GTFRS Stage 1 Final Report – Volume 1 – Report

Graiguenamanagh-Tinnahinch Flood Relief Scheme

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Preamble

This Report presents a summary of the reports prepared to-date for the Graiguenamanagh-Tinnahinch Flood Relief Scheme. The Final Report is delivered in three volumes as follows:

- Volume 1 – Report and Appendices
- Volume 2 – Surveys and Investigations (Digital Files)
- Volume 3 – Model and GIS (Digital Files)

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Executive Summary

Graiguenamanagh Town, County Kilkenny, and Tinnahinch Town, County Carlow, have historically encountered flood events. Reports of significant floods have been recorded since 1930. Ayesa were commissioned by Kilkenny County Council to develop and implement the Graiguenamanagh-Tinnahinch Flood Relief Scheme to alleviate the risk of 1% Annual Exceedance Probability (1 in 100-year flood event) and to provide a scheme that is technically, socially, environmentally and economically acceptable.

The scheme is categorized into five stages as follows:

- Stage I: Identification and Development of a Preferred Scheme
- Stage II: Planning process
- Stage III: Detailed Construction Design, Compilation of Work Packages and the Preparation of Tenders for Contracts
- Stage IV: Construction Supervision & Project Management Services
- Stage V: Handover of Works

This report outlines the body of work that has been undertaken as part of Stage 1 of this scheme.

Initially, detailed surveys were undertaken to inform on hydrological assessment, hydraulics modelling and scheme development.

A hydrological analysis was undertaken to determine hydrology inputs for the River Duiske and the River Barrow. The hydrological approach follows OPW standard methodology, and a mixed statistical and ungagged catchment approach was adopted across the scheme.

Hydraulic modelling was undertaken using Autodesk ICM software to construct a detailed 1D-2D hydraulic model to establish flood risk in the scheme. The model was calibrated and verified against historic flood data and reports. Flood levels for the design, climate change, sensitivity, and blockage runs were completed for the current and future events. The baseline flood risk was then determined and the damages associated with the 1% AEP event were calculated.

Option assessment began with a review of a long list of measures, narrowed down to the applicable viable individual measure. These were combined to form 5 options which were presented to the public. The preferred option emerged from these 5 options following an assessment methodology consisting of applying OPW recommended approaches, environmental assessment and professional judgement.

Raised Defences and Flood Storage Area was identified as the preferred option. Scheme development focused on establishing a scheme that was technical, environmental and socially acceptable. The scheme was presented at the final public consultation and refined to accommodate public requests, issues raised, and submissions gathered from public consultations, workshops and landowner meetings.

A draft environmental impact assessment report has been prepared for the scheme. It presents a systematic analysis of the impact of the proposed scheme in relation to the existing environment. A draft Natura Impact Statement (NIS) has also been prepared to address impacts on Natura sites. These documents, along with others will be submitted to An Bord Pleanála for planning in Stage 2.

[1] Introduction

[1.1] Background

The towns of Graiguenamanagh, in County Kilkenny, and Tinnahinch, in County Carlow have a long history of flooding. The two towns are separated by the River Barrow which causes flooding when flood events exceed its channel capacity. Additionally, Graiguenamanagh experiences flooding from the River Duiske. The River Duiske is a tributary to the Barrow and flows through Graiguenamanagh Town. It is a small, flashy catchment and it joins the River Barrow downstream of Graiguenamanagh Bridge. The most severe recorded flooding occurred in December 2015/January 2016 with flooding on both the Duiske and Barrow.

Kilkenny County Council (KCC) as the Lead Authority, in partnership with Carlow County Council (CCC) and The Office of Public Works (OPW) are advancing the Graiguenamanagh-Tinnahinch Flood Relief Scheme (GTFRS).

Ayesa (formerly ByrneLooby) were commissioned in February 2020 by KCC, to develop and implement a Flood Relief Scheme (FRS) that alleviates the risk of flooding to the community of Graiguenamanagh and Tinnahinch by providing a scheme that is technically, socially, environmentally and economically acceptable.

[1.2] Report Objectives

The purpose of this report is to give a summary and collate of individual reporting deliverables conducted as part Stage 1 reporting of the Graiguenamanagh-Tinnahinch Flood Relief Scheme.

[1.3] Graiguenamanagh-Tinnahinch Flood Relief Scheme

[1.3.1] Scheme Objectives

The purpose of the Graiguenamanagh-Tinnahinch Flood Relief Scheme is to alleviate the risk of flooding to the Community of Graiguenamanagh-Tinnahinch by providing a scheme that is technically, socially, environmentally and economically acceptable. The target Standard of Protection (SoP) of the Scheme is to prevent flooding of properties and assets within the Scheme Area during flood events with a 1% AEP for fluvial floods, often referred to as 1 in a 100-year flood.

[1.3.2] Scheme Area

An overview of the Scheme Area and important watercourses for the Scheme is provided in Figure 1-1. The Scheme Area encompasses the urban area of both Graiguenamanagh, Co Kilkenny and Tinnahinch, Co. Carlow.

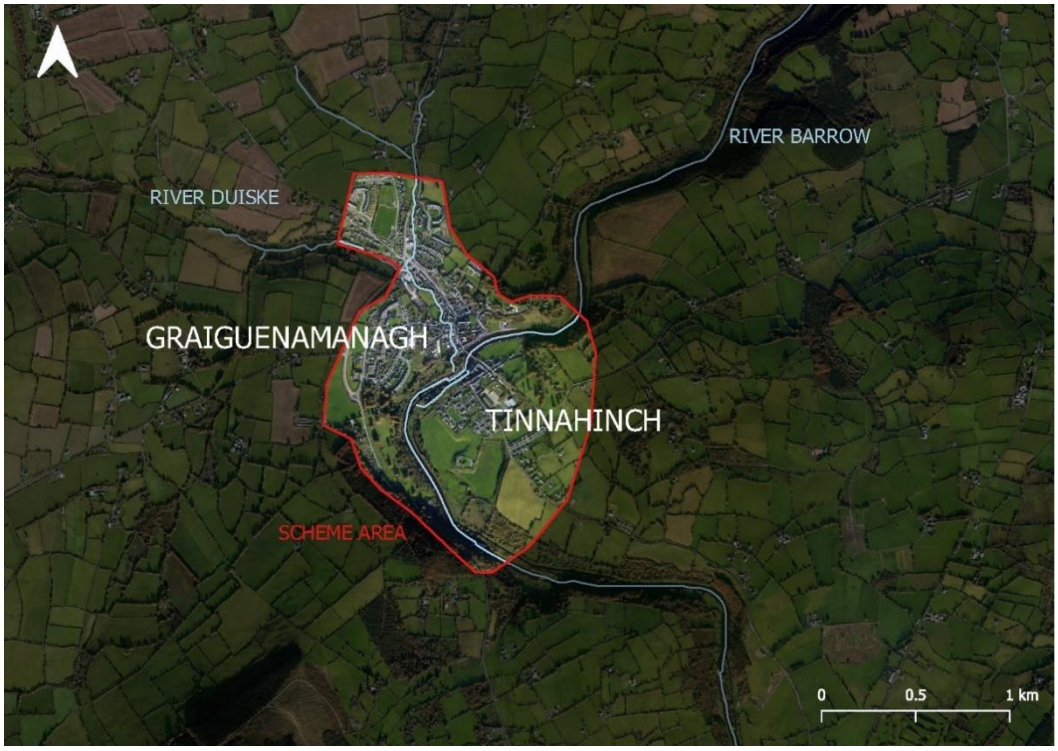

Figure 1-1: GTFRS Scheme Area

[1.3.3] Scheme Stages

This Report forms the Final deliverable of Stage 1 of the Flood Relief Scheme. The Purpose of Stage 1 is to complete a range of baseline assessments to establish the existing Environmental and Flood Risk conditions at the site and then develop a preferred scheme option to be progressed for planning approval.

The Scheme is to be delivered over five stages:

- Stage I: Identification and Development of a Preferred Scheme
- Stage II: Planning process
- Stage III: Detailed Construction Design, Compilation of Work Packages and the Preparation of Tenders for Contracts
- Stage IV: Construction Supervision & Project Management Services
- Stage V: Handover of Works

[2] Technical Surveys & Investigations

[2.1] Overview

A number of technical surveys and investigations were carried out throughout Stage 1 to support the development of the scheme to support the delivery of the hydraulic modelling, optioneering and environmental assessment. A list of the surveys and investigations is provided below in Table 2-1 along with a brief summary of each survey/investigation. Copies of the final deliverables can be found in Volume 2 of this report.

Environmental surveys to support the constraints assessment and EIAR are not included in this section.

Table 2-1: List of Technical Surveys / Investigations

No.	Survey / Investigation	Supplier
1	Lot 1 - Channel, Threshold & Topographical Survey	Murphy Surveys
2	Lot 4 - CCTV, Manhole Survey	Amelio
3	Lot 5 - Utilities GPR Survey	Murphy Surveys
4	Aldi Infill Survey	Ayesa
5	IAS Survey	Knotweed Solutions, Ayesa
6	Infill Survey - Storage Area, The Hub & Hotel St.	Apex Surveys
7	River Flow Monitoring	CWS
8	Site Investigations	OCB Geotechnical
9	Geophysical Survey	Minerex
10	PRAI Landownership Survey	PRAI
11	2017 Threshold Survey	Murphy Surveys
12	CCTV of Foul Sewers	KCC
13	IAS Final Stage 1 Treatment Survey	KCC
14	Outfall Survey	Equilibrium, Ayesa
15	Structural Surveys	Murphy Surveys

[2.2] Topographical and Channel Surveys

Murphys Geospatial Surveyors (Murphys Surveys) were appointed to complete a topographical survey in accordance with the OPW's Specification for Surveying. The scope of works included:

- Channel Surveys – 105 cross-section every 0-100m over 10.9km of river reach.
- Riverbank surveys were completed along channel reaches to identified top of bank on both left and rights banks.
- Threshold Surveys – 446 threshold levels/elevations/basement levels and flood levels were surveyed.
- Topographical survey – This survey covered 133,480m^2 area across Graiguenamanagh Town, Graiguenamanagh and Tinnahinch Quay, and upper reaches. Street furniture, services, underground utilities, natural features, built features, roads and road markings were captured.
- Structure Survey and Flood Defence – Flood defences structures, Bridge Structures, and Weir Structures were identified and measured for crest, toe, elevation dimensions.

[2.3] Culvert Surveys

Amelio Utilities Ltd. conducted CCTV services on culverts and pipelines within Graiguenamanagh and Tinnahinch in February 2021. The survey evaluated 850m of culvert length across twenty-nine sections and determined culvert conditions, blockages, adequacy and functionality during flood period. The culvert conditions were graded as per Table 2-2**Error! Reference source not found.**. Seven culverts were Grade 5, and Thirteen culverts were abandoned during surveying due to culvert submerges, restrictions and blockages.

Table 2-2: Culvert Condition Defect Grade

Structural Defects Grade	Culvert Recommendation Based on Grade
Grade 3	Best practice suggests consideration should be given to repairs in the medium term.
Grade 4	Best practice suggests consideration should be given to repairs to avoid a potential collapse.
Grade 5	Best practice suggests that this pipe is at risk of collapse at any time. Urgent consideration should be given to repairs to avoid total failure.

[2.4] GPR/Utilities Survey

Murphys Surveys conducted a Ground Penetrating Radar (GPR) and Utilities Survey across the scheme area. The objective of the survey was to locate the position and depth of all existing underground utilities using a combination of non-intrusive survey techniques. Utilities identified under 2 metres include: Drainage systems, water/fire mains, electricity cables, eircom, gas, and fuel mains.

Thirty-eight manholes were surveyed in Graiguenamanagh to record each cover/invert level, dimensions, structural condition, service type and connectivity and adjoining pipe sizes. CCTV footage of each manhole and connected services were captured. The conditions of these pipeline were graded as per Table 2-2. Five service pipelines were Grade 3, Eleven as Grade 4, Two as Grade 5 and nine were abandoned due to submerged manholes and blockages.

[2.5] Aldi Infill Survey

Ayesa undertook a small site survey to obtain ground levels in an area where out of bank flows were identified on the River Duiske. This area had also undergone recent development and the accuracy of the OPW obtained Lidar data was uncertain.

[2.6] Invasive Alien Species Survey

Aquafact undertook a site survey for Alien Invasive Species on behalf of Ayesa in July 2020 to inform the constraints of scheme development. This survey was used to specify a scope and more detailed topographical and treatment survey which was undertaken by Knotweed Solutions.

[2.7] Infill Survey - Storage Area, The Hub & Hotel St.

Apex Survey were appointed to undertake a further infill survey after upstream storage was identified as a viable emerging option. Infill survey was completed at the upstream storage area, at The Hub and near Hotel Street, where there was a gap in the data from the original topographical surveys.

[2.8] River Flow Monitoring

Capital Water Systems were appointed to undertake a detailed instream flow monitoring campaign to develop a detailed relation of flow versus wate dept at the Turf Market gauging stations. The station was installed by OPW at the beginning of the scheme and development of a rating curve was challenging given the paucity of data available.

The main body of data was collected from January 2024 to April 2024 and capture a number of high flow events.

Water level and velocity were recorded, and based on the cross-sectional areas, flows were determined. The data was used to further calibrate the model in August 2024 and to update the rating curve for the station.

Data collection remains ongoing.

[2.9] Site/Ground Investigations

Site operations were conducted in Graiguenamanagh from the 20th of March 2023 to the 21st of March 2024. The works included:

- Twenty-two Cable Percussion Boreholes

- Two Cable Percussion Boreholes with follow-on rotary
- Fourteen Rotary Drilled Boreholes
- Seven Standpipe Installations
- Fourteen Trial Pits
- Twenty-one Slit Trenches
- Twenty-thee Foundation Inspection Pits
- One Infiltration Test
- Four Plate Load Tests

Surficial Materials at Tinnahinch Quay include Bituminous Asphalt (50mm to 100mm) thick, granular subbase and Topsoil/Made Ground was 300mm to 400mm thick at the southwest end of the project area. Surface cover materials at Graiguenamanagh Quay consist of Bituminous Asphalt, typically in 50mm to 100mm thick, overlying granular subbase, typically to depths varying from 0.15m to 0.25m, but locally overlying cobbles to a depth of up to 0.6m BGL. In addition, a former bituminous asphalt road surface and associated granular subbase was encountered locally within the uppermost 0.5m. Glacial Till/Deposits, Made ground, granular soils and cohesive soils were consistent across the remaining scheme area.

Selected soils samples were analysed for a Waster Acceptance Criteria (WAC) suite to assess the potential categorisation of waste from the site.

The site investigation also included archaeological monitoring of all works undertaken and associated reports were produced.

[2.10]Geophysical Survey

Minerex Geophysics Ltd. carried out a geophysical survey for flood storage area dam. The survey consisted of 2D-Resistivity (ERT) and Multichannel Analysis of Surface Waves (MASW, s-wave) measurements. This survey utilized two complementary geophysical methods to improve final interpretations. The role of geophysics as a non-destructive fast method is to provide a geological interpretation over a wide area to complement direct ground investigations at specific locations.

The survey determined:

- Ground conditions under the site
- The depth of rock and the overburden thickness
- Strength and stiffness and compaction of overburden materials
- Type of overburden and rock
- Lateral changes within the geological layers

The results of this survey were included in the geotechnical design of the upstream storage area for the scheme.

[2.11]PRAI Landownership Search

A scheme enveloped was developed and landownership searches undertaken to establish the owners and occupiers of the scheme. The PRAI provide an initial dataset which was subsequently supplements by adding ownership data collected through local site visits and knowledge.

A resulting geospatial dataset is being maintained as a live register of landowners.

[2.12]Outfall Survey

An outfall survey was conducted along the River Duiske by Ayesa and Equilibrant in May 2023. Equilibrant undertook all underwater surveys, whilst Ayesa undertook the wade surveys along the Duiske River, and assessment of the data collected by Equilibrant.

The objective of the outfall survey was to record the following:

- Outfall discharge location (i.e. Irish Transverse Mercator (ITM) Co-ordinates)
- Outfall position relative to adjacent river bed level.
- Outfall position relative to adjacent quay wall/bank.
- Outfall pipe material
- Outfall diameter
- Outfall protrusion length (relative to quay wall/ bank)
- Outfall condition.

The deliverable include a recommendation on the type and nature of non-return valves to be fitted at each location.

[2.13]CCTV of Foul Sewers

KCC undertook a CCTV of the foul sewer along the Dock and along the River Duiske to ascertain the condition of the pipelines. The collected data included CCTV footage, but no tracing was undertaken.

[2.14]Invasive Alien Species Final Stage Treatment Survey

A final IAS treatment campaign was conducted in 2024 for Stage 1. This survey outlined the remaining locations of IAS for continued treatment. Generally, IAS is not a significant concern for the scheme.

[3] Hydraulics and Hydrology

[3.1] Hydrological Method Statement (HMS)

A Hydrological Method Statement was developed to outline data and procedures required to complete a Hydrology Report for GTFRS.

The report detailed:

- An overview of the hydrological methodology completed for the Graiguenamanagh AFA in the South Eastern CFRAM.
- Identification of data available since the CFRAM was completed.
- Outlined methodology for completing the hydrological analysis of the GTFRS.

The content of each report were subsequently included in the Hydrology Report.

[3.2] Hydromorphology Baseline Report

A baseline Hydromorphology report (Appendix C) was developed for the scheme to outline the existing Hydromorphology of the reaches of watercourse within the study area.

The study evaluated the current bed morphology, sediment processes and patterns in the River Barrow and River Duiske and an assessment of how these will be impacted by the proposed works as part of the Graiguenamanagh-Tinnahinch flood relief scheme. The study included a walkover survey of the Rivers Barrow and River Duiske combined with a desk study of the wider catchment.

[3.3] Flood Defence Asset Survey

A Flood Defence Assets survey was conducted and a report produced for the scheme. The data was used to inform of defended versus undefended model runs for the baseline scenario. Details of the flood defence assets can be found in the report in Appendix B.

[3.4] Hydrology Report

The scheme Hydrology Report is included in Appendix A and includes the detail on all hydrological work undertaken to characterise the flood hydrology relating to the scheme. A summary of this report is provided below:

[3.4.1] Overview of the Flood History in the Scheme Area

The review of Flood History since CFRAM assessment conducted in the hydrological method statement was implemented in the hydrology report and further assessments were conducted on potential available data. There was no further flood events since the development of the HMS and Hydrology report. The recorded hydrometric data for the nearest hydrometric gauge for the flood events for the River Barrow was Royal Oak (14018), 23km upstream of the scheme area. A gauge was installed on the Duiske River, near Turf Market; Flow data was captured and used.

[3.4.2] Identification and review of meteorological data

Meteorological data is recorded at weather stations and is used to record different weather conditions such as rain, wind and temperature. Using the Graiguenamanagh, Thomastown and Ballyogan House daily rainfall stations' records and Flood Study Update (FSU) Depth-Duration-Frequency model the Annual Exceedance Probability (AEP) for the maximum rainfall event for each year was derived.

The extreme rainfall for the study area was taken from Met Éireann's Depth Duration Frequency (DDF) Model. The national dataset provides sliding durations for a suite of return periods over 1x1km2 grids, which aided development of flood depths for each AEP period – See table 3-3 in Hydrology Report.

Time of Concentration (ToC) for the drainage catchments were calculated and were 7mins and 5mins for the Duiske and Barrow discharge points, respectively.

[3.4.3] Identification and review of hydrometric data

Three hydrometric stations were taken forward for analysis. A rating review was completed on Graiguenamanagh u/s (14029) and Royal Oak (14018) to assess the impact of spot gauging's taken post the rating review completed for the South Eastern CFRAM. The Graiguenamanagh d/s (14023) station is inactive since 1996 meaning no new data was available to produce a new rating.

[3.4.4] Review and update of select Physical Catchment Descriptors

Hydrological Estimation Points (HEPs) were identified along the River Barrow and the River Duiske and its tributaries. These points are located at inflows for the hydraulic model, junctions of tributaries and hydrometric stations.

Physical Catchment Descriptors (PCDs) were assessed at each HEP, one catchment that was not updated as part of the FSU WP 5.3 was delineated in GIS using a rolling ball technique. The DTM data available from the CFRAM study with a resolution of 2m was used for the delineation.

Catchments were compared with Corine Land Cover (CLC) data inventory which provides national scale maps of landcover and landcover change on a six-year basis. Catchments on the Duiske were found consistent with original values. The Barrow was found to have increase in urban area and was updated.

[3.4.5] Analysis of sources of flooding

From desktop review there was no evidence found to indicate any significant source of groundwater flooding in the Scheme Area. Similarly, no reports have been found to indicate flooding from this source. For purpose of this Scheme, analysis relating to the flooding from groundwater was not carried forward.

Graiguenamanagh is not at risk of coastal flooding.

Using a 2D TuFlow direct rainfall model, rainfall events were simulated for the Scheme Area. Pluvial flooding was also assessed with inputs such as design rainfall, model surface, roughness and conditions. Pluvial sources were carried into hydraulic modelling for further risk analysis

[3.4.6] Analysis of and estimation of design flow for the Scheme.

Design flows were calculated from the CFRAM study, where available, and the percentage increase in flow values from the CFRAM to GTFRS. On the Duiske the same estimation methodology is used as the CFRAM however updated Physical Catchment Descriptor (PCD) values and redistribution of flows have caused 2% to -16.8% changes in Qmed flows across the catchment. A catchment specific pooling group was used to generate growth curve which has lower growth factors with flows changed between -40% and -50% in the upper catchment and a -18% change in the lower reaches through the town centre area. On the Barrow updated PCD values, redistribution of flows and longer station record for the pivotal site at Graiguenamanagh u/s has changed Qmed between 3.8% to -0.1%. Similarly, the longer station record, and rating review, has favoured a single-site analysis to generate the growth factors over the CFRAM pooling group. This has led to an increase of the 1% AEP by 7.4% to 11.8%.

In summary there is an approximate 11% increase to the River Barrow 1% AEP design flow and a 6% decrease on the River Duiske in its lower reaches.

[3.4.7] Analysis of and estimation of hydrograph shape for the Scheme.

Hydrographs are created by combining a hydrograph shape with the estimated peak flows. The FSU [WP 3.1] includes a set of methodologies for creating normalised hydrograph shapes on gauged and ungauged catchments. Tools developed from this have been integrated within the FSU flood portal.

The Duiske Catchment was treated as ungauged, so a pivotal catchment was selected to perform the hydrograph width analysis.

For HEP's on the Barrow the gauge data at Graiguenamanagh u/s was used to create the hydrograph shape. The hydrograph generated from the PCD's was compared to the recorded flood hydrographs and adjusted to fit the average shape.

[3.4.8] Conclusion of Hydrology Report

The flood estimation hydrology for the GTFRS has been estimated for the Barrow and Duiske Catchments.

On the Barrow it was possible to derive design flows with reasonable confidence due to the gauging station at Graiguenamanagh (14029) where records of peak flow and flood hydrographs over a lengthy period are available. Data transfer from this gauging station has been used to update design flow estimates on the Barrow, specifically for the FRS.

On the small ungauged catchments of the Duiske peak flow estimation is less certain as Qmed has been estimated from catchment descriptors due to lack of suitable donor catchments being identified for adjustment of Qmed. A suite of hydrological estimation methodology has been used with the FSU Urb methodology selected after calibration of the baseline hydraulic model.

The design flows estimation presented in this report was used in the hydraulic modelling stage of this project. The calculated flows were distributed and applied to best replicate flow collection in the watercourses with checks conducted at the calculation locations ensuring hydrology was correctly applied. Using the hydraulic model and hydrological inputs existing and future flood risk, mitigation measures and flood damages were evaluated.

[3.5] Hydraulics Report

The objective of the hydraulics report was to provide detail on work undertaken to produce a hydraulic model to inform and assess the Graiguenamanagh-Tinnahinch Flood Relief Scheme (FRS). The scheme Hydraulics Report is included in Appendix D. A summary of the report is detailed below.

A location specific detailed 1D-2D model was developed using Infoworks ICM software (version 2021.2) to establish baseline flood risk and to assess options proposed as part of the flood relief scheme. The model was prepared using detailed ground based topographical and bathymetric survey information collected August 2020 and additional information collected April 2021.

The river channel and structures have been represented in 1D, while the floodplain and overland flow routes have been represented in 2D.

The modelling approach for the existing scenario is summarised as follows:

- Watercourses have been modelled using detailed cross section survey data recently commissioned for the purpose of this study.
- Structures have been built into the model based on detailed survey information obtained as part of this study.
- Out of bank flooding has been modelled using a 2D meshed ground model. The ground model was based upon ground based topographical survey within Graiguenamanagh town supplemented by 2m LiDAR data provided by the project team.
- Buildings were represented within the model based on threshold survey carried out for key buildings. Non-surveyed buildings were represented using industry standard methodologies.

Distributed hydrology was applied to the model to accurately represent the application of flows to the watercourse network and enable verification of the model to available data. The hydrology was applied in such a manner to reflect conditions encountered on site and based on initial model build and testing.

Modelling indicated substantial flood risk within the study area originating from the Barrow and the Duiske watercourses. Elevated water levels from the Barrow cause extensive flooding around the quay area of Graiguenamanagh, Kilkenny, and Tinnahinch, Carlow. Elevated water levels and velocity of the River Duiske indicates flooding from Main Street, upper Graiguenamanagh to The Hub, located at the confluence of the Duiske to the River Barrow. 1% AEP model results are shown in Figure 3-1.

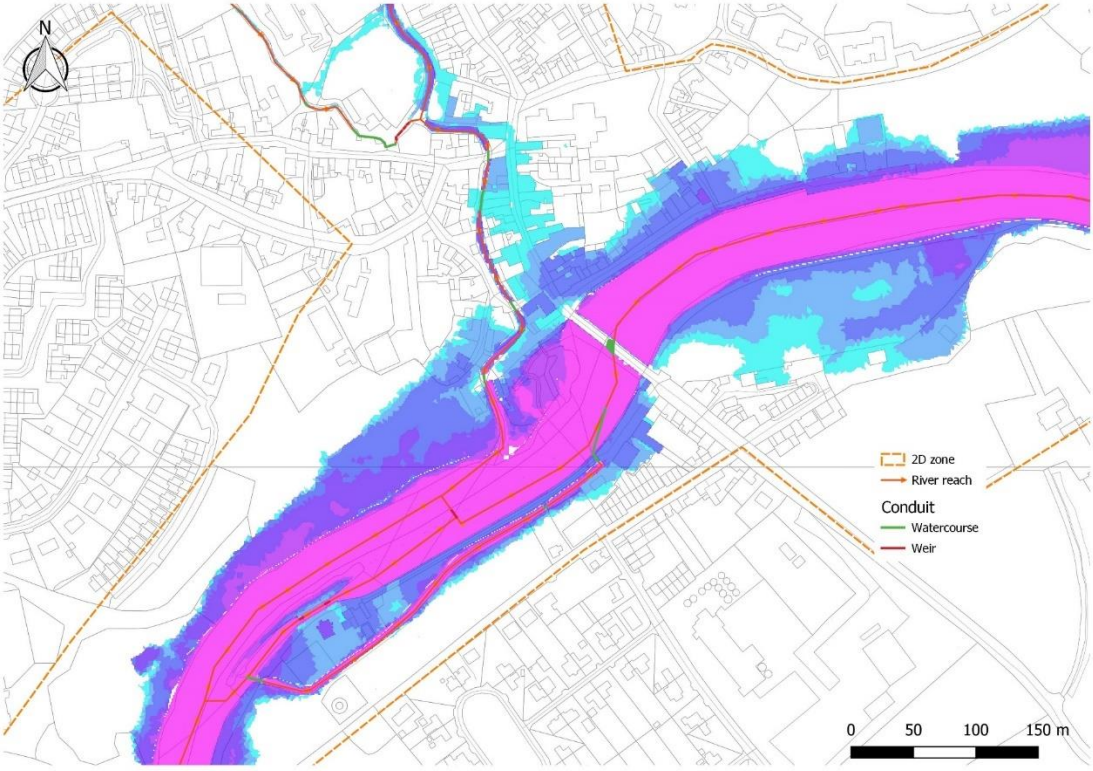

Figure 3-1: 1% AEP Flood Event Extract from Hydraulic Modelling

Model sensitivity analysis was carried out to assess the sensitivity of the simulation to changes in base parameters. The sensitivity testing makes comparisons to the baseline model within the vicinity of the site and was carried out for the 1% AEP duration flood event as the key standard of protection event.

Comparative analysis was undertaken at cross section locations to assess effect in the 1D across the entire model and within the main area of interest. The sensitivity analysis demonstrated that parameters selected for the model build are appropriate. Effects on absolute predicted water levels generally do not exceed normally anticipated inherent uncertainty in flood model estimation, and in terms of end-use would be accommodated within industry standard freeboard allowances with regards to flood protection standards.

The baseline model was validated and there is no indication that previous flooding observed has been significantly influenced by blockages of culverts or other structures. A blockage analysis was undertaken on four locations on the River Duiske where a blockage is likely and where it may cause a significant increased flood risk to receptors in the scheme area. Culverts were screened in areas where there is existing flood risk to receptors, and where options are proposed to defend receptors, those being areas where any emerging option may be affected or compromised if a blockage is likely and causes a significant consequential change to flood characteristics.

The flood hazard has been determined by implementing a blockage for each structure in isolation within the flood model corresponding to 25% / 50% / 75% of the opening sizes, coinciding with a 1% AEP flood.

Scheme options were developed using hydraulic modelling for the River Barrow and the River Duiske. Climate change runs, sensitivity runs, and design runs were completed on each proposed option to evaluate flood characteristics and water levels during various scenarios. These flood levels were incorporated into optioneering infrastructure design.

[3.6] Nature-based Solutions

Nature-based Solutions (NbS) formerly known as Natural Water Retention Measures (NWRM) is a catchment wide approach with measures typically used to slow or store flood waters. This is usually focused in upper catchment areas or away from exiting property and infrastructure. Traditional flood defences commonly use hard defences such as wall, embankments and flow control structure while NbS uses tree or vegetation planting, leaky dams, land management practices and wetlands.

Mapping for the potential of NbS for the Study Area was completed by adapting the methodology from SEPA 2013. The potential mapping categorises runoff reduction, floodplain storage and sediment management for the Duiske and Barrow Catchments draining to the scheme area.

Using the potential mapping a list of NbS were screened to determine their suitability for use in the Barrow and Duiske Catchments. A summary of results is provided in Table 3-1 below, whilst the full report is included in Appendix F. Woodland creation and offline wetlands were found to be an effective NbS for both catchments and was appraised in terms of climate change, cost, their ability to achieve policy object and additional benefits. From this it was identified that the cost and performance of these NbS were not suitable for implementation as part of the GTFRS.

Table 3-1: Assessed NbS for the GTFRS

Measure Group	Specific NWRM	Main Action	Potentially Viable?
Woodland creation	Catchment woodlands	Runoff reduction	Yes
	Floodplain woodlands	Runoff reduction/floodplain storage	No
	Riparian woodlands	Runoff reduction/floodplain storage	No
Land management	Land and soil management practices	Runoff reduction	Yes
	Agricultural and upland drainage modifications	Runoff reduction	Yes
	Non-floodplain wetlands	Runoff reduction	Yes
	Overland sediment traps	Runoff reduction/sediment management	No
River and floodplain restoration	Riverbank restoration	Sediment management	No
	River morphology and floodplain restoration	Floodplain storage/sediment management	No
	Instream structures (e.g. large woody debris)	Floodplain storage	No
	Washlands and offline storage ponds	Floodplain storage	No

[3.7] Turf Market Rating Review Technical Note

Prior to completion of Stage 1, a review of the hydrology was conducted to inform on the ongoing viability of both the Qmed estimates on the River Duiske and the rating curve at Turf Market Gauge.

The Qmed was assessed by undertaking a probably maximum flood review and indicated that the flow estimates on the River Duiske at the upstream storage were appropriate. However, flow estimates at Turf Market were found to return water levels much higher than the model predictions.

A rating review was then conducted and updates were made to the model, including channel data. This was reported on in a Technical Note.

[4] Environmental Constraints & Surveys

[4.1] Constraints Report

The objective of this project is the identification, design, and submission of a Flood Relief Scheme, to alleviate the risk of flooding for the communities of Graiguenamanagh and Tinnahinch. The Scheme will be technically, socially, environmentally and economically acceptable to the standards of the EU Directive on the Assessment and Management of Flood Risk (Floods Directive 2007/60/EC) transposed into Irish Law as SI 122 of 2010.

The scheme identified for Graiguenamanagh and Tinnahinch comprises of the construction of hard defences and associated works through the urban area of Graiguenamanagh-Tinnahinch along the banks of both the River Duiske and Barrow.

The aim of the project at preliminary design stage was to carry out a detailed evaluation of viable flood relief measures, select the best measure or combination of measures and carry out a preliminary design.

The Constraints Report is included in Appendix E. A summary of the key constraints identified for each of the environmental disciplines considered as part of the baseline constraints identification exercise is described below. They include:

- Resources and Materials.
- Population and Human Health.
- Hydrology.
- Soils, Geology and Hydrogeology.
- Ecology and Biodiversity.
- Cultural Heritage and Archaeology.
- Landscape and Visual.
- Air Quality.
- Noise and Vibration.

Constraints have been further designated as follows:

- Programme constraints.
- Engineering/Design constraints.
- Legal constraints.

Resources and Materials
Impacts on services and utilities such as watermains, gas mains, underground powerlines etc. will all need to be considered during the design process. The possible interruption of these services

and utilities should be minimised, where possible. Furthermore, impacts on road and rail infrastructure, public rights of way and land ownership will need to be considered.
Additional general and site-specific constraints will need to be considered as the scheme progresses, including: • During planning, development, and construction, the utilities infrastructure must be fully considered to ensure that disruptions to the utilities infrastructure are avoided. • During the construction stage, measures may have to be taken to ensure that construction does not interfere in any of the underground or overground utilities services. • It will be necessary to contact ESB if there is a need for lines to be turned off for a period of time (e.g. for works or relocation of infrastructure) and to determine if the affected residences could be serviced from elsewhere. • It will be necessary to contact Irish Water if there is a need for water utilities to be turned off for a period of time (e.g. for works or relocation of infrastructure) and to determine if the affected residences could be serviced from elsewhere. • During planning, development, and construction, any proposals by the applicant to divert existing water services (watermains, service connections, rising mains, foul and surface water sewers, culverts, etc.) will need to be submitted to Irish Water prior to works commencing. • During the construction stage, measures should be taken in order to ensure the construction does not interfere with underground services. Where works occur in proximity to electrical lines, some areas may have to be cut-off for the remainder of the work. This could cause a constraint to local residents and business. • Underground electrical lines in the study area may be at risk of flooding in extreme weather conditions causing power outages in areas of Graiguenamanagh-Tinnahinch. The location of the underground cable routes in the planning and construction stages of the scheme should be taken into consideration. • Consideration of the designs effect on sewerage capacity in the event of hydrological changes or flooding. • Impacts on road infrastructure and land ownership will need to be considered. • Impacts on public rights of way, footpaths and cycle routes will need to be considered. The proposed scheme design should ensure continuity of the public walkways within its footprint and future plans for same. • Graiguenamanagh Bridge provides a significant crossing of the River Barrow and public right of way and access should be maintained throughout the project construction and operation phases.

Population and Human Health
Constraints on population and human health will depend on the final nature and extent of the scheme, as well as the duration and nature of the construction phase.
Public and tourist amenities and facilities should also be considered key constraints. Impacts on public amenity areas adjacent to and requiring access to the rivers such as riverside walks, parks. playgrounds and tourist features should be considered, with replacement mitigation proposed if necessary. Impacts on tourist facilities, recreation and amenity facilities in the area should be considered constraints, especially those requiring access to the watercourses in the area.
Development of the proposed scheme must take into consideration: areas of commercial or tourist potential maintain their aesthetic and public attractiveness both during construction and operation of the scheme.

Development of the proposed scheme must take into consideration ways to complement and enhance public amenities including green spaces in the proposed scheme footprint. Measures to protect extant recreational areas and green public spaces should be developed within the proposed scheme. The proposed scheme design should ensure continuity of the public walkways within its footprint.
The scheme design should take into account the value (both cultural and economic) of any buildings (residential, retail, etc.) close to the rivers' edges or flood storage areas or likely to be adversely affected by the scheme within the scheme study area.
Regional roads in the project are likely to be congested at peak travel times. Some roads in the scheme area are narrow and may not be suitable for site access. Graiguenamanagh Bridge provides road and pedestrian access between Graiguenamanagh and Tinnahinch as is the only bridge crossing the River Barrow in the vicinity of the scheme and access to the bridge should be maintained throughout scheme construction and development. There is a potential for construction to make traffic more congested in the study area and vicinity. A traffic management plan will be required with the CEMP.
Any design proposals should ensure that any bridges over watercourses are maintained where feasible so that temporary or permanent disruption of local transport links and access to homes and businesses in the study area are minimised. It is also noted that facilities such as schools, medical facilities, and shops are located predominantly in Graiguenamanagh, fewer and less diverse facilities are available in Tinnahinch.
The River Barrow and River Duiske have access and movement limited by urban development in some areas. During construction of the scheme, traffic restrictions could pose problems for deliveries and site access and traffic management measures will need to be considered as part of the environmental impact assessment process.
Construction works will have to be mindful of maintaining access for both pedestrians and cyclists. A traffic management plan will be required during construction works.
The traffic associated with construction works will need to be mindful of the tourist and retail trades.
Sensitive receptors e.g. homes, schools, medical facilities, and outdoor learning/training organisations should be considered key constraints in the design of the flood relief scheme. The scheme design should take into account the value (both cultural and economic) of any buildings (residential, retail, etc.) close to the rivers' edges or likely to be adversely affected by the scheme within the scheme study area. Medical facilities in the scheme study area are sensitive receptors and must be given due consideration. Flooding events can cause devastation to homes, businesses and local facilities, with social and human health impacts. Their specific protection through adequate flood defences should be considered in the design of the scheme.
Other impacts to population that are also concerned with human health, including material assets such as water supply, wastewater treatment, and utilities should also be given due consideration.

Hydrology
Some of the principal surface water bodies in the study area are classed under the Water Framework Directive as 'At risk.' Under WFD requirements, the development of the scheme should incorporate measures not to worsen its status. All possible risks of point source pollution or runoff during construction and operation should be assessed and prevented. Works during the

construction of the scheme could pose a threat to the water quality of water bodies within and downstream of the study area though various mechanism, chiefly: (1) Increasing suspended solids in the water bodies through release or run-off of significant amounts of suspended solids during enabling works and construction; and (2) Unplanned events such as leaks/spills/runoff/accidental release or escape of fuels, oils and lubricants, bulk liquid cement, contaminated leachate, etc. Measures to protect surface water from leaks/spills, contamination, increased turbidity or input of suspended solid, etc, should be considered.
Contamination potentially present on site from historical land use must also be considered. The CEMP for the scheme will include measures to avoid mobilising and/or creating pathways for any contaminants present on site to the surface where surface runoff can introduce contaminants to surface water during enabling and construction works.
Measures to protect active national water monitoring stations and hydrometric gauges and avoid impacting their data collection processes should be considered during design and construction phases.
The scheme design and schedule will need to take into consideration the development of any WWTPs, water abstraction facilities or third party 'WFD' projects in the vicinity of the scheme area, including potential impacts to utilities and infrastructure.

Soils, Geology and Hydrogeology
Made ground Depending on the scheme design and type of works, for areas where made ground is uncompacted and/or highly variable it may be required to excavate and place this material and replace with suitable founding material. This material may also be a possible a source of contamination. As this material will be excavated during construction, it may require contamination testing be undertaken during the detailed site investigation.
Contaminated land The scheme area is located in an area with industrial heritage and commercial properties. If intrusive works are required during construction at locations where known or unknown contaminated land may be present (e.g. from recorded historical land-use), an investigation may be required into determine if land contamination is present and, if present, to determine its nature and extent.
Soils and groundwater Poor draining soils occurring within the scheme footprint are potentially soft and compressible and may require further site investigation (SI) in order to design a suitable flood defence scheme. Appropriate environmental controls and management measures will be implemented for any advance SI works and such SI works have been noted as potentially being needed in the draft EIAR for the scheme. A CEMP will be developed for construction activities. The CEMP will identify appropriate equipment and construction techniques that should be used in circumstances where there is a potential impact to the environment. Engineering design should minimise the impacts of the flood relief scheme on the sections of river within the study areas and the wide catchment.
Groundwater vulnerability to contamination

Depending on the design of the scheme, works may occur adjacent or within areas where groundwater is classified by the GSI as 'extremely vulnerable' to contamination. Appropriate environmental controls and management measures will be implemented for any advance SI works. A CEMP will be developed for construction activities.

Karst features

GSI data indicated that there are no recorded karst features in the study area. However, despite the lack of carbonate lithologies in bedrock in the study area it is prudent to consider that karst features such as caves, swallow holes, weathered rock and dolines may be present and can lead to ground surface and ground instability and are a constraint to be considered in the engineering design of the scheme.

Geoheritage

It is good practice to inform the Geological Survey Ireland (GSI) (contact: Beatriz.Mozon@gsi.ie) where:

- construction works temporarily or permanently uncover significant outcrop.
- were reports detailing any site investigations can be made available to the GSI.
- a digital photographic record of any significant new excavation can be produced and provided to the GSI.

Ecology and Biodiversity

Protected Sites

The most significant ecological constraints at Graiguenamanagh are the River Barrow and the River Duiske given their status as an SAC. For this reason, any works that are to be carried out to reduce flooding must take this sensitivity into account. Where at all possible, any in-river works should be avoided and every effort must be made to minimise, if not avoid, any run off to it.

All work that is to be carried out on the river bank must be carried out in such a way as to minimise the potential for events such as diesel or concrete spillages, run off of water with suspended sediment loadings or any accidental spillages. If it considered necessary to re-build weirs or sluices, the same sort of construction approach should be designed in to minimise resuspension and loss of concrete to the river.

Appropriate Assessment under Articles 6(3) and 6(4) of the EU Habitats Directive (Directive 92/43/EEC) will be required for the proposed scheme.

Protected/notable Species

In ecological terms, the river corridor (including the river itself) supports a number of protected species including two species of lamprey, salmon, sea and brown trout, otter, bats, badger, and potentially red squirrel, pine martin, white-clawed crayfish and the common frog.

Any in-river and bankside works have to be designed to minimise potential impacts on these (and all other) species.

All works should be planned wherever possible to be carried out at times of the year that are ecologically least sensitive e.g. outside bird nesting (March – September) and fish migration periods (Spring/Summer, depending on species).

Otter

The ecological study area contains suitable commuting, foraging, breeding and resting habitats for otter, although it should be noted that no holts or field signs of otter were recorded during the ecological walkover survey. Desktop study indicates that otters have previously been reported as occurring in the vicinity of the scheme. As a European protected species, the otter is fully protected under the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended). Any scheme option that may have the potential to disturb otters must be assessed. A full mammal survey including otters was completed. Otters are known to be present in the scheme area. There are currently no works planned in the vicinities of known holts. However, if a holt is discovered during the preconstruction survey, then KCC must about for a license to allow development of works. The potential impacts on otter has been assessed and reported in the EIA.

Otter mitigation works can potentially be conducted at any time of year but must avoid the breeding season (usually Spring but can be any time of year) if holts are present on site.

Red Squirrel

Although red squirrel have been recorded in the study area, no dreys or field signs were recorded during the site visit. Construction work is very unlikely to threaten red squirrel as no drey sites were recorded within the proposed scheme area.

Pre-construction surveys would be undertaken for all suitable habitat that will be impacted by the proposed scheme. Should any drey be confirmed as having red squirrel present, works would cease in the vicinity of the drey, and discussion would be held with NPWS to determine the most appropriate course of action including possible erection of artificial nesting sites within suitable retained vegetation.

Should a drey be recorded within the scheme extents prior to construction works then appropriate mitigation and a licence for works will be required. Works affecting red squirrel habitat should be timed to avoid the breeding season (1st February – 30th September inclusive); and protection zones of a minimum of 5m or one tree buffer should be employed around active dreys.

Pine Marten

Although pine marten have been recorded in the study area, no breeding or resting places or field signs were recorded during the site visit. Construction work is very unlikely to threaten pine marten as no den sites were recorded within the proposed scheme area.

Pre-construction surveys would be undertaken for all suitable habitat that will be impacted by the proposed scheme. Should any breeding or resting places be confirmed as having pine marten present, works would cease in the vicinity of the location, and discussion would be held with NPWS to determine the most appropriate course of action including the provision of artificial den boxes in suitable adjacent habitat.

Should a den be recorded within the scheme extents prior to construction works then appropriate mitigation and a licence for works will be required. Works affecting pine marten habitat should be

timed to avoid the breeding season (March - June inclusive); and protection zones of a minimum of 5m buffer should be employed around active dens.

Badgers

Although badgers have been recorded in the study area, no setts or field sign were recorded during the site visit. Construction work is very unlikely to threaten badger as no setts were recorded within the proposed scheme area.

Pre-construction update surveys would be carried out to maintain the validity of species data. The results of these would inform the decision as to whether to close a sett through exclusion or to destroy it if it is no longer active. Alternative locations for artificial setts would also be scoped in these updates. Surveys would be carried out in accordance with best practice guidance.

Should a badger sett be recorded within the scheme extents prior to construction works then appropriate mitigation and a licence for works will be required. Construction of new setts must be completed in Spring/Summer with blocking and destruction of existing setts completed in Autumn/early winter.

Bat

The scattered mature trees, bridges, architecture (churches, masonry) and areas of low water flow provide good foraging, roosting and commuting routes for bat species in the area. Options that require the removal of mature trees or works to bridges or other riverine structures with the potential to support roosting bats shall be assessed for bat potential. Bat surveys shall be conducted on any features with medium or high potential for roosting bats and an initial survey has been undertaken in the scheme area. Once more detail becomes available pertaining to the proposed structural alterations to the site (including the proposed methods of construction), the site should be re-visited for the purpose of:

- Surveying key locations (e.g. where it is known that potential roosting habitat will be removed or disturbed); and
- Obtaining more detailed information about any potential bat roosts (i.e. whether it is a maternity roost, hibernaculum etc.)

This information will inform any considerations of mitigation measures that may need to be implemented. The optimal time to conduct map surveys are May and August when bats are most active. If bats are found, they should not be disturbed during hibernation period (October to March) or maternity period (June to August). If a bat roost requires removal, then a licence would be required. Removal of roosts should be carried out during the summer months for hibernation roosts and during the winter months for maternity roosts.

As all Irish bats and their roosts are protected under national and EU legislation it is an offence to disturb or interfere with them without a licence. Such a derogation (which must be given by the Minister for the Environment, Heritage and Local Government) can only be sanctioned where there is no satisfactory alternative and where it will not be detrimental to the favourable conservation status of the species concerned. Therefore, any felling of trees or work on bridges which provide suitable roost habitat for bats should be sought in advance of any development that may interfere with such roost sites.

Freshwater Fish

Fish present in the river include both brook and river lamprey (*Lampetra planeri* and *L. fluviatilis*), brown trout (*Salmo trutta*), sea trout (*Salmo trutta morpha trutta*), stone loach (*Barbatula barbatula*), three-spined stickleback (*Gasterosteus aculeatus*) and eel (*Anguilla anguilla*). Salmon (*Salmo salar*) have been recorded in the river's lower course. Netting and electrofishing surveys were completed on site to establish the presence/absence/abundance of the fish species listed above.

In terms of the construction programme, it should be noted that in salmonid catchments, in-stream works are not permitted between the months of January to April (migration) and October to December (spawning). This corresponds with guidance from Inland Fisheries Ireland (Murphy, 2016).

Lamprey (both species) spawning takes place in the spring and early summer period in often the same habitats where salmon and trout spawn (O'Connor, 2017). The spawning season for brown and sea trout is November to February. If spawning grounds are found to be present in the construction zone for the scheme, then this period should be avoided.

A full impact assessment and management plan for these fish species will be produced as part of the EIA report once full scheme details (including construction methods) are known.

Freshwater pearl mussels *(Margaritifera margaritifera)*

Freshwater pearl mussels are present in the Ballymurphy and Mountain River, tributaries of the River Barrow. However, these populations are 4km upstream of the Graiguenamanagh scheme area. Any impacts that result in a decrease in anadromous salmonid populations (Atlantic salmon and sea trout) could have a significant impact upon the viability of the freshwater pearl mussel population. The lifecycle of freshwater pearl mussel is reliant upon the development of glochidia which that attach to the gills of host fish, usually juvenile salmonids, to continue development (Skinner et al., 2003). Therefore, a decline in the salmonid population within the River, as a result of construction and operational disturbance to migration, could have an impact upon the future viability and population size of freshwater pearl mussel. Works therefore should be carried out outside the period when salmon are migrating either upstream to breed or when fish return to the sea as smolts or adults.

White-clawed Crayfish *(Austropotamobius pallipes)*

Any works carried out on the riparian habitat and banks should where possible be restricted to between July and October as this is a period when white-clawed crayfish are less sensitive, with females already having released their young and individuals being more active and not seeking refuge deep in bankside burrows as they do in winter months. Pre-construction surveys may be required, depending on the extent and location of the proposed measures.

Biosecurity (Crayfish Plague)

Crayfish Plague (a water-mould *Aphanomyces astaci*) has previously been reported in waterways the vicinity of the scheme area with periodical outbreaks occurring within different locations with the catchment. The plague can be spread by moving equipment that has been used in an affected area to an unaffected catchment and strict biosecurity measure will need observed when working in affected catchments. Prior to any in river works during construction the NPWS should be contacted

to confirm the status of any outbreaks in the rivers and suitable biosecurity measure should be put in place.

Invasive Species

Japanese Knotweed, Himalayan balsam, and Gunnera are listed as invasive plants under the EC (Birds and Natural Habitats) Regulations 2011 (S.1. 477/2011) and have been found within the study area. The regulations prohibit the introduction or dispersal of invasive species and appropriate measures should be undertaken in the proposed scheme development. Therefore, any works occurring in areas where invasive species are present must use appropriate measures. An invasive species treatment and management plan has already been implemented.

Cultural Heritage and Archaeology

Archaeological Heritage

There is one national monument within the proposed development area, Duiske Abbey (RMP KK029-01800, National Monument No 620). It is the physical and visual focal point of the town.

There are sixteen recorded archaeological monuments (RMP sites) within study area, all relating to the medieval heritage and industrial character of the area:

- Castle - tower house, Tinnahinch.
- ChurchTinnahinch.
- Graveyard, Tinnahinch.
- Ritual site - holy well, Tinnahinch.
- Bridge Tinnahinch, Carlow Brandondale.
- Historic town, Graiguenamanagh.
- Religious house - Cistercian monks, Graiguenamanagh.
- Cross - High cross (present location), Graiguenamanagh.
- Tomb – effigial, Graiguenamanagh.
- Wall monument, Graiguenamanagh.
- Cross, Graiguenamanagh.
- Burial, Graiguenamanagh.
- Ritual site, holy well Graiguenamanagh.
- Clapper bridge, Graiguenamanagh.
- Water mill – unclassified, Graiguenamanagh.
- Cross - High cross, Graiguenamanagh, Kilkenny.

There is a designated Zone of Archaeological Potential (ZAP) in the Record of Monuments and Places around the historic town of Graiguenamanagh (KK029-018). Any development within this zone is considered to be of archaeological potential and is likely to reveal medieval or later archaeological remains, features finds or soils.

Architectural Heritage

Graiguenamanagh town is an Architectural Conservation Area (ACA). The boundary encompasses the medieval core of the town, it incorporates the Turf Market, the bridge and the historic quay.

There are thirty-five RPS sites within the constraints study area, of these seven are outside of the ACA. These structures/features should be considered as cultural heritage constraints during the design of the proposed flood relief scheme and avoided where possible.

There are twenty-seven NIAH sites in the study area that have not been added to the RPS, however there is a potential that they may be added in the future.

Every care should be taken in these locations to avoid direct impacts on protected structures or by means of careful design or by the application of appropriate mitigation measures. This includes development that might adversely affect the setting of the protected structure. Any design proposals in the vicinity of protected structures vicinity should be carried out in a way that will not materially affect the character, integrity, amenity and setting of these sites. An architectural conservation specialist may be required advise on appropriate measures mitigate any potential impact on this.

Archaeological/ Cultural Heritage Potential

There is the strong possibility that previously unknown archaeological deposits or features associated with the medieval and later milling in the area or with earlier river crossings may survive subsurface within the study area. For example, there a possibility that evidence of the medieval wooden bridge at Brandondale (KK029-042-) may be unearthed during works (on both sides of the river bank) along the Barrow. Historic accounts of oak piles being recovered at the site during the construction of the Tinnahinch Lock further affirm this risk.

There is a general riverine archaeological potential along the Duiske River and the River Barrow to reveal milling activity that could date from the 12th to the post medieval period.

There is a significant amount of industrial heritage features recorded in the RMP and RPS in the study area which is associated with a legacy of milling and transport. However, there are several sites and features that have yet to be recorded or identified. The industrial heritage potential is high. Some unrecorded features include:

- A mill race running parallel to the Duiske river which that connected several recorded mills, any development in the vicinity of this has the potential to reveal further milling activity. The proposed storage areas are located in the vicinity of the mill race.
- There is also a mill race in Tinnahinch running parallel to the river Barrow and Canal tow path.
- There are several former mill/ industrial structures that are not protected. These include structures in the Turf Market area and along the mill race and Duiske River.
- The canal and its associated protected lock and lock keepers house is considered to be of cultural heritage value and are part of the curtilage of the protected structures.

There are several heritage trails within the town that must be maintained/enhanced.

Field work will identify unrecorded industrial heritage and cultural heritage features that might be impacted by the scheme.

Historic Character and Setting

- Duiske Abbey commands a focal point at the centre of Graiguenamanagh. The narrow and winding medieval streets of the town centre, their interconnection with the Abbey, and the relationship with the River Barrow, and the Duiske River gives Graiguenamanagh its unique visual and aesthetic character.
- The River Barrow, with its historic quays, mill buildings, mill races, bridges, canal, canal lock and weirs, is a rich and highly significant cultural, historical industrial and social amenity of Graiguenamanagh- Tinnahinch. It is also a defining character, its visual relationship to the town and the Abbey should be retained. Every effort should be made to retain or enhance this amenity.
- While change within the setting of an historic site or landscape may be acceptable, in certain instances development will be considered intrusive and inappropriate (such as large embankments, walls or similar permanent infrastructure). This effect on the setting of archaeological and architectural heritage sites requires an assessment to be made on a case-by-case basis according to the type of development, its location and landscape

setting by means of objective analysis based on a set of predefined criteria and professional judgement, supported by appropriate descriptive material.

- Specific mitigation requirements can only be identified as issues for development once the design options are defined. Further assessments such as archaeological testing, underwater archaeological assessments, structural architectural heritage appraisals or structural surveys etc. may be required in the next phases of the assessment or as mitigation measures for the scheme.
- It should be noted, however, if flood relief measures impact any areas in proximity to an RMP, or in the ZAP of the town, the judicious use of archaeological assessment techniques may be required in these areas in order to understand the implications for the proposed scheme.
- In accordance with the Architectural Heritage Guidelines any work to or in the vicinity of a Protected Structure, NIAH site or the ACA require a conservation heritage impact assessment by a conservation architect.
- All recommendations made in this report are subject to approval of the relevant Local Authorities and the National Monuments Service, Department of Culture, Heritage and the Gaeltacht.

Landscape and Visual
Existing Trees and Hedgerows The study area contains outdoor amenity areas, matures stand of trees and small woodlands and tree lined recreational pathways along both sides of the River Barrow and sections of the River Duiske. The retention and protection of trees and woodlands within Graiguenamanagh - Tinnahinch and surrounding areas in the valley is emphasised with the Kilkenny CDP (2014 - 2020). There are areas of woodland, trees and hedgerows also contained with the River Barrow and River Nore Special Area of Conservation (SAC Site Code: 002162). The existing trees and planting within the study area provides both visual and recreational amenity for the residential and amenity areas within the study area and the wider districts. Additionally, the 'green' character of the landscape is considered by KCC and CCC to be a key component of local tourism development for Graiguenamanagh-Tinnahinch and the wider area. Additionally, such areas also provide a network of habitats, ecological 'corridors' and 'stepping stones' essential for wildlife.
Landscape Character The proposed development of the subject site will result in a change to the landscape character which will be most noticeable locally, such as from the adjacent residential and tourist areas (including along the river banks and bridges). It may also result in a change to the landscape character within the wider vicinity of the Barrow Valley. The potential magnitude of this change will be assessed when the details, scale and extent of the proposed interventions have been finalised.
Historical landscape character and cultural heritage Within the study area there are several designations and structures of national interest that need to be considered such as: • A number of Protected Structures and Recorded Monuments within or in close proximity of the study area (refer to section 8 of this report for more details). • Conservation Area. • Zone of Archaeological Interest. • Sites of Archaeological Interest.
Recreational amenity value

There are several recreational amenities within the study area that need to be considered in relation to possible impacts on their accessibility, recreational and visual values:

- Walking/ cycling pathways along much of the length of the river, including national Waymarked Ways.
- An outdoor activities hub located in Graiguenamanagh on the bank of the River Barrow.
- Land use zoning objectives in county development plans – areas zoned as Amenity and Open Space/ Biodiversity.
- Swimming area and diving board area in the River Barrow.

Views & Visual Amenity Value

Key viewpoints will be selected when the details, scale and extent of the proposed interventions have been defined, these shall include views into and out of the study area and those that demonstrate the visual amenity value within the locality.

There is a need to protect:

- Residential views towards the rivers and Graiguenamanagh Bridge.
- Views towards the rivers and Graiguenamanagh Bridge from businesses serving the tourism and recreational sector (e.g. cafes, etc).
- Recreational views – towards and from the river (e.g. public pathways and parks).
- Views for entering the town from the surrounding areas in the valley by road (e.g. for drivers, cyclists, walkers, etc).
- Views from the national waymarked trails.

Views to be preserved and protected in the vicinity of Graiguenamanagh, as identified in the Kilkenny development Plan 2014 – 2020 and the Graiguenamanagh Local Area Plan 2009 are:

- V1 View east and south over the Barrow valley on the Thomastown / Graiguenamanagh Road, R703 from Coppenagh Hill between the junctions with road numbers LP 4203 and LT 82152.
- V2 View East over the Barrow Valley on the Graiguenamanagh / New Ross Road and in particular the views overlooking St. Mullins, between the junctions with road numbers LP 4209 and LT 82463.
- V3 View east over the Barrow Valley on the Graiguenamanagh / Ullard Road just North of Graiguenamanagh, Road No. LS 8221 between the junctions with road numbers 438 and LS 8222.

There is a need to protect and minimise any negative impact on the following views in particular:

- Protected views as identified in the KCDP 2014 – 2020 and the GLAP 2009.
    - particularly the protected views along the R705 which forms the boundary of the study area to the west.
- Public, recreational and residential views to and from the rivers and bridges, with emphasis on area that may be visually impacted by the suggested hard defence proposals in CFRAM:
    - Towards and from The River Barrow and River Nore Special Area of Conservation SAC (including the Duiske River)
    - Towards and from Recorded Monuments and Protected Structures e.g. bridge, Tinnahinch Castle
    - Public pathways, amenity areas and national ‘Waymarked Ways’ such as The South Leinster Way and The Barrow Way which pass through the study area.
    - Other tourist amenities e.g. guesthouses, cafes, restaurants, seating areas.

Construction Phase and Operational Phase

During the construction phase, the following elements of the proposed development have the potential to cause visual impacts, they will however be short to medium term in duration:

- Temporary site works – hoarding, lighting, cranes, car parking, storage areas.
- Construction traffic – dust and emissions.
- Tree and vegetation clearance.
- Groundworks – cut and fill excavations.
- Laying of foundations.

The principal elements which are likely to give rise to landscape and visual impact in the long term/operational phase are:

- Removal of some existing trees.
- Height of proposed structures/ interventions.
- New structures/ interventions.
- Change of character – dependent on proposed interventions type and scale.
- Proposed tree and shrub planting.

Appropriate design, siting and mitigation measures are required to integrate the proposed scheme within the landscape.

Air Quality

The key constraints in relation to air quality and climate are any sensitive receptors in proximity to the location of construction works. The scheme design should take into consideration any sensitive receptors such as residences, schools, businesses, and medical facilities located in proximity to works associated with the flood relief scheme. The CEMP for the construction phase of the scheme should include mechanisms to reduce air quality impacts during construction and a traffic management plan should be developed.

Noise and Vibration

Noise and vibration effects are expected to occur during the construction phase only and would be expected to include:

- Construction traffic.
- Earthmoving plant and equipment.
- Sheet piling.
- Power tools and generators.

The CEMP for the construction phase of the scheme should include mechanisms to reduce noise generated during construction and a traffic management plan should be developed.

Construction noise is temporary in nature, and therefore the normal way of minimising the impact is to limit the working hours. For larger infrastructure projects the Local Planning Authority may place noise limits on the construction works.

A number of structures potentially vulnerable to vibrations associated with construction works have been identified in the vicinity of the proposed locations for hard defences (in the preferred option of the CFRAM):

- Graiguenamanagh Tinnahinch Bridge.
- Ruins on the waterfront adjacent to the Graiguenamanagh Tinnahinch Bridge.
- A stone building on the waterfront at Graiguenamanagh.
- A derelict building at the waterfront, may be sensitive to vibration.
- Waterfront shops/residential property.

- Tinnahinch Castle.
- Graiguenamanagh Mill.
- Barrow tributary bridge and adjacent building.
- A brick chimney located adjacent to the Aldi supermarket entrance,
- Graiguenamanagh Abbey, and
- Clapper Bridge

The scheme design and methods for works during construction should consider potential impacts to such structures and consider if there is a requirement for ongoing noise and vibration monitoring during construction.

The following tables provide a summary of the above constraints summarised according to programme, engineering/design and legal constraints.

Programme Constraints
Protected/notable Species. All works should be planned wherever possible to be carried out at times of the year that are ecologically least sensitive e.g. outside bird nesting (March – September) and fish migration periods (Spring/Summer, depending on species (see below)).
Otter. Otters are known to be present in the scheme area. There are currently no works planned in the vicinities of known holts. However, if a holt is discovered during the preconstruction survey then KCC must about for a license to allow development of works. The potential impacts on otter will be assessed and reported in the EIA. Otter mitigation works can potentially be conducted at any time of year but must avoid the breeding season (usually Spring but can be any time of year) if holts are present on site.
Red Squirrel. Construction work is very unlikely to threaten red squirrel as no drey sites were recorded within the proposed scheme area. The potential impacts on this species will be assessed and reported in the EIA. Works affecting red squirrel habitat should be timed to avoid the breeding season (1st February – 30th September inclusive).
Pine Marten. Construction work is very unlikely to threaten pine marten as no den sites were recorded within the proposed scheme area. The potential impacts on this species will be assessed and reported in the EIA. Works affecting pine marten habitat should be timed to avoid the breeding season (March - June inclusive).
Badger. Although badgers have been recorded in the study area, no setts or field sign were recorded during the site visit. Construction work is very unlikely to threaten badger as no setts were recorded within the proposed scheme area. Should a badger sett be recorded within the scheme extents prior to construction works then appropriate mitigation and a licence for works will be required. Construction of new setts must be completed in Spring/Summer with blocking and destruction of existing setts completed in Autumn/early winter.
Bats. The scattered mature trees, bridges, architecture (churches, masonry) and areas of low water flow provide good foraging, roosting and commuting routes for bat species in the area. Options that require the removal of mature trees or works to bridges or other riverine structures with the potential to support roosting bats shall be assessed for bat potential. Bat surveys shall be conducted on any features with medium or high potential for roosting bats. The optimal time to conduct map surveys are May and August when bats are most active. If bats are found, they should not be disturbed during hibernation period (October to March) or maternity period (June to August). If a bat roost requires removal, then a licence would be required. Removal of roosts

should be carried out during the summer months for hibernation roosts and during the winter months for maternity roosts.
Freshwater Fish. Fish present in the river include both brook and river lamprey *(Lampetra planeri* and *L. fluviatilis*) (O'Connor, 2017), brown trout *(Salmo trutta)*, sea trout *(Salmo trutta morpha trutta)*, stone loach *(Barbatula barbatula)*, three-spined stickleback *(Gasterosteus aculeatus)* and eel *(Anguilla anguilla)*. Salmon *(Salmo salar)* have been recorded in the river's lower course. In terms of the construction programme, it should be noted that in salmonid catchments, in-stream works are not permitted between the months of January to April (migration) and October to December (spawning). This corresponds with guidance from Inland Fisheries Ireland. Lamprey (both species) spawning takes place in the spring and early summer period in often the same habitats where salmon and trout spawn. The spawning season for brown and sea trout is November to February. If spawning grounds are found to be present in the construction zone for the scheme, then this period should be avoided.
White-clawed Crayfish (*Austropotamobius pallipes) Any* works carried out on the riparian habitat and banks should where possible be restricted to between July and October as this is a period when white-clawed crayfish are less sensitive, with females already having released their young and individuals being more active and not seeking refuge deep in bankside burrows as they do in winter months.
Japanese Knotweed, Himalayan balsam, and Gunnera are listed as invasive plants under the EC (Birds and Natural Habitats) Regulations 2011 (S.1. 477/2011). These regulations prohibit the introduction or dispersal of invasive species and appropriate measures should be undertaken in the proposed scheme development. Therefore, any works occurring in areas where invasive species are present must use appropriate measures.
Any in-river works will need to ensure compliance with the WFD. Co-ordination of any in-river works with the IFI and adherence to any IFI requirements.
The presence of previously un-recorded underwater archaeological artefacts may significantly slow down the construction programme.
The application for derogation licences should be applied for in advance of any works which may disrupt any protected species.
Replies to requests for further information/clarification from An Bord Pleanála.

Engineering/Design Constraints
The design of the final scheme will be subject to a number of site investigations and may change depending on the findings of these investigations.
The made ground is uncompacted and highly variable may require excavation and replacement with suitable founding material.

Legal Constraints
A 3rd party challenge to the application to An Bord Pleanála and a request for an oral hearing.
All works must comply with all national and international laws and treaties as mentioned in the relevant sections of this report as well as the environmental reports provided as appendices.

Compliance with relevant European Directives (EIA Directive, Birds Directive, Habitats Directive, Water Framework Directive, etc) and the instruments transposing these into Irish Law will be required.
Screening for EIA and AA are being undertaken in line with national and international laws, and using: • appropriate specialist topic-specific guidance. • national and EU guidance for environmental assessment. The outcome of these assessments will inform the requirement for further environmental assessment. It is understood on the basis of information available at the time of writing that AA/NIS and EIA will be required. An EIA Scoping Report is ongoing and will be submitted in Spring 2025.

[4.2] Ecology Surveys

Ecology surveys were conducted by specialist contractors throughout Stage 1 including top-up surveys, these are outlined in Table 4-1 below.

Table 4-1: Ecological Surveys Completed for the Scheme

Survey Name	Surveyor(s)
Specialist survey for Bats	Ayesa and Veon Ecology
Habitats and species walkover	
Specialist survey for wintering birds	
Specialist survey for Breeding birds	
Specialist surveys for mammals, including otter, badger, pine martin, red squirrel	
Specialist survey for herpetofauna	
Specialist survey for flora	
Specialist survey for trees	
Specialist survey for alien invasive flora species	Aquafact and Envirico
Specialist survey for Q values/invertebrates	Triturus Env Services and Aquafact
Specialist electrofishing survey	
Specialist Survey for White-Clawed Crayfish (eDNA sampling and testing)	
Specialist Survey for Freshwater Pearl Mussel (eDNA sampling and testing)	

[4.3] Cultural Heritage Surveys

A number of specialist have been employed to ensure the scheme is cognisant to the cultural heritage sensitivities within the scheme area. The specialist activities are outlined in Table 4-2 below.

Table 4-2: Cultural Heritage Surveys Completed for the Scheme

Survey Name	Surveyor

Geophysical Survey	Terradat
Underwater Archaeological Survey	ADCO
Building Conservation Survey	Southgate Associates
Archaeological Monitoring of Geotechnical Site Investigations	Archaeological Consultancy Services Unit
Archaeological Test Trenching	Courtney Deery
Orthophotography of Wall and Structural Elevations	Philips & Associates
Wade Survey – Upstream Storage Area	ADCO

[4.4] Other Environmental Surveys

A number of additional surveys have been undertaken to inform the Environmental Impact Assessment Report. These surveys are outlined in Table 4-3.

Table 4-3: Additional Surveys Completed for the Scheme

Survey Name	Surveyor
Baseline Noise Survey	Amplitude Acoustics
Baseline Landscape Survey	The Big Space

[5] Scheme Analysis

[5.1] Screening of Measures

An initial preliminary screening of the viable measures for the GTFRS was undertaken and reported on in 2021.

Measures progressed to further assessment included:

For the Barrow

- Flood Warning/Alert system (for demountables if forming part of a viable option)
- Hard defences (incl. consideration of demountables if required for access)

For the Duiske

- Upstream storage area
- Diversion channel (Tunnelling or open cut)
- Hard defences

In addition, measures such as IPP, channel maintenance and removal of channel restrictions, whilst not offering a significant portion of flood mitigation were suggested for consideration.

Based on the screening, five options were identified for further assessment:

- Option 1: Flow Diversion Only
- Option 2: Hard Defences Only
- Option 3: Flow Diversion and Hard Defences
- Option 4: Storage and Hard Defences (to be checked for economic viability before modelling)
- Option 5: Storage and Diversion (to be checked for economic viability before modelling)

[5.2] Option Development & Selection

The five options above were brought forward for detailed assessment, including hydraulics modelling and environmental assessment. The Option Report is provided as Appendix H to this report. These are described below.

[5.2.1] Option 1 - Raised Defences Only

This option consists of providing raised defences walls and flood gates along mainly the left bank of the River Duiske from Well Lane downstream to Turf Market Bridge.

This measure would impact on private property and the many established accesses from Turf Market over the River Duiske to the properties on the left bank.

Modelling was undertaken of this option which showed that the water levels increased slightly due to the containment within the Duiske and the Barrow locally, but properties not affected significantly

elsewhere (outside the protected areas). Tinnahinch would be protected by the measures on the River Barrow. Flood defence walls, floodgates to maintain access would be required to mitigate the food risk.

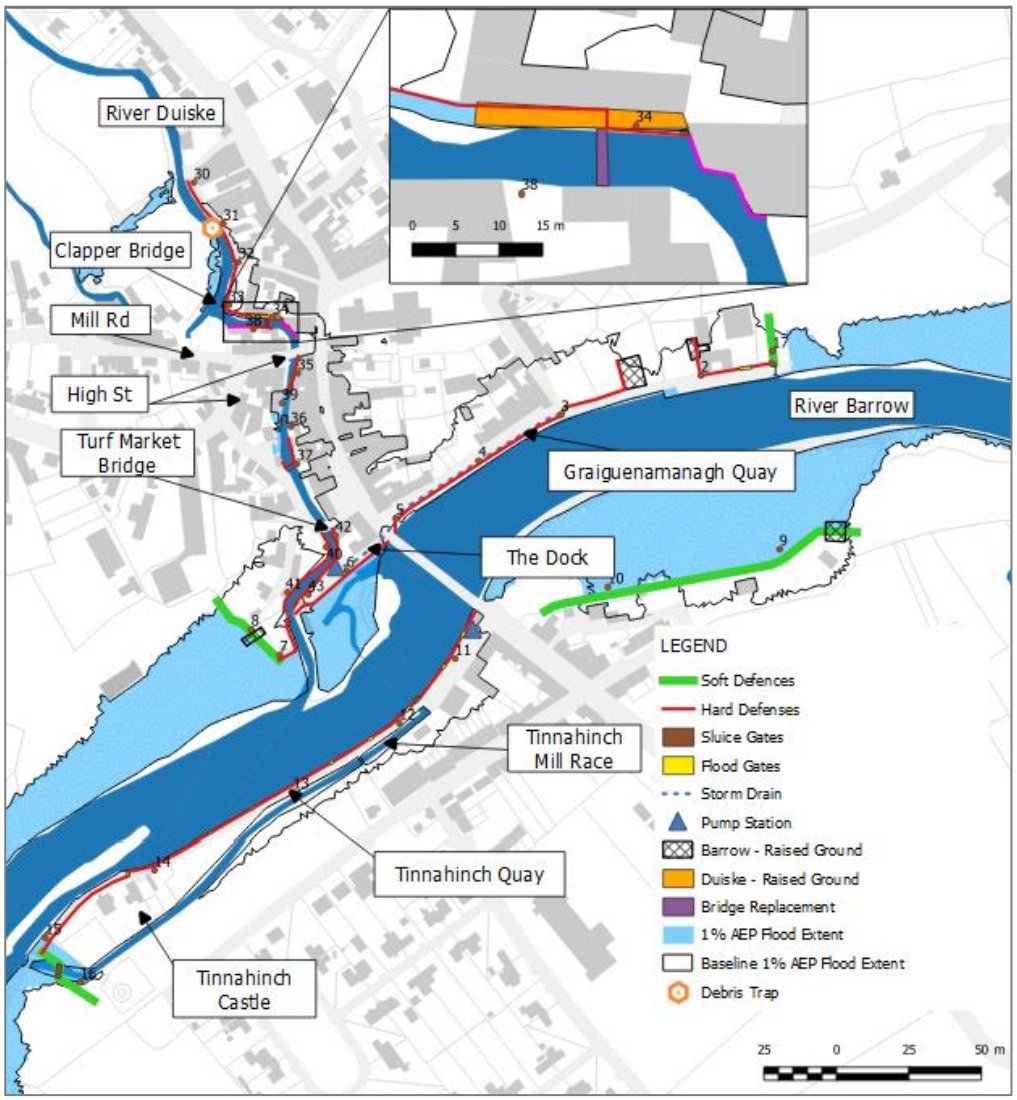

Figure 5-1: Option 1

[5.2.2] Option 2 – Raised Defences and River Duiske Flow Diversion

This option explored the use of a flow diversion combined with raised defences on the River Duiske to allow assessment of the level of reduction in raised defences on the Duiske – in particular, the need for raised defences between Well Lane and Turf Market Bridge where significant technical and environmental challenges exist. The option would entail the construction of a flow diversion pipeline and also includes a raised defence on the left bank of the River Duiske at Well Lane downstream to Clapper Bridge area to tie in with the proposed in channel flow control structure/weir.

A new access bridge would be required to maintain access to the Hub, and a new open channel would be provided in the grounds of the Hub.

The modelling results indicated that this option was technically viable. Flood levels increase locally upstream of the diversion location where an instream structure would be required near to Clapper Bridge, but given the steepness of the River Duiske, the effects are relatively local and are not observed upstream of the R705 bypass road. However, the local increases are in the order or 1-1.2m at the most impacted area and would result in significantly higher walls on Well Lane compared to any of the other options.

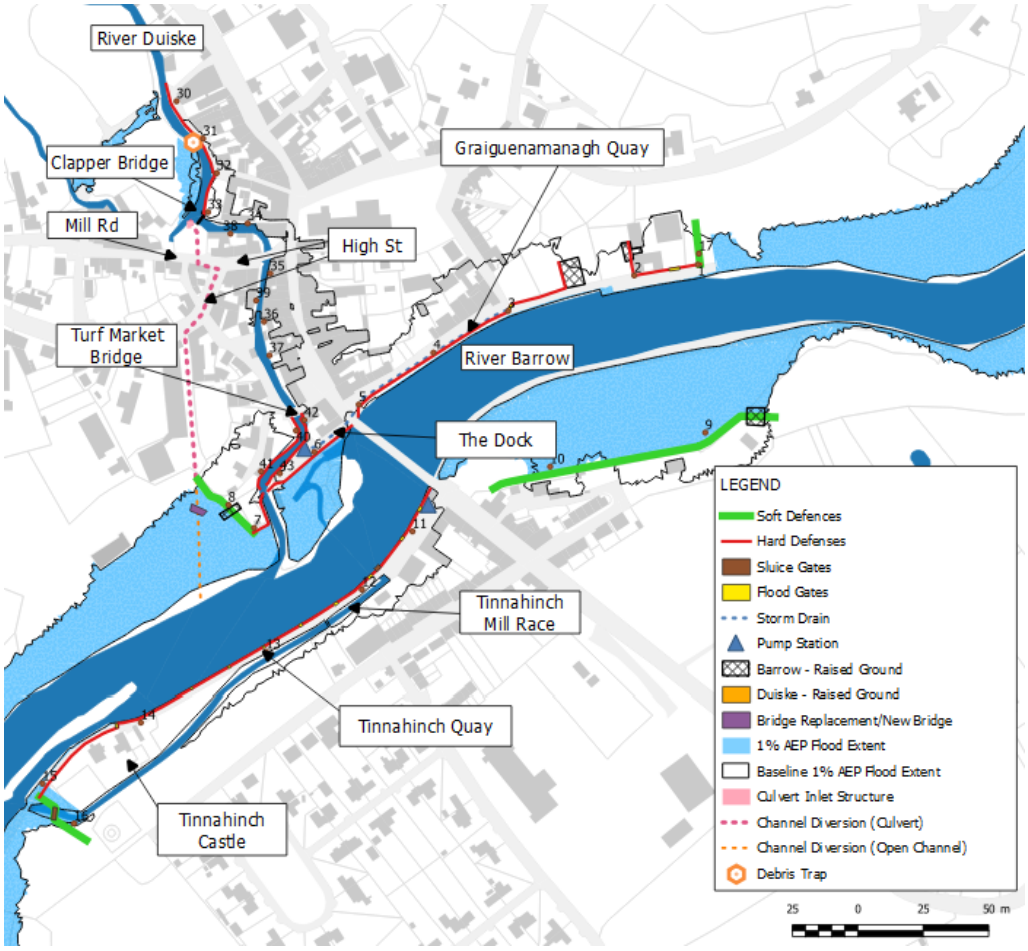

Figure 5-2: Option 2

[5.2.3] Option 3 – Raised Defences and River Duiske Storage – Preferred Option

Initial modelling showed that storage alone could not reduce flows such that flooding can be avoided in Graiguenamanagh from the River Duiske. This option therefore consists of upstream storage of flood waters, which facilitates a reduced extent of flood walls downstream in the built-up area of Graiguenamanagh.

Localised areas where channel capacity is low require raised defences, such as on the left bank between Clapper Bridge and The Globe and on the left bank immediately downstream of High Street Bridge.

Raised ground level on the left bank of the river along the Mass path and a wall to tie into The Globe premises provide cut-off whist maintaining pedestrian access.

Flood levels increase upstream of the storage area, which is composed of agricultural pasture. Raised defences in the town area are significantly reduced, particularly in the complex areas of Turf

Market where there are significant buildability and archaeological constraints. This is a significant advantage over the other options.

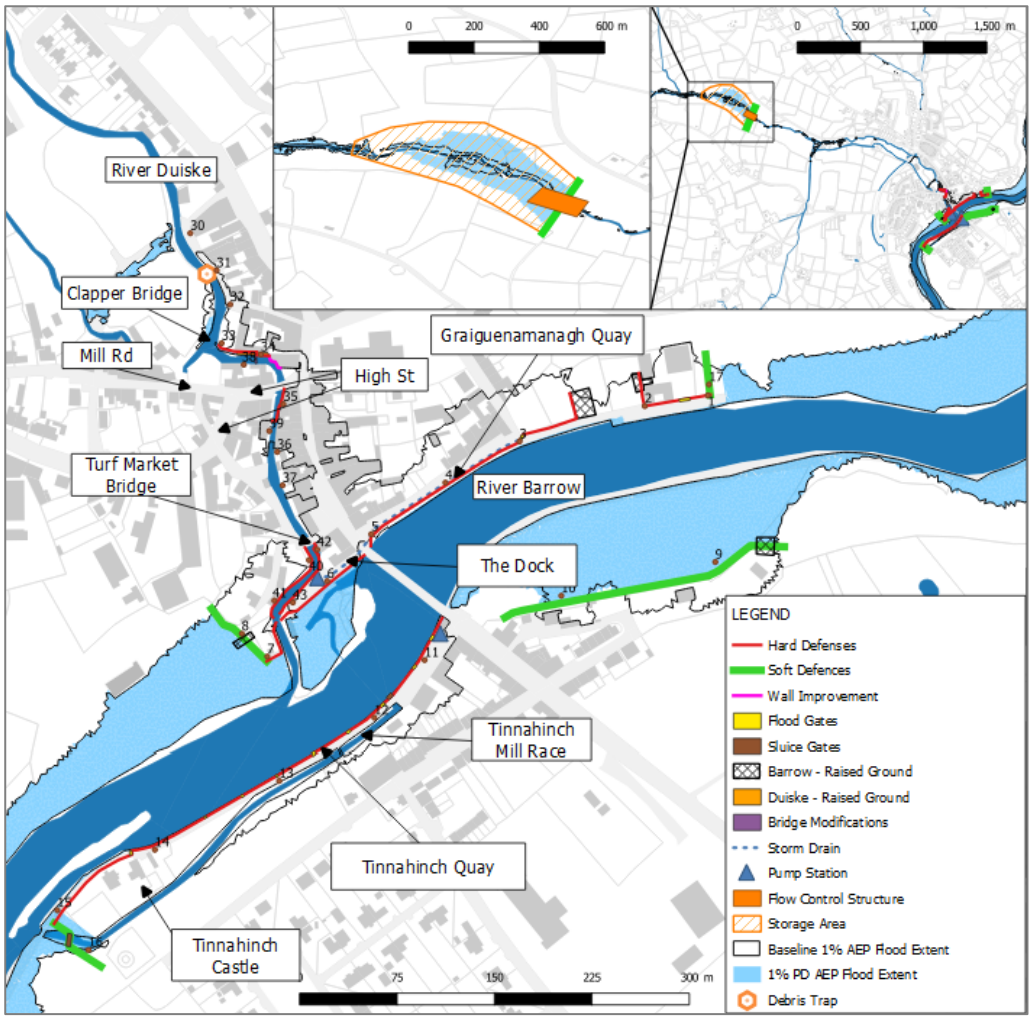

Figure 5-3: Option 3 - Preferred Option

[5.2.4] Option 4 – Raised Defences and River Duiske Storage and Diversion

As above, storage alone could not reduce flows such that flooding can be avoided in Graiguenamanagh. This option therefore consisted of upstream storage of flood waters, which facilities a reduced volume capacity requirements for the diversion arrangement, making it technically possible to address flood risk. Raised defences on the Duiske are entirely avoided. As with all options with diversion as a measure, an instream flow control structure would be required in the Clapper Bridge area.

A new access bridge would be required to maintain pedestrian access to the Hub, and a new open channel would be provided in the grounds of The Hub.

The modelling results indicated that this option was technical viable and achieved the desired outcome of avoiding raised defences on the riverbanks. Flood levels increased upstream of the storage area, which is composed of agricultural pastureland. Unlike Option 2, flood levels are not significantly increased upstream of the flood control structure near Clapper Bridge due to the smaller peak flood flows facilitated by the storage area.

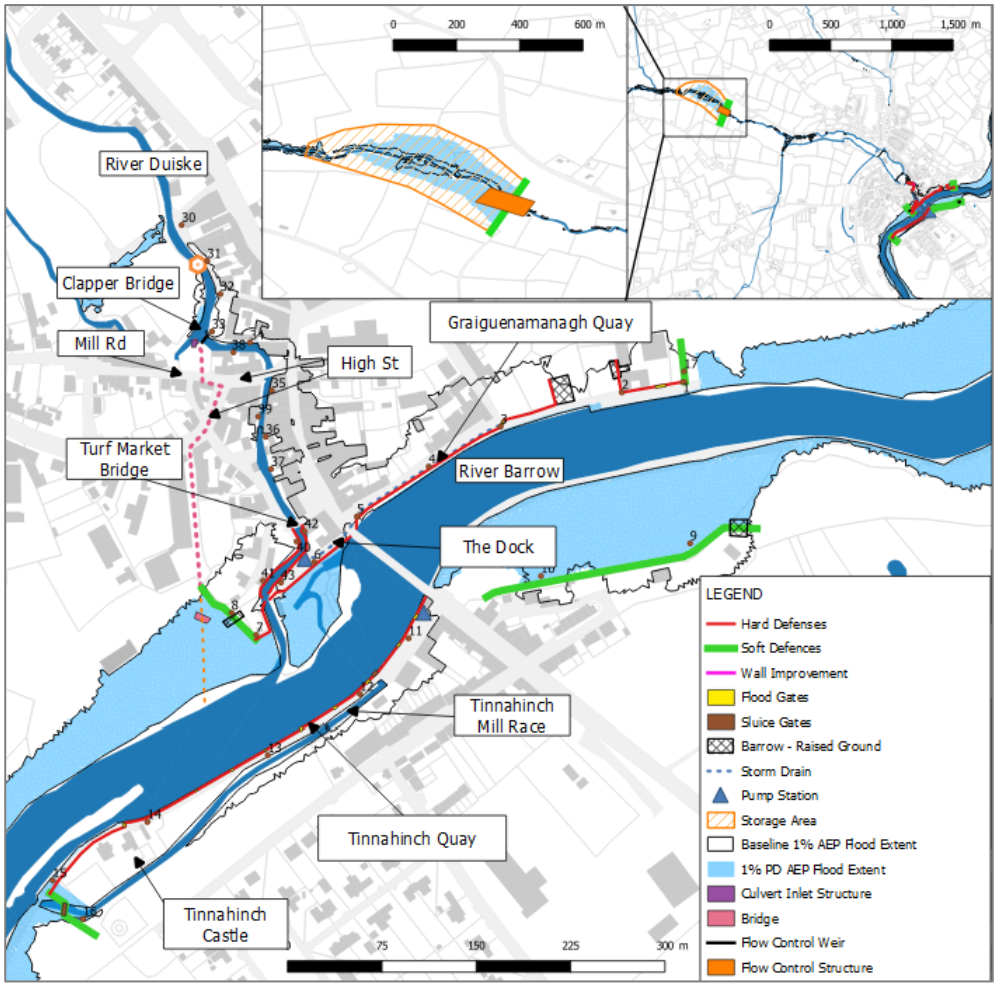

Figure 5-4: Option 4

[5.2.5] Option 5 – Raised Defences and River Duiske Culvert

This option is a slightly modified version of Option 1, wherein the extent of raised defences downstream of High St. Bridge are reduced by the inclusion of a culvert downstream of High St. Bridge. This option was considered because this reach of the Duiske is already heavily modified and partially covered.

The option consists of raised defences on the left bank of the River Duiske between Well Lane and High St. Bridge. A new section of culvert would be installed from High Street Bridge to upstream of the Mill building on the right bank of the River Duiske at Turf Market, which avoids the need for raised defences in this section and maintains the existing access arrangements to the properties for the long term. It is noted that there remains significant buildability challenges with this option as well as temporary access arrangements during construction, but long term it would be a better option both technically and socially. It will not be favourable from an environmental or archaeological viewpoint as compared to the other options.

This option did not eliminate the need for a wall on the left bank opposite the Mill building at Turf Market which would have been advantageous as against Option 1. The modelling results indicated that this option was technical viable and achieves the desired outcome of avoiding the vast majority of raised defences in the Turf Market area.

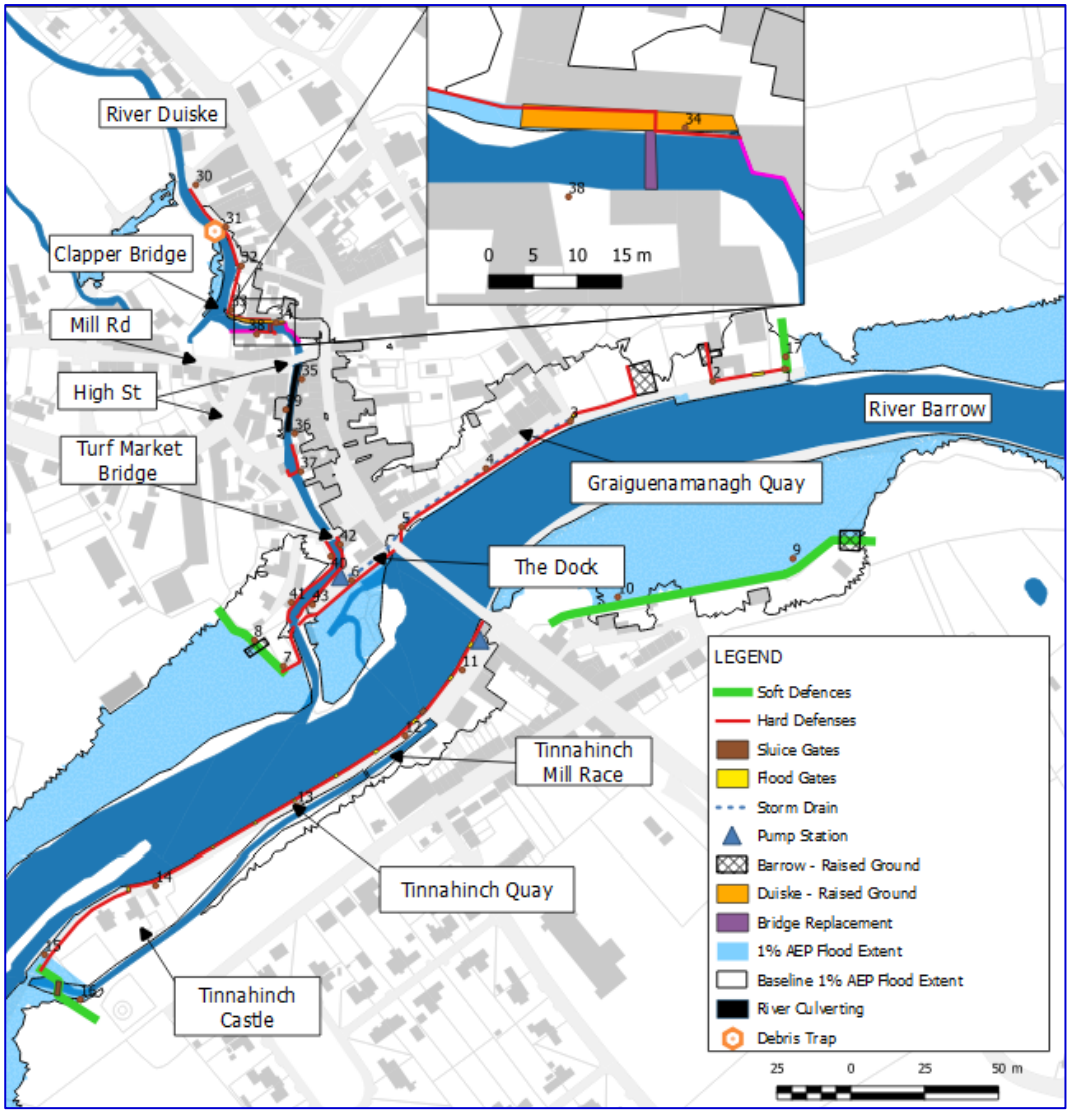

Figure 5-5: Option 5

[5.3] Cost-Benefit Analysis

[5.3.1] Damages

The economic flood damages for the Graiguenamanagh-Tinnahinch Flood Relief Scheme were calculated based on the OPW Technical Methodology Note – Cost Benefit Analysis (CBA), 2018, Flood and Coastal Erosion Risk Management, the Handbook for Economic Appraisal (HEA), 2021, known as 'the Multi-Coloured Manual' (MCM).

The Options Report, contained in Appendix H outlines the calculation in detail. The NPV of the scheme benefits was calculated as €18,207,506 (see Table 5-1). Table 5-2 provides the numbers of properties to benefit from the scheme.

Table 5-1: Summary of Damages Avoided in Scheme Area for 1% AEP Design Scenario

	Principal Direct Damage (PDD)	Infrastructural Utility Assets (IUA)	Emergency Services (ES)	Tangible Damages	Intangible Damages	TOTAL PV Damages (€)
Uncapped AAD	€1,055,863	€211,172	€85,524	€1,352,560	€1,055,863	€3,760,985
Capped PV Damages Avoided	€7,809,916	€2,587,673		€10,397,589	€7,809,916	€18,207,505

Table 5-2: Number of properties benefitting from Scheme

Property Type	Number of properties benefiting for the 1% AEP Design Standard
Residential	31
Commercial	53
TOTAL	84

[5.3.2] Scheme Costs

Capital cost estimates for each of the flood alleviation options discussed were developed using the OPW Unit cost database, updated to April 2021 using a Consumer Price Index (CPI) factor. The applied CPI was 1.46. The resulting cost comparison for the options were:

Table 5-3: Preliminary Cost Estimates

	Option 1: Raised Defences Only	Option 2: Raised Defences and River Duiske Flow Diversion	Option 3: Raised Defences and River Duiske Storage	Option 4: Raised Defences and River Duiske Storage and Diversion	Option 5: Raised Defences & River Duiske Culvert
Capital Cost					
Construction Cost Estimate (Incl. for unmeasured & Prelims)	€6,338,441	€9,251,858	€6,280,495	€9,463,270	€6,832,371
Archaeology (7.5-15%)	€950,766	€693,889	€628,050	€709,745	€1,024,856
Environmental Monitoring/Mitigation (5%)	€316,922	€462,593	€314,025	€473,164	€341,619

Sub-total for Construction Cost	**€7,606,129**	**€10,408,341**	**€7,222,570**	**€10,646,179**	**€8,198,845**
Other Related Costs					
Fees and Supervision (10%)	€760,613	€1,040,834	€722,257	€1,064,618	€819,884
Land Acquisition	€75,000	€100,000	€450,000	€475,000	€75,000
Art (1% up to €125k)	€76,061	€104,083	€72,226	€106,462	€81,988
Surveys	€100,000	€100,000	€100,000	€100,000	€100,000
Site investigation	€306,940	€356,328	€356,328	€356,328	€306,940
Sub-total	**€8,924,743**	**€12,109,587**	**€8,923,381**	**€12,748,587**	**€9,582,658**
Optimism Bias (20%)	€1,521,226	€2,081,668	€1,444,514	€2,129,236	€1,639,769
Maintenance Costs (incl. 20% Optimism Bias)	€1,633,963	€2,385,002	€1,619,025	€2,439,501	€1,761,291
Total Project Cost	**€12,079,932**	**€16,576,256**	**€11,986,920**	**€17,317,323**	**€12,983,718**

[5.3.3] Cost Benefit Ratios

The overall scheme benefits and costs were calculated for each of the selected options. A summary of the calculations is presented in Table 5-4 below.

Table 5-4: Options Benefit Cost – Ratios

Construction Cost Sensitivity	Option	Capital Costs	NPV Total Benefits	Benefit-Cost Ratio
Baseline	Option 1	€12,079,932	€18,207,506	1.51
	Option 2	€16,576,256		1.10
	Option 3	€11,986,920		1.52
	Option 4	€17,317,323		1.05
	Option 5	€12,983,718		1.40
+ 20% of construction costs	Option 1	€14,495,918	€18,207,506	1.26
	Option 2	€19,891,507		0.92
	Option 3	€14,384,304		1.27
	Option 4	€20,780,788		0.88
	Option 5	€15,580,462		1.17
- 20% of construction costs	Option 1	€9,663,945	€18,207,506	1.88
	Option 2	€13,261,005		1.37
	Option 3	€9,589,536		1.90
	Option 4	€13,853,859		1.31
	Option 5	€10,386,975		1.75

[5.4] Multi-Criteria Assessment

In accordance with the OPW's 2018 guidance, a Multi-Criteria Analysis (MCA) was carried out on the options as outlined above. The MCA provides a scoring to the options considering the following four categories:

- Technical
- Economic
- Social
- Environmental

Table 5-5 shows the results of the MCA. After the completion of this exercise, Option 3 scores highest under the Economic Benefit – Cost Ration (BCR). It is 3rd highest in Options Selection MCA Score and MCA Benefit Score primarily due to its economic value and whilst its overall environmental score (MCA Benefit Score) is in the lower ranges, this is primarily down to the scoring mechanism which treats unfavourably new works that affect the WFD objectives and fisheries, regardless of the nature of impact. However, using professional judgement, it was considered that Option 3 represents the optimum combination of measures with the most appropriate balance of impact across all disciplines.

Table 5-5: Summary of MCA

CRITERIA	Option 1: Raised Defences Only	Option 2: Raised Defences and River Duiske Flow Diversion	Option 3: Raised Defences and River Duiske Storage	Option 4: Raised Defences and River Duiske Storage and Diversion	Option 5: Raised Defences & River Duiske Culvert
1. Social	923	923	923	923	923
2. Economic	416	412	407	412	416
3. Environmental	-307	-404	-613	-726	-615
4. Technical	450	350	500	250	400
TOTALS	1,482	1,280	1,217	858	1,124

[5.5] Preferred Option

[5.5.1] Overview

From objective analysis using the multi-criteria assessment methodology and application of professional judgement with reference to the information gathered through the environmental assessment and public consultation there would appear to be an alternative preferred option. That is:

- Option 3 – Raised Defences and River Duiske Storage

Having considered the results of the various assessments it is our professional judgement that Option 3 – Raised Defences and River Duiske Storage represents the optimum combination of measures with the most appropriate balance of impact across all disciplines.

It also meets the council's desire for passive, sustainable flood defences, whilst balancing the various and competing interests of other legislation and objectives. The main reasons why this is the Preferred Option over all the others and in particular Option 1 is that:

- A significant element of the work is concentrated outside of the town.
- A large portion of the works on the River Duiske are located outside the SAC.
- The works within the town are reduced in nature and scale to a reasonable extent.
- The option will not negatively impact on the water quality objectives under the WFD of the Barrow or the Duiske.
- The risk to the project budget due to construction price inflations is lower than for the other options.
- It is the least sensitive options to ground conditions, a major source of cost overruns on projects.
- The risk of flooding during construction is reduced as the volume of instream works in the River Duiske is reduced compared to Option 1.
- The extent of works instream in the SAC is reduced compared to Option 1.
- In consideration of the Climate Sectoral Adaptation Plan for Flood Risk Management (2019 - 2024) this approach allows for an integrated assessment of flood management at the catchment scale.
- The WFD has also called for a shift in flood management approach away from site specific raised engineering solutions, towards an integrated assessment of water resources and flood management at the catchment scale.

[5.5.2] Detailed Description

The following sections present a summary of the preferred scheme. The scheme has been fully detailed and scheme drawings are included in Appendix L to accompany the descriptions below.

[5.5.2.1] Storage Area, Graiguenamanagh

The Storage Area entails the establishment of a flood storage area by constructing a raised earthen dam 8m in height, which will impound flood waters during extreme events up to the design flood extents shown in the imagery. Water will be conveyed through the dam in a Hydrobrake, which will have a debris screen upstream to prevent blockage. Erosion and flow control measures will be placed on the downstream face. Landscaping in the form of tree planting is to be screened in the area to offset tree loss in urban areas.

Water levels will be monitored using sensors which can be accessed remotely. Task lighting and access to the site will also be provide from the R705.

Access to the storage area will be from the R705, where a new vehicular access road will be constructed, respecting and maintaining the exiting field boundaries. Minor grading of the land will be required to provide safe access.

[5.5.2.2] Well Lane, Graiguenamanagh

Well Lane to High Street Bridge includes the construction of a debris trap at Well Lane, improvements to existing walls on the left bank along the Mass Path to The Globe. The wall improvement will entail casting a waterproof casing to the existing walls to the rear of Doyle's. An existing private footbridge is to be modified, raised, and ground raised to maintain access and adequate protection against flooding. A low-level flood defence wall (0.5m) will replace an existing stub wall.

The debris trap will entail placing auger or driven piles into the bed of the river to trap and catch any heavy debris flowing down the Duiske River. This will serve to protect the Clapper Bridge from future damage and ensure blockages do not impact the scheme area further downstream where multiple structures exist. This trap will be maintained from Well Lane.

[5.5.2.3] Upper Turf Market, Graiguenamanagh

Upper Turf Market includes the construction of a flood defence wall and bridge replacement which will act, in combination with the upstream storage, to limit flows downstream. Site clearance will consist of the demolition down to below bed level of the existing walkway to the rear of Hughes and removal of the existing pedestrian access bridge. Vegetation clearance will also take place.

The proposed flood defence wall is to be in a restricted working environment, which will require instream works. The wall will be approx. 1.8m above bed level and 0.7m above existing ground level along the path. Non-Return Valves will also be fitted onto outlets that could provide water pathways behind the flood defences.

A new access bridge will replace the existing bridge at a slightly higher level and wall improvements (repointing and replacement of masonry) to the existing stone masonry wall along the left bank of the Duiske as far as Turf Market Bridge will be provided.

Flood proof doors and pump sumps will be provided in a number of low-lying properties behind the defences.

[5.5.2.4] Lower Turf Market to the Hub, Graiguenamanagh

Turf Market to the Hub consists of the construction of flood defence walls on both banks of the River Duiske. On the right bank the walls vary from approx. 1.2-1.5m above ground level, whilst on the left bank, facing The Dock, the walls are a typically 1.1m above ground level.

On the left bank- Immediately downstream of Turf Market Bridge, the wall will sit on a bored pile foundations to avoid excavations and reduce vibrations on the adjoining structure and provide cut-off for seepage. A pump sump and drainage will be provided for low-lying ground.

On the right bank - Immediately upstream of The Hub Bridge, leading to Peg Washingtons Lane, a bored pile solution will also be implemented to reduce excavation next to the historic building and to provide cut-off for seepage. The existing stone wall will be retained so much as is possible.

[5.5.2.5] The Boat Club, Graiguenamanagh

The Boat Club entails the construction of flood defence walls, an embankment and associated works surrounding the boat club on the right bank of the River Barrow. The flood defence wall in front of

the Boat Club will be circa 1.5m high above ground level. This wall will include 1m high glazing in front of the clubhouse to retain the views of the river.

Both sides of the wall will be cladded in natural stone. Lift and turn hinged flood gates will be provided to maintain access for vehicles. An area of the carpark will be raised by up to 800mm to provide adequate flood protection whilst maintaining access to the boat storage building.

A flood defence wall will also be constructed along the entrance to the boat club, set back from the existing boundary which is part of the National Heritage Inventory of Ireland.

[5.5.2.6] Graiguenamanagh Quay

Graiguenamanagh Quay includes the construction of flood defence glass and stone walls from the entrance to the Boat Club downstream to Graiguenamanagh Bridge. The new flood defence wall is to be built set back from the quay edge by 4-5m, to allow adequate space for pedestrian and quay use simultaneously, minimising impacts to archaeology under Graiguenamanagh Quay. Vehicular access on Graiguenamanagh Quay will be restricted to one directional travel towards Barrow Lane.

The wall consists of at least 1m high glass panels sitting on a reinforced concrete wall with natural cut stone cladding both sides. Three (3no.) sliding flood gates are included to allow openings in the wall to maintain connectivity between both sides of the wall at the public Quayside. Further swing type floodgates are included to provide suitable access elsewhere.

The street will be completely resurfaced, including footpath and new pedestrian crossings added at both ends. Various types of surfaces, materials, street furniture and lighting are proposed to add visual interest and functionality. These have been selected appropriate to the historical quayside setting. A granite paving area is proposed to provide a café terrace near the Waterside Guesthouse, whilst still maintaining pedestrian movement.

[5.5.2.7] The Dock, Graiguenamanagh

The Dock includes the construction of flood defence walls from Graiguenamanagh Bridge to The Hub Bridge. The flood defence wall will be built along the left bank of the River Barrow and will follow the already existing natural line of the edge of the carriageway. Pedestrian and cyclist access is to be retained to The Hub from the east (i.e., Graiguenamanagh Town).

An underground storm water pumping station and overground control kiosk are also proposed. The northern section of the existing old building will be demolished to make way for a new outfall and to allow the new flood defence wall to be constructed safely.

The riverside wall will be clad in stone and localised landscaping and planting will be incorporated near the entrance to The Hub.

[5.5.2.8] The Hub, Graiguenamanagh

The Hub entails the construction of a flood defence wall along the bank of the River Duiske. The wall will tie into an earthen embankment within grounds of The Hub and ties back into high ground to the north-east of The Hub building.

A 42m long flood defence wall will be constructed on sheet piles to a maximum height of 1.6m above ground level. The wall will be clad with natural stone with a rounded capping.

The embankment is 62m in length and will be grass seeded. Pathways will be provided to retain the existing connection routes coming from the town centre to the Hub and to the path to the north of the Hub.

Pitches/sites for Campervans will be amended to suit the new grade, including electrical equipment. Vehicular access to The Hub will continue to be from the west, through the Brandondale area. Access for Uisce Eireann to the existing pumping station will be via The Dock as is the current case.

[5.5.2.9] Hotel Street, Tinnahinch

Hotel St. includes the construction of a flood defence embankment and wall along the left bank of the River Barrow.

The embankment will be circa 240m long with a maximum height of 1.25m above ground level and will be grass seeded.

To preserve the marsh/wetland towards the east, the embankment will merge into a concrete flood wall 38m long and maximum 1.5m high to serve protection against 1% AEP Flood Events.

[5.5.2.10] Tinnahinch Quay

Tinnahinch Quay includes the construction of a flood defence wall from Graiguenamanagh Bridge to Tinnahinch Car Park at the mill channel. The defence consists of a reinforced concrete flood wall with sheet piles for seepage cut-off and hinged flood gates along the Quay to maintain access. Most of the wall will be approx. 0.8m high, but it will be up to 1.2m high at Tinnahinch carpark. The hinged flood gates will default in an open position.

Improved and safer pedestrian movement is proposed from the bridge and new pedestrian crossing. The amenity pathway along The Quay will form part of the regional hiking trail, The Barrow Way.

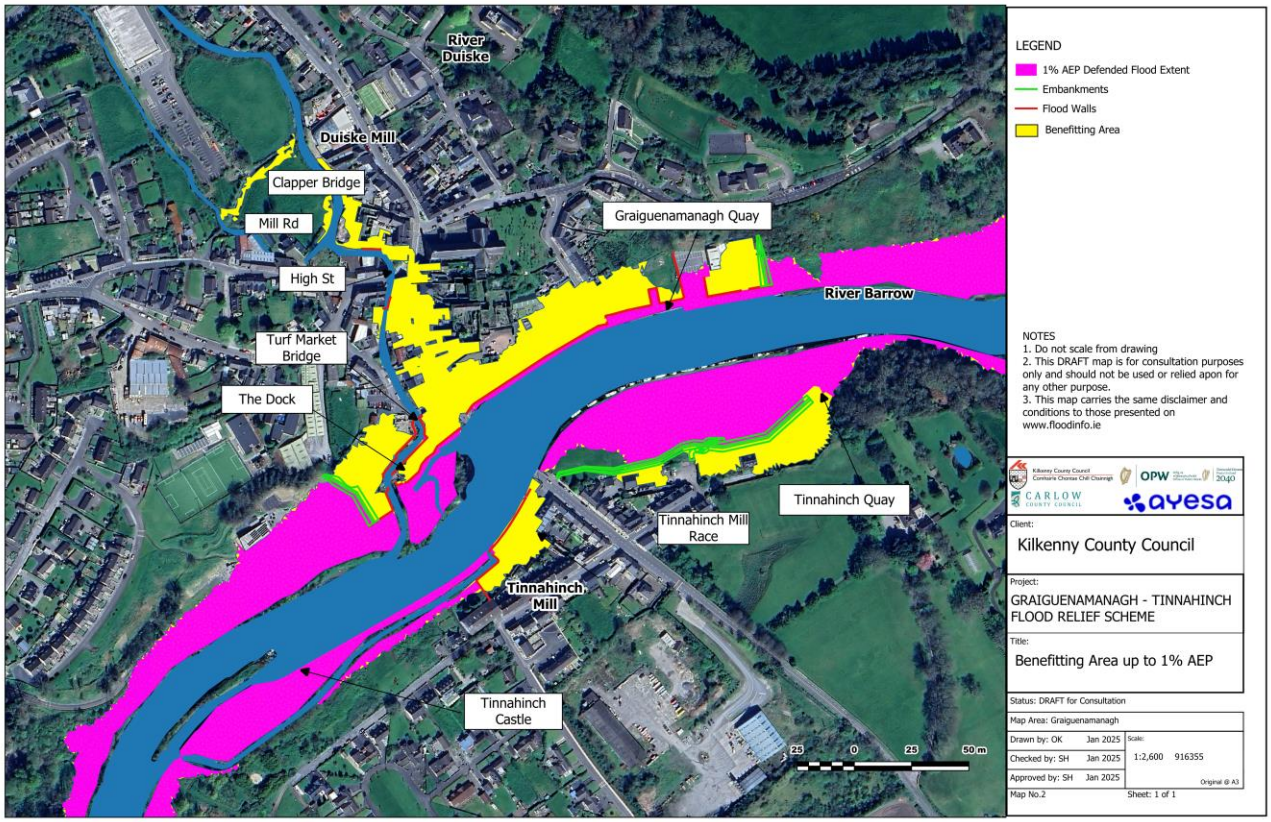

Figure 5-6: Refine Preferred Option and Benefitting Area

[5.5.3] Further Development

During the detailed development stage of the preferred option, the preferred option has been continuously refined following discussions with KCC, CCC, landowners and stakeholders.

In addition, the factors in Table 5-6 have influenced the final development stages of the preferred option.

Table 5-6: Main Factors influencing further Development of the Scheme

Factor	Impact/Influence on preferred option
Ground Investigations	Used to finalise foundation design and seepage cut-off requirements. Cut-off walls required along Graiguenamanagh Quay, Tinnahinch Quay, Hotel Street and long Duiske downstream of High Street Bridge.
Duiske Rating Curve Review	A hydraulics Modelling task was completed to review water levels in the River Duiske as a sufficient period of time had elapsed since the installation of gauges. This resulted in an update to flood levels locally to the downstream areas of the River Duiske, and a corresponding update to defence levels. Significant changes were not warranted. Additional 'backup' measures were also added to certain low-lying properties along the Duiske such as pump-sumps and flood doors where appropriate.
Final Design – Flood gates	The locations of flood gates and the nature of such gates has been developed with stakeholders and landowners.
Final Design – Walls Alignments & Levels	Once the full design requirements were established, the cost-benefit of the scheme was reviewed by updating the costs. Costs have been updated to reflect the changes in the nature of the scheme. Benefits have also been reviewed to check the BCR. Review of the scheme indicated an area in Tinnahinch that does not justify capital expenditure. The scheme has thus been adapted to provide greater economic efficiency in one area. Full details are outlined in the Options Report. Uisce Eireann advised the design team in June 2024 of a planned storage tank for storm overflows that has a direct clash with the proposed walls. Both design teams have worked together to resolve the alignment on both projects to facilitate one another. A number of wall alignments have been modified slightly following discussion within KCC and with landowners. Modelling and alignment refinement of upstream storage has taken place. The location and geometric properties of the storage area embankment have been optimised throughout the development.
Final Design – Conservation Engineering	Significant work has been undertaken to develop a conservation strategy associated with the project to retain the cultural heritage significance of the town.
Final Design – Landscape Deign	Significant work has been undertaken to develop a landscape/public realm design for the project.

[5.6] Quick Wins

A technical note on Quick Wins was issued to KCC in 2022 for consideration. No quick wins have been implemented to the end of Stage 1.

[6] Public Events

[6.1] Workshops

[6.1.1] Collaborative Workshop 1

The first collaborative workshop was held on 16th of July 2020 online. The purpose of this workshop was to discuss the purpose, impacts, identified constraints, opportunities and issues of the FRS with Kilkenny County Council and Carlow County Council. Discussions and queries were documented from this workshop and incorporated in the design process.

[6.1.2] Collaborative Workshop 2

The second collaborative workshop was held on 23rd of August 2022. The purpose of the workshop was to present progress from the first collaborative workshop and present five options, which emerged from hydraulic modelling and optioneering, to relevant stakeholders.

[6.2] Public Consultation Events

[6.2.1] PCD 1

A Public Consultation was held online at Consult.Kilkenny.ie. The consultation period was for three weeks between Thursday June 18th June to Thursday July 9th, 2020.

The purpose of the Public Consultation was to promote awareness of the scheme and to begin initial engagement with all interested parties. Additionally, the event was used to gather local information about experience of previous flooding in the study area along with their thoughts on the likely cause and the potential flood mitigation measures.

The online event included a recorded presentation, an information leaflet and an online questionnaire. Information was available to be downloaded and returned by post. A project email address was also provided should participants wish to contact the project team directly.

These materials are available via the project website at:

https://www.floodinfo.ie/frs/en/graiguenamanagh-tinnahinchfrs/home/

The original hosting page was at:

https://consult.kilkenny.ie/en/consultation/graiguenamangh-tinnahinch-flood-relief-scheme-public-consultation-no-1

All relative materials from this consultation period were published on the scheme website and a summary of discussions and results was provided in the Public Consultation 01 Summary Report (W3451-W-PCD02, 7th October 2020).

[6.2.2] PCD 2

The second public consultation event took place at The Hub, Graiguenamanagh on Tuesday, 9th August 2022 between 2pm and 7pm. Councillors were invited along prior to the event from 12pm to 2pm.

The purpose of the second consultation event was to present to the community with the five options developed to alleviate flooding in Graiguenamanagh-Tinnahinch. During the event, information posters were made available for public viewing with opportunity for discussion with the project team and provision of feedback.

Questionnaires were made available in hard copy and through an online survey format, to either be filled in on the day or at the individual's convenience. Stamped and addressed envelopes were provided to those who received a hard copy questionnaire. The questionnaire sought to gain an understanding of the individual's experience with flooding, their main concerns with the FRS, and their preference of flood defence options presented to them. Individuals were given a three-week period to return all questionnaires to the project team (i.e., to 30th August 2022).

The technical and environmental concerns submitted from the public consultation directed areas required for site investigations, environmental studies and other assessments for the schemes data collection, which determined the preferred option. Details of the preferred option are highlighted in Section [5.2.3] and Section [5.5].

The summary report for the second public consultation is available under stakeholder engagement on the scheme website (W3451- PCD-03, 26th September 2022).

[6.2.3] PCD 3

The third public consultation event took place at The Hub, Graiguenamanagh on Thursday 23rd of January 2025 between 2pm and 7pm. Councillors, landowners, interested parties and local residents were invited to visit the consultation between this timeframe.

The purpose of the third consultation event was to present the emerging preferred option - Option 3 Raised Defences and Storage Area.

Informative posters were displayed around the room, detailing the stages of the schemes, overall targeted areas, in-depth detail designs of each areas, planning approach, cultural heritage and archaeology, and environmental and biodiversity. These posters are available on the scheme website.

Public feedback was documented and requests for proposed changes were considered. These included additional access flood gates and minor adjustments to defence lines.

A summary report of the third public consultation will be available under stakeholder engagement on the scheme website.

[7] Climate Change Adaptation

A Scheme Climate Change Adaptation Plan (SCCAP) adaptation plan has been developed for the scheme. The SCCAP is a ‘live’ document, and it is intended to monitor, review and amend it as the scheme progresses through to completion and the operational phase. The current plan is included in Appendix G.

The plan demonstrate that the preferred scheme is adaptable to climate change and outlined an adaption pathway.

[8] Environmental Assessment

[8.1] Scoping Report

A scheme Environmental Scoping Report was completed in May 2023 (Appendix I). This report set out the proposed scheme and set out the intended scope and methodologies for the assessment of likely significant environmental effects as part of the EIAR.

The aim was to ensure that the scheme has due regard for the environment, by mitigating significant adverse environmental effects where possible, while taking advantage of opportunities for environmental and social enhancement.

[8.2] Environmental Impact Assessment

The Environmental Impact Assessment Report (EIAR) presents a systematic analysis of the impact of the proposed scheme in relation to the existing environment. This document has been prepared considering guidelines published by Environmental Protection Agency (EPA, 2022), as part of the Environmental Impact Assessment process. The proposed scheme was assessed under the following disciplines:

- Material assets
- Hydrology
- Cultural Heritage
- Biodiversity
- Landscape and Visual
- Land, Soils, Geology and Hydrogeology
- Air Quality
- Climate
- Noise and Vibration

This document will be submitted to the Competent Authority (An Bord Pleanála) as part of the planning process.

[8.3] Natura Impact Statement

A draft Natural Impact Statement (NIS) and Appropriate Assessment (AA) was developed for the GTFRS. The primary purpose of these reports is to provide relevant material to inform a decision by the Competent Authorities, as required under Articles 6.3 and 6.4 of the EU Habitats Directive, as to whether the proposed development is likely to have any significant impacts on the Conservation Objectives of a Natura 2000 (European) site. Where there are potential adverse impacts, an assessment of the prescribed mitigation of those impacts is presented.

This Appropriate Assessment Natura Impact Statement was completed in compliance with the relevant European Commission and national guidelines. The potential impacts during the construction and operation of the proposed scheme works have been considered in the context of

the European Sites potentially affected, their Qualifying Interests, Features of Interest, Special Conservation Interests and Conservation Objectives.

Robust and effective mitigation measures have been proposed for the avoidance of any impacts affecting water quality. Likewise, precautions will be taken in relation to non-native invasive species during the construction phase. Further, mitigation measures have been provided to reduce the impacts of noise and vibration during the construction phase. These will form part of a required Method Statement for the proposed works. Inland Fisheries Ireland (IFI) and the NPWS will be consulted to agree the provisions of a detailed Method Statement outlining the proposed methodology for the undertaking of works within and affecting the watercourse.

This assessment has shown that, given the proposed mitigation measures and based on the best scientific knowledge available, there will be no significant adverse impact on the integrity of the River Barrow and Nore SAC and River Nore SPA owing to the following reasoning:

- Best practice mitigation has been included in the scheme design (which would be implemented in any case i.e., even without a European Site being in the vicinity).
- Mitigation will be put in place.
- An Ecological Clerk of Works will be present on site when required.
- The proposed scheme will not result in any loss or fragmentation of habitats for which the SAC or SPA is designated.
- The proposed scheme will not have any long-term recurring significant impacts on the water quality or water levels of the River or its tributaries; and
- The proposed scheme will not have any significant negative impacts on the Qualifying Interests for which the SAC or SPA is designated.

The draft NIS concluded that the conservation objectives and integrity of any Natura 2000 site will not be adversely affected by the proposed scheme works.

[9] Buildability & O&M

Buildability and O&M for the scheme was considered at options stage, for the emerging option and then for the final developed option. The following matters were considered:

- Need for site compounds
- Site Access
- Management of Materials and Plant
- Interaction with other projects
- Temporary Works requirements
- Impact on existing properties
- Road Closure Requirements
- Environmental Issue during construction
- Construction Methodologies
- Phasing
- Long Term O&M & Staffing Requirements

The scheme was demonstrated to be buildable and maintainable. It is intended to update this report in Stage 3, but the final version for Stage 1 can be found in Appendix K.

[10] Planning Route Report

A report on the planning routes for the scheme was developed in March 2023 (See Appendix J). Subsequently in April 2023, KCC confirmed that a Part 10 planning application, in accordance with The Planning & Development Acts 2000 would be the desired planning approach.

The main driver for this decision was the Compulsory Purchase Order (CPO) process. Site access issues, which commonly arise, can be avoided under the planning development approach if the CPO documents are thoroughly prepared as the CPO legislation allows the local authority access to the CPO'd lands as soon as a vesting order is made and, given the anticipated timeframe between CPO and construction commencement, there is a higher chance that landowner disagreement can be avoided when following the PDA approach.

The SID route was not considered feasible for the Project, as there was not confidence that the project would be considered 'strategic.'

[11] Conclusions

The various technical, environmental and optioneering assessments collate the Graiguenamanagh-Tinnahinch Stage 1 Final Report. The objective of Stage 1 is to develop the flood relief scheme and preliminary design of the emerging preferred option.

The preferred option has been identified as Option 3 – Raised Defences and Storage area. This option was further developed since the selected process from the second public consultation and updated with damage assessment, MCA and remodelled for defence heights. Scheme drawings have been produced and are available in Appendix L.

The preferred option will be carried into Stage 2 – Planning Statutory Delivery Route and Public Exhibition. In this stage the preferred option will undergo Compulsory Purchase Orders (CPO) processes and temporary and permanent works will be sort during land acquisition.

The EIAR and scheme drawings will be updated following the planning submission of the scheme to An Bord Pleanála. Approval of planning will allow the scheme to transition into Stage 3 Detailed Construction Design, Compilation of Work Packages and the Preparation of Tenders for Contracts.

Appendix A – Hydrology Report

Appendix B – Flood Defence Asset Condition Report

Appendix C – Hydromorphology Report

Appendix D – Hydraulics Report

Appendix E – Constraints Report

Appendix F – Potential for Natural Water Retention Measure Report

Appendix G – Climate Change Adaption Plan

Appendix H - Options Report

Appendix I – Environmental Scoping Report

Appendix J - Planning Route Report

Appendix K – Preliminary Buildability and O&M Report

Appendix L – Scheme Drawings