



South Western CFRAM Study

Final Report UoM 21

30 May 2017

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Executive Summary

The Office of Public Works (OPW) are undertaking six catchment-based flood risk assessment and management (CFRAM) studies to identify and map areas with existing and potential future flood risk across Ireland. Mott MacDonald Ireland Limited has been appointed by the OPW to assess flood risk and develop flood risk management options in the South Western River Basin District.

This final report summarises the content of the project deliverables as they relate to the Dunmanus-Bantry-Kenmare River Basin.

Flooding is a significant issue in the following towns in the Dunmanus-Bantry-Kenmare River Basin:

- Bantry
- Castletownbere
- Kenmare

In order to manage flood risk in the Dunmanus-Bantry-Kenmare River Basin the following non-structural flood risk management measures are required:

- Planning Control
- Building Regulations
- Consideration of Flood Risk in Local Adaptation Planning
- Sustainable Urban Drainage Systems (SUDS)
- Public Awareness
- Individual Property and Community Flood Resilience
- Voluntary Home Relocation
- Land Use Management and Natural Flood Risk Management Measures
- Emergency Response Planning

The preferred Flood Risk Management Options identified for each of the AFAs in UoM 21 are set out below:

- The preferred option for Bantry is Flood Defences.
- The preferred option for Castletownbere is Flood Defences.
- The preferred option for Kenmare is Conveyance and Flood Defences.

1 Introduction

1.1 Background

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

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

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

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

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

Mott MacDonald Ireland Limited has been appointed by the OPW to undertake the Catchment-Based Flood Risk Assessment and Management Study (CFRAM Study) for the South Western River Basin District, henceforth referred to as the SW CFRAM Study. Under the project, Mott MacDonald Ireland Limited have produced a FRMP which sets 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.

1.2 SW CFRAM Study Process

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

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

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

- Data collection;
- Hydrological analysis;
- Hydraulic analysis;
- Development of flood maps;

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

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

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

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

1.3 Report Structure

The structure of this report is set out as follows:

1. Introduction
2. Project Inception
3. Flood Risk Review
4. Hydrology
5. Hydraulic Modelling and Mapping
6. Development of Flood Risk Management Options
7. Strategic Environmental Assessment
8. Appropriate Assessment
9. Flood Risk Management Plans
10. Lessons Learned
11. Health and Safety
12. Review of Project Scope
13. Non-Reported Deliverables
14. Digital Deliverables

A schedule of the deliverables referred to in this report is included in Appendix A.

2 Project Inception

At the outset of the South Western CFRAM Study Mott MacDonald set out their proposed approach to the study in UoM 21 in an Inception Report. This report included the following:

- Detailed Methodology
- Data & Data Requirements
- Survey Requirements
- Preliminary Hydrological Approach

3 Flood Risk Review

3.1 The Preliminary Flood Risk Assessment

The Preliminary Flood Risk Assessment (PFRA) concluded that there was potential significant risk in the following areas in UoM 21:

- Bantry
- Castletownbere
- Durrus
- Kealkill
- Kenmare
- Kilcrohane
- Sneem
- Templenoe

3.2 Flood Risk Review

The flood risk in each of these areas was reviewed by on site surveys, interviews with residents and Local Authority Staff and consultation with the SW CFRAM Steering Group. Following the review, it was concluded that the following areas were Areas for Further Assessment and should be included in the SW CFRAM Study:

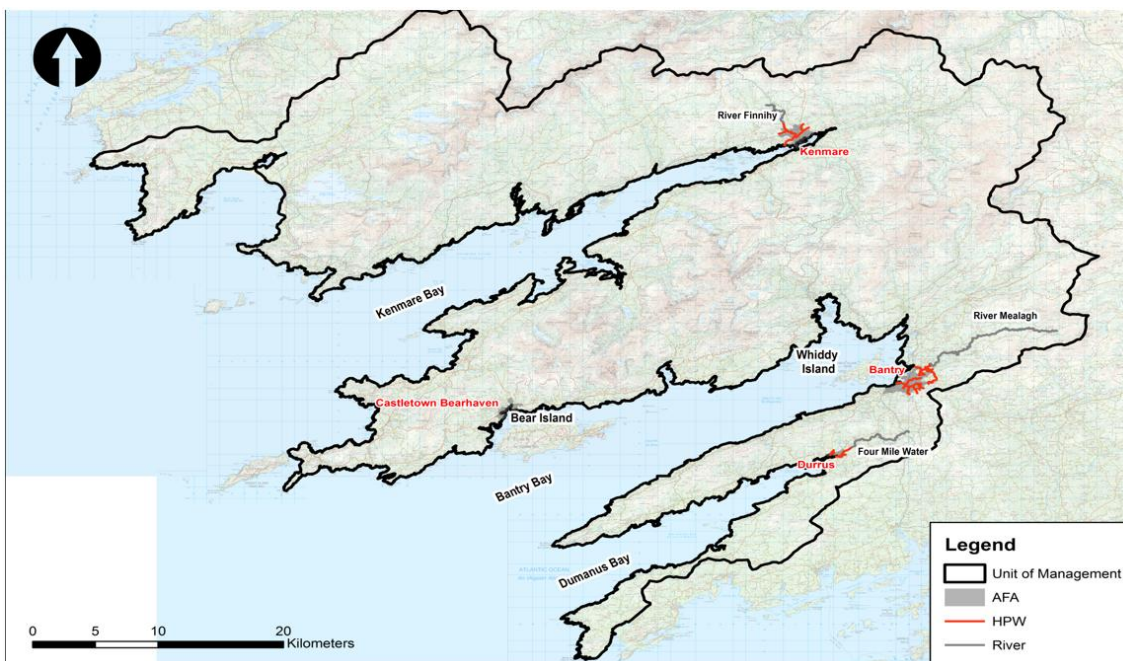
- Bantry
- Castletownbere
- Durrus
- Kenmare

4 Hydrology

4.1 Sub-Catchments & Coastlines

The Dunmanus-Bantry-Kenmare UoM can be split into sub-catchments covering the AFAs as shown in Figure 1.

Figure 1: The Dunmanus-Bantry-Kenmare UoM



Source: UoM 21 Hydrology Report

4.1.1 River Features

The Study considers 26km of High Priority Watercourse (HPW) in Bantry, Durrus and Kenmare. There are no HPW river features in Castletownbere as the town is not considered to be at fluvial flood risk.

4.1.1.1 Bantry AFA

There are three distinct hydrological catchments in the Bantry AFA. The Mealagh catchment to the north of Bantry Town is a reasonably large catchment covering 56km². The River Mealagh rises in the uplands of the Maughanaclea Hills and flows approximately 10km to the west before skirting around Drombrow Lough and entering the Bantry AFA. The Mealagh flows through the town of Dunmark before passing through Dunmark Bridge and down a steep section into the tidally affected harbour. There is a small ridge to the west of Drombrow Lough that forms a low barrier between the Lough and the Mealagh. The water in the Lough flows into the Mealagh by a small channel that has its confluence to the northeast, away from the AFA. In the area near to the AFA, where there is a risk of flooding from tributaries to the Mealagh, there are the Raheen Beg, Doneelagh, Milleencolla East and Milleencolla West streams. Flooding from the Ardnageehy tributaries in the upper reaches of the Doneelagh Stream has been shown during

the course of this study to flow to the west, into the River Bantry catchment and not, as expected to the northeast into Doneelagh Stream.

Bantry Town itself resides in the River Bantry catchment, the middle hydrologically distinct catchment in the Bantry AFA. The River Bantry is 2.2km long, rises near Ardnageehy More and flows along a fairly steep channel (a gradient of up to 1 in 30) before passing into a tidally influenced culvert under Chapel Street in Bantry. The culvert passes under Bantry town centre and terminates in an outfall into Bantry Harbour. The River Bantry is joined by five tributaries: the Knocknaveagh, Sheskin East, Carrignagat, Dromleigh and Reenroul tributaries. The four tributaries to the south of Bantry River, the Knocknaveagh, Sheskin East, Carrignagat and Dromleigh, are all narrow and steep channels with many engineered sections, including culverts, weirs, bridges and aqueducts. The Reenroul Stream is the largest tributary to Bantry River and it has a shallower gradient of approximately 1 in 50. The lowest reach of the Reenroul is culverted and has a junction with Bantry River in the long culvert beneath Bantry Town.

The third hydrological catchment in the Bantry AFA contains the Kilnaruane and Dromacoosane Rivers which flow through a predominantly rural area on the coast to the south of Bantry.

4.1.1.2 Durrus AFA

The Durrus River runs approximately 10km from its source in the Coomnagoragh Mountain range. At Ballycommane it is renamed Four Mile Water and continues as an open channel to Dunmanus Bay. The Four Mile Water River is tidally influenced as far upstream as the waterfall 500m upstream of Carrigboy Bridge. The only tributary to Four Mile Water is the Ahanegavanagh Stream which flows southwards from the Coomkeen area to Dunmanus Bay, joining the Four Mile Water River in the tidally influenced reach downstream of Durrus town.

4.1.1.3 Kenmare AFA

The River Finnihy flows from Barfinnihy Lough down a very steep channel before being joined by a number of small tributaries, and flowing south-eastwards towards Kenmare. Within the town, the River Finnihy flows over a waterfall 300m upstream of Finnihy Banks estate, and is joined by the Lissaniska tributary immediately upstream of Finnihy Bridge. The river channel then meanders to the west, under Cromwell's Bridge and continues to outfall into Kenmare Bay/River. The River Finnihy is tidally influenced as far as Cromwell's Bridge under typical tidal conditions but the tidal influence can extend beyond Finnihy Bridge under extreme high tides. The only other tributary considered in Kenmare is Gortamullen Stream which drains the bog land to the north of the N70. The Gortamullen Stream rises and then splits flow between the Claddanure catchment to the west and the Finnihy catchment to the east. The eastern branch flows down a stream reach (a gradient of 1 in 55) before entering a long culvert at the N70 to join the River Finnihy immediately downstream of the waterfall.

4.1.2 Coastal Features

The Kenmare, Bantry and Dunmanus Bays are orientated to the prevailing south-westerly storms. The shallow bathymetry in the bays funnels any incoming storm surges, increasing coastal risk and tide-locking of rivers entering the bays.

4.1.2.1 Kenmare AFA

Kenmare Bay known as Kenmare "River" is protected under the Natura 2000 act as a Special Area of Conservation for its shallow inlets and varying shoreline cliffs and dune areas. It narrows towards Kenmare into "The Sound" inland of the N71 crossing. The Sound is characterised by more estuarine features including a series of in-channel bars and tidal channel

loops. The low tide channel width and shape is highly variable in this dynamic fluvial-tidal environment and varies from channel widths of 50m to 195m. There are also low-lying areas at Reennagross which are covered by high spring tides.

4.1.2.2 Bantry Bay including Castletownbere and Bantry

Bantry Bay is a narrow tidal bay which extends from Dursey Island inland to Ballylicky and the Owvane River outfall. Bantry Bay has a number of islands which modify the tidal current and provide some protection to the mainland from incoming storm waves. These islands include Bear Island at Castletownbere and Whiddy Island at Bantry. Castletownbere Harbour is further protected from extreme waves by Dinish Island which is a low-lying extension of the Castletownbere port with low sea walls protecting the quayside.

4.1.2.3 Dunmanus Bay including Durrus

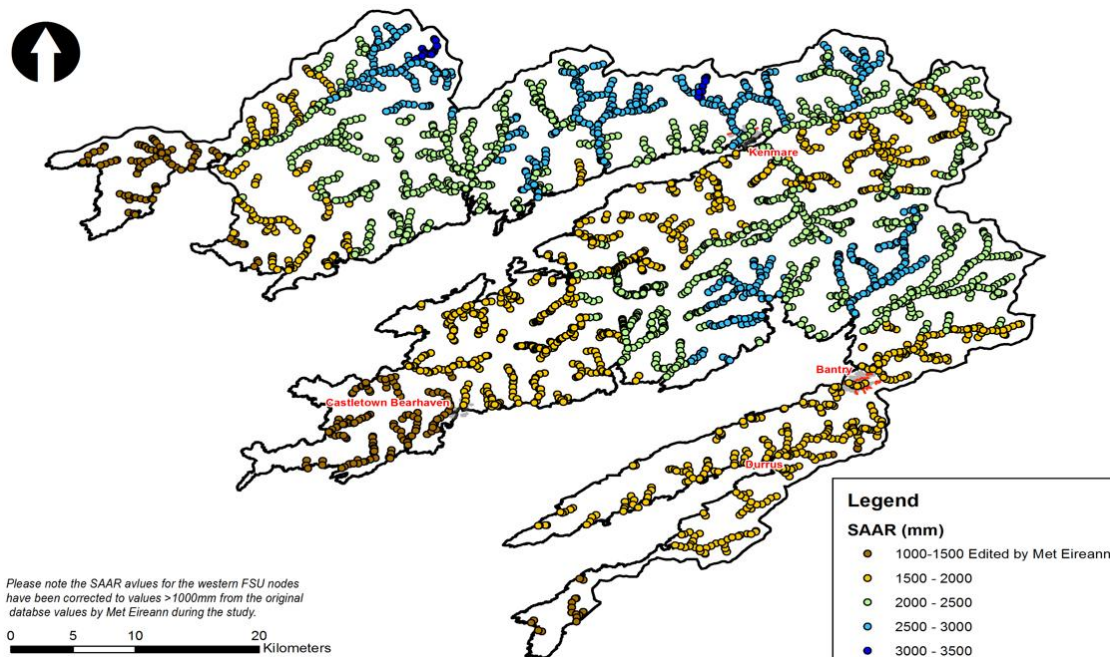
Dunmanus Bay is the smallest and narrowest of the three bays considered in UoM21. It extends from Mizen Head to Four Mile Water at Durrus. The Bay is characterised by steep cliffs along the headlands but develops more estuarine tidal bars at Four Mile Water outfall. Durrus AFA is actually located some distance from the tidal outfall of Four Mile Water, and well above the extreme coastal conditions. Therefore, flooding from coastal sources has not been assessed at Durrus for the CFRAM study.

4.2 Rainfall Distribution

Figure 2 shows the variation in Standard Average Annual Rainfall (SAAR) across UoM21. The SAAR typically increases with elevation. The highest values are associated with the highest relief near Kenmare. Bantry and Durrus have slightly lower SAAR values below 2000mm due to the lower relief in this area.

Prolonged frontal Atlantic storm events dominate the rainfall events in UoM21, tracking from west to east. These heavy rainfall events combined with the relatively small steep catchments can cause overland flow and flooding issues. This is particularly acute in Bantry where it has overwhelmed the urban drainage network and caused landslides in the past.

Figure 2: Standard Annual Average Rainfall



4.3 Recommendations for Future Analysis

The following recommendations were drawn from the hydrological analysis for future analysis in the catchment:

- Additional high flow monitoring at Inchiclogh gauge as the only gauge within an AFA catchment would be beneficial to confirm the extension of the rating curve at this location and improve the estimate of flood flows in the Mealagh catchment.
- Additional spot gaugings and a review of high flow ratings at all Irish gauge records following the CFRAM study analysis would improve the estimate of flood flows nationally.
- Continued efforts to collate historic flood evidence for past and any new flood events is critical to improve the hydrological and hydraulic outputs in Durrus and Castletownbere.

Full details of all the available and reviewed data for the UoM are available in the UoM 21 Hydrology Report.

5 Hydraulic Modelling and Mapping

Three 1D-2D ISIS-TUFLOW hydraulic models were developed for Durrus, Bantry and Kenmare to assess fluvial and coastal flood risk for various flood probabilities. The river channels were modelled using 1D ISIS software to calculate flows and head loss at hydraulic structures. The 2D TUFLOW software was used to simulate the multi-directional flows across the complex urban floodplains. The 1D and 2D components of the models are hydrodynamically linked such that water can flow between the river and floodplain during the event to simulate the observed flood mechanisms. A 2D TUFLOW model was developed to assess coastal flood risk in Castletownbere as it was not deemed to be at risk from fluvial flooding.

The layout of the hydraulic models can be seen in Figure 3.

The Bantry and Kenmare models were calibrated to flood events of 17th October 2012 and 23rd October 2008 where sufficient data enabled full calibration of the hydraulic parameters. Sensitivity tests were undertaken on flow, downstream level and Manning's 'n' for all models. An additional sensitivity test on the assumptions on the utility pipe at Finnihy Bridge, Kenmare was also undertaken.

The calibrated and tested models were then run for eight flood probabilities under the current design scenario, eight flood probabilities under the mid-range future scenario, and three flood probabilities under the high-end future scenario from both fluvial and coastal sources. The flood extent, flood zone, flood depth, flood velocity and flood hazard were all mapped for the specified scenarios, and are provided in the Appendices to the Hydraulics Report.

5.1 Hydraulic Recommendations

The following recommendations were drawn from the key findings of the Hydraulics Report:

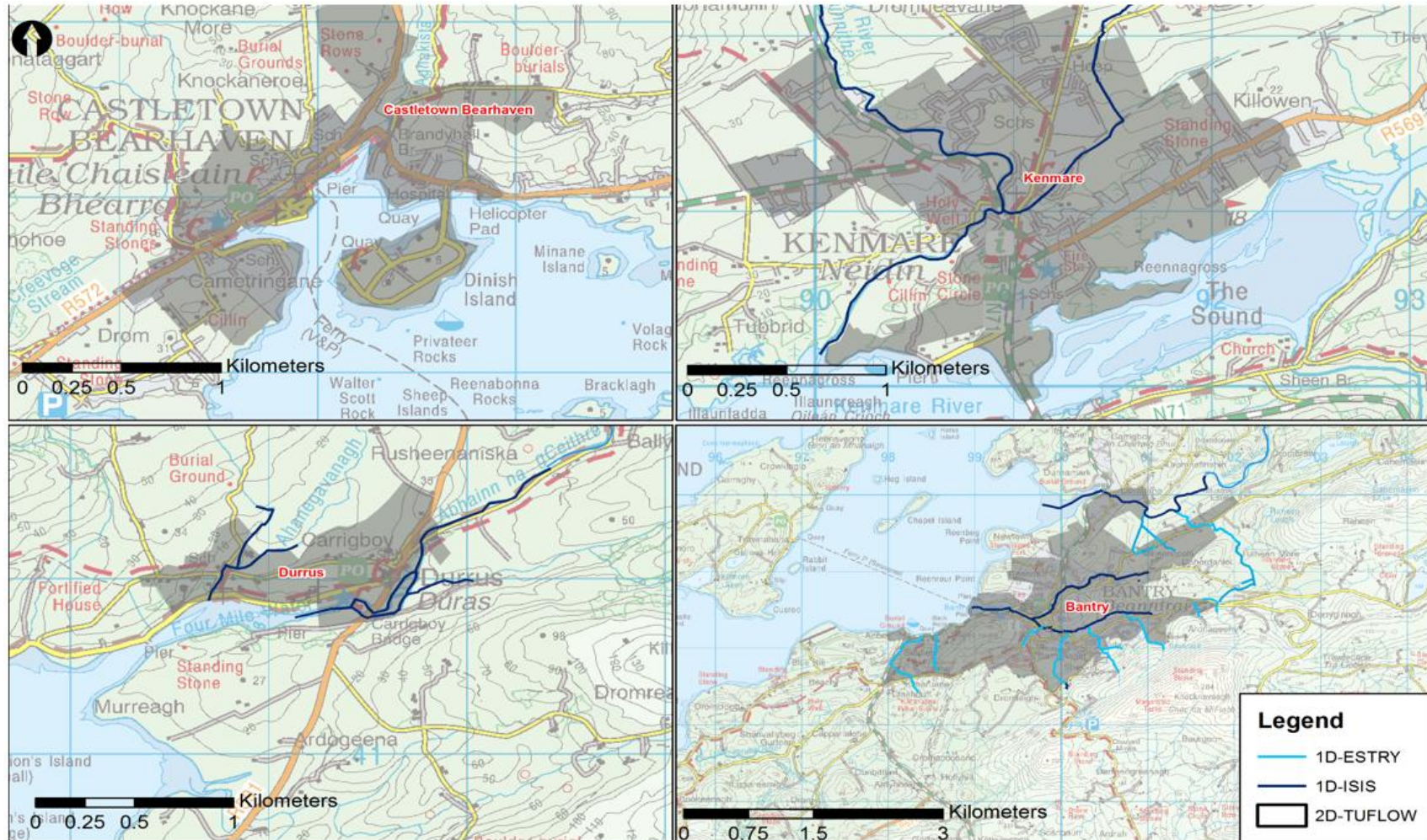
- The uncertainty and sensitivity to peak flow and duration estimates should be considered in the sizing and operation of any flood management options based on the storage of flood waters in Kenmare and Bantry.
- The uncertainty in the total tide plus surge levels should also be considered in the development of any flood embankment/walls to protect against coastal flooding in Kenmare, Castletownbere and Bantry.
- Reducing the roughness of the channel may increase channel capacity and reduce water levels for events which are closer to the threshold of flooding i.e. more frequent events than 1%AEP event.
- The capacity of Finnihy Bridge and neighbouring bridges in Kenmare should be carefully considered for increased conveyance options to reduce flood risk upstream, as these have been shown to be critical during the calibration and sensitivity tests.
- The capacity of the culverts in the Bantry Town catchment should be carefully considered for increased conveyance options to reduce flood risk upstream.
- Infilling works (temporary or permanent) of the access gaps in the sea wall at Bantry and Castletownbere should be considered to block flow routes before the wall itself is overtopped.
- It is recommended that post-flood surveys are continued for all significant future flood events where properties and/or infrastructure are affected. Data should be collected shortly after the event and include: sources of flooding, timing of overtopping, any

actions taken and at what time, blockages of structures, flood levels in the channel and on the floodplain and accompanying photographs.

- It is recommended that surface water flooding and the interaction of flooding with the urban drainage network is investigated in Bantry, given the history of pluvial flooding around Wolfe Tone Square.

Full details of the hydraulic modelling and mapping are included in the Hydraulics Report for UoM 21.

Figure 3: Model layout



6 Development of Flood Risk Management Options

6.1 Option Development

The process undertaken to develop flood risk management options for each AFA is set out in the Preliminary Options Report.

In the first instance, a screening and preliminary assessment was carried out to identify which Flood Risk Management (FRM) measures were applicable to each of the Spatial Scales of Assessment (SSA) within UoM 21. The SSAs identified for UoM 21 were the UoM and the AFAs.

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

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

The viability of each of the measures was assessed to a preliminary degree only. The purpose of the screening process was to identify the FRM measures that are clearly not applicable or viable within UoM 21.

A Flood Risk Management (FRM) option consists of one, or more commonly a combination of FRM measures. Potential Flood Risk Management (FRM) options for each of the AFA's within UoM 21 were developed.

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

6.2 Cost Estimates

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

The total cost of the option was calculated by adding costs for the following to the basic construction cost:

- Optimism Bias; A percentage add-on was applied to take account of issues unknown at preliminary design stage. This percentage was evaluated separately for each measure.
- Preliminaries
- Design fees
- Archaeology

- Environmental mitigation
- Compensation and land acquisition
- Site investigations
- Maintenance costs

6.3 Benefit Evaluation

6.3.1 Economic damage caused by flooding

The potential economic damage that could be caused by the flood event scenarios was calculated for every property in each of the UoM 21 AFAs. The damage to a property is related to the type, area and predicted depth of flooding within the property. It is possible to calculate the damage that could arise from a series of floods of different Annual Exceedance Probability (AEP). Using these damage values, the Annual Average Damage for the AFA can be calculated by measuring the area under the Damage / Probability Curve.

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

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

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

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

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

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

6.3.2 Benefit calculation

The benefit of a flood risk management option (Scheme) was also calculated which is the damage avoided by implementing a scheme to the required Standard of Protection (SOP).

6.4 Flood Risk Assessment

Flood risk mapping for the UoM 21 AFAs and Medium Priority Watercourses (MPWs) has been undertaken as part of this Study. The mapping includes the receptors that are at risk from flooding in the following categories:

- Society
- The Environment
- Cultural Heritage
- The Economy

The number of receptors at risk from the various flooding scenarios are listed in the Preliminary Options Report.

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

6.5 Preferred Options

The preferred Flood Risk Management Options selected for inclusion in the Flood Risk Management Plan for UoM 21 are set out below.

- Planning Control
- Building Regulations
- Consideration of Flood Risk in Local Adaptation Planning
- Sustainable Urban Drainage Systems (SUDS)
- Public Awareness
- Individual Property and Community Flood Resilience
- Voluntary Home Relocation
- Land Use Management and Natural Flood Risk Management Measures
- Emergency Response Planning

Planning control and development management can be a viable flood risk management measure. Using flood hazard information developed as part of the CFRAM study, it was possible to identify areas that are zoned for development that are at risk of flooding. The Spatial Planning and Flood Risk Report identifies such areas in UoM 21 and makes recommendations to manage flood risk in these areas for the consideration of the local authorities and the OPW.

As part of the CFRAM study, the applicability of SUDS was assessed for each AFA. It was found that SUDS is not applicable to existing developed areas in these AFAs, as the required area for storage of surface water flows is not available. However, SUDS is applicable to areas that have been zoned by local authorities for future development. By adopting a SUDS approach for containing surface water within new developments, flooding events can be mitigated by storing surface water on-site. The Strategic Sustainable Urban Drainage System Report for UoM 21 outlines natural drainage patterns in each of the AFAs and identifies the volume of storage to be provided for areas zoned for future development.

The preferred Flood Risk Management Options selected for inclusion in the Flood Risk Management Plan for each of the AFAs in UoM 21 are set out below:

- The preferred option identified for Bantry is and Flood Defences.
- The preferred option for Kenmare is conveyance and Flood Defences.
- The preferred option for Castletownbere is Flood Defences.

7 Strategic Environmental Assessment

7.1 The SEA Directive

Strategic Environmental Assessment is required under the EU Council Directive 2001/42/EC on the Assessment of the Effects of Certain Plans and Programmes on the Environment, more commonly known as the “SEA Directive” which has been transposed into Irish law by the following regulations:

- European Communities (Environmental Assessment of Certain Plans and Programmes) Regulations, 2004 (S.I. 435 of 2004) and the
- Planning and Development (Strategic Environmental Assessment) Regulations, 2004 (S.I. 436 of 2004).

Strategic Environmental Assessment (SEA) is a formal, systematic evaluation of the likely significant environmental effects of implementing a plan or programme, prior to a decision being made to adopt a plan or programme.

SEA in Ireland is based on Directive 2001/42/EC (Assessment of the Effects of Certain Plans and Programmes on the Environment), more commonly known as the “SEA Directive” which has been transposed into Irish law by the European Communities (Environmental Assessment of Certain Plans and Programmes) Regulations, 2004 (S.I. 435 of 2004) and the Planning and Development (Strategic Environmental Assessment) Regulations, 2004 (S.I. 436 of 2004). These regulations were replaced in 2011 by the European Communities (Environmental Assessment of Certain Plans and Programmes) (Amendment) Regulations, 2011 (S.I. No. 200 of 2011) and the Planning and Development (Strategic Environmental Assessment) (Amendment) Regulations 2011 (S.I. No. 201 of 2011).

The main objective of the SEA Directive is to:

“Provide for a high level of protection for the environment and to contribute to the integration of environmental considerations into the preparation and adoption of plans and programmes with a view to promoting sustainable development.”

7.2 The SEA Process

The SEA process requires the assessment and evaluation of the FRMP measures to identify the potential significant effects of the options on the receiving environment and to identify the preferred options and appropriate mitigation and monitoring required to offset potential impacts. This assessment has been done as part of an overall Multiple Criteria Analysis where the SEA Objectives are utilised to assess the measures proposed in the FRMP for the UoM. The principle steps in the assessment process are as follows:

Flood Management Option Development and Assessment: The SEA process has been fully integrated into the overall appraisal process for the identification of flood risk management options. Based on a detailed understanding of the flood risk identified for each Area of Further Assessment (AFA), a number of different flood alleviation risk management options were developed. Each of these options was then assessed based on a multi-criteria option assessment (MCA) process. The MCA used a suite of project objectives, which include the SEA objectives to rate each of the proposed plan options. This assessment was then used to identify the preferred flood risk management options. In order to facilitate a more accurate assessment, a semi-quantitative approach was adopted whereby each plan option was assessed against the

SEA objectives and sub-objectives having regard to the indicators, basic requirements and aspirational targets:

- **Indicator:** The indicators are parameters, measurable and numeric where possible by which the success of an option in meeting a particular objective is gauged;
- **Basic Requirements:** A basic requirement is set for each objective as a measure to gauge whether the proposed option meets a minimum standard with regard to each objective. The Basic requirement is a measure below which the proposed objective would have a negative effect.
- **Aspirational Targets:** This is a target set for each objective and defines the perfect outcome with regard to the potential impact of the objective.

Each option was scored against the objectives and sub-objectives based on the scoring matrix. Once a score was defined for each objective then a global weighting was applied which defined the perceived importance of the objective in question. Furthermore, local conditions were also considered for each AFA whereby a local weighting was applied based on an understanding of the local conditions relevant to the objective in question.

Following the identification of preferred flood risk management options from the MCA process, the next stage of the study comprised the development of an overall flood risk management strategy which would comprise a combination of flood prevention measures, flood protection measures and flood preparedness.

8 Appropriate Assessment

8.1 The Habitats Directive

In accordance with Article 6(3) of the Habitats Directive (92/43/EEC), Appropriate Assessment is required where a plan or project not directly connected with or necessary to the management of a Natura 2000 site(s), may give rise to significant effects upon a Natura 2000 site(s). The requirement for Article 6 Assessments has been transposed into Irish law by the European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. No. 477 of 2011), herein referred to as the 'Regulations'. Natura 2000 sites include Special Protection Areas (SPAs), Special Areas for Conservation (SACs), which have been adopted by the European Union (EU), but not yet formally designated by the governments of Member States, as well as candidate SPAs and SACs. In accordance with the Regulations, Natura 2000 sites are herein referred to as European sites.

8.2 Natura Sites

8.2.1 Kenmare River SAC (002158)

Flood risk management options in Kenmare are proposed for both the Finnihy River and the Kealnagower River. The Kenmare River SAC (002158) extends from the N71 road bridge crossing seaward as far as Dursey Island and Scariff Island and includes the tidal extent of the Finnihy River which stops approximately 200m short of the Finnihy Bridge. Flood risk management measures are proposed at the Finnihy Bridge and may extend to within the SAC.

8.2.2 Beara Peninsula SPA (004155)

The Castletownbere AFA boundary does not overlap with any Natura 2000 site boundary. The nearest Natura 2000 site is the Beara Peninsula SPA (004155), which is approximately 3.5km south of Castletownbere.

The Bantry AFA boundary does not overlap with any Natura 2000 site boundary.

8.3 Potential Impacts on Qualifying Features

8.3.1 Bantry AFA

There are no potential impacts for the flood risk management works in the Bantry AFA.

8.3.2 Castletownbere AFA

Disturbance to wetland birds is extremely unlikely given distance from site.

8.3.3 Kenmare AFA

Impacts on Annex I habitats are determined to be extremely unlikely given that these are primarily coastal habitats and the options will be implemented inland.

Impacts on Whorl Snail, Lesser Horseshoe Bat, Otter and Common Seal are determined to be extremely unlikely given the distance of these species from the indicative locations for the viable flood risk management works.

The Finnihy River hosts a Freshwater Pearl Mussel population. This is not a qualifying feature of the Kenmare River SAC therefore there can be no impacts on the conservation objectives of the SAC.

8.4 Significance of Impacts for AFAs within UoM 21

No likely significant effects on Natura 2000 sites are reasonably foreseeable as a result of the implementation of flood risk management measures in UoM 21 of the SWRBD catchment area.

9 Flood Risk Management Plan

The Flood Risk Management Plan is a public facing document that outlines the process undertaken as part of the CFRAM Study and sets out the flood risk management policies, strategies, actions and measures to be implemented by the OPW, Local Authority and other relevant bodies.

9.1 Public Consultation

Following publication of the Draft Plan and associated SEA Environmental Report (SEA ER) and Appropriate Assessment (AA) in July 2016, a series of public consultation events took place to give members of the public an opportunity to discuss the contents of the plan with members of the study team.

Table 1: Public Consultation Days

Location	Date	Venue	Nr. of Attendees
Cork City	31/8/16	Cork County Hall	24
Skibbereen	1/9/2016	The Library Building	18
Castleisland	2/9/2016	Kerry County Council Offices	30
Killarney	5/9/2016	The Plaza Hotel	25

9.2 Selected Feedback on the Plan

Observations on the plan, the SEA ER and the AA were received by OPW. Some selected feedback on the documents are summarised below:

9.2.1 Bantry

Some stakeholders wanted to ensure that the proposed Flood Defences did not impact on proposals to provide more parking in the town.

9.2.2 Kenmare

Some stakeholders were concerned that Flood Defences could detract from the landscape of the town.

9.3 Changes made to the Plan following Public Consultation

No changes were made to the plan following the receipt of observations on the draft plan.

10 Lessons Learned

10.1 Stakeholder Consultation and Engagement.

Through the delivery of the South Western CFRAM Study in UoM 21 we have concluded that further iterations of the CFRAM studies could benefit from a revised approach to stakeholder consultation and engagement. Some of the difficulties encountered are listed below:

- People affected by flooding or flood risk management measures did not know about the study or consultation events.
- People felt that their suggested FRM measures had not been considered.
- People attending consultation on Preliminary Options felt that the team had already made their minds up as to what the preferred option was.
- Stakeholders adopted an adversarial approach to their review of the project deliverables.

We would recommend that expert advice is sought in developing a methodology and programme of public and stakeholder engagement to ensure that in future studies, there is a better buy in from the stakeholders. Early stakeholder participation would be of benefit in this. In order to achieve buy-in, it would be necessary to demonstrate that the input of stakeholders has been considered and forms part of the analysis. The best way to do this may be through workshops.

Some of the constraints that the OPW currently has to operate within include the environmental and economic feasibility. These constraints, and the parts they play in the decision-making process act as barriers to meaningful public consultation and engagement. Careful consideration should be given to how the conflicting objectives of public will, the environment and the cost benefit ratio can be resolved to improve the consultation and engagement process.

The consultation and engagement of environmental stakeholders may be improved with targeted workshops. At these, environmental experts could engage directly with environmental stakeholders (SWAN, NPWS).

11 Health and Safety

11.1 Safety, Health and Welfare at Work Regulations 2013

The South Western CFRAM study includes the preparation of designs that could lead to construction work. In accordance with the 2013 Construction Regulations the OPW are obliged to appoint a Project Supervisor for the Design Process (PSDP). The PSDP is tasked with co-ordinating the work of designers on a project to ensure that they fulfil their duties in respect of the Construction Regulations. The PSDP is also required to prepare a Safety and Health Plan that includes the following:

- A general description of the project
- A description of other work activities ongoing at the site
- A description of the works which will involve particular risks to the safety and health of those constructing the works and
- Information from designers in respect of the decisions they made to mitigate the risk to persons constructing, operating, maintaining and demolishing the works

Mott MacDonald Ireland were appointed by OPW to carry out this role.

The particular risks associated with the preferred options include the following:

- Falling from height
- Drowning
- Electrocution
- Burial under earthfalls
- Engulfment in swampland
- Chemical and biological agents
- Heavy prefabricated components
- Interaction with traffic

In addition, Mott MacDonald Ireland, as designers, are obliged under the regulations to consider how their designs can be constructed, operated, maintained and demolished safely. As designers, Mott MacDonald Ireland are obliged to design out risk in their designs where possible. Decisions made by designers in this regard are documented in Designer's hazard elimination and management record sheets which are appended to the Preliminary Health and Safety Plan for the UoM.

12 Review of Project Scope

12.1 Hydrology

In viewing the hydrology of an entire catchment, it should be recognised that, for various reasons, the extreme peak flow will not always increase as you progress downstream. In future studies, greater weight should be permitted to single site analysis in areas where there is a significant flood risk.

12.2 Hydraulic Modelling

In future studies, it should be recognised that there is little value in modelling steep watercourses that do not give rise to flood risk in their upper reaches. Steep rivers can carry significant volumes of water without giving rise to flood risk. It can be very difficult to construct stable models of steep rivers.

Greater flexibility should be allowed in future studies for consultants to use other methods to calculate flood depths. In certain AFAs it could have been possible to use simple calculations to determine flood depth.

Based on the screening carried out during this study, future studies should include the impact of blockage at high risk structures. This data may not necessarily be reproduced on the flood extent maps but these maps should highlight that there could be a blockage issue and refer to supplementary flood extent maps.

Future studies should focus on more user friendly digital deliverables as opposed to pdf drawings. In particular, GIS deliverables and web mapping could speed up, and reduce the cost of, the delivery of flood data.

13 Non-Reported Deliverables

This section contains summaries of deliverables that have not previously been reported in SW CFRAM Deliverables.

13.1 Defence Asset Condition Survey

The condition of flood defence assets in AFAs and identified in the project brief was ascertained by on-site inspection. The condition of the assets was recorded in the Flood Defence Asset Database.

13.2 Uncertainty Mapping

The uncertainty associated with the flood extents for various models is shown on the uncertainty mapping. The mapping was carried out as per the methodology set out in the RPS Document “Methodology for Uncertainty Mapping Dodder CFRAMS”. The uncertainty associated with flood extents is associated with uncertainty in the hydrology and in the hydraulic modelling.

The uncertainty related to the hydrology for an area was scored based on the method used to derive extreme flows. The scores for hydrology are shown in Table 2.

Table 2: Hydrological Uncertainty

Method		Score
Catchment Descriptors - FSR	FSR Rainfall Runoff	4
Catchment Descriptors - FEH	FEH Rainfall Runoff	3
Short record (<10 years)	Calibrated Rainfall Runoff	2
Long record (≥10 years)		1

The uncertainty related to the hydraulic modelling for an area was scored based on the complexity of the models. The scores for hydraulic modelling are shown in Table 3.

Table 3: Hydraulic Complexity

	Model Description	Score
Simple	Few inflows, branches and structures	0
Medium	Some inflows, branches and structures	1
Complex	Reservoir units, many inflows, and/or many branches	2

Large increases in flow for different AEP flood events gives rise to an increase in uncertainty. To take account of this a third score is used, the Return Period Score.

The uncertainty Scores for UoM 21 are shown in Table 4.

Table 4: Uncertainty Scores

Model	Hydrology Score	Hydraulic Complexity
Durrus	3	0
Bantry	3	2
Castletownbere	1	0
Kenmare	3	1

The uncertainty line for a flood extent is calculated based on the design flow, the design flood extent, the next extreme flood extent and the uncertainty score.

14 Digital Deliverables

Details of deliverables that have been issued in interactive digital formats are described below.

14.1 Defence Asset Condition Database

The condition of flood defence assets in AFAs and identified in the project brief was ascertained by on-site inspection. The condition of the assets was recorded in the Flood Defence Asset Database which is an Excel spreadsheet with hyperlinks to photographs of the assets.

14.2 River Channel and Structure Survey

AutoCAD drawings of the river channel and structure surveys specified to facilitate the construction of hydraulic models were issued to OPW. Watercourses were given a 6-digit reach code to identify them. The watercourses surveyed in UoM 21 are listed in Table 5.

Table 5: Surveyed Watercourses

Watercourse	Reach Code
GORTAMULLIN SOUTH	21GORN
Finnihy (River)	21FINN
KILOWEN	21KILO
LISSANISKA	21LISS
Mealagh (River)	21MEAL
Carrigboy Link	21FMWN
Carrigboy Loop	21FMWS
Four Mile (Water) NORTH	21LINK
Four Mile (Water) SOUTH	21LOOP
CLADDANURE	21CLAD
ARDNAGEEHY	21ARDN
ARDNAGEEHY EAST TRIB	21ARET
ARDNAGEEHY NORTH TRIB	21ARNT
DERRYGINAGH	21DONE
Doneelagh (Stream)	21GINA
RAHEEN BEG	21RBEG
TRAWLEBANE	21TRAW
MILLEENCOLLA EAST	21MILE
MILLEENCOLLA WEST	21MILW
BANTRY	21BANT
CARRIGNAGAT	21CARR

Watercourse	Reach Code
DROMLEIGH	21DROL
KNOCKNAVEAGH AREA	21KNOC
KNOCKNAVEAGH WEST TRIB	21KNWT
REENROUR	21RENT
REENROUR TRIB	21ROUR
SHEKIN EAST	21SHEE
SHEKIN EAST TRIB	21SHET
CAPPANALOHA	21CAPA
DROMACOOSANE	21DROM
KILNARUANE	21KILE
AHANEGAVANAGH	21NAGH

14.3 Hydraulic Models

The hydraulic models built as part of the South Western CFRAM study were issued to the OPW on a hard disk drive. Separate models were built to prepare flood maps, to analyse flood defence failure and to develop options. These models are contained in folders called DESIGN, BREACH and OPTION. The models relating to the AFAs and MPWS are listed in Table 6.

Table 6: Hydraulic Models

Model Number	Name	Location
29	Durrus	Durrus AFA
30	Bantry	Bantry AFA
31	Castletownbere	Castletownbere AFA
32	Kenmare	Kenmare AFA

14.4 Flood Maps

Flood maps were prepared and delivered in pdf and in GIS format.

Table 7: Flood maps

Map Nr	Map Type	GIS format	Probabilities mapped per scenario		
			Current	MRFS	HEFS
1	Flood Extent	Polygon	All	All	10,1,0.1
2	Flood Zone	Polygon	1, .01	1, .01	N/A
3	Flood Depth	Raster Grid	All	10,1,0.1	N/A
4	Flood Velocity	Raster Grid	All		N/A
5	Risk to Life	Raster Grid	10,1,0.1		N/A
6	Defence Failure Extent	Polygon	1 Scenario		N/A

Map Nr	Map Type	GIS format	Probabilities mapped per scenario		
	Defence Failure Depth	Raster Grid	1 Scenario		N/A
	Defence Failure Velocity	Raster Grid	1 Scenario		N/A
7	Specific Risk, Inhabitants	Raster Grid	10,1,0.1	10,1,0.1	N/A
8	Specific Risk, Type of Activity	Raster Grid	10,1,0.1	10,1,0.1	N/A
9	Specific Risk, Economic Risk	Raster Grid	.01	.01	N/A
10	General Risk, Social	Point	10,1,0.1	10,1,0.1	N/A
11	General Risk, Environment	Point	10,1,0.1	10,1,0.1	N/A
12	General Risk, Cultural Heritage	Point	10,1,0.1	10,1,0.1	N/A
13	General Risk, Economy	Point	10,1,0.1	10,1,0.1	N/A

Appendices

A.	Schedule of Reports	30
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A. Schedule of Reports

Table 8: Schedule of Reports

Report Name	Report Nr
Inception Report	296235-IWE-CCW-R06
Flood Risk Review	296235-IWE-CCW-R01
Hydrology Report	296235-IWE-CCW-R15
Hydraulics Report	296235-IWE-CCW-R20
Draft Flood Mapping Consultation Report	296235-IWE-CCW-CR2101
Preliminary Flood Risk Management Options Report	296235-IWE-CCW-R25
Preliminary Options Consultation Report	296235-IWE-CCW-CR2102
Preliminary Safety and Health Plan	296235-IWE-CCW-H2002
Planning and Development Report	296235-IWE-CCW-R40
Strategic Sustainable Urban Drainage Report	296235-IWE-CCW-R45
Strategic Environmental Assessment Scoping Report	296235-IWE-CCW-ES01
Strategic Environmental Assessment Option Appraisal Report	296235-IWE-CCW-ES02
Strategic Environmental Assessment Environmental Report	296235-IWE-CCW-ES05
Strategic Environmental Assessment Non-Technical Summary	296235-IWE-CCW-ES10
Strategic Environmental Assessment Statement	296235-IWE-CCW-ES015
Appropriate Assessment Screening	296235-IWE-CCW-EA05
Flood Risk Management Plan	296235-IWE-CCW-R35
Draft FRMP Consultation Report	296235-IWE-CCW-CR1803
Defence Asset Database Handover Report	296235-IWE-CCW-R55

