SWRBD CFRAM Study

Inception Report - Unit of Management 19

September 2013
Office of Public Works

OPW
The Office of Public Works
Oifig na nOibreacha Poiblí

SOUTH WESTERN CFRAM STUDY
CATCHMENT FLOOD RISK ASSESSMENT AND MANAGEMENT

Mott MacDonald

SWRBD CFRAM Study

Inception Report - Unit of Management 19

September 2013

Office of Public Works

Jonathan Swift Street
Trim
Co. Meath

Mott MacDonald, 5 Eastgate Avenue, Eastgate, Little Island, Cork, Co Cork, Ireland
T +353 (0)21 4809 800   F +353 (0)21 4809 801,   W www.mottmac.com

Issue and Revision Record

Revision	Date	Originator	Checker	Approver	Description
A	May 2012	M. Piggott T. Donovan	B. O'Connor	F. McGivern	Initial Issue
B	November 2012	M. Piggott T. Donovan	B. O'Connor	F. McGivern	Revised Issue
C	February 2013	M. Piggott A. Lambe	B. O'Connor	F. McGivern	Revised Issue
D	September 2013	T. Donovan	B. O'Connor	F. McGivern	Revised Issue

Mott MacDonald, 5 Eastgate Avenue, Eastgate, Little Island, Cork, Co Cork, Ireland
T +353 (0)21 4809 800 F +353 (0)21 4809 801, W www.mottmac.com

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1. Introduction

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

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

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

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

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

1.1 Aims and Objectives

The objectives of this Project are to:

- Identify and map the existing and potential future flood hazard within the Study Area.
- Assess and map the existing and potential future flood risk within the Study Area.
- Identify viable structural and non-structural options and measures for the effective and sustainable management of flood risk in the Areas for Further Assessment Risk (AFA's) and within the Study Area as a whole.
- Prepare a FRMP for each Unit of Management within the Study Area, and associated Strategic Environmental and, as necessary, Habitats Directive (Appropriate) Assessment, that sets out the policies, strategies, measures and actions that should be pursued by the relevant bodies, including the OPW, Local Authorities and other Stakeholders, to achieve the most cost-effective and sustainable management of existing and potential future flood risk within the Study Area, taking account of environmental plans, objectives and legislative requirements and other statutory plans and requirements.

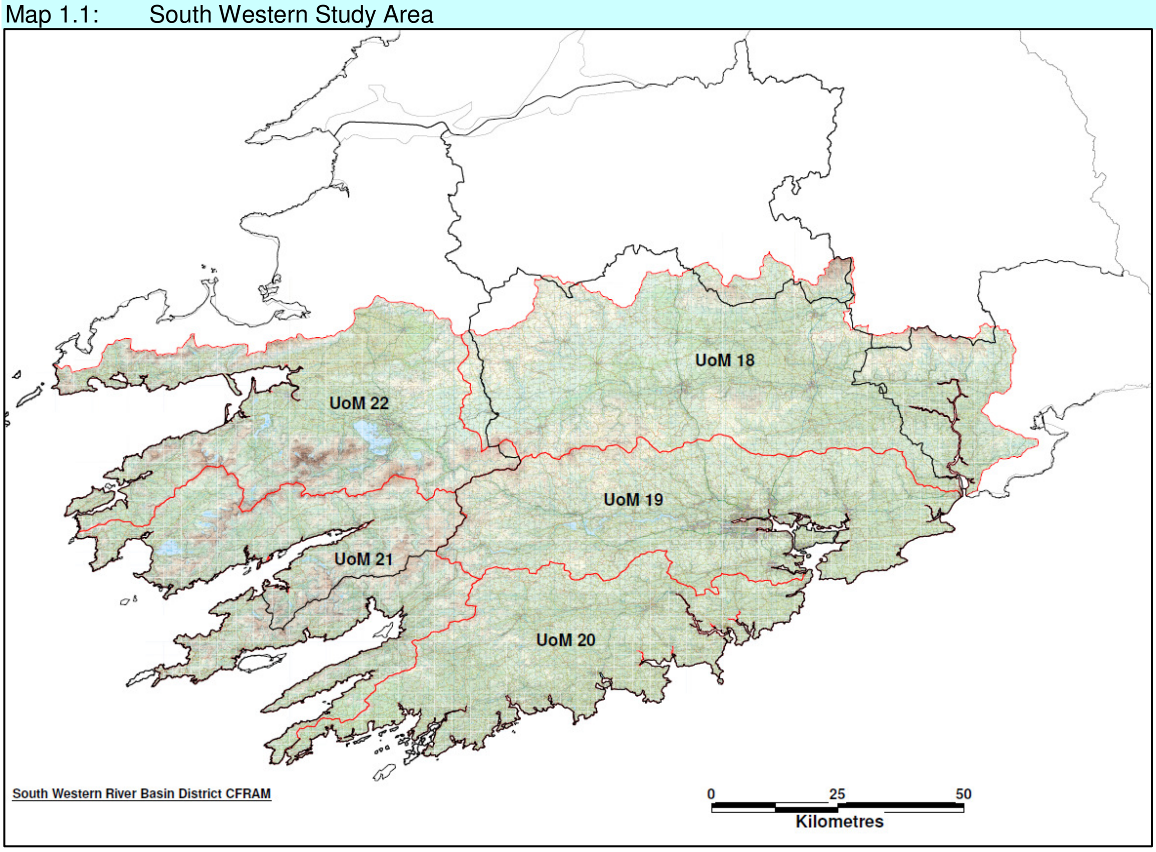
1.2 Description of the South Western Study Area

The South Western River Basin District (SWRBD), which forms the Study Area, covers an area of approximately 11,160 km^2. The Study Area includes most of county Cork, large parts of counties Kerry and Waterford along with small parts of the counties of Tipperary and Limerick. The Study Area contains over 1,800 km of coastline along the Atlantic Ocean and the Celtic Sea. In total, 6 Local Authorities administer the regions within the Study Area: Cork County Council, Cork City Council, Kerry County Council, Waterford County Council, South Tipperary County Council and Limerick County Council. Much of the Study Area is rural and the predominant land usage is agriculture. The Study Area contains Cork City (pop. 119,418) and a number of other large towns such as Killarney (pop. 13,497), Mallow (pop. 7,864) and Bandon (pop. 6,640).

The Study Area includes the rivers, Munster Blackwater, Lee, Bandon, Maine, Laune, their associated tributaries, and a large number of smaller coastal catchments. There are five Units of Management within the Study Area, which are listed below:

- Unit of Management 18
- Unit of Management 19
- Unit of Management 20
- Unit of Management 21
- Unit of Management 22

Map 1.1: South Western Study Area



The Study includes 26 Nr. Areas for Further Assessment (AFA's) which are listed in Table 1.1 below.

Table 1.1: Areas for Further Assessment (AFAs)

UoM	Name	Unique ID	Fluvial	Coastal	County	Easting	Northing
18	Aglish	180247	Yes	No	Waterford	212250	91500
18	Ballyduff	180248	Yes	No	Waterford	196500	99500
18	Fermoy	180252	Yes	No	Cork	182750	99500
18	Freemount	180253	Yes	No	Cork	139500	114250
18	Kanturk	180254	Yes	No	Cork	138250	102750
18	Mallow	180262	Yes	No	Cork	155250	98500
18	Rathcormack	180265	Yes	No	Cork	181750	91000
18	Tallow	180266	Yes	No	Waterford	199750	93750
18	Youghal	180267	Yes	Yes	Cork	210250	78750
19	Killeagh	190274	Yes	No	Cork	200750	75750
19	Castlemartyr	190277	Yes	No	Cork	196250	73250
19	Ballingeary	195499	Yes	No	Cork	115090	67135
20	Clonakilty	200294	Yes	Yes	Cork	138000	41250
20	Dunmanway	200297	Yes	No	Cork	122250	52750
20	Inishannon	200298	Yes	No	Cork	155000	57000
20	Schull	200303	Yes	No	Cork	92500	31500
21	Bantry	210307	Yes	Yes	Cork	99750	48500
21	Castletown Bearhaven	210308	No	Yes	Cork	68000	46000
21	Durrus	210309	Yes	No	Cork	95000	42000
21	Kenmare	210312	Yes	Yes	Kerry	90750	70500
22	Castleisland	220323	Yes	No	Kerry	97750	110000
22	Dingle	220327	Yes	Yes	Kerry	44500	101000
22	Glenflesk	225502	Yes	No	Kerry	106621	85316
22	Killarney	220337	Yes	No	Kerry	97000	90500
22	Milltown	220339	Yes	No	Kerry	82500	101000
22	Portmagee	220340	No	Yes	Kerry	36500	73000

This report outlines how Mott MacDonald proposes to carry out the South Western RBD CFRAM study in respect of the AFAs and the MPWs in **Unit of Management 19**, the River Lee Catchment.

1.3 Unit of Management 19

Unit of Management 19, which forms part of the SWRBD covers an area of approximately 2,145 km^2. The entire area of UoM 19 is within County Cork. The main rivers within UoM 19 are the Lee, Owenboy and Womanagh.

The OPW have undertaken a separate Catchment Flood Risk Assessment and Management (CFRAM) Study within UoM 19 for the Lee Catchment. However, the town of Ballingeary in the upper reach of the Lee, which has been identified as an AFA was not included in the Lee CFRAM. This study includes the Womanagh and its tributaries the Kiltha and the Dissour which are outside of the Lee Catchment and the watercourses in Ballingeary.

1.4 Areas for Further Assessment

As part of this study, there are three Areas for Further Assessment (AFAs) within Unit of Management 19. These are listed in Table 1.2 below. Associated with the AFA's is over 29km of high and medium priority watercourse. Further details are provided in Section 4.0.

Table 1.2: Areas for Further Assessment within Unit of Management 19

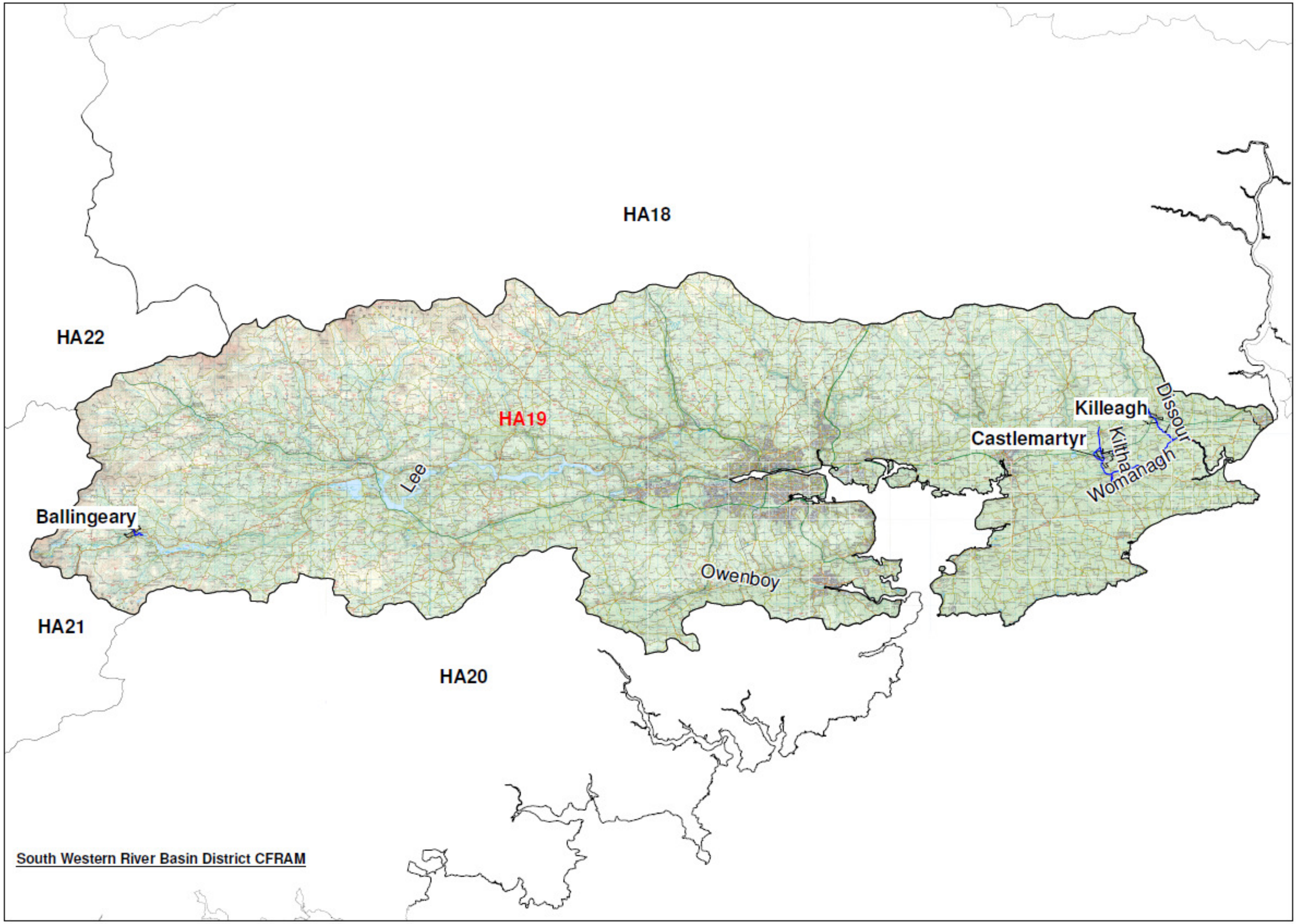
UoM	Name	Unique ID	Fluvial	Coastal	County	Easting	Northing
19	Killeagh	190274	Yes	No	Cork	200750	75750
19	Castlemartyr	190277	Yes	No	Cork	196250	73250
19	Ballingeary	195499	Yes	No	Cork	115090	67135

1.5 SW CFRAMs Project Delivery

The CFRAM programme is split up into four key steps that have to be completed by certain deadlines. These deadlines are set out in the European Communities (Assessment and Management of Flood Risks) Regulations of 2010 (SI 122/2010). These are;

- The Preliminary Flood Risk Assessment (PFRA) – Completed December 2011
- Flood Risk Review – Completed December 2011
- Flood Risk Mapping – To be completed December 2013
  - This involves the mapping of areas that are at significant risk from flooding. The maps will show the extent of flooding likely, how deep the water could get and how fast the water will flow.
- Flood Risk Management Plans – To be completed December 2015
  - This involves the development of flood risk management options to mitigate the risk of damage resulting from flooding in areas at significant risk. The options considered could include the construction of flood walls or embankments, the installation of a flood warning system of the use of catchment management techniques to reduce the risk from flooding.

Map 1.2: Unit of Management 19



2. Data Availability and Requirements

2.1 Data Collection

This section details the data collected and highlights any data that is currently outstanding or unavailable.

2.2 Hydrometric Data

Hydrometric data for river flow and level gauges in UoM 19 was provided by OPW and the EPA. Table 2.1 summarises the available hydrometric gauges from both OPW and EPA.

Table 2.1: Available Hydrometric Gauges

Type	OPW gauges	EPA gauges (operated by Cork County Council)	Total Gauges Available	Gauges available for Ballingeary, Castlematyr or Killeagh
River Flow and Water Level Gauges	3	15	18	0
River Level Gauges	3	13	16	1
River Flow and Level Observation Locations	0	22	22	13

The majority of the hydrometric gauges in UoM 19 are located within the River Lee catchment, downstream of Inchigeelagh. These gauges have been reviewed by the River Lee Pilot CFRAM study, therefore these gauges are not considered within this report. Only one river level gauge is used namely Castlemartyr (19003) with data ranging from 1976 to 1993. The river level gauges have recorded water levels at 15 minute intervals using telemetry since 1976 and these river level gauges will be used to inform the calibration of the hydraulic models. Data quality and coverage has been reviewed in Chapter 4 of this report.

EPA has also provided spot river flow and level measurements which are observed manually on a regular basis (2 to 8 measurements per year). These spot gaugings are often observed during periods of low flow to monitor water resource and environmental demands as well as minimise health and safety risks. It is not appropriate to use these observations in the analysis of high flows for the UoM19. However, the spot gauging data will help inform typical water level profiles across Lough Allua from Ballingeary to Inchigeelagh.

2.3 Meteorological Data

Meteorological data for rainfall gauges in and around UoM 19 was provided by Met Éireann. Table 2.2 summarises the available meteorological gauges.

Table 2.2: Available Rainfall Gauges

Type	Met Éireann Gauges	Total Gauges Available	Gauges Used in Study
Daily Rainfall Gauges	73	73	7
Synoptic Stations (weather forecasting locations including rainfall)	2	2	2

Of the 73 daily rain gauges, 61 have data over 10 years with the longest data record at University College Cork with 105 years of rainfall records. The synoptic stations are located outside Cork and provide hourly

rainfall data from 1955 onwards. Chapter 4 of this report provided further analysis of the rainfall data coverage, quality and suitability for derivation of design rainfall.

2.4 Coastal Data

Tidal and sea level data was provided by OPW for Youghal Bay in UoM 18 along with the calculated points from the national studies on extreme coastal conditions. The only tidal gauge available for the SWRBD CFRAM Study located at Ballycotton. The Ballycotton sea level gauge records total sea level at 15 minute intervals and has been operational since 2007. There was no other observed tidal data available for the SWRBD CFRAM Study. The impacts of this are discussed in Section 2.11 of this report.

The Irish Coastal Protection Strategy Study (ICPSS) data has been approved by OPW for use directly as the coastal boundaries for the South Western CFRAM models. The extreme sea levels will be used to define the magnitude of the tidal events at the tidal outfall of the River Womanagh. The coverage of this data is discussed in greater detail in Chapter 4 of this report.

The Irish Coastal Water Level and Wave Study (ICWWS) did not identify any areas at risk from flooding caused by waves in UoM 19. Therefore we will not consider wave overtopping in UoM 19.

2.5 Survey Data (including LIDAR & IFSAR)

Chapter 3 outlines the required survey data which is being procured under Survey Contract 5 which is currently underway. However, final delivery dates are not yet clear due to issues with Fresh Water Pearl Mussels. IFSAR data has been provided.

2.6 Environmental Data

An extensive range of environmental and land use information has been gathered for use in the study. We shall draw upon this information for the purpose of meeting our project deliverables. The data will be used to inform environmental site surveys, to cross compare Water Framework Directive and Flood Studies Update catchment boundaries, to inform the Strategic Environmental Assessment and Appropriate Assessment and as necessary to portray relevant information at public consultation. A list of the environmental data collected is contained in Table 2.3 below.

Table 2.3: Environmental Data

Description	Format	Owner	Date	Fitness for purpose / Quality
Abstractions	GIS		17/12/2009	Fit For Purpose
Alien Species	GIS	NPWS	12/05/2005	Needs to be updated
Aquaculture Sites (Licensed)	GIS	-	22/12/2009	Fit For Purpose
Artificial Water Bodies	GIS	SWRBD	23/10/2008	Fit For Purpose
Bat Roosts in South West	GIS	NPWS	03/01/2012	Fit For Purpose
Coastal Water Body Status (as per RBMP)	GIS	EPA	17/02/2010	Fit For Purpose
Combined Sewer Overflows	GIS	EPA	01/03/2005	Needs to be updated
Corine 2006	GIS	EPA	03/09/2009	Fit For Purpose
Ecological Information - confidential information	GIS	NPWS	05/04/2012	Needs to be updated
EPA Biological Stations (Q Stations)	GIS	EPA	16/11/2005	Needs to be updated

Description	Format	Owner	Date	Fitness for purpose / Quality
EPA Waste facilities (including landfills)	GIS	EPA	20/04/2012	Fit For Purpose
Fresh Water Pearl Mussel	GIS	NPWS	12/05/2005	Needs to be updated
FWPM SAC	GIS	NPWS	19/08/2009	Needs to be updated
Groundwater Bodies	GIS	EPA	02/02/2008	Fit For Purpose
Groundwater Body Status (as per RBMP)	GIS	EPA	17/02/2010	Fit For Purpose
Groundwater Monitoring Stations	GIS	EPA	22/03/2007	Fit For Purpose
Groundwater Status	list	RPS	17/02/2010	Fit For Purpose
Heavily Modified Water Bodies	GIS	SWRBD	12/12/2008	Fit For Purpose
IPPC Licenses	GIS	EPA	20/04/2012	Fit For Purpose
Lake Status	list	RPS	17/02/2010	Fit For Purpose
Lake Topography & Bathymetry	GIS	SWRBD	26/06/2008	Fit For Purpose
Lake Water Bodies	GIS	EPA	04/05/2005	Fit For Purpose
Lake Water Body Status (as per RBMP)	GIS	EPA	17/02/2010	Fit For Purpose
Landscape	pdf	LA	02/12/2011	Needs to be updated
License Aquaculture	GIS	-	12/12/2009	Fit For Purpose
Main Lakes	GIS	EPA	01/03/2003	Fit For Purpose
Mines	GIS	GSI	01/03/2005	Fit For Purpose
Monuments - Summary of Types in National Monuments Data Series	Excel	OPW	02/12/2011	Fit For Purpose
NHA	GIS	NPWS	04/05/2005	Needs to be updated
Non-EPA Landfills	GIS	LA	01/03/2005	Needs to be updated
Quarries	GIS	LA	01/03/2005	Needs to be updated
Recreational Waters	GIS	NPWS	19/07/2006	Needs to be updated
River Segments and Status	list	RPS	17/02/2010	Fit For Purpose
River Water Body Basin Polygons	GIS	EPA	04/05/2005	Fit For Purpose
River Water Body Status (as per RBMP)	GIS	EPA	17/02/2010	Fit For Purpose
River Waterbody Status	list	RPS	17/02/2010	Fit For Purpose
SAC	GIS	NPWS	16/03/2010	Fit For Purpose
SAC Vulnerability Assessment - habitats & species assessment and overall site classification	Excel	OPW	02/12/2011	Fit For Purpose
Salmonid Waters	GIS	NPWS	12/05/2002	Needs to be updated
SEA Background Information	Excel	OPW	02/12/2011	Fit For Purpose
SEA Background Information - AA EPA feedback	pdf	EPA	02/12/2011	Fit For Purpose
SEA Background Information - emails and feedback	pdf	EPA	02/12/2011	Fit For Purpose
SEA Background Information - emails and non-technical summary with review comments	pdf, Word	OPW	02/12/2011	Fit For Purpose
SEA Background Information - EPA preliminary comments (17.05.10)	Word	EPA	02/12/2011	Fit For Purpose
SEA Background Information - FEMFRAM Scoping Report comments from EPA	pdf	EPA	02/12/2011	Fit For Purpose
SEA Background Information - NPWS comments on FEMFRAM AA	pdf	NPWS	02/12/2011	Fit For Purpose
SEA Background Information - Suir Scoping Report comments from EPA	pdf	EPA	02/12/2011	Fit For Purpose

Description	Format	Owner	Date	Fitness for purpose / Quality
Section 4 Licenses	GIS	LA	20/04/2012	Fit For Purpose
Shellfish Designated Areas	GIS	DEHLG	27/04/2009	Fit For Purpose
Soils	GIS	Teagasc	30/04/2006	Fit For Purpose
SPA	GIS	NPWS	-	Needs to be updated
SPA Vulnerability Assessment - classification	Excel	OPW	02/12/2011	Fit For Purpose
Subsoils	GIS	Teagasc	30/04/2006	Fit For Purpose
Surface Water Monitoring Stations	GIS	EPA	22/03/2007	Fit For Purpose
SWRBD Onsite Waste Water treatment systems	GIS	-	22/12/2009	Fit For Purpose
SWRBD Private Forestry	GIS	RPS	15/01/2010	Fit For Purpose
SWRBD Public Forestry	GIS	RPS	15/01/2010	Fit For Purpose
Trac Status	list	RPS	17/02/2010	Fit For Purpose
Transitional Water Bodies	GIS	EPA	04/05/2005	Fit For Purpose
Transitional Water Body Status (as per RBMP)	GIS	EPA	17/02/2010	Fit For Purpose
Waste Water Treatment Plants	GIS	EPA	04/11/2009	Needs to be updated
Water Treatment Plants	GIS	LA	-	Needs to be updated

2.7 Receptor Data

Extensive receptor data was gathered which when combined with the flood hazard will allow for determination of flood risk. A list of the receptor data is contained in Table 2.4 below.

Table 2.4: Receptor Data

Category	Description	Format	Owner	Date	Fitness for purpose / Quality
Cultural Heritage	Monuments - National Datasets	Mapinfo	DEHLG	02/12/2011	Fit For Purpose
Cultural Heritage	Museum Directory	MapInfo, Excel	IMA	02/12/2011	Fit For Purpose
Cultural Heritage	National Monuments - National Data Series	Excel	OPW	02/12/2011	Fit For Purpose
Cultural Heritage	NIAH Buildings - National Dataset	Mapinfo	NIAH	02/12/2011	Fit For Purpose
Economic	Airports	Mapinfo	Irish Aviation Authority	02/12/2011	Fit For Purpose
Economic	EPA Waste Facilities (including landfills)	GIS	EPA	20/04/2012	Fit For Purpose
Economic	Harbours & Slips	GIS	SWRBD	09/05/2005	Fit For Purpose
Economic	IPPC Licenses	GIS	EPA	20/04/2012	Fit For Purpose
Economic	Mines	GIS	GSI	01/03/2005	Fit For Purpose
Economic	Non-EPA Landfills	GIS	LA	01/03/2005	Needs to be updated
Economic	NRA Road Network (2010)	ESRI	NRA	02/12/2011	Fit For Purpose
Economic	Ports and Harbours in Ireland	MapInfo, Excel, pdf	Department of Agriculture, Fisheries,	02/12/2011	Fit For Purpose

Category	Description	Format	Owner	Date	Fitness for purpose / Quality
			Food and Transport		
Economic	Quarries	GIS	LA's to start reporting in June 2010	01/03/2005	Needs to be updated
Economic	Rail Network and Stations	AutoCAD	Iarnrod Éireann	02/12/2011	Fit For Purpose
Economic	Section 4 Licenses	GIS	LA	20/04/2012	Fit For Purpose
Economic	Utilities Data	MapInfo	ESB, Bord Gais, Eircom	02/12/2011	Fit For Purpose
Economic	WWTPs & WTPs Locations	MapInfo	EPA	02/12/2011	Needs to be updated
Environmental	Abstractions	GIS	-	17/12/2009	Fit For Purpose
Environmental	Aquaculture Sites (Licensed)	GIS	-	22/12/2009	Fit For Purpose
Environmental	Bat Roosts in South West	GIS	NPWS	03/01/2012	Fit For Purpose
Environmental	Fresh Water Pearl Mussel	GIS	NPWS	12/05/2005	Needs to be updated
Environmental	FWPM SAC	GIS	NPWS	19/08/2009	Needs to be updated
Environmental	Groundwater Bodies	ESRI & Excel	EPA	02/12/2011	Fit For Purpose
Environmental	Licensed IPPC Facilities	ArcView	EPA / LA	02/12/2011	Fit For Purpose
Environmental	Natural Heritage Areas	Mapinfo	NPWS	02/12/2011	Needs to be updated
Environmental	Outstanding Landscapes in Ireland	pdf		02/12/2011	Fit For Purpose
Environmental	Proposed Natural Heritage Areas	Mapinfo	NPWS	02/12/2011	Needs to be updated
Environmental	Recreational Waters	GIS	NPWS	19/07/2006	Needs to be updated
Environmental	SAC	GIS	NPWS	16/03/2010	Needs to be updated
Environmental	SAC Habitats & Species Assessment and Overall Site Classification	Excel	OPW	02/12/2011	Needs to be updated
Environmental	Salmonid Waters	GIS	NPWS	12/05/2002	Needs to be updated
Environmental	Shellfish Designated Areas	GIS	DEHLG	27/04/2009	Fit For Purpose
Environmental	SPA	GIS	NPWS	-	Needs to be updated
Environmental	SPA - Classification	Excel	OPW	02/12/2011	Needs to be updated
Environmental	Special Areas of Conservation	Mapinfo	NPWS	02/12/2011	Needs to be updated
Environmental	Special Protection Areas	Mapinfo	NPWS	02/12/2011	Needs to be updated
Social	Civil Defence HQ's	Mapinfo, Word	Department of Defence	02/12/2011	Fit For Purpose
Social	CSO 2006 Census	Excel	An Post GeoDirector y	02/12/2011	Fit For Purpose will need to be updated
Social	Fire Stations	Mapinfo, Excel	DEHLG	02/12/2011	Fit For Purpose
Social	Garda Stations	Mapinfo, Excel	OPW	02/12/2011	Fit For Purpose
Social	Geo-directory (July 2011)	MS Access Database	An Post GeoDirector y	02/12/2011	Fit For Purpose
Social	Government Building under OPW	Mapinfo, Excel	OPW	02/12/2011	Fit For Purpose

Category	Description	Format	Owner	Date	Fitness for purpose / Quality
Social	Health Centres	Mapinfo, Excel	HSE	02/12/2011	Fit For Purpose
Social	Hospitals	Mapinfo, Excel	HSE	02/12/2011	Fit For Purpose
Social	Nursing Homes	Mapinfo, Excel	HSE	02/12/2011	Fit For Purpose
Social	Post Primary Schools	MapInfo	Department of Education	02/12/2011	Fit For Purpose
Social	Primary Schools	MapInfo	Department of Education	02/12/2011	Fit For Purpose
Social	Public Residential Care for The Elderly	Mapinfo, Excel	HSE	02/12/2011	Fit For Purpose
Social	Third Level Institutions	Mapinfo	Higher Education Authority	02/12/2011	Fit For Purpose

2.8 Flood Event Data

A significant amount of flood event data has been identified and collected from a number of sources. These sources include the OPW Floodmaps website, Local Authorities and other stakeholders. All flood event data including maps, photographs and reports has been downloaded from floodmaps.ie and all available reports and studies from Local Authorities and stakeholders gathered. In addition to the above, flood event data and information was also gathered during the Flood Risk Review stage and following specific Flood Event Reviews. This information / data includes anecdotal evidence and testimonials from landowners, locals etc. A summary list of flood event data sources used is contained in Table 2.5 below.

Table 2.5: Flood Event Data

Description	Format	Owner	Date	Fitness for purpose / Quality
Flood Data Collection	Excel	OPW	02/12/2011	Professional judgement should be applied to the use of data
Historical Flood Data	MapInfo, Excel	OPW	02/12/2011	Professional judgement should be applied to the use of data
PFRA Groundwater Flooding Reports	pdf	OPW	02/12/2011	Professional judgement should be applied to the use of data
Cork – New PFRA data	pdf	OPW	08/02/2012	Fit for purpose
Waterford – New PFRA data	pdf	OPW	08/02/2012	Fit for purpose
Flood Risk Review Reports	MS Word	OPW	01/02/2012	Fit for purpose
Flood Event Review Reports	Excel / pdf	OPW	Ongoing-	Professional judgement should be applied to the use of data

2.9 Flood Defence Asset Data

Data relevant to flood defence assets, which includes data used to identify and locate flood defence assets within AFAs, MPWs and HPWs, has been gathered. A list of the relevant flood defence asset data is contained in Table 2.6 below. This data does not represent the survey requirements for flood defence assets and as stated, contains data used only in identifying and locating defence assets.

Table 2.6: Relevant Flood Defence Asset Data

Description	Format	Owner	Date	Fitness for purpose / Quality
Dredged Area	GIS	SWRBD	09/05/2005	Fit for purpose
HDTM (20m resolution hydrologic correction to DTM)	GIS files	EPA	02/12/2011	Fit for purpose
Lakes	MapInfo	EPA	02/12/2011	Fit for purpose
Marine Embankments	GIS	SWRBD	01/04/2008	Fit for purpose
Marine Shoreline Reinforcement	GIS	SWRBD	15/04/2008	Fit for purpose
NDHM (5m resolution IFSAR)	MapInfo	OPW	02/12/2011	Fit for purpose
Omitted Watercourses	MapInfo	JBA	02/12/2011	Fit for purpose
OPW Benefiting Lands	MapInfo	OPW	02/12/2011	Fit for purpose
OPW Channels	MapInfo	OPW	02/12/2011	Fit for purpose
OPW Embankments	MapInfo	OPW	02/12/2011	Fit for purpose
OSi Maps	Mapinfo	OPW	02/12/2011	Fit for purpose
PFRA Breakdown	MapInfo	OPW	02/12/2011	Fit for purpose
PFRA Combined Point Receptors	MapInfo	Various	02/12/2011	Fit for purpose
PFRA Final Database	Access, MapInfo	OPW	02/12/2011	Fit for purpose
PFRA Pluvial Screening	pdf	OPW	02/12/2011	Fit for purpose
River Centrelines	ESRI	OPW (FSU)	02/12/2011	Generally OK. Some discrepancies.
Tidal Barrages	GIS	SWRBD	09/05/2005	Fit for purpose

2.10 Outstanding Data

Table 2.7 lists the outstanding data that is required for the detailed hydrological and hydraulic assessments.

Table 2.7: Outstanding Data for UoM 19

Type	Location	Comments	Source	Required by	Impact of non provision of data
River Lee Pilot CFRAM Study ISIS Model Upper Lee	Upper Lee, Ballingeary and Inchigeelagh	ISIS model and results files for 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP events at Ballingeary	Lee Catchment Flood Risk Management Study, Hydraulics Report. Halcrow/OPW	08/03/2013	Will not be able to review Study
Womanagh River Photos and extents report	Womanagh River (Castlemartyr / Killeagh)	Photos and extent information of October 2004 flooding	OPW	08/02/2013	Models will be calibrated with less accuratet data

2.11 Unavailable Data

It has been determined that some hydrometric data will not be available for the South West CFRAMs. Table 2.8 lists the data that is not available and suggests how these data gaps will be overcome in the hydrological assessment.

Table 2.8: Unavailable Hydrometric and Coastal Data for UoM 19

Data Type	Impact	Proposed Mitigation
Rainfall data at Inchigeelagh post-1992	Limits calibration of hydraulic model	Apply relationship between with Ballingeary and Inchigeelagh derived from earlier concurrent data period
Observed Lough Allua levels	Limits analysis of the Lough Allua and accuracy of downstream conditions for Ballingeary	Use historic reports and OPWs local knowledge to inform the development of a representative water level profile.
Castlemartyr and Killeagh observed flow for all calibration events and observed level data for 2009 calibration event	Limits calibration of hydraulic models	Use photos, historic flood reports and anecdotal evidence to conceptually calibrate the model. Undertake sensitivity testing to establish uncertainty in model results

3. Survey Requirements

3.1 River Channel Survey

The Survey Requirements for Unit of Management 19 are detailed in Table 3.1 below. These include the survey of a total of 184 river cross sections, approximately 13 linear kilometres of flood defence assets and approximately 29km of water courses.

The required survey information will be gathered as part of Survey Contract Nr. 5 which is currently underway. Final delivery of the data for UoM 19 is due in December 2012.

Table 3.1: Survey Requirements within Unit of Management 19

Description	Units	UoM 19
Total Nr. Cross Sections	**Nr.**	**184**
upstream node at a junction	Nr.	0
downstream node at a junction	Nr.	3
conduit section	Nr.	0
upstream node at a bridge	Nr.	18
downstream node at a bridge	Nr.	14
extended cross section	Nr.	0
upstream node at a floodplain section	Nr.	0
downstream node at a floodplain section	Nr.	0
open channel	Nr.	139
upstream node at a culvert inlet\outlet unit	Nr.	0
downstream node at a culvert inlet\outlet unit	Nr.	0
lateral spill on the left bank	Nr.	0
upstream node at an orifice	Nr.	0
downstream node at an orifice	Nr.	0
lateral spill on the right bank	Nr.	0
upstream node at a spill	Nr.	0
downstream node at a spill	Nr.	0
upstream node at a weir	Nr.	7
downstream node at a weir	Nr.	3
Total Linear Flood Defences	**km**	**13.1**
Identified	km	2.7
Possible	km	10.4
Total Length of Watercourse	**km**	**29.3**
HPW	km	8.3
MPW	km	21.0

3.2 Floodplain Survey

The floodplain survey includes level and location data for the floodplains of the relevant reaches of the channels in the study area. This survey is necessary for the construction of a hydraulic model adequate to meet the objectives of the study. The floodplain survey will be in the form of DTM and, or, DEM data derived from a survey using LIDAR or similar systems.

This data has been provided by OPW. Following receipt of the data from Survey Contract 5, the floodplain survey will be reviewed and assessed to determine if it is fit for purpose and compatible with the modelled schema.

3.3 Flood Defence Asset Condition Survey

The flood defence asset condition survey is a condition survey of all flood defences identified within AFA's and all defined flood defences along MPW's or in coastal areas. The survey includes the identification, inspection, photographing and assessment of flood defence assets and the entry of all relevant data into the Defence Asset Database. Details of the location and type of flood defence assets to be surveyed as part of the CFRAM Study are contained in a GIS database file entitled SWCFRAM_Flood_Defence_Assets. This file will be made available to the Study team along with this report.

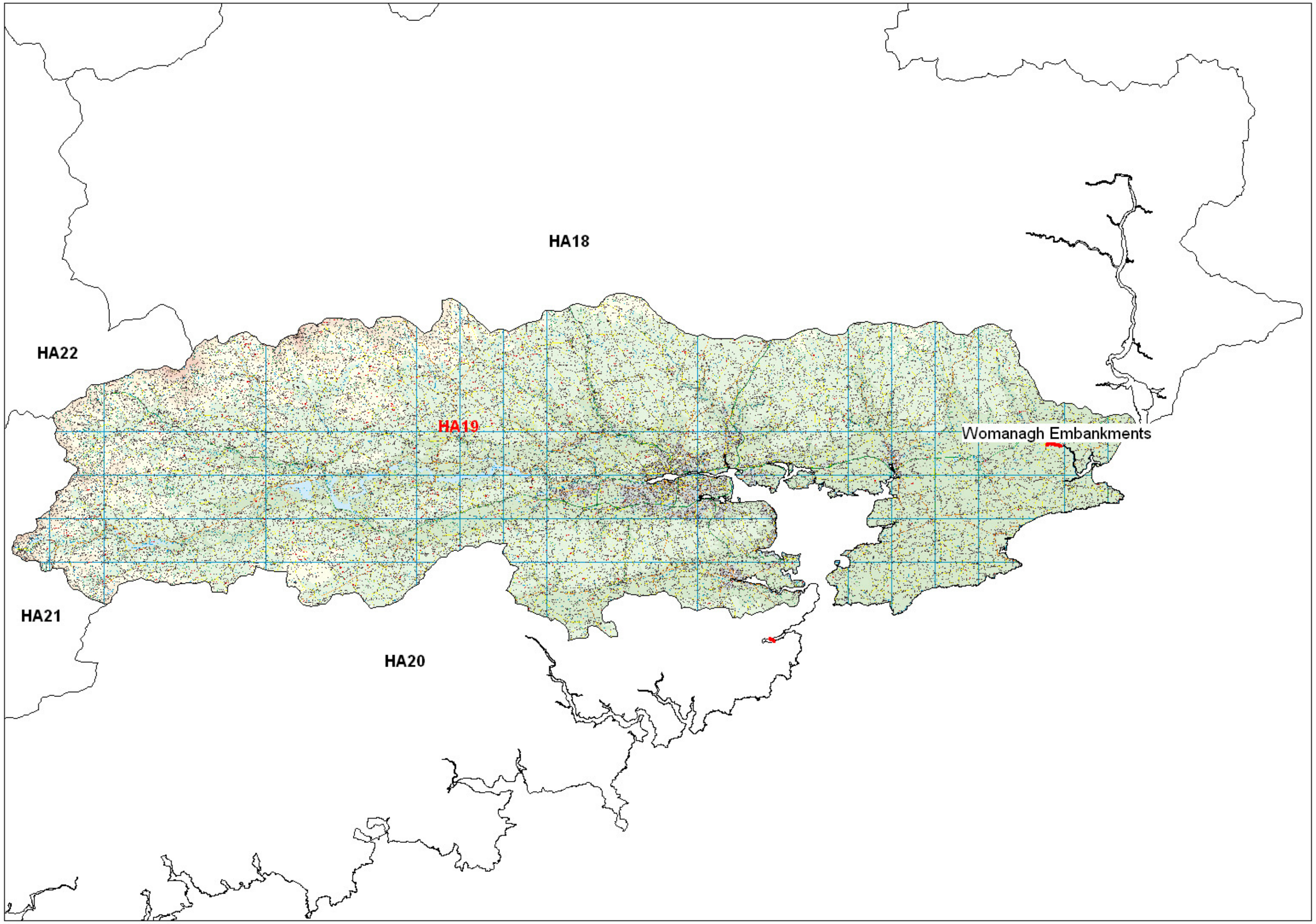
The flood defence asset condition survey has not yet been carried out. The survey will be undertaken following the completion of the river channel survey, which will identify undefined assets, and receipt of the flood plain survey (DTM / DEM data).

The flood defence assets to be surveyed as part of the Study are listed in Table 3.2 below. The locations of these defences are shown in Figure 3.1.

Table 3.2

Name	Type	Description
Womanagh Embankments	Embankment	Womanagh DD

Figure 3.1: Flood Defence Locations



3.4 Property Level Survey

The property survey includes gathering information on property location, type, use, etc. for all properties potentially at risk from flooding. The primary purpose of the property survey is to inform the damage / benefit analysis required to meet the project objectives. OPW have provided a licensed copy of the An Post GeoDirectory. Property ground floor levels will be determined using the DTM data and a specific height that will be based on observations / measurements for each AFA along with spot checks.

The property level survey has not yet been carried out. The survey will be undertaken following the completion of the river channel survey.

4. Preliminary Hydrological Assessment

This section details the analysis of river flow, rainfall and tidal level data to be as well as a preliminary review of historical flood events.

This section covers the following requirements of the CFRAM brief:

- Review and analyse recorded water levels, including tidal and surge levels, and estimated flows with a description of the quality, fitness-for-purpose and interpretation of such data.
- Review and analyse recorded rainfall data with a description of the quality, fitness-for-purpose and interpretation of such data.
- Review and analyse all available previous studies and reports and the historic flood data collected in terms of peak levels, flood extents, etc. and rank in terms of magnitude.

4.1 Hydrometric Data Review

The locations of river gauges in the catchment with available water level and flow data are shown in Map 4.1.

The existing hydrometric data has been assessed for the following common issues:

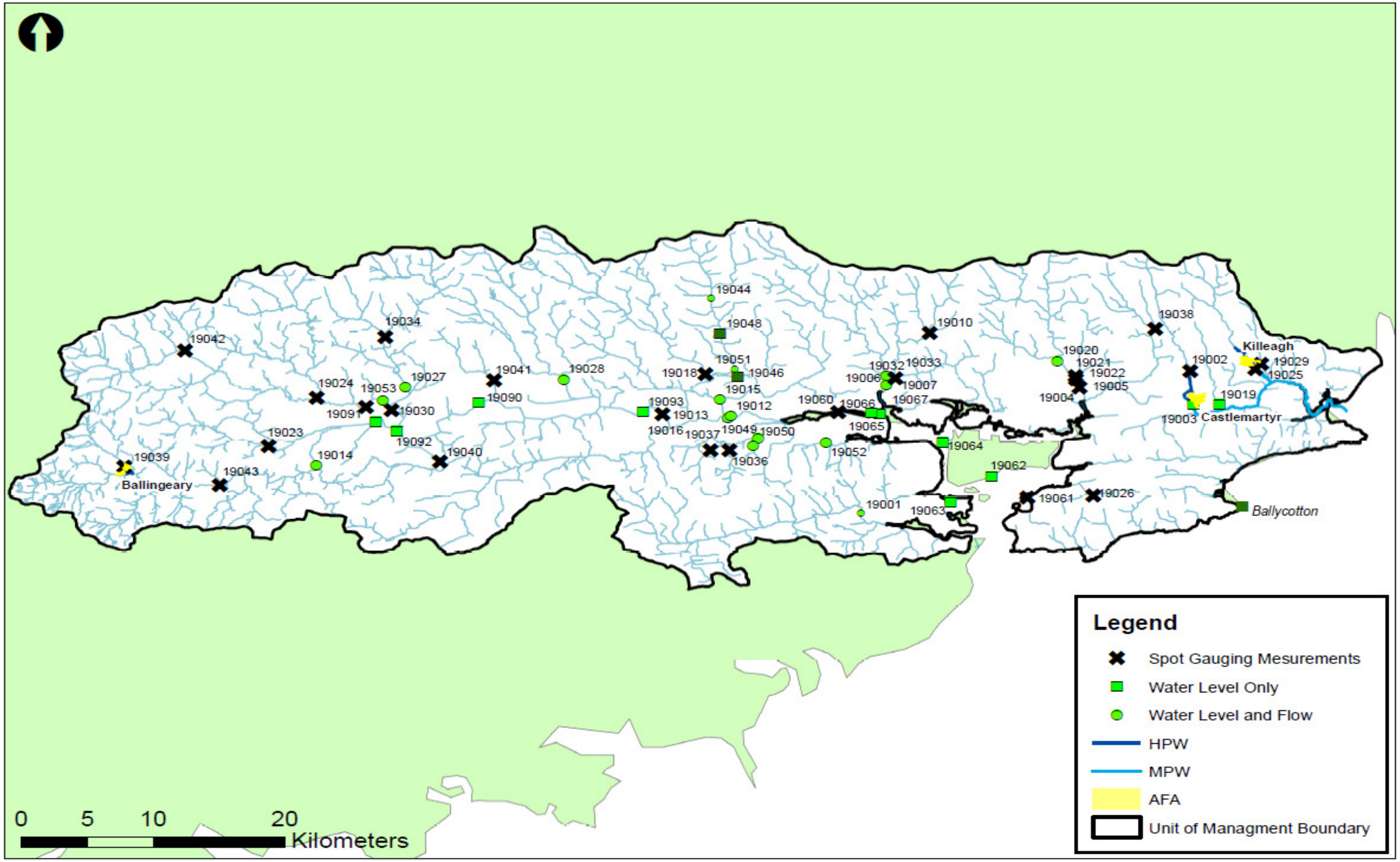
- Anomalous spike or dips in water level and/or flow from the continuous data records;
- Capping of water level and/or flow, particularly for extreme events at fluvial gauges where extreme flows may be out-of-range;
- Trends in water level or flow over time that might be caused by systematic error of gauging equipment or erosion/sedimentation;
- Sudden shifts in level of the gauging datum;
- Comparison of AMAX flows and levels from digital gauged data with manually extracted AMAX series;
- Anomalously high or low AMAX flood event AMAX series at each gauge;
- Consistency of concurrent high flows downstream for AMAX events;
- Length of data record to enable hydrological analysis; and,
- Any significant data gaps.

Stations 19003 and 19019: Castlemartyr gauge on the Kiltha River and Dower gauge on the River Dower were found to be unsuitable for statistical analysis as there are no existing flow records or spot gaugings to derive a rating curve. Furthermore, the Dower gauge has less than 2 years' record and displays significant periods of missing data, trending and capping of peak flows. The Dower gauge is also located at the spring outfall of a karstic system so the gauge records are heavily influenced by groundwater and subterranean flows, making surface water flood estimation difficult. The poor data quality at Dower gauge has resulted in the site being rejected for statistical analysis. However, the water level record at Castlemartyr gauge will be used to inform the calibration process and typical hydrograph shape at Castlemartyr for events up to 1993 (record end).

Station 19039 and 19043: There were only low flow spot gaugings available for the Ballingeary and Inchigeelagh gauges on the Upper Lee/ Lough Allua, making these unsuitable for statistical analysis of extreme flood events. However, the available spot gaugings will be used in conjunction with OPW's local knowledge to inform the lake level profile and representative flood hydrograph shape that leads to flooding in Ballingeary.

Appendix A contains a list of the selected gauges for the preliminary hydrological analysis.

Map 4.1: Available Hydrometric Data



Source: OPW and EPA

4.2 Meteorological Data Review

Available meteorological data from rain gauges and synoptic stations in and near to catchment are shown in Map 4.2.

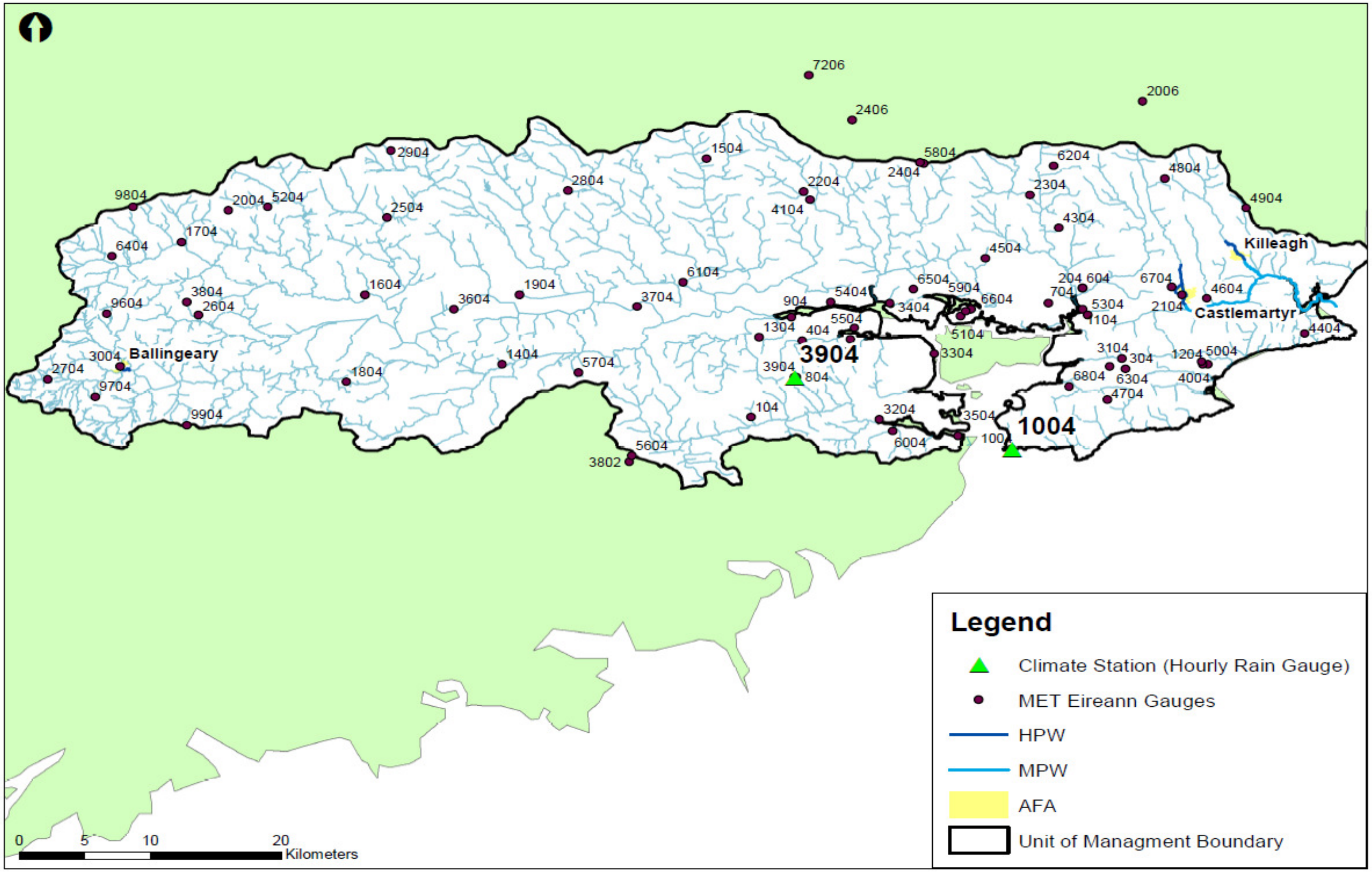
The existing meteorological data has been assessed for the following common issues:
- Spatial distribution of intensity loggers and respective storage gauges (event based);
- Identification of gaps or erroneous data which have been cross-referenced with the Met Eireann climate stations to assess if significant events have been omitted;
- Identification of shifts in rainfall records using temporal and cumulative plots; and,
- Analysis of cumulative rainfall for key historic events.

The rain gauges at Ballingeary (3004) and Tarelton near Inchigeelagh (1804) have been selected for the analysis of typical rainfall patterns and phasing for the Ballingeary AFA.

Detailed hourly rainfall is limited to Cork Airport (3904) and Roches Point (1004) only. However, there is good spatial coverage of daily rainfall gauges. In particular there is long term daily rainfall data in the vicinity of Ballingeary which will help provide flow information for the AFA as there is no long term water level or flow data.

There is no rainfall data for Castlemartyr from 1965 to 2000. However, rainfall will be interpolated from nearby gauges to the west of Cork Harbour to establish representative rainfall for calibration events. Rainfall-runoff modelling is not necessary for the derivation of design flows for the Womanagh Catchment as pivotal sites will be used to calculate design flows.

Map 4.2: Available Meteorological Data

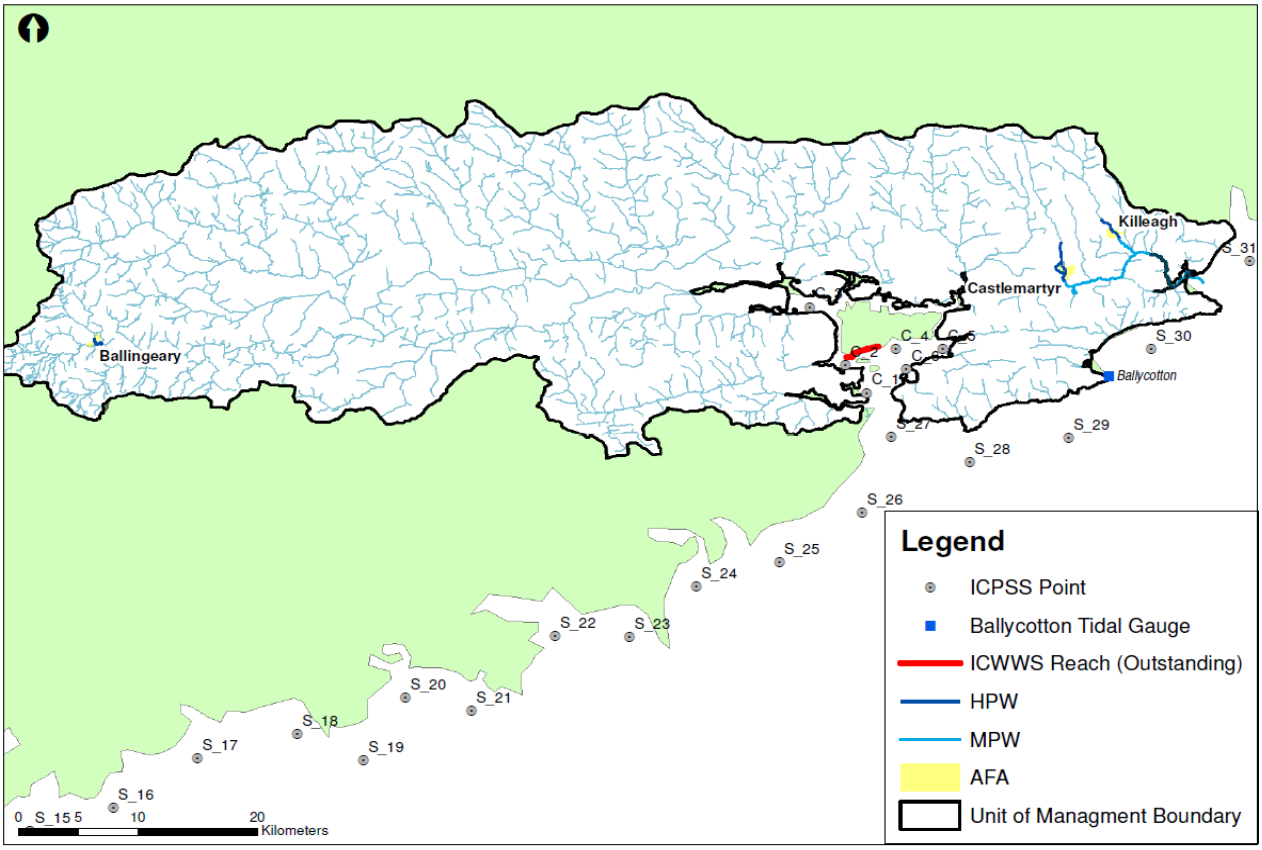


Source: Met Éireann

4.3 Coastal Data Review

Map 3.3 shows the extreme coastal water level points and locations of other available coastal data.

Map 4.3: Available Coastal Data



Source: ICPSS, ICWWS and OPW

The Irish Coastal Protection Strategy Study (ICPSS) data has been approved by OPW for use directly as the coastal boundaries for the South Western CFRAM models. The extreme sea levels will be used to define the magnitude of the tidal events in Youghal Bay, including the tidal outfall of the River Womanagh. The Irish Coastal Water Level and Wave Study (ICWWS) will also provide extreme water levels along with extreme wave heights, wave periods and mean wave direction at Cobh. However, assessment of Cobh is not within the scope of the SWRBD CFRAM study.

Sea level data is also available at Ballycotton gauge since 2007. The data record was checked for erroneous or poor quality data such as shifts in the datum, anomalous spikes and capping. There was minor variation in the peak tide level and low tide levels, probably as a result of the gauging equipment and variable atmospheric influences. The oscillation was within a 0.1 m tolerance and the data series was deemed fit for purpose.

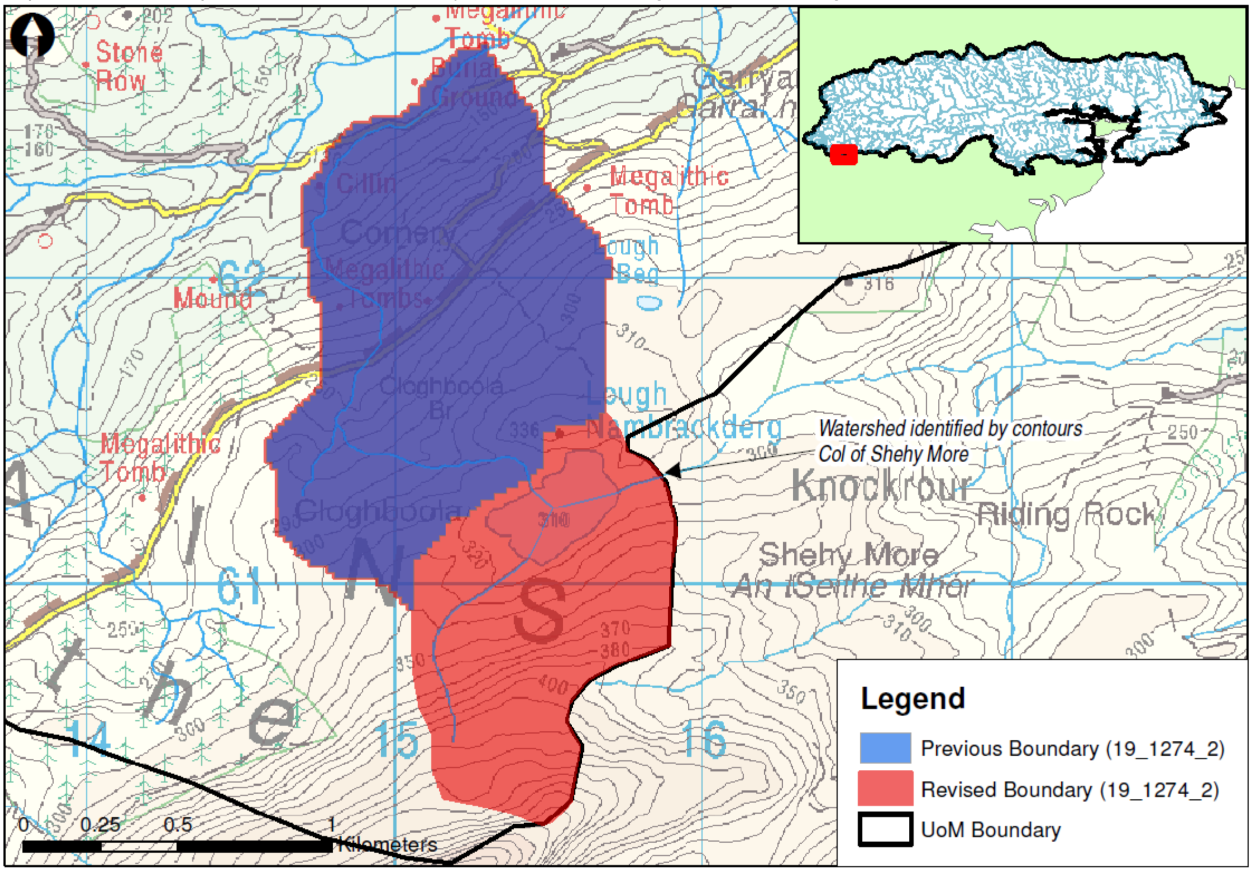
4.4 Physical Catchment Descriptor Review

The catchment has been conceptualised into four major hydrological catchments; the River Womanagh, Kiltha River (Castlemartyr), Dissour River (Killeagh) and Upper Lee (Ballingeary), based on the following principles:

- The characteristics of the sub-catchments and their dominant features;
- The location of the gauging stations providing information on the catchment response to rainfall,
- Information on inter-catchment flow;
- Information on particular flood mechanisms; and
- The level of detail required for the hydraulic modelling inflows as it focuses on AFAs.

GIS spatial analysis was undertaken on the national digital elevation model to determine slope aspect and subsequently used identify the watersheds for each catchment. The outputs from this GIS analysis was compared with the automated FSU catchment boundaries and verified against manual interpretation from ordnance survey mapping at 1:50,000 scale; previous hydrological reports; and, observations from site visits. Overall, the automated FSU catchment boundaries were found to match the ordnance survey mapping well in areas of steep relief. There largest modification was at Lough Nambrackderg with flows into Lough Allua further downstream as shown in Map 4.4 The modifications to the physical catchment descriptors did not significantly changes the parameters for HEP inflow to Lough Allua downstream.

Map 4.4: Example Catchment Boundary Modification, Lough Nambrackderg



The other physical catchment descriptors were also reviewed including; average slope (S1805); average rainfall (SAAR); runoff indicators (SPR); permeability indicators (BFI); and attenuation (FARL). Information

from the Geological Survey of Ireland (GSI) was also used to assess the impact of underlying geology and aquifers on permeability and groundwater dominance as well as inform those catchments influenced by karstic systems.

Analysis of the catchment parameters for UoM 19 indicates that:

- The Womanagh catchment is underlain by karst. The River Dower tributary typically flows through this karstic system via swallow holes which resurface just upstream of Dower.
- The highest standard average rainfall is in the west and north east of the River Lee.
- Ballingeary and areas around Lough Allua tend to have a flashy/rapid response hydrograph when pre-event conditions are already wet. This combined with higher Lough levels from previous rainfall can cause flooding.

All the modifications made to the original FSU database are highlighted in Table B.1, Appendix B.

4.5 Historical Flood Events

4.5.1 Review of Historical Flood Data

Severe historic flood events in the UoM 19 were identified from the historical flood database provided by OPW, from discussions with stakeholders during the Flood Risk Review, from reports carried out on behalf of the Local Authority and the observed water level, flow and meteorological records. A detailed web search was also undertaken to identify reporting of flooding in local newspapers and community forums in the vicinity of the AFAs. Table 4.1 summarises and ranks the key flood events reported at Ballingeary, Castlematyr and Killeagh. The rank refers to peak flow / magnitude only, where flow data is available within the AFA or at a nearby gauge. The hydrographs and historic flood evidence will inform the calibration and verification events for the hydraulic modelling process.

4.5.2 Historical Flood Event Summaries

Flood Event of 2nd November 2011

Due to a period of prolonged rainfall, particularly over an 18 hour period in the Upper Lee Catchment, substantial areas of land flooded, almost flooding local road. No property was damaged, but grazing land was inundated.

Source: OPW South West Region Maintenance (November 2011) South West Upper Lee Flood Report.

Flood Event of 15th January 2011

Flooding affected the areas of Inchigeelagh and Ballingeary on this date and was due to overtopping on the River lee. OPW flood reports indicate that Ballingeary suffered damage to two commercial and one residential building. Within one of the commercial buildings (Butchers) flood waters rose to 0.125m and the main road was temporarily closed.

Inchigeelagh was flooded to the North of the River Lee by up to 0.15m in both the residential and commercial building that was flooded. The road from the bridge to the town centre was closed for several hours.

Source: OPW (January 2011) Flood Event Report Ballingeary 15 January 2011.

Table 4.1: Key Historic Flood Events

	Nearest Gauging Station		Historic Flood Event					
AFA/ HPW	**Station No.**	**Location**	**Date**	**Peak Flow (m3/s)**	**Estimated Duration (hours)**	**Rank**	**AEP (%)**	**Flood Mechanism**
Castlemartyr/ Womanagh River-Kiltha	19019	Dower	19/11/2009	No Data*	15+	1-4 (estimate)	-	Fluvial: Overtopping at Castlemartyr Bridge on the Kiltha River, due to the constriction of flow.
			Recurring†	-	N/A	-	>50	
Inchigeelagh/ River Lee-Lough Allua	N/A	N/A	15/01/2011	No Data‡	5+	-	-	Fluvial: Typically due to the overtopping of the River Lee when the water level at Lough Allua has risen due to previous rainfall events.
Ballingeary/ River Lee-Lough Allua			07/01/2005	No Data‡	-	-	-	
			19/11/2009	No Data‡	15+	1-4 (estimate)	-	
	N/A	N/A	15/01/2011	No Data‡	<24	-	-	
Killeagh/ Dower	19019	Dower	19/11/2009	No Data‡	15+	1-4 (estimate)	-	Pluvial: Surface water runoff caused by poor drainage.
Lee Catchment			06/08/1986	<574**	22	1-4 (estimate)	>1	Fluvial: Prolonged heavy rainfall caused water level rises across lakes and rivers across the lee catchment, causing overtopping in place.
			November 2000	c. 460***	-	1-4 (estimate)	>1	
	N/A	Carrigadrohid Dam	27/10/2004	-	-	1-4 (estimate)	>1	
Upper Lee Catchment	N/A	N/A	02/11/2011	-	-	-	-	Fluvial: Prolonged period of rainfall led to overtopping on the River Lee.

*Gauged data rejected due to poor quality.

†Recurring flooding occurs at this location regularly.

‡No flow data available due to lack of gauged data within catchment.

**Peak inflow to Carrigadrohid dam, according to ESB (1997) River Lee - Flood of 5th/6th August 1986.

***Peak inflow to Carrigadrohid dam, according to ESB (2001) River Lee - Flood of November 2000.

A summary of the key flood events for Ballingeary, Castlematryr and Killeagh areas is given below. Events in the wider Lee catchment have been assessed as part of the Pilot CFRAMs and therefore have not been included here.

Flood Event of 19th November 2009

The flooding of November 2009 was attributed to the heavy rainfall that fell in the preceding days and particularly due to torrential rainfall that fell overnight in the upper Lee Catchment.

Ballingeary experienced flash flooding with depths of up to 1.2 metres. Flooding occurred at 17:30 due to overtopping on the Bunsheelin River at the eastern end of the village. Overall, 19 residential properties were affected, the local school and six commercial properties. 340m of the R584 was also known to be flooded. Residential and commercial losses were estimated at €300,000 and €750,000 respectively (*Meitheal Forbartha na Gaeltachta*, 2009)[1].

At Castleymartyr, flood levels rose to a depth of 0.25m as flood waters rose out-of-bank on the River Kiltha, the R632 road was flooded and 3 residential properties were affected. Killeagh also saw flooding with a maximum level of 0.5m observed.

Source: Meitheal Forbartha na Gaeltachta (2009) Report on Ballingeary Flood, 19th November 2009.

Flood Event 7th January 2005

This flood event was identified by OPW's online historic floods database (www.floodmaps.ie). However, there was insufficient reliable historical evidence regarding this flood event after review of the available reports and online sources to identify the further details of the causes or impacts.

Flood Events November 2000

Rainfall was in excess of 200% the normal monthly average for November. Flooding occurred earlier in the month on the 5th of November and a further event occurred later on the 28th. Across the region large areas of land and some roads were subject to flooding, but no houses were evacuated.

Source: Halcrow (2008) Lee CFRAMS Pilot Hydrology Report.

Flood Event of 6th August 1986

The flood event of August 1986 affected the South West of Ireland most severely and was attributed to a prolonged rainfall event lasting 22 hours. The flooding was widespread throughout the Lee Catchment, affecting the Upper Lee and areas further downstream, such as Macroom, Sullane, Laney Ballincollig and areas of Carrigrohane. Major lakes and rivers reached their maximum level or higher during the flood event and flooding upstream of the Carrigadrohid Reservoir at Ballvourney caused extensive structural damage to three bridges, almost demolishing one at Pol na Bro. At Macroom it was believed to be the most severe flooding that has ever been encountered at the time and a previously unused secondary channel was filled and its course permanently changed by the flood torrents. The flood flow is estimated at 300m^3/s and at Carrigadrohid Dam the highest ever inflow was recorded.[2]

[1] Meitheal Forbartha na Gaeltachta (2009) Report on Ballingeary Flood, 19th November 2009.

[2] Development Planning & Hydraulic Studies Division (1987) River Lee Flood of 5th/6th August 1986 [www.floodmaps.ie]

Extreme flood events also occurred in August 1986, November 2000, November 2002 and December 2006 across the rest of River Lee catchment. However there are no reliable records of flooding at the Ballingeary, Castlemartyr or Killeagh for these events.

Source: Development Planning & Hydraulic Studies Division (1987) River Lee Flood of 5th/6th August 1986 [www.floodmaps.ie]

4.5.3 Selection of Calibration/Verification Events

The calibration and verification of the hydraulic models is important to ensure confidence in the flood modelling and mapping results. The calibration process aims to achieve the best match possible between the model predicted values against observed levels, flood extents and photographic evidence for the out of bank flooding by adjusting key model parameters. The historical events listed in Table 4.1 were assessed for quality and availability of gauge data and supporting historic flood evidence to calibrate water levels and flood extent from photos, reports and anecdotal evidence.

Ballingeary, Castlematyr and Killeagh do not have flow data and only limited historic flood evidence with which to undertake model calibration. Therefore, only two historical events were selected based on the available historic flood evidence for the relevant AFAs in UoM 19:

- 19th November 2009 –Severe catchment wide event with good quality gauge data in the River Lee catchment available and extensive flood photos aerial photograph and reports to calibrate the models.
- 15th January 2011 – Recent flood event at Ballingeary with good quality flood report data and rainfall data.

Extensive sensitivity testing will also be undertaken on the following key parameters to ensure confidence in the results for the hydraulic models:

- Channel and floodplain roughness (Manning's 'n' values)
- Bridge and culvert loss coefficients
- Pre-event catchment conditions/saturation (baseflow levels)

We will seek to verify these sensitivity tests with observed data should any flood event occur during the hydrological stage of SWRBD CFRAM study (completion due in June 2013).

4.6 Flooding Mechanisms

Following the review of the historic reports and other data, the key flood mechanisms identified in UoM 19 include:

- **Fluvial or river flooding:** Fluvial flooding can occur when the capacity of the river channel is exceeded due to excess flow from heavy rainfall or releases from reservoirs upstream. Flood waters typically overtop river banks at low sections or where water is constricted by bridges or culverts forcing water levels to rise upstream and flood surrounding areas. Most of the flooding reported in UoM 19 is attributed to fluvial flooding mechanisms.
- **Pluvial or surface water flooding:** Pluvial flooding can occur when overland flow from intense rainfall or prolonged heavy rainfall is unable to enter the urban drainage network or river channel either because they are already full or there is a blockage. Pluvial flooding is exacerbated by the increase of impermeable areas (such as concrete or tarmac) associated with urbanisation which increases the amount of overland flow. The most recent flooding in Ballingeary was partly attributed to pluvial flooding. It should be noted that the study of pluvial flooding is not included in the scope of the CFRAM Study.

In addition to the mechanisms listed above, flooding in Ireland can also occur from the following:

- **Groundwater flooding:** Ground water flooding can occur when waters levels rise above the ground to flood low-lying fields and property basements, typically when the catchment is saturated. The onset of flooding is very slow and therefore hazard to people is limited. The River Womanagh catchment is likely to be susceptible to this form of flooding as it underlain by highly permeable karstic systems. However, there are no records of groundwater flooding at Ballingeary or in the River Womanagh catchment and groundwater flooding has been discounted from further analysis. It should be noted that the study of groundwater flooding is not included in the scope of the CFRAM Study.
- **Coastal or tidal flooding:** Extreme sea levels, waves and storm surges overtop coastal defences and river banks in tidally influenced reaches, particularly when combined with high river flows for tidal rivers. The risk to people can be very high from this form of flooding as the flood waters can be fast-flowing water. However, there are no records of this flooding mechanism in the River Womanagh catchment and as Ballingeary is remote from the sea, coastal flooding has been discounted from further analysis.

Based on the historical flood evidence, the key mechanisms for each of the AFAs are as follows:

- **Ballingeary and Inchigeelagh:** Flooding typically occurs due to the overtopping of river banks along the River Lee and Bunsheelin River because the excess flows are unable to discharge into Lough Allua when water levels are raised water from previous events. Ballingeary is also identified as at risk from pluvial flooding during intense rainfall events due to the limited capacity of the urban drainage network.
- **Castlemartyr:** Flooding typically occurs due to the overtopping of river banks along the Kiltha River at Mogeely Road as flow through Castlemartyr Bridge is constricted, causing water levels to rise upstream and flood the surrounding area.
- **Killeagh:** Flooding typically occurs due to the overtopping of the banks along River Dissour at Church View as flow through the bridges downstream is constricted, causing water levels to rise upstream and flood Church View.

5. Detailed Method Statement

5.1 Flood Risk Review Approach

The overall flood risk review process ensured that the final definition of the AFA's, which are taken forward for the more detailed aspects of the CFRAM methodology, takes full account of local data. During this process regular feedback was provided to OPW. The Risk Review Report included details on the following aspects:

- The new data received, in addition to the information available during the PFRA stage.
- Details of how the data impacts on the existing AFA's definition.

5.1.1 Site Visits

We carried out walkover surveys of the Communities at Risk and the Areas for Flood Risk Review. We reviewed and updated key aspects of the AFA designation, with particular attention to the preliminary flood hazard and receptor data from the PFRA in each case. This involved the completion of proforma documents during the site visits, for example, to ensure consistency between the reviews of the different areas.

5.1.2 Flooding History

Flooding history taken from anecdotal information from OPW, Local Authorities, previous reports and from the historical analysis for the PFRA was examined as part for the flood risk review. All data on flooding history was given a level of confidence based on the data source and detail. Areas identified as being at flood risk from the flooding history information, but not highlighted within the PFRA, were examined further to see if local characteristics would adversely impact results from the normal depth method. Depending on the level of confidence attached to the data sources the AFA regions were altered to incorporate historical evidence.

5.1.3 Flood Risk Review Report

A Flood Risk Review Report was prepared and submitted to OPW. The report included the following:

- Flood Risk Review methodology (including datasets, information and knowledge used, and details from preliminary risk assessments);
- Outcomes of the Review in areas of significant risk.

5.2 Survey Approach

5.2.1 Channel and Structure Survey

The surveys have been specified and procured. We are currently managing the execution, delivery and quality control of the geometric and geo-referenced survey of channel cross-sections required for the river modelling.

5.2.2 Defence Asset Condition Survey

Once the channel and structure survey is complete (Section 3.3) we shall undertake a condition survey of the flood defence assets as required. This shall include a geometric survey, visual inspection and condition survey of flood defences and their component assets, structures and elements. All data will be inputted to

the Defence Asset Database, including location, photography, flow level and assessment details as well as areas benefiting from protection and the economic value of defended risk receptors.

5.3 Hydrology Approach

5.3.1 Overview

In UoM 19, we will derive peak flood flows and typical hydrographs for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP fluvial flood events along the River Lee and Bunsheelin River at Ballingeary and the River Womanagh catchment including Castlemartyr and Killeagh. The design hydrology for the remaining River Lee catchment has been assessed as part of the River Lee CFRAM pilot study (2009). The hydrological analysis from the pilot study will be reviewed in conjunction with the modelling to incorporate the results into the final flood maps.

The hydrological approach draws on the data review described in Chapter 4 of this report and the latest Flood Studies Update (FSU) guidance. The following sections state the approach for remaining steps to derive design fluvial hydrographs for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP events as boundary conditions for the hydraulic modelling, including:

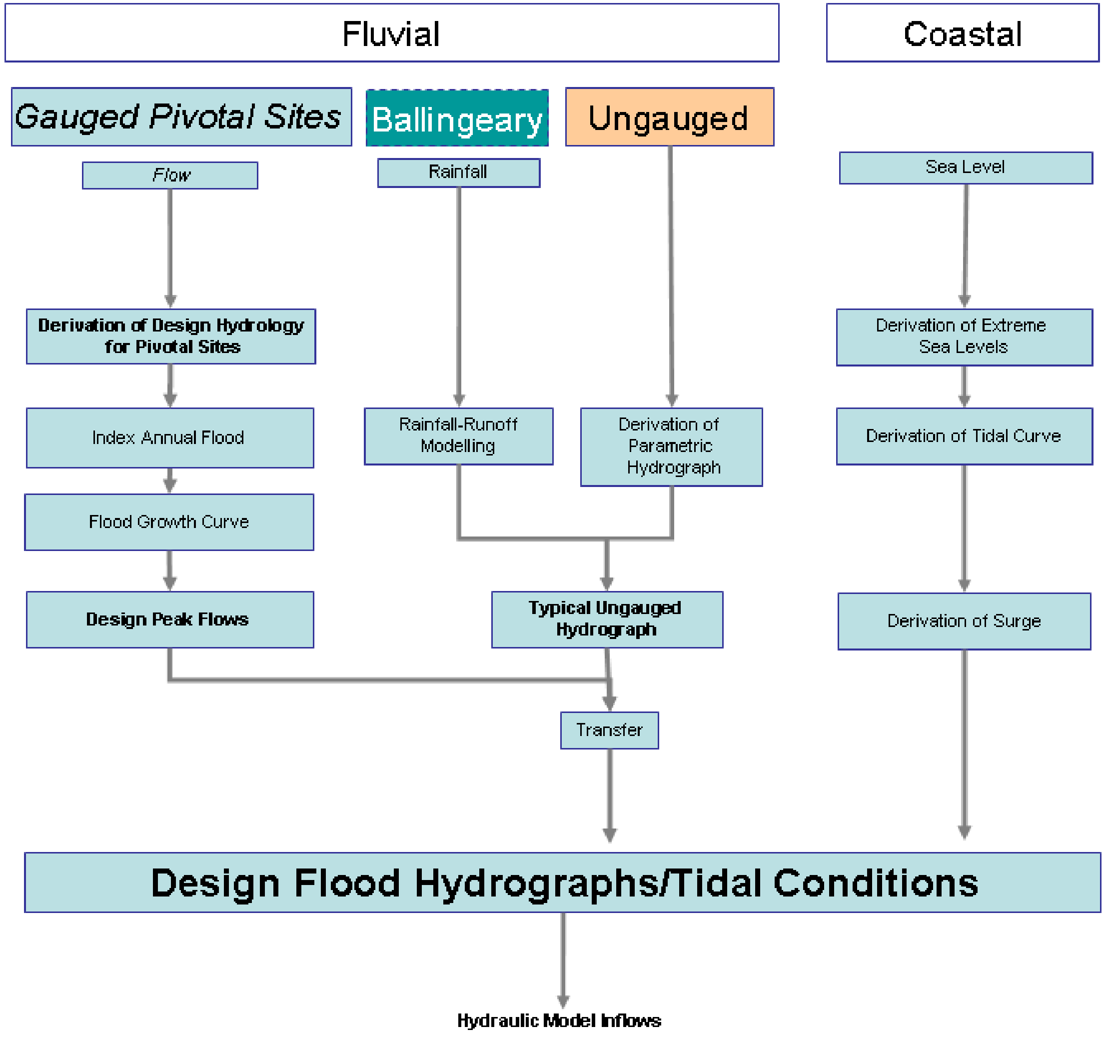
- Hydrological Estimation Point (HEP) Conceptualisation;
- Gauging Stations Rating Reviews;
- Derivation of the Index Flood Flow;
- Derivation of the Flood Growth Curves;
- Derivation of the Typical Flood Hydrograph;
- Phasing of inflows; and
- Consideration of Climate Change.

The design tidal conditions for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP events will follow a similar process, including:

- Derivation of the index extreme sea level;
- Derivation of the tidal flood growth curves;
- Derivation of the typical tidal flood hydrograph;
- Phasing of the tidal, surge and fluvial components; and
- Consideration of Climate Change.

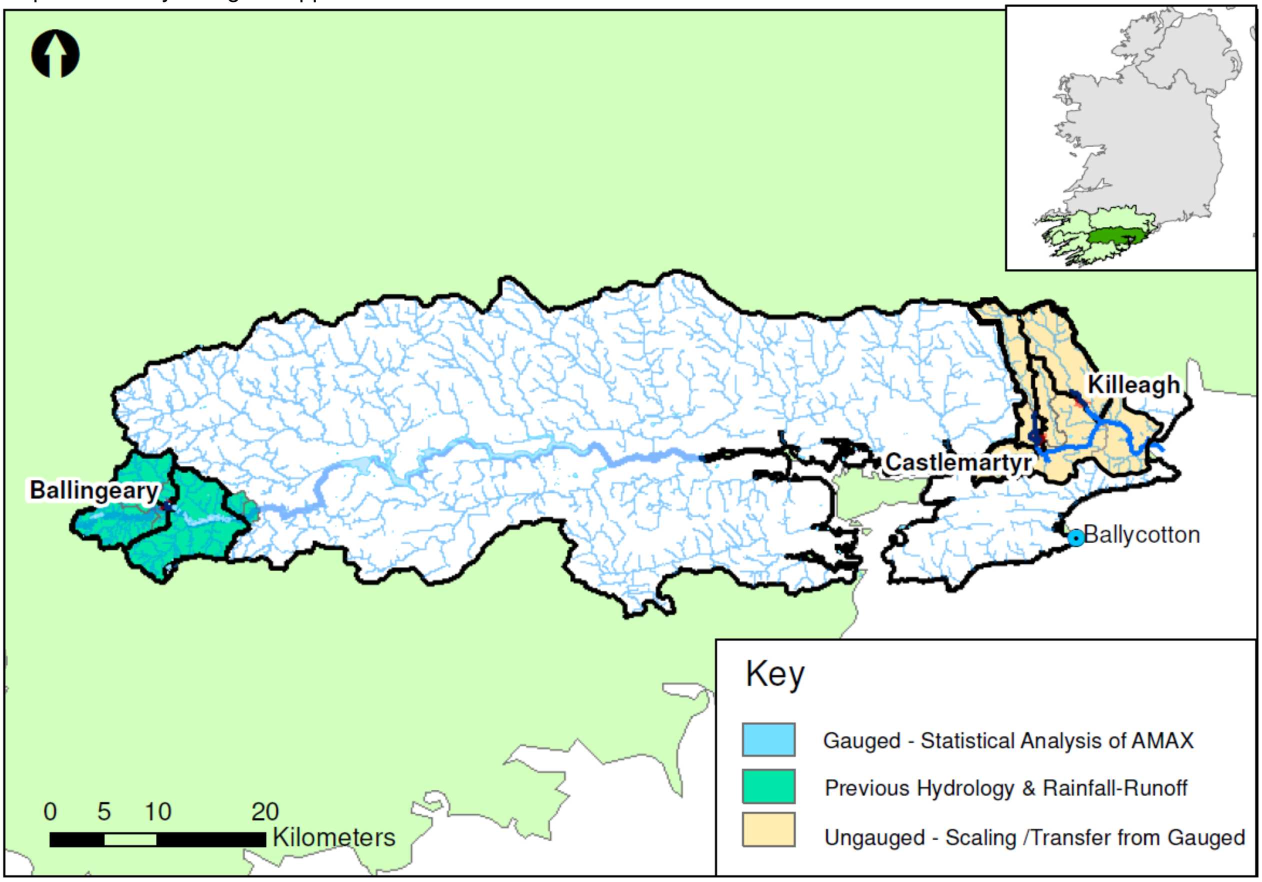
Figure 5.1 outlines the key steps that will be undertaken for each HEP in the hydrological analysis phases as a simplified flow chart.

Figure 5.1: Flowchart of Hydrological Approach in UoM 19



Following this review, the conceptualisation of the major catchments and sub-catchments carefully considered the balance between having too many inflows, thus complicating the model, or too few inflows, so misrepresenting the catchment response at key locations such as the AFAs and major confluences, shown in Map 5.1.

Map 5.1: Hydrological Approach



5.3.2 HEP Conceptualisation

Following this review of catchment descriptors in Section 4.4, hydrological estimation points (HEPs) were selected along each modelled watercourse to represent the inflows to the hydraulic models, intermediate target points to check the models and the downstream boundaries for the hydraulic models. The HEPs were identified through a GIS analysis using the criteria set out in section 6.5.3 of the Project Brief which include;

- Central points within AFAs;
- Flow gauging stations used in the hydrological analysis;
- Upstream and downstream limits of each hydraulic model reach;
- Major confluences which contribute significant flow to the modelled reach*;
- Locations where the physical catchment descriptors significantly change from the upstream catchment i.e. catchment centroid more than 25km away, ±0.15 change in BFI and ±0.07 change in FARL; and,
- At 5km intervals along each watercourse.

The conceptualisation of the HEPs carefully considered the balance between having too many inflows, thus complicating the model, or too few inflows, so misrepresenting the catchment response at key locations such as the AFAs and major tributaries.

The FSU guidelines define a major confluence as any tributary that contributes more than 10% flow to the model reach downstream. This approach can lead to an over representation of HEPs in the upper reaches of the River Lee. Other CFRAM studies have used a different approach to overcome this imbalance by applying a 5km^2 catchment area thresholds to define a major confluence. However, this results in excessive HEPs to calculate model inflows in large catchments such as the River Lee further downstream. Therefore, we have applied the same HEPs as the Lee CFRAM study.

There were no HEPs identified within the River Womanagh catchment where the catchment descriptors varied significantly from the upstream HEP because there are no large reservoirs and there were already sufficient HEPs identified by the previous three guidelines to cover the variation in catchment response. For Ballingeary, a HEP was already identified at Inchigeelagh as the downstream limit of this model which covers the variation in catchment response across Lough Allua.

Table 5.1 summarises the HEPs identified for the MPW and HPW modelled reaches in UoM 19. Appendix B.1 details the location of these HEPs and sets out the proposed physical catchment descriptors for each of these HEPs considering the modifications described in Section 4.4.

Table 5.1: Summary of Hydrological Estimation Points (HEPs)

Type	Number of HEPs
Gauged HEP	1
Upstream or downstream limit of model HEP	6
Major confluence inflow HEP	9
Significant variation in catchment descriptors HEP	0
TOTAL	**16**

5.3.3 Rating Reviews

No rating reviews are required for the Lee or Womanagh catchments as part of the South West CFRAM study. However, eleven gauges across the Lee catchment were reviewed as part of the River Lee Pilot CFRAM study, separate to this study.

5.3.4 Approach for Gauged Fluvial Locations

There are no available flow records in River Womanagh catchment and no spot gaugings available to derive appropriate rating curves as discussed in Chapter 3. Therefore, Castlematyr and Killeagh will be treated as ungauged catchments. The approach for these ungauged locations is discussed below.

Gauges in the River Lee catchment were assessed separately in the pilot CFRAM study. However, OPW require a review of the design hydrology at Ballingeary to consider the latest 2009 and 2011 events. The approach for Ballingeary is discussed below.

5.3.5 Approach for Ungauged Fluvial Locations

Ungauged inflows are shown as yellow or green in Map 5.1.

Index Flood and Flood Growth Curve

Hydrologically similar gauged sites will be selected as pivotal sites based on AREA, BFI, FARL, URBEXT and other key physical catchment descriptors as per FSU WP 2.3. The selection process will carefully consider the impact of groundwater to identify similar sites to the River Kiltha, Dower and Dissour which are all underlain by karst.

For the selected pivotal sites, we will use the median descriptor (QMED) from the Annual Maximum Series (AMAX) to minimise outlier skew instead of the average (Q_{BAR}) used in the previous Floods Studies Report. The majority of flood events occur in the winter months (October to March) in Northern Europe, therefore the AMAX series is based on the annual maximum flood that occurs in each water year, i.e. from October to October, to avoid counting two consecutive flood events in December and January if the calendar year was applied.

Flood growth curves for the pivotal sites will be derived using the pooled analysis from WP 2.2 to extend the record length and estimate the more extreme design peak flows

The index flood values for the ungauged fluvial sub-catchments will be transferred from the gauged locations identified in Section 5.5. The QMED at the target ungauged site will be adjusted by the ratio between the observed $QMED_{amax}$ and calculated $QMED_{rural}$ at the pivotal site. The selected flood growth curve from the pivotal site will then be used to derive the design peak flows for the ungauged site based on the adjusted QMED.

The index flood flow and flood growth curve from the River Lee pilot CFRAMs will be reviewed in the context of Ballingeary. If the previous statistical analysis is found to be acceptable, the design peak flows from the River Lee pilot CFRAMs will be used for the Ballingeary model to ensure consistency between the previous and current study.

Alternative methodologies for estimating the design hydrology for small ungauged catchments have been considered and discounted for the following reasons in UoM 19:

- ***Rational Method:*** The rational and modified rational method estimates greenfield (undeveloped) runoff rates from runoff coefficients, rainfall intensity measures and catchment area principally for sewer design. Previous research has shown that these methods tend to overestimate peak flood flows compared to observed data in test small lowland catchments. Therefore, the rational and modified rational methods have been discounted for SWRBD CFRAMs.
- ***IH124 Method:*** The Institute of Hydrology Report 124 Method (IH124) estimates peak flood flows from time to peak (Tp) and index flood (QBAR) equations. The equations were derived from 71 catchments in England and Wales based on data up to 1990. As such, the coefficients may not represent Irish catchments which have far greater annual rainfall and different catchment responses to those catchments in England. Therefore, the IH124 method has been discounted for SWRBD CFRAMs.
- ***ADAS 345 Method:*** The ADAS Report 345 method estimates peak flood flows from land use, soil type and rainfall parameters related to the rational method equations for the purpose of design field drainage systems. Previous research has shown this method tends to underestimate the index flood flow compared to observed data in test catchments and has a higher mean error than other methods

possibly due to a smaller database from which the ADAS345 equations were derived. Therefore, the ADAS345 method has been discounted for SW RBD CFRAMs.

- ***Gebre Small Catchment Method:*** Research by OPW in 2012 developed a revised regression equation for $QMED_{rural}$ based on 38 small gauged catchments (Area between 5km^2 and 30km^2). However, this revised small catchment QMED equation requires further verification before widespread use. Therefore, it was not recommended to replace the original FSU 7 variable $QMED_{rural}$ equation for small catchment.

Typical Hydrograph and Phasing

Given the lack of suitable flow or level records at the ungauged locations in the River Womanagh catchment, the 3 parameter regression-based equations from WP3.1 will be used to derive a representative design hydrograph based on the BFI, FARL, ALLUVIAL soils, ARTDRAIN artificial drainage and S1085 catchment average slope physical catchment descriptors. Local catchment knowledge from anecdotal sources and OPW will be used to modify the derived hydrograph where the catchment response is known to be atypical such as the groundwater dominated Dower catchment. The derived hydrograph will then be compared with the symmetrical hydrograph produced from previous FSR/FEH methods for flows above 50% of the peak flow and discussed with OPW to agree the most appropriate design hydrograph.

The phasing of inflows will be based the FSU time difference equation (WP 3.4). The timing of hydrograph will be adjusted so that the peak occurs at the time predicted at the gauged location downstream and in the modelled reach.

However, the approach for Ballingeary will be different at the request of OPW. Recent flooding at Ballingeary and Inchigeelagh has suggested that the greatest flood risk arises from raised Lough levels from a long duration event followed by a short duration intense rainfall event. This double peak scenario will be assessed by rainfall-runoff modelling to identify the combination of long duration event followed by a short duration event and the observed phasing to assess flooding from the mechanisms described in the historic flood reports. The rainfall-runoff modelling will be based on rainfall gauges identified in Chapter 3, in accordance with the Flood Studies methodology (Volume 1 and supplementary report No 16). The agreed typical hydrograph will then be scaled to the design peak flows from the River Lee pilot CFRAM study to generate the design inflows and boundary conditions for the hydraulic modelling.

5.3.6 Tidal Locations

The River Womanagh is tidally dominated downstream of Gortnagark to its outfall in Youghal Bay. Contributing sub-catchments in the lower reaches for these two rivers will be calculated as for ungauged fluvial catchments. However, the downstream tidal conditions will be derived as follows.

Design Extreme Sea Levels

The design extreme sea levels at the Womanagh outfall will be linearly interpolated from the nearest Irish Coastal Protection Strategy Study (ICPSS) calculated points which for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP events as specified. The hydraulic model of the lower Womanagh will transform the water levels upstream considering shoaling effects and the combination with the fluvial inflows.

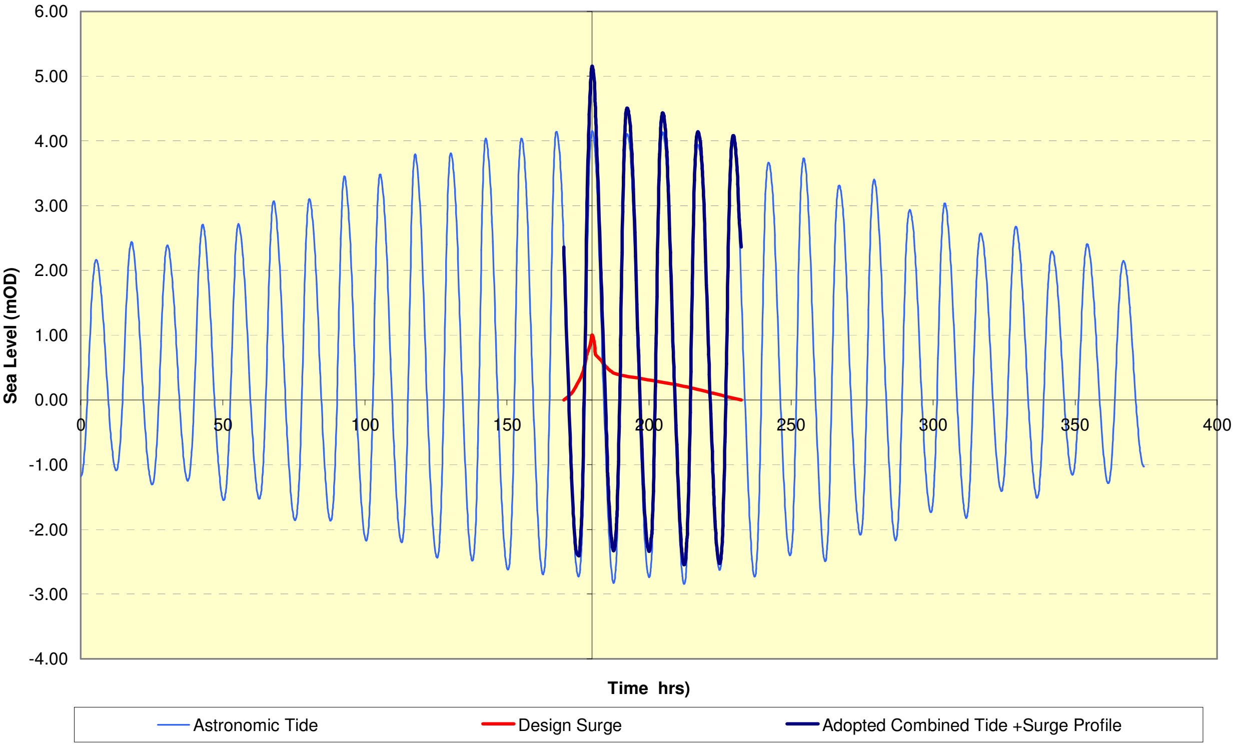
Design Combined Tidal and Surge Hydrograph

In addition to the peak water levels, the tidal hydrograph shape is key in determining the volume and duration of tidal flooding and tide-locking on the River Womanagh and its tributaries. The astronomic tidal curve will be derived initially from the mean high water spring and mean low water spring nearby port predictions. This astronomic curve will then be adjusted based on the local knowledge from OPW, the Local Council, the local communities in the Youghal Bay.

The statically representative surge profile will be derived from the surge residual records at Ballycotton despite the short data record (less than four years) using the methodology described in Evans et al. 2006. The design surge profile will be discussed and agreed with OPW before being standardised and scaled on top of the astronomic curve to meet the design extreme sea levels (Figure 5.2). We will discuss and agree with OPW the appropriate phasing of the surge such as matching the peak surge with the peak coastal water level as a conservative estimate.

Recent research (DEFRA FD2308) indicates that the phasing of extreme tides does not necessarily correspond to rainfall and fluvial flood events. There is no gauge at the tidal outfall so it is not possible to statistically assess the joint probability at this location. Therefore the appropriate phasing between the tidal and fluvial flood will be informed by existing analysis in the area, the FD2308 report and local knowledge to be agreed with OPW. If no additional information can be ascertained through discussions with the council, we will discuss and agree with OPW the appropriate phasing and joint probability such as matching the peak coastal water level as a conservative.

Figure 5.2: Example of Design Tidal Hydrograph for a Coastal Flood Event



Wave Conditions

No areas were found to vulnerable to wave overtopping from the Irish Coastal Water Level and Wave Study preliminary results (ICWWS) within AFAs assessed by this study in UoM 19. Therefore, wave overtopping is not considered for UoM 19 as part of this study.

5.3.7 Future Scenarios

The design hydrology described in Sections 5.2.4 to 5.2.6 will be based on present day climate conditions using data (where available) up to 2012. However, climate change is predicted to change the hydrological conditions over the next 100 years. The predicted impacts of climate change over the next 100 years are likely to include:

- Increase in rainfall depth,
- Increase in flow,
- Sea level rise (including land movement),

For the SWRBD CFRAMs, Table 5.2 sets out the predicted changes in the key catchment parameters over the next 100 years. The range of potential impacts of climate change may vary AFA to AFA as there are significant uncertainties associated with global climate predictions and local variation in urbanisation and forestation beyond 20 years. Therefore, two scenarios will be assessed to quantify the sensitivity of flood risk to these uncertainties, namely; the Mid-Range future scenario (MRFS) and the High-Range future scenario (HRFS) as detailed in Table 5.4.

Table 5.2: Allowance for Change in Catchment Parameters Over 100 Years

Catchment Parameter	MRFS	HRFS
Extreme Rainfall Depth	+20%	+30%
Flood Flows[1]	+20%	+30%
Mean Sea Level Rise[1]	+0.5m	+1.0m
Land Movement[2]	-0.5mm/year i.e. -0.05m over 100 years	-0.5mm/year i.e. -0.05m over 100 years
Urbanisation	Specific to each Town	Specific to each Town
Forestation[3]	Tp reduced by factor of 6	Tp reduced by factor of 3 +10% SPR

Note 1: Applies to entire range of flows or tidal levels, not just the peak.

Note 2: Land movements as a result of postglacial rebound since the last ice age. Applies to all locations south of Dublin to Galway which includes the entire SWRBD CFRAM study area.

Note 3: Reduction in time to peak (Tp) and increase in standard percentage runoff (SPR) allows for potential accelerated runoff that may arise as a result of drainage of afforested land.

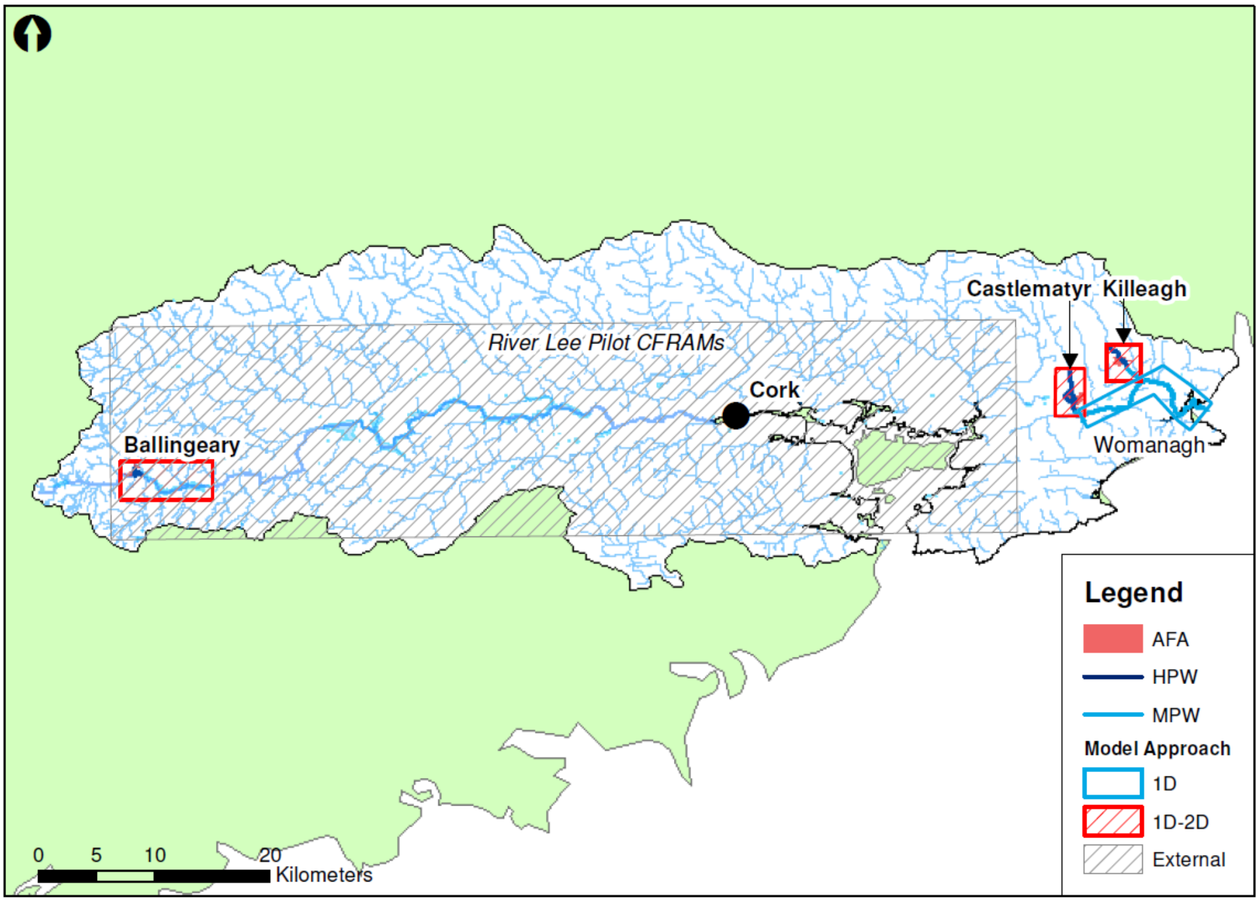
Source: Reproduced from Appendix F of National Flood Risk Assessment and Management Programme, Catchment-Based Flood Risk Assessment and Management (CFRAM) Studies, Stage I Tender Documents: Project Brief.

The urbanisation rates will be based on future development plans from the local councils combined with OPW's local knowledge for each AFA to derive a mid and high annual rate of growth. This will consider a long-term assessment of urbanisation since 1960 (or earlier where records permit) to reduce the influence of the rapid increase from 2000 to 2008 and stagnation in since 2008 in some areas. This will then be extrapolated over 100 years to adjust the extent of urban land cover (URBEXT) for each HEP, adjust the representation of urban extent in the hydraulic models of the floodplain and economical appraisal of flood damages.

5.4 Hydraulic Analysis Approach

The River Lee and River Womanagh catchment has been divided into four separate model reaches to produce flood extent mapping for all Medium Priority Watercourses (MPW) and flood hazard mapping for all High Priority Watercourses (HPW). The River Lee downstream of Ballingeary to Cork Harbour is considered in the pilot CFRAM study by Halcrow, completed in 2010. As such the River Lee downstream of Ballingeary will not be re-modelled as part of the SWRBD CFRAMS. Map 5.2 summarises our approach to the assessment of flood risk in the River Lee and River Womanagh catchment.

Map 5.2: Approach to UoM 19



Independent hydraulic models will be developed for each reach to simulate the flood extent for the design flood as follows:

- **1D Hydraulic Models for MPWs:** A 1D ISIS hydraulic modeling approach will be sufficient to simulate peak water levels and flows for the downstream MPWs reaches of the River Womanagh where a less detailed flood risk assessment is required by OPW.
- **1D/2D Hydraulic Models for HPWs:** A 1D/2D ISIS/TUFLOW hydraulic modelling approach will be taken for all the AFAs listed in Table 1.2 to enable a detailed assessment of depth, velocity and hazard across urban areas. The existing 1D hydraulic model of the Upper Lee from the River Lee CFRAMs pilot study will be reviewed and used to develop the a 1D/2D model for Ballingeary to better simulate the conditions in Lough Allua downstream.

In each case the HPW and MPW hydraulic models will be developed in seven steps as follows:

1. Model Conceptualisation and Configuration: We will review available maps, the existing River Lee CFRAMS ISIS model at Ballingeary and other information from OPW and the Local Authorities to understand and schematise the river network for Ballingeary and River Womanagh catchment. This will focus on changes in slope and channel morphology based on review of the river channel survey; any hydraulic structures and linking watercourses (such as drains); flow routes and barriers for flood waters from roads, railways and embankments; major areas of attenuation such as floodplain depressions; and, any areas of noted concern. For the 1D/2D models of the HPWs at Castlemartyr and Killeagh, a grid size will be determined by the complexity of the floodplain without compromising run time and efficiency.

2. Representation of Channels, Structures and Floodplain Interface: River channels will typically be represented by a series of nodes (cross-sections) and reaches. We will make informed use of channel roughness guides, such as by Chow 1959, in conjunction with engineering judgement, and the river channel survey and surveyors observations/photos to assign Manning's 'n' roughness values for each reach to best represent changes in channel slope, morphology and flooding mechanisms without compromising the stability and robustness of the hydraulic models.

It is important to incorporate all significant online bridges, weirs and culverts in the channel within the 1D modelling for both MPWs and HPWs, considering losses around and through structures. Only those structures that significantly influence flow for the MPW or HPW reach during flood will be incorporated as specified for the survey. Parameters such as afflux, weir discharge coefficients and structure losses will initially be set to industry standard values using catchment knowledge from site visit, industry guides and drawing on expertise of senior hydraulic modellers/engineers.

For both the HPWs and MPWs, the river bank elevations will be based on the river bank surveys collected as part of this CFRAM study ensuring any known low points are fully represented in the 1D/2D river/floodplain interface. In the case of the HPWs 1D/2D modelling this will usually form the interface between the 1D river channel and the 2D floodplain model, therefore it is vital to have confidence in the surveyed bank elevations which will be verified by spot checks as part of the survey.

3. Representation of the Floodplain and Floodplain Features: A digital terrain model (DTM) will be created using the existing DTM at Ballingeary from the Lee CFRAMs pilot ,the latest LiDAR surveys of the Castlemartyr and Killeagh and the national digital elevation model (IFSAR data) for the more rural areas. The final DTM will be used to inform the geometry and formulation of the floodplain model. All topographic data will be cross-checked in areas of overlap to ensure consistency on receipt of data.

For the 1D/2D models of the HPWs, a preliminary grid size of 5m will be applied to accurately represent the urban floodplain without compromising the simulation time and efficiency. Any further revisions to the grid size will be determined by the complexity of the floodplain. Key features less than 5m in size, will be explicitly enforced in the 2D domain using 3D breaklines, regions or flow constrictions to modify the underlying grid.

On the floodplain, we propose to use a combination of the following to classify land use: topographic survey data; photographs captured at the time of the survey; OSi Mapping and the EU Environment Agency's latest CORINE dataset. The photographs captured at the time of survey and available aerial photography will then be used to assign the appropriate Manning's 'n' roughness value to each land use classification. We will incorporate relevant barriers and potential flow routes as identified in the schematisation using 3D breaklines to represent the effective crest of floodplain features such as roads, railways and embankments.

The urban environment can significantly modify flow paths, depth and velocities. To model this satisfactorily requires, in our experience, paying particular attention to how the buildings are incorporated. Buildings can be represented in the 2D models in variety of ways depending on data availability and output requirements. Buildings will be considered using a combination of buildings footprints raised to a uniform threshold value of 300mm and assigned with depth variable roughness values to enable simple extraction of results of economic, social and environment assessment at a property level.

4. Upstream Boundary Conditions We will develop appropriate boundary conditions for fluvial inflows and lateral inflows for intermediate catchments. The upstream boundary conditions will apply the design flows from the hydrological analysis or the outflow from the upstream model where the target model reach is located downstream of another a MPW or HPW.

Upstream boundary conditions will typically be located at the HEPs as derived during the hydrological analysis. Where the target model is located downstream of another MPW or HPW reach, we will seek to located the upstream limit where there is a clear defining feature determining the interaction of flow in the channel and on the floodplain such as weir or road. The adjacent models will be run iteratively to fully consider the interaction of flow and level between the upstream and downstream reaches of a catchment. The orientation and immediate topography at upstream boundary will be considered in the creation of the 2D domain and are important in influencing flow routes and flow distribution. It is also important to carefully consider the location of lateral inflows along the 2D boundary to represent inflows from intermediate catchments and/or drainage catchments, distributing and transferring flows between the various drains where appropriate as identified by the Hydrological Estimation Points.

5. Downstream Boundary Conditions The downstream boundaries will be located at a known gauged sites or control structures (e.g. weir, gates etc.) where possible, or sufficiently away from the area of interest in order to minimise the uncertainty associated on backwater effects or any assumptions made with the downstream boundary conditions.

Where the target model is located upstream of another MPW or HPW reach, we will seek to located the downstream limit where there is a clear defining feature determining the interaction of flow in the channel and on the floodplain such as weir or road. The adjacent models will be run iteratively to fully consider the interaction of flow and level between the upstream and downstream reaches of a catchment.

For fluvial reaches, the downstream boundary will typically be represented using water level- time series for calibration/verification which will inform the design stage-discharge relationship downstream boundary for design events. For tidally influenced reaches, water level- time boundaries will be used. The phasing and timing between river flows and the tidal boundary will be such that the peaks coincide in accordance with the joint probability guidance note (due late 2012).

6. Initial Conditions: Where required, appropriate initial hydraulic conditions will be established prior to model simulation.

7. Calibration: A proportionate approach will be taken to the representation of floodplain features. All the hydraulic models will be calibrated for historic flood events where there is sufficient data, as outlined in Section 5.2. For a widespread event, the model predicted flows will be calibrated across catchment where there are several gauges along a river. This will mean iterative calibration across several models for larger catchments.

Reality checks will be undertaken instead of model calibration where there is insufficient gauge data or only anecdotal historic flood evidence as set out in Guidance Note 23. The design flood outlines and water level profiles will be checked against anecdotal flood evidence and estimated frequency of historic events as an indicative measure of what might be considered reasonable.

This calibration will focus on the structure coefficients and head losses at bridges and weirs as well as Manning's 'n' roughness values for the river channel and floodplain. Section 5.2 summarises the historic events and available calibration data in UoM 19 for each AFA. The limited availability of flow data at Ballingeary, Castlemartyr and Killeagh means that a full event calibration is unlikely to be feasible. Therefore, sensitivity tests will be carried out for relevant hydrological assumptions and hydraulic parameters including sensitivity tests on roughness values and on the assumed level of Lough Allua for Ballingeary based on historic flood reports.

The calibrated or tested models will be used to simulate and map the current and future flood extents and flood hazard for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP fluvial flood events considering scenarios with existing defences in place and without defences in place to assess the protection afforded by the existing defences.

We will use the resultant modelled maximum water levels and flows for the HPWs and MPWs in addition to the depth, velocity and hazard results for the HPWs to produce flood extent and flood hazard maps as follows:

- **1D Model Flood Mapping for MPWs:** We will use our in-house tool, developed in ArcGIS, to generate flood maps from one-dimensional model cross-sections, intersecting the maximum water level with the digital terrain model to produce flood extent and flood depth grids. The resultant GIS files will be converted into the appropriate MapINFO GIS format to produce the specified flood maps.
- **1D/2D Model Flood Mapping for HPWs:** Water level, depth, velocity and flood hazard can be directly extracted from the model and then post-processed into the appropriate MapINFO GIS format to produce flood maps. Flood hazard will not consider the impact of debris as specified by OPW. If information is required for the one-dimensional channel, water level lines will be incorporated into the model so that water level, depth, velocity and hazard function can be mapped for the channel.

The flood extent for the River Womanagh is subject to both fluvial and tidal influence. Joint probability analysis of fluvial and tidal events will be undertaken as set out in Section 5.2 of this report to determine the fluvially-dominated and tidally-dominated scenarios. The resultant flood extents from each scenario will be merged to show the maximum extent of flooding from either source thus meeting the CFRAM requirements for flood mapping. This will be an automated process carried out using the 'union overlay' function in ArcMap. The merged map will then be converted to the appropriate MapINFO GIS format to produce the flood extent map. It will not be produced for the other map formats.

5.5 Flood Risk Assessment (FRA)

Flood risk is a combination of the probability and degree of flooding (the 'hazard') and the damage caused by the flood (the 'consequences'). What constitutes hazard and consequences are described below.

Flood hazard can arise from a range of sources of flooding, the SW CFRAM Study addresses the following sources:
- Rivers (fluvial)
- Sea (coastal and tidal)

The following four risk receptor groups are vulnerable to the potential adverse consequences of flooding:

- Society
- Environment
- Cultural
- Economy

We will assess and map the potential adverse consequences associated with flood hazard in each of the AFAs.

5.5.1 Social Risk

The social flood risk shall be assessed, mapped and reported upon using four methods and indicator sets:

- the location and number of residential properties
- the location, type, and an indicator of vulnerability and number of potentially high vulnerability sites, such as residential homes for children, the elderly or disabled, etc.
- the location, type, and an indicator of vulnerability and number of valuable social infrastructural assets, such as fire stations, Garda stations, ambulance stations, hospitals, government and council buildings, etc.
- the location, type, and an indicator of vulnerability and number of social amenity sites, such as parks, leisure facilities, etc.

5.5.2 Risk to the Environment

The flood risk to the environment shall be assessed and mapped and reported upon using three methods and indicator sets:

- The location, type, an indicator of vulnerability and number of installations referred to in Annex I to EU Directive 96/61/EC (1996) concerning integrated pollution prevention and control and other significant potential sources of pollution.
- The location, extent, nature and an indicator of vulnerability of areas identified in Annex IV (1) (i), (iii) and (v) to the Water Framework Directive (EU Directive 2000/60/EC)
- The nature, location, an indicator of vulnerability and areas of other environmentally valuable sites, such as SACs.

5.5.3 Risk to Cultural Heritage

The flood risk to cultural heritage shall be assessed and mapped and reported upon using one method and indicator set:

- The location, type, an indicator of vulnerability and number of sites or assets of cultural value

5.5.4 Risk to the Economy

The flood risk to the economy shall be assessed and mapped and reported upon using four methods and indicator sets:

- The location, type (residential and classifications of non-residential) and numbers of properties, with associated frequency-depth-damage information based on property type
- The density of economic risk expressed as annual average damage (euro / year) per unit area (e.g., per 100m or 500m square)
- The location, type, an indicator of vulnerability and number (and / or lengths) of transport infrastructural assets, such as airports, ports, motorways, national and regional roads, rail, etc.

- The location, type, an indicator of vulnerability and number of utility infrastructural assets, such as electricity generation and sub-stations, water supply and treatment works, natural gas and oil facilities, important telecom interchanges, data repositories, etc.

5.5.5 Indicators of Vulnerability

Indicators of vulnerability are typically a categorisation of vulnerability (e.g., very high to very low) or, a numerical or economic consequence or depth-consequence curve in the event of flooding. The indicators of vulnerability are to be provided by OPW for each type of social, environmental, cultural and economic risk receptor.

The definition of the indicators of vulnerability shall be reviewed and, if necessary and agreed, refinement of the NTCG, subject to approval of the OPW.

5.5.6 Risk Assessments

We will undertake the risk assessments using relevant information for all of the design flood event probabilities for existing conditions and for the MRFS. We will prepare the Preliminary Options Report where the results of the flood risk assessments under the four risk receptor groups shall be described. For each AFA, we will prepare a range of flood risk maps that present the flood risk in a clear manner.

5.6 Strategic Environmental Assessment (SEA)

We will prepare the SEA to have due regard to best practise guidance in the context of its application to CFRAMS which will include the EPA SEA Pack 2010, the Strategic Environmental Assessment (SEA) And Climate Change: Guidance For Practitioners, 2004, the 'Draft GISEA Manual' updated in 2010 and DEHLG guidance on the Implementation of SEA Directive (2001/42/EC): Assessment of the Effects of Certain Plans and Programmes on the Environment Guidelines for Regional Authorities and Planning Authorities November 2004.

5.6.1 Phase I Screening Assessment

A Screening Assessment has been completed by others for this project. Our first task will be to confirm the basis for and conclusions of the Screening Assessment to ensure that all parties are moving from the same starting position in relation to the basis for the requirement for the SEA. This is an important legal consideration which will need to be clearly documented and tracked in later deliverables as the legal process is completed.

5.6.2 Phase II Constraint and SEA Scoping Study

This phase essentially sets the goalposts for the assessment process to ensure that it remains relevant, focussed and coherent. We will assess other plans and programmes relevant to the South Western District and will determine the aspects of such plans / programmes that should be considered as part of the South Western CFRAM Study in order to ensure consistency across the board.

There are clear interrelationships between the mitigation and monitoring measures committed to the SEA for the South Western River Basin District Management Plan and the CFRAM Study SEA which need to be

carefully integrated, particularly where requirements for Appropriate Assessment and other such commitments have been identified as being necessary. Similarly, Freshwater Pearl Mussel Plans and Shellfish Pollution Reduction Programmes in the SWRBD prescribe measures that will be considered in the CFRAM SEA. The Lee CFRAMS SEA will also be considered.

We will complete the necessary desk studies and preliminary site visits to identify any significant constraints which would have a significant influence on the design and / or implementation of any flood risk management measure. We intend to do this by identifying the key environmental sensitivities in the study area, the basis for these sensitivities and how they can be managed such that options are presented to the Steering Group / Progress Group rather than constraints.

In order to assess the vulnerability of sites and areas to flooding it will be necessary to characterise the sites in terms of their sensitivity. Vulnerability of the designated areas / environmentally valuable sites to pollution loading from licensed discharges will be spatially evaluated against 'flood hazard' areas.

5.6.3 Phase III Option Appraisal Study

We will assess and report on the possible environmental benefits and impacts associated with each measure and option. The evaluation of the 'Do Nothing' or 'Do-Minimum' scenarios will be very important to set the context of the FRMP.

We will assess and rank the options (with and without impact mitigation measures) against the environment objectives, indicators and targets identified at the Scoping Stage.

In assessing the options there is a necessity to ensure that the alternatives are evaluated using clear multi-criteria analysis developed in consultation with the OPW. The selection of the evaluation mechanism, weighting and scoring will need to be carefully analysed and subjected to sensitivity analysis to underpin the robustness of the outputs. We will also have due regard to the experience gained by the OPW in the Lee CFRAMS SEA as the statutory consultees (e.g. EPA) will have reviewed the methodology presented therein. It will be important to demonstrate cross-comparability in the logic applied across individual CFRMPs. We will set out clearly the justification for choosing each of the preferred options.

The environmental benefits / impacts of each measure / option may be ex situ or in situ and may be direct or indirect. The relationship between each measure / option and environmental receptor(s) will be considered and a source-pathway-receptor evaluation made. The impacts / benefits will be evaluated with respect to their duration, scale, extent and nature. Cumulative impacts / benefits will also be assessed. Where negative effects are predicted we will set out recommendations for environmental mitigation. Mitigation will follow the 'mitigation hierarchy' i.e. Avoid at source; Reduce at source; Abate on site; Abate at receptor. We will ensure that all mitigation measures pass the SMART test, i.e. specific, measurable, achievable, with responsibility for their implementation clearly assigned and time limited (i.e. when they are required to be implemented). Mitigation measures will be reflective of any prescribed in the Habitats Directive Assessment and will also incorporate relevant mitigation from protected area/species plans.

Having due regard to the proposed monitoring programme, it is very important that third parties to the process understand the legal interpretation of what is meant by monitoring. Certain parties will consider this to be field investigations, etc. however due to the nature of SEA it is more typical to consist of strategic level datasets and monitoring have they are being effected, in this case, the CFRMP.

In specifying the content of the Monitoring Programme we will ensure that validity, accessibility, frequency of update and ownership of the datasets to determine the applicability and the extent to which they are meaningful or 'fit for purpose'.

5.6.4 Phase IV SEA Report

In parallel and close co-ordination with the identification and development of the preferred flood risk management strategy and the preparation of the Flood Risk Management Plan, we will prepare an SEA Report covering the preferred options and Plan. Very importantly it will also contain a history of the SEA process and how it was conducted particularly emphasising stakeholder and public involvement.

5.6.5 Phase V Update of SEA Report

We will undertake any necessary revisions to the SEA arising from submissions on the draft Final Report of the CFRAM Study, including speedy, yet robust SEA on significant changes to the plan.

5.6.6 Production of the SEA Statement

From a legal and process perspective the production of the SEA Statement is the most important phase in the process. The function of the SEA Statement is to identify how the SEA process has influenced the plan. This requires careful scripting, particularly in the context of how differing opinions from consultees have been managed throughout the process.

5.7 Appropriate Assessment

We shall carry Appropriate Assessments in accordance with the requirements of Articles 6(3) and 6(4) of Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora (Habitats Directive) to inform the Competent Authority of whether the plan will have adverse impacts on the conservation objectives of the relevant Natura 2000 sites within the zone of influence. The Appropriate Assessment shall be conducted in accordance with all relevant guidance and legislation including:

- European Communities (Birds and Natural Habitats) Regulations 2011
- NPWS (2012) Marine Natura Impact Statements in Irish Special Areas of Conservation, A working Document.
- DEHLG (2009) Appropriate Assessment of Plans and Projects in Ireland Guidance for Planning Authorities;
- EC (2000) Managing Natura 2000 Sites: The provisions of Article 6 of the 'Habitats' Directive 92/43/EEC.
- EC (2001) Assessment of plans and projects significantly affecting Natura 2000 sites: Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC.
- EC (2007) Guidance document on Article 6(4) of the 'Habitats Directive' 92/43/EEC: Clarification of the concepts of alternative solutions and imperative reasons of overriding public interest, compensatory measures, overall coherence, opinion of the Commission.

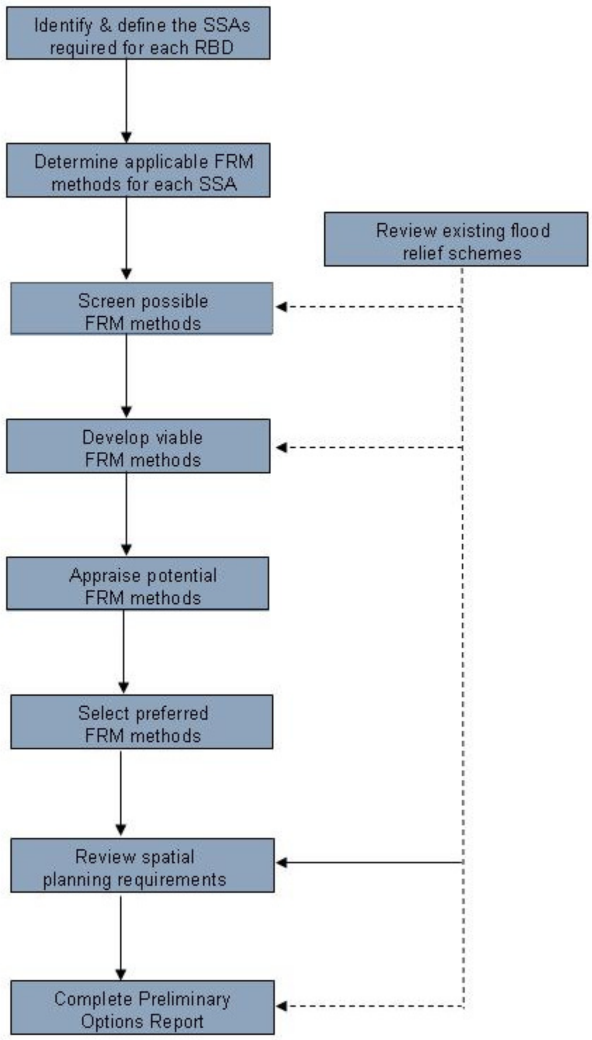
5.8 Development of Flood Risk Management Options

5.8.1 Summary

Each FRMP will set out a list of actions required for various spatial scales. Each action will be supported by a description of the objectives and need for that action, an indicative cost, a timescale for implementing the action, and identification of responsibility.

We will derive these actions from a detailed option appraisal, described in the following Section (and summarised in Figure 5.3). This appraisal will not only identify the recommended way forward, but will also provide robust and clear opinion on why other options were deemed to be inappropriate. This clear and auditable process will provide the requisite sound foundation for future full development of measures to be taken to planning and subsequent implementation.

Figure 5.3: The Flood Risk Management Process



5.8.2 Preferred Design Standards

The preferred design standards that we will adopt for the development of flood risk management options will be the 1% AEP for fluvial flooding and the 0.5% AEP for tidal flooding.

Notwithstanding the above, there may be instances where higher design standards can be accommodated for at little or no additional cost. For example, closure of a low spot, or saddle, within a natural embankment could provide a standard of protection significantly in excess of the required standard for limited additional cost. Where this is the case we will use a benefit:cost analysis to determine appropriate defence levels.

Likewise there may be instances where it is unviable to provide the preferred design standard for every property within an AFA. For example the infilling of gaps in a quay wall may provide a cost effective means of protecting properties from frequent flooding where a 2m high river wall necessary to protect an area from the 1% AEP flood may not be acceptable. In this case we will assess viable options using a benefit:cost model and determine an appropriate way forward.

5.8.3 Flood Risk Management Methods

5.8.3.1 Flood Forecasting Systems

Flood forecasting is one of the commonly used methods of managing flood risk. Although it does not reduce the extent of flooding, it provides a means of reducing the socio-economic impacts of flooding if combined with an efficient action plan.

For each AFA we will investigate the potential for the development of a flood forecasting system. Although envisaged for individual AFAs we consider it important to assess how individual components can be linked. We will use the modelling results from the hydraulic models to initially assess key information such as the travelling time of flow peaks and the relation between flood levels in the AFA and levels recorded at gauges further upstream.

We will develop a conceptual design of rainfall and flow gauges, existing and new, required to provide reliable forecasts. We will gather information as to the availability and accuracy of RADAR rainfall forecasts in the study area which will be pivotal to the accuracy of any water level forecasts. The use of gauge corrected rainfall radar datasets is also being studied by OPW. The output of their study may be of benefit to this study. We will also refer to ongoing studies relating to Storm Surge forecasting to address tidal flood risk forecasting.

As the rainfall – runoff modelling applied for the purpose of flood forecasting requires the consideration of the actual status of the catchment in terms of storages, generally event based approaches such as FSR and FEH techniques are inadequate. We will propose suitable software for the rainfall – runoff modelling based on our and other consultants' experience.

Equally, the hydraulic modelling techniques used for the modelling of flood risk are not necessarily applicable for the purpose of flood forecasting. This is particularly the case where 1D-2D models have been chosen as their run-time renders them unsuitable for flood forecasting. We will propose suitable software and approaches for the routing of flows from catchments to the AFAs.

We will also investigate operational systems which have the ability to link the input data, the rainfall runoff model and routing model together and provide the level predictions in an appropriate format.

Upon agreement of draft conceptual designs we will provide a comprehensive cost estimate for the installation and the operation of the flood forecasting systems

5.8.3.2 Strategic Sustainable Urban Drainage Systems

The use of SUDS to attenuate discharges and intercept pollution flowing into river and other watercourses, and thus reduce flooding, is a key issue. We would analyse existing information in flood mapping reports on soil types, infiltration drainage capacity, topography, watertable depths and watercourse capacities held by the OPW and other authorities. This baseline information would be used to develop a map showing potential areas in which SUDS might be used.

5.8.3.3 Dams, Reservoirs and Operable Control Structures

It will be required to review the operational and regulatory controls at dams and other hydraulic structures on HPW's and MPW's to determine the potential for a general reduction in flood risk.

When doing this work it is vital to understand that dams and other storage facilities provide value to the community in a number of different ways, including:

- Reduction in flood risk
- Provision of a robust water supply system
- Supply of irrigation water
- Hydropower
- Amenity (i.e. sailing, fishing, visual improvement)

Usually a single structure will provide more than one of the above benefits meaning that it is a multi-functional asset. Where this is the case, we must take into account the fact that while altering the operational strategy at the structure may, for example, mitigate flood risk, a by-product could be reduced long term average reservoir water levels which would impact on amenity and storage potential. In simple terms a greater reduction in flood risk can be gained by keeping the storage reservoir as empty as possible. Clearly this strategy could be at odds with other stakeholder beneficiaries.

The above are common issues. In these situations it is relatively easy to compare the different types of benefit afforded by the reservoir through a traditional financial analysis, however, we have found that this represents only a small percentage of the work required to develop an acceptable operational plan. The "owners" of water supply, flood risk, power and amenity facilities tend to be different private and public bodies, all of which have their own requirements and objectives. An effective operating plan will require a comprehensive understanding of the needs of all these project stakeholders. We have found that this is best achieved through a co-ordinated stakeholder engagement strategy which facilitates catchment wide discussions and solutions.

5.8.3.4 Structural Measures

Storage: In certain circumstances the upstream storage of flood water will be an effective measure to reduce the potential damage that could result from flooding. This is achieved by reducing the peak flow that would be experienced in a watercourse and thereby reducing the depth of flooding experienced for a certain AEP. Flood storage will be effective where the magnitudes of peak flows are relatively small and there are suitable sites upstream of the at risk area to hold the flood water in either a single site or a number of smaller sites. This methodology may be suitable for use in the areas at risk in UoM 20 and 21 which are located on relatively short watercourses. For larger, flatter catchments storage is not always a

viable option as the volume of storage required to dampen the peak flow can be very large giving rise to large areas of land that have to be set aside for flood storage. This in turn may lead to the cost of providing storage being prohibitively expensive.

Flow diversion: In certain areas at risk it may be possible to divert peak flows away from areas at risk thus reducing flood depth in those areas during extreme events. Important considerations in deciding whether a flood channel such as this is viable or not include; the topography of the area, the length of by-pass required, the infrastructure that would require diversion (bridges, services, etc.) and the possible backwater effect from where the flood flow rejoins the existing channel.

Flood Defences: In areas where receptors are grouped together it may be feasible to protect them from flooding by the construction of solid flood defences. Earthen embankments can be very effective flood defences as long as the seepage under the defences is not excessive. Embankments require a large footprint and are generally suitable for use in open areas only. Where space for the construction of defences is restricted flood defence walls are required. These can be expensive to construct when compared to embankments as the materials are more expensive and for given ground conditions the depth of groundwater cut-off required for walls is considerably deeper than for embankments. In many AFAs there may be existing flood defences which could be repaired to a useful state. Generally the height of existing defences are much lower than would be required by modern design standards and the level of defence offered by repairing existing defences can be difficult to justify in terms of AEP.

In addition to the above mentioned methodologies we would consider other options for flood risk management including but not limited to works that would lead to improvements in channel conveyance characteristics by the widening and or deepening of river channels, the relocation of properties at risk and the provision of temporary flood barriers where long lead flood forecasting is possible.

5.8.4 Screening of Possible FRM Methods

We will develop flood risk management options for three Spatial Scales of Assessment (SSAs). These are at the Unit of Management Scale, The Sub Catchment or Coastal area scale and the AFA scale. We will develop these options using a defined process which will include:

- An initial high level screening of FRM options
- Development of the screened options to identify tentative scheme solutions
- Appraisal of scheme solutions using a multi-criterion analysis
- Selection of the preferred scheme

The high level screening will look at individual solutions to determine their viability based on a set of criteria, namely: applicability to the relevant area and, economic, environmental, social and cultural aspects. This screening will usually be based upon an assessment of issues and benefits using experience and professional judgement except in specific cases where quantitative data is available. A brief example of an initial screening exercise is provided in Figure 5.4.

Figure 5.4: Example of an Initial Screening Exercise

Identified Risk:	Significant fluvial flooding of 3 residential properties at a calculated rate of occurrence of 2% (on average once in fifty years).
Objective:	Remove flooding to the 3 properties for the 1% AEP
FRM Method:	Construct a Flood Storage Area (FSA) upstream of the properties
Applicability:	Satisfactory. Rural area with geotechnical and geological conditions commensurate with the construction of an impounding embankment. Local construction materials available. Access to construct and maintain the FSA is reasonable.
Economic:	Questionable. The economics of building a FSA to protect only 3 properties are likely to be unviable. There are no realistic opportunities for micro-hydro or amenity benefits.
Environmental:	Slightly positive. Likely to enhance marginal flora and fauna as existing land is used for grazing only.
Social:	Significantly negative. Likely to be extensive land ownership issues with local farmer known to be unwilling to sell. Landowner is an influential local politician.
Cultural:	No known issues
Outcome:	Given the questionable economic outcome of the method and the known issues with land ownership, our recommendation is not to pursue this option.

We recognise the importance at this stage of only ruling out those methods which are clearly inappropriate. For this reason we recommend carrying out an initial review of each method (as above). Where the outcome recommends abandoning the option we will then briefly revisit the screening to expand and confirm those criteria which are deemed to be critical – in the above example, economics and land acquisition.

5.8.5 Development of Potential Options

When developing options we will utilise those methods which the screening analysis confirmed as being appropriate and develop / combine them into a scheme solution. In most cases we expect that a single solution (e.g. enhancement of flood defences within the urban area) will be unlikely to fully mitigate the identified risk. We will therefore need to combine this with other approved methods, such as implementation of a sustainable urban drainage system, provision of upstream storage, construction of a flood bypass channel or implementation of a catchment wide flood forecasting and warning system.

The intent will be to develop a series of schemes which each satisfy the identified flood risk objective. The number of schemes identified in this development phase will vary according to the particular issues observed at the locale; however, we would endeavour to provide at least three to enable a realistic comparison and appraisal to take place.

Some of the schemes may have sub-options associated with them (i.e. provide a flood bypass channel in open cut or using a culvert) and some may look at alternative flood design standards (2%, 1% and 0.5% AEP). However, our extensive understanding of flood risk engineering will be used to identify sustainable and innovative solutions while rigorously assessing each scheme to ensure that we do not go down the path of “option overload”.

5.8.6 Appraisal of Potential Options

We will discuss and agree with OPW the detailed methodology to be adopted for the appraisal of the different schemes.

We currently see the appraisal as being a two phased approach involving a multi-criteria analysis set against a series of minimum and aspirational targets for each objective, and a detailed benefit:cost analysis. As with all appraisals of this type, we will endeavour to use quantitative evidence where it is available but recognise that in some cases this will not be possible and in these instances a quantitative approach will be developed.

There are two traditional approaches to a multi-criteria appraisal:
- An un-weighted analysis
- A weighted analysis

The un-weighted approach does not attempt to directly compare say, infrastructure benefits with environmental benefits. It merely assigns a score for each objective. Schemes can then be compared at an objective level, but not at an overall scheme level.

A weighted analysis attempts to allow comparison across objectives by, for example, assigning a factor which allows protection of a cultural asset to be directly compared with an environmental asset. This allows a scoring system to be developed for an entire scheme with the objective being that the scheme that scores most highly is deemed the preferred option. This approach has clear advantages over the un-weighted analysis in terms of affording much better comparability, but it suffers from the inevitable qualitative assumptions made when setting the weighting criteria.

The weighted multi-criteria analysis will be followed by a standard benefit:cost analysis for each scheme. We do not anticipate incorporating amenity, environmental or similar potential indirect scheme benefits in the economic benefit:cost appraisal, as the results of doing this are highly qualitative; instead we will consider these issues in the multi-criteria analysis.

We will develop scheme costs to the required level of detail. For this we will utilise our extensive internal cost database of similar construction activities, allied to external sources where required. These will include SPONS, WESSEX and the EA’s cost database for river based engineering works. We are fully aware that scheme cost assessments carried out at feasibility and outline design phases traditionally underestimate final outturn costs by up to 60%. We will therefore discuss with OPW a rationale for using an optimisation bias in all cost determinations to offset this.

5.8.7 Selection of Preferred Options

The preferred option shall be identified using the above option appraisal methodology. In addition we are required to confirm that the preferred scheme is:

- Viable against all criteria
- The most beneficial option relative to cost
- Spatially coherent
- Temporally coherent

In terms of spatial coherence we will consider whether the scheme provides advantages or disadvantages to other SSAs in the vicinity and in terms of temporal coherence we recognise the need to consider the timing of additional options required as a result of future variation, such as climate change.

For each preferred option we will identify a series of actions and measures which need to be undertaken to implement the scheme. These will then form the basis of the Flood Risk Management Plan. In addition, and in consultation with OPW and the steering and stakeholder groups, we will prioritise the actions, taking account of potential budgets and time constraints.

5.8.8 Spatial Planning and Impacts of Development

We will review the Development Plans, Local Area Plans and any other spatial planning documents relevant to each AFA and each Unit of Management as a whole, including Plans or documents in force or in draft form at the time of the review.

We will discuss potential land use, spatial planning and development management policies, objectives, zoning and issues with the planning departments of Local Authorities whose jurisdiction falls in part or in whole within the AFAs and / or Units of Management.

On the basis of the review and discussions and with reference to all other work undertaken under the Project, and to the Guidelines on the Planning System and Flood Risk Management, we will develop and discuss the high-level draft recommendations. We note that such recommendations shall, where appropriate, form actions or measures to be included in the FRMP.

5.8.9 Preliminary Options Report

We will prepare and submit the Preliminary Options Reports. In particular we note the requirements to potentially provide copies of the Spatial Planning and Strategic SUDS sections of the report in isolation and the need to prepare separate reports for each Unit of Management within the study area.

5.9 Flood Risk Management Plan (FRMP)

We will prepare a separate Flood Risk Management Plan (FRMP) for each Unit of Management, including a 10-15 page executive summary that can be read in isolation.

The FRMP will briefly outline the Project and the flood risk assessment and analysis, and then clearly set out the flood risk management policies, strategies, actions and measures (proposed) to be implemented by the OPW, Local Authorities and other relevant bodies.

The flood extents generated will be used to assess the flood risk in the study area in terms of the economy, society, the environment and cultural heritage. This will be done using the methodologies outlined in our tender submission in conjunction with the receptor data listed in Section 3.1.6. This data will be supplemented with property occupancy data gathered from each AFA.

Following the completion of the analysis of the potential damage that could be caused by flooding we will investigate the available options to mitigate that damage in each of the AFAs as described in our submission.

We will carry out environmental assessments as described in our tender methodology. The Appropriate Assessments carried out will determine the environmental impacts of each of the various potential flood risk management options identified. These assessments will form an integral part of the selection of preferred options.

Throughout the study we will seek to engage with stakeholder as set out in the Communication Plan.

We understand that the FRMP will be publicly available, and should be non-technical and suitable for use by politicians, stakeholders and the public. The main text of the FRMP will typically be in the order of 100 pages in length (excluding the executive summary and appendices).

The hydraulic models developed for the assessment of current and future flood risk will be used to develop and appraise the potential strategic flood risk management options developed in the flood risk management plan. The modelling results will be compared to the existing risk and used to inform the economic, social and environmental impacts for each proposed option.

Subsequently, the model results will be used to develop and assess sustainable flood management options as part of the FRMPs.

5.10 Constraints and Opportunities

The key hydrological constraints for UoM 19 are associated with water level, flow and rainfall gauge data availability both in terms of spatial and temporal coverage. The data availability and quality has been assessed as part of the data review (Chapter 3 in this report).

The key hydraulic constraints for UoM 19 are as follows:

- The spatial coverage of the river channel survey which could limit accuracy in more rural areas (see Chapter 4 in this report)
- The spatial coverage and quality of topographical data for the floodplain which could limit accuracy in more rural areas where IFSAR data is used(see Chapter 4 in this report)
- The spatial and temporal coverage of river flow and level data which could limit calibration of the hydraulic models, especially for AFAs such as Ballingeary, Castlemartyr and Killeagh which have limited data available (see Chapter 3 in this report). In such data poor locations, the design flood outlines and water level profiles will be compared with anecdotal flood evidence and estimated frequency of historic events as an indicative measure of what might be considered reasonable in place of full calibration.
- The limited timescale to develop the draft flood risk maps ready for the EU Floods Directive 01 January 2014 deadline constrains the detail in the hydraulic modelling approach for MPWs. Therefore, a strategic approach using 1D modelling has been applied to ensure the EU Flood Directives deadline can be met.

Therefore, the level of assessment outlined in Map 2.1 is proportionate to the level of risk and availability of data so that the EU Floods Directive deadline can be met.

The key opportunities for UoM 19 arising from the SWRBD CFRAMs are as follows:

- Opportunity to improve understanding on flood risk from fluvial and coastal sources and key flood mechanisms and scenarios incorporating the influence of Lough levels for Ballingeary;
- Opportunity to improve underlying topographic data through new surveys.
- Opportunity to communicate with and build relationship with other stakeholders and local communities, to improve knowledge and understanding of the risk and viable options to mitigate any existing risk.
- Opportunity to improve management of flooding whether through development of flood alleviation schemes, property level protection measures or improve flood forecasting and warning services to better prepare local communities.

6. Summary

6.1 Progress to Date

6.1.1 Flood Risk Review Reports

The Flood Risk Review has been completed and the final AFA definitions agreed. This process included a review of the PFRA outputs, data collection on historical events and consultation with Local Authorities and Stakeholders. Following this, site inspections were carried out which informed the final AFA definitions. These AFA's are listed in Table 1.1.

6.1.2 Preliminary Hydrological Analysis

Chapter 4 of this report assess the hydrometric, meteorological and historic flood data for UoM 19 River Lee and River Womanagh. The key findings include:

- There are no suitable river flow gauges for the derivation of design flows at Ballingeary or within the River Womanagh catchment.
- There is 1 river level gauge at Castlematyr suitable for calibration of water levels and assessment of hydrograph shape.
- There Ballycotton tidal gauge in Youghal Bay is suitable for analysis of typical tidal hydrograph shape at the tidal outfall River Womangh.
- Preliminary flows and return periods were estimated for historic flood events since 1980
- The November 2009 flood event is the largest magnitude events which flooded large areas of the River Lee and Womanagh catchment and caused over €100 million in damages.
- Two separate calibration events were selected for the hydrological and hydraulic calibration
- Typical flooding mechanisms were identified for each of the AFAs in UoM 19.

Section 5.3 of this report expands on the proposed hydrological methodology as applied to UoM18. The hydrological method statement incorporates the latest Flood Studies Update approach and sets out the methodology for the assessment of design flows including:

- Conceptualisation of 1 MPW and 3 HPW hydraulic model reaches (4 in total);
- Conceptualisation of over 16 HEPs to form the inflows, intermediate targets and downstream conditions to those hydraulics models;
- Estimation of the design index flood value, flood growth curve and typical hydrograph shape at the ungauged fluvial locations in the River Womanagh catchment;
- Revision of the typical hydrograph shape at the ungauged fluvial locations in Ballingeary based on rainfall-runoff techniques and historic flood evidence to capture the impact of Lough Allua levels on flood risk;
- Estimate of tidal boundary conditions at the tidal outfall of the River Womnagh; and,
- Assessment of climate change impacts on design hydrology over the next 50 and 100 years.

6.2 Upcoming Works

Following this inception report, the following tasks will be undertaken for UoM 19 to meet the deadlines set out by the EU Flood Directive:

- River Channel Survey – final delivery December 2012
- Hydrological Analysis – to be completed by June 2013
- Draft Flood Maps and Hydraulic Report – to be completed by June 2013
- Public Consultation and Engagement on Draft Flood Maps – September to October 2013
- Final Flood Maps and Hydraulics Report – to be completed by January 2014
- Flood Risk and Strategic Environmental Assessment – to be completed by July 2015
- Development of Draft Flood Risk Management Plans (FRMPs) – to be completed by April 2014
- Public Consultation and Engagement on Draft FRMPs – January to June 2015
- Final Flood Risk Management Plans (FRMPs) – to be completed by November 2015

Appendices

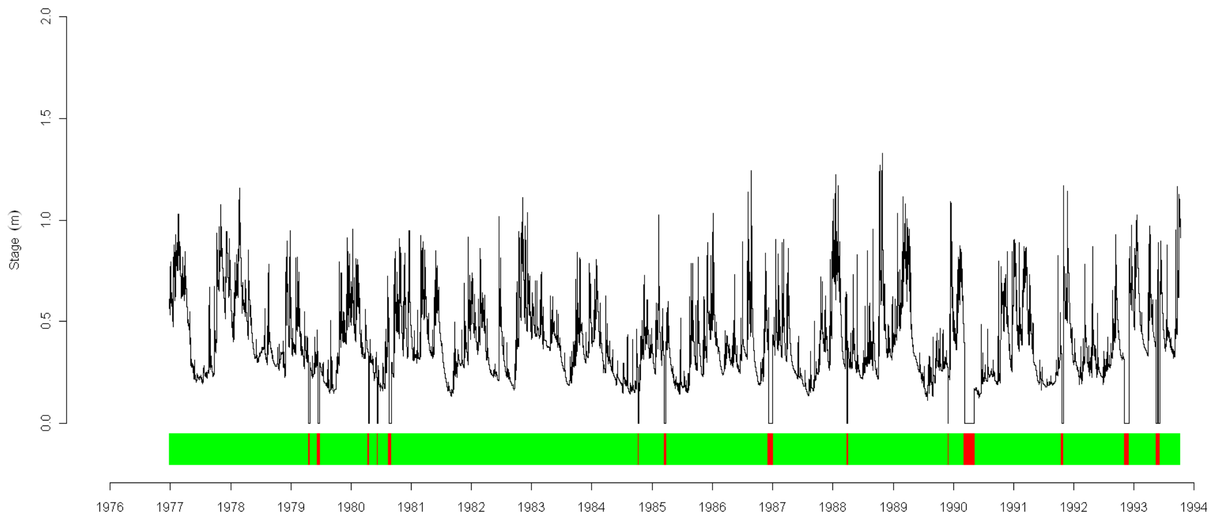
Appendix A. Hydrometric Data Review

Table A.1: Selected Hydrometric Gauge Data

Stn No.	Station Name	River Name	Model	Easting	Northing	Record Start	Years Data	Owner	Rating Curve	Comments	Fit for Calibration Purposes?	Fit for Statistical Analysis?
19003	Castlemartyr	Kiltha	Castlemartyr	196196	72804	23/12/1976	17	EPA	No	No flow available, few missing periods otherwise good quality data. Data only available up to 1993 and does not cover all calibration events	No	(Yes) water level used as proxy to check transferred flows
19019	Dower	Dower	Womanagh	198183	72846	14/04/2010	2	EPA	No	Short record with no flow available, significant missing periods and capping	No	No
19020	Ballyedmond	Owennacurra	Owennacurra	185923	76618	15/06/1977	36	EPA	Yes	Water level and flow gauge with long data series. Post 1996 Q15 data. Potential pivotal site.	Yes	Yes
19039	Ballingeary/Kilmore	Bunsheelin	Ballingeary	115137	67415	13/05/1991	18	EPA	No	Low flow measurements/spot gaugings only (3 to 5 per year) No multiple flow measurements for any event	No, Although can inform typical profile for Lough Allua in conjunction with 19043	No
19043	Inchigeelagh	Lee	(Ballingeary)	122352	65782	22/08/1991	9	EPA	No	Low flow measurements/spot gaugings only (3 to 5 per year) No multiple flow measurements for any event	No, Although can inform typical profile for Lough Allua in conjunction with 19039	No

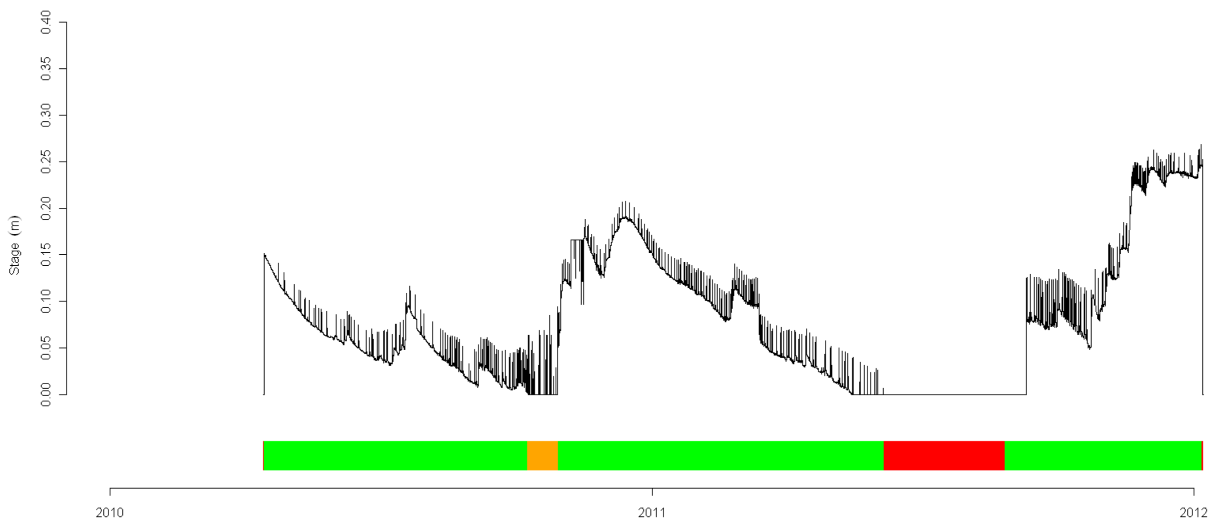
N.B. No plots have been provided for 19039 and 19043 as there is no continuous flow data

Figure A.1: Water Level Data Quality Plot for Kiltha @ Castlemartyr Gauge (EPA - 19003)



Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.2: Water Level Quality Plot for Dower @ Dower Gauge (EPA - 19019)



Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Table A.2: Selected Meteorological Gauge Data

Station Number	Name	Catchment	Easting	Northing	Elevation (mAOD)	Opened	Years Data	Data Interval	Average Annual Rainfall	Comments	Fit for Calibration?	Fit for Statistical Analysis?
1004	Roche's Point	Cork Harbour	183100	60100	43	1955	57	Hourly	1177.00	Data quality reasonable and covers the 2009 flood event	Yes	Not Required
3904	Cork Airport	Owenboy - Douglas	166500	66200	154	1961	51	Hourly	1215.45	Data quality reasonable and covers the 2009 flood event	Yes	Not Required
9704	M. Ballingeary	Ballingeary	113100	64500	323	1948	61	Daily	N/A	No recorded rainfall on record	No	No
3004	Ballingeary (Voc.Sch.)	Ballingeary	163200	62800	73	1948	61	Daily	1871.48	Reasonable quality and covers required 2009 calibration event	Yes, 2009 only	Yes, to determine hydrograph shape and phasing only
9604	M. Ballingeary (Meelin Mtn.)	Ballingeary	114000	71600	341	1948	61	Daily	N/A	No recorded rainfall on record	No	No
2104	Castlemartyr G.S.	Castlemartyr	196100	73200	14	1944	21	Daily	1057.82	Does not cover calibration events required	No	Not Required
6704	Castlemartyr (Killamucky)	Castlemartyr	195300	73900	18	2000	4	Daily		Does not cover calibration events required	No	Not Required
6304	Cloyne (Lisanley)	Cork Harbour	190600	67100	55	1998	14	Daily	1021.49	Covers calibration events as proxy for Womanagh catchment	Yes	Not Required
1804	Tarelton G.S.	Ballingeary (Inchigeelagh)	132300	65800	155	1942	50	Daily	1234.98	Does not cover calibration events post 1992. Could be used to determine relationship with Ballingeary for concurrent period 1948- 1992	No	Yes, to determine hydrograph shape and phasing only

Appendix B. Preliminary Hydrological Parameters

Table B.1: Catchment Descriptors at HEPs for Lee and Youghal Bay Unit of Management (UoM 19)

NODE_ID	WATERCOURSE	PRELIMINARY HYDROLOGICAL APPROACH	EASTING	NORTHING	DTM_AREA	MSL	NETLEN	DRAIND	S1085	TAYSLO	ARTDRAIN2	FARL	SAAR	URBEXT	BFISOILS
19_867_2	River Lee	Ungauged - Rainfall-runoff to determine hydrograph shape only	122444	65868	112.5	19.966	190.65	1.693	5.583	0.309	0.000	0.841	2213	0.000	0.453
19_879_2	River Lee	Ungauged - Rainfall-runoff to determine hydrograph shape only	123852	66655	117.9	21.738	197.438	1.674	4.903	0.269	0.000	0.848	2195	0.000	0.419
19_921_2	River Lee	Ungauged - Rainfall-runoff to determine hydrograph shape only	114098	66704	25.5	9.731	58.609	2.300	12.282	0.913	0.000	0.937	2308	0.000	0.496
19_927_2	Busheelin River	Ungauged - Rainfall-runoff to determine hydrograph shape only	115269	66764	19.8	7.132	31.141	1.570	25.280	15.371	0.000	0.995	2181	0.000	0.492
19_1031_5	Owengariff River	Ungauged - Rainfall-runoff to determine hydrograph shape only	114098	66704	5.7	4.384	7.113	1.255	32.914	36.757	0.000	0.988	2311	0.000	0.394
19_1266_7	River Womanagh	Ungauged -Transfer	196533	71947	14.4	6.602	10.502	0.728	1.149	0.278	0.000	1.000	1024	0.000	0.667
19_1432_3	River Lee	Ungauged - Rainfall-runoff to determine hydrograph shape only	122444	65868	3.6	2.816	5.209	1.443	27.424	16.214	0.000	1.000	1879	0.000	0.433
19_1714_2	River Lee	Ungauged - Rainfall-runoff to determine hydrograph shape only	115878	66805	54.2	11.875	104.334	3.089	10.111	1.072	0.000	0.947	2265	0.000	0.425
19_1755_1	Busheelin River	Ungauged - Rainfall-runoff to determine hydrograph shape only	114428	68259	16.5	5.105	28.210	1.712	27.638	16.733	0.000	1.000	2142	0.000	0.548
19_1794_1	River Womanagh	Ungauged -Transfer	202187	74754	130.6	24.238	107.542	0.824	5.268	0.664	0.000	1.000	1136	0.210	0.671
19_1798_3	Dissour River	Ungauged -Transfer	202187	74754	41.9	14.573	39.856	0.951	10.108	2.983	0.000	1.000	1206	0.000	0.681
19_1909_9	River Kiltha	Ungauged -Transfer	195980	75719	20.8	12.781	20.727	0.997	8.550	2.264	0.000	1.000	1210	0.000	0.674
19_1909_17	River Kiltha	Gauged – Castlematyr gauge	196533	71947	29.3	16.846	24.794	0.845	7.597	1.635	0.000	1.000	1172	0.940	0.668
19_867_2	River Lee	Ungauged - Rainfall-runoff to determine hydrograph shape only	122444	65868	111.8	19.966	189.225	1.693	5.583	0.309	0.000	0.841	2213	0.000	0.453
19_879_2	River Lee	Ungauged - Rainfall-runoff to determine hydrograph shape only	123852	66655	117.9	21.738	197.438	1.674	4.903	0.269	0.000	0.848	2195	0.000	0.419
19_921_2	River Lee	Ungauged - Rainfall-runoff to determine hydrograph shape only	114098	66704	25.5	9.731	58.609	2.300	12.282	0.913	0.000	0.937	2308	0.000	0.496

Source: FSU Database. Highlighted cells indicate modified physical catchment descriptors based on data review. The + sign after a FSU Node ID indicates a number of catchments lumped together, particularly for inflows in tidal reaches where there are no FSU node along the main river.

Appendix C. Hydrometric Gauges

Station Number	Name	River Name	Model	Easting	Northing	Record Start	Years Data	Owner	Rating Curve	Comments	Fit for Calibration Purposes?	Fit for Statistical Analysis?
19003	Castlemartyr	Kiltha	Castlemartyr	196196	72804	23/12/1976	17	EPA	No	No flow available, few missing periods otherwise good quality data. Data only available up to 1993 and does not cover all calibration events	No	(Yes) water level used as proxy to check transferred flows
19019	Dower	Dower	Castlemartyr	198183	72846	14/04/2010	2	EPA	No	Short record with no flow available, significant missing periods and capping	No	No
19020	Ballyedmond	Owennacurra	Owennacurra	185923	76618	15/06/1977	36	EPA	Yes	Water level and flow gauge with long data series. Post 1996 Q15 data. Potential pivotal site.	Yes	Yes
19039	Ballingeary/ Kilmore	Bunsheelin	Ballingeary	115137	67415	13/05/1991	18	EPA	No	Low flow measurements/spot gaugings only (3 to 5 per year). No multiple flow measurements for any event	No, Although can inform typical profile for Lough Allua in conjunction with 19043	No
19043	Inchigeelagh	Lee	(Ballingeary)	122352	65782	22/08/1991	9	EPA	No	Low flow measurements/spot gaugings only (3 to 5 per year). No multiple flow measurements for any event	No, Although can inform typical profile for Lough Allua in conjunction with 19039	No
19001	Ballea	Owenboy	N/A	170971	63276	01/10/1956	56	OPW	Yes	Long record, most flows appear to be above the reliable rating. Watercourse not on modelled reach	No	No
19006	Glanmire Road	Glashaboy	N/A	172913	74488	09/10/1979	31	EPA	N/A	Water level only. Unsuitable for study as gauge does not form part of modelled reach	No	No
19011	Lee Mount U/S	Lee	N/A	160932	71695	N/A	N/A	EPA	N/A	N/A	N/A	N/A
19012	Leemount D/S	Lee	N/A	161140	71790	N/A	N/A	EPA	N/A	N/A	N/A	N/A
19014	Dromcarra	Lee	N/A	129670	67519	31/12/1946	N/A	EPA	N/A	N/A	N/A	N/A
19015	Healy's Br.	Shournagh	N/A	160310	73266	10/11/1973	N/A	EPA	N/A	N/A	N/A	N/A
19027	Kill	Laney	N/A	136455	74301	N/A	N/A	EPA	N/A	N/A	N/A	N/A
19028	Dripsey	Dripsey	N/A	148463	74959	22/11/1984	28	EPA	N/A	N/A	N/A	N/A
19031	Macroom	Sullane	N/A	134743	73133	23/06/1983	29	EPA	N/A	N/A	N/A	N/A
19032	Meadowbrook	Glashaboy	N/A	172917	75280	15/051986	26	EPA	Yes	Long data record with lots of data gaps. Most significant gaps between 1990-1995 and late 2009 to 2010.	No	No
19044	Kilmona	Martin	N/A	159637	82006	01/10/1992	20	OPW	Yes	Not on modelled reach.	No	No
19049	Bishopstown House	Curragheen	N/A	163196	69896	18/04/1997	N/A	EPA	N/A	N/A	N/A	N/A
19050	Ballinaspeg More	Toopot	N/A	162837	69210	18/04/1997	N/A	EPA	N/A	N/A	N/A	N/A
19052	Cork Landfill	Tramore	N/A	168337	69448	22/10/2009	2	EPA	No	Short record and water level only. Unsuitable for study as gauge does not form part of modelled reach	No	No
19062	Cobh Port Station	Lee Est.	N/A	180900	66500	N/A	N/A	EPA	N/A	N/A	N/A	N/A
19063	Ringaskiddy	Lee Est.	N/A	177800	64300	N/A	N/A	EPA	N/A	N/A	N/A	N/A
19064	Marino Port	Lee Est.	N/A	177200	69500	N/A	N/A	EPA	N/A	N/A	N/A	N/A
19065	Blackrock Castle	Lee Est.	N/A	172400	72000	N/A	N/A	EPA	N/A	N/A	N/A	N/A
19066	Glanmire Road	Lee Est.	N/A	172400	72000	N/A	N/A	EPA	N/A	N/A	N/A	N/A

19067	Tivoli	Lee Est.	N/A	171800	72100	N/A	N/A	EPA	N/A	N/A	N/A	N/A
19068	Ballycotton	Sea	N/A	199948	63930	22/02/2007	4	OPW	N/A	Minor variation of data, short data record. Use to derive typical tidal hydrograph shape	Yes	Yes (hydrograph shape)
19090	Carrigadrohid	Lee	N/A	142000	73000	N/A	N/A	EPA	N/A	N/A	N/A	N/A
19091	Lee Bridge	Lee Reservoir Upper	N/A	134200	71300	N/A	N/A	EPA	N/A	N/A	N/A	N/A
19092	Belanaglashan	Lee Reservoir Upper	N/A	135800	70500	N/A	N/A	EPA	N/A	N/A	N/A	N/A
19093	Inniscarra Power Stn.	Lee	N/A	154483	72149	N/A	N/A	EPA	N/A	N/A	N/A	N/A

Type	OPW gauges	EPA gauges (operated by Cork County Council)	Total Gauges Available	Gauges available for Ballingeary, Castlematyr or Killeagh
River Flow and Water Level Gauges	2	13	15	0
River Level Gauges	1	12	13	1
River Flow and Level Observation Locations	0	22	22	13

Appendix D. Rainfall Gauges

Station Number	Name	Catchment	Easting	Northing	Elevation (mAOD)	Opened	Years Data	Data Interval	Comments	Fit for Calibration?	Fit for Statistical Analysis?
1004	Roche's Point	Cork Harbour	183100	60100	43	1955	57	Hourly	Data quality reasonable and covers the 2009 flood event	Yes	Not Required
3904	Cork Airport	Owenboy - Douglas	166500	66200	154	1961	51	Hourly	Data quality reasonable and covers the 2009 flood event	Yes	Not Required
9704	M. Ballingeary	Ballingeary	113100	64500	323	1948	61	Daily	No recorded rainfall on record	No	No
3004	Ballingeary (Voc.Sch.)	Ballingeary	163200	62800	73	1948	61	Daily	Reasonable quality and covers required 2009 calibration event	Yes	Yes, to determine hydrograph shape and phasing only
9604	M. Ballingeary (Meelin Mtn.)	Ballingeary	114000	71600	341	1948	61	Daily	No recorded rainfall on record	No	No
2104	Castlemartyr G.S.	Castlemartyr	196100	73200	14	1944	21	Daily	Does not cover calibration events required	No	Not Required
6704	Castlemartyr (Killamucky)	Castlemartyr	195300	73900	18	2000	4	Daily	Does not cover calibration events required	No	Not Required
6304	Cloyne (Lisanley)	Cork Harbour	190600	67100	55	1998	14	Daily	Covers calibration events as proxy for Womanagh catchment	Yes	Not Required
1804	Tarelton G.S.	Ballingeary (Inchigeelagh)	132300	65800	155	1942	50	Daily	Does not cover calibration events post 1992. Could be used to determine relationship with Ballingeary for concurrent period 1948-1992	No	Yes, to determine hydrograph shape and phasing only
1204	Shanagarry (Kinoith)	Womanagh	197700	67300	24	1910	23	Daily	Short data gaps covering no calibration events	No	No
2604	Ballyvourney (Clountycarty)	Toom	121000	71500	152	1948	64	Daily	High quality dataset with very few data gaps. Includes 2009 calibration event data	Yes	Yes
2704	Gouganebarra	Le	109500	66000	183	1948	64	Daily	High quality dataset with very few data gaps. However, does not include calibration event data.	No	Not Required
3804	Macroom (Renanirree)	Suillane	120100	72600	198	1959	53	Daily	Long record with minimal data gaps, includes 20009 calibration event.	Yes	Not Required
4404	Ballymacoda (Mountcotton)	Stream-Womanagh	205500	69900	64	1976	36	Daily	Good dataset, with data short data gaps. Covers the 2009 calibration event.	Yes	Yes
4804	Dungourney (Ballyeightragh)	Kiltha	194800	83100	157	1976	36	Daily	Data gaps throughout. November 2000 and 2009 calibration events missing from data.	No	No
4904	Killeagh (Monabraher)	Dissour-Womanagh	201000	80600	98	1976	36	Daily	Data gaps throughout.		
5004	Shanagarry North	Stream-Ballycotton Bay	197600	67500	27	1976	36	Daily	Reasonable quality data, with frequent gaps, particularly in the 1990's. Post 2000 is of high quality and includes the 2009 calibration event. Cross referencing reveals, loss of data during a large event in October 1995 and late August 1998.	Yes	Yes
6404	Coolea (Milleans)	Bardinch-Suillane	114400	76500	198	1999	13	Daily	Good quality dataset with a gap during May 2000. Does not include calibration event data.	No	Not Required
9904	M. Inchigeelagh (Pipe Hill)	Lee	120100	62100	299	1948	64	Daily	Gauge inactive/No recorded data	No	Not Required

Type	Met Éireann gauges within or used for subject catchments	Met Éireann gauges within or used for subject catchments	Total Gauges Available
Daily Rainfall Gauges	19	19	8
Synoptic Stations (weather forecasting locations including rainfall)	2	2	2

Glossary

AEP	Annual Exceedance Probability; this represents the probability of an event being exceeded in any one year and is an alternative method of defining flood probability to 'return periods'. The 10%, 1% and 0.1% AEP events are equivalent to 10-year, 100-year and 1000-year return period events respectively.
AFA	Area for Further Assessment – Areas where, based on the Preliminary Flood Risk Assessment and the CFRAMS Flood Risk Review, the risks associated with flooding are potentially significant, and where further, more detailed assessment is required to determine the degree of flood risk, and develop measures to manage and reduce the flood risk.
AMAX	Annual Maximum Flood
ARR	Area for Risk Review
CAR	Community at Risk
CFRAM	Catchment Flood Risk Assessment and Management – The 'CFRAM' Studies will develop more detailed flood mapping and measures to manage and reduce the flood risk for the AFAs.
DAD	Defence Asset Database
DAS	Defence Asset Survey
DEFRA FD2308	United Kingdom Government Department for Environment, Food and Rural Affairs, Joint probability - dependence mapping and best practice Report (2005)
DTM	Digital Terrain Model (often referred to as 'Bare Earth Model')
EPA	Environmental Protection Agency
EU WFD	European Union Water Framework Directive (2000)
EurOtop	European Wave Overtopping of Sea Defences and Related Structures Manual (HR Wallingford 2008)
FRI	Flood Risk Index - a metric that allows the risk to different types of assets (e.g., home, business, monument, utility asset, etc.) to be expressed numerically, but without attempting to assign monetary values to all types of damage.
FRMP	Flood Risk Management Plan. This is the final output of the CFRAM study. It will contain measures to mitigate flood risk in the AFAs.
FRR	Flood Risk Review – an appraisal of the output from the PFRA involving on site verification of the predictive flood extent mapping, the receptors and historic information.
FSU (WP)	Flood Studies Update (Work Package) (2008)
GIS	Geographical Information Systems
HA	Hydrometric Area. Ireland is divided up into 40 Hydrometric Areas.
HEP	Hydrological Estimation Point
HPW	High Priority Watercourse. A watercourse within an AFA.
ICPSS	Irish Coastal Protection Strategy Study (2012)
ICWWS	Irish Coastal Water Level and Wave Study (2013)
IRR	Individual Risk Receptors
ISIS	One dimensional hydraulic modelling software approved for the CFRAM framework
MPW	Medium Priority Watercourse. A watercourse between AFAs, and between an AFA and the sea.
OPW	Office of Public Works, Ireland

OSI	Ordnance Survey Ireland
PFRA	Preliminary Flood Risk Assessment – A national screening exercise, based on available and readily-derivable information, to identify areas where there may be a significant risk associated with flooding.
SEA	Strategic Environmental Assessment. A high level assessment of the potential of the FRMPs to have an impact on the Environment within a UoM.
SW CFRAM	South Western Catchment Flood Risk Assessment and Management study
UoM	Unit of Management. The divisions into which the RBD is split in order to study flood risk. In this case a HA.
WFD	Water Framework Directive. A European Directive for the protection of water bodies that aims to, prevent further deterioration of our waters, to enhance the quality of our waters, to promote sustainable water use, and to reduce chemical pollution of our waters.