicates an increased risk to transport infrastructure.
Economic 2C – Minimise risk to utility infrastructure	Scoring is based on degree of reduction of flood risk to utility receptors at risk from flooding. Each type of utility receptor is assigned a score and scoring is calculated based on a score derived from the number and type of utility infrastructure receptors potentially affected by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of that receptor. This score can be adjusted by professional judgement.	14	Based on calculated assessment, adjusted by professional judgement, subject to a maximum local weighting of 5.	N/A : No utility infrastructure at risk 5 : The risk to utility infrastructures is reduced to zero 0 : No change in risk to utility infrastructure < 0 : A negative score indicates an increase in risk to utility infrastructure
Economic 2D – Manage risk to agriculture	Scoring is by professional judgement, taking into account local advice.	12	By professional judgement, taking account of the value and social importance of the agricultural industry in the area (this is aided by the percentage of non-urban land in the AFA). Subject to a maximum local weighting of 5.	Scoring is by professional judgement, taking into account local advice.

Table F.3 Social Objective

Social Objective				
Objective	**Description of Scoring**	**Global Weighting**	**Local Weighting**	**Scoring Range**
Social 3A(i) – Minimise risk to human health and life – Residents	Scoring is calculated based on a score derived from the number of residential properties potentially affected by flooding and the highest probability (lowest magnitude) of a flood event that causes flooding of each property. This score can be adjusted by professional judgement.	27	Based on calculated assessment, adjusted by professional judgement. Subject to a maximum score of 5	5 : 100 % reduction in the number of residential properties at risk 0 : No change to the number or probability of flooding to residential properties at risk < 0 : A negative score indicates the number of residential properties at risk or the probability of flooding is increased
Social 3A(ii) – Minimise risk to human health and life – High Vulnerability	Scoring is calculated based on a score derived from the number and type of high vulnerability properties potentially affected by flooding, and the highest probability (lowest magnitude), adjusted by professional judgement of a flood event that causes flooding of that property. This score can be adjusted by professional judgement	17	Based on calculated assessment, adjusted by professional judgement. Subject to a maximum score of 5	5 : 100 % reduction in the number of high vulnerability properties at risk 0 : No change to the number of high vulnerability properties at risk < 0 : A negative score indicates the number of high vulnerability properties at risk is increased or the probability of flooding is increased
Social 3B(i) – Minimise risk to community – Social Infrastructure	Scoring is calculated based on a score derived from the number of social infrastructure assets potentially affected by flooding, and the highest probability (lowest magnitude) of a flood event that causes flooding of each asset. This score can be adjusted by professional judgement.	9	Based on calculated assessment, adjusted by professional judgement. Subject to a maximum score of 5	5 : 100 % reduction in the number of social infrastructure assets at risk 0 : No change to the number of social infrastructure assets at risk < 0 : A negative score indicates the number of social infrastructure assets at risk is increased or the probability of flooding is increased
Social 3B(ii) – Minimise risk to community – Local Employment	Scoring is calculated based on a score derived from the number of non-residential properties (taken as a place of employment) potentially affected by flooding, and the highest probability (lowest magnitude) of a flood event that causes flooding of each property. This score can be adjusted by professional judgement.	7	Based on calculated assessment, adjusted by professional judgement. Subject to a maximum score of 5	5 : 100 % reduction in the number of non-residential properties at risk 0 : No change to the number of non-residential properties at risk < 0 : A negative score indicates the number of non-residential properties at risk is increased or the probability of flooding is increased

Table F.3 Environmental Objective

Environmental Objective				
Objective	**Description of Scoring**	**Global Weighting**	**Local Weighting**	**Scoring Range**
Environmental 4A – Support the objectives of the WFD	Scoring is guided by professional judgement with reference to a specified scoring system which takes into account the duration and permanence of likely impacts of the options on water body status elements, the sensitivity of the receiving bodies and the potential sources of pollution in the flood extent area. A generic description of the likely impacts of measures of water body status is also taken into account	16	5 (Constant)	5 : Permanent or long term contribution to the achievement of wb objectives 0 : No constraint of the achievement of wb objectives -999 : Unacceptable negative impact where feasible alternative exists
Environmental 4B – Support the objectives of the Habitat and Birds Directives	Scoring by professional judgement based upon the following key datasets: - Natura 2000 sites (SACs, SPAs) - Ramsar Site - Annex IV (Habitats Directive) species of flora and fauna and their key habitats	10	By professional judgement, taking into account local advice. Subject to a maximum local weighting of 5.	5 : Potential to create or enhance NHA sites to SAC, SPA or Ramsar status 0 : No impact on existing SAC, SPA or Ramsar sites -999 : Any detrimental impact upon existing SAC, SPA or Ramsar sites
Environmental 4C – Avoid damage to, and where possible enhance the flora and fauna of the catchment	Scoring by professional judgement based upon the following key datasets: - Natural Heritage Areas (& proposed Natural Heritage Areas) - Nature Reserves - Wildfowl Sanctuary - OSPAR - National Parks	5	By professional judgement, taking into account local advice. Subject to a maximum local weighting of 5.	5 : Potential to create new national, regional and local conservation sites 0 : No impact on existing national, regional and local sites -999 : Any detrimental impact upon national, regional or local sites
Environmental 4D – Protect and where possible enhance fisheries resource within the catchment	Scoring is guided by professional judgement with reference to a specified scoring system which takes into account the duration and permanence of likely impacts of the options on fisheries and fisheries potential and the sensitivity of the receiving bodies and species	13	By professional judgement, taking into account local advice. Subject to a maximum local weighting of 5.	5 : Creation of fisheries habitat or removal of barrier to upstream migration for wb where sensitive species are known to be present 0 : No change to fisheries potential of wb -999 : Unacceptable negative impact where a feasible alternative exists
Environmental 4E – Protect, and where possible, enhance landscape character and visual amenity within zone of influence	Scoring is guided by professional judgement taking into account the duration and permanence of the likely impacts of the options on landscape value and the sensitivity of landscape to change	8	By professional judgement, taking into account local advice. Subject to a maximum local weighting of 5.	5 : Permanent significant enhancement of high sensitivity landscape character/feature in the zone of visibility of the selected measure 0 : No change to existing landscape character/feature in the zone of influence of the selected measure -999 : Unacceptable negative impact where feasible options exist
Environmental 4F(i) – Avoid damage to or loss of architectural features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods	Scoring is guided by professional judgement taking into account the number of architectural features, institutions and collections subject to flooding and the impact of the flood risk management measure on architectural features, institutions and collections.	4	By professional judgement, taking into account local advice. Subject to a maximum local weighting of 5.	5 : Complete removal of all architectural features, institutions, and collections form the risk of harm by extreme floods and enhanced protection and value of architectural features, institutions, and collections importance arising from the implementation of the FRM. 0 : No effects on architectural features, institutions, and collections. -999 : Unacceptable negative impact where feasible options exist

Environmental 4F(ii) – Avoid damage to or loss of archaeological features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods	Scoring is guided by professional judgement taking into account the number of archaeological features, institutions and collections subject to flooding and the impact of the flood risk management measure on architectural features, institutions and collections.	4	By professional judgement, taking into account local advice. Subject to a maximum local weighting of 5.	5 : Complete removal of all architectural features, institutions, and collections form the risk of harm by extreme floods and enhanced protection and value of archaeological features, institutions, and collections importance arising from the implementation of the FRM. 0 : No effects on architectural features, institutions, and collections. -999 :Unacceptable negative impact where feasible options exist

Appendix G Freeboard

Appendix G Freeboard

Introduction

This Appendix provides a detailed assessment of the freeboard allowances adopted in the outline design of embankments and flood walls for this Shannon CFRAM Study. The assessment is based on the Environment Agency's Fluvial Freeboard Guidance Note, R&D Technical Report W187 (2000) which provides practical guidance on the determination of freeboard allowances during the design of flood defences and is therefore appropriate for use in the design of all embankments and flood walls for this Study. The guidance note divides freeboard into two elements, with an allowance to take account of the physical processes that affect the defence level and an allowance to account for the uncertainty in the prediction of physical processes.

Methodology

The Guidance Note details a 'Quick' and 'Detailed' method. Given the catchment scale assessment of CFRAMs, it is appropriate that the 'Quick' method is used. However, it is recommended that during the future detailed design stages, the freeboard allowances should be rechecked using the 'Detailed' method.

The 'Quick' method involves two stages. Firstly, the physical processes affecting the defence performance is determined. Secondly, the uncertainty is quantified.

The assessment is applicable to the following four design scenarios:

1. Embankment design (fluvial)
    - Physical processes: Settlement of embankment foundations (consolidation settlement).
    - Uncertainty allowance
2. Embankment design (coastal)
    - Physical processes: Settlement of embankment foundations, wave overtopping (surcharge) allowance
    - Uncertainty allowance
3. Flood wall design (fluvial)
    - Physical processes: N/A
    - Uncertainty allowance
4. Flood wall design (coastal)
    - Physical processes: Wave overtopping (surcharge) allowance
    - Uncertainty allowance

Physical Processes

As outlined above, there are the following two physical processes which can apply during the design scenarios:

- Settlement (consolidation settlement)
- Wave overtopping (surcharge).

Settlement

The settlement (consolidation settlement) is calculated using the below formulae. This takes account of the coefficient of volume compressibility, the shape of the foundation and the applied pressure.

$$\rho_c = \mu_g \rho_{oed}$$

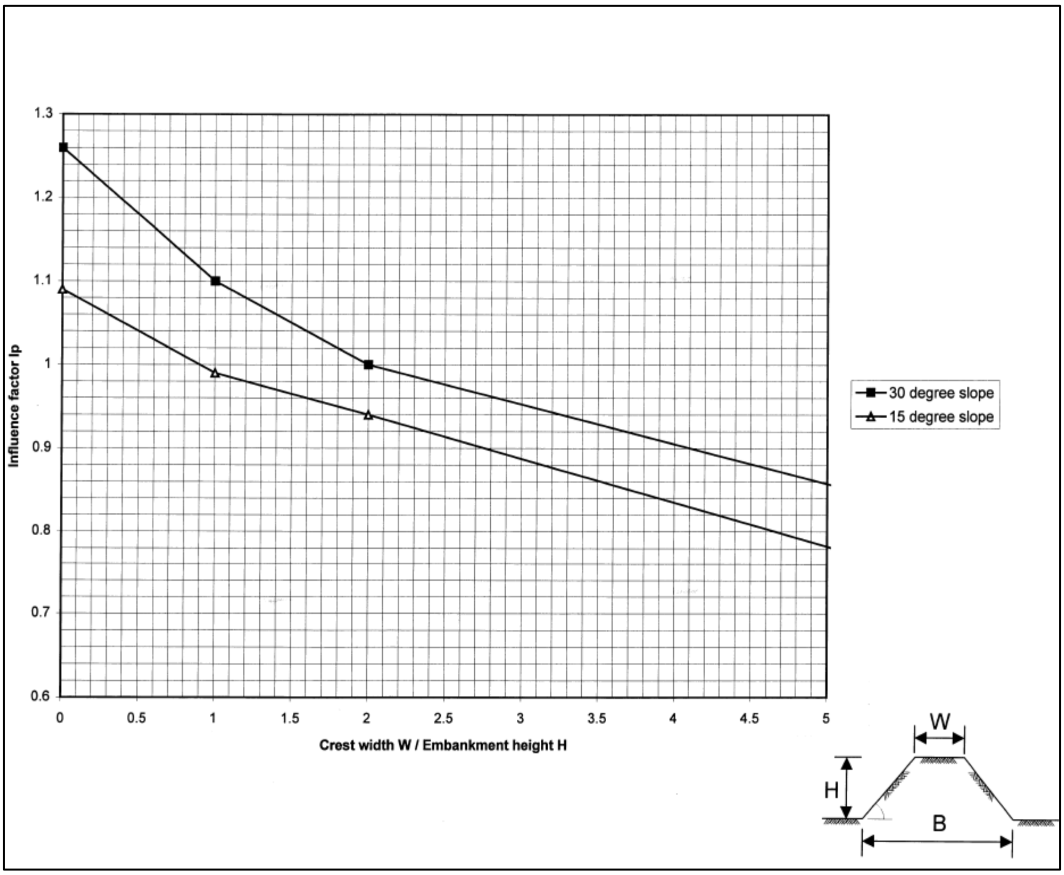
$$\rho_{oed} = I_p m_v p B$$

Where:

I_p = influence factor
m_v = average coefficient of volume compressibility
p = applied pressure (kN/m²)
B = foundation width (m)

For CRFAMS the following typical embankment design has been adopted: height of the embankment at 1.5m (which is the typical height of high embankments), the crest width of 4m and side slopes as 1:3. The influence factor is determined from Figure 1 below.

Figure 1: Influencing Factor Graph



The underlying material is assumed to be normally consolidated alluvial clay. The coefficients μ_g and m_v are dependent on this clay selection, with the range of values detailed in Tables 1 and 2 below.

Table 1: Values of coefficient μ_g

Type of Clay	μ_g
Heavily over-consolidated clays (glacial till, Keuper Marl)	0.2 - 0.5
Over-consolidated clays (London Clay, Weald, Kimmeridge, Oxford, and Lias Clays)	0.5 - 0.7
Normally-consolidated clays	0.7 - 1.0
Very sensitive clays (soft alluvial, estuarine, and marine clays)	1.0 - 1.2

Table 2: Typical values of the coefficient of compressibility mv

Type	Qualititative Description	m_v (m^2/kN)
Heavily over-consolidated boulder clays (e.g. many Scottish boulder clays) and stiff weathered rocks (e.g. weathered siltstone), hard London Clay, Gault Clay, and Oxford Clay	Very low compressibility	Below 0.05×10^{-3}
Boulder Clays (e.g. Tees-side, Chesire) and very stiff 'blue' London Clay, Oxford Clay, Keuper Marl	Low compressibility	$(0.05 \text{ to } 0.10) \times 10^{-3}$
Upper 'blue' London Clay, weathered 'brown' London Clay, fluvio-glacial clays, Lake Clays, weathered Oxford Clay, weathered Boulder Clay, weathered Keuper Marl, normally consolidated clays (at depth)	Medium compressibility	$(0.10 \text{ to } 0.30) \times 10^{-3}$
Normally-consolidated alluvial clays (e.g. estuarine clays of Thames, Firth of Forth, Bristol Channel)	High compressibility	$(0.30 \text{ to } 1.50) \times 10^{-3}$
Very organic alluvial clays and peats	Very high compressibility	Above 1.50×10^{-3}

Based on the normally consolidated alluvial clay assumption, the value of μ_g assumed to be 0.8, and m_v as $1\text{x}10^{-3}$.The soil weight is assumed to be 20kN/m^3. This yields a value of 19.62 kN/m^2 for the applied pressure coefficient.

Wave Overtopping

The Guidance Note assumes that the wave overtopping associated with non-erodible defences (sheet pile walls or concrete retaining walls) is unlikely to cause failure of the defence. Therefore a wave surcharge allowance of nil for the flood wall design scenario is assumed.

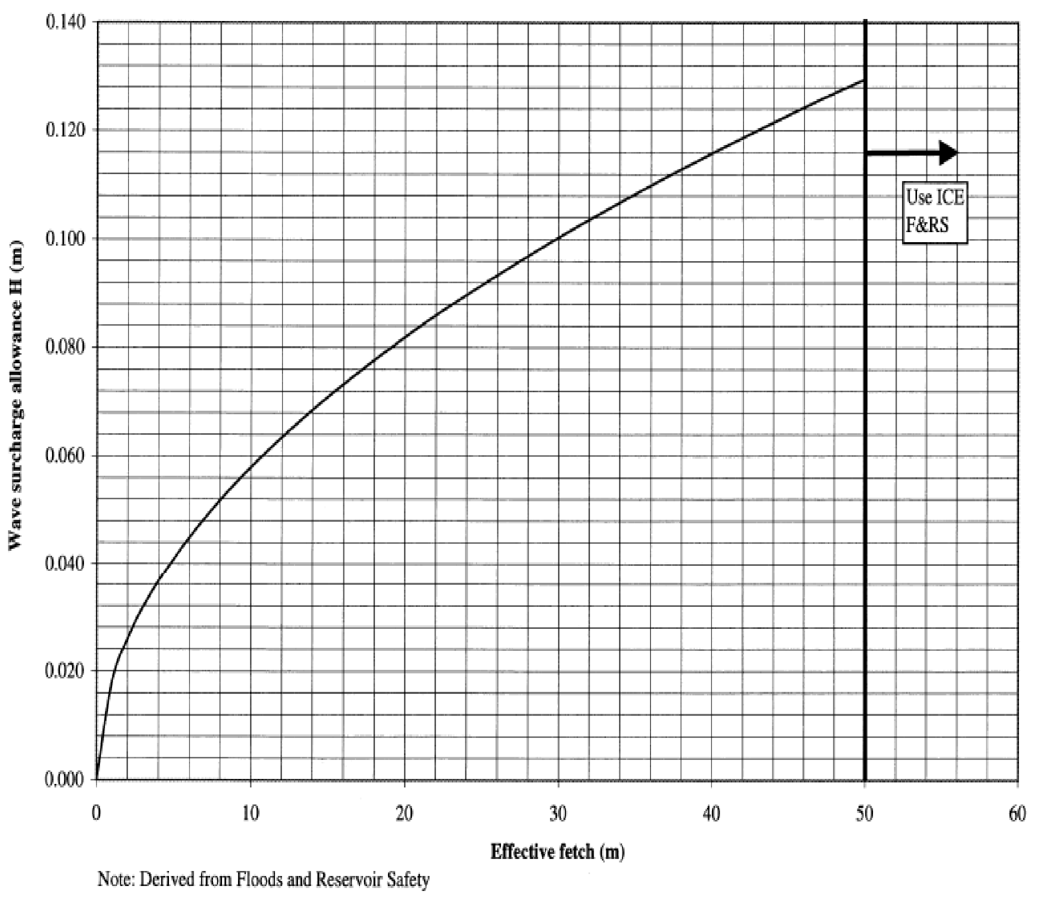
Regarding embankment design, the wave surcharge allowance for erodible defences is broken down into four conditions, as detailed in the below Table 3. Depending on the wave surcharge calculated, the actual surcharge to be provided is 0m, 0.05m or 0.1m.

Table 3: Surchage Calculation

Calculated wave surcharge allowance H (m)	Actual wave surcharge allowance to be provided (m)
0.000 < H < 0.025	0
0.025 < H < 0.075	0.05
0.075 < H < 0.125	0.10
0.125 < H	Recalculate using ICE's Floods and Reservoirs Safety

The wave surcharge is determined from Figure 2 below. The figure is based on a grassed embankment with a 1:2.5 slope, a typical average annual maximum wind speed of 16m/s and a non-worst case scenario of the river in relation to the predominant wind direction.

Figure 2: Wave Surcharge



If the defence being considered does not conform with the above description the estimated wave surcharge value is multiplied by the factors in the below Table 4 to take account of different embankment slopes and embankment types (with the values chosen highlighted).

Table 4: Multiplication Factors

Type	Factor
Embankment Slope	
1:2.0 slope	1.13
1:3.0 slope	0.9
1:3.5 slope	0.81
Embankment Type	
Crest protected	0.92
Crest and backslope protected	0.85

The determination of wave surcharge is dependent on the effective fetch of the river. A value of 0.05m is chosen for the actual wave surcharge allowance, which is the value to be used if the calculated wave surcharge allowance falls in the range of 0.025m to 0.075m. Taking account of the embankment type and slope, this range corresponds to an effective fetch in the range of 2.5m to 24m, which is deemed a suitable range.

Uncertainty Assessment

Having determined the physical processes affecting the flood defence level, the next step is to quantify the level of uncertainty associated with the prediction of the physical processes, using the following calculation.

$$Uncertainty\ Allowance\ (\mathrm{m}) = k \times \frac{Overall\ Score\ (in\ range\ 6-30)}{30} \times (FL - MAMWL)$$

Overall Score

The Guidance Note sets out that the Overall Score should be assessed by allowing for the uncertainty associated with the following six parameters:

- Accuracy of hydrological data
- Accuracy of hydrological analysis
- Accuracy of hydraulic data
- Accuracy of hydraulic model
- Consequences of failure
- Accuracy of the physical processes

Each parameter is assigned a score from 1 to 5, where 1 represents a low level of impact and 5 a high level of impact. For each of the parameters a description is provided against each score, this is provided below with the adopted score for each parameter highlighted below.

Accuracy of Hydrological Data

1	Hydrological conditions throughout catchment well defined or reliable continuous flow gauging records on river at area of interest
2	Hydrological conditions throughout catchment fairly well defined or flow gauging records available on river at some distance from area of interest or water level records available at area of interest
3	Some variability in hydrological conditions in catchment or water level records available at more than one site at some distance from area of interest or flow gauging records available for similar nearby catchment flow
4	Hydrological conditions in catchment fairly variable or water level records available at one site some distance from area of interest
5	Complex catchment with wide variation in hydrological conditions or limited water level records

Accuracy of Hydrological Method

1	Rainfall runoff analysis give consistent results using different methods, or greater than 75 years of flow records for statistical analysis
2	Rainfall runoff analysis give consistent results using different methods, long duration storm gives greatest discharge or 50 to 75 years of flow records available for statistical analysis
3	Rainfall runoff analysis give fairly consistent results using different methods, moderate duration storm gives greatest discharge or 25 to 50 years of flow records available for statistical analysis
4	Rainfall runoff analysis gives poor correlation between results using different methods, short duration storm gives greatest discharge or 10 to 25 years of flow records available for statistical analysis
5	Rainfall runoff analysis gives very poor correlation between results using different methods, very short duration storm gives greatest discharge or less than 10 years of flow records available for statistical analysis

Accuracy of Hydraulic Data

1	Very well defined channel, no floodplain flow, channel roughness low and consistent seasonally along river and across river section
2	Well defined channel, no floodplain flow, channel roughness fairly low, only small changes in roughness likely
3	Minor floodplain flow, moderate changes in roughness likely
4	Poorly defined channel, some floodplain flow, changes in roughness likely
5	Very poorly defined channel with mobile bed, considerable complex floodplain flow, channel roughness very variable seasonally, along river and across river section

Accuracy of Hydraulic Method

1	Well defined boundary data, well defined flood routing, transient model
2	Fairly well defined boundary data and flood routing, transient model
3	Moderately well-defined boundary data and flood routing, steady state model
4	Fairly poorly defined boundary data and flood routing, steady state model
5	Poorly defined or complex boundary data and flood routing, simple backwater analysis

Significance of Physical Parameters

1	Uncertainties in physical processes are negligible, allowance is < 5% of (FL - MAMWL)
2	Uncertainties in physical processes are of marginal significance, allowance is = 5 to 10% of (FL - MAMWL)
3	Uncertainties in physical processes are of some significance, allowance is = 10 to 20% of (FL - MAMWL)
4	Uncertainties in physical processes are significant, allowance is = 20 to 30% of (FL - MAMWL)
5	Uncertainties in physical processes are very significant, allowance is > 30% of (FL - MAMWL)

Consequences of Failure

1	Typically low grade agricultural land, often grass, at risk from flooding or impeded land drainage, with isolated agricultural properties at risk from flooding, or environmental assets at little risk frequent inundation
2	Typically mixed agricultural land with occasional, often agriculturally related, properties at risk from flooding. Agricultural land may be prone to flooding or water-logging. May also apply to environmental assets of local significance
3	Typically large areas of high grade agricultural land and/or environmental assets of national significance at risk from flooding or impeded drainage with some properties also at risk from flooding
4	Typically less extensive urban areas with some high grade agricultural land and/or environmental assets of international importance requiring protection
5	Typically large urban areas at risk from flooding

For the purposes of this assessment, conservative figures are chosen, ranging from 4 to 5. As equal weight is given to each parameter, the scores are then accumulated to give an overall score out of a total of 30.

FL-MAMWL

This is the difference between the flood level and mean annual maximum water level. The Q_2 and Q_{100} mean water levels for the Shannon River Basin District were reviewed and the differences between these mean water levels is in summarised in the below table for the different UoMs.

Location	Average Diff
UOM23	0.6m
UOM24	0.4m
River Shannon	0.5m
UoM25/26 (Tribs of the Shannon)	0.4m
Overall Average	**0.5m**

0.5m was the overall average, and this has therefore been used as the FL – MAMWL value throughout.

K coefficient

The uncertainty allowance is calculated using the below formula, in which the coefficient k is assumed to be 0.5, based on advice provided within the Guidance Note

$$Uncertainty\ Allowance\ (\mathrm{m}) = k \times \frac{Overall\ Score\ (in\ range\ 6-30)}{30} \times (FL - MAMWL)$$

Results

The freeboard allowance figures yielded from the model for the four scenarios are set out below:

1. Embankment design
    - Physical processes: Settlement of embankment foundations
    - Uncertainty allowance

Freeboard allowance = 0.396m, therefore take freeboard allowance as 400mm

2. Embankment design (coastal)
    - Physical processes: Settlement of embankment foundations, wave overtopping (surcharge) allowance
    - Uncertainty allowance

Freeboard allowance = 0.896m, therefore take freeboard allowance as 900mm

3. Flood wall design
    - Physical processes: N/A
    - Uncertainty allowance

Freeboard allowance = 0.208m, therefore take freeboard allowance as 210mm

4. Flood wall design (coastal)
    - Physical processes: Wave overtopping (surcharge) allowance
    - Uncertainty allowance

Freeboard allowance = 0.208m, therefore take freeboard allowance as 210mm

Appendix H Cost Database

JBA consulting

DONNACHADH O'BRIEN
& ASSOCIATES CONSULTING ENGINEERS

CFRAM Unit Cost Development Project

Final Report

October 2014

OPW
The Office of Public Works
Oifig na nOibreacha Poiblí

Office of Public Works
Jonathan Swift Street
Trim
Co. Meath
Ireland

JBA Project Manager

Deirdre McDonnell
24 Grove Island
Corbally
Limerick
Ireland

Revision History

Revision Ref / Date Issued	Amendments	Issued to
Draft Report / 21-2-2014	-	OPW
Final Report / 25-7-2014	Amendments to report and all associated cost sheets.	OPW
Final Report / 08-10-2014	Final Amendments to report	OPW
Final Report / 09-01-2015	Minor amendment to copyright reference	OPW

Contract

This report describes work commissioned by Eileen Hughes, on behalf of the OPW, by a letter dated 18/09/2013. The OPW's representative for the contract was Conor Galvin. Angus Pettit, Deirdre McDonnell and Jonathan Garrett of JBA Consulting and Donnachadh O'Brien of Donnachadh O'Brien & Associates carried out this work.

Prepared by .... Angus Pettit BSc MSc CEnv CSci MCIWEM C.WEM

Principal Analyst

Reviewed by .... Jonathan Cooper BEng MSc DipCD CEng MICE MCIWEM C.WEM MIoD MIEI

Director

Purpose

This document has been prepared as a final report for the OPW. JBA Consulting accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

JBA Consulting has no liability regarding the use of this report except to OPW.

Acknowledgements

JBA would like the acknowledge the following parties for their assistance and input to the unit cost database;

Mr. Shane Hayes	Office of Public Works
Mr. Tony Brew	Office of Public Works
Mr. Jamie Keogh	Office of Public Works
Mr. Paul Costello	Office of Public Works
Mr. John Kelly	Office of Public Works
Mr. Cian O Domhnaill	Office of Public Works
Mr. Vincent Rhatigan	Office of Public Works
Peter Newport	Office of Public Works
Gerry O'Connell	Dublin City Council
Mr. Ruairi O Conchuir	Inland Fisheries Ireland - Mulkear Life Project
Mr. Tony Moran	JBA Consulting

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JBA is aiming to reduce its per capita carbon emissions.

Executive Summary

This report provides a summary of the methodology and the approach to estimating costs for flood risk management measures to support the CFRAM studies. This report provides background to whole life costing and details the methodology for each method and factor.

A range of costing approaches have been presented and used depending on the availability of information, costing requirements and future needs. Nineteen further method specific summary spreadsheets are provided separately and contain all relevant costing information and whole life cost tools.

In addition JBA have provided explanatory text on the approach adopted for whole life costing which included key cost components (where applicable and proportional) to include the following:

- Enabling costs (if applicable)
- Capital costs
- Operation and maintenance costs
- Other costs (e.g. event costs for demountables or running costs for pumping stations)

This document also outlines some of the key assumptions and factors that need to be considered at this stage to ensure a consistent approach across all CFRAM studies. This included factors such as:

- Discounting
- Financial periods
- Base dates
- Timing of works

In addition, an optimism bias tool is provided to ensure that a standard approach to construction risk is undertaken across all CFRAM studies.

Cost calibration has been completed for 4 separate projects illustrating that the tools and unit costs provided adequately estimate construction and whole life costs for real flood defence works in Ireland. Confidence can therefore be given to the results and costs provided for use within early stage appraisals as part of the wider CFRAM process.

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Abbreviations

CFRAM	Catchment-based Flood Risk Assessment and Management
CIRIA	Company providing research and training in the construction industry
CPI	Consumer Price Index
EA	Environment Agency
FRM	Flood Risk Management
JBA	JBA Consulting – Engineers & Scientists
LA	Local Authority
MCM	Multi-Coloured Manual (Flood Hazard Research Centre damage data)
MCA	Multi-criteria Analysis
OPW	Office of Public Works
PV	Present Value
R&D	Research and Development
RPI	Retail Price Index
SUDS	Sustainable Urban Drainage Systems
PVc	Present Value Cost
WLC	Whole Life Costing

1 Introduction

1.1 Background

The Office of Public Works (OPW) has commissioned six Catchment-based Flood Risk Assessment and Management (CFRAM) studies to assess and determine viable measures for managing flood risk in a large number of locations around Ireland. To determine the viability of the selected measures at each location and to help prioritise budgetary spend, it is necessary to determine their likely costs of construction and long term maintenance.

Once the preferred measures have been determined, they will need to be prioritised to ensure that communities most at risk are protected. It is therefore important that measures in different parts of the country are comparable in the terms of their viability, which in turn requires a consistent approach to determining the likely costs of construction and long term maintenance.

The OPW has commissioned JBA Consulting to undertake this project to prepare a database of unit costs to enhance consistency in determining the likely costs of construction and maintenance of measures under the CFRAM project.

1.2 Purpose of this report

The objective of the project is to determine appropriate unit costs for common methods of flood risk management, for a range of conditions and scales, calibrated against actual costs (taking into account the date, condition and scale of construction), and to present the costs in a simple database for easy use by the OPW and the consultants appointed to undertake the CFRAM studies.

This report provides a summary of the project and an introduction to whole life costing for those consultants undertaking the appraisal of flood risk management measures. The report summarises the approach to costing for each mitigation method and gives indicative costs for each. This report should be read in accordance with the summary MS Excel templates produced for each flood risk method.

1.3 Generic cost guidance

The OPW are currently developing guidance notes on appraisal and the assessment of flood risk damages and cost estimation (Guidance Note 27). This report is primarily aimed at providing information and guidance to support cost estimation at the CFRAM level of assessment. The approach takes into account standard approaches currently used within the industry and provides the necessary level of accuracy for the regional and initial level of appraisal of options within a CFRAM study.

1.4 Whole life cost estimation

Whole life cost (WLC) estimation is a process that helps to combine cost elements incurred over time for different asset types and alternative approaches to flood risk management (FRM) intervention. The use of whole life cost estimation procedures will help to achieve the following aims for flood and coastal erosion management:

- Good decision making about FRM options.
- Consistent approach across different areas for CFRAM appraisal.
- Helps to determine the longer term expenditure budget for the OPW.
- Encourages efficient resource allocation.

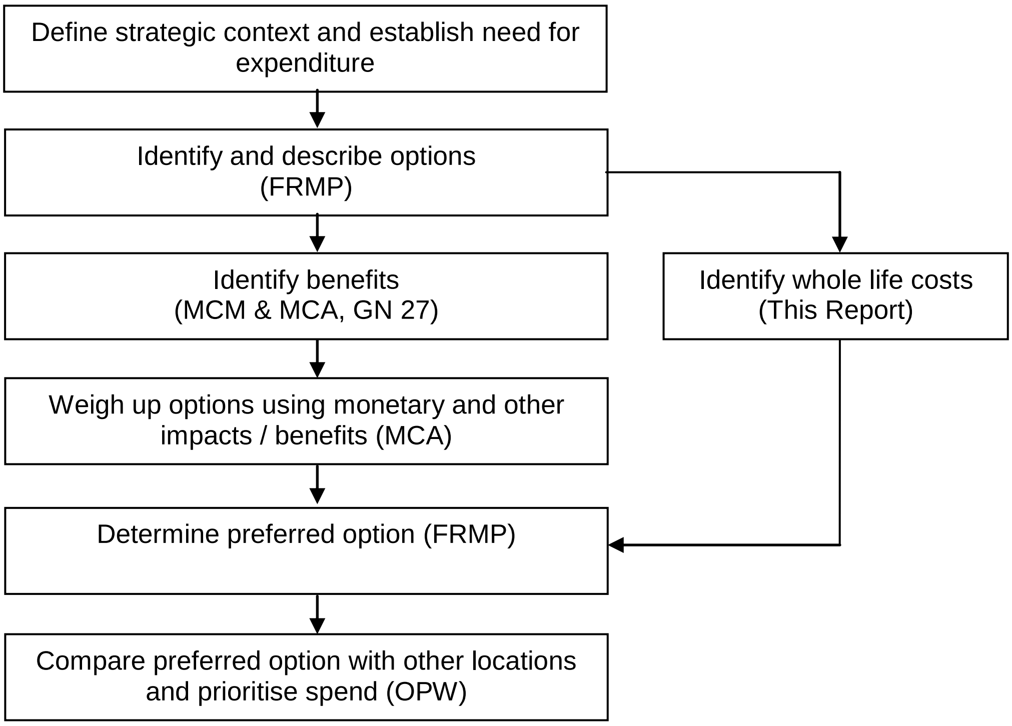
Whole life costing is an essential tool to help manage future and ongoing costs associated with capital and expenditure/operational costs and to help make informed choices between different approaches of delivering an option that meets the needs of communities at risk. The choice is often one between high capital and low maintenance or vice versa and the use of whole life costing and the consistent comparison between options allows an economic valuation of these aspects to be considered.

1.5 Cost estimation within the appraisal process

Whole life cost estimation forms part of the overall CFRAM appraisal process, as shown in the figure below. Each of the steps below forms part of standard appraisal processes. This report

and the costs derived aim to assist those undertaking cost estimates and provides guidance and data to support cost estimation and the appraisal process.

Figure 1-1: Cost estimation within the wider appraisal process



2 Categorisation of methods and factors

Whole life cost estimates should be based on data appropriate and proportional to the level of assessment of options. Costs are typically based on data assembled from recent tenders, completed projects, published articles and estimating price books, estimates and quotations from companies for specialist work and the estimator's own experience.

2.1 Generic cost estimation methodologies

At different stages of an analysis, different data will be appropriate for cost estimation, as indicated below. There are four general approaches to estimating project costs:

1. Estimation of labour, plant and materials costs for each specific activity.
2. Estimation of costs from first principles using industry or specific unit costs for materials and construction activities to derive a unit cost per unit.
3. Reliance on existing outturn costs or cost relationships from previous projects that hide certain internal costs such as overheads, minor and temporary works.
4. Engineering judgement in cases where existing data are unobtainable or measures are poorly understood / tested.

In addition to this there are obviously target costs for tendering purposes and recorded quantities. These are the most accurate as they are based on site specifics or real costs, however the recording of this information varies between and within organisations.

Each of the above approaches has benefits and constraints for the application on the CFRAM. None of the approaches is applicable to all flood risk management methods, however Option 2 is preferred for the majority of methods as this will provide the most applicable costs for Ireland at the level of detailed required.

2.2 Cost methodology approach

In total, 19 key flood risk management methods were investigated and costed. With the inclusion of key asset factors (e.g. cost variations by defence height or length) a total of over 220 combinations have unit costs mapped out within the database provided.

The methodology undertaken varies with each measure due to the varied nature of the measures and the fact that they cover both structural and non structural options. Both core unit costs and factors have some uncertainty that is presented in this report and the cost database assumptions. This uncertainty needs to be understood and accepted by CFRAM consultants in order to ensure that consultants apply the costs appropriately.

Ideally, costing would be undertaken through a robust review of previous OPW schemes. Unfortunately, data sources from past OPW schemes are statistically limited and not recorded in a way that specific asset or flood risk mitigation method costs can be extracted to enable past scheme costs as a guide to the future. As a result 'bottom-up' pricing was the preferred option for this study. Furthermore, this approach allowed the extrapolation of costs to account for the specified range of factors required.

Thus our preferred approach was to generate a series of 'typical' engineered elements for each method that can be costed by an experienced quantity surveyor using local rates reflecting the market. Once complete for each method, variations in costs for each factor have been generated either from variations in key elements or by scaling and weighting approaches from other available unit costs. This latter approach helps to identify economies of scale and other cost savings (or risks), where appropriate.

In some instances, alternative approaches have been taken to provide the necessary coverage of costs for all methods and factors required. This includes:

- The use of outturn costs from existing projects collated within available unit cost reports (option 3 above). The risk is that these outturn costs do not necessarily reflect the costs associated with schemes constructed in Ireland. It should be noted that the applicability of costing databases derived using UK data in Ireland may significantly under-predict costs.
- The scaling of unit rates derived for this project based on weightings provided in available UK cost databases (e.g. the Environment Agency unit cost handbook).

- A 'top down' approach whereby cost estimates gathered purely from example projects and case studies is used to inform and provide indicative unit costs.

Full details of the costing approach used for each method and the level of detail and confidence that can be applied are discussed further in Section 4.

2.3 Flood risk management methods and factors

Unit costs for a range of methods have been determined to support the CFRAM process. The costs relate to the construction and implementation of each method and include relevant annual operation and maintenance costs (if applicable). The range of factors cover a range of flood risk management activities covering both structural and non-structural approaches. A full list of the methods and factors costed is provided in Table 2-1.

The list is not exhaustive but cover the majority of measures likely to be required as part of the CFRAM process. Unit costs have been defined for a range of factors that cover the typical range of method variables (e.g. length and height).

The unit costs are intended to be indicative, generic costs that might be expected for the implementation of a method in typical conditions. They are not intended to be accurate across the full range of potential application of such methods, and the CFRAM Consultants will review the local context for application and adjust the Unit Cost accordingly, where necessary.

It should be noted that the unit costs are intended to be for outline design and pricing only, and are applicable for a common, representative type of each method and factor listed. It should be noted that the CFRAM Consultants are required to use their professional judgement in using the unit costs, and should vary costs to take into account local requirements or conditions that are not provided for explicitly in the methods and factors.

Other methods or factors outside the range costed here, may be applicable in some sites or special circumstances. In these instances, the CFRAM consultants will need to prepare bespoke cost estimated using experienced engineers and/or specialist advice.

Table 2-1: Summary of flood risk methods and factors assessed within this report

Method	Relevant Factor Types				
Flood Protection Wall	Urban / Rural	Quay / Floodplain / Coastal sea wall	Structure	Height	Length
Embankment	Rural	Structure	Height	Length	Material
Demountable Barriers	Length	Height	Wall/Gate	With/without Ground Beam	
In-Channel Excavation	Urban / Rural	Material	Volume	Material disposal	
Excavation on Land	Rural	Material	Volume		
Weir	Height	Weir Length			
Weir Removal	Weir Length				
Bridge Removal	Bridge Type				
Bridge Construction	Bridge Type				
Bridge Underpinning					
New Culvert	Urban / Rural	Size	Length	Depth of Invert	Material
Sluice Gate	Flap Gate / Vertical Sluice		Size		
Road Raising	Urban / Rural	Height	Length		
Pumping Station	Capacity				

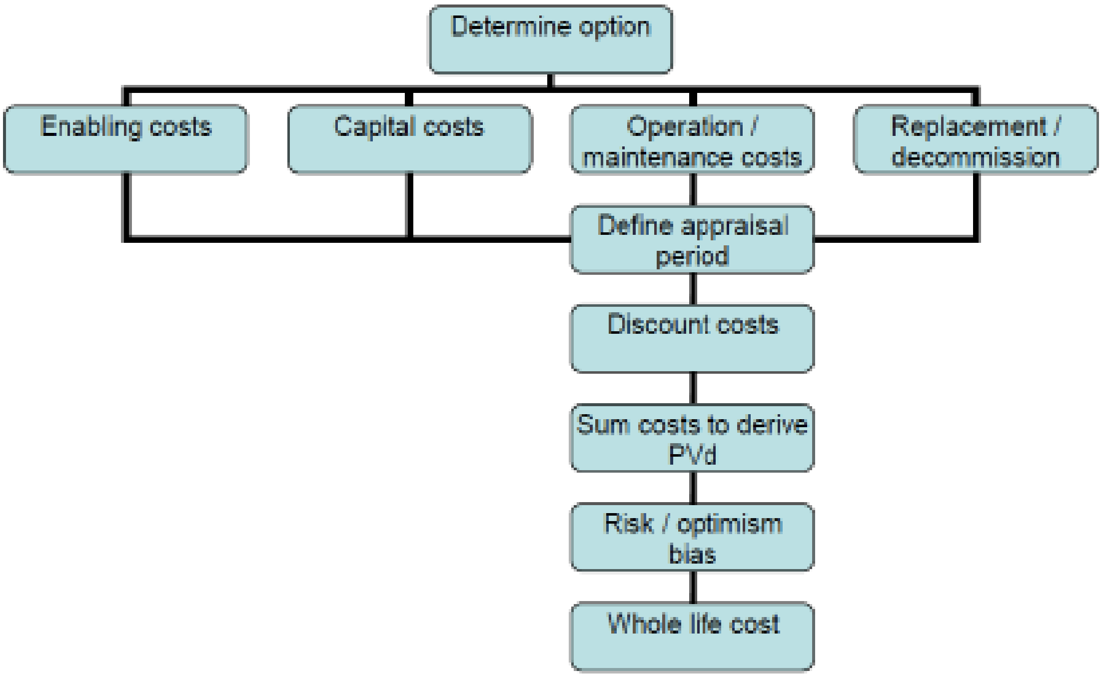
Method	Relevant Factor Types				
Individual Property Protection	Property Type	PLP Type (Manual / Automatic			
Hydrometric Gauging Station					
Flood Forecasting System	Simple Alarm / Simple Forecast / Complex Forecast				
River Maintenance	Channel Width	Urban / Rural			
Bank Protection	Coastal Erosion Protection / River Bank Protection				Length
Manhole Sealing					
Mobilisation and Site Set-Up	Urban / Rural	Construction Cost			

3 Whole life costing and methodology

Whole life costs enable investment options to be more effectively evaluated through the consideration of all costs rather than just the initial capital costs. This facilitates the choice between competing alternative options/strategies and ensures planning decisions and sustainable solutions are sufficiently robust and backed up by consistent and accurate costed programmes of activities.

Whole life estimation will require costs of acquiring the solution (consultancy, design, construction etc), operating the system, and maintaining the system over the whole life through to disposal (as shown in the figure below).

Figure 3-1: Whole life cost estimation



Whole life cost estimation needs to identify all activities that constitute flood defence management practice e.g. inspection, vegetation management, repair, operations, incident management, general administration and regulatory activities.

3.1 Cost elements

The four key cost elements that would normally need consideration as part of a whole life cost include the following:

- Acquisition or enabling costs.
- Capital costs.
- Operational costs.
- Other and end of life costs.

This report focuses on the capital and operational cost elements.

3.1.1 Enabling costs

Enabling costs include all pre construction costs and may include planning and administration, scheme feasibility and appraisal, design, project management and consultation costs. Enabling costs can be a significant cost to whole life costs but can also be highly variable. These costs are typically 10-30% of the capital costs.

Appraisers should be aware that land purchase costs can be significant and should be included within capital costs if these have not yet been considered. This can be important for schemes where flood storage, managed retreat or channel diversion is required.

These costs have been ignored by this project as it is assumed that all costs required have already been considered by the OPW and included within the wider CFRAM process. They are thus 'sunk costs' as they represent expenditure on goods and services, or resources that are already irrevocably committed and should be ignored within an appraisal of the schemes.

As such, all unit costs provided as part of this report and associated spreadsheets exclude enabling costs. If this is not appropriate for any given project, the inclusion of these must be confirmed with the OPW.

3.1.2 Capital costs

The construction costs of a project are made up of many elements such as mobilisation, demolition and site clearance, materials, compensation, insurance, diversion of existing facilities, construction and post construction landscaping.

3.1.3 Operation and maintenance costs

Whole life cost estimation needs to identify all activities that constitute flood defence management practice e.g. inspection, vegetation management, repair, operations, incident management, general administration and regulatory activities. Operational costs may include annual maintenance as well as intermittent costs if relevant and proportional and data is available.

3.1.4 Other costs

Other costs are likely to vary by the categories and measures. For example, other costs for demountable barriers such as event response, training and practice sessions are critical and essential to include within the whole life costs. Other costs may also include decommissioning or replacement costs at the end of the design life although these costs may be less important in terms of whole life costs due to the heavy discounting of these costs late in the financial period.

3.2 Whole life costing and present values

3.2.1 Discounting and Present Value Costs (PVc)

Appraisals need to compare options that will impact over a period of years into the future. Discounting is commonly used to compare costs and benefits over this time period and how future cost and benefits should be valued in today's terms. The discount rate used by the OPW assumes a standard rate of 4% over the appraisal period.

This standard discount rate has been used in the calculation of present value costs. The sum of discount rates over the standard 50 year appraisal period (the discount factor) is 22.3415 and can be used by appraisers to calculate PV costs for annual maintenance costs, for example.

3.2.2 Financial period

The estimation of Present Value costs is typically applied over a project financial period. For the case of flood mitigation works for the OPW, this is usually assumed to be a 50 year financial period for consistency. It is anticipated that a 50 year financial period is typical and appropriate for most studies. If a shorter financial period is required, whole life costing will need to be carried out separately.

3.3 Other cost considerations

3.3.1 Cost conversions

Where applicable costs from the UK have been used, a conversion from Euros to Sterling has been applied based on a factor of 1.161 for 2013 (year of latest values). This is based on using Purchasing Power Parities (PPP) with current factors derived from the Organisation for Economic Co-Operation and Development (OECD)[1] using Purchasing Power Parities (PPP) statistics.

This dataset contains Purchasing Power Parities for GDP for OECD countries. PPP table is net of currency conversion with the US$ as the baseline, so to derive the value of £ in € in Ireland,

[1] http://stats.oecd.org/Index.aspx?DataSetCode=PPPGDP

one needs to divide the Ireland value (0.806 for 2013) by the UK value (0.694), which gives 1.161. .

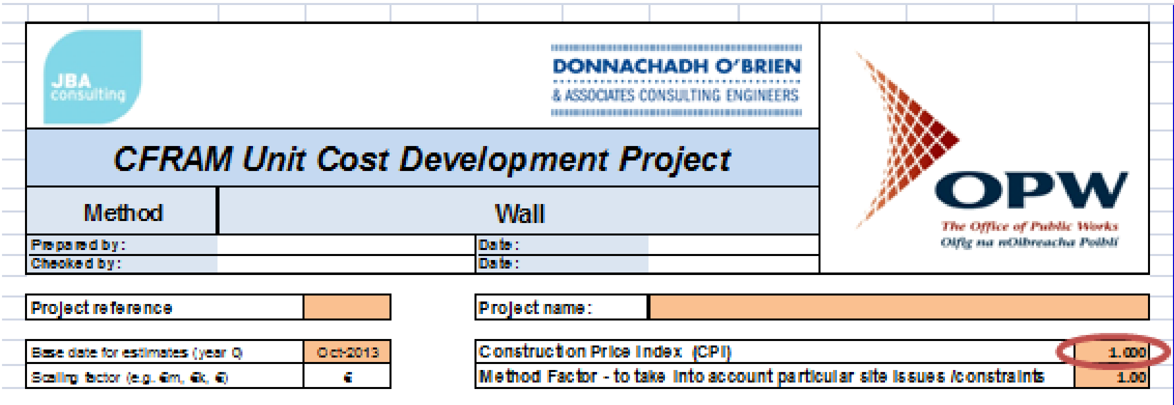
3.3.2 Base dates and updating of costs

Provided inflation for all costs is approximately equal, it is normal practice to exclude inflation effects when undertaking WLC analysis and to only include these aspects as a sensitivity test or when these uncertainties may affect the option choice. As such, inflation has not been considered for the purposes of this project.

The year used as the basis for pricing is 2013 and has been indicated in the summary sheets for each method. This is to ensure consistency across all measures and categories. All costs have been updated using either the Central Statistics Office (CSO) Production in Building and Construction Index[2] or the Consumer Price Index[3].

Future updating of costs can be done for all associated cost summary sheets by applying a weight to the 'Construction Price Index (CPI)' cell (as shown in the figure below). For example, the first quarter 2014 Indices of Production in Civil Engineering is 88.0. The 2013 fourth quarter value was 89.2. Thus a CPI weighting of 0.987 (88.0/89.2) would be used to update costs within the cost spreadsheets.

Figure 3-2: Updating of costs to analysis base date



3.3.3 Design life assumptions

The design life of a measure is the minimum length of time that the asset performs to its intended function. The design life may vary depending upon external factors that impact upon the assets condition or deterioration and the maintenance carried out on the asset. The design life can also be applied to components within an asset where internal structures might have shorter life cycles to the overall asset.

Where design life is thought to be less than the 50 year financial period of assessment an understanding of the design life is critical for the whole life costing. Most assets constructed will have a design life in excess of 50 years and will be maintained over the appraisal period. Therefore is has been assumed that no end of life replacement or decommissioning costs are applicable.

3.4 Risk and optimism bias

There is a demonstrated, systematic, tendency for project appraisers to be overly optimistic. The aim of adding an optimism bias is to allow a contingency on cost estimates to cater for unknowns and help ensure project promoters retain adequate project budget.

An appropriate uplift or optimism bias is recommended at the relevant stage of the appraisal process to negate this optimism. An optimism bias of 60% is typically used for projects at an early stage of consideration, and a value of 30% at the more detailed project stage.

Optimism bias has not been included within the costs provided but will need to be included as part of the appraisal process. Appraisers must ensure that an appropriate allowance for optimism bias is included within the total whole life costs. The reason for excluding optimism

[2] http://www.cso.ie/en/statistics/construction/
[3] http://www.cso.ie/en/releasesandpublications/prices/

bias is that appraisers typically apply a standard uplift at the appraisal or design stage without further proper consideration of project risks.

For the purpose of this project and the CFRAM studies, the OPW wish to apply a more robust appraisal of risk for each site. Rather than to supply a specific rate that would not reflect site specifics, this project has defined a set of standard key components of risk for all projects that typically increase or decrease the construction risk. By presenting these factors, appraisers can then select whether the specific factor is present or applicable and score the risk accordingly. A separate weighting methodology used to weight each individual risk/factor. Total risk scores are generated and used to define an appropriate optimism bias that should be used within pre-defined boundaries.

For example, a site with good access to be constructed in summer months, with low complexity, available funding and good community involvement would have a low optimism bias (for example; between 10-20%). On the other hand, a tidally located site with known invasive species and located on contaminated land, with poor urban access and a highly innovative, complex design would have a higher optimism bias (for example; between 45-60%).

3.4.1 Optimism bias tool

JBA Consulting have developed an optimism bias tool that CFRAM appraisers should use when determining the optimism bias for each appraisal site. The tool forces users to determine the relative risk value for a range of risk components broken down into the following 5 categories:

- Procurement risks
- Project specific risks
- Client specification risks
- Environmental risks
- External influence risks

For each risk component under the above categories the appraiser should select a risk category (Very High to Very Low) from the pull down menu. Additional comments are provided to assist users for each risk component (within the MS Excel 'Comments' functionality). The default value is set to medium risk. There is space for appraisers to add remarks or comments to justify each risk component score.

A pre-defined weighting is also supplied to weight the score based on existing OPW knowledge of relative risks. For example 'Services' and 'Ground Conditions' have a weighting of 3 whereas 'Amenity and Art' have a score of 1 to reflect the impact that these uncertainties can have on the overall project costs.

Once all risk components have been defined, the tool will multiply each risk component by the weight to derive an overall site/option weighting. The weighting is then used to define the optimism bias between pre-selected upper and lower optimism bias bands (currently set at 10% and 70%).

Should a medium weighting be given to all risk components the resulting optimism bias is 40%. Should all risk be set to Very Low (10%) or Very High (90%) the resulting optimism bias are 16% and 64% respectively.

Figure 3-3: Optimism bias tool

CFRAM Unit Cost Development Project

Optimism Bias Calculator

Prepared by:	AEP	Date:	December 2013
Site Reference:		Site Name:	

Key:
- Default weighting defined by OPW for all CFRAM projects
- Default risk value defined for all CFRAM projects
- Automated function cell (no input required)
- User defined - risk value, comments, justification

Project risk components that influence total project cost	Weight 1-3 (3 being a higher weight)	Risk value (0-100%) 0% = no risk 100% = risk expected and not mitigated		
Procurement	*Weight*	*Risk score*		*Comment/justification*
Complexity of Contract Structure	1	Medium	50%	
Late Contractor Involvement in Design	2	Medium	50%	
Poor Contractor Capabilities	1	Medium	50%	
Government Guidelines	1	Medium	50%	
Dispute & Claims Occured	3	Medium	50%	
Information Management	1	Medium	50%	
Budgetting	2	Medium	50%	
Other	1	Medium	50%	
Project Specific				
Design Complexity	2	Medium	50%	
Degree of Innovation	2	Medium	50%	
Technology	2	Medium	50%	
Services	3	Medium	50%	
Ground conditions	3	Medium	50%	
Health and Safety	3	Medium	50%	
Other	1	Medium	50%	
Client Specification				
Inadequacy of the Business Case	3	Medium	50%	
Large No. of Stakeholders	2	Medium	50%	
Funding Availability	2	Medium	50%	
Project Management Team	1	Medium	50%	
Poor Project Intelligence	2	Medium	50%	
Other	1	Medium	50%	
Environment				
Public Relations	2	Medium	50%	
Site Characteristics	2	Medium	50%	
Environmental Impact	3	Medium	50%	
Permits / Consents / Approvals	2	Medium	50%	
Amenity and art	1	Medium	50%	
Contaminated land	3	Medium	50%	
Archaeology	3	Medium	50%	
Other	1	Medium	50%	
External Influences				
Political	3	Medium	50%	
Economic	2	Medium	50%	
Legislation / Regulations	1	Medium	50%	
Multiple river users / stakeholders	2	Medium	50%	
Flood events during construction	3	Medium	50%	
Other	1	Medium	50%	
	68	50%		

		Minimum Optimism Bias:	10%
		Maximum Optimism Bias:	70%
Weighting to apply:	0.800	Calculated Optimism bias:	40%

4 Summary of costs

4.1 Overview of summary templates

A summary template is provided for each flood risk management method. These sheets highlight key aspects with regard to each method and provide available information and the derived cost estimates for each of the flood risk methods and factors. Costs are broken down by capital costs and operation and maintenance costs. Each summary sheet prepared contains the following aspects:

- A summary of types of FRM measures covered and method of assessment.
- The assumptions used to derive the costs.
- Unit costs for each Method and Factor.
- Any specific data comments or additional factor considerations that may influence the costs and require adjustments to the costs (using the method factor or as part of the wider project risks in the Optimism Bias adjustment).
- Calibration and validation data used to benchmark the derived costs.
- Operation and maintenance costs applicable for each method.
- Links to any relevant documents used as part of the cost estimation.

It is expected that this information will be useful in developing costs for CFRAM appraisal options. It is not anticipated that the cost information provided will be relevant for detailed scheme estimates where site specific information is required.

Nineteen separate summary sheets have been generated. Each method has differing levels of detail depending on the costing approach and the available data, which are discussed further in the sub-sections below.

4.2 Overview of costing approach and data quality

The summary table below illustrates the costing approach undertaken for each method assessed and the relative data quality. This data should be reviewed by all appraisers to assess the level of detail used within the calculations and to highlight which methods are based on more broad scale data.

As discussed in Section 2.1 most methods have used a more reliable 'bottom up' approach using unit rates defined by an experienced quantity surveyor. However, some methods use a less reliable (top down) methodology due to the limited available data or the fact that some methods are simply too broad to be able to provide sufficiently accurate unit costs. These include methods such as bridges and weir removal.

Those methods where only indicative costs have been provided reflect the fact that unit costs cannot be provided for all sites and asset variations without a more detailed understanding of the design and site constraints. Appraisers should be aware that unit costs provided for these lower quality methods are indicative only and should be treated as a starting point only in terms of cost estimation. Where applicable, appraisers should seek more specialist advice or at least consider varying the costs to account for site specific or asset specific variations.

Table 4-1: Summary of flood risk methods and factors assessed within this report

Method	Costing approach	Quality
Flood Protection Wall	Bottom up analysis for majority of factors, calibrated against out-turn costs. Some scaling used for certain factors.	Best in class
Embankment	Bottom up analysis for all factors, calibrated against out-turn costs.	Best in class
Demountable Barriers	Costs provided by suppliers. O&M costs based on experience and best practice.	Data with known deficiencies
In-Channel Excavation	Bottom up analysis for all factors. Limited calibration data to validate costs.	Data with known deficiencies
Excavation on Land	Bottom up analysis for all factors. Limited	Best in class

Method	Costing approach	Quality
	calibration data to validate costs.	
Weir Construction	Bottom up analysis for all factors. Limited calibration data to validate costs.	Best in class
Weir Removal	Top down approach based on multiple case studies.	Gross assumptions
Bridge Removal	Costs based available but external (non Irish) unit rates.	Gross assumptions
Bridge Construction	Costs based available but external (non Irish) unit rates.	Gross assumptions
Bridge Underpinning	Bottom up analysis, calibrated against out-turn costs. Highly site specific and variable method.	Data with known deficiencies
New Culvert	Bottom up analysis for majority of factors, calibrated against out-turn costs. Some scaling used for certain factors.	Best in class
Sluice Gate	Bottom up analysis with supply informed rates for gate/penstock costs. Limited calibration data to validate costs.	Best in class
Road Raising	Bottom up analysis. Limited calibration data. Highly site specific and variable method.	Data with known deficiencies
Pumping Station	Top down approach based on JBA data for capital, running and O&M costs.	Data with known deficiencies
Individual Property Protection	Top down approach based on available research and internal JBA data, calibrated against Irish studies.	Best in class
Hydrometric Gauging Station	Bottom up analysis, calibrated against out-turn costs.	Best in class
Flood Forecasting System	Top down approach based on OPW research and internal data.	Data with known deficiencies
River Maintenance	Generic cost information based on OPW internal data.	Data with known deficiencies
Bank Protection	Bottom up analysis for all factors. Limited calibration data to validate costs.	Best in class
Manhole Sealing	Bottom up analysis. Limited calibration data to validate costs.	Data with known deficiencies
Mobilisation and Site Set-Up	Bottom up analysis for all factors.	Best in class

4.3 General costing assumptions

A number of assumptions have to be made for any costing approach and particularly for those aspects costed from first principals ('bottom up'). Individual assumptions for each method are provided in the summary sheets. However these are a number of generic assumptions as listed below:

- Rates used are inclusive of labour, plant and materials and assume a competent civil engineering contractor undertakes the work.
- The rates used represent a 'sunny day' scenario and in no way try to cover all possible risks or unseen eventualities. For this reason, consultants should take care when using the rates and applying these to the sites of interest. It will be important to fully consider all possible risks as part of the assessment and to make allowances for these as part of the method factor or optimism bias.

- Rates used are generally based on Dublin region prices, but it is considered that limited regional variations would be warranted, as insufficient data was available to determine this.
- Temporary works have been allowed for based on what we consider to be reasonable, but are not intended to be definitive for all possible eventualities or be a definitive methodology or sequence.
- Health and safety aspects assume a competent contractor, but site specific risks have not been allowed for. This aspect could be covered by the optimism bias risks.

A summary of the methodology and key factors costed for each option is provided in the following sections.

4.4 Walls

Costs have been derived from bottom up analysis using unit rates defined by an experienced quantity surveyor based on a specific set of design requirements for each wall type and factor variation. Full details and all assumptions are given in the summary spreadsheet.

All walls assume a reinforced concrete construction, with urban wall including the option for stone cladding. Costs include hoarding fence, removal of concrete path to facilitate construction and services diversions, wall foundation costs, replacement of paths and reinstatement of area.

Cost information is provided for the following factors:

- **Wall type**. Costs have been provided for rural, urban walls, quay walls and sea walls. Quay walls have been provided for 0.0, 0.6 and 1.2m heights only. Sea walls assume a single height based on the required design for an exposed location with re-curve wall.
- **Rural and urban**. It is assumed that urban walls will include stone cladding and a degree of works associated with services (excavation, lighting, backfill etc.).
- **Height variations of 0.6m, 1.0m, 2m and 3m**. These are typical wall heights used for flood mitigation. Wall heights assume a freeboard is included. Walls heights of 0.6m assume a 0.6m high railing on top.
- **Asset length categories of <100m and >100m**. Efficiencies of scale are anticipated for longer lengths, although analysis based on the above assumptions suggests that this is not as sensitive as expected. Users may wish to apply a factor for very short or much longer asset lengths.
- **Structure type**. An allowance for sheet piling has been included within the urban and quay walls. Sheet piling is not anticipated for rural locations. A sheet piling depth of 2m is included within the sea wall design as standard. Sheet piling costs are highly variable and will depend on site characteristics, ground conditions and the difficulty of installation. For this reason, sheet piling costs for urban walls have been derived based on weighting from an existing unit cost database. Sheet piling costs for quay walls have been estimated from rates supplied by an engineering contractor.

For comparison, we have provided the unit cost results and compared these against unit cost database rates from the Environment Agency. The comparison for urban and rural walls is shown below. The generated urban walls unit costs compare well with the Environment Agency unit costs. The rural walls unit costs are at the lower end of costs available which is to be expected for rural walls.

Figure 4-1: Urban wall cost curve and comparison with Environment Agency unit costs (adjusted to € and preliminaries removed)

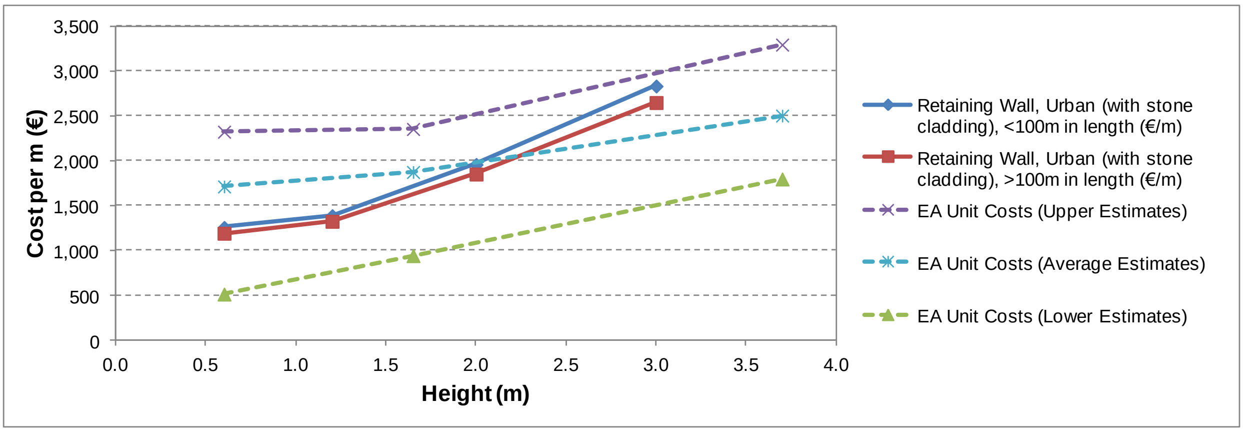
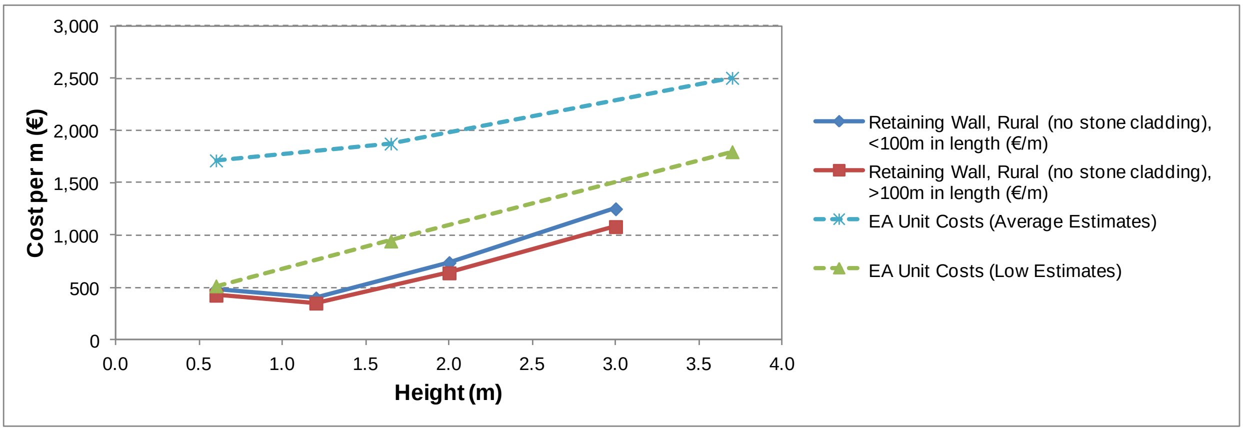


Figure 4-2: Rural wall cost curve and comparison with Environment Agency unit costs (adjusted to € and preliminaries removed)



4.5 Embankments

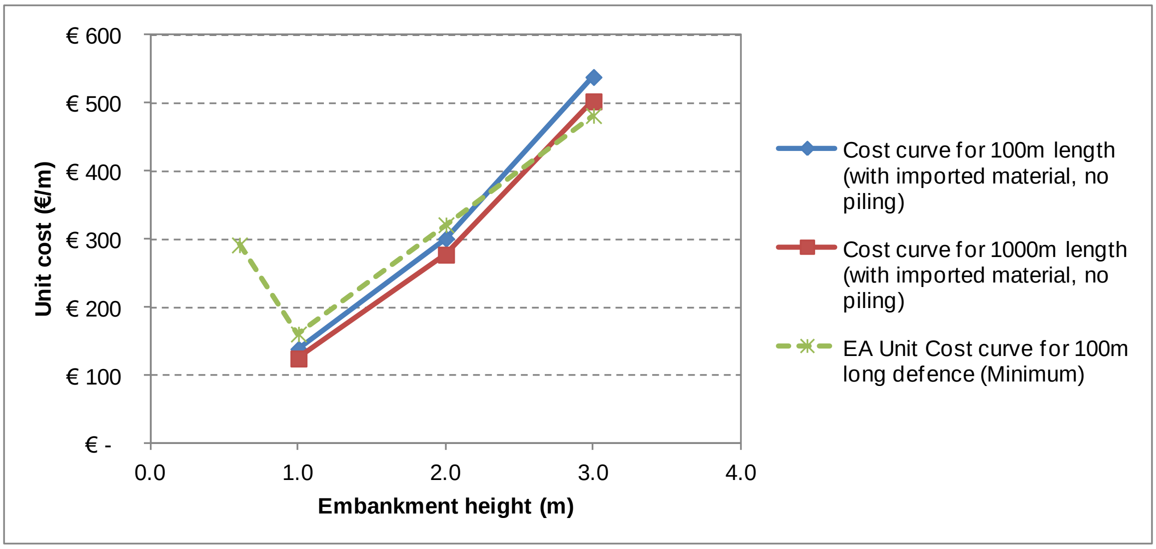
Costs have been derived from bottom up analysis using unit rates defined by an experienced quantity surveyor based on a specific set of design requirements for each embankment type and factor variation. Full details and all assumptions are given in the summary spreadsheet.

It is assumed that embankments will be constructed of suitable soil types, with a top width of 2m and a side-slope of 3:1 (i.e. 3m horizontally for each metre of height).

Cost information is provided for the following asset types:

- **Rural assets only**. It is not anticipated that embankments in urban locations will vary in cost as embankments will only be located in areas of open access.
- **Height variations of 1.0m, 2m and 3m**. These are typical embankment heights used for flood mitigation. Embankment heights assume a freeboard is included.
- **Asset length categories of <100m, 100-1,000m and >1000m**. Efficiencies of scale are anticipated for longer lengths.
- **Embankments formed from imported material and local material.** This is an important aspect that was included as the source of material can impact on costs significantly.
- **Embankment construction type**. Costs for standard embankments, embankments with a 5m pile and embankments with a 10m pile were costed separately as aspects will significantly influence costs.

Figure 4-3: Embankment cost curve and comparison with Environment Agency unit costs (adjusted to € and preliminaries removed)



4.6 Demountable barriers

Costs have been derived and obtained from a number of suppliers of demountable barriers and flood gates. Demountable barrier costs assume a pillar and slat type of construction and include the supply and installation of barriers. Costs for gates have been provided for a range of types.

Cost information is provided for the following factors:

- **Rural and urban**. No cost variation is provided for this aspect. The costs of supply will be the same for both scenarios. The ground work costs may vary due to the need for concrete foundations and possible cut-off, although this factor will depend on ground conditions at site rather than a rural or urban classification.
- **Height variations of 0.6m, 1.2m, 1.8m and 2.1m**. These are typical demountable barrier heights used for flood mitigation. Costs over and above 2.1m are possible but would need bespoke design from a specialist. Gates have been provided for 0.6m, 1.0m, 1.2m and 1.8m.
- **Asset length categories of 1m, 2.5m and 5m**. Costs have been provided by suppliers for very short lengths only. Costs for longer reaches should use the 5m lengths to scale up costs as barrier lengths beyond 5m will have less scale efficiencies unless suppliers choose to provide this. For very long lengths we recommend that costs are obtained from suppliers at an early stage.
- **Foundations**. Supply costs include the installation and supply of a ground beam. This incorporates the fixing plates for the posts and thus takes the onus off the contractor for the accuracy required with these. The greater cost however is the foundation cost. This could be as simple as a 600m x 600m concrete trench, although past experience suggests that costs for cut-offs and poor ground conditions can make up a large proportion of costs for these works.

In some circumstances demountable barriers will be constructed on top of flood walls. In this instance, appraisers should combine the two unit costs making any additional allowance for the works to tie the two together structurally and any additional costs associated with improved or extended foundations.

To aid this combined measure a range of basic additional foundation costs have been provided depending on the approach proposed. The three options where costs are provided include:

- Cost per m for basic foundation
- Cost for low wall (assuming demountables on top)
- Cost for quay wall

It should be noted that the wall unit costs provided do not allow for a further demountable barrier on top and that the wall foundations would need to make an allowance for the additional barrier height. An appropriate contingency should be applied for this aspect unless additional specific engineering design and expertise is provided to inform the design and costs.

All relevant event, operation and maintenance and storage costs are provided. These costs include general administration, storage costs and all inspection costs.

4.7 In-channel excavation

Costs have been derived from bottom up analysis using unit rates defined by an experienced quantity surveyor based on a specific set of design requirements for in-channel excavation works. The above costs have been developed from a breakdown of costs for excavation and disposal costs along with costs for construction of silt traps, replacement of gravel layer post works and the reinstatement of works access and storage areas. Full details and all assumptions are given in the summary spreadsheet.

Cost information is provided for the following factors:

- **Rural and urban**. Costs are broken down into rural and urban locations reflecting the more complex access and obstructions within urban locations.
- **Excavation material**. Costs are provided for excavation in soft soil and rock. Costs assume that all materials excavated are taken to a waste facility.
- **Volume of material**. Costs have been assessed for 3 categories: $100m^3$, $500m^3$ and $1000m^3$.

Operation and maintenance costs are assumed to be zero in the long term and do not add to expenditure budgets. Appraisers should consider initial post works monitoring for a number of years if this is anticipated to be required.

4.8 Excavation on land

Costs have been derived from bottom up analysis using unit rates defined by an experienced Irish quantity surveyor based on a specific set of design requirements for in-channel excavation works. The above costs have been developed from a breakdown of costs for excavation and disposal costs. Excavation on land is anticipated for channel diversions or natural flood management purposes. Full details and all assumptions are given in the summary spreadsheet.

Cost information is provided for the following factors:

- **Rural only**. Costs are broken down into rural locations only as unit costs cannot be provided for excavation of land in urban areas due to the highly variable site conditions and constraints.
- **Excavation material**. Costs are provided for excavation in soft soil and rock.
- **Disposal**. Costs have been provided assuming that all materials excavated are either taken to a waste facility or disposed on site. The latter may be applicable for rural works.
- **Volume of material**. Costs have been assessed for 3 categories: $100m^3$, $550m^3$ and $1000m^3$.

Operation and maintenance costs are assumed to be zero in the long term and do not add to expenditure budgets. Appraisers should consider initial post works monitoring for a number of years if this is anticipated to be required. Additionally, operation and maintenance costs may be required for channel creation aspects. In this instance, channel maintenance costs should be applied.

4.9 Weir construction

It is not anticipated that new in-line weirs would be constructed for flood risk management purposes as part of the CFRAM process, other than for lateral weirs (side spillways) to convey water into new diversion channels or storage areas. Therefore costs have been derived from bottom up analysis using unit rates defined by an experienced quantity surveyor based on a specific set of design requirements for a side weir construction.

Costs assume a reinforced concrete construction (similar to the assumptions used for concrete walls) with all necessary temporary works and bank protection. Full details and all assumptions are given in the summary spreadsheet.

There are considerable uncertainties associated with providing unit rates for all possible weir structures proposed as part of the CFRAM projects. As a result the rates provided should be used with caution and as a starting point only.

Cost information is provided for the following factors:

- **Weir height**. Costs have been provided for 1m and 2m high weirs. Total costs and unit costs are provided.
- **Weir length**. Costs have been assessed for 10m and 20m long weir lengths. Total costs and unit costs are provided.

Operation and maintenance costs have been provided.

4.10 Weir removal

Costing and providing unit rates for weir removal is complicated by the inherent variations in weir design and size, site specifics and site constraints. As a result costs have been derived from top down analysis derived from gathering case studies of weir removal to derive example costs. A number of examples have been sourced and provided to illustrate the range of costs likely. Costs appear to correlate with structure length and an indicative cost curve has been provided. It should be noted however that most sites collated are predominantly rural rather than urban and care should be utilised when applying this cost curve to urban sites as costs could be substantially higher.

There are considerable uncertainties associated with providing unit rates for the removal of weir structures proposed as part of the CFRAM projects. As a result the values used and cost curve provided should be used with caution and as a starting point only.

Operation and maintenance costs have been included to account for post works monitoring to ensure watercourse channels remain stable.

4.11 Bridge construction/removal

Costing and providing unit rates for bridge construction/removal is complicated by the inherent variations in bridge design and size, site specifics and site constraints. As a result costs have been derived from top down analysis, derived from existing unit costs from a range of available sources from the UK and the USA. The UK costs are deemed to be most applicable although data from the USA provides additional confidence in the data used. There are existing National Roads Authority (NRA) cost databases that have this information and could be used to reduce the reliance on non-Irish unit rates. We recommend that access to the cost database is agreed between the NRA and the OPW to improve future bridge costs.

Costs are available for the following:

- Footbridge
- Reinforced concrete bridges
- Bridge removal

These costs are highly indicative and should only be used for early level appraisals where bridge costing is required, and where site details and designs are not yet understood. Costs should therefore be used with care and may not be applicable to all structures. Costs will be highly dependent on the presence of existing services and anticipated traffic loading and these factors should be considered by the CFRAM consultants when using the rates provided.

Appraisers should select an appropriate unit cost from the range provided based on the site characteristics and the risk factors identified.

4.12 Bridge underpinning

Costs have been derived from bottom up analysis using unit rates defined by an experienced quantity surveyor based on a specific set of design requirements for in-channel excavation works. The unit costs have been developed from a breakdown of costs for all associated site works, temporary works and phased construction works. The costing process is based on a theoretical case study: a 3 span bridge with four 13m long support walls. Full details and all assumptions are given in the summary spreadsheet.

No further cost factors have been allowed for, therefore care should be exercised in using these costs for anything other than early level appraisals where bridge underpinning has been identified, but site details and designs are not yet fully understood.

Operation and maintenance costs are assumed to be zero in the long term and do not add to expenditure budgets (these works may actually reduce inspection and maintenance costs for at risk structures). Appraisers should consider initial post works monitoring for a number of years if this is anticipated to be required.

4.13 Culvert

Costs have been derived from bottom up analysis using unit rates defined by an experienced quantity surveyor based on a specific set of design requirements for each culvert type and factor variation. Full details and all assumptions are given in the summary spreadsheet.

All culverts assume a site preparation and trench excavation, disposal, granular bedding, supply and placement of precast culvert, backfilling and reinstatement. In addition to culvert works, the costs of headwall construction are provided separately. Full details and all assumptions are given in the summary spreadsheet.

Cost information is provided for the following factors:

- **Rural and urban**. Culverts in an urban area assume additional works for manhole provision, additional excavation and service diversions, temporary trenching and traffic management, road re-instatement and connection of existing services. Costs for urban culverts relate to new culverts and the replacement of existing culverts. Costs for urban reaches only relate to pipes as it is unlikely that long lengths of box culverts will be needed in urban environments.
- **Culvert sizes for pipes (1.05 and 1.5m dia) and box culverts (2.1x1m, 2.4x2.1m and 3.0x2.1m)**. These are typical culvert sizes applicable for a range of flood mitigation measures. Costs for replacement culvert sizes (pipes of 1.05m and 1.5m diameters) were selected as it is assumed that large culvert online replacement is unlikely in the in the urban environment.
- **Depth of invert (2, 4, 6m)**. The depth of invert can influence the construction costs due to greater excavation and backfilling costs.
- **Excavation material (soil and rock)**. Costs of construction will vary greatly for construction in rock. This variation has been applied to rural culverts only.
- **Disposal of waste material**. Costs for disposal will vary depending on where material is disposed and distance of haulage. Costs have been broken down between disposal on site and disposal at a licensed tip. This variation has been applied to rural culverts only.
- **Asset length**. Costs have been developed for a 100m culvert length. Costs increase substantially for short lengths. To take this aspect into consideration existing unit rates have been used to define factor adjustments for very short culvert lengths. Users may wish to apply a factor for very short or much longer asset lengths.
- **Headwalls**. Costs have been developed for headwalls as a separate item. Costs have been provided for the 5 culvert size dimensions and assume that the total height of the reinforced concrete headwall will be 1500mm above the top of the pipe or culvert.

Operation and maintenance costs are provided for short, medium and long culvert lengths and for 3 categories of culvert size ($<1.2m^2$, $1.2\text{-}4.0m^2$ and $>4.0m^2$).

4.14 Road Raising

Costs have been derived from bottom up analysis using unit rates defined by an experienced quantity surveyor based on a defined set of design requirements for road raising. It is very difficult to provide a unit cost that will be applicable for all sites. Therefore costing process is based on a theoretical road raising approach that allows for the raising of a 7.5m road, kerbs, grass verges and footpath. Full details and all assumptions are given in the summary spreadsheet.

No further cost factors have been allowed for, therefore care should be exercised in using these costs for anything other than early level appraisals where road raising is proposed but specific site details and designs are not yet fully understood.

This operation is not anticipated to have any net increase in existing operation and maintenance costs: indeed it may reduce them.

4.15 Individual property protection

Costs for individual property protection have been derived from existing research into PLP costs and JBA information on survey and administration costs. Unit rates for individual property level protection products have been used and multiplied by standard packages for typical property types in order to derive a unit cost per property. Costs allow for survey and administration, door guards, airbrick covers, sump pumps, waterproofing of external walls, non return valves or toilet bungs. Full details and all assumptions are given in the summary spreadsheet.

Cost information is provided for the following factors:

- **Property type**. Unit costs have been provided for the following property types: Detached, Semi-Detached, Terraced, Flat, Residential Average (where property types are unknown), shops and offices.
- **PLP product type**. Unit costs have been provided for manual products and automatic measures. Manual products need to be fitted manually by residents or homeowners, whereas automatic measures require minimal operation prior to a flood event but are generally more costly.

O&M costs are recommended to be 2% for manual measures and 5% for automatic measures.

4.16 Hydrometric gauging station

Costs have been built up from unit rates for specification/administration, monitoring equipments and installation/communication rates to cover the cost of installation and running of a hydrometric gauging station. It is assumed that this is a relatively simple water level monitoring station fitted with telemetry and costs include annual costs for undertaking flow gaugings.

No further cost factors have been allowed for. Costs do not assume weir, stilling wells, recorder house and cableway construction. Whilst the unit cost for such stations will be significantly greater and are excluded, the summary provides costs for such structures based on other unit rates from the UK for completeness.

4.17 Flood forecasting

Costs for the provision of flood forecasting are highly variable and will depend on the level of existing hydrometric coverage, the size of catchment, the forecasting requirements and the degree of software and hardware to support forecast data and models.

Costs have been broken down into simple alarms and complex forecasting models. Rates for simple alarms have been built up from unit rates for specification/administration, monitoring equipment and installation/communication rates. Costs are broken down into the following factors:

- **Simple alarm system**. Water level monitoring station fitted with public alarm when level reaches specified level(s). Costs are provided per station for gauges with audio alarms and those with signage (e.g. for road crossings liable to flooding).
- **Simple forecast system**. Water level monitoring station fitted with telemetry to send text messages when level reaches specified level(s). Costs are provided per station for gauges with audio alarms and those with signage (e.g. for road crossings liable to flooding).

Costs for complex alarm systems have not been defined although a range of typical costs are provided for key aspects that may be needed depending of the site of catchment and scope required. These costs are predominantly based on existing information provided by the OPW and updated from other sources. Costs include specification, site survey and administration, gauging and telemetry, forecast model set-up, calibration, configuration and testing, forecasting system development, design and plan of training package and public awareness campaigns.

The Present Value cost summary tool allows users to specify the number and rate (guided by typical rates) for each item for a specified forecast model. Obviously there are large uncertainties and the rates used are indicative. Whilst costs include hardware and software costs for new forecasting capabilities (if not already available), appraisers should be aware that if multiple

forecast models and systems are proposed and run regionally or centrally, there may be cost savings that apply.

4.18 Pumping stations

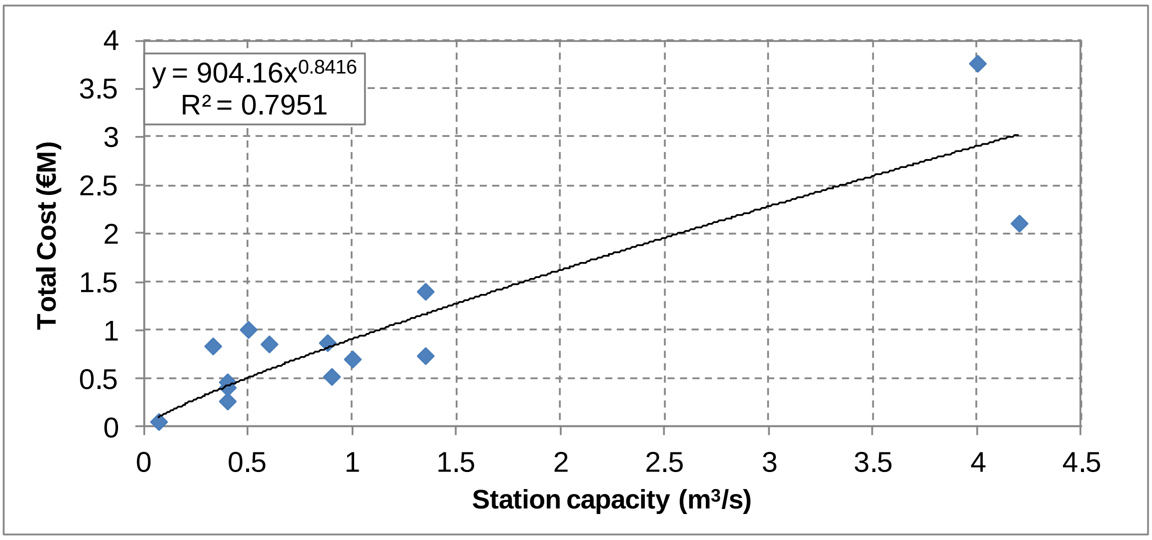
Costs have been derived from top down analysis through the assessment of multiple pumping station case studies. Costs are highly indicative due to the large variation in design of pumping stations and the wide range of factors that need to be considered. Capital costs will relate to the supply of pumps and construction of all pumping station civil works. This may include site clearance, pump installation and ancillary electrical and mechanical equipment, excavation, pipework and manhole construction, kiosk/housing installation/construction, connection with power supplies, and telemetry/cctv installation and testing.

Whilst a range of factors need to be considered for all pumping stations, all costs gathered have been plotted against the pump capacity to determine a cost curve for use at the high level, early stage assessment prior to site specific design (Figure 4-4).

Cost information is provided for the following factors:

- **Capacity**. Based on cost curve derived a series of unit costs have been derived for 7 categories of pump capacity (20l/s, 50l/s, 100l/s, 500l/s, 1,000l/s, 2,000l/s and 3,000l/s).

Figure 4-4: Pumping station construction cost curve



No further cost factors have been allowed for, therefore care should be exercised in using these costs for anything other than early level appraisals where pumping stations have been identified, but site details and designs are not yet fully understood.

Operation and maintenance costs are an important consideration for pumping stations due to the annual running and operational costs and annual/intermittent maintenance costs. Detailed analysis of existing pumping stations assessed by JBA have been used to define unit rates for these aspects for this study. The following aspects are provided:

- **Annual maintenance costs**. These are highly variable and will depend on the need for inspections, condition assessments, repairs and replacement of parts, removal of blockages and telemetry checks. A unit rate for each category of pump station capacity has been provided as well as an upper and lower rate.
- **Running costs**. This will include all electricity costs. Based on the output of JBA analysis a cost curve has been derived to determine costs for the range of pumping station capacities. It should be noted that Maximum Import Capacity (MIC) charges may also apply for larger pumping stations with significant implications for running costs (see below).
- **Intermittent replacement costs**. In addition to annual and periodic maintenance costs, refurbishment works are generally carried out at approximately 15 to 25 year intervals for

mechanical and electrical equipment with any major structural repairs and improvements being carried out. For the purposes of whole life costing we recommend that refurbishment costs are included every 25 years over the appraisal period.

4.18.1 Note on Maximum Import Capacity (MIC) charges

MIC charges are applied for all new pumping stations to cover the energy distributor's costs of connection and meter installation. However, for larger pumping stations MIC charges may also be applied as an annual cost. The current MIC charge is €0.0734/kVA/day. This charge is applied whether the pump is in use or not and is set to cover the demand usage of the pumping station when required. An example is the Ennis FRS which has a pump capacity of 3.8m3/s and a power requirement of 1000KVA. This results in an annual MIC charge of €28965 (including VAT).

These costs are not included in the running costs provided, but need to be included for larger pumping stations to ensure that these important costs are fully considered by the CFRAM consultants. There are options to design out these charges however, that may need to be investigated at an early stage in the appraisal process. Options may include the use of more efficient pumps with lower power requirements (although higher capital costs), the use of generators to power the pump (noting that there may be maintenance and site layout constraints to consider also).

4.19 Channel maintenance

Channel maintenance costs vary considerably depending on the state of watercourse and channel sizes. Unit costs have been derived from a top down approach utilising existing information from the OPW and the Environment Agency (the latter adjusted to Euros).

Costs relate to inspections, bank clearance, obstruction removal, weed control and intermittent works such as bank protection and repairs. A range of costs (broken down by channel type (urban/rural), clearance method (manual/mechanical)) are provided as well as upper and lower bounds for the EA data.

All costs represent annual costs rather than capital costs. Full details and all assumptions are given in the summary spreadsheet. Recommended costs are provided for the following factors:

- **<5m wide channels in rural areas**
- **<5m wide channels in urban areas**
- **5-10m wide channels in rural areas**
- **5-10m wide channels in urban areas**
- **Channels in poor condition requiring heavy maintenance**

4.20 Bank protection

Costs have been derived from bottom up analysis using unit rates defined by an experienced Irish quantity surveyor based on a specific set of design requirements for each bank protection type and factor variation. Full details and all assumptions are given in the summary spreadsheet.

Cost information is provided for the following factors:

- **Fluvial and coastal**. Two alternative designs have been prepared for bank protection in a fluvial environment (4m high gabion protection) and in a coastal environment (rock revetment).
- **Length**. Fluvial bank protection costs have been provided for 3 length categories (<25m, 25 to 100m and >100m). Coastal rock revetments have been costed for a single 100m length although additional unit rates have been used to apply weightings to longer and shorter lengths. .

Operation and maintenance costs are also provided but are anticipated to be minimal.

4.21 Manhole sealing

Manhole sealing costs have been provided by Gerry O'Connell of Dublin City Council for a range of options including alternative pressures and construction methods. Costs include the supply and fit of a pressure manhole cover of 1-2 bar rating (10-20m water head).

4.22 Additional cost elements

4.22.1 Preliminaries

Construction costs do not include preliminaries as these are most likely to be applied to the total cost for a range of asset types rather than per asset. Despite this the user can apply them to the PV cost tool for individual methods or as part of the combined portfolio of methods tool. To assist the inclusion of preliminaries a method of estimating preliminaries has been derived.

Preliminaries and other construction costs have been built up from unit rates for the following items:

- Compound
- Site cabins and services
- Temporary power and generators
- Protection to overhead services
- Protection to underground services
- Road sweeping of public roads
- Preparation of as constructed drawings
- Health and safety
- Security
- Wheel wash provision at exits to public roads
- Manual washing prior to vehicles existing to public roads
- Supervision
- Setting out
- Mobilisation and demobilise
- Insurance

In addition to the above, each of the separate unit costs includes an estimate of some of the additional preliminaries, such as temporary works, environmental mitigation and temporary flow controls. The temporary works costs are based on what would be required on all sites but are not intended to be definitive for all possible eventualities. As a result, CFRAM consultants should increase the preliminary or method costs to take into account those sites where non-standard, difficult, or additional temporary works are likely to be required.

For each of the above factors a representative cost has been determined for a particular project total cost from €100,000 to €15,000,000. These are shown in Table 4-2 below.

Table 4-2: Preliminaries cost curve

Construction cost:	€100k	€250k	€500k	€1m	€2m	€5m	€10m	€15m
Total Preliminaries	€32k	€51k	€89k	€199k	€330k	€512k	€743k	€932k
Preliminaries as a % of total	32%	20%	18%	20%	16%	10%	7%	6%

Based on the above analysis we recommend that typical preliminary estimates should be between 10-30% of total construction costs, although the tool provided allows appraisers to estimate the preliminaries costs for any given total construction cost.

4.22.2 Haul roads

Construction costs do not include method related costs. A method of estimating two key method related costs (haul roads and works access) have been derived to assist CFRAM consultants. These costs have been derived from worked up rates for a range of activities. It is recommended that the above costs are applied to all capital costs estimates where haul roads or works access is required. This has been addressed in the preliminaries summary cost sheet.

5 Cost database structure

5.1 Database files

A number of files have been prepared and provided to OPW and CFRAM consultants. These include the following:

- 20 CFRAM Consultant FRM method summary cost sheets
- CFRAM Consultant Combined Method WLC tool
- CFRAM Consultant Optimism Bias tool (see Section 3.4.1)
- OPW calculation sheets

5.2 CFRAM Consultant summary sheets

The CFRAM consultant spreadsheets provide all necessary unit rates derived, but none of the background base rates or breakdown of costs. These are included in associated OPW calculation spreadsheets. This is to ensure that the OPW remains the keepers of the data and can make updates to specific rates as and when changes and updates are required, without overloading the CFRAM consultants.

5.2.1 Approach to cost estimation

The basic approach to cost estimation is shown in the Figure 5-1 overleaf. It is up to the consultant to review both this report and each of the summary reports to firstly check that the costs provided cover the types of works proposed and include the factors and sizing applicable to the site. If this database of costs does not provide the necessary information, additional bespoke costing may be required.

Consultants should also review the assumptions used for each approach and decide if any additional weighting or adjustments to the unit costs are required to match the particular site, or whether these can be suitably allowed for as part of an overall optimism bias.

5.3 Layout of CFRAM Consultant Summary sheets

For each method a summary MS Excel workbook exists. Within each is a series of sheets as follows:

- **Revision History** sheet. A basic history of revisions to be kept up to date by JBA/OPW.
- **PVc Summary** sheet (See Figure 5-1 as an example). This allows whole life present value costs to be derived for single method cases (e.g. a series of walls). Appraisers can enter a series of assets and apply specific rates and units to develop a total cost. Appraisers must also enter in any applicable preliminaries, enabling, O&M costs and other costs to derive a whole life cost. A separate tool is provided to generate a whole life cost for a portfolio of assets/methods.
- **Cost Summary** sheet. This sheet provides the unit costs derived, information on how the costs were derived, key assumptions and O&M/other costs.
- **Example** sheet. This is provided for methods were costs have been built up from bottom up costing and includes drawings illustrating the asset type.

The PVc summary sheet should not be used to combine method costs as items like preliminaries will be double counted.

Figure 5-1: Example of PvC summary sheet

DONNACHADH O'BRIEN
& ASSOCIATES CONSULTING ENGINEERS

CFRAM Unit Cost Development Project

Method	Embankment		
Prepared by:		Date:	
Checked by:		Date:	

OPW
The Office of Public Works
Oifig na nOibreacha Poiblí

Project reference	XXXXXX		Project name:	EXAMPLE PROJECT

Base date for estimates (year 0)	Oct-2013
Scaling factor (e.g. €m, €k, €)	€

Construction Price Index (CPI)	1.000
Method Factor - to take into account particular site issues/constraints	1.10

This sheet should only be used when assessing single method options as double counting may occur when method costs are added.

Single Method Capital Cost Tool

	1	2	3	4	5	6	Comment/justification
Embankment ref/type	Left bank	Right bank					*Embankments on both banks required*
Embankment length	50	200					*2m high embankment costs*
Embankment unit rate	300	285					*Costs assume imported material*
Total costs						€72,000	
Apply update to unit rate (CPI) if appropriate (cell N15)						€72,000	
Enter appropriate preliminaries estimate (%)						15%	*15% enabling costs assumed*
Enter other applicable costs (€)						10000	*Access over embankment required*
Total capital cost (€)						€92,800	
Consider amendments based on site issues/constraints (cell N16)						€102,080	*Difficult access, 10% uplift assumed*
Total capital cost (€)						**€102,080**	

Operation and Maintenance Cost Tool

Total annual O&M costs	€100	

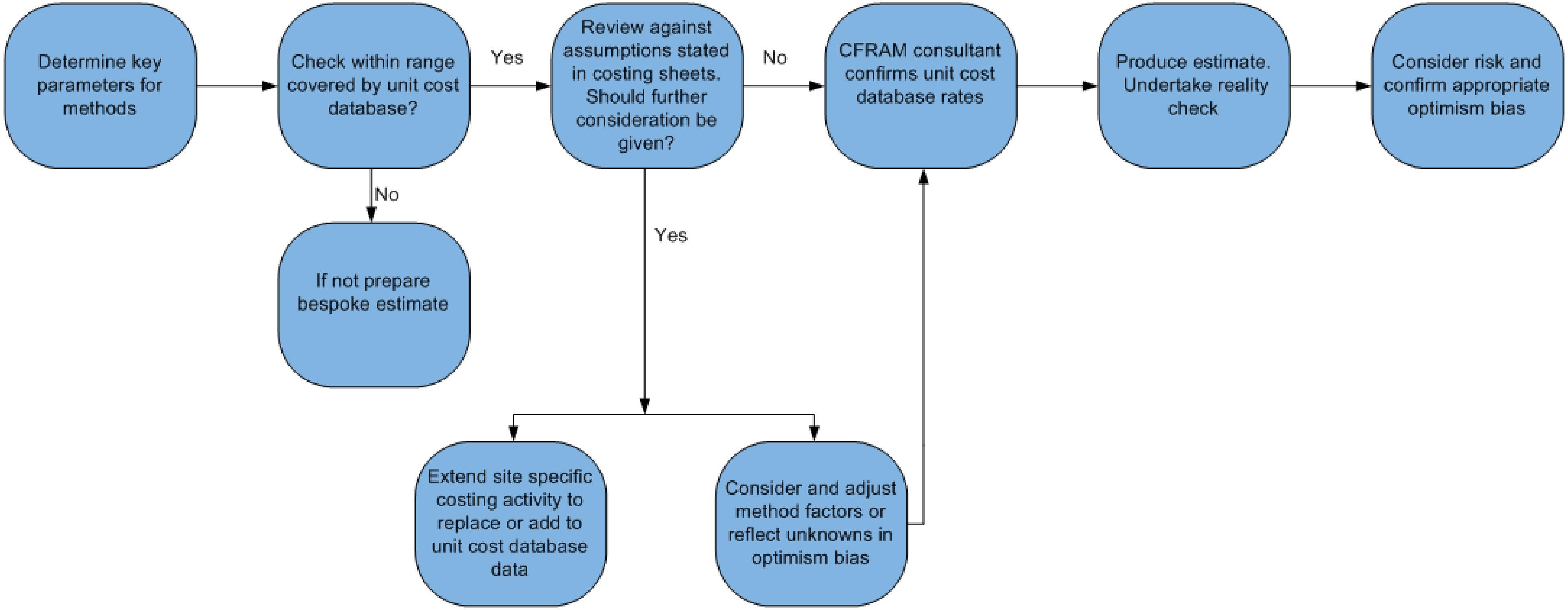
Other costs

Other costs (user defined - consider the need for additional longer term or intermittent costs)		

Total PV Cost

Total PVc costs (see PVc calculator below)	**€104,214**	
Optimism bias rate (from external sheet)	50%	
Total Cost including Optimism Bias	**€156,321**	

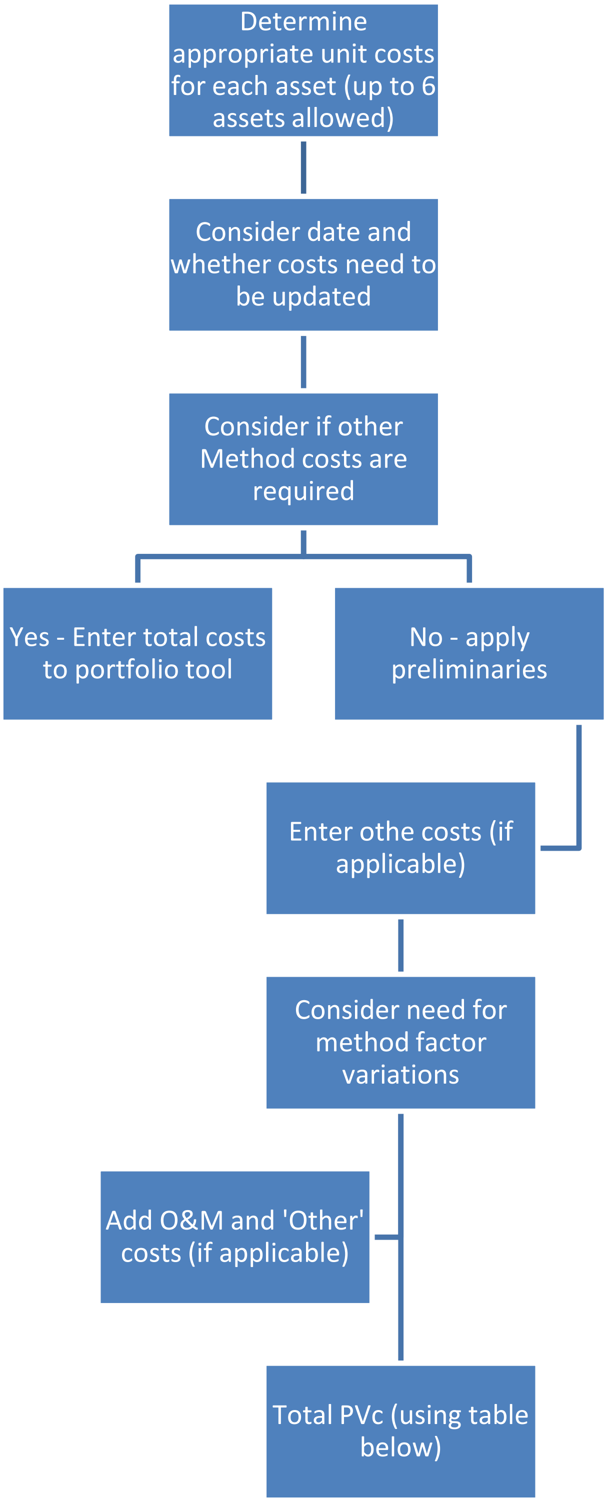
Figure 5-2: CFRAM costing approach



5.3.1 Present Value (whole life cost) summary explanation

The PVc summary is provided in each summary sheet and enables whole life costs for single asset cases to be derived. The following flow path should be followed when entering data from the 'Cost summary' sheet.

Figure 5-3: Present Value Cost tool process



Each stage is provided in the spreadsheet as a separate row with space consultants to enter appropriate comments and/or justification for the values entered as shown in Figure 5-4.

Figure 5-4: Cost summary inputs

Single Method Capital Cost Tool

	1	2	3	4	5	6	Comment/justification
Culvert ref.							
Culvert length (m)	25	50					
Culvert unit rate (€/m)	2500	1800					
Total costs						€152,500	
Apply update to unit rate (CPI) if appropriate (cell N15)						€152,500	
Enter appropriate preliminaries estimate (%)						15%	
Enter other applicable costs (€)						0	
Total capital cost (€)						€175,375	
Consider amendments based on site issues/constraints (cell N16)						€175,375	
Total capital cost (€)						€175,375	

Operation and Maintenance Cost Tool

Total annual O&M costs		

Other costs

Other costs (user defined - consider the need for additional longer term or intermittent costs)		

Total PV Cost

Total PVc costs (see PVc calculator below)	€168,630	
Optimism bias rate (from external sheet)	50%	
Total Cost including Optimism Bias	€252,945	

5.3.2 Data inputs

In each summary sheet the following colour codes apply to cells within the working area:

- Cells normally requiring data entry: Orange
- Cells where data may be amended, if necessary: White
- Main calculation areas where values generated automatically: Light Green
- Titles, etc. outside main calculation areas: Blue

It should be noted that unit costs from the 'Cost Summary' sheets are not linked and need to be added by CFRAM consultants

5.3.3 Present Value cost tool inputs

For the purposes of this project a standard present value spreadsheet has been developed to allow appraisers to input basic cost information and to derive whole life costs by applying standard discount rates over the standard appraisal period. The tool automatically brings in summary costs for each of the applicable cost elements (Capital, O&M, and 'Other' costs).

This tool is provided for each method summary (to allow whole life costing for single asset types, e.g. embankments) and on a separate 'portfolio tool' that allows appraisers to input costs for a range of flood risk management methods. An example of the spreadsheet is shown in Figure 5-4.

Enabling costs (***(a)*** in Figure 5-5), if applicable, are assumed to occur in year 0. If enabling works are likely to extent to 2 or more years, users should enter these manually within the PVc table.

Whilst the user has the ability to define the year of capital costs (***(b)*** in Figure 5-5)[4], the OPW standard for the purposes of CFRAM projects is that this should be set to year 0 as it will not be known when projects will be implemented (this will only be known once prioritisation of schemes has been completed). This application has only been given for completeness and users should only change this value with the consent of the OPW for particularly larger schemes where construction may be delayed or phased.

Maintenance works are assumed to be annual starting the year after capital works. The user has the ability to enter intermittent or other costs. The 'other' costs element is linked to the cost summary, although users should enter the frequency (***(c)*** in Figure 5-5), of these costs (e.g. 1 for annual costs, 5 for 5 yearly repeat costs). These costs are repeated for the full 50 year period starting the year after the capital works are completed.

[4] Entering a value of 2 for example shifts the capital costs to year 1. Should users wish to enter a phased or multi-year construction period, this must be done manually.

Figure 5-5: Whole life cost and PVc analysis tool

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	€10,000	*(a)*
Year of capital works (year)	1	*(b)*
Capital cost (€)	€250,000.0	
Annual maintenance cost (€)	€2,500.0	
Other cost (€)	€10,000.0	
Other works frequency (years)	10	*(c)*

Key

	Information
	Calculation
	Cost input

Discount rate:	**4.0%**	**Present Value Factor:**	**22.341**		**Total PVc (€k):**		**317186** *(e)*
	Cash sum	10000	250000	120000	40000	420000	**317186**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.00 *(d)*	10000				10000.0	10000.0
1	0.962		250000			250000.0	240384.6
2	0.925			2500		2500.0	2311.4
3	0.889			2500		2500.0	2222.5
4	0.855			2500		2500.0	2137.0
5	0.822			2500		2500.0	2054.8
6	0.790			2500		2500.0	1975.8
7	0.760			2500		2500.0	1899.8
8	0.731			2500		2500.0	1826.7
9	0.703			2500		2500.0	1756.5
10	0.676			2500		2500.0	1688.9
11	0.650			2500	10000	12500.0	8119.8
12	0.625			2500		2500.0	1561.5
13	0.601			2500		2500.0	1501.4
14	0.577			2500		2500.0	1443.7
15	0.555			2500		2500.0	1388.2
16	0.534			2500		2500.0	1334.8
17	0.513			2500		2500.0	1283.4
18	0.494			2500		2500.0	1234.1
19	0.475			2500		2500.0	1186.6
20	0.456			2500		2500.0	1141.0
21	0.439			2500	10000	12500.0	5485.4
22	0.422			2500		2500.0	1054.9
23	0.406			2500		2500.0	1014.3

The tool enters the annual cash costs for the 50 year appraisal period (years 0 to 49) based on the input data. Standard discount rates (***(d)*** in Figure 5-4) are provided in the second column and total cash and Present Value costs are summed in 'totals' columns to the right. The total PV cost is summed in the upper right cell (***(e)*** in Figure 5-4). PV costs determined can then be added to the optimism bias tool to generate a total PVc including project risks.

5.4 Updating of costs

The unit rates supplied in each individual sheet are intended as a starting point for cost estimation and should be used by experienced staff with knowledge of scheme design and cost estimation. It should be noted that the costs represent common, representative types for each method and factor listed. CFRAM Consultants are required to use their professional judgement in using the unit costs, and should vary costs to take into account local requirements or conditions that are not provided for explicitly in the methods and factors.

Two options have been provided to allow CFRAM Consultants to update costs in the PVc summary sheet:

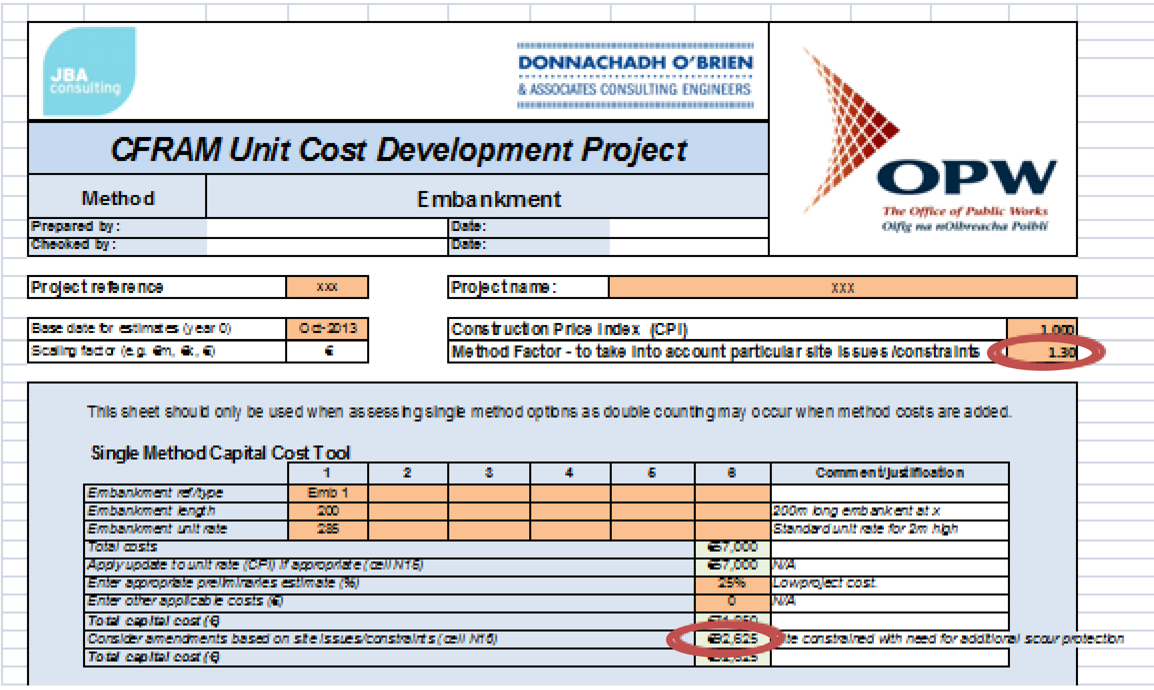
- **Construction Price Index**. This allows appraisers to update costs for future years if a rise in inflation or construction prices occurs.
- **Method factors**. This allows users to apply adjustments to the total capital cost for each method based on known and particular site issues and constraints. This is separate from the optimism bias that tries to take into account of under-predictions due to unforeseen risks in the design and construction.

Whilst method factors may be open to mistreatment and goes against the aim of the project to provide a consistent approach to costing across all CFRAM studies, the costs provided are a single cost for each method and factor that cannot necessarily cover every site and situation. The use of method factors are therefore recommended to enable CFRAM consultants to vary costs for those sites where the standard assumptions for each method and factor will not apply.

For example, a consultant requires a 200m long embankment of 2m height made from imported material with no piling (unit cost of €285 per m length). However, access is constrained and the current watercourse bank is showing signs of erosion so additional scour protection will be required. Based on this knowledge and experience, the consultant applies a 1.3 method related factor to increase the unit cost by 30% to account for these site conditions.

Factors that should be considered by consultants for each method and factor are provided in the summary sheets. Furthermore, for quality control and auditing purposes and in order to allow the OPW to review each cost estimate, consultants should provide justification on the method related factor used (see below).

Figure 5-6: Example use of method factors within PVc cost sheet



5.5 Portfolio whole life cost tool

In addition to the 20 summary sheets we have provided a whole life cost tool that combines costs from different methods to help build up a total cost for a scheme. This tool allows users to enter in capital and O&M costs for each method defined as well as a user specified entry if required. Total capital costs across all methods are summed, after which users can update to current prices, enter other applicable costs and add appropriate total preliminaries costs. The Present Value calculations undertaken are then applied as per the single method cost tool. This is shown in Figure 5-7.

Figure 5-7: Portfolio tool (to gather multiple asset costs and derive a scheme PVc

Project reference			**Project name:**	
Base date for estimates (year 0)	Oct-2013		**Construction Price Index (CPI)**	**1.000**
Scaling factor (e.g. €m, €k, €)	€		**Method Factor - to take into account particular site issues /constraints**	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	**Cost (€)**	**Comment**
Total wall costs		
Total embankment costs		
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€0	
Apply update to unit rate (CPI) if appropriate (cell N15)	€0	
Enter appropriate preliminaries estimate (%)		
Enter other applicable costs (€)	0	
Total capital cost (€)	€0	
Consider amendments based on site issues/constraints (cell N16)	€0	
Total capital cost (€)	€0	

5.6 OPW calculation sheets

The OPW calculation sheets include the following sheets:

- A summary unit cost sheet
- A base rate sheet holding all rates used in the calculations
- Cost calculation sheets for each method/factor

5.6.1 Updating of costs

In order for the database to remain up to date and applicable, we recommend that certain factors are updated or modified. All costs are applicable to 2013 values. Updating of costs may be needed in the future once updated inflation or construction price indices are released.

The OPW may wish to update the base rates used in the analysis. This may need to be done for particular rates that could change significantly beyond normal construction price indices e.g. rebar costs, sheet piling, pre-cast culverts and fuel costs.

This can be done in the 'base rate' sheet for each of the calculation sheets. A comment specifying the reason for change should be added. Any updates to these base rates will be applied to each relevant cost sheet and relevant summary tables. Manual edits required to update the summary sheets as these are not currently linked to the summary sheets provided to CFRAM Consultants.

6 Cost validation

6.1 Methodology

In order to confirm that the unit costs provided are applicable to real-world examples a number of validation tests have been undertaken on 4 case studies in Ireland. The aim of these validation tests are to independently calculate the costs of the schemes based on initial design proposals using the unit costs and spreadsheet tools provided as part of this project.

This assessment investigates four projects that serve as acceptable surrogates for the work expected as part of any CFRAM flood relief or management scheme.

6.2 Calibration projects

The calibration projects are as follows:

- Deansgrange Flood Alleviation Scheme. Located in Clonkeen Park, South Dublin.
- Rolestown Minor Works Flood Scheme. Located in Rolestown a small village 10 km north-west of Swords in County Dublin.
- Mornington Flood Relief Scheme. Located at the downstream end of the Mornington catchment near the Boyne Estuary.
- Clonmel Drainage Scheme.

6.3 Deansgrange Flood Alleviation Scheme

The purpose of the scheme is to protect residential properties in the Monaloe Way and Little Meadow housing estates from excessive water levels, whilst retaining the public amenity function of the park. Historical flooding has occurred in this area a number of times affecting local residents, with the most severe flooding witnessed on the 24th October 2011. The proposed works include:

- The realignment of the Deansgrange Stream towards the centre of the park, which includes the construction of a wider open channel to provide additional conveyance capacity.
- Re-grading of lands to provide additional flood storage capacity.
- Construction of a section of new culvert, with associated culvert inlet and headwalls to increase inlet capacity.
- Decommission & backfilling of the existing stream channel, a section of existing culvert, headwall and screen.
- Diversion of existing stormwater drainage where required and construction of new stormwater drainage and French drain inclusive of outfalls to new channel.
- Provision of an earth embankment along the left bank of Deansgrange Stream.
- Additional landscaping, fencing, boundary works and realignment of existing cycle track and associated public lighting. Other miscellaneous works (inclusive of fencing, new footpaths, new lighting etc)

The results of the analyses, as tabulated on the Whole Life Cost Tool spreadsheet, are summarised below:

- Total Capital Cost €206,600
- Total O&M Cost (Annual) €4,707
- Total Present Value Cost €322,599
- Total PV Cost inc. Optimism Bias (40%) €451,639

This scheme was designed by JBA and JBA have been involved in the project from concept stage through to construction and completion. The project is now at substantial completion stage. .

In summary, the total sum tendered by the appointed contractors was €239,000 ex. VAT and the actual final account is balancing generally close to the tendered sum. The same figure, as calculated by the Unit Cost database, was €206,600. In general, when comparing the tendered

sums and the total costs calculated by the Unit Cost database, there is an acceptable level of agreement. This is despite large variations in some areas. For example, the appointed Contractor priced the installation of the new culvert at €19,700, significantly less than the tool at €29,700.

The spreadsheet tool lacked the ability in this instance to account for the construction of a new off-line manhole, nor the construction of a new permanent cycle-track. Thus, whilst there are many nuances and project-specific tasks that cannot be accounted for in the spreadsheets that would explain any differences in cost estimations, the overall costs seem to predict the costs well in this instance.

One must also remember that upon application of the Optimism Bias, the total cost of the project becomes €451,639. This an overly conservative figure compared to the tendered sum in this instance.

6.4 Rolestown Minor Works Flood Scheme

The site is a small development consisting of three properties and is bounded by the R125 to the north and the Rolestown Stream to the east, south and west. The Rolestown Stream diverges at the southern boundary of the site and is an artificial watercourse that has been diverted to supply a mill in the village. The proposed works include:

- A concrete spillway
- Embankment stability works
- Western Channel culvert
- New embankment
- Eastern channel spillway wall
- East Channel culvert
- Relief Stream widened
- Spillway service and paving

The results of the analyses, as tabulated on the Whole Life Cost Tool spreadsheet, are summarised below:

- Total Capital Cost €107,344
- Total O&M Cost (Annual) €2,681
- Total Present Value Cost €157,854
- Total PV Cost inc. Optimism Bias (40%) €220,996

This scheme was also designed by JBA Consulting. The OPW constructed this scheme and provided cost estimates.

The actual costs for this projects were circa €105,840. In general, when comparing the build costs (€105,840) and the total costs calculated by the Unit Cost database (€107,344), there is an acceptable level of agreement. The optimism bias adjustment provides a more conservative estimate.

One must also remember that upon application of the Optimism Bias, the total cost of the project becomes €220,996. This an overly conservative figure compared to the tendered sum in this instance.

6.5 Mornington Flood Relief Scheme

Historically, there has been a severe tidal flooding problem at the downstream end of the Mornington catchment near the Boyne Estuary. The completed works include;

- 1540m of flood protection wall
- 4600m of clay embankments
- Construction of a footbridge
- 48 sluice gates
- The underpinning of 2 bridges

- The culvert on the tributary
- Upsizing of minor culverts and the channel capacity increased
- Two minor pumping stations were constructed to alleviate internal drainage problems at the two worst affected areas
- A linear storage channel was installed at Tower Road.
- Where discharge outfalls are located at a level below that of the 1:100 year flood level flap valves were installed
- The number of surface water drainage outlets through the flood defence structures were be minimised by the connection of outlets to a main interceptor pipeline which would discharge at one point
- Temporary river gauge was installed on the Mornington River to help verify the hydrological analysis

The results of the analyses, as tabulated on the Whole Life Cost Tool spreadsheet, are summarised below:

- Total Capital Cost €3,516,971
- Total O&M Cost (Annual) €38,102
- Total Present Value Cost €4,158,219
- Total PV Cost inc. Optimism Bias (40%) €5,821,507

The OPW provided scheme and actual build cost details for this project. The estimated build cost of the project is circa €3,974,343

In summary, the cost to date is €3,974,343. The same figure, as calculated by the Unit Cost database, was €3,516,971 providing confidence in the unit costs used for such a complex scheme. Despite this similarity in total costs, there are many nuances and project-specific tasks that cannot be accounted for in the spreadsheets that explain some of the internal differences for certain asset types. For example, the spreadsheets cannot account for the drainage system in the project and a lack of information regarding the pumping stations, the storage channel and the culvert replacements.

One must also remember that upon application of the Optimism Bias, the total cost of the project becomes €5,821,507. This an overly conservative figure compared to the final cost.

6.6 Clonmel Drainage Scheme

The Clonmel Drainage Scheme was designed to protect the town of Clonmel from flooding from the River Suir, the Whitening Stream and the Auk Streams. A number of works were included as part of the 3 projects including:

- Dredging and widening of the channel
- Construction of a town bypass channel
- Upstream storage
- A channel bypass around Dudley's Mills
- A fully defended urban area
- Replace masonry arch bridges at Old Bridge
- Demountable barriers
- Embankments
- Sheet piled walls
- Rock ramp fish-pass

The results of the analyses, as tabulated on the Whole Life Cost Tool spreadsheet, are summarised below:

- Total Capital Cost €32,232,000
- Total O&M Cost (Annual) €253,105
- Total Present Value Cost €30,922,308
- Total PV Cost inc. Optimism Bias (45%) €44,938,846

The OPW provided scheme and actual build cost details for this project. The estimated build cost of the project is circa €40,000,000

In general, when comparing the final cost of the project and the costs calculated by the Unit Cost Database, there is an acceptable level of agreement with an inclusion of the optimism bias. The estimated cost of the project is €40,000,000. The same figure, as calculated by the Unit Cost database, was €32,232,000.

There are many nuances and project-specific tasks that cannot be accounted for in the spreadsheets that would explain any differences in estimations. For example, the spreadsheets cannot account for the drainage system in the project. Given this and the lack of information for the 3 bridges that were replaced, this explains the key reasons for the price from the database is considerably lower.

One must also remember that upon application of the Optimism Bias, the total cost of the project becomes €44,938,846. This a conservative figure compared to the final cost. Therefore, any decision with regards to project approval would be made using this figure rather than the €32,232,000 total. This demonstrates the importance of the application of the optimism bias.

6.7 Summary of calibration

The above calibration sites cover a wide range of flood protection measures included within the CFRAM unit cost project and a range of project types and spatial extents. Overall the costs derived adequately match the out-turn costs. One of the case studies underestimates the out-turn costs, but are within the optimism bias allowance for all examples, whereas the other three projects derive a similar capital cost but the inclusion of optimism bias would appear to overly estimate total project costs. Despite these variations, a consistent approach is required for CFRAM projects and the need to assess optimism bias as best as can be based on site knowledge and project requirements should be carefully considered.

7 Recommendations

7.1 Cost data and cost capture

This project has delivered cost estimates for a wide range of flood risk management methods and factors. It should be seen as a starting point to inform the CFRAM process as well as a resource that needs to be maintained and kept up to date. Key to this is the updating of the database with new data as and when this becomes available.

The recording of cost information for capital and maintenance activities is essential to ensure that data is recorded in a way that the database can be added to and updated. This will necessitate requirements for the OPW and partners to record and report on cost information in a more detailed way than is currently undertaken. Enabling this and providing procedures to allow this will help to improve cost estimation in the future.

Some cost data uniform or repeated activities should be available to inform future updates, although substantial analysis may be required for other areas where costs are harder to separate out. The collation of this information will need to be consistent with benchmarking required to check information between regions.

It is hoped that this report and cost database forms the baseline for collation of future data and updating of outturn cost information. This could be achieved by initiating procedures to collate outturn costs at the asset level and through the provision of a pro-forma for the collection of future project costs. This would help to build up a longer term database of costs that could eventually be used to update and improve the costs derived as part of this study, for benchmarking future studies and to increase the range of factors and accuracy of cost information.

It may also be worth investigating additional cost factors excluded from this analysis such as regional cost variations.

8 Glossary

The following definitions in relation to cost estimation and useful terms referred to elsewhere in this guidance are provided for completeness below.

Appraisal period – the period over which costs and benefits are assessed. This period is defined by guidance from the OPW and is normally 100 years for capital assessments.

Benefit-Cost Analysis (BCA) - Analysis that seeks to quantify all of the costs and benefits of a proposed scheme in monetary terms, including items for which the market does not provide a satisfactory monetary value. Sometimes referred to as Cost-Benefit Analysis.

Benefit-Cost Ratio (BCR) - A ratio of the present benefits and costs of an option, calculated as the total benefits divided by the total costs. A BCR of >1 indicates benefits are greater than costs.

Capital costs - Costs incurred during detailed planning, design and construction of an asset or service. Also referred to as Capital Expenditure (CAPEX).

Cost-Effectiveness Analysis (CEA) - Analysis that compares the costs of alternative ways of producing the same or similar outputs.

Design life – The design life of a new structure or structural component under normal loading and environmental conditions before replacement or major rehabilitation is expected.

Discounting - The conversion of future costs or benefits to present values using a discount rate. It is often necessary to compare options that will impact over a period of years into the future, which raises the question of how future cost and benefits should be valued in today's terms. Normally people prefer to receive cash sooner rather than later, and pay bills later rather than sooner. This is true even after allowing for inflation. For an individual this time preference may be indicated by the real interest rate on money lent or borrowed. In the public sector, likewise, we reflect social time preference by giving more weight to earlier than to later costs and benefits. This process of “discounting” is usually given effect by applying a "discount rate" to future costs and benefits.

Discount Rate - The annual percentage rate at which the present value of a future Euro, or other unit of account, is assumed to fall away through time. It is currently set at 4% pa in real terms. Mathematically, a discount rate is the opposite of a compound interest rate. The discount rate defines how rapidly the value today of a future Euro declines through time in real terms, just as a real rate of interest determines how fast the real value of a Euro invested now will increase over time.

Enabling costs - Costs those incurred between the decision to proceed with the procurement and the construction of the asset. Some of these may represent sunk costs depending on the point of appraisal within the whole life cost process.

End life costs - Costs associated with the disposal, decommissioning, termination or replacement of the asset or service. These costs can be split between replacement/refurbishment costs (where an assets standard of service is not altered) or change works (where the intention is to alter the standard of service of an asset).

Expenditure budgets - longer term revenue costs outside capital expenditure budgets.

Frequent maintenance – Activities that maintain current defence standards by reducing the rate of deterioration. Frequent maintenance provides for efficient, effective and safe operation in a cost-effective manner. It normally includes annual costs associated with planned proactive activities.

Intermittent maintenance – Infrequent and one-off activities that cover infrequent planned and recurring activities required within an assets design life.

Maintenance – Work that sustains the desired condition and intended performance of an asset. In some circumstances maintenance may accept a gradual decline in standard. For existing assets that have no residual life, maintenance may not result in an acceptable Standard of Service and only refurbishment or replacement will reinstate an acceptable Standard of Service.

Net Present Value (NPV) - The discounted value of a range of costs and benefits. Calculated as the PV benefits minus the PV costs. NPV is used to describe the difference between the

present value of costs and benefits in future years. NPV is a primary investment decision criterion. NPV is defined as the difference between the present value of a stream of benefits and that of a stream of costs. A positive NPV occurs when the sum of the discounted benefits exceeds the sum of the discounted costs. A negative NPV is usually called a Net Present Cost (NPC). The decision rule is to select the option that offers to maximise NPV, or minimise NPC. This is subject to assessment of those impacts that cannot be valued in money terms. NPV takes account not only of social time preference through discounting, but also, by combining capital and recurrent cost and benefits into a single present day value indicator, enables direct comparison of options with very different patterns of costs and benefits over time.

Operational costs - The costs incurred through the day-to-day management of an operation, and maintenance of an asset or a scheme. (Also known as revenue costs or Operational Expenditure - OPEX). See also Expenditure Budgets.

Optimism Bias - The demonstrated systematic tendency for appraisers to be over-optimistic about key project parameters, including capital costs, operating costs, works duration and benefits delivery.

Present Value - The present day value of a future stream of costs or benefits. Calculated by discounting a stream of future costs or benefits. (See also Net Present Value, Discount Rate).

Price Index - A measure of the amount by which prices change over time. General price indices cover a wide range of prices and include the Consumer Price Index (CPI) and the Retail Price Index (RPI).

Residual life – Residual life is the time until assets need replacing. Residual life can be extended or reduced by altering maintenance practices. The point at which the asset requires replacement may be estimated by a condition grade or performance measures that reflect an unacceptable Standard of Service.

Risk Register / Risk log - A useful tool to identify, quantify and value the risks and uncertainties relating to a proposal.

Sensitivity Analysis - Analysis of the effects on an appraisal outcome of varying the projected values of important variables.

Sunk Costs - Expenditures that have already been incurred on goods and services, or resources that are already irrevocably committed. These costs should be ignored in an appraisal. Sunk costs may include items such as previous investment in defences and expenditure on feasibility studies.

Unit rates - The cost per unit measure (number/length/area/volume) to replace an asset or part of an asset.

Whole life cost – The total cost of managing an asset over the design life of the asset. This will include the full cost of construction, use, maintenance and replacement/decommission. All reasonably foreseeable costs over the whole life period should be included.

A Example costs

A.1 Single asset whole life cost example

A.1.1 Example of option

A single pumping station is proposed in an urban area to pump water backing up within a small watercourse over an existing embankment in a tidal location when water levels are high. The pump capacity required from modelling is 2m^3/s.

A.1.2 Capital costs

Based on the unit rate cost curve provided the anticipated capital costs are €1,620,000. Due to the urban location, existing services and construction through the embankment a method factor of 1.2 is recommended by the appraiser as an uplift to the basic unit cost.

An estimate of preliminaries of 16% is assumed.

Other costs for the replacement of the embankment for a 2m height and 40m length is also assumed at a unit rate of €301/m.

Based on the above a total capital cost of €2,269,500 is assumed.

A.1.3 O&M and other costs

Standard unit rates for operation and maintenance and running costs are applied.

Other costs assume a 25 year pumping station replacement cost of €900,000.

Figure A-1: Example of cost inputs

Project reference	Example 1
Base date for estimates (year 0)	Oct-2013
Scaling factor (e.g. €m, €k, €)	€

Project name:	Example Project Name x
Construction Price Index (CPI)	**1.000**
Method Factor - to take into account particular site issues /constraints	**1.20**

This sheet should only be used when assessing single method options as double counting may occur when method costs are added.

Single Method Capital Cost Tool

	1	2	3	4	5	6	Comment/justification
Pumping Station ref/type	Ref 1						
Pumping Station number	1						*Single 2m3/s pump*
Pumping Station unit rate	1620000						*Rate based on existing cost curve*
Total costs						€1,620,000	
Apply update to unit rate (CPI) if appropriate (cell N15)						€1,620,000	
Enter appropriate preliminaries estimate (%)						16%	
Enter other applicable costs (€)						12040	*Embankment replacement*
Total capital cost (€)						€1,891,240	
Consider amendments based on site issues/constraints (cell N16)						€2,269,488	*Urban site with existing services*
Total capital cost (€)						€2,269,488	

Operation and Maintenance Cost Tool

Total annual O&M costs	€10,600	*Basic cost from cost curve*
Total annual running costs	€18,600	*Basic cost from cost curve*

Other costs

Other costs (user defined - consider the need for additional longer term or intermittent costs)	€900,000	*Refurbishment costs at year 25*

A.1.4 Whole life cost assumptions

Enabling costs assume £100,000 for additional design, consultant, administration and land consultation fees that have not been included within the capital costs and are not yet been incurred as part of the CFRAM process.

The year of capital works is assumed to be year 1, with enabling costs in year 0.

Other works (refurbishment costs) are assumed at a 25 year interval.

The total PVc is assumed to be €3,202,000, exclusive of optimism bias.

Figure A-2: Example of present value cost inputs and calculations

Whole life cost and PVc analysis - for Pumping Station

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	£100,000.0
Year of capital works (year)	1
Capital cost (€)	£2,269,488.0
Annual maintenance cost (€)	£29,200.0
Other cost (€)	£900,000.0
Other works frequency (years)	25

Key

	Information
	Calculation
	Cost input

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**	**Total PVc (£k):**		**3201914**
	Cash sum	100000	2269488	1401600	900000	4671088	**3201914**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	100000				100000.0	100000.0
1	0.962		2269488			2269488.0	2182200.0
2	0.925			29200		29200.0	26997.0
3	0.889			29200		29200.0	25958.7
4	0.855			29200		29200.0	24960.3
5	0.822			29200		29200.0	24000.3
6	0.790			29200		29200.0	23077.2
7	0.760			29200		29200.0	22189.6
8	0.731			29200		29200.0	21336.2
9	0.703			29200		29200.0	20515.5
10	0.676			29200		29200.0	19726.5
11	0.650			29200		29200.0	18967.8
12	0.625			29200		29200.0	18238.2
13	0.601			29200		29200.0	17536.8
14	0.577			29200		29200.0	16862.3
15	0.555			29200		29200.0	16213.7
16	0.534			29200		29200.0	15590.1
17	0.513			29200		29200.0	14990.5
18	0.494			29200		29200.0	14413.9
19	0.475			29200		29200.0	13859.6
20	0.456			29200		29200.0	13326.5
21	0.439			29200		29200.0	12813.9
22	0.422			29200		29200.0	12321.1
23	0.406			29200		29200.0	11847.2
24	0.390			29200		29200.0	11391.5
25	0.375			29200		29200.0	10953.4
26	0.361			29200	900000	929200.0	335152.4
27	0.347			29200		29200.0	10127.0
28	0.333			29200		29200.0	9737.5
29	0.321			29200		29200.0	9363.0
30	0.308			29200		29200.0	9002.9
31	0.296			29200		29200.0	8656.6
32	0.285			29200		29200.0	8323.7
33	0.274			29200		29200.0	8003.5
34	0.264			29200		29200.0	7695.7
35	0.253			29200		29200.0	7399.7
36	0.244			29200		29200.0	7115.1
37	0.234			29200		29200.0	6841.5
38	0.225			29200		29200.0	6578.3
39	0.217			29200		29200.0	6325.3
40	0.208			29200		29200.0	6082.0
41	0.200			29200		29200.0	5848.1
42	0.193			29200		29200.0	5623.2
43	0.185			29200		29200.0	5406.9
44	0.178			29200		29200.0	5199.0
45	0.171			29200		29200.0	4999.0
46	0.165			29200		29200.0	4806.7
47	0.158			29200		29200.0	4621.9
48	0.152			29200		29200.0	4444.1
49	0.146			29200		29200.0	4273.2

A.2 Multiple asset whole life cost example

A.2.5 Example of option

The same option as above is assumed, although further investigation has indicated that the embankment is no longer suitable and a new embankment needs to be constructed. The required additional embankment is 3m in height for a length of 80m with a lower section of 2m in height for a length of 200m. Two headwall outlet structures (600mm) with flap valves are also required.

A.2.6 Capital costs

The pumping station costs are the same as in the previous example - €1,620,000. The embankment is made up the following unit costs:

- 80m with a unit rate of €539/m
- 200m with a unit rate of €516/m
- The appraiser also allows for a unit rate of €50/m for the removal of the existing embankment.

The total embankment cost is therefore €160,300.

The headwall structure with flap valves with a unit cost of €9,750 are taken from the sluice gate summary sheet.

The total costs for each asset are added to the portfolio tool to estimate total capital costs as shown below.

Figure A-3: Example of cost inputs

Project reference	Example 1
Base date for estimates (year 0)	Oct-2013
Scaling factor (e.g. €m, €k, €)	€

Project name:	Example Project Name x
Construction Price Index (CPI)	**1.000**
Method Factor - to take into account particular site issues /constraints	**1.20**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	**Cost (€)**	**Comment**
Total wall costs		
Total embankment costs	160300	*2 sections of embankent plus removal of existing*
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs	19500	*2 600mm headwall structures with flap valves*
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs	1620000	*2m3/s pumping station*
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€1,799,800	
Apply update to unit rate (CPI) if appropriate (cell N15)	€1,799,800	
Enter appropriate preliminaries estimate (%)	16%	*Based on preliminaries cost curve*
Enter other applicable costs (€)	0	*None assumed*
Total capital cost (€)	€2,087,768	
Consider amendments based on site issues/constraints (cell N16)	€2,505,322	*Uplift for urban area and existing services*
Total capital cost (€)	€2,505,322	

Due to the urban location and existing services a method factor of 1.2 is recommended by the appraiser as an uplift to the basic unit costs.

An estimate of preliminaries of 16% is assumed.

Based on the above a total capital cost of €2,505,300 is assumed.

A.2.7 O&M and other costs

O&M costs assume the following:

- Standard pumping station unit rates for O&M and running costs (€29,200 per annum)
- Other costs assume a 25 year pumping station replacement cost of €900,000
- Embankment O&M costs (€2,725/km, or €763 per annum)
- Sluice gate O&M costs of €2,700 per gate per annum

Figure A-4: Example of O&M cost inputs

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs		
Total embankment O&M costs	763	*280m length of embankment*
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs	5400	*2 No. sluice gates in urban area*
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs	29200	*O&M and running costs*
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€35,363	

A.2.8 Whole life cost assumptions

Enabling costs assume £120,000 for additional design, consultant, administration and land consultation fees that have not been included within the capital costs and are not yet been incurred as part of the CFRAM process.

The year of capital works is assumed to be year 1, with enabling costs in year 0.

Other works (refurbishment costs) are assumed at a 25 year interval.

The total PVc is assumed to be €3,574,000, exclusive of optimism bias.

Figure A-5: Example of present value cost inputs and calculations

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	€120,000
Year of capital works (year)	1
Capital cost (€)	€2,505,321.6
Annual maintenance cost (€)	€35,363.0
Other cost (€)	€900,000.0
Other works frequency (years)	25

Key

	Information
	Calculation
	Cost input

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**		**Total PVc (€k):**	**3574279**
	Cash sum	120000	2505322	1697424	900000	5222746	**3574279**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	120000				120000.0	120000.0
1	0.962		2505322			2505321.6	2408963.1
2	0.925			35363		35363.0	32695.1
3	0.889			35363		35363.0	31437.6
4	0.855			35363		35363.0	30228.4
5	0.822			35363		35363.0	29065.8
6	0.790			35363		35363.0	27947.9
7	0.760			35363		35363.0	26873.0
8	0.731			35363		35363.0	25839.4
9	0.703			35363		35363.0	24845.6
10	0.676			35363		35363.0	23890.0
11	0.650			35363		35363.0	22971.1
12	0.625			35363		35363.0	22087.6
13	0.601			35363		35363.0	21238.1
14	0.577			35363		35363.0	20421.3
15	0.555			35363		35363.0	19635.8
16	0.534			35363		35363.0	18880.6
17	0.513			35363		35363.0	18154.4
18	0.494			35363		35363.0	17456.2
19	0.475			35363		35363.0	16784.8
20	0.456			35363		35363.0	16139.2
21	0.439			35363		35363.0	15518.5
22	0.422			35363		35363.0	14921.6
23	0.406			35363		35363.0	14347.7
24	0.390			35363		35363.0	13795.9
25	0.375			35363		35363.0	13265.3
26	0.361			35363	900000	935363.0	337375.4
27	0.347			35363		35363.0	12264.5
28	0.333			35363		35363.0	11792.8
29	0.321			35363		35363.0	11339.2
30	0.308			35363		35363.0	10903.1
31	0.296			35363		35363.0	10483.7
32	0.285			35363		35363.0	10080.5
33	0.274			35363		35363.0	9692.8
34	0.264			35363		35363.0	9320.0
35	0.253			35363		35363.0	8961.5
36	0.244			35363		35363.0	8616.9
37	0.234			35363		35363.0	8285.4
38	0.225			35363		35363.0	7966.8
39	0.217			35363		35363.0	7660.4
40	0.208			35363		35363.0	7365.7
41	0.200			35363		35363.0	7082.4
42	0.193			35363		35363.0	6810.0
43	0.185			35363		35363.0	6548.1
44	0.178			35363		35363.0	6296.3
45	0.171			35363		35363.0	6054.1
46	0.165			35363		35363.0	5821.2
47	0.158			35363		35363.0	5597.3
48	0.152			35363		35363.0	5382.1
49	0.146			35363		35363.0	5175.1

A.3 Optimism Bias example

Risks for the above project have been assessed and noted within the Optimism Bias calculator. For each risk component a risk value (from Very High to Very Low) has been defined with additional user remarks made. These are completely theoretical for this above case study but aim to give CFRAM consultants an indication of the level of detail required.

Based on the assumptions applied for each risk component an optimism bias of 46% is recommended for this scheme.

Figure A-6: Example Optimism Bias calculator

JBA consulting

DONNACHADH O'BRIEN & ASSOCIATES CONSULTING ENGINEERS

OPW The Office of Public Works Oifig na nOibreacha Poiblí

CFRAM Unit Cost Development Project

Optimism Bias Calculator

Prepared by:	**AEP**	**Date:**	**December 2013**
Site Reference:	**Example 1**	**Site Name:**	**Example Project Name x**

Project risk components that influence total project cost	Weight 1-3 (3 being a higher weight)	Risk value (0-100%) 0% = no risk 100% = risk expected and not mitigated		User remarks/comments/justification
Procurement				
Complexity of Contract Structure	1	High	70%	Contract structure unknown at present - high defined for this reason
Late Contractor Involvement in Design	2	High	70%	Possible risk
Poor Contractor Capabilities	1	Medium	50%	Pumping station design required experienced engineering and conctract team
Government Guidelines	1	Very Low	10%	Not anticipated to alter
Dispute & Claims Occurred	3	Medium	50%	Too early to tell
Information Management	1	Very Low	10%	Not anticipated to alter risk
Budgetting	2	High	70%	Mutliple schemes from CFRAM identified in area - budgetting risk
Other	1	Medium	50%	No other risks identified
Project Specific				
Design Complexity	2	High	70%	Complex design
Degree of Innovation	2	Medium	50%	No complex innovation required at present
Technology	2	Low	30%	Not anticipated to be a key risk
Services	3	High	70%	Urban area - high risk
Ground conditions	3	High	70%	Unknown at present - assume high risk until additional GI undertaken
Other	1	Medium	50%	No other risks identified
Client Specification				
Inadequacy of the Business Case	3	Medium	50%	Not anticipated at this time
Large No. of Stakeholders	2	Medium	50%	Medium risk
Funding Availability	2	High	70%	Mutliple schemes from CFRAM identified in area - funding risk is high
Project Management Team	1	High	70%	Large pumping station requires experience
Poor Project Intelligence	2	Very High	90%	Additional surveys required to reduce this aspect
Other	1	Medium	50%	No other risks identified
Environment				
Public Relations	2	High	70%	Urban area
Site Characteristics	2	High	70%	Urban area
Environmental Impact	3	Medium	50%	Average risk
Permits / Consents / Approvals	2	Medium	50%	CFRAM environmental scoping indicates possible risks with mitigation measures possible
Amenity and art	1	High	70%	Urban area and large pump building required - amenity value needs to be considered
Contaminated land	3	High	70%	Unknown - set at high until investigations can reduce this
Archaeology	3	High	70%	Unknown - set at high until investigations can reduce this
Other	1	Medium	50%	No other risks identified
External Influences				
Political	3	Medium	50%	Unknown - set at medium risk for now
Economic	2	Medium	50%	Unknown - set at medium risk for now
Legislation / Regulations	1	Medium	50%	Unknown - set at medium risk for now
Multiple river users / stakeholders	2	High	70%	Urban site with multiple interested parties
Flood events during construction	3	High	70%	Yes - possible risk even with temporary works
Other	1	Medium	50%	No other risks identified
	65		57%	

		Minimum Optimism Bias:	10%
		Maximum Optimism Bias:	70%
Weighting to apply:	**0.592**	**Calculated Optimism bias:**	**46%**

Registered Office

24 Grove Island
Corbally
Limerick
Ireland

t: +353 (0) 61 345463
e:info@jbaconsulting.com

JBA Consulting Engineers
and Scientists Limited

Registration number 444752

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Appendix I Flood Defence Asset Failure Maps

There are no Flood Defence Asset Failure Maps for the AFA's in this UoM.

Appendix J OPW Guidance Notes

CFRAM Guidance Note 24 – Breach Analysis

Originators: Sun Yan Evans and Marianne Piggott

Revision E Date: 19 June 2013

1.0 Overview

Flooding can be categorised as arising from two main sources: i) Coastal sources when extreme storm surges and/or waves overtop coastal defences or marine infrastructure inundating the areas inland of the coastal defences; (ii) Inland sources, i.e. overland flow from excess rainfall, excess river flows overflowing the river banks or defence; urban drainage flooding; excess groundwater; and, estuarial flooding.

Additionally, flooding can occur due to the failure of flood defence assets or infrastructure during a flood event. Because of the sudden onset, the impacts of this form of flooding can be severe and should be assessed where appropriate. Therefore, all CFRAM studies will assess flooding arising from flood defence asset failure in Areas for Further Assessment.

2.0 Purpose

This note aims to provide a consistent approach for all CFRAM studies to simulate the inundation of the failure of flood defence assets or infrastructure. The model outputs from the flood defence failure scenarios will inform the Preliminary Options Report in the CFRAM studies.

This note focuses on:

(i) The selection of breach parameters;

(ii) The selection of modelling techniques to simulate the inundation due to the failure of flood defence assets.

This guidance note does not address or cover the assessment of flooding from breaches of dams or reservoirs. The assessment of failure or breach scenarios of such structures is NOT included in the scope of the CFRAM Studies. If further information is required, please refer to specific guidelines for assessing dam breach inundation, such as the DEFRA National Reservoir Inundation Mapping Specification (Mott MacDonald June 2009)[1] for general information.

3.0 Requirements for CFRAM Studies

The requirements from the Stage I and Stage II CFRAM Briefs below are clarified in sections 4, 5 and 6 of this guidance note.

The CFRAM Studies Stage I Project Brief [2] Section 7.6 states:

"In the event of a failure of flood defence assets (such as the collapse of a section of wall or breach of an embankment), areas that would otherwise be defended against flooding during a given event severity might become subject to flooding. The Consultant shall undertake analysis to identify and assess the flood hazard and risk that may be caused or significantly increased (with due consideration for flow velocities, rate of onset of flooding, likely flood volumes and potential flood damage), by the occurrence of failures of defence assets providing protection to the areas at risk from flooding. The Consultant shall undertake such analysis using appropriate hydraulic modelling techniques in line with best practice using the models identified in Section 7.2, or the JFlow modelling software."

The CFRAM Studies Stage II Project Brief[3] states:

"The Consultant shall undertake such analysis for two (2) failure scenarios (comprising potential breach extents / breach development scenarios or locations) for each of the existing flood defence assets where the retained depth of water above ground level exceeds 1.0m during a flood event of a probability equal to the standard of defence of the asset, and only for defences providing some degree of protection to APSRs.

The Consultant shall also undertake such analysis for one (1) failure scenarios (comprising potential breach extents / breach development scenarios or locations) for up to two locations that may be at risk from future coastal erosion under either a current scenario or future scenario, and only for defences providing some degree of protection to APSRs."

The required outputs from each defence failure scenario are as follows:

- Maximum flood extent map (excluding degrees of confidence, table of peak flows and levels and defended areas).
- Maximum flood depth map; and
- Maximum flow velocity map.

4.0 Breach Formation

4.1 Flood Defence Asset Types

Flood defence assets can be broadly classified into the following types:

- Flood embankments;
- Flood walls;
- Hydraulic structures, such as flood gates, adjustable weirs, pumps, flapped valves etc.;
- Other naturally occurring features that can provide flood protection; and
- Other infrastructure that can provide flood protection as a secondary purpose.

The type of flood defence asset is important to consider as it partly determines the mode of failure, rate of breach formation and breach dimensions. Other factors such as asset condition and the flood event characteristics also influence mode of failure, rate of breach formation and breach dimensions as discussed below. Naturally occurring and other informal defences, such as sand dunes, should be assessed on a case-by-case basis with OPW to establish the need of breach analysis that is in line with the definition of flood defences in Appendix C of CFRAM Framework Stage I Brief.

4.2 Mode of Failure

Generally speaking, there are two modes of failure: (i)overtopping[a] and (ii) piping[b]. The EU IMPACT study (WP 6, 2005)[4] and Management of Flood Embankments Good Practice Review (FD2411/TR1, 2007)[5] draw together over 100 European examples of historic breaches. Both these studies conclude that overtopping is the dominant failure mechanism for over 70% of cases reported. Analysis by the EU IMPACT study suggests that as flood embankments and walls are raised over time there is an increased risk of failure from piping as the join is exposed leading to the development of hydraulic soil failure or wall collapse.

4.3 Breach Location

The location of a breach depends on a number of factors as outlined by WP 2 of the EU Impact project[6]:

- Internal factors: Understanding of these factors needs a complete knowledge of the geotechnical properties of the interior of each specific asset such as potential lines of weakness in concrete, moisture content, cohesion, permeability, compaction, pore water pressure etc.
- External factors: These factors could be detected by a visual survey, including: settlement of the crest level, localised dipping of the crest, cracking of walls, bulging at the base of the asset, slumping , sink holes, vegetation changes etc.

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[a] Overtopping may be as a result of flood water overtopping the crest of an embankment, or through wave action resulting in periodic overflowing of a coastal defence.

[b] Critical conditions resulting from piping (seepage or leakage) are, typically, when flow increases to a significant level causing erosion of material and progressively creating a larger hole through the embankment. Eventual subsidence of the bank material above the 'pipe' and rapid breaching of the embankment will follow.

- Environmental factors: These factors correspond to the physical elements surrounding embankments and affecting their overall performance, such as, flow velocities, burrowing animals, scour holes at base of the wall or embankment, vegetation cover or vegetation growing in the wall etc.
- Human factors: These factors involve human actions and events and can include the presence of outfall structures through the embankment or wall, footpath erosion or loading by vehicles on roads, wash from boats, grazing animals and lack of maintenance.

There is insufficient research and understanding in the breach formation process to reliably predict breach location. The CFRAM Brief limits breach locations to existing flood defence assets within AFAs where the retained water level exceeds the adjacent ground level by 1.0m during a flood event (Section 2 of this note). However, interviews with expert local engineers and All Panel Reservoir Engineers during the NRIM pilot study[1] found that the setting of any threshold has the following effects;

- Exclusion of important flood defences that were critical to the receptors at risk, e.g. communities, properties and environmentally important sites.
- Inappropriate analysis of flood defences that were not critical to receptors at risk.

Therefore, the consultant is required to validate vulnerable locations and select the most appropriate breach locations based on the knowledge of the factors listed above. Additionally, the Irish Coastal Protection Strategy Study (ICPSS) has identified sections at risk from erosion in the future. This ICPSS data can be used to supplement expert engineering judgement to identify potential breach locations in coastal areas.

Recommendation: Selection of Breach Location

It is recommended that the Consultant identifies potential feasible breach locations considering the following aspects:

- Known problem embankments;
- Areas where failures have previously occurred;
- Current asset condition and rate of deterioration from the asset conditions survey where available;*
- Topographic survey data;
- Presence of strategic receptors at risk downstream such as; hospitals, garda stations, other emergency service stations, carehomes, nurseries, schools or areas of high population density relative to the rest of the AFA.

The most appropriate breach locations for each AFA should then be agreed with OPW prior to modelling.

* Good, fair and poor asset should all be considered in conjunction with estimated rate of deterioration.

4.4 Breach Parameters

4.4.1 Time of Failure

The time at which the breach forms can have a significant impact on the flood conditions downstream of the failure.

Laboratory and field tests by the EU IMPACT study and United States Department of Agriculture experiments[7] indicate that failure may occur rapidly after the onset of overtopping. Conversely, the field data suggests piping failure is a relatively slower process, occurring over a period of weeks before eventual failure of the embankment. Once the piping flow through the embankment becomes turbulent (identifiable as cloudy with sediment), the failure can occur within minutes.

Therefore, any breach can be assumed to form rapidly within minutes of overtopping the defence or the presence of turbulent flow through the defence. These conditions may be formulated prior to the peak flow for an event.

The time at which the failure occurs relative to the peak flow also determines the severity of flood risk to receptor in terms of velocity, hazard rating and flood extent. Mott MacDonald undertook a number of sensitivity tests on the time failure of flood embankments in Lincolnshire[8,9] and found:

- The flood extent is often the greatest if the breach is assumed to occur during the rising limb or close to the peak of the hydrograph as this often provides the greatest volume during the breach.
- The flood velocities and hazard are often the greatest if the breach is assumed to occur at the peak of the hydrograph, especially in the vicinity of the breach. This often provides the greatest potential head for flow through the breach and onto the floodplain.

Recommendation: Selection of Time of Failure

The prediction of the likely time to failure during an event is best made through expert judgement by an experienced engineer familiar with construction of flood embankments, the relevant hydraulics and geotechnical theory and the purposes of the breach analysis[5].

A simplified approach is recommended for the CFRAM studies. This assumes that the breach will initiate when the water level reaches the defence crest level or at its peak level if the peak water level is below the defence crest level.

4.4.2 Breach Dimension

A) Breach Height

The breach height or depth can be defined as the distance from the defence crest to minimum elevation through the breach. In most studies, a conservative estimate of the breach height is taken to be the defence crest to the floodplain level as this provides the largest head through the breach[10].

Datasets complied by Wahl[11] and IMPACT WP 6[4] suggest that breach height varies in historic breach failures depending on the mode of failure, activity taken to repair the breach, and the potential head available.

B) Breach Width

The results from the laboratory and field tests undertaken as part of the EU IMPACT study[10] suggest that: (i) the breach side walls are typically vertical during breach development; (ii) the typical breach width varies with defence type, material and many other factors; (iii) the breach width depends on the number of factors as summarized in the formula below:

L = L (H, G, R, S, Q, A, T)

Where:

- H - head through the breach
- G - the dimensions and geotechnical properties of the dike
- R - river flow conditions in the vicinity of breach
- S - topographic conditions on the protected side
- Q - the discharge of the river
- A - the activity of flood fighters
- T - the function of time

A range of models have been tested in the EU IMPACT project to estimate the breach dimensions and/or discharge hydrographs. The results suggest that all the models have limitations and associated uncertainties in the results predicted. Without local validation of these models, it was difficult to reliably predict breach width. Therefore, Morris et al. (2007)[5] recommend that breach dimensions are estimated

using engineering judgement based on historic failures and conditions surveys. A similar approach was taken to derive parameters for the Environment Agency's Anglian Region breach specification as used in the Northern Area Tidal Modelling Study[8].

4.4.3 Breach Repair and Closure

The repair or closure of a breach during a flood event has not been well documented in historic defence failures[5]. The time it takes to repair or close a breach will ultimately determine the duration of the breach and flow into the floodplain. The time it takes to close a breach in a flood embankment or wall is dependent on the following:

- The discharge and velocities through the breach;
- The duration of high flows and levels in the river or sea;
- The soil conditions;
- Availability of material to repair the breach;
- Access to the breach site;
- Health and safety considerations; and
- The legislation and procedures in place for emergency teams to respond.

For example, a breach in a river embankment may be repaired relatively quickly once the water levels have receded. However, a breach in a coastal embankment may only be repaired during short period at low tide if water levels drop below the breach base level. Therefore, it may take several tidal cycles to repair a coastal breach.

Selection of Breach Dimension (Breach Height and Width) and Time to Closure

The following breach parameters are recommended to inform the selection of breach dimensions and time to closure for the CFRAM studies:

a) **Breach Height** – as a conservative estimate, the breach height is taken to be the difference between the defence crest and a representative floodplain level adjacent to the breach.

b) **Breach Width and Time to Closure as tabulated in the table below**:

Location	Defence type	Breach width (m)	Time to Closure (hrs)
Open coast	Earth embankment	200m or the total asset length where < 200m	72
	Dunes*	100 or the total asset length where < 100m	72
	Hard (walls)	50 or the total asset length where < 50m	72
Estuary and Tidal Rivers	Earth embankment	50 or the total asset length where < 50m	72
	Hard (walls)	20 or the total asset length where < 20m	72
Fluvial Rivers	Earth embankment	40 or the total asset length where < 40m	36
	Hard (walls)	20 or the total asset length where < 20m	36

Parameters based on those applied by the Environment Agency, UK.

* Sand dunes and other informal defences should be assessed on a case-by-case basis in consultation with OPW to establish the need for breach analysis that is in line with the definition of flood defences in Appendix C of CFRAM Framework Stage I Brief.

5 Breach Inundation Modelling

5.1 Approach

Flooding arising from a catastrophic failure of a defence is more difficult to simulate than fluvial or tidal flooding over a prolonged event. This is due to the presence of rapidly varying flow conditions including mixed sub, super and transcritical flows, 'shock-wave' propagation, interaction and reflections (EU IMPACT Project 2005).

There are three main approaches to the modelling of inundation resulting from a breach:

- Independent modelling
- Iterative modelling
- Dynamic modelling.

Both 1D and 2D hydraulic models can be used for modelling of flow conditions on the floodplain, but the 1D approach is limited in the prediction of variable floodplain velocities. Therefore, 2D modelling techniques would be the preferred approach to simulate the variable floodplain velocities and other flood conditions arising from a defence failure scenario.

5.2 Independent Modelling

Independent modelling is a simplistic approach that assumes that there is no interaction between the flow through the breach and the floodplain downstream.

Independent modelling was found to be appropriate for breach scenarios where the floodplain downstream does not limit the volume or head through the breach opening i.e. no backwater effect. This approach is applicable to simulate defence failure for the following locations in CFRAM studies:

- Coastal locations where the volume entering through the breach is predominately influenced by the tidal conditions; and,
- Locations where the floodplain topography is low-lying and expansive hence the storage on the floodplain does not limit inundation.

5.3 Iterative Modelling

Iterative modelling uses the same approach as the independent modelling (i.e. separate breach formation and hydraulic model) but attempts to consider scenarios where the floodplain influences flow through the breach by modifying the breach hydrograph based on iterative modelling of the breach formation model and hydraulic model. This approach is applicable to simulate defence failure for the following locations in CFRAM studies:

- Locations where the floodplain topography is constrained with limited storage on the floodplain thus limiting the discharge through the breach due to backwater effects; and
- Locations where the floodplain features form barriers to flow, such as raised roads and other urban infrastructure, thus limiting the discharge through the breach due to backwater effects.

5.4 Dynamic Modelling

Dynamic modelling seeks to dynamically solve the flow through the breach by linking the 1D or 2D model of the river channel to the 2D model of the floodplain. This enables full hydrodynamic calculations through the breach and taking into account any back water effects. This approach is applicable to simulate defence failure for the following locations in CFRAM studies:

- Locations where the floodplain topography is constrained with limited storage on the floodplain thus limiting the discharge through the breach due to backwater effects; and
- Locations where the floodplain features form barriers to flow, such as raised roads and other urban infrastructure, thus limiting the discharge through the breach due to backwater effects.

In the context of the CFRAM studies, the dynamic modelling approach has the advantage of utilising the existing baseline 1D/2D models and only requiring one model simulation for each breach scenario. However, there might be an increased risk of model instability arising from the rapidly varying flow conditions through the breach.

Recommendation: Selection of Modelling Techniques for Breach Inundation Modelling

It is recommended that 2D modelling techniques are used to simulate the variable floodplain velocities and other flood conditions arising from a defence failure scenario. There should be existing 1D/2D models for breach analysis which have been developed for AFAs as part of the CFRAM studies.

The following three modelling techniques are recommended for the predicted of breach inundation:

- Independent modelling for locations where the water levels on the floodplain or floodplain features do not influence flow through breach;
- Iterative modelling for locations where the water levels on the floodplain or floodplain features influence flow through the breach; and
- Dynamic modelling for locations where the water levels on the floodplain or floodplain features influence flow through the breach.

Quality, time and cost implications should be taken into consideration when selecting between iterative and dynamic modelling techniques to effectively assess the impact of a breach. Dynamic modelling is the preferred choice if there is an existing dynamic model such as developed for AFAs in the CFRAM Studies. However, iterative modelling may be more appropriate if the existing dynamic model would take too long to run or has stability issues.

6 Selection of % AEP Flood Event

The discussion with OPW and the CFRAM consultants on the selection of %AEP Flood Event for breach analysis at the recent NTCG3 is summarised below.

The application of a single design %AEP flood event, such as the 1%AEP for fluvial locations and 0.5%AEP for coastal locations, provides a consistent approach and comparable results between different locations for planning purposes. However, this approach may result in inappropriate breach analysis for flood defence assets that are already overwhelmed in the selected %AEP flood event.

To avoid this problem, it was agreed that the %AEP flood event for breach analysis should be that which is closest to defence crest level but does not overtop the defence asset, with a limit of the 1%AEP for fluvial flooding and 0.5%AEP for tidal flooding. It is recognised that this will result in different %AEP events being selected at different breach locations.

Recommendation: Selection of %AEP Flood Event

It is recommended that the %AEP flood event for breach analysis should be that which is closest to defence crest level but does not overtop the defence asset, with a limit of the 1%AEP for fluvial flooding and 0.5%AEP for tidal flooding.

References:

[1] Mott MacDonald (2009) National Reservoir Inundation Modelling Specification. United Kingdom DEFRA/ Environment Agency.

[2] Office of Public Works (2010) Catchment-based Flood Risk Assessment and Management (CFRAM) Studies Stage I Tender Documents: Project Brief.

[3] Office of Public Works (2011) South Western River Basin District Catchment-based Flood Risk Assessment and Management (CFRAM) Studies Stage II Tender Documents: Project Brief.

[4] Nagy-Toth (2005) EU IMPACT Project Work Package 6: Detailed Technical Report on the collation and analysis of dike breach data with regards to formation process and location factors. H-EURAqua Ltd.

[5] Morris, Dyer and Smith (2007) Management of Flood Embankments: A good practice review. FD2411/TR1.United Kingdom DEFRA/Environment Agency.

[6] EU IMPACT (2004) Work Package 2 Deliverable 2.4.1: Identifying Potential Breach Location. Investigation of Extreme Flood Processes & Uncertainty (IMPACT).

[7] Damme et al (2012) WP 4.4 A new approach to rapid assessment of breach driven embankment failures. Flood risk management Research Consortium. United States Department of Agriculture - Agricultural Research Service (1999) Dam Breach Experiments.

[8] Mott MacDonald (2010) Anglian Region Northern Area Tidal Modelling. Volume 4: Breach Hazard Mapping. Environment Agency.

[9] Mott MacDonald (2013 ongoing) Lincoln Breach Hazard Mapping. Environment Agency.

[10] Morris, Hassan and Vaskinn (2005) Conclusions and Recommendations from the IMPACT project WP2: Breach Formation. EU IMPACT Project.

[11] Wahl (1998) Prediction of embankment dam breach parameters – a literature review and needs assessment. US Bureau of Reclamation Dam Safety Report DSO-98-004.

FLOOD RISK ASSESSMENT & MANAGEMENT SECTION

NATIONAL CFRAM PROGRAMME
GUIDANCE NOTE NO. 27

Title:	**Economic Damage and Benefit Calculation and Cost-Benefit Analysis**
Version:	Rev. C – Final
Author:	Mark Adamson
Date:	21st July 2014
Issued to:	CFRAM Consultants
Date Issued:	21st July 2014

1.0 PURPOSE

The purpose of National CFRAM Programme Guidance Note No. 27 is to set out a common approach to the calculation of monetarised, economic flood damages and the economic benefits of flood risk management options, and for undertaking a cost-benefit analysis, with a view to ensuring that damages, benefits and benefit-cost calculations are determined in a nationally consistent manner, to enable inter-comparability of proposed measures across the country.

2.0 SCOPE

GN 27 relates to the calculation of monetarised, economic flood damages and the potential economic benefits of options for flood risk management measures, for the purposes of:

- The calculation of the economic (monetary) benefit-cost ratio for options for flood risk management measures (to be used for option appraisal and economic flood risk mapping – see GP comment on Section 4.3)
- Option appraisal against Objective 2.a (Minimise Economic Risk) under the Multi-Criteria Analysis (MCA)

Note that there are minor variations in the benefit / damage values to be used for the two purposes above (see Section 4.5 herein).

GN 27 does not address to:

- The calculation of the costs of options for flood risk management measures, which is outlined in Guidance Note 32, with reference to the OPW Unit Cost Database
- The application of the Multi-Criteria Analysis (MCA) to appraise flood risk management measures (except for Objective 2.a), for which guidance is produced in Guidance Note 28 (GN28)

	A glossary of abbreviations / acronyms used for this GN is provided in Appendix A. An explanatory table is provided in Appendix B, that might be useful for clarity.
3.0	**CALCULATION OF ECONOMIC FLOOD DAMAGES**
3.1	**General Requirements** The requirements for the calculation of economic risk, and hence economic flood damages are as set out in Section 8 and Appendix I of the Generic CFRAM Project Brief. ***General Methodology*** The calculation of flood damages should be based on the Flood Hazard Research Centre Handbook of 2010 (FHRC, 2010) and the 'Multi-Coloured Manual' of 2005 (FHRC, 2005) as referred to in FHRC 2010, subject to caveats, amendments and clarifications set out herein ***Price Conversions*** Prices (damage costs) in the data provided by FHRC 2010 should be converted to euro rates applicable to Ireland in 2013 by: - Applying a 'PPP' multiplication factor of 1.279. This is derived from the relative OECD Purchasing Price Parity values for the UK and for Ireland for 2010. The 'PPP' factor is net of currency conversion (i.e., already includes for exchange rates as well as price differences, and so no currency conversion rate should be applied in addition to this factor) - Applying an inflation multiplication factor of 1.051. This is derived from inflation rates based on the CPI in Ireland for the period 2010 - 2013 ***Flood Duration*** The damages should be calculated assuming long duration (>12 hours) flooding for residential properties, except where shorter duration flooding (including the time required for the draining away of flood waters) would clearly be expected, e.g., in small, flashy catchments, where the duration of <12 hours should be applied instead. For non-residential properties, shorter duration flooding (<12 hours) should be assumed, as depth-damage data for longer duration flooding of non-residential properties is not provided in FHRC 2010. ***Coastal Flooding*** The addition of 10% on building fabric damages should be used when assessing flooding from coastal / tidal sources.
3.2	**Scope of Assessment** The calculation of flood damages should be undertaken for: - AFAs and APMRs - The current scenario and MRFS based on each of the range of flood event probabilities as set out in Section 6.5.1 of the Generic CFRAM Project Brief

	- The HEFS in an indicative manner, making use of calculated damages for the 10%, 1% (0.5% for coastal flooding) and 0.1% damages for the HEFS, and using these values to shift the MRFS damage curve to derive an indicative damage curve for the HEFS.
3.3	**Residential Property Damages** ***Residential Property Classifications*** For the purposes of determining the appropriate residential property damages, and the depth-damage curve / data to be used, account should be taken of: - Property type (detached, semi-detached, terraced, bungalow, etc.) but not: - Property age - Social class (and without inclusion of the Distributional Impact Factor) - Property size The use of properties marked as 'unknown' in the GeoDirectory can be confirmed through the site visits and/or by remote data such as Google Street Map ***Property Floor Levels and Flood Depths*** As set out in Section 5.4.2 (and 8.1.4) of the Generic CFRAM Project Brief, residential property floor levels (which is the base-line or zero-depth against for the calculation of flood damages) may be determined, subject to confirmation by the CFRAM Consultant through spot-checks, on the basis that doorstep / floor levels of ground-floor properties are a specific height above ground level as determined from the DTM data. The specific height of the doorstep / floor level adopted for each AFA should be based on observation / measurement for each AFA. Flood damages should be assumed to begin at flood depths of –0.3m relative to floor levels. This only applies however to properties whose foot-print lies within the flooded area, and does not need to be calculated for properties that are situated outside of the flood extents for the given event. For properties with basements, the flood damages for the property assuming a depth of 2.4m (typical ceiling height) should be applied once the flood depth exceeds the threshold level for the basement (i.e., the lowest level that allows significant flood waters to enter). This damage should be in addition to the normal depth-damage calculation for the ground floor of the property.
3.4	**Non-Residential Property Damages** ***Non-Residential Property Classifications*** The Indicative Susceptibility depth-damage curve / data should be used, unless there is a clear and specific reason to use the High or Low Susceptibility Band data for a given property.

	For the purposes of determining the appropriate non-residential property damages, and the depth-damage curve / data to be used, account should be taken of: - Property type (i.e., sub-classes of the 'Bulk Code Class', and with a three-digit 'MCM Code', as referred to in FHRC 2005 & 2010) - Property area ***Property Floor Levels and Flood Depths*** As set out in Section 5.4.2 (and 8.1.4) of the Generic CFRAM Project Brief, non-residential property floor levels may generally be determined, subject to confirmation by the Consultant through spot-checks and the exceptions as set out below, that doorstep / floor levels of ground-floor properties are a specific height above ground level as determined from the DTM data. The specific height adopted for each AFA should be based on observation / measurement for each AFA. Surveys of the threshold levels for flooding of major commercial properties (those with estimated potential damages greater or equal to €500,000 for an event of annual exceedence probability of 0.1% in the AFA), and also for entry points to significant basements or underground car-parks, are however required, and these levels where captured should be used. Flood damages should be assumed to begin at flood depths of 0m. For mixed-use properties, i.e., where the property includes both residential and (non-residential) commercial use, it could be assumed (unless otherwise verified through site visit / remote data) that the ground floor will typically be in non-residential (commercial) use, and so the non-residential approach should be applied, i.e., assume flood damages begin at 0m rather than -0.3m. For converted properties that are now non-residential, the non-residential approach should be applied The 'with basements' or 'without basements' depth-damage data for non-residential properties should be used as appropriate. Where the existence or otherwise of a basement is unknown for a given property, then the 'without basement' depth-damage data should be used. In line with good practice, a 'reality-check' should be undertaken for any property that contributes more than 1% of the total PV damages for an AFA.
3.5	**Other Damage Costs** ***Principal Direct Damage (PDD) Costs*** The PDD Costs are calculated as the sum of the residential and non-residential property damages. The PDD Cost is used as the baseline for the calculation of other damage costs, as set out below. ***Infrastructural Utility Assets*** Economic damages to infrastructural utility assets (e.g., electrical sub-stations, gas installations and pipe-work, telecommunications assets, etc.) should be calculated as 20% of total PDD Costs for the AFA or SSA. *(Note: 20% value has been derived from the analysis of damages of past floods in the UK).*

	Infrastructural Utility Damage Costs should be included for the economic CBA, but should not be included in the appraisal against Objective 2.a under the MCA. ***Emergency Services*** Costs to emergency services (which include evacuation costs) should be included in the economic damages, and should be calculated as 8.1% of the total PDD Costs for the AFA or SSA. *(Note: 8.1% value derived as average of the measured emergency services costs for the 2000 and 2007 floods in the UK).* ***Traffic Disruption*** Costs of traffic disruption may typically be excluded from the calculation of the economic damages, as it will typically not be significant within the overall damages. This would be, for example, where the flooding would be of minor roads or local urban streets and where alternative local routes are available and/or traffic volumes will not be high. Traffic disruption costs may however be included where there are major (high volume) roads affected and / or where deviation routes are of significant distance. The inclusion or otherwise of traffic disruption costs is at the discretion of the CFRAM Consultants, subject to advice from the Steering / Progress Group. In the event that traffic disruption costs are calculated, then such damages / costs should be included for the economic CBA, but should not be included in the appraisal against Objective 2.a under the MCA. ***Risk to Life*** While clearly of significant importance in the overall appraisal under the MCA, the potential damage costs of loss of life in a flood event are not to be included in the assessment of economic damages. *(Note: This is excluded because, while loss of life can occur in flood events, in Ireland loss of life in a community that might be classified as an APSR (AFA) is very rare. As such, it would not materially change the economic analysis.)* Where risk to life is of potentially significant concern (e.g., where there is a prevalence of basements and / or by observation of the flood hazard (risk to life) mapping and the location of residential / high vulnerability properties), this should be noted in the description of flood risk for the AFA, and can be taken into account in option selection and justification. ***Other Excluded Damage Costs*** Damage costs can arise in relation to various other types of damage, impacts or costs arising in the event of a flood. However, these are either not economic losses (i.e., to the overall national economy), are provided for under another included cost, and / or are typically relatively small as a percentage of the overall damage and hence do not need to be considered in the economic appraisal at this strategic level of assessment.

	Such excluded costs would include: - Damage to roads - Damage to parked cars - Environmental damage - Personal evacuation costs - Temporary accommodation - Extra heating costs - Losses to businesses - Recreational losses Many of the above costs are deemed to be included within the Intangible and Indirect Damages (see Item 3.6 below).
3.6	**Intangible and Indirect Damages** Flood events can cause significant stress, anxiety and ill health to potentially affected people, during and then after a flood. Individuals generally also incur some costs due to their properties flooding that are not directly related to damage, such as evacuation, temporary accommodation, loss of earnings, increased travel and shopping costs, etc. While these negative impacts are difficult to monetarise or quantify, it is recognised that these impacts are significant, and professional opinion (Chatterton, pers. comm) has indicated that they could well be greater than the direct damages to residential properties. For residential properties, the intangible and indirect flood damages shall together be set equal to the total (direct) property damage. Intangible damages may also be applied in the case of small, individually or family-owned businesses where the intangible impact would be personal and similar in nature to that which might be experienced were the property residential. The inclusion of intangible damages for non-residential properties (if included) shall however be justified on a property-by-property basis, and may not be generally applied across an entire sector or sub-sector. While recognising that there will be some impact to those living above ground floor level (e.g., in apartment buildings), the intangible impact will, in line with the economic damages, be quite limited relative to those in properties that are flooded, and so these damages should not be included at the CFRAM level of analysis. Intangible and indirect damages should be included for the economic CBA, but should <u>not</u> be included in the appraisal against Objective 2.a under the MCA (as they are provided for under other MCA objectives).

3.7	**Calculation of Annual Average Damage** The Annual Average Damage (AAD) shall be calculated using linear interpolation between damage values for each of the eight defined design event probabilities, i.e., with a damage value calculated for each 'slice' based on the average of the damages for the design event damages that form the probability boundaries for the 'slice', and the probability range of the 'slice'. The AAD is calculated as the sum of the damage values of each slice, up to and including the 'slice' with the 0.1% AEP event as the upper bounding event.
3.8	**Calculation of the Present Value of Damages (PVd)** The PVd should be calculated as the discounted sum of the annual average damages over the project horizon, where: - The discount rate to be applied is 4% - The project horizon is 50 years The discount rate is subject to sensitivity testing (see Section 5.1).
4.0	**CALCULATION OF ECONOMIC BENEFITS OF FLOOD RISK MANAGEMENT OPTIONS**
4.1	**General Requirements** The economic benefits of an option for a flood risk management measure, or of a proposed flood risk management measure, are calculated as the reduction in the economic damages the option or measure will provide. The benefits / damages should be calculated assuming protection to the defined / proposed Standard of Protection (SoP), i.e., not taking into account freeboard / factor of safety. ***Baseline Scenario*** The baseline scenario against which benefits of an option or measure should be compared is the current situation or 'continue with existing practice' in terms of arterial drainage maintenance, local authority maintenance regimes for urban channels, culvert inlets, etc. *(Note: This is different from the usual 'Do Nothing' baseline scenario against which benefits of further action, or maintaining the status quo, are measured. This is necessary due to the nature of current activities, and the uncertainty associated with damages that would arise should those activities cease).* ***Defence Options or Measures*** For options or measures involving direct flood defence of an area, such as a wall or embankment, the reduction in damages should be calculated as the damages avoided to up and including the standard of protection of the option or measure, with no benefit offered for events greater than standard of protection. *(Note: This approach will tend to under-estimate the benefits of an option or measure, as it ignores the residual benefits for greater-than-design events. However, these residual benefits would be offset to some degree by increased damages that could arise in the event of the failure of the defence, and the above approach simplifies that analysis required.)*

	Other Flood Hazard Reduction Options or Measures For options or measures that involve reducing flood flows or levels through the relevant area, such as flood water retention or increasing in-bank channel capacity, the reduction in damages will need to be calculated by running the model for the flood event probabilities for which flooding and damage will occur to determine the flood damages for those events, and hence the reduction in damages from the current scenario. The event of probability equal to the standard of protection, or for which no flooding or damages would arise, will also need to be run to demonstrate the effectiveness of the option or measure at the intended 'zero-damage' event probability.
4.2	**Present Value of Benefits (PVb)** The PVb of an option or measure is the reduction in the Present Value of damages (PVd) that would be achieved by implementing the option or measure (where the PVd is calculated as set out in Section 3.8 herein based on the discount rate and the project horizon), but also taking into account the capping of benefits as set out in Section 4.3 below.
4.3	**Property Value Capping** The costs of a measure or scheme (i.e., an option) with respect to a particular property should not exceed the total value of that property and, where relevant, the intangible damages that can be avoided through relocation; otherwise the State could end up investing more in protecting an asset than the value of that asset and associated intangible consequences, and a lower cost alternative measure (relocation) could be implemented instead. Capping values are hence applied to PVb of an option when undertaking an economic CBA. Capping should not be applied to the property damages for the appraisal against Objective 2.a under the MCA nor for the economic damage risk maps, as these should reflect the 'Do Nothing' or current situation. ***Residential Property Value Capping*** The capping value of the Principal Direct Damages (PDD) for a residential property is based on the value of that property. The value for a given property can be based on local or regional valuations of that type of property, i.e., a property-specific valuation is not required. Information on residential property prices is available from a number of publicly available sources (e.g., Residential Property Price Register, Daft.ie, etc.). The total capping value should however also take into account the PVd related to the intangible damages for a property, noting that these can be ongoing and not only the direct consequences of a given flood. The PVb capping value for intangible benefits of an option should be set equal to the capping value for the PDD for the property, representing the intangible damages avoided over the project horizon if the property (and it's residents) were to be relocated, but taking into account the capping of the PDD of the property.

	The Total Capping Value for the PVb for a residential property is therefore calculated as the sum of the capping value for the PDD for a property and the capping value of the intangible damages for that property. As the latter is equal to the former, this value is effectively double the capping value for the PDD of a property (i.e., double the property value). **Non-Residential Property Value Capping** The capping value for the PVb for a given non-residential property can be derived from regional valuations of that type of property, taking account of typical stock, or as ten (10) times the current rateable value of the property. **Capping of Other Damages** Capping should be applied to property damages and intangible damages only. Capping should not be applied to damages calculated as a percentage of the Principal Direct Damages (PDD), such as emergency services costs.
4.4	**Exclusions from Benefit Calculations** Potential increases in property value (including land value) arising from the implementation of a scheme may not be counted as scheme benefits.
4.5	**Reduction in Risk (Benefits) for Appraisal against MCA Objective 2.a** The economic benefits used for the economic cost-benefit analysis (CBA) to determine the benefit-cost ratio should be as set out above. The economic benefits used for the appraisal of options or measures under the MCA against Objective 2.a (Minimise Economic Risk) are as set out above, but should not be capped (Section 4.3) and with certain exclusions as referred to above, including: - Benefits to infrastructural utilities (Section 3.5) - Benefits in reduction of disruption to traffic (Section 3.5) - Intangible and indirect benefits (Section 3.6) These exclusions are to avoid double-counting benefits within the MCA. Further guidance on scoring under the MCA against Objective 2.a is given in GN28.
5.0	**COST – BENEFIT ANALYSIS**
5.1	**General Methodology** The benefit-cost ratio (BCR) to be produced as the output of the cost-benefit analysis is calculated by dividing the PVb for an option or measure, capped as appropriate, by the whole life cost (PVc) of that option or measure. The Net Present Value of the benefits (NPVb) of the option should also be calculated by deducting the PVc from the capped PVb.

Further guidance on deriving costs for options or measures is provided under the guidance on the use of Unit Cost Database. The whole life cost is determined from the sum of the costs over the project horizon, with future costs discounted by the set discount rate (see Section 3.8 herein).

It should be noted that residual asset values of potential flood risk management measures (i.e., at the end of the project horizon) should be assumed to be zero.

Measures are only likely to be recommended as measures to be put forward in the Flood Risk Management Plan if their BCR is greater than unity.

As set out in the Generic CFRAM Project Brief, sensitivity tests should be undertaken to determine the BCR using higher or lower discount rates, which should be 5% and 3% respectively.

6.0 ECONOMIC RISK MAPPING

For the economic risk mapping, the AAD should be calculated in the same way as calculating the economic damages to be used for the economic cost-benefit analysis (CBA) to determine the benefit-cost ratio (i.e., including damages related to infrastructure and traffic disruption (if relevant) and indirect and intangible damages).

Capping (as used in calculating PVb – See Section 4.3) is not relevant to, and should not be applied for, the economic risk mapping.

7.0 REFERENCES AND RESOURCES

References

– FHRC 2010: The Benefits of Flood and Coastal Risk Management: A Handbook of Assessment Techniques – 2010, Flood Hazard Research Centre, Middlesex University

– FHRC 2005: The Benefits of Flood and Coastal Risk Management: A Manual of Assessment Techniques – 2010, Flood Hazard Research Centre, Middlesex University

Resources

– GN28 – Option Appraisal and the Multi-Criteria Analysis Framework

– GN32 – Calculation of the Costs of Flood Risk Management Options and Measures

– OPW Unit Cost Database

APPENDIX A

GLOSSARY OF ABBREVIATIONS

AAD	Annual Average Damages
AEP	Annual Exceedance Probability
AFA	Area for Further Assessment
APMR	Area of Potentially Moderate Risk (associated with Medium Priority Watercourses, or 'MPWs')
BCR	Benefit – Cost Ratio (Benefits / Costs)
CBA	Cost – Benefit Analysis
CPI	Consumer Price Index
DTM	Digital Terrain Model
FHRC	Flood Hazard Research Centre (Middlesex University, London)
HEFS	High End Future Scenario
MCA	Multi-Criteria Analysis (see GN28)
MCM	Multi-Coloured Manual
MRFS	Mid-Range Future Scenario
NPVb	Net Present Value of the benefits of a potential Scheme (PVb - PVc)
OECD	Organisation of Economic Co-operation and Development
PPD	Principal Direct Damages (sum of direct damages to residential and non-residential damages)
PPP	Purchasing Power Parity
PVb	Net Present Value of Benefits (whole life, discounted benefits)
PVc	Net Present Value of Costs (whole life, discounted costs)
PVd	Net Present Value of Damages (whole life, discounted damages)

APPENDIX B

EXPLANATORY TABLE

The table below sets out which parameters are applicable for each use (Economic CBA, Economic Risk Mapping and appraisal against MCA Objective 2.a), and how some of the parameters (e.g., Total damages for a given event, AAD) are calculated based on previous parameters.

The relevant sections in the Guidance Note are given in parentheses after the comment on application.

Parameter		Application		
		Economic CBA	**Economic Risk Mapping**	**MCA Appraisal: Objective 2.a**
1	Residential Damages	Yes (3.3)	Yes (3.3)	Yes (3.3)
2	Non-Residential Damages	Yes (3.4)	Yes (3.4)	Yes (3.4)
3	Principal Direct Damages (PDD)	1 + 2	1 + 2	1 + 2
4	Intangible Damages	Yes (3.6)	Yes (3.6)	No
5	Infrastructural Utility Damages	Yes (3.5)	Yes (3.5)	No
6	Emergency Services	Yes (3.5)	Yes (3.5)	Yes (3.5)
7	Traffic Disruption	Possibly (3.5)	Possibly (3.5)	No
8	Event Damage	3 + 4 + 5 + 6 + 7	3 + 4 + 5 + 6 + 7	3 + 6
9	Annual Average Damage (AAD)	Annualise 8	Annualise 8	Annualise 8
10	Present Value of Damages (PVd)	Discounted sum of 9 over Project Horizon	N / A	Discounted sum of 9 over Project Horizon
11	Un-capped PVb	Reduction in PVd (10) provided by Option (4.2)	N / A	Reduction in PVd (10) provided by Option (4.2)
12	Capping Value	Double Residential Property Value, or, = Non-residential Property Value (4.3)	N / A	N / A
13	Capped PVb	11, but not > 12 (4.3)	N / A	11 (4.3)
14	PVc	Whole Life Scheme Cost	N / A	Whole Life Scheme Cost
15	BCR	13 / 14 (5.1)	N / A	13 / 14 (5.1)
16	NPVb	13 - 14 (5.1)	N / A	13 - 14 (5.1)

NATIONAL CFRAM PROGRAMME
GUIDANCE NOTE NO. 28

Title:	**Option Appraisal and the Multi-Criteria Analysis Framework**
Version:	**Rev. C**
Author:	Mark Adamson, Richael Duffy, CFRAM Consultants
Date:	March 2015
Issued to:	CFRAM Consultants
Date Issued:	March 2015

1.0 PURPOSE

The purpose of National CFRAM Programme Guidance Note (GN) No. 28 is to clarify certain requirements of the process for the development of flood risk management (FRM) options, including screening, and to set a common approach to the multi-criteria analysis (MCA) for option appraisal.

2.0 SCOPE

GN 28 relates to:

– Flood Risk Management Objectives (Section 8.4 and Appendix J),
– Screening of Possible FRM Methods (Section 11.4 of the Stage I [Generic] Project Brief),
– Appraisal of Potential Options (Sections 11.6)
– Selection of Preferred Options (Section 11.7)

GN 28 does not address or cover:

– Defining the Spatial Scales of Assessment (SSAs) for urban areas, which is covered by GN 19
– Methods for the evaluation of adaptability to climate change, which is covered under GN 29.
– Methods for undertaking the Strategic Environmental Assessment (SEA), as the requirements for this are set out in the Project Brief with the consultants employed as experts to undertake the SEA.
– The development of flood risk management options (Section 11.5) from the methods that have been deemed potentially viable through the screening process. This is deemed to be a matter for the Consultants to determine in the manner they deem appropriate.

3.0	OVERVIEW OF SCREENING AND MCA OPTION APPRAISAL FRAMEWORK
3.1	***Framework Overview*** An objective of the CFRAM Projects is to: *"Identify viable structural and non-structural options and measures for the effective and sustainable management of flood risk in the Areas of Potential Significant Risk (APSRs) and within the Study Area as a whole"* (Section 1.2.1, Generic Project Brief), where *"The analysis, and method and option development and appraisal, to derive the set of actions and measures to be defined in the FRMP, as described herein, should form a robust and sound foundation for the future full development (after completion of this Project) of a measure to be taken to public exhibition or planning (as appropriate) and subsequent implementation."* (Section 11.1, Generic Project Brief) and *"The rejection of any method or option shall be robust and with clear and transparent reasoning, as rejected methods and options shall not be reconsidered in future projects."* (Section 11.1, Generic Project Brief) The screening and MCA option appraisal process is intended to provide an efficient, staged approach to achieving the above stated objective in the robust manner required, taking into account the wide range of potential benefits and impacts that flood risk management measures can have, and in coordination with the SEA/AA processes. The MCA appraisal outcomes will also inform the national prioritisation of preferred options and measures. There is hence a strong need for consistency across the CFRAM Programme to ensure that all potential works are considered on an equal basis.
3.2	***Robustness*** Appendix M of the Generic Project Brief sets out a non-exhaustive range of flood risk management (FRM) methods. The purpose of the screening and option appraisal process is to review all possible FRM methods, including those in Appendix M, and to identify the most appropriate suite of FRM options to be set out in the FRMP that the OPW, Local Authorities and other agencies can take forward to full scheme development, exhibition / planning and implementation. The processes must be sufficiently robust such that a re-evaluation of methods and options for a given location or for the Study Area as a whole, in terms of option selection, is not required for the implementing agency to move forward with the measures and strategies set out in the FRMP.

3.3	***Application of Professional Judgement*** In the interests of efficiency, the screening process and option appraisal process should, as far as reasonably possible, be automated, making use of the measurable parameters. However, an automated system cannot always take account of specific or local issues or particular circumstances. It is therefore essential that the processes and all outcomes are subject to the application of professional review and judgement. With respect to all objectives, other than objective 2.A (Reduce Economic Damages), professional judgement needs to be applied within the requirements and guidance provided. Notwithstanding this, with a view to ensuring national consistency, the professional judgement should typically not change the calculated Local Weighting or scoring by more than 1 point, or by more than 2 points in exceptional circumstances. Any changes beyond this limit should be discussed and agreed with OPW (who will have a national overview of weighting and scoring). Wherever professional judgement forms the basis of an amendment to the Local Weighting or score, then the reasoning for this should be recorded and reported.
3.4	***Design Standards*** Section 11.2 of the Generic Brief defines the 1% Annual Exceedance Probability (AEP) event and the 0.5% AEP event as the preferred design standards against which measures should provide protection for fluvial and coastal flooding respectively. However, the Brief also defines that other design standards should be considered under certain circumstances. The screening and option appraisal processes need to keep this potential flexibility in mind. It is not however expected that extensive work will be done at screening stage to re-screen each measure for alternative design standards where a measure fails to meet the screening criteria at the preferred standard, nor that extensive work will be done at appraisal stage to determine the optimum design standard for an option. It is expected that: – Professional judgement be applied at screening to retain a measure that might fail at the preferred design standard, but that could be attractive and viable at other design standards – Professional judgement be applied at appraisal stage, and where it is considered that a scheme might be preferable and / or be more cost – beneficial at a higher or lower design standard then this should be noted in the Preliminary Options Report (and the FRMP if / as appropriate) – A measure be appraised at an alternative design standard if a potentially preferred (or the only potentially viable) option proves not to be viable at the preferred design standard, but, based on professional judgement and the risk information available, is likely to be viable at an alternative standard.

4.0	**FLOOD RISK MANAGEMENT OBJECTIVES**
4.1	Section 8.4 of the Generic Project Brief introduces the FRM objectives, with provisional objectives then set out in Appendix J, along with indicators that act as a means by which achievement or otherwise of the objectives can be measured or assessed. The objectives are defined under four categories: – Technical – Economic – Social – Environmental Note that the environmental category includes cultural heritage, which is assessed as part of the SEA process. The objectives have been developed to broaden the range of potential impacts of flooding and FRM measures that are taken into account in the development and selection of FRM options and strategies, and their subsequent prioritisation. All four categories are deemed important criteria in the selection of flood risk management measures for a given location. However, only the latter three (i.e., excluding the 'Technical' category) refer to benefits, and so it is only these that should be used to provide an indication of benefit relative to cost, and be used for the purposes of prioritisation (of programme investment to maximise benefit). The OPW have reviewed the provisional objectives, taking into account the lessons learned from the pilot studies and further consultation. A revised set of objectives is set out in Appendix A.
5.0	**SCREEING PROCESS**
5.1	***Overview of the Screening Process*** The purpose of the screening process is to filter out FRM methods that are not going to provide applicable, acceptable or viable options or measures, either alone or in combination with other methods, for a given flood problem for a given location in the SSA under consideration. The screening process requires an indicative appraisal of <u>all</u> possible FRM methods for <u>each</u> of the various SSAs against each of the criteria set out in Section 11.4 of the Generic Brief. Considerations for each of the criteria are set out below. ***A) Applicability to Relevant Area*** Certain FRM methods would simply not be applicable to certain flood risk circumstances, and may be rejected on this basis. Examples might include: – Increasing conveyance or flow diversion in purely coastal flood situations – Rehabilitation of existing defences where no existing defences exist

Methods that may be applicable, even if unlikely to be viable or appropriate for other reasons, should not be rejected on the basis of applicability.

B) Economic

While the screening process is an indicative appraisal, it should make use of available information. The economic risk assessment previously undertaken (as part of the Flood Risk Assessment) will provide an envelope of potential economic benefits. Professional experience, and some simple costing using unit costs, can be used to estimate the possible minimum* costs of a method. On this basis, an indicative benefit – cost ratio for a method, in isolation or potential combination with other methods, can be determined.

In assessing the potential benefits of a method, the standard of protection and the effectiveness of the method in reducing risk should be considered (i.e., it should not be assumed all of that the damages up to the 0.1% AEP event will be prevented, unless that is the standard being considered, and a percentage degree of reduction in risk (e.g. option take-up rate and effectiveness) should be applied for non-structural measures such as flood forecasting and warning).

* On the basis of a precautionary approach to avoid rejecting methods that may prove economically viable, supplementary items used in detailed costing (unmeasured items, optimism bias, archaeology, land purchase / compensation, etc,) may be excluded from the costing at this stage. On the same basis, the threshold for the indicative benefit – cost ratio for rejection of a method should not be set equal to unity, and a threshold of 0.5 should be applied.

C) Environmental

The environmental screening should make use of the SEA scoping and any other environmental assessment work available at the time.

Methods should not be rejected only on the basis that a method may have a detrimental impact on an environmentally or culturally valuable or protected site, as mitigation measures may be available. Screening should take into account the degree of detrimental impact on the site, the scope for mitigation and whether there are apparently viable and acceptable alternative approaches available.

D) Social

In considering the social dimension during the screening process, outcomes of consultation processes previously undertaken (e.g., for start-up / SEA scoping and flood mapping) should be taken into account, along with the application of professional judgement and experience. Rejection of a method should only occur however where all variants of the measure would be unacceptable, for example, a permanent wall of 2m height may be unacceptable along the banks of a river through the middle of an urban area, but a permanent wall of 1.2m height topped with demountables to the 2m height may be acceptable.

	E) Cultural The approach taken to the cultural criteria of the screening should be similar to that undertaken for the environmental criteria, whereby a method should not be rejected only on the basis of a potentially minor negative impact. ***Consideration of Criteria in Combination*** The screening process may need to consider the criteria in combination as well as individually, e.g., for the example given under social criteria above, the permanent plus demountable option may be rejected if there would be a requirement for extensive demountables and the urban area in question is in a flashy catchment where there would not possibly be adequate warning time (based on recorded rather than predicted rainfall) to permit erection of the demountables without an intolerable level of false warnings. As with all rejections, the justification of rejection on the basis of 'in combination' reasons should be robust.
5.2	***Justification of Rejection of Methods at Screening*** In all cases where potential methods are rejected, justification should be provided which is robust, and with a clear and transparent reasoning. Such justification should be self-explanatory, but may vary in detail, with only brief text provided in some instances where the case for rejection is in itself self-evident (and would be so to the public and stakeholders) but with more detailed description required in other circumstances where the case for rejection is not so clear.
5.3	***Automation*** There is only limited scope for automation in the screening process, as much of the decision-making is indicative and will rely heavily on professional judgement and non-numeric factors. The exception to this may be the economic criteria where use may be made of the economic risk outcomes and unit costs. If an automated process is used, consideration should be given to the use of lookup tables for values or parameters that are used frequently (e.g., for multiple locations or multiple methods) to facilitate a single point amendment approach that, based on experience, can make significant savings in time as consultation and review processes lead to amendments in such values or parameters.
5.4	***Design Standards*** Given the potential for flexibility in the design standard, or standard or protection that may be adopted, methods or measures that might be effective and potentially viable at design standards other than those preferred, even if not so at the preferred standards, should not be rejected. This would apply in particular where: – A certain method is very likely to form (part of) a preferred option, but needs to be to a higher or lower standard due to factors such as health and safety requirements, available space for the method, social factors, etc. – There appears to be no viable methods that could achieve the preferred standard of protection

	– A method at a lower or higher standard of protection may become (part of) the preferred option overall, even if another option might (at this screening stage) appear to be more beneficial at the preferred standard.
5.5	***Requirements for Modelling*** The screening process is intended to be indicative and the OPW does not require that hydraulic modelling of all methods be undertaken at this stage. However, modelling may be appropriate in some instances to provide the required sound and robust justification for rejection, or indeed may be desirable, depending on the approach taken, to reduce the work required at the appraisal stage.
5.6	***Non-Structural FRM Methods*** Some non-structural FRM methods may be rejected during screening for various reasons. However, it should be noted that many non-structural methods are complimentary to structural methods in providing residual flood risk management, as well as providing stand-alone options in their own right, and some may represent the implementation of national policy (e.g., spatial planning, preparation of emergency response plans – See Section 6.6). As such, non-structural measures should not be rejected on the basis that other structural measures appear to be viable, but only on the basis that they are not applicable, appropriate or viable in the same manner as other methods. Land use management, natural flood management, green infrastructure, river restoration, etc. are terms used to cover (some of) 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 others measures to achieve flood risk management targets. At screening, such measures should not be rejected on the basis that other structural measures appear to be viable, but only on the basis that they are not applicable, appropriate or viable in the same manner as other methods.
6.0	**MCA OPTION APPRAISAL PROCESS**
6.1	**Overview of MCA Option Appraisal Process** The option appraisal process is set out in Section 11.6 of the Generic Brief, with reference made to Section 8.4 and Appendix J in relation to the FRM objectives that will form part of the appraisal process. Section 8 of the Generic Brief notes that both the Flood Risk Management Objectives set out in Appendix J, and the descriptions of the local weightings provided in Section 8.4, are subject to review and refinement, with guidelines to be issued by the OPW for consultation with the NTCG. As stated in Section 1 herein, the purpose of this GN is to clarify the requirements of the option appraisal process, and to set a common approach to the multi-criteria analysis (MCA) for option appraisal, and hence provide the guidelines referred to above.

This section outlines the overall structure of the MCA framework, which forms the core of option appraisal, and provides a description of each component of the framework. The objectives are set out in Appendix A herein, with detailed guidance on the approach to be taken with respect to each objective then set out in Appendix B, including definition of global weightings and indicators, and guidance on assessing local weightings. Guidance on scoring the performance of different options under the MCA with respect to each objective is set out in Appendix C.

Overall Framework

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

The MCA framework has been developed to broaden the range of potential impacts that flooding and the implementation of FRM measures can have that are taken into account in the development and selection of FRM options and strategies, and their subsequent prioritisation. It is based on the numeric, but non-monetarised assessment of options against a range of objectives, whereby indicators are set for each objective. These indicators are then used to define scores for that objective on the basis of the degree to which the option being appraised goes beyond the Basic Requirement for that objective towards meeting the Aspirational Target. Weightings are applied globally (nationally) for each objective, with local weightings then applied to reflect the local importance of that objective in the context of the respective SSA, and these weightings are applied to the scores derived as above.

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

Each component of the MCA Framework is explained in more detail below.

Objectives

The FRM objectives reflect what the overall flood risk management programme is seeking to achieve, expanding on the requirements of the National Flood Policy Review and the EU 'Floods' Directive.

At a local level, and for the purposes of the MCA, the objectives set out an aim that each flood risk management option should be seeking to achieve, if possible. The degree to which an option achieves the objective is an indication of the 'success' of the option, and equally, the more an option achieves across all of the objectives, then the greater the preference that will be given to that option relative to others, taking account also of the cost of each of the options.

Indicators
The indicators are parameters, measurable and numeric where possible, by which the 'success' of an option in meeting a particular objective can be gauged.

Basic Requirements and Aspirational Targets
The objectives are termed as general aims for the management or reduction of flood risk, or for other benefits that can be accrued through the implementation of flood risk management measures.

To enable the assessment of the degree to which an option 'succeeds' in meeting the stated aims, a more defined aim needs to be set, along with a benchmark for neutral status (i.e., no impact).

The Basic Requirements and Aspirational Targets are set in terms of the defined indictor, i.e., make use of the same parameter for setting target or threshold values as that used for scoring against the objective.

Aspirational Targets
The aim is defined as an Aspirational Target, whereby an option would be deemed as perfect with respect to the given objective if it were to meet the Aspirational Target. Typically this will represent complete removal of a risk, or the full achievement of another benefit, and it will be rare that any option will meet such Aspirational Targets for even one, let alone all, objectives.

The Aspirational Targets are therefore NOT requirements that must be met, and very effective options may still fail to meet the Aspirational Targets.

Basic Requirements
The Basic Requirement represents a neutral status or 'no change', whereby if an option has no impact on the matter the objective relates to, or meets what might be termed for some objectives as minimum requirements for acceptability, then that option will have met the Basic Requirement. If an option performs worse than the Basic Requirement, i.e., has a negative impact (a dis-benefit) or does not meet the minimum requirements for acceptability, it will score a negative-value score for that objective, but might still be considered further, depending on the degree of the dis-benefit or failure to meet the requirements.

The Basic Requirement is therefore NOT an absolute minimum requirement for acceptability, but a benchmark to define positive versus negative impacts or performance.

Scoring Against Objectives
An option may be scored against the objective by determining the degree to which it performs, measured using the defined indicator, in going beyond the Basic Requirement towards meeting the Aspirational Target (which are both expressed in the same terms as the indicator). The following generic rules should be applied in scoring, although specific guidance is given in Appendix B:

- An option that meets the Basic Requirement only should be given a score of zero.
- An option that meets the Aspirational Target should be given a score of five.
- An option that performs somewhere between the Basic Requirement and the Aspirational Target should be given a score proportional to the degree to which it achieves the objective beyond the Basic Requirement towards meeting the Aspirational Target.
- An option that performs better than the Aspirational Target (which for most objectives will not be possible) should still only be limited to a maximum score of five.
- An option that performs worse than the Basic Requirement, i.e., creates a dis-benefit or does perform to an acceptable standard, should be given a negative score down to –5 using, where possible, the same scoring mechanism as that used for scoring options that achieve between the Basic Requirement and the Aspirational Target.
- There are exceptions to the negative scoring where the performance or impact of the option becomes unacceptable, and the option should be rejected on the basis of its performance on the given objective alone. In such circumstances the option should be given a '-999' score and be rejected from further consideration. The thresholds for unacceptability of an option are defined where relevant in the detailed objective description sheets in Appendix B.

The resultant scores should only be considered as initial guidance for decision-making, and the arithmetic calculation of scores can sometimes give misleading results that do not take account of all relevant issues. The application of professional judgement in reviewing and confirming or amending all of the derived scores is essential.

Justification of the score assigned should be provided which is robust, and with a clear and transparent reasoning that should include quantitative evidence where reasonably possible. Such justification should be self-explanatory, but may vary in detail, with only brief text (potentially a standard comment) provided in instances where the basis for score is clear (and would be so to the public and stakeholders) but with more detailed description required in other circumstances where the basis for the score assigned is not so clear, such as where amendments have been made to numerically-derived scores or where the scoring has varied from the guidance for certain reasons.

Global Weightings

Global Weightings are assigned to each objective to give it more or less weight in the overall assessment of the suitability or value of the option. The Global Weightings are fixed nationally to ensure a consistent approach and basis for prioritisation, and are intended to represent the 'societal value' for the objective relative to the others, i.e., with those of most weight representing the most important objectives.

	Local Weightings The Local Weightings are assigned to each objective for each location under consideration (i.e., each SSA), and are intended to represent the local importance of that objective within the local context. They are very important within the framework as they provide scale to the process, whereby if the subject of a given objective is of much greater significance than another in the same location, and should have a greater influence on the choice of option, then this can be provided for through the Local Weightings. Similarly, the importance of an issue / objective in one location relative to another can also be provided for through the Local Weightings. Local Weightings for some objectives will be numerically determined according to the degree of risk (e.g., economic annual average damages, number of properties, etc.), but for some others will need to be set by professional judgement. In both instances however, the assignment should take into account local knowledge provided at the stakeholder and public consultation events (primarily for events during the mapping stage, but account may also need to be taken of significant issues raised during the optioneering stage PCDs). Guidance is provided on assigning Local Weightings in the detailed objective description sheets in Appendix B. Justification should be provided to the degree necessary to permit defence for the Local Weighting assigned in the face of public or stakeholder questioning. Such justification should be self-explanatory, but may vary in detail, with only brief text (potentially a standard comment) provided in instances where the basis for weighting is clear (and would be so to the public and stakeholders) but with more detailed description required in other circumstances where the basis for the weighting assigned is not so clear, and / or varies from the guidance provided or the numerical value derived.
6.2	***MCA Outcomes*** **Criteria Scores:** Once the MCA has been applied, each option will have a weighted score for each objective. For each option, the scores for each of the four criteria should be summed to provide the Criteria Scores. **MCA Benefit Score:** To derive the MCA Benefit Score, the scores for the economic, social and environmental Criteria Scores should be summed. This score represents the net benefits of the option. **Option Selection MCA Score:** To derive the Option Selection MCA Score, the scores for all four of the criteria should be summed. This score compliments the MCA Benefit Score with the Technical Criteria Score, and hence includes all of the aspects that should be taken into account in considering the preferred option for a given location.

	MCA Benefit – Cost Ratio (BCR): The MCA Benefit Score should then be divided by the cost of the option to provide a numerical, but non-monetarised, MCA Benefit - Cost Ratio that provides an indication of the overall benefits that can be delivered per Euro invested. The **Economic Benefit – Cost Ratio (BCR)** should also be calculated using the more traditional techniques (i.e., the FHRC Multi-Coloured Manual, rather than the option appraisal MCA set out herein). The above scores and ratio can be used to inform decisions on which option might be preferred for each SSA, as set out in Section 7 herein.
6.3	***Automation*** With the exception of most of the environmental objectives, there is significant scope for automation in the application of the MCA given the numeric nature of many of the indicators and function-based approach to scoring for many of the objectives. Where an automated process is used, serious consideration should be given to the use of lookup tables for values or parameters that are used frequently (e.g., for multiple locations or multiple methods) to facilitate a single point amendment approach that, based on experience, can make very significant savings in time in application of the MCA as consultation and review processes lead to amendments in such values or parameters.
6.4	***Application of Professional Judgement*** As noted in Section 3.1, an automated system can be prone to error and cannot take always account of specific or local issues. It is therefore essential, particularly for the option appraisal process, that the processes and all outcomes are subject to the application of professional review and judgement. The decisions on recommendations for preferred options is one to be made by the consultant, not by the MCA process.
6.5	***Design Standards*** As set out in Section 3.4, while the 1% AEP event and the 0.5% AEP event have been identified as the preferred design standards against which measures should provide protection for fluvial and coastal flooding respectively, other design standards should be considered under certain circumstances. In the event that professional judgement and / or consultation feedback indicates that alternative standards of protection might be preferred, then the appraisal should be undertaken for a sample alternative standard. It is not however expected that a full analysis be undertaken to optimise and define the alternative standard of protection for each option, but the appraisal should be undertaken on at least one alternative standard to demonstrate that alternative standards could provide (or

	indeed would not provide) greater benefit or return on investment, or provide benefits / viability in a manner that is more socially or environmentally acceptable, which in turn should inform the outline design of the option and be reported in the FRMP. The post-CFRAM full scheme development process can then undertake the more detailed analysis to identify the optimal standard of protection for the preferred option.
6.6	**Measures Required under National Policy** Certain non-structural flood risk management measures are required as matters of national policy. These would include: - Application of the Guidelines on the Planning System and Flood Risk Management (DoECLG & OPW, November 2009) - Preparation of emergency response plans for severe weather events, including flood events (A Framework for Major Emergency Management, DoECLG) As these measures are required to be applied regardless of other proposed measures, or of the outcomes of an appraisal under the MCA process, then they do not need to be subjected to an MCA appraisal, but may be assumed to be applicable and required for all AFAs and other SSAs. Standard texts can be prepared for the inclusion of these measures in the Preliminary Options Reports and the FRMPs.
7.0	**SELECTION OF PREFERRED OPTIONS AND PRIORITISATION**
7.1	***Option Selection*** The option selection process is set out in Section 11.7 of the Generic Brief. The following outcomes of the MCA process should be used to guide the decision-making process, subject to the application of professional judgement and consultation with the Steering and Progress Groups (and subsequently stakeholder and public consultation): – The Technical Criteria Score – The MCA Benefit Score – The Option Selection MCA Score – The MCA BCR – The Economic BCR Noting other considerations outlined below, greatest weight should be given in the option selection to the MCA BCR, which provides a measure of the overall benefits per euro investment. However, professional judgement must be applied at this stage, taking into account local consultation outcomes. The reasoning for the selection of a given option should be recorded and reported.

	All proposed measures (i.e., options selected as preferred options for a given AFA or SSA) should have a economic BCR in excess of unity, unless clear and robust justification can be given as to why an option that is not economically cost-beneficial is being proposed for implementation. The options should also be considered across all SSAs to check for spatial coherence, as set out in Section 11.7 of the Generic Project Brief. The options should also be considered across the SSAs with consideration of the potential impacts of future changes, such as climate change, as set out in Section 11.7 of the Generic Project Brief, and is discussed in further detail in GN 29.
7.2	***Prioritisation*** The prioritisation of recommended options across all SSAs will be lead by the OPW as an inter-project, i.e., national, assessment taking account of projected multi-annual budgets. This will make use of the following MCA outcomes: – The MCA Benefit Score – The MCA BCR – The Economic BCR While the national prioritisation process will be lead by the OPW, the consultants should annotate the preferred options during the option selection process with any particular factors that they consider should be taken into account in the prioritisation process. Such factors might include special risks that have not been properly accounted for in the standardised MCA process.
8.0	**DEFINITIONS**
	No new definitions are established herein.
9.0	**REFERENCES AND RESOURCES**
	References – National CFRAM Programme – Stage I Tender Documents: Project Brief – 2149/RP/002/F, May 2010 – Report of the Flood Policy Review Group – OPW, 2009 – Directive on the assessment and management of flood risks (the EU 'Floods' Directive) – 2006/60/EC – Guidelines on the Planning System and Flood Risk Management (DoECLG & OPW, 2009) – A Framework for Major Emergency Management (DoECLG)

APPENDIX A TABLE OF FLOOD RISK MANAGEMENT OBJECTIVES

CRITERIA		OBJECTIVE		SUB-OBJECTIVE		GLOBAL WEIGHTING
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	
		b	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	

CRITERIA		OBJECTIVE		SUB-OBJECTIVE		GLOBAL WEIGHTING
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.	
		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.	

APPENDIX B DETAILED DESCRIPTIONS OF INDIVIDUAL OBJECTIVES

OBJECTIVE 1.A.	
Objective	**Ensure flood risk management options are operationally robust**
Indicator	Level of operational risk of option - Degree of reliance on mechanical, electrical or electronic systems, or on human intervention, action or decision, for the option to operate or perform successfully
Scoring	By professional judgement, based on the guidance and criteria set out below
Basic Requirement	Moderate to high, but manageable, degree of operational risk, i.e., an option with a high degree of reliance on mechanical, electrical or electronic systems, or on human intervention, action or decision, but which, with the allocation of adequate resources, could be operated with an acceptable degree of risk of failure
Aspirational Target	No operational risk, i.e., no reliance on mechanical, electrical or electronic systems, or on human intervention, action or decision for the option to operate or perform successfully
Global Weighting	20
Local Weighting	Constant and equal to 5, i.e., no amendment to local weighting

Guidance on Assignment of Local Weightings

The Local Weighting to be applied for this objective is constant, and should always be set equal to 5, as it always a consideration in option design and selection.

Guidance on Scoring

Scoring is to be by professional judgement, based on the guidance and criteria set out below, taking into account the degree of reliance of the option on mechanical, electrical or electronic systems (‘systems’), or on human intervention, action or decision (‘intervention’) to operate or perform successfully (i.e., to design). The scoring should also consider and be adjusted where necessary other relevant factors, such as:

- The risks / consequences of failure of the system or intervention (with a higher risk, and hence lower score, being given where failure would result in total or major failure and resultant flooding, as opposed to partial failure leading to only localised or minor flooding)
- Whether the interventions required are during times of flood (e.g., erection of demountables) or at other times (e.g., routine maintenance), where interventions required during a flood event would be deemed to represent a higher risk, and hence be assigned a lower score, due to potential travel or communications difficulties

- The frequency that interventions would be required, with a higher risk, and hence lower score, being assigned to measures that require frequent interventions
- Whether institutional changes will be required to effectively implement and operate a measure, with a higher risk, and hence lower score, if change is required
- Other locally context-specific issues that should give cause to deviate from the guidance below

Indicative Scoring for Objective 1.A
Description of operational risk for relevant score, with examples given in italics

Score	Description / ***Examples***
5	No operational risk, i.e., no reliance on systems or intervention, with limited monitoring / maintenance requirements *Fixed flood defence walls, Increased conveyance in self-cleansing rivers or diversion channels, Relocation*
4	Negligible operational risk, i.e., no reliance on systems or intervention, with more regular monitoring and intermittent, but potentially substantial, maintenance requirements *Fixed flood defence embankments, Uncontrolled storage, Increased conveyance measures (incl. diversion channels) where maintenance required*
3	Very low operational risk, i.e., there is a requirement for simple systems or interventions for the option to operate, with regular monitoring and maintenance required, but a very low likelihood of system / operation failure *Pumping systems, Tidal barriers, Storage with controlled inflow / outflow mechanisms, Simple flood forecasting and warning systems with long advance warning periods available (appx. 12 hours+)*
2	Low risk, i.e., there is a requirement for systems or interventions for the option to operate, with regular monitoring and maintenance required, and / or a low to moderate likelihood of system / operation failure *Complex flood forecasting and warning systems with long advance warning periods available, with a limited number of rapidly deployed in-situ flood defences (e.g., flood gates, tipping defences)*
1	Low / moderate risk, i.e., options that are fully reliant on systems or interventions for the option to operate, with regular monitoring and maintenance required, and a low to moderate likelihood of system / operation failure *Simple flood forecasting and warning systems with medium-range advance warning periods available (appx. 6 hours), with several rapidly deployed in-situ flood defences (e.g., flood gates, tipping defences)*

0	Moderate, but manageable, risk, i.e., options that are fully reliant on systems or interventions for the option to operate, with regular monitoring and maintenance required, and a moderate likelihood of system / operation failure *Complex flood forecasting and warning systems with medium-range advance warning periods available (appx. 6 hours), with several rapidly deployed in-situ flood defences (e.g., flood gates, tipping defences) or limited demountable defences that are stored on-site*
-1	Moderate / high risk, i.e., options that are fully reliant on systems or interventions for the option to operate, with regular monitoring and maintenance required, and a moderate to high likelihood of system / operation failure *Flood forecasting and warning system of long advance warning periods with substantial demountable defences requiring transport from off-site*
-3	High risk, i.e., options that are fully reliant on systems or interventions for the option to operate, with regular monitoring and maintenance required, and a high likelihood of system / operation failure *Flood forecasting and warning systems of medium-range advance warning periods with substantial demountable defences requiring transport from off-site*
-5	Foreseeable likelihood of failure that would render the measure ineffective *Flood forecasting and warning systems with short advance warning periods available (appx. 3 hours or less) and interventions or actions by the public required for damage to be avoided*
-999	Unacceptable risk, i.e., options that are fully reliant on systems or interventions for the option to operate that will be difficult to achieve, and for which failure of the system / intervention is likely and would have unacceptable consequences

Note: Where systems / interventions are required, it is assumed that redundancy and / or back-up systems will be included as part of the option design, e.g., manual overrides for automated systems, duplicate telemetry / communication systems, etc.

OBJECTIVE 1.B	
Objective	**Minimise health and safety risk in construction, maintenance and operation of the flood risk management option**
Indicator	Degree of health and safety risk during construction, maintenance and operation
Scoring	By professional judgement, taking into account the guidance and criteria set out below, with review of candidate preferred options by PSDP
Basic Requirement	Moderate to high, but acceptable and manageable, level of health and safety risk during construction, maintenance or operation
Aspirational Target	Negligible risk to health and safety during construction, maintenance or operation
Global Weighting	20
Local Weighting	Constant and equal to 5, i.e., no amendment to local weighting

Guidance on Assignment of Local Weightings

The Local Weighting to be applied for this objective is constant, and should always be set equal to 5, as it always a consideration in option design and selection.

Guidance on Scoring

Scoring is to be by professional judgement, taking into account the guidance and criteria set out below.

The indicative score under this objective should be set at five, and then have a point deducted for each specific risk (as defined under the Safety, Health and Welfare at work (Construction) Regulations) likely to be encountered in a) construction and then again in b) operation and maintenance.

As an example, a measure requiring deep excavation and working near water during construction, and then working near water during operation / maintenance, would have a score of 2 (5 – 2 (construction stage) – 1 (operation / maintenance stage) = 3).

Professional judgement needs then to be applied to take into account any locally or context-specific issues, e.g., specific hazards, or a potentially higher risk for construction in an urban environment.

The PSDP (or person assigned the duties of PSDP where a company is nominated as PSDP) should review the scoring afforded to the preferred option(s) and other options that would be realistically in contention to be adopted as a preferred option based on other objectives, to ensure that the scoring is appropriate and reasonable.

Note: It should be assumed in assigning scores that good construction health and safety practices will be implemented.

OBJECTIVE 1.C	
Objective	**Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change**
Indicator	Sustainability and adaptability of the flood risk management measure in the face of potential future changes, including the potential impacts of climate change
Scoring	By professional judgement, based on the guidance and criteria set out below
Basic Requirement	Option should not hinder future interventions that may be required to manage potential future increases in risk
Aspirational Target	Option to provide for, or be adaptable to, the HEFS in terms of maintaining the standard of protection at no or negligible cost
Global Weighting	20
Local Weighting	Constant and equal to 5, i.e., no amendment to local weighting

Guidance on Assignment of Local Weightings

The Local Weighting to be applied for this objective is constant, and should always be set equal to 5, as it always a consideration in option design and selection.

It is recognised that the impacts of, and vulnerability to, potential future changes will vary significantly from community to community. However, this objective is used only for option selection, and is not used for prioritisation, and so the relative significance of the impacts and vulnerability to potential future change between communities is not relevant. As promoting adaptability is always important, the local weighting is to be kept constant.

Guidance on Scoring

Scoring is to be by professional judgement, taking into account the guidance and criteria set out below.

The scoring for a given measure should reflect the cost and the degree of difficulty and potential impacts (technically, socially, environmentally, legislatively, etc.) of potential future adaptations that would be necessary to maintain the Standard of Protection of the measure under the MRFS and/or HEFS, whereby the greater the cost, difficulty and impact, the lower the score.

This assignment of a score should reflect the findings of the application of GN29 on climate change adaptation, and account should be taken of the robustness of the option in terms of the need for possible future interventions that may be through additional measures as well direct adaptation of the option under consideration. For example, an option may not be, nor need to, adaptable itself, but may nonetheless score highly if it is shown through a decision-tree analysis this it is very robust in terms of options for future interventions.

The guidance given below gives examples for certain scores. Other scores (between 5 and -5) should also be used, where appropriate, interpolating between the scores for which examples are given, where the costs and degree of difficulty and impact may be at the high or low relative to the examples given.

Score	**Description / *Examples***
5	Option is inherently adaptable at no / negligible cost, difficulty and impact and provides no impediment to future interventions to address new potential future risk areas (i.e., that are separate from the area benefitting from the option in question). This would include Non-Structural measures, and Structural measures designed using the assumptive approach to the HEFS and / or that would be able to maintain the standard of protection / risk reduction under the HEFS with no or negligible further cost or intervention
4	Option is readily adaptable at limited cost, difficulty and impact, and provides no impediment to future interventions to address new potential future risk areas, e.g.: • *Walls where the foundations and wall are built to permit an extension in height to maintain the required level of protection / risk reduction for the HEFS, which would be acceptable locally (e.g., typically less than 1.2-1.5m height in public areas after being raised)* • *Structural measures (e.g., walls) designed using the assumptive approach to the MRFS and / or that would be able to maintain the standard of protection / risk reduction under the MRFS with no or negligible further cost or intervention* • *Embankments, earth flow diversion channels or other such structures that could be readily topped-up / enhanced*

3	Option is adaptable at moderate cost, difficulty and impact, and provides no impediment to future interventions to address new potential future risk areas, e.g.:
	• *Walls where the foundations and wall are built to permit an extension in height to maintain the required standard of protection / risk reduction for :*
	    o *the HEFS, which would be acceptable locally but where adaptation would have other negative implications / costs (e.g., more than 1.2-1.5m height in public areas after being raised, but with demountable defences necessary to provide protection above 1.2-1.5m)*
	    o *the MRFS, which would be acceptable locally (e.g., typically less than 1.2-1.5m height in public areas after being raised)*
	• *Conveyance enhancement, major earth storage structures or similar measures where substantial earthworks would be required to enhance performance, but where adaptation would not require replacement of structural works*

Score	Description / *Examples*
2	Option is adaptable at moderate to significant cost, difficulty and impact, and provides no impediment to future interventions to address new potential future risk areas, e.g.: • *Walls where the foundations and wall are built to permit an extension in height to maintain the required standard of protection / risk reduction for the MRFS, which would be acceptable locally but where adaptation would have other negative implications / costs (e.g., more than 1.2-1.5m height in public areas after being raised, but with demountable defences necessary to provide protection above 1.2-1.5m)*
1	Option is adaptable only at significant cost, difficulty and impact, and provides no impediment to future interventions to address new potential future risk areas, e.g.: • *Conveyance enhancement (including flow diversions), flow retention or similar measures where significant structural replacement works would be required* • *Protection measures which, once adapted, would exceed 1.2-1.5m in height in public areas with no scope for demountable barriers*
0	Option is not adaptable, but provides no impediment to future interventions to address new potential future risk areas. *Options that are not adaptable, although additional works (e.g., separate measures) may need to be undertaken to address potential future increases in risk to the area benefitting from the option in question, e.g.,:* • *Coastal / tidal defence walls that can not be raised (e.g., due to visual impact, and / or where demountables are not a viable option), but where a tidal barrage could be implemented as a separate future intervention* *Option does not hinder future interventions to address new potential future risk areas*
-1	Option is not adaptable, and will create a minor interference or impediment to with potential future measures *Options that will cause a minor impediment and some additional cost to future interventions that may be needed to address the MRFS or HEFS.*
-3	Option is not adaptable, and will create a moderate interference with or impediment to potential future measures *Options that will cause a moderate impediment and additional cost to future interventions that may be needed to address the MRFS or HEFS.*
-5	Option is not adaptable, and will create a major interference with or impediment to potential future measures *Options that will cause a major impediment and substantial additional cost to future interventions that may be needed to address the MRFS or HEFS.*
-999	Unacceptable interference with potential future measures

OBJECTIVE 2.A	
Objective	**Reduce economic damages**
Indicator	Annual Average Damage (AAD) expressed in Euro / year, calculated in accordance with the economic risk assessment methods, but with no allowance for social / intangible benefits
Scoring	0.05 X percentage reduction in AAD
Basic Requirement	AAD is not increased
Aspirational Target	100% reduction in AAD
Global Weighting	30
Local Weighting	AAD for the SSA / €75,000

Guidance on Assignment of Local Weightings

The Local Weighting should be calculated as:

Local Weighting = AAD for the SSA / €75,000

Where:

The Local Weighting may not exceed the ceiling value of 5, and,

AAD is the Annual Average (economic) Damages, excluding any allowances for social and intangible benefits

'€75,000' is a factor that has been selected to set the Local Weighting equal to 5 in SSAs / AFAs where economic damages are among the highest typically encountered in Ireland, i.e., it has been set to ensure that there will not be a large number of locations where the ceiling value of 5 is exceeded. This factor has been selected based on trial application on a number of test cases to ensure that the factor meets the above criteria.

The above calculation process is automated, and in this instance the outcome should be used as calculated. Professional judgement does however need to be applied within the requirements and guidance provided in relation to the calculation of the Annual Average Damages.

Guidance on Scoring

Indicator Calculation

The indicator should be calculated on the basis of the economic damage analysis, to be undertaken in accordance with Appendix I of the Generic Project Brief and guided by Guidance Note 27, but with no allowance for social / intangible benefits as these are provided for under other objectives within the MCA.

Option Scoring

The score for a given option should be calculated as:

Score = 0.05 X Percentage Reduction in AAD

Standard of Protection Factor

A Standard of Protection Factor is not applicable to this objective, as it is implicit within the scoring process.

Non-Structural Option Risk Reduction

The following values should apply as the percentage reduction in AAD for non-structural options (i.e., those that do not reduce hazard, but can reduce risk):

Non-Structural Measure	% Reduction in AAD
Flood Forecasting and Warning: Warning Period > 12 hrs	10%
Flood Forecasting and Warning: Warning Period 6 - 12 hrs	6%
Flood Forecasting and Warning: Warning Period 2 - 6 hrs	4%
Flood Forecasting and Warning: Warning Period < 2 hrs	0%

OBJECTIVE 2.B	
Objective	**Minimise risk to transport infrastructure**
Indicator	Number and type of transport routes at risk from flooding
Scoring	Based on calculated assessment, adjusted by professional judgement
Basic Requirement	No increase in risk to transport infrastructure
Aspirational Target	Reduce risk to transport infrastructure to zero
Global Weighting	10
Local Weighting	Based on calculated assessment, adjusted by professional judgement

Guidance on Assignment of Local Weightings

The local weightings should be calculated based on a score derived from the number and type of transport routes potentially blocked by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of that route, taking account of the duration of flooding and the diversion time (in relation to road flooding).

Route and Airport Scoring

Each type of transport route and airport is assigned a score. The types of transport routes and airports are categorised and scored as follows:

Type	Road	Rail	Airports	Score
IRR			International	500
A	Motorway	Main line / DART / Luas		250
B	National Primary		Regional	150
C	National Secondary	Branch Line		75
D	Regional			25
E	Local Rural			10
F	Local Urban (Street)			See below

Local Urban Roads (Streets)

Within an AFA there may be multiple local roads (streets) at risk from flooding, and the flooding of these does not necessarily have a proportional cumulative effect in terms of impact on transport. As such, a maximum value of 25 should be applied with respect to the flooding of urban streets, with professional judgement applied in determining the score up to this maximum score.

Note that each road joining a junction should be treated as an individual road, and similarly train stations / rail junctions prone to flooding might reflect interruption to multiple routes.

Probability Factoring

For each route, the score is then factored by the probability of the highest probability (least severe) flood event that causes flooding of that route, where the factor applied is calculated as:

Factor = Probability of flooding (expressed as the AEP, e.g., 0.01 for 1% / 100-yr)

For example, a National Primary road at risk from flooding in events of probability of 0.02 and less, then the factored score would be = 150 X 0.02 = 3

Other Factors

Duration of Flooding

The damages associated with the flooding of transport routes are related to the duration of the flooding. It is assumed that substantive flooding of the route will last approximately 6 to 12 hours. However, if the duration of flooding, and hence disruption, is significantly greater or less than this, then professional judgement should be applied to increase or decrease the score accordingly, noting amended or compensatory behaviours when flooding is known but also the impact of long-term isolation of properties.

Diversion Time for Road Flooding

The damages associated with the flooding of roads are related to the length of diversion in terms of additional journey time. It is assumed that diversion would typically increase journey time by approximately 15 to 30 minutes. However, if the duration of flooding, and hence disruption, is significantly greater or less than this, then professional judgement should be applied to increase or decrease the score accordingly. In determining diversion time, advice should be sought on which routes are likely to remain open during a flood.

Calculation of Other Factors

Note that the factors for duration and diversion time do **NOT** need to be calculated based on distance, speed, etc., but may be estimated based on professional judgement taking into account local anecdotal information derived from local authority staff and public observations.

Total AFA Score (Local Weighting)

For the given AFA, the total AFA score is calculated as the sum of the factored scores for each transport route at risk from flooding, subject to a maximum score of 5.

For example, an AFA with a national secondary road and regional road at risk from flooding in events of probability of 0.01 and 0.05 respectively, and multiple urban streets at risk from flooding in events of probability from 0.1, then the factored score would be:

(National secondary road: 75 X 0.01 = 0.75) + (Regional road: = 25 X 0.05 = 1.25) + (Multiple urban streets) = 25 X 0.1 = 2.5 = Total AFA Score (i.e., Local Weighting) = 4.50

Note that final local weighting taking into account the application of the factors for duration and diversion time should still not exceed a maximum of 5.

The above provides guidance on the setting of local weightings for this objective. However, professional judgement should also be applied as per Section 3.3, taking account of other local factors.

Guidance on Option Scoring

Residual Risk Score

The residual risk score for a flood risk management option should be calculated in the same manner as the local weighting, but based on the flood hazard with the option applied.

In the case of measures providing flood defence, then the residual risk score can be calculated simply by adjusting the factor for probability to that of the standard of protection (following the simplistic assumption that once the standard of protection is exceeded for a given flood defence, then no defence is provided).

Option Scoring

Options are scored based on the degree of reduction in the risk to transport routes, calculated using the residual risk score as determined for the relevant option, and the final local weighting, and multiplied by a factor of 5.

The score for a given option should be calculated as:

Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]

The other factors detailed under the guidance on the assignment of Local Weighting should also be taken into account in assigning the score for a measure.

Standard of Protection Factor

A Standard of Protection Factor is not applicable to this objective, as it is implicit within the scoring process.

Non-Structural Option Risk Reduction

Flood warning does not reduce hazard, but generally can reduce risk. While transport routes will still be blocked in the event of a flood regardless of the advance warning of the flooding, the negative impact (delay and disruption) could be slightly reduced if advance warning were available. As such, non-structural measures should afforded the percentage reduction in score as set out below:

Non-Structural Measure	% Reduction in Factored Score
Flood Forecasting and Warning: Warning Period > 12 hrs	10%
Flood Forecasting and Warning: Warning Period 6 - 12 hrs	6%
Flood Forecasting and Warning: Warning Period 2 - 6 hrs	4%
Flood Forecasting and Warning: Warning Period < 2 hrs	0%

Professional judgement should be applied to review and confirm scores as per Section 3.3.

OBJECTIVE 2.C	
Objective	**Minimise risk to utility infrastructure**
Indicator	Number and type of infrastructure assets at risk from flooding
Scoring	Based on calculated assessment, adjusted by professional judgement
Basic Requirement	No increase in risk to utility infrastructure
Aspirational Target	Reduce risk to utility infrastructure to zero
Global Weighting	10
Local Weighting	Based on calculated assessment, adjusted by professional judgement

Guidance on Assignment of Local Weightings

The local weightings should be calculated based on a score derived from the number and type of utility infrastructure receptors potentially affected by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of that receptor.

Receptor Scoring

Each type of utility receptor is assigned a score. The types of utility receptors are categorised and scored as follows:

Receptor Type	Score
Power Stations	500
HV Sub-Stations	250
Gas Assets – High Priority	100
Gas Assets – Medium Priority	25
Water Treatment Plants & Primary Pumping Facilities	250
Waste Water Treatment Plants & Primary Pumping Facilities	250
Core Telecommunication Exchanges	100
Non-Core Telecommunication Exchanges	25

Probability Factoring

For each receptor, the score is then factored by the probability of the highest probability (least severe) flood event that causes flooding of that receptor, where the factor applied is calculated as:

Factor = Probability of flooding (expressed as the AEP, e.g., 0.01 for 1%)

For example, a Water Treatment Plant at risk from flooding in events of probability of 0.02 and less, then the factored score would be:

Factored score = 250 X 0.02 = 5

Other Factors

Service Area / Population

The impact of flooding of a utility asset, and the associated damage and disruption of service, is related to the population and/or area it serves. It is assumed that an asset would be typical of its classification. However, if the population and/or area served is significantly greater or less than this, then professional judgement should be applied to increase or decrease the score accordingly.

Calculation of Other Factors

Note that the factors for service area / population do **NOT** need to be calculated based on the area or population served, but may be estimated based on professional judgement taking into account local anecdotal information derived from local authority staff and public observations. (Note: The OPW will seek industry standard data re typical service numbers).

Total AFA Score (Local Weighting)

For the given AFA, the total AFA score is calculated as the sum of the factored scores for each receptor at risk from flooding, subject to a maximum score of 5.

Note that final local weighting taking into account the application of the factors for service area / population should still not exceed a maximum of 5.

The above provides guidance on the setting of local weightings for this objective. However, professional judgement should also be applied as per Section 3.3.

Guidance on Option Scoring

Residual Risk Score

The residual risk score for a flood risk management option should be calculated in the same manner as the local weighting, but based on the flood hazard with the option applied.

In the case of measures providing flood defence, then the residual risk score can be calculated simply by adjusting the factor for probability to that of the standard of protection (following the simplistic assumption that once the standard of protection is exceeded for a given flood defence, then no defence is provided).

Option Scoring
Options are scored based on the degree of reduction in the risk to utility receptors, calculated using the residual risk score as determined for the relevant option, and the final local weighting, and multiplied by a factor of 5.

The score for a given option should be calculated as:

Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]

The other factors detailed under the guidance on the assignment of Local Weighting should also be taken into account in assigning the score for a measure.

Standard of Protection Factor
A Standard of Protection Factor is not applicable to this objective, as it is implicit within the scoring process.

Non-Structural Option Risk Reduction
Flood warning does not reduce hazard, but generally can reduce risk. While utility receptors could still be flooded in the event of a flood regardless of the advance warning of the flooding, the negative impact (damage to the utility and disruption to the service the utility provides) could be slightly reduced if advance warning were available. As such, non-structural measures should afforded the percentage reduction in score as set out below:

Non-Structural Measure	% Reduction in Factored Score
Flood Forecasting and Warning: Warning Period > 12 hrs	10%
Flood Forecasting and Warning: Warning Period 6 - 12 hrs	6%
Flood Forecasting and Warning: Warning Period 2 - 6 hrs	4%
Flood Forecasting and Warning: Warning Period < 2 hrs	0%

The above provides guidance on the setting of local weightings and scoring for this objective. However, professional judgement should also be applied as per Section 3.3.

OBJECTIVE 2.D	
Objective	**Manage risk to agriculture**
Indicator	Agricultural production
Scoring	By professional judgement, taking account of local advice
Basic Requirement	No increase in the negative impact of flooding on agricultural production
Aspirational Target	Provide the potential for enhanced agricultural production
Global Weighting	10
Local Weighting	By professional judgement, taking account of local advice

Guidance on Assignment of Local Weightings

Setting of the Local Weighting is to be by professional judgement, taking account of the value and social importance of the agricultural industry in the area guided by advice from the steering and progress groups and via submissions from the public.

Guidance on Scoring

Option Scoring

Scoring is to be professional judgement, taking into account local advice.

Consideration in setting the scores for an option should include:

- An increase or decrease in the area of agricultural land subject to flooding
- The frequency and seasonality of flooding, and the seasonality of agricultural production and land use in the area
- The duration of flooding
- The source of floodwaters, noting that salt water flooding can cause significantly more damage to agricultural production than river flooding
- The overland flow velocity
- The existing and potential other agricultural uses of the land
- The potential for flood warning to mitigate the impacts of flooding on agriculture
- Factors that may not affect the area of land flooding but that could otherwise impact positively or negatively on agricultural production (e.g., risk to local dairy factory, long-term isolation of farms, etc.)
- The potential to enhanced agricultural production, such as through the reduction of the frequency or extent of flooding of agricultural land.

OBJECTIVE 3.A (i)	
Objective	**Minimise risk to human health and life – Residents**
Indicator	Annual Average Number of residential properties at risk from flooding
Scoring	Based on calculated assessment, adjusted by professional judgement
Basic Requirement	Number of properties at risk is not increased
Aspirational Target	100% reduction in number of residential properties at risk
Global Weighting	30
Local Weighting	Based on calculated assessment, adjusted by professional judgement

Guidance on Assignment of Local Weightings

The local weightings should be calculated based on a score derived from the number of residential properties potentially affected by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of each property.

Receptor Scoring

All residential properties should be treated as equal for the purposes of the calculated score. To ensure that the local weighting on this category is appropriately scaled, each ground floor property should be afforded a score of 2, and each property above ground floor should be afforded a score of 1.

Probability Factoring

For each property, the score (2) is then factored by the probability of the highest probability (least severe) flood event that causes flooding of that property, where the factor applied is calculated as:

Factor = Probability of flooding (expressed as the AEP, e.g., 0.01 for 1%)

Total AFA Score (Local Weighting)

For the given AFA, the total AFA score is calculated as the sum of the factored scores for all of the residential properties at risk from flooding, subject to a maximum score of 5.

Other Factors

Known Areas of Highly Vulnerable People

The risk to life associated with the flooding of residential properties is related to the vulnerability of the people living in that property, with the elderly and very young particularly vulnerable.

The scoring should typically assume that a reasonable cross section of society exists in those that inhabit all of the properties at risk within an AFA. However, if it is known that an area is occupied by particularly vulnerable or resilient set of people then professional judgement should be applied to increase or decrease the score accordingly.

Rate of Onset
The risk to health and life is associated with the flooding of residential properties is related to the rate of onset of flooding and hence the time available to evacuate the vulnerable people. It is assumed that typically it will be evident that flooding may occur with a 1 to 2 hours available to then evacuate the vulnerable people before the depth / velocity of flood water creates difficulties for evacuation and / or a moderate risk to life. However, if the rate of onset is significantly greater or less than this, then professional judgement should be applied to decrease or increase the score accordingly.

Flood Depths and Velocities (Risk to Life)
The risk to life associated with the flooding of residential properties is related to the projected depths of flooding and the velocity of overland flood flow (i.e., the risk to life). It is assumed that typically a Low risk to life will exist for the community in general and residential areas within a community in particular. However, if the risk to life is greater than this, then professional judgement should be applied to increase or the score accordingly.

Existing Flood Warning Schemes
Where an existing flood warning scheme is in place, then the local weighting should be multiplied by a factor of 0.5, 0.7 and 0.9 for effective advance warning periods in excess of 6 hours, 4 hours and 2 hours respectively.

Final Local Weighting
Note that final local weighting taking into account the application of the factors for known areas of highly vulnerable people, the rate of onset, flood depths and velocities and the presence of existing flood warning schemes should still not exceed a maximum of 5.

The above provides guidance on the setting of local weightings for this objective. However, professional judgement should also be applied as per Section 3.3, and should take into account other factors that may influence the risk to life, such as the presence of basement properties.

Guidance on Option Scoring

Residual Risk Score
The residual risk score for a flood risk management option should be calculated in the same manner as the local weighting, but based on the flood hazard with the option applied.

In the case of measures providing flood defence, then the residual risk score can be calculated simply by adjusting the factor for probability to that of the standard of protection (following the simplistic assumption that once the standard of protection is exceeded for a given flood defence, then no defence is provided).

Option Scoring

Options are scored based on the degree of reduction in the risk to residential properties, calculated using the residual risk score as determined for the relevant option, and the final local weighting, and multiplied by a factor of 5.

The score for a given option should be calculated as:

Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]

The other factors detailed under the guidance on the assignment of Local Weighting should also be taken into account in assigning the score for a measure.

Standard of Protection Factor

A Standard of Protection Factor is not applicable to this objective, as it is implicit within the scoring process.

Non-Structural Option Risk Reduction

Flood warning does not reduce hazard, but generally can reduce risk. In the case of risk to people in residential properties, advance warning of an impending flood can be vital in providing sufficient time to evacuate the residents, and so flood forecasting and warning can significantly reduce the risk to life. The option score for non-structural measures involving advance warning should therefore be 4, 2 and 1 for effective advance warning periods in excess of 6 hours, 4 hours and 2 hours respectively.

The above provides guidance on the setting of local weightings and scoring for this objective. However, professional judgement should also be applied as per Section 3.3.

OBJECTIVE 3.A (ii)	
Objective	**Minimise risk to human health and life – High vulnerability properties**
Indicator	Number and type of high vulnerability properties at risk from flooding
Scoring	Based on calculated assessment, adjusted by professional judgement
Basic Requirement	Number of high vulnerability properties at risk not increased
Aspirational Target	100% reduction in number of high vulnerability properties at risk
Global Weighting	10
Local Weighting	Based on calculated assessment, adjusted by professional judgement

Guidance on Assignment of Local Weightings

The local weightings should be calculated based on a score derived from the number and type of high vulnerability properties potentially affected by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of that property.

Property Scoring

Each type of high vulnerability property is assigned a score. The types of high vulnerability properties are categorised and scored as follows:

Property Type	Score
Hospitals	500 (IRR)
Nursing / Residential Homes	250
Prisons	250
Camping / Caravan / Halting Sites	100
Schools	50

Probability Factoring

For each property, the score is then factored by the probability of the highest probability (least severe) flood event that causes flooding of that property, where the factor applied is calculated as:

Factor = Probability of flooding (expressed as the AEP, e.g., 0.01 for 1%)

Other Factors

Rate of Onset of Flooding

The risk to life associated with the flooding of high vulnerability properties is related to the rate of onset of flooding and hence the time available to evacuate the vulnerable people. It is assumed that typically it will be evident that flooding may occur with 1 to 2 hours advance warning available to evacuate the vulnerable people before the depth / velocity of flood water creates difficulties for evacuation and / or a moderate risk to life. However, if the rate of onset is significantly greater or less than this, then professional judgement should be applied to decrease or increase the score accordingly.

Flood Depths and Velocities (Risk to Life)

The risk to life associated with the flooding of high vulnerability properties is related to the projected depths of flooding and the velocity of overland flood flow (i.e., the risk to life). It is assumed that typically a Low risk to life will exist for high vulnerability properties. However, if the risk to life is greater than this, then professional judgement should be applied to increase or the score accordingly.

Calculation of Other Factors

The rate of onset of flooding and the risk to life at the high vulnerability property can be determined from the outputs of the hydraulic modelling and flood mapping.

Total AFA Score (Local Weighting)

For the given AFA, the total AFA score is calculated as the sum of the factored scores for each property at risk from flooding, subject to a maximum score of 5.

Note that final local weighting taking into account the application of the factors for Rate of Onset of Flooding and Flood Depths and Velocities (Risk to Life) should still not exceed a maximum of 5.

The above provides guidance on the setting of local weightings for this objective. However, professional judgement should also be applied as per Section 3.3.

Guidance on Option Scoring

Residual Risk Score

The residual risk score for a flood risk management option should be calculated in the same manner as the local weighting, but based on the flood hazard with the option applied.

In the case of measures providing flood defence, then the residual risk score can be calculated simply by adjusting the factor for probability to that of the standard of protection (following the simplistic assumption that once the standard of protection is exceeded for a given flood defence, then no defence is provided).

Option Scoring
Options are scored based on the degree of reduction in the risk to high vulnerability properties, calculated using the residual risk score as determined for the relevant option, and the final local weighting, and multiplied by a factor of 5.

The score for a given option should be calculated as:

Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]

The other factors detailed under the guidance on the assignment of Local Weighting should also be taken into account in assigning the score for a measure.

Standard of Protection Factor
A Standard of Protection Factor is not applicable to this objective, as it is implicit within the scoring process.

Non-Structural Option Risk Reduction
Flood warning does not reduce hazard, but generally can reduce risk. In the case of high vulnerability properties, advance warning of an impending flood can be vital in providing sufficient time to evacuate the vulnerable people, and so flood forecasting and warning can significantly reduce the risk to life. The option score for non-structural warnings involving advance warning should therefore be 4, 2 and 1 for effective advance warning periods in excess of 6 hours, 4 hours and 2 hours respectively.

The above provides guidance on the setting of local weightings and scoring for this objective. However, professional judgement should also be applied as per Section 3.3.

OBJECTIVE 3.B (i)	
Objective	**Minimise risk to community – Social Infrastructure and Amenity**
Indicator	Number of social infrastructure assets at risk from flooding
Scoring	Based on calculated assessment, adjusted by professional judgement
Basic Requirement	Number of social infrastructure assets at risk not increased
Aspirational Target	100% reduction in number of social infrastructure assets at risk
Global Weighting	5
Local Weighting	Based on calculated assessment, adjusted by professional judgement

Guidance on Assignment of Local Weightings

The local weightings should be calculated based on a score derived from the number of social infrastructure and amenity assets potentially affected by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of each asset.

Receptor Scoring

All social infrastructure and amenity assets should be treated as equal for the purposes of the calculated score. To ensure that the local weighting on this category is appropriately scaled, each asset should be afforded a score of 25.

A weighing has not been applied to the scores, as all social infrastructure and amenity assets (where included) were designated during the PFRA vulnerability assessment as being of 'moderate' vulnerability, except for schools where a 'high' vulnerability classification was assigned due to elevated risk to human health and life arising from the concentration of children, which is provided for under Objective 3.A. (ii).

The relevant social infrastructure and amenity assets include:

- Schools and educational facilities
- Libraries
- Community centres
- Local and central government offices, including post offices
- Emergency services facilities (fire, Garda, civil defence, RNLI and coast guard stations)
- Health centres (other than hospitals and nursing homes)
- Churches and other religious centres

- Parks and public gardens, sports facilities, playgrounds
- Local cultural heritage sites or collections, sites of ecological interest or other sites of social amenity

Probability Factoring

For each asset, the score (25) is then factored by the probability of the highest probability (least severe) flood event that causes flooding of that asset, where the factor applied is calculated as:

Factor = Probability of flooding (expressed as the AEP, e.g., 0.01 for 1%)

Total AFA Score (Local Weighting)

For the given AFA, the total AFA score is calculated as the sum of the factored scores for all of the social infrastructure and amenity assets at risk from flooding, subject to a maximum score of 5.

Other Factors

Assets of Particular Social Value

A particular social infrastructure and amenity asset may be of exceptional local importance, i.e., where the loss of the asset (permanently or over a long period of time) would have a very severe detrimental impact on the functioning of the community as a whole and on the day-today lives of the people in the community (i.e., well beyond the normal expected impact that the loss of one of the listed social infrastructure assets might have. In such cases, professional judgement should be applied to increase the weighting accordingly.

Note that final local weighting taking into account the application of the factors for assets of particular social value should still not exceed a maximum of 5.

The above provides guidance on the setting of local weightings for this objective. However, professional judgement should also be applied as per Section 3.3.

Guidance on Option Scoring

Residual Risk Score

The residual risk score for a flood risk management option should be calculated in the same manner as the local weighting, but based on the flood hazard with the option applied.

In the case of measures providing flood defence, then the residual risk score can be calculated simply by adjusting the factor for probability to that of the standard of protection (following the simplistic assumption that once the standard of protection is exceeded for a given flood defence, then no defence is provided).

Option Scoring
Options are scored based on the degree of reduction in the risk to social infrastructure and amenity, calculated using the residual risk score as determined for the relevant option, and the final local weighting, and multiplied by a factor of 5.

The score for a given option should be calculated as:

Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]

The other factors detailed under the guidance on the assignment of Local Weighting should also be taken into account in assigning the score for a measure.

Standard of Protection Factor
A Standard of Protection Factor is not applicable to this objective, as it is implicit within the scoring process.

Non-Structural Option Risk Reduction
Flood warning does not reduce hazard, but generally can reduce risk. However, social infrastructure and amenity assets will still be damaged in the event of a flood regardless of the advance warning of the flooding (unless combined with individual protection measures), and so the negative impact (damage to the fabric and disruption to the service the asset provides) will still occur. While it is recognised that advance warning gives more time to prepare damage reduction measures, etc., it is considered that such mitigation measures should be part of a well-formed flood event emergency response plan, and so the advance warning will bring limited benefit. As such, a zero degree of reduction of risk to social infrastructure and amenity should be assumed in relation to non-structural options.

Enhancement or Creation of Social Amenity Sites
Where an option would enhance an existing social amenity site, or involve the creation of a new site, then professional judgement should be used to increase the score afforded that option under this Objective, taking account of the number and value of the sites involved.

The above provides guidance on the setting of local weightings and scoring for this objective. However, professional judgement should also be applied as per Section 3.3.

OBJECTIVE 3.B (ii)	
Objective	**Minimise risk to community - Local Employment**
Indicator	Number of non-residential (i.e., commercial) properties at risk from flooding
Scoring	Based on calculated assessment, adjusted by professional judgement
Basic Requirement	Number of non-residential properties at risk not increased
Aspirational Target	100% reduction in number of non-residential properties at risk
Global Weighting	10
Local Weighting	Based on calculated assessment, adjusted by professional judgement

Guidance on Assignment of Local Weightings

The local weightings should be calculated based on a score derived from the number of non-residential properties (taken as a place of employment) potentially affected by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of each property.

Receptor Scoring

All non-residential properties that are not derelict should be treated as equal for the purposes of the calculated score. To ensure that the local weighting on this category is appropriately scaled, each property should be afforded a score of 5.

A differential weighting has not been applied to the count, as reliable information would not be available as to the number of employees for any given property, nor of the indirect employment associated with that property / business

The relevant non-residential properties include:

- Offices
- Shops
- Services (Restaurants, Pubs, Hotels, etc.)
- Factories, Workshops and other Manufacturing Facilities
- Warehouses
- Health Centres (including hospitals and nursing homes)
- Other places of employment

Probability Factoring

For each property, the score (5) is then factored by the probability of the highest probability (least severe) flood event that causes flooding of that property, where the factor applied is calculated as:

Factor = Probability of flooding (expressed as the AEP, e.g., 0.01 for 1%)

Total AFA Score (Local Weighting)

For the given AFA, the total AFA score is calculated as the sum of the factored scores for all of the non-residential properties at risk from flooding, subject to a maximum score of 5.

Other Factors

Properties of Particular Importance for Local Employment

A particular non-residential property may be of exceptional local importance, i.e., where the property is the location for the employment of a particularly large number of people or a very high proportion of the people employed within the local area. Flooding of such a property (and the interruption to business and potential closure) would have a very severe detrimental impact on the community and could lead to a significant rise in local unemployment. In such cases, professional judgement should be applied to increase the weighting accordingly.

Local Employment Generated through Tourism

Local employment may be generated through local features and assets that are not based in particular buildings (and hence not included as non-residential properties). Such features may include local angling sites, tourist features or walks, sites of ecological value, heritage sites, etc. Flooding of such features and assets may negatively impact on local employment. In such cases, professional judgement should be applied to increase the weighting accordingly.

Note that final local weighting taking into account the application of the factors for properties of particular importance for local employment should still not exceed a maximum of 5.

The above provides guidance on the setting of local weightings for this objective. However, professional judgement should also be applied as per Section 3.3.

Guidance on Option Scoring

Residual Risk Score

The residual risk score for a flood risk management option should be calculated in the same manner as the local weighting, but based on the flood hazard with the option applied.

In the case of measures providing flood defence, then the residual risk score can be calculated simply by adjusting the factor for probability to that of the standard of protection (following the simplistic assumption that once the standard of protection is exceeded for a given flood defence, then no defence is provided).

Option Scoring

Options are scored based on the degree of reduction in the risk to local employment, calculated using the residual risk score as determined for the relevant option, and the final local weighting, and multiplied by a factor of 5.

The score for a given option should be calculated as:

Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]

The other factors detailed under the guidance on the assignment of Local Weighting should also be taken into account in assigning the score for a measure.

Standard of Protection Factor

A Standard of Protection Factor is not applicable to this objective, as it is implicit within the scoring process.

Non-Structural Option Risk Reduction

Flood warning does not reduce hazard, but generally can reduce risk. However, non-residential properties will still be damaged in the event of a flood regardless of the advance warning of the flooding (unless combined with individual property protection measures), and so the negative impact (damage to the fabric and disruption to the employment the property provides) will still occur. While it is recognised that advance warning gives more time to prepare damage reduction measures, etc., it is considered that such mitigation measures should be part of a well-formed flood event emergency response plan, and so the advance warning will bring limited benefit. As such, a zero degree of reduction of risk to local employment should be assumed in relation to non-structural options.

The above provides guidance on the setting of local weightings and scoring for this objective. However, professional judgement should also be applied as per Section 3.3.

OBJECTIVE 4.A	
Objective	**Support the objectives of the WFD**
Sub-Objective	Provide no impediment to the achievement of water body objectives and, if possible, contribute to the achievement of water body objectives.
Scoring	Likelihood to impact on water body status elements: – Biology; – Physico-chemical; – Hydrology and morphology; – Priority substances and priority hazardous substances.
Basic Requirement	Provide no constraint to the achievement of water body objectives.
Aspirational Target	Contribute to the achievement of water body objectives.
Global Weighting	15
Local Weighting	5

Guidance on Assignment of Local Weightings

The Local Weighting to be applied for this objective is constant, and should always be set equal to 5 as WFD objectives must be achieved and are relevant to all waterbodies.

Guidance on Option Scoring

Scoring should be guided by professional judgement with reference to the scoring guidance below and the generic desciption of the likely impacts of measures on water body status.

The scoring of the options for this objective should take into account the duration and permanence of the likely impact(s) of the options on water body status elements, the sensitivity of the receiving water bodies, and the potential sources of pollution in the flood extent area.

Duration is defined in terms of:
- long term;
- medium term;
- short term.

Permanence is defined in terms of:
- permanent;
- recurring;
- intermittent.

Sensitive water bodies include:

- water bodies listed in the register of protected areas;
- high status water bodies.

Significant polluting sources include:

- plants licensed under Directives 96/61/EC and 91/271/EC;
- septic tanks greater than 500 PE;
- significant slurry storage facilities.
- establishments defined under Directive 2012/18/EU

Combining positive and negative scores

Most options will have the potential for both positive and negative impacts on water body status as, regardless of the nature of the options, they will all be designed to reduce flood risk which in turn will reduce pollution risk (by reducing the occurence of flood waters carrying pollutants from inundated areas back into the river – the significance of this positive impact varies depending on the potential sources of pollution within the inundated area and the sensitivity of the water body). Therefore, the overall score applied should be a combination of the best case positive score and the worst case negative score.

Example of combining scores

Option = hard defences and flow diversion

- +2 due to reduction of pollution risk to sensitive water bodies
- -2 due to construction stage impacts associated with walls
- -5 associated with diversion of flow into another river

In this case, the overall score should be '-3', combining the best case positive score and the worst case negative score.

Comparing options

When scoring multiple options for one AFA, it may happen that the options score the same even if they have varying degrees of impact. Professional judgement should be used to ensure that the scores reflect the varying degrees of impact between the options i.e. the scores should be manually adjusted to reflect the different degrees of impact associated with the different options.

Example of manual adjustment

Option 1 = flow diversion

- +2 due to reduction of pollution risk to sensitive water bodies
- -5 associated with diversion of flow into another river

Overall score = -3

Option 2 = flow diversion plus walls

- +2 due to reduction of pollution risk to sensitive water bodies
- -2 due to construction stage impacts to sensitive water bodies associated with walls
- -4 due to excavation and restoration of natural banks in sensitive water bodies
- -5 associated with diversion of flow into another river

Overall score = -3 (combining best case positive score and worst case negative score)

These options score the same even though Option 2 has more negative impacts associated with it. In this example, using professional judgement, Option 2 should be manually adjusted downwards by 1 point to reflect the comparitive difference in impacts between the options. If more than two options are being compared, and all differ in terms of the severity of their likely impacts on this objective, but all score the same using this methodology, the options should be manually adjusted upwards or downwards by a maximum of two points in either direction to reflect the comparitive difference in impacts between the options. Such adjustments will ensure that the overall MCA scores for the options reflect their differing degree of potential impact on this objective and will therefore ensure that this objective will have an influence in terms of the choice of a preferred option. In such cases a clear rationale should be recorded for the adjustment. It should be noted that such adjustments may have a significant impact on the overall MCA score of the preferred option (perhaps up to 10% of the overall MCA score).

Scoring Table

Score	Duration of impact	WB sensitivity	Examples
5	Permanent or long-term contribution to the achievement of wb objectives	All	Reinstatement of natural hydrological or morphological regime.
4	Medium-term or recurring contribution to the achievement of wb objectives	Sensitive	Reduced flooding in area with significant polluting sources in 1% AEP extent.
3		Non-sensitive	
2	Short-term or intermittent contribution to the achievement of wb objectives	Sensitive	Reduced flooding in area with no significant polluting sources in 1% AEP extent.
1		Non-sensitive	
0	No constraint to the achievement of wb objectives	All	No connectivity between measure and channel or flow.
-1	Short-term or intermittent impediment to the achievement of wb objectives	Non-sensitive	Construction phase impacts. In-stream or on-bank maintenance impacts. Overland floodways. Off-line storage. Rehabilitation of existing in-stream or on-bank defences.
-2		Sensitive	
-3	Medium-term or recurring impediment to the achievement of wb objectives	Non-sensitive	Excavation and restoration of banks. Flow diversion within the same river. One-off or very occasional dredging. Short culverts (e.g. under a road).
-4		Sensitive	
-5	Permanent or long-term impediment to the achievement of wb objectives	All	Channelisation / realignment that does not constitute a reinstatement of natural hydrological or morphological regimes. Regular dredging. Flow diversion to a different river (See futher guidance in tabvle below). Extensive culverting. Tidal barrage. On-line storage (dams and reservoirs). Improvement of channel conveyance. Permanent removal of natural banks.
-999	Unacceptable negative impact where feasible alternative exists		

The table below describes the likely impacts of flood risk management measures on the objectives of the WFD. It sets out a description of likely impacts that can be referred to when undertaking the scoring process to help ensure consistency between studies.

Category	Measure	Code	Likely Impacts (WFD)
NFM Protect	Land Use Management	LM	Effective land use management has the potential for positive impacts on water body status through the reduction of pollutants entering rivers and the restoration of natural hydrological and morphological regimes.
Protect	Maintenance Programme	MP	The maintenance of existing in-stream or on-bank flood defences has the potential for short-term and intermittent negative impacts on water status.
Protect	Upstream storage / Storage	S	On-line storage: creation of a dam and reservoir across the floodplain of a river, often with an outlet control structure such as an undershot culvert or sluices, to control outlet flow, and with an overflow weir and spillway. Positive impacts include reduced flooding and therefore reduced pollution. Negative impacts include permanent changes to hydrological and morphological regimes, barrier to migration. There is also the potential for eutrophication within the reservoir which can affect the channel downstream. Off-line storage: area of floodplain embanked to prevent or control flooding within the storage area or wash-land during minor events. Positive impacts include reduced flooding and therefore reduced pollution. Negative impacts include changes to hydrological (and to a lesser extent morphological) regimes.
Protect	Tidal Barrage	TB	Tidal barrages have the potential for significant negative impacts on migratory fish and other water dependent species and are a permanent change to hydrological and morphological regimes.
Protect	Improvement of Channel Conveyance	IC	Increased conveyance improves the efficiency of the channel, and thereby reduces the water levels for a given flow. This is often done by deepening or widening a channel, cutting berms to take more flow during flood events, realigning the bed profile (e.g. removing outcrops) or lining the channel with an artificial or soft (but low resistance) material (ranging from concrete or steel piles to low grass over geotextile). These measures all have the potential for negative effects to hydrological and morphological regimes (permanent or long term), physico-chemical conditions (short-term during construction), biology (arising from other impacts described).

Category	Measure	Code	Likely Impacts (WFD)
Protect	Hard Defences	D	Embankments are unlikely to have negative impacts upon water bodies except in areas where embankments extend right up to the channel bank in which case there may be short-term construction phase impacts. Flood walls have the potential for impacts depending on the distance of the wall from the channel. Some walls will require excavation of the bank during the construction phase followed by bank restoration – wwith short-term effects associated with construction and medium-term associated with bank recovery. There would also potentially be long-term hydrological or morphological impacts. In some areas, walls may replace natural banks and this would represent a permanent impact on the hydrological and morphological regime of the channel.
Protect	Culverting	C	Culverting represents a permanent morphological and hydrological impact. The extent of culverting is important is assessing the impact.
Protect	Diversion of Flow	DF	Flow diversion measures include realigning the entire river or creating by-pass channels. Realigning a river in a way that does not constitute a reinstatement of more natural hydrological or morphological regimes constitutes a permanent negative impact to the hydrological and morphological regime of a river and is also associated with short term construction-related water status impacts. Flow diversion via a bypass chanell from one point of a river to another point of the same river would have short-term and intermittent negative impacts to the hydrological and morphological regime of a river during periods of overflow. However, it represents a significant change to the river regime, even when the diversion is not taking place. Flow diversion from one river to another is an interbasin transfer and can therefore affects the flow regime in both the contributing and receiving rivers and can also affect water quality in the receiving river. When scoring this option consider the quality of the water in receiving river versus the quality of water in the contibuting river, the quantity of water being transfered and whether there is any contaminant/invasicse specises in the contributing water that isn't present in the receving water.
Protect	Overland Floodways	OF	Overland floodways consitute a short-term and intermittent negative impact to the hydrological and morphological regime of the river and could also impact on the physico-chemical condition of the river as well as on the biology due to pollutants on the floodways being carried into the river during periods of operation.

Protect	Rehabilitation of Existing Defences	ED	Rehabilitation of existing in-stream and on-bank defences has the potential for short-term and occasional impacts of the physcio-chemical conditions of the river associated with the works phase.

OBJECTIVE 4.B	
Objective	**Support the objectives of the Habitats and Birds Directives**
Sub-Objective	Avoid detrimental effects to, and where possible enhance, Natura 2000 network, protected species and their key habitats, recognising relevant landscape features and stepping stones
Scoring	Area of Natura 2000 site at risk of flooding and qualitative assessment of impact (flooding may have a positive, neutral or negative impact) Loss of, or significant changes to habitat of, riverine and wetland species associated with Natura 2000 sites.
Basic Requirement	No deterioration in the conservation status of designated sites as a result of flood risk management measures
Aspirational Target	Improvement in the conservation status of designated sites as a result of flood risk management measures
Global Weighting	15
Local Weighting	By professional judgement, taking account of local advice

Guidance on Assignment of Local Weightings

The local weighting may not exceed a ceiling value of 5. Professional judgement should be applied in assigning this weighting. After consultations with progress group, steering group and members of the stakeholder group, this weighting may change.

The presence of Annex IV (Habitats Directive) species of flora and fauna, and their key habitats, which are strictly protected wherever they occur, whether inside or outside the SAC/SPA, will have an impact on this weighting.

Guidance on Option Scoring

Scoring by professional judgement, based upon the following key datasets:

- Natura 2000 sites (SACs, SPAs)
- Ramsar Sites
- Annex IV (Habitats Directive) species of flora and fauna, and their key habitats

Note that the scoring allows a negative score of -5 to reflect the importance of avoiding environmental impacts. The positive scores reflect the opportunities for environmental enhancement. <u>The network of sites must also be considered together with the impact upon the individual site.</u>

Score	Description
+5	Potential to create new candidate SAC, SPA or Ramsar sites or enhance NHA sites to SAC, SPA or Ramsar status, which extend the existing network of international and European designations as a result of flood risk management measures.
+3	Improvement or enhancement of the condition or management of existing SAC, SPA or Ramsar sites and network as a result of flood risk management measures.
+1	Localised improvement or enhancement of the condition or management of existing SAC, SPA or Ramsar sites and network as a result of flood risk management measures.
0	No impact on existing SAC, SPA or Ramsar sites as a result of flood risk management measures.
-1	Any detrimental impact upon existing SAC or SPA site, including a delay in recovery of the site, but excluding impacts on the conservations objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.
-3	Any detrimental impact upon existing SAC or SPA site, including a delay in recovery of the site, but excluding impacts on the conservations objectives of the site, as a result of flood risk management measures, where there are no suitable mitigation measures.
-5	Any detrimental impact upon conservation objectives of existing SAC, SPA or Ramsar site, including a delay in recovery of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.
-999	Any detrimental impact upon existing conservation objectives of SAC, SPA or Ramsar site, as a result of flood risk management measures, where there are no suitable mitigation measures.

OBJECTIVE 4.C	
Objective	**Avoid damage to, and where possible enhance, the flora and fauna of the catchment**
Sub-Objective	Avoid damage to, and where possible enhance, legally protected sites / habitats and other sites / habitats of national, regional and local nature conservation importance
Scoring	Area of national, regional or local conservation designations at risk of flooding and qualitative assessment of impact (flooding may have a positive, neutral or negative impact) Loss of, or significant changes to habitat of, riverine and wetland species associated with national, regional and local conservation designations.
Basic Requirement	No deterioration of in condition of existing sites due to the implementation of flood risk management option
Aspirational Target	Creation of new or improvement in condition of existing sites due to the implementation of flood risk management option
Global Weighting	5
Local Weighting	By professional judgement, taking account of local advice

Guidance on Assignment of Local Weightings

The local weighting may not exceed a ceiling value of 5. Professional judgement should be applied in assigning this weighting. After consultations with progress group, steering group and members of the stakeholder group, this weighting may change.

Guidance on Option Scoring

Scoring by professional judgement, based upon the following key datasets:

- Natural Heritage Areas (& proposed Natural Heritage Areas)
- Nature Reserves
- Wildfowl Sanctuary
- OSPAR
- National Parks

Note that the scoring allows a negative score of -5 to reflect the importance of avoiding environmental impacts. The positive scores reflect the opportunities for environmental enhancement. The network of sites must also be considered together with the impact upon the individual site.

Score	Description
+5	Potential to create new national, regional and local conservation sites as a result of flood risk management measures.
+3	Improvement or enhancement of the condition or management of existing national, regional and local sites as a result of flood risk management measures.
+1	Potential for localised improvement of flora/fauna
0	No impact on existing national, regional and local sites as a result of flood risk management measures.
-1	Potential localised loss of or disturbance to flora/fauna limited by the already modified nature of the channel/shoreline.
-3	Potential localised loss of or disturbance to flora/fauna
-5	Any detrimental impact upon the condition of existing national, regional or local sites as a result of flood risk management measures, where suitable mitigation measures are technically feasible.
-999	Any detrimental impact upon national, regional or local sites as a result of flood risk management measures, where there are no suitable mitigation measures.

OBJECTIVE 4.D	
Objective	Protect and where possible enhance fisheries resource within the catchment
Sub-Objective	Maintain existing and where possible create new fisheries habitat including the maintenance or improvement of conditions that allow upstream migration for fish species.
Scoring	• Area of suitable habitat supporting salmonid and other fish species • Number of upstream barriers
Basic Requirement	• No loss of integrity of fisheries habitat • Maintenance of upstream accessibility
Aspirational Target	• No loss of fisheries habitat • Improvement in habitat quality / quantity • Enhanced upstream accessibility
Global Weighting	5
Local Weighting	By professional judgement, taking account of local advice

Guidance on Assignment of Local Weightings

The local weighting may not exceed a ceiling value of 5. Professional judgement should be applied in assigning this weighting. After consultations with progress group, steering group and members of the stakeholder group, this weighting may change.

The following weighting system may be adopted.

Weighting	Description
5	Where there are designated waters (e.g. under EU Shellfish Waters Directive; EU Freshwater Fish Directive)
4	Waterbody supports substantial salmonid fisheries/shellfisheries and is of national value for fishing/angling
3	Waterbody supports substantial fisheries/shellfisheries and is of regional value for fishing/angling
2	Waterbody supports fisheries/shellfisheries and is of local value for fishing/angling
1	Fisheries could be present but unlikely given the modified nature of the channel/presence of barriers to movement; no known angling/fishing activities
0	No fisheries or angling areas present

Guidance on Option Scoring

Scoring by professional judgement with reference to the scoring guidance below and the generic desciption of the likely impacts of measures.

It is noted that this objective only relates to inland fisheries and not marine fisheries. Shellfish waters in particular are included under the register of protected areas under the WFD and as such are included in Objective 4a.

The scoring of the options for this objective should take into account the duration and permanence of the likely impact(s) of the options on on fisheries and fisheries potential, the sensitivity of the receiving water bodies, and species e.g. salmonid sp. and designated salmonid waters.

Duration is defined in terms of:
- long term;
- medium term;
- short term.

Permanence is defined in terms of:
- permanent;
- recurring;
- intermittent.

Sensitive waters include:
- designated salmonid waters

Sensitive species include*:
- Atlantic Salmon
- Lamprey
- Shad
- Pollan
- Arctic Char
- Smelt

*Based on 2011 IFI National Programme: Habitats Directive and Red Data Book Fish species

Combining positive and negative scores

Instream and bank options have the greatest potential to impact negatively on fisheries, however some options may offer improvements and as such the overall score applied should be a combination of the positive and negative scores with reference to the worst case and best case scores.

Example of combining scores

Option = hard defences and flow diversion
- +2 due to reduction of pollution risk to sensitive water bodies and sensitive species
- -2 due to construction stage impacts associated with walls
- -5 associated with diversion of flow into another river

In this case, the overall score should be '-3', combining the best case positive score and the worst case negative score.

Comparing options

When scoring multiple options for one AFA, it may happen that the options score the same even if they have varying degrees of impact. Professional judgement should be used to ensure that the scores reflect the varying degrees of impact between the options i.e. the scores should be manually adjusted to reflect the different degrees of impact associated with the different options.

Example of manual adjustment

Option 1 = flow diversion

- +2 due to improved fisheries potential as a result of reduction of pollution risk to sensitive water bodies and species
- -5 associated with diversion of flow into another river

Overall score = - 3

Option 2 = flow diversion plus walls

- +2 due to improved fisheries potential as a result of reduction of pollution risk to sensitive water bodies and species
- -2 due to construction stage impacts to sensitive water bodies and species associated with walls
- -4 due to excavation and restoration of natural banks in sensitive water bodies
- -5 associated with diversion of flow into another river

Overall score = - 3 (combining best case positive score and worst case negative score)

These options score the same even though Option 2 has more negative impacts associated with it. In this example, using professional judgement, Option 2 should be manually adjusted downwards by 1 point to reflect the comparitive difference in impacts between the options. If more than two options are being compared, and all differ in terms of the severity of their likely impacts on this objective, but all score the same using this methodology, the options should be manually adjusted upwards or downwards by a maximum of two points in either direction to reflect the comparitive difference in impacts between the options. Such adjustments will ensure that the overall MCA scores for the options reflect their differing degree of potential impact on this objective and will therefore ensure that this objective will have an influence in terms of the choice of a preferred option. In such cases a clear rationale should be recorded for the adjustment. It should be noted that such adjustments may have a significant impact on the overall MCA score of the preferred option.

Scoring Table

Score	Duration of impact	Sensitivity	Examples
5	Creation of fisheries habitat or removal of barrier to upstream migration for wb where sensitive species are known to be present e.g. salmonids	Any wb	Reinstatement of natural hydrological or morphological regime.
4	Creation of fisheries habitat or removal of barrier to upstream migration for wb where other species are present e.g. coarse fish	Any wb	Reinstatement of natural hydrological or morphological regime.
3			
2	Creation of fisheries potential	Any wb	Land Use Management
1			
0	No change to fisheries potential of the wb	Any wb	Measures with no connection to channel, flow, bank side vegetation
-1	Short-term minor impacts to fisheries habitat	Non-sensitive wb	Construction phase impacts.
-2		Sensitive wb	
-3	Medium to long-term alternation of fisheries habitat	Non-sensitive wb	In-stream or on-bank maintenance impacts. Walls that require excavation and restoration of banks. Flow diversion within the same river. Rehabilitation of existing in-stream or on-bank defences. Dredging
-4		Sensitive wb	
-5	Permanent loss or removal of fisheries habitat and / or introduction of barriers to upstream migration.	Any wb	Channelisation/realignment. Regular dredging. Extensive culverting. Tidal barrage. On-line storage (dams). Improvement of channel conveyance. Walls that replace natural banks. Flow diversion to a different river.
-999	Unacceptable negative impact where feasible alternative exists		

The table below describes the likely impacts flood risk management measures fisheries. It can be referred to when undertaking the scoring process to help ensure consistency between studies.

Category	Measure	Code	Likely Impacts (Fisheries)
NFM Protect	Land Use Management	LM	Effective land use management has the potential for positive impacts on fisheries through the reduction of pollutants entering rivers and the restoration of natural hydrological and morphological regimes with the possibility of restoration and / or creation of fisheries potential.
Protect	Maintenance Programme	MP	The maintenance of existing flood defense measures is likely to result in some positive impacts to fisheries through removal of debris and other physical obstructions etc, particularly following flood events. There is however potential for negative impacts where management of vegetation leads to loss of habitat or disturbance to species. All in-stream works have potential to negatively impact directly on fish species and as such would have to be carried out with due care and attention. On-bank works also have potential for negative impacts, particularly with regard to release of sediment and other organic matter.
Protect	Upstream storage / Storage	S	On-line storage refers to creating a dam and reservoir across the floodplain of a river, often with an outlet control structure such as an undershot culvert or sluices, to control outlet flow, and with an overflow weir and spillway. Such a measure has the potential to negatively impact on fisheries through disturbance or loss of habitat and blockage to migratory routes. This will be particularly significant in sensitive waters and for sensitive species. Creation of eutrophic conditions in the reservoirs could also impact on fisheries down-stream. Off-line storage refers to an area of floodplain that is embanked to prevent or control flooding within the storage area or wash-land during minor events. This can produce positive effects including creation of new habitat. Negative impacts may occur where the storage interferes with the existing riparian zone.
Protect	Tidal Barrage	TB	Tidal barrages have the potential for significant negative impacts on migratory fish and other water dependent species and are a permanent change to hydrological and morphological regimes.
Protect	Improvement of Channel Conveyance	IC	Increased conveyance improves the efficiency of the channel, and thereby reduces the water levels for a given flow. This is often done by deepening or widening a channel, cutting berms to take more flow during flood events, realigning the bed profile (e.g. removing outcrops) or lining the channel with an artificial or soft (but low resistance) material (ranging from concrete or steel piles to low grass over geotextile). This measure includes primarily in-stream work elements and as such represents one of the measures with most negative possibility in terms of fisheries potential.

Protect (cont'd)	Improvement of Channel Conveyance (cont'd)	IC (cont'd)	All aspects are likely to result in short-term construction related impacts however, some, over the medium to long term will have significant potential to cause loss of habitat, disturbance of species through changes to hydrological and morphological regimes (permanent or long term), physico-chemical conditions (short-term during construction) and biology . In the medium to long-term there may be the possibility for positive impacts where new habitat can be generated.
Protect	Hard Defences	D	Flood walls have the potential for impacts for fisheries depending on the distance of the wall from the channel. Some walls will require excavation of the bank during the construction phase followed by bank restoration – with short-term effects associated with construction and medium-term associated with bank recovery. There would also potentially be long-term hydrological or morphological impacts. In some areas, walls may replace natural banks and this would represent a permanent impact on the hydrological and morphological regime of the channel and in turn on the habitats and species present.
Protect	Culverting	C	Culverting represents a permanent morphological and hydrological impact with has the potential to permanent impact on fisheries habitat and species particularly with regard to upstream movement of fish species. The extent of culverting is important is assessing the impact.
Protect	Diversion of Flow	DF	Realigning a river constitutes a permanent negative impact to the hydrological and morphological regime of a river which have potential for both short and medium term impacts to fisheries through loss of habitat and disturbance to species. Flow diversion via a bypass chanell from one point of a river to another point of the same river would have short-term and intermittent negative impacts to the hydrological and morphological regime of a river and consequently fish species during periods of overflow but this impact may have longer term consequences on fisheries habitat also. Flow diversion from one river to another is an interbasin transfer and can therefore affects the flow regime in both the contributing and receiving rivers and can also affect water quality in the receiving river. Such a measure should always be considered of maximum significance with respect to fisheries protection.
Protect	Overland Floodways	OF	Overland floodways consitute a short-term and intermittent negative impact to the hydrological and morphological regime of the river and could also impact on the physico-chemical condition of the river as well as on the biology due to pollutants on the floodways being carried into the river during periods of operation.

Protect	Rehabilitation of Existing Defences	ED	The rehabilitation of existing flood defense measures is likely to result in some negative impacts to fisheries where management of vegetation leads to loss of habitat or disturbance to species. All in-stream works have potential to negatively impact directly on fish species and as such would have to be carried out with due care and attention. On-bank works also have potential for negative impacts, particularly with regard to release of sediment and other organic matter. This measure has the potential for short-term and occasional impacts to the physcio-chemical conditions of the river associated with the works phase.

OBJECTIVE 4.E	
Objective	**Protect, and where possible enhance, landscape character and visual amenity within the zone of influence.**
Sub-Objective	Protect, and where possible enhance, visual amenity, landscape protection zones and views into/from designated scenic areas within the zone of influence.
Scoring	1. Length of waterway corridor qualifying as a landscape protection zone within urban areas 2. Change of quality in existing scenic areas and routes 3. Loss of public landscape amenities
Basic Requirement	1. No significant impact on landscape designation (protected site, scenic route/amenity, natural landscape form) within zone of visibility of measures 2. No significant change in the quality of existing landscape characteristics of the receiving environment
Aspirational Target	1. No change to the existing landscape form 2. Enhancement of existing landscape or landscape feature
Global Weighting	10
Local Weighting	By professional judgement, taking account of local advice

Guidance on Assignment of Local Weightings

The local weighting may not exceed a ceiling value of 5. Professional judgement should be applied in assigning this weighting. After consultations with progress group, steering group and members of the stakeholder group, and with the local community, this weighting may change.

Consideration may be given to the public use of landscape and cultural associations, history and memories. The following weighting system may be adopted.

Weighting	Description
5	Landscape designated as a internationally/nationally important landscape and potentially affected
4	Landscape character type designated at a county level as highly sensitive and/or exceptional/high value and potentially affected
3	Landscape character type designated at a county level as moderate sensitivity and/or medium value; protected views present that could be affected
2	Landscape character type designated at a county level as low sensitivity and/or low value and potentially affected
1	No specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected
0	No specific landscape designation, and no landscape value/sensitivity

Guidance on Option Scoring

Scoring should be guided by professional judgement with reference to the scoring guidance below and the generic description of the likely impacts of measures.

The scoring of the options for this objective should take into account the duration and permanence of the likely impact(s) of the options on landscape value and the sensitivity of the landscape to change.

Duration is defined in terms of; • Long term; • Medium term; • Short term.	**Permanence is defined in terms of;** • Permanent; • Recurrent; • Intermittent.
Range of Sensitivities include; • High (International/National); • Moderate (Regional/County/City; • Low (County/City/Local)	**Permanence is defined in terms of;** • Permanent; • Recurrent; • Intermittent.

Examples of Sensitive Landscapes include;

- World Heritage Sites (International);
- National Parks (International/National);
- Sensitive/Vulnerable Landscapes (National/Regional/County);
- High Amenity Landscapes/Areas (County);
- Scenic Views/Prospects and Routes (County/Local);
- Sensitive Riverscapes/Seascapes/Streetscapes/Local Amenity Walks (County/City/Local).

Combining Positive and Negative Scores
Constructing hard defences adjacent to watercourses has the potential to impact positively and negatively on landscape. A negative impact may arise from the construction of a visible man-made structure on the opposite bank of a river with a scenic walkway. A positive impact may arise from the removal of invasive species encroaching on the river bank.

+2 due to enhancement of local landscape feature (e.g. removal of invasive vegetative species)

-5 due to construction of hard defence where no defence existed prior

In the above example the overall score should be '-3', combining the best positive score with the worst negative score.

Comparing Options
When scoring multiple options for one AFA, it may happen that the options score the same even if they have varying degrees of impact. Professional judgement should be used to ensure that the scores reflect the varying degrees of impact between the options, i.e. the scores should be manually adjusted to reflect the different degrees of impact associated with the different options.

Example of manual adjustment
Option 1= flood storage

- +1 due to clearance of natural flood storage area
- -1 short term construction stage impacts
- -4 due to change in existing landscape form in the locality

Overall Score = -3 (highest positive added to highest negative)

Option 2 = river morphology changes

- -3 due to construction stage impacts in a riverscape recognised as being of high value in a County/City Development Plan

Overall Score = -3

The above options score the same even though Option 2 is more likely to be perceived to have the more significant negative impact arising from the inclusion of the riverscape in a County or City Development Plan. Option 2 should then be manually adjusted downwards by 1 point to reflect the comparative difference in impacts between the options. If more than two options are being compared, and all differ in terms of the severity of their likely impacts on this objective, but all score the same using this methodology, the options should be manually adjusted upwards or downwards by a maximum of 2 points in either direction to reflect the comparative difference between the options.

Scoring Table

Score	Duration of Impact	Sensitivity	Examples
5	Permanent significant enhancement of high sensitivity landscape character/feature in the zone of visibility of the selected measure	High	Reinstatement of natural river corridor morphology in a riverscape recognised as being of high value included in a County/City Development Plan
4	Permanent significant enhancement of moderate sensitivity landscape character/feature in the zone of visibility of the selected measure	Moderate	Clearance of significant extent of riparian vegetation/man-made obstructions in a river corridor of high landscape/amenity value included in a County/City Development Plan
3	Permanent localised enhancement of high value landscape/feature in the zone of visibility of the selected measure	High	Channel widening and deepening at specific location on a watercourse of high landscape value removing risk of flow restriction and visual impacts from blockages with detritus (vegetative/rubbish).
2	Permanent localised enhancement of moderate value landscape character/feature in the zone of visibility of the selected measure	Medium	Clearance of local area for use as temporary overland flow storage returning land-use to natural function.
1	Permanent localised enhancement of local sensitivity landscape character/feature in the zone of visibility of the selected measure	Low	Removal of artificial visible man-made flow restriction from local amenity view (screens from under bridge on local amenity walk).
0	No change to existing landscape character/feature in the zone of influence of the selected measure	-	No change to existing landscape character or features.
-1	Short term impact (construction) on local sensitivity landscape character/feature in the zone of visibility of the selected measure.	Low	Construction or extension to local flood embankment prior to establishment of vegetative mitigation (i.e. screening).
-2	Short term impact (construction) on moderate sensitivity landscape character/feature in the zone of visibility of the selected measure.	Low	Construction of significant flood storage area in large area of natural landscape prior to mitigation establishment
-3	Short term impact (construction) on high/moderate value landscape character/feature in the zone of visibility of the selected measure	Medium	Re-establishment of natural river corridor morphology in a riverscape recognised as being of high value in a County/City Development Plan
-4	Permanent impact on local/moderate value landscape character/feature in the zone of influence of the selected measure	Medium	Construction of permanent hard defences (flood walls) adjacent to a local amenity walkway in a historic garden/demesne
-5	Permanent impact on high value landscape character/feature in the zone of influence of the selected measure	High	Construction of tidal barrage in high amenity seascape which is the subject matter of a protected view/prospect
-999	Unacceptable negative impact where feasible options exist	High	Site specific.

OBJECTIVE 4.F.i	
Objective	**Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.**
Sub-Objective	Avoid damage to or loss of features, institutions and collections of **architectural** value and their setting, and improve their protection from extreme floods where this is beneficial.
Scoring	a) The number of architectural features, institutions and collections subject to flooding. b) The impact of flood risk management measures on architectural features, institutions and collections.
Basic Requirement	a) No increase in risk to architectural features, institutions and collections at risk from flooding. b) No detrimental impacts from flood risk management measures on architectural features, institutions and collections.
Aspirational Target	a) Complete removal of all relevant architectural features, institutions and collections from the risk of harm by extreme floods. b) Enhanced protection and value of architectural features, institutions and collections importance arising from the implementation of the selected measures.
Global Weighting	5
Local Weighting	By professional judgement, taking account of local advice

Guidance on Assignment of Local Weightings

The local weighting may not exceed a ceiling value of 5. Professional judgement should be applied in assigning a value to this weighting but some guidance has been provided below. After consultations with progress group, steering group and members of the stakeholder group, this weighting may change.

Reference should be made to the PRFA Methodology for Classifying the Vulnerability of National Monuments from Flooding in the Republic of Ireland (OPW, 2011).

Score	Description
5	Internationally important feature(s) (i.e. Structures or sites of sufficient architectural heritage importance to be considered in an international context. These are exceptional structures that can be compared to and contrasted with the finest architectural heritage in other countries) present and potentially affected.
4	Nationally important feature(s) (e.g. Structures or sites that make a significant contribution to the architectural heritage of Ireland. These are structures and sites that are considered to be of great architectural heritage significance in an Irish context) present and potentially affected with a high to moderate vulnerability.
3	A number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a high to moderate vulnerability.
2	A number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a moderate to low vulnerability.
1	No architectural features are at risk from flooding but potential effects on the settings of designated architectural features.
0	No sites/features at risk.

Guidance on Option Scoring

FRM measures may have both positive and negative effects on features of cultural heritage, and these need to be taken into account when identifying and scoping potential effects. Scoring should be based on professional judgement guided by the criteria provided below.

Score	Description / *Examples*		
5	No negative effects on architectural features and a number of architectural features (Internationally and Nationally important features) completely saved from what would otherwise have been inevitable loss from flooding.	Creation of elements which significantly enhance the setting of architectural features (Internationally and Nationally important features).	Creation of amenity value for a number of architectural features (Internationally and Nationally important features) which was previously not present.
4	Architectural features (Nationally important features, Record of Protected Structures and NIAH) partially saved from what would otherwise have been inevitable loss from flooding.	Creation of elements which enhance the setting of architectural features (Nationally important features, Record of Protected Structures and NIAH).	Creation of amenity value for a number of architectural features (Nationally important features, Record of Protected Structures and NIAH) which was previously not present.
3	Increase in the level of protection for a number of architectural features (Record of Protected Structures and NIAH) from flooding, such that they are substantially less vulnerable to flood damage.	Removal of negative elements from the setting of architectural features (Record of Protected Structures and NIAH) so that the setting of the features is significantly enhanced.	Protection of the existing amenity for a number of architectural features (Record of Protected Structures and NIAH).
2	Increase in the level of protection for a number of architectural features (Record of Protected Structures and NIAH) from flooding, such that they are significantly less vulnerable to flood damage.	Removal of negative elements from the setting of a number architectural features (Record of Protected Structures and NIAH) so that the setting of the architectural features is noticeably enhanced.	Partial protection of the existing amenity for a number architectural features (Record of Protected Structures and NIAH).
1	Increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.	Removal of negative elements from the setting of architectural features (Record of Protected Structures and NIAH) so that its setting is enhanced.	Protection of the existing amenity for architectural features (Record of Protected Structures and NIAH).
0	**No effects on architectural features**		

-1	No physical effects on architectural features (Record of Protected Structures and NIAH)	Changes to the setting of architectural features (Record of Protected Structures and NIAH) such that it is slightly changed.	Partial loss of access to architectural features (Record of Protected Structures and NIAH) which does not affect their existing amenity value.
-2	Multiple effects which score -1 individually and/or Physical effects on architectural features (Record of Protected Structures and NIAH) such that the structure is partially removed.	Changes to the setting of architectural features (Record of Protected Structures and NIAH) such that it is clearly modified.	Loss of access to architectural features (Record of Protected Structures and NIAH) such that its current amenity value is altered.
-3	Multiple effects which score -2 individually and/or Physical effects on architectural features (Record of Protected Structures and NIAH) such that the structure is completely removed.	Changes to the setting of architectural features (Record of Protected Structures and NIAH) such that it is completely altered.	Loss of access to architectural features (Record of Protected Structures and NIAH) such that its current amenity value is completely lost.
-4	Multiple effects which score -3 individually and/or Physical effect on architectural features (Nationally important features, Record of Protected Structures and NIAH) such that the structure is partially removed.	Changes to the setting of architectural features (Nationally important features, Record of Protected Structures and NIAH) such that it is clearly modified.	Loss of access to architectural features (Nationally important features, Record of Protected Structures and NIAH) such that its current amenity value altered.
-5	Physical effect on architectural features (Nationally important features, Record of Protected Structures and NIAH) such that the structure is completely removed.	Changes to the setting of architectural features (Nationally important features, Record of Protected Structures and NIAH) such that it is completely altered.	Loss of access to architectural features (Nationally important features, Record of Protected Structures and NIAH) such that its current amenity value is completely lost.
-999	Physical effects on architectural features (Internationally important) such that its Outstanding Universal Value (OUV) is altered.	Effects on the setting of an architectural features (Internationally important) such that its Outstanding Universal Value (OUV) is altered.	

OBJECTIVE 4.F.ii	
Objective	**Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.**
Sub-Objective	Avoid damage to or loss of features, institutions and collections of **archaeological** value and their setting, and improve their protection from extreme floods where this is beneficial.
Scoring	a) The number of archaeological features, institutions and collections subject to flooding. b) The impact of flood risk management measures on archaeological features, institutions and collections.
Basic Requirement	a) No increase in risk to archaeological features, institutions and collections at risk from flooding. b) No detrimental impacts from flood risk management measures on archaeological features, institutions and collections.
Aspirational Target	a) Complete removal of all relevant archaeological features, institutions and collections from the risk of harm by extreme floods. b) Enhanced protection and value of archaeological features, institutions and collections arising from the implementation of the selected measures.
Global Weighting	5
Local Weighting	By professional judgement, taking account of local advice

Guidance on Assignment of Local Weightings

The local weighting may not exceed a ceiling value of 5. Professional judgement should be applied in assigning a value to this weighting but some guidance has been provided below. After consultations with progress group, steering group and members of the stakeholder group, this weighting may change.

Reference should be made to the PRFA Methodology for Classifying the Vulnerability of National Monuments from Flooding in the Republic of Ireland (OPW, 2011).

Score	Description
5	Internationally important archaeological feature(s) (i.e. World Heritage Site including those on the tentative list present and potentially affected.
4	Nationally important archaeological feature(s) (e.g. National Monument in State Care, sites on which Preservation Orders or Temporary Preservation Orders have been served) present and potentially affected.
3	A number of sites listed on the RMP/RPS present and potentially affected. (high to moderate vulnerability)
2	A number of sites listed on the RMP/RPS present and potentially affected. (moderate to low vulnerability)
1	Limited potential for effects on archaeological features and their setting.
0	No archaeological features at risk.

Guidance on Option Scoring

FRM measures may have both positive and negative effects on archaeological features, and these need to be taken into account when identifying and scoping potential effects. Scoring should be based on professional judgement guided by the criteria provided below

Score	Description / *Examples*		
5	No negative effects on archaeological features, and, A number of archaeological features (Recorded Monuments or National Monuments) completely saved from what would otherwise have been inevitable loss from flooding.	Creation of elements which significantly enhance the setting of archaeological features (Recorded Monuments or National Monuments).	Creation of amenity value for a number of archaeological features (Recorded Monuments or National Monuments) which was previously not present.
4	Archaeological features (Recorded Monuments or National Monuments) partially saved from what would otherwise have been inevitable loss from flooding.	Creation of elements which enhance the setting of an archaeological feature (Recorded Monuments or National Monuments).	Creation of amenity value for a number archaeological feature (Recorded Monuments or National Monuments) which was previously not present.
3	Increase in the level of protection for a number of archaeological features (Recorded Monuments) from flooding, such that they are substantially less vulnerable to flood damage.	Removal of negative elements from the setting of archaeological features (Recorded Monuments) so that the setting of the features is significantly enhanced.	Protection of the existing amenity for a number of archaeological features (Recorded Monuments).
2	Increase in the level of protection for a number of archaeological features (Recorded Monuments) from flooding, such that they are significantly less vulnerable to flood damage.	Removal of negative elements from the setting of a number archaeological features (Recorded Monuments) so that the setting of the archaeological features is noticeably enhanced.	Partial protection of the existing amenity for a number of archaeological features (Recorded Monuments).
1	Increase in the level of protection for archaeological features (Recorded Monuments) from flooding, such that it is less vulnerable to flood damage.	Removal of negative elements from the setting of archaeological features (Recorded Monuments) so that it's setting is enhanced.	Protection of the existing amenity for archaeological features (Recorded Monuments).
0	**No effects on archaeological features**		

-1	No physical effects on archaeological features (Recorded Monuments or National Monuments)	Changes to the setting of archaeological features (Recorded Monument or National Monument) such that it is slightly changed.	Partial loss of access to archaeological features (Recorded Monuments or National Monuments) which does not affect their existing amenity value.
-2	Multiple effects which score -1 individually and/or Physical effects on archaeological features (Recorded Monuments) such that the monument is partially removed.	Changes to the setting of archaeological features (Recorded Monuments) such that it is clearly modified.	Loss of access to archaeological features (Recorded Monuments) such that its current amenity value is altered.
-3	Multiple effects which score -2 individually and/or Physical effects on archaeological features (Recorded Monuments) such that the monument is completely removed.	Changes to the setting of archaeological features (Recorded Monuments) such that it is completely altered.	Loss of access to archaeological features (Recorded Monuments) such that its current amenity value is completely lost.
-4	Multiple effects which score -3 individually and/or Physical effect on archaeological features (National Monuments) such that the monument is partially removed.	Changes to the setting of archaeological features (National Monuments) such that it is clearly modified.	Loss of access to archaeological features (National Monuments) such that its current amenity value altered.
-5	Physical effect on archaeological features (National Monuments) such that the monument is completely removed.	Changes to the setting of archaeological features (National Monuments) such that it is completely altered.	Loss of access to archaeological features (National Monuments) such that its current amenity value is completely lost.
-999	Physical effects on archaeological features (a World Heritage Site) such that its Outstanding Universal Value (OUV) is altered.	Effects on the setting of an archaeological feature (a World Heritage Site) such that its Outstanding Universal Value (OUV) is altered.	

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Appendix M Economic Sensitivity Analysis

Only AFA's with Options are displayed below

AFA	Option	3%	4%	5%
Listowel	Option 1	€ 1,276,746	€ 1,259,812	€ 1,246,898
	Option 2	€ 1,234,657	€ 1,212,109	€ 1,194,912
Abbeyfeale	Option 1	€ 154,239	€ 152,373	€ 150,950
Athea	Option 1	€ 563,698	€ 533,035	€ 509,488
	Option 2	€ 384,529	€ 381,747	€ 379,626
Banna	Option 1	€ 149,211	€ 144,933	€ 141,671
Abberydorney	Option 1	€ 215,530	€ 209,648	€ 205,163
	Option 2	€ 286,866	€ 278,059	€ 271,342
Moneycashen	Option 1	€ 273,471	€ 247,868	€ 228,343
Tralee	Option 1	€ 13,328,658	€ 13,198,688	€ 13,099,567
	Option 2	€ 14,271,684	€ 14,064,878	€ 13,907,158
	Option 3	€ 14,405,819	€ 14,258,122	€ 14,145,482
	Option 4	€ 19,164,446	€ 19,012,090	€ 18,895,896

AFA	Total Capped CBA								
	3%			4%			5%		
	Coastal	Fluvial	Combined	Coastal	Fluvial	Combined	Coastal	Fluvial	Combined
Listowel		€12,662,082	€12,662,082		€11,931,988	€11,931,988		€9,172,964	€9,172,964
Abbeyfeale		€340,992	€340,992		€287,462	€287,462		€246,673	€246,673
Athea		€869,887	€869,887		€809,096	€809,096		€629,275	€629,275
Banna	€1,978,936	€1,902,265	€2,766,502	€1,663,874	€1,720,700	€2,674,804	€1,436,116	€1,476,538	€2,546,110
Abberydorney		€1,010,040	€1,010,040		€964,689	€964,689		€835,271	€835,271
Moneycashen	€770,608	€50,339	€766,251	€678,899	€42,437	€ 707,820	€588,739	€36,416	€585,587
Tralee	€4,239,003	€38,916,671	€40,163,918	€3,817,011	€38,271,668	€39,841,064	€3,466,158	€28,839,025	€27,184,602