

# Graiguenamanagh–Tinnahinch Flood Relief Scheme

## Background, Timeline and Public Consultation Process

### Introduction

The OPW, working in partnership with Kilkenny County Council and other Local Authorities, commissioned and completed the South-Eastern Catchment Flood Risk Assessment and Management (CFRAM) Study over 10 years ago. Graiguenamanagh/Tinnahinch was within this study area.

The South-Eastern CFRAM identified and mapped existing and potential future flood risks and reported on these in a Flood Risk Management Plan published in 2018.

The CFRAM identified numerous structural and non-structural options which could be adopted for effective and sustainable management of flood risks within the study area. These options were then screened under the following headings:

- Technical
- Economic
- Environmental
- Social

The South-Eastern CFRAM Study Area concluded that in Graiguenamanagh/Tinnahinch a flood relief scheme would be viable and effective for the community. The most viable scheme option identified was hard defences and associated works through the urban area of Graiguenamanagh along both banks of the River Duiske and similarly hard defences on both banks of the River Barrow through Graiguenamanagh

and Tinnahinch.

To assess and develop a suitable flood relief scheme for Graiguenamanagh-Tinnahinch, ByrneLooby have been appointed by Kilkenny County Council (KCC) to provide engineering and environmental consultancy services for the Graiguenamanagh-Tinnahinch Flood Relief Scheme (GTFRS). OPW is funding the project.

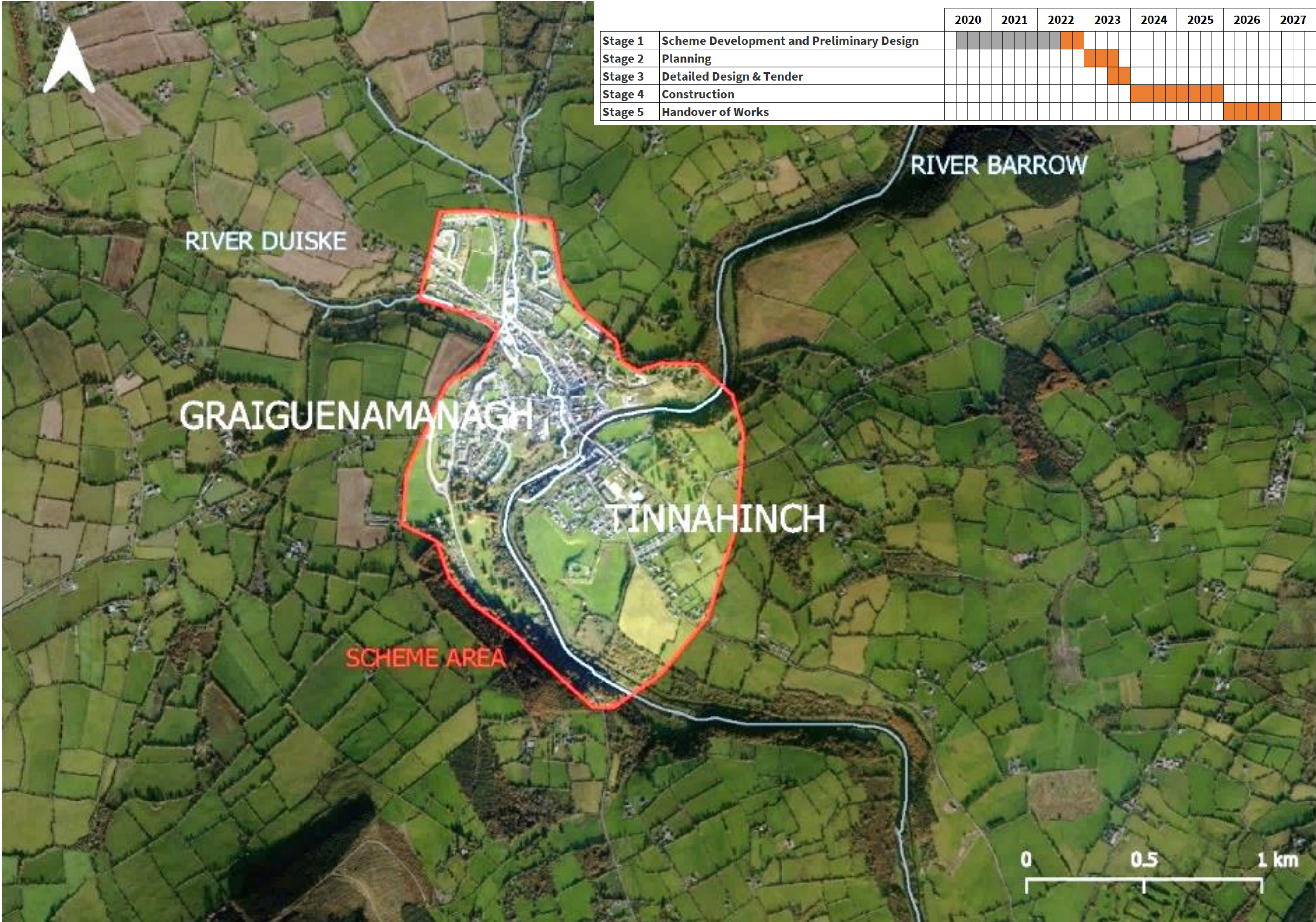
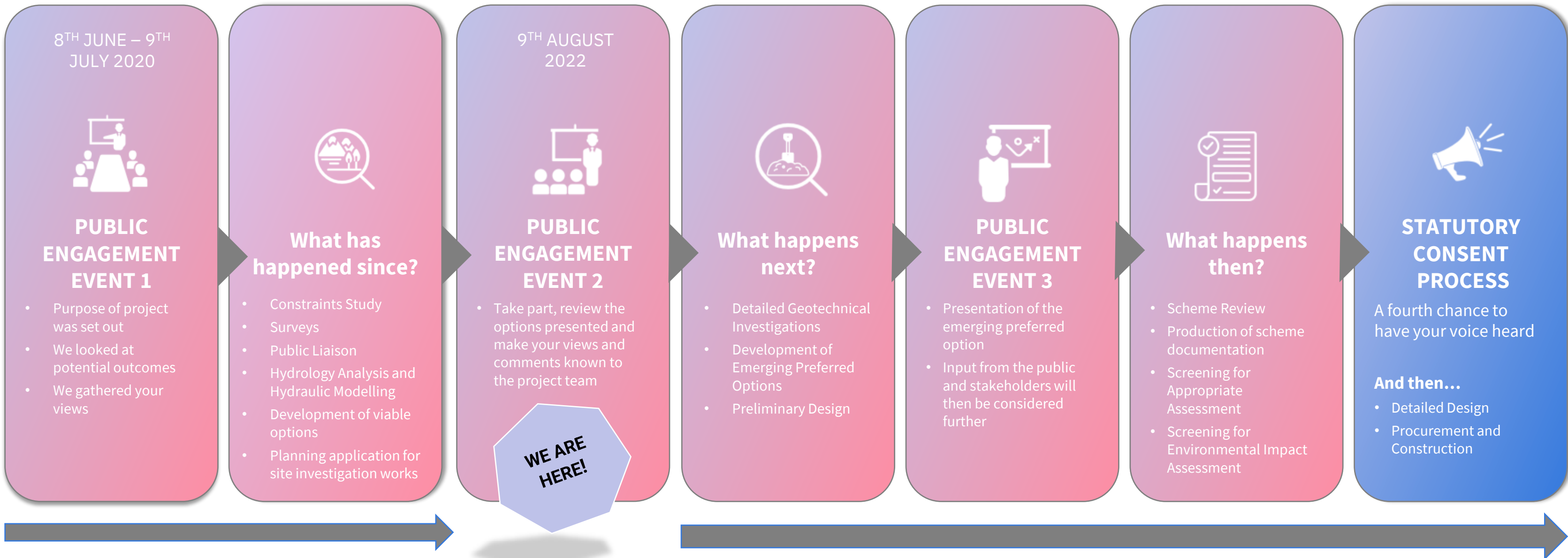
### DESIGN STANDARD

The design Standard of Protection (SoP) sought for the Graiguenamanagh-Tinnahinch Flood Relief Scheme (GTFRS) is the 1% annual exceedance probability (AEP) event. This can be thought of as a flood with a magnitude such that it has a 1% chance of occurring in any given year and is sometimes referred to as the 100-year flood.

The scheme will also be assessed for resistance/adaption to climate change for flood events that are greater than the design flood event.

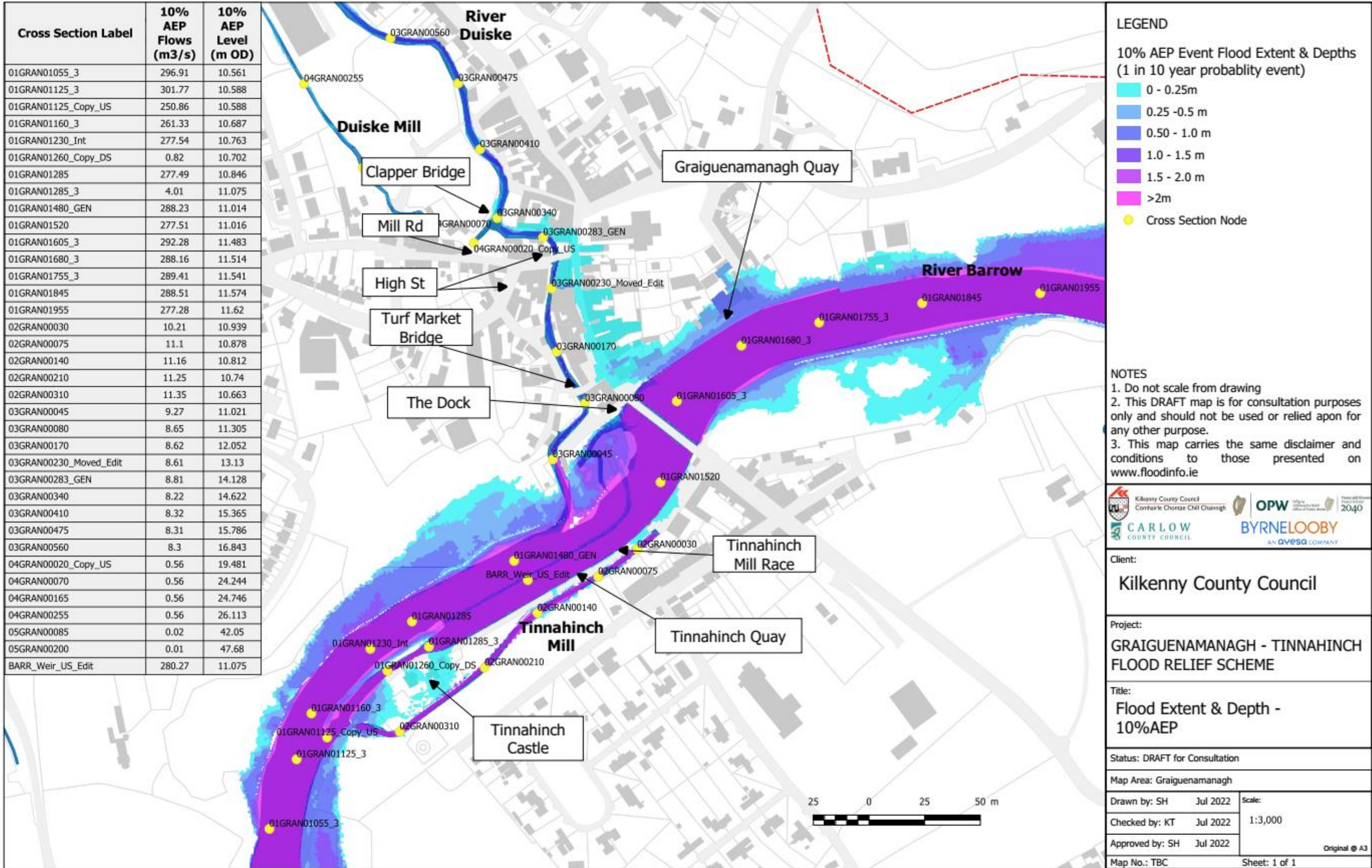
### STAGES & TIMELINES

The diagram below outlined the steps in Stages 1-2 that lead up to the statutory approval for the scheme. Once this is obtained, the detailed design will begin and a construction contractor will then be procured to build the scheme. The timeline for the entire project is shown inset below.



# Graigenamanagh–Tinnahinch Flood Relief Scheme

## Flood Extent Mapping



Cross Section Label	1% AEP Flow (m <sup>3</sup> /s)	1% AEP Level (m OD)
01GRAN01055_3	410.9	11.027
01GRAN01125_3	415.45	11.075
01GRAN01125_Copy_US	333.98	11.075
01GRAN01160_3	350.08	11.196
01GRAN01230_Int	363.48	11.291
01GRAN01260_Copy_DS	4.04	11.24
01GRAN01285	355.29	11.413
01GRAN01285_3	18.37	11.653
01GRAN01480_GEN	387.47	11.599
01GRAN01520	413.41	11.539
01GRAN01605_3	409.43	12.18
01GRAN01680_3	392.68	12.219
01GRAN01755_3	393.06	12.253
01GRAN01845	388.71	12.287
01GRAN01955	372.75	12.338
02GRAN00030	10.58	11.526
02GRAN00075	11.59	11.498
02GRAN00140	12.02	11.466
02GRAN00210	15.66	11.381
02GRAN00310	21.51	11.198
03GRAN00045	11.52	11.603
03GRAN00080	11.25	11.685
03GRAN00170	11.17	12.271
03GRAN00230_Moved_Edit	11.16	13.39
03GRAN00283_GEN	11.84	14.355
03GRAN00340	11.06	14.798
03GRAN00410	11.52	15.526
03GRAN00475	11.5	15.959
03GRAN00560	11.48	17.027
04GRAN00020_Copy_US	0.66	19.528
04GRAN00070	0.66	24.273
04GRAN00165	0.67	24.783
04GRAN00255	0.66	26.143
05GRAN00085	0.02	42.059
05GRAN00200	0.02	47.686
BARR_Weir_US_Edit	397.81	11.653

**LEGEND**

1% AEP Event Flood Extent & Depths (1 in 100 year probability event)

- 0 - 0.25m
- 0.25 - 0.5 m
- 0.50 - 1.0 m
- 1.0 - 1.5 m
- 1.5 - 2.0 m
- >2m

● Cross Section Node

**NOTES**

- Do not scale from drawing
- This DRAFT map is for consultation purposes only and should not be used or relied upon for any other purpose.
- This map carries the same disclaimer and conditions to those presented on [www.floodinfo.ie](http://www.floodinfo.ie)

**Client:** Kilkenny County Council

**Project:** GRAIGUENAMANAGH - TINNAHINCH FLOOD RELIEF SCHEME

**Title:** Flood Extent & Depth - 1% AEP

**Status:** DRAFT for Consultation

**Map Area:** Graigenamanagh

**Drawn by:** SH Jul 2022 **Scale:** 1:3,000

**Checked by:** KT Jul 2022

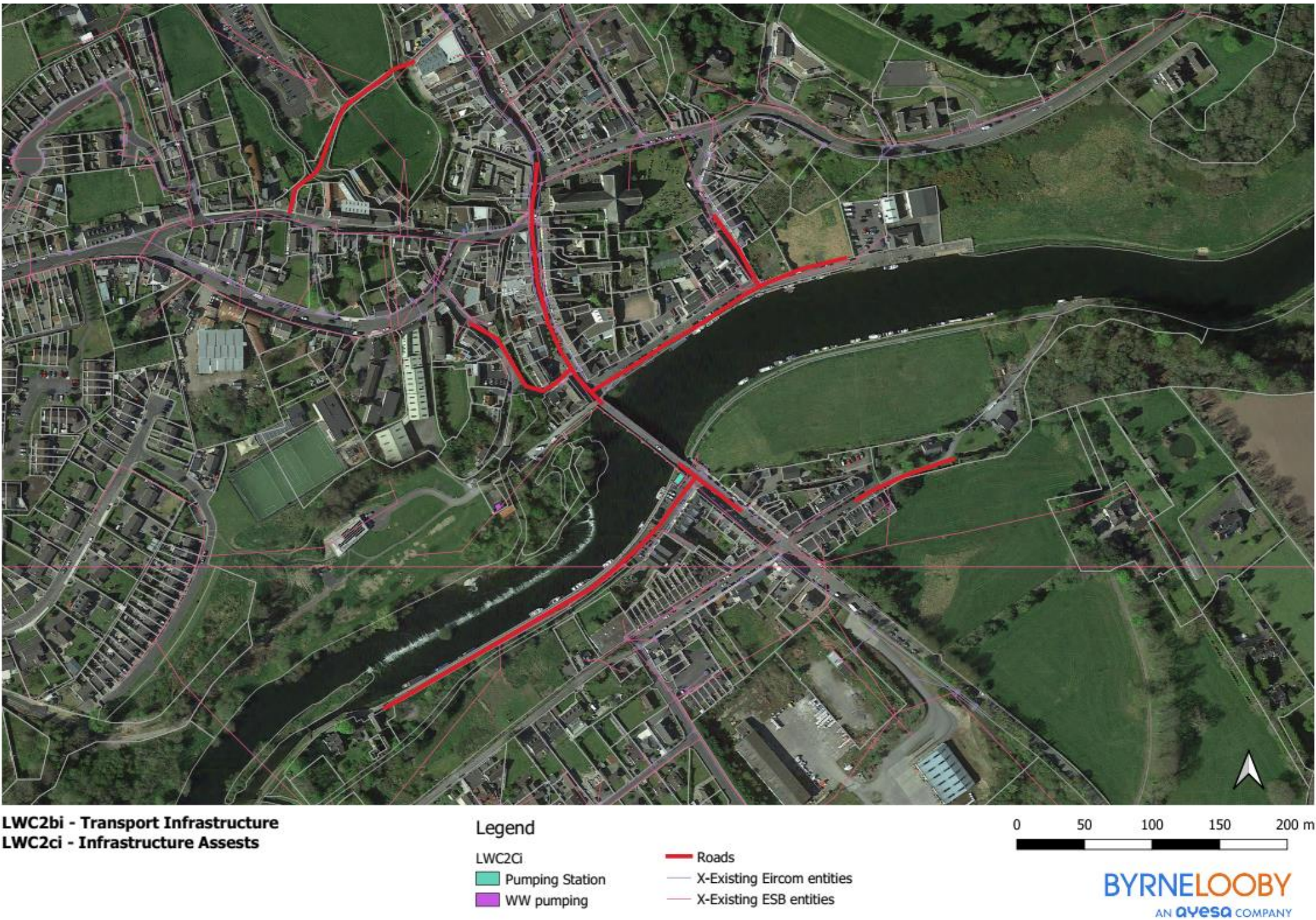
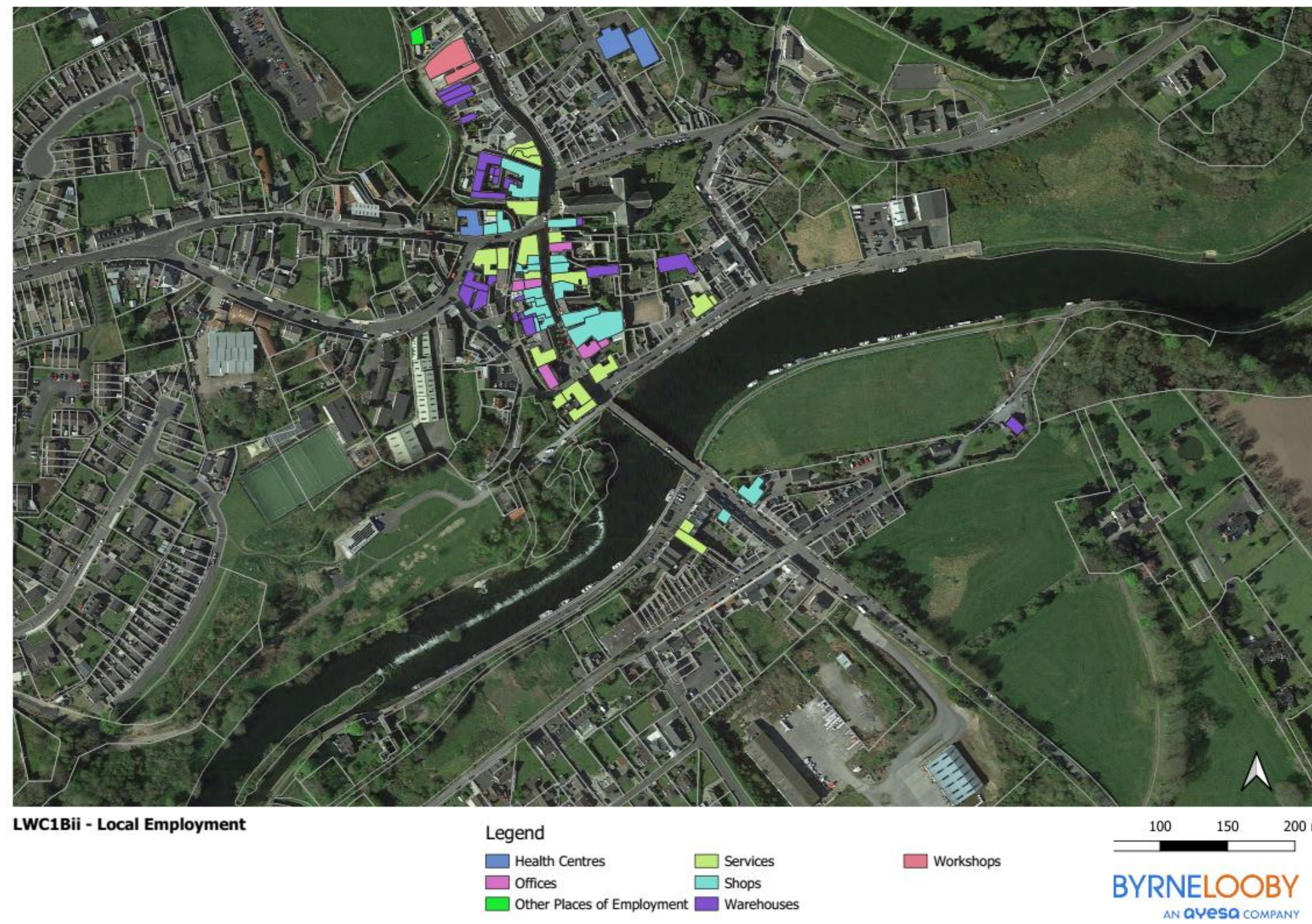
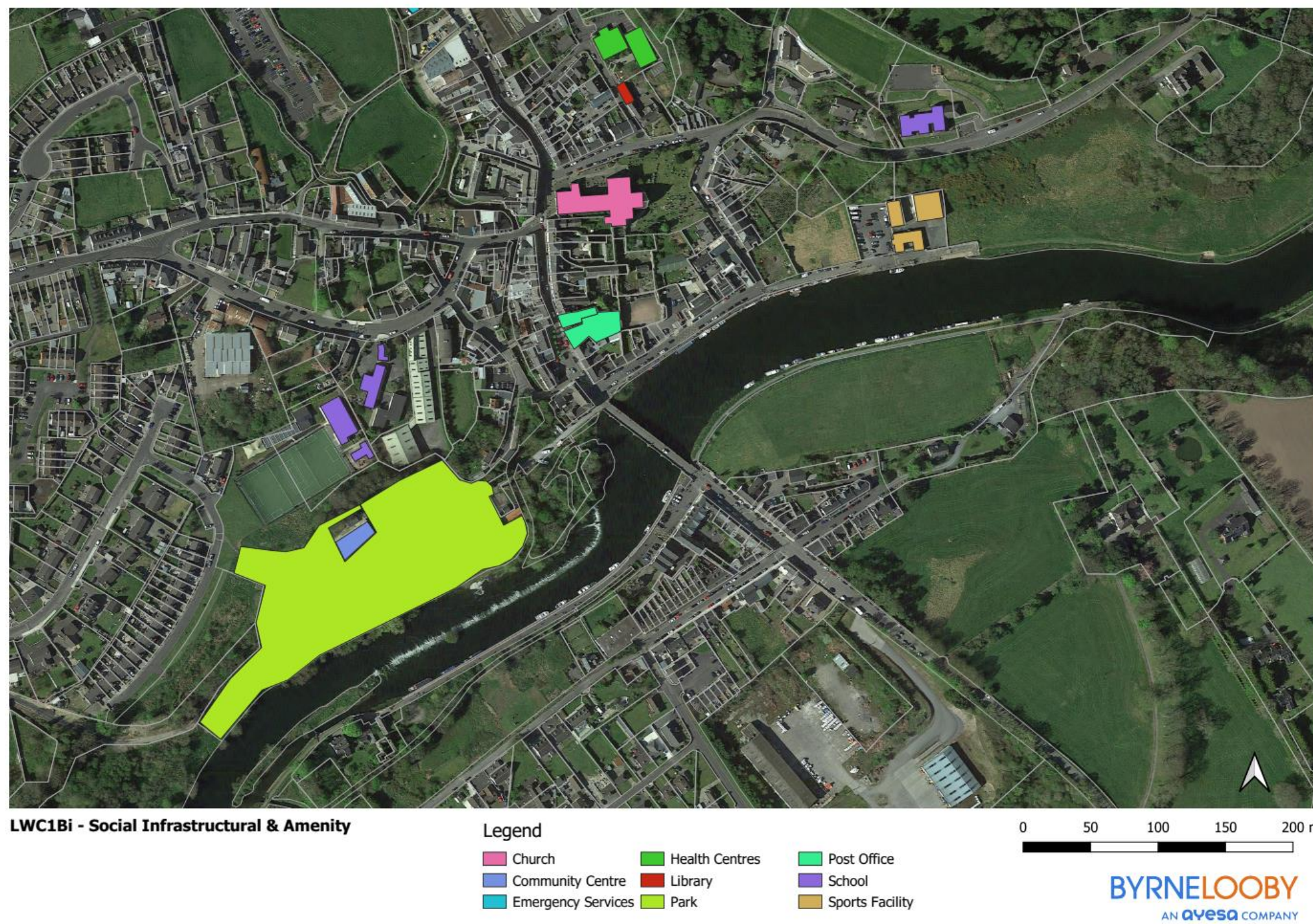
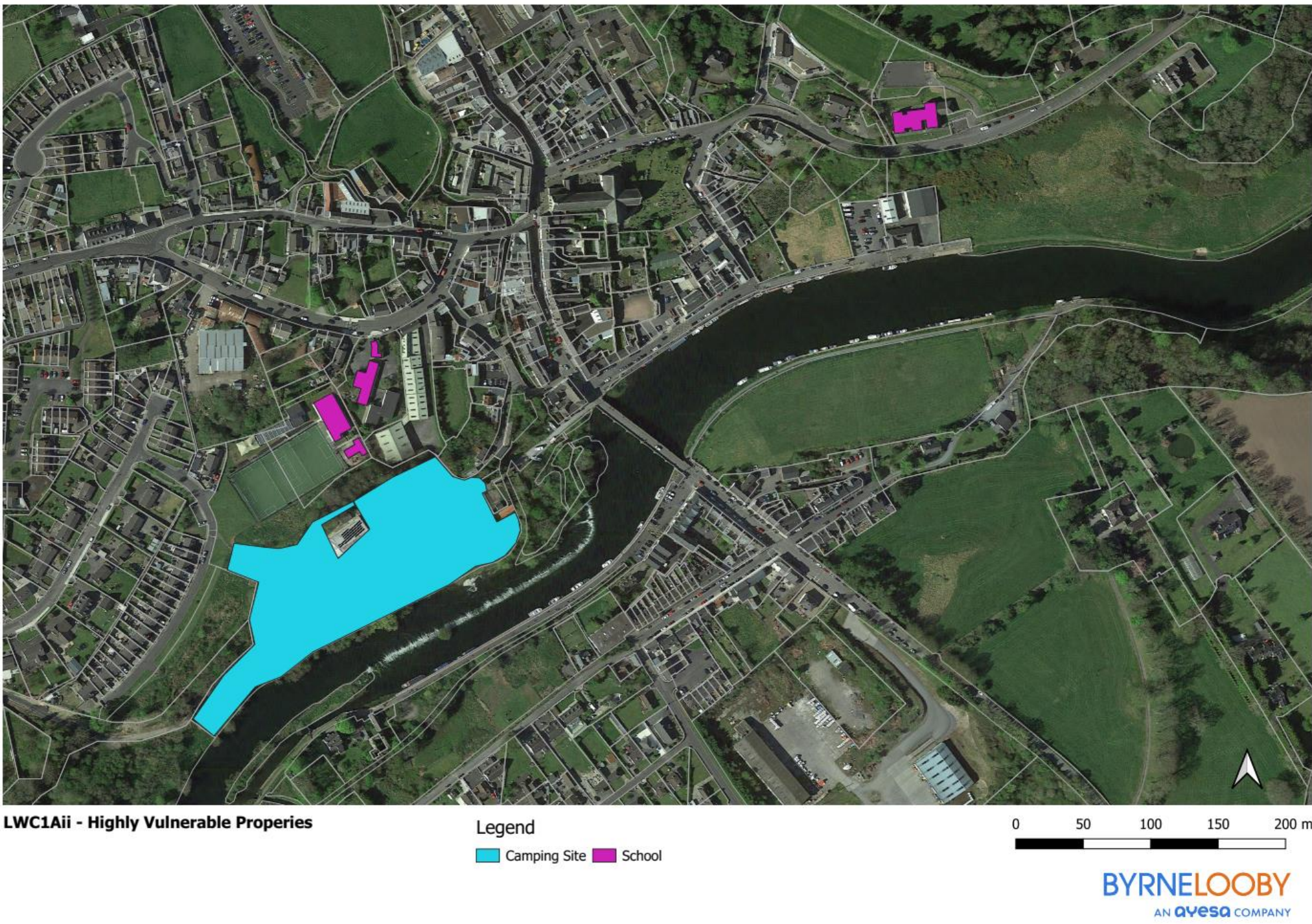
**Approved by:** SH Jul 2022 **Original @ A3**

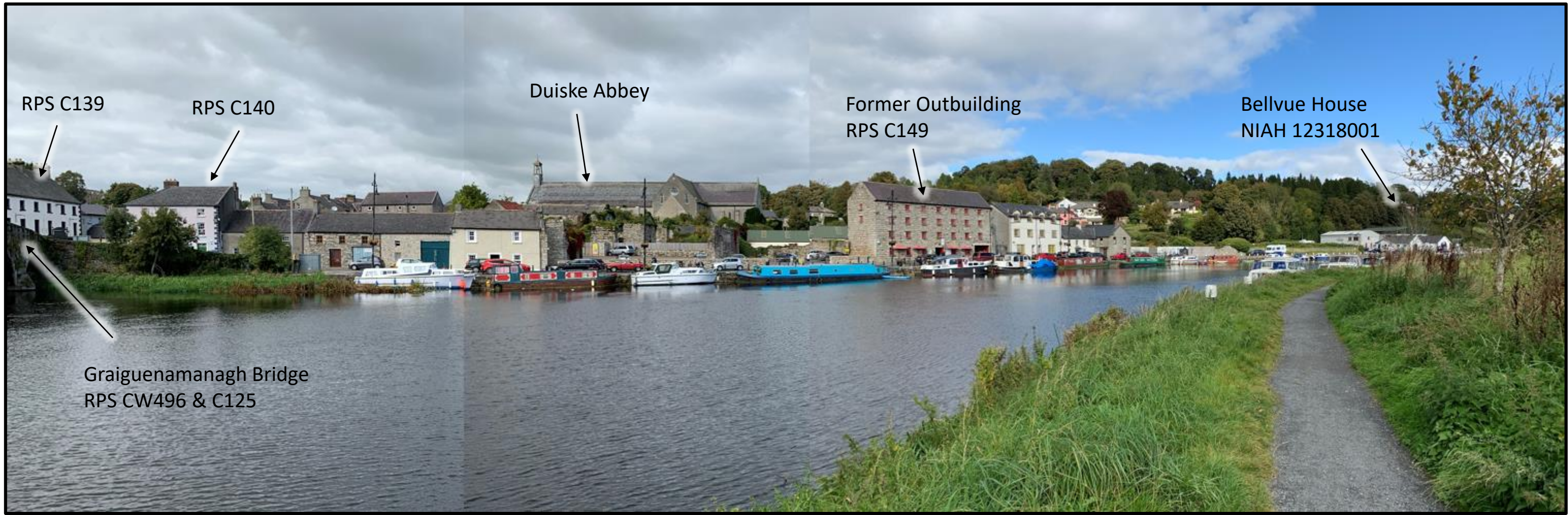
**Map No.:** TBC **Sheet:** 1 of 1

# Graiguenamanagh–Tinnahinch Flood Relief Scheme

## Affected Properties & Types

Property types have been classified as shown below, in order to assist the assessment of the social and economic considerations relating to the scheme. This has been done in accordance with national OPW guidance. These categorisations will facilitate the assessment and contribute to the identification of the emerging preferred option. This will emerge by assessing the buildability, cultural heritage, the views of the public and using a Multi-criteria-Analysis (MCA).

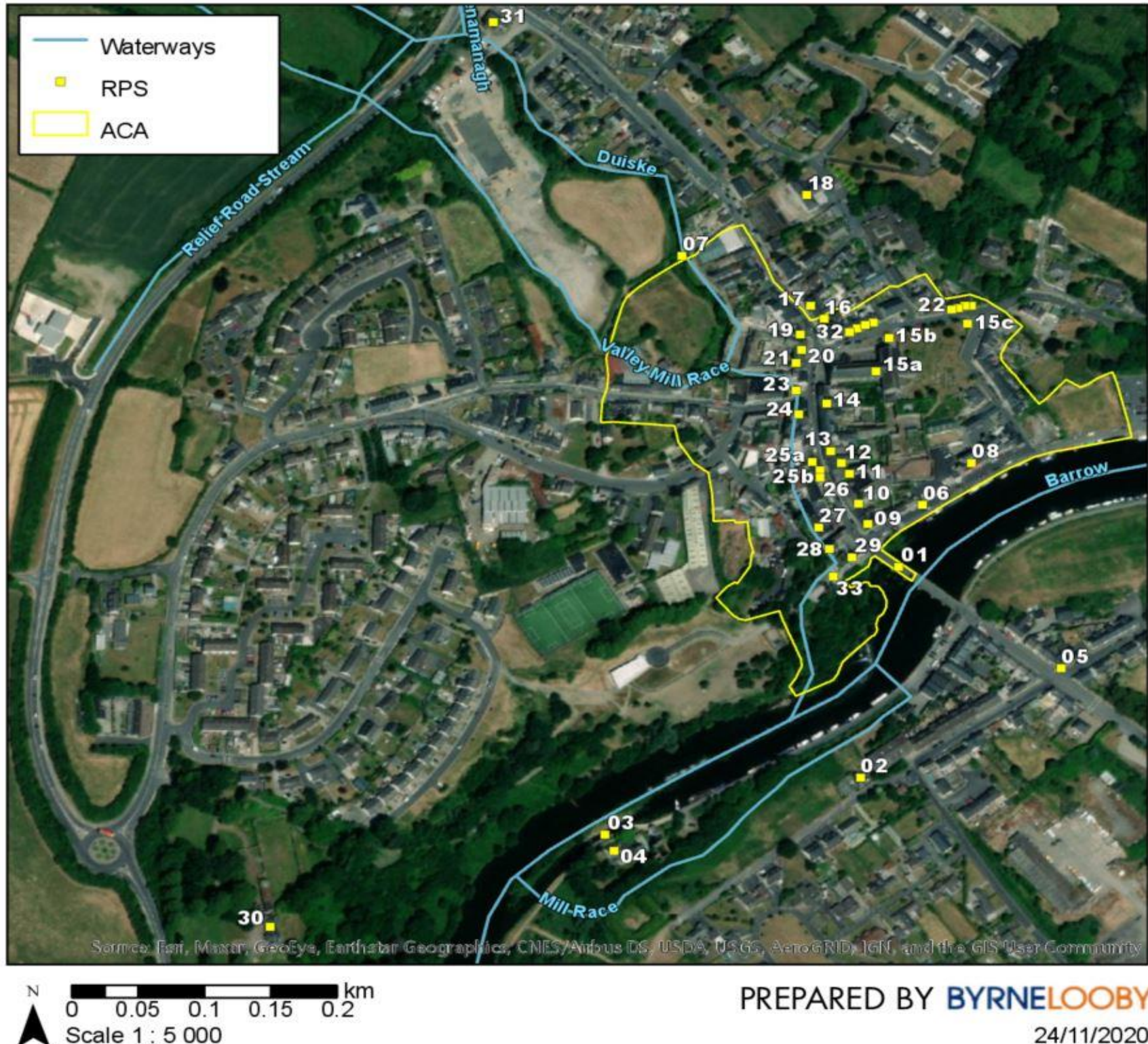
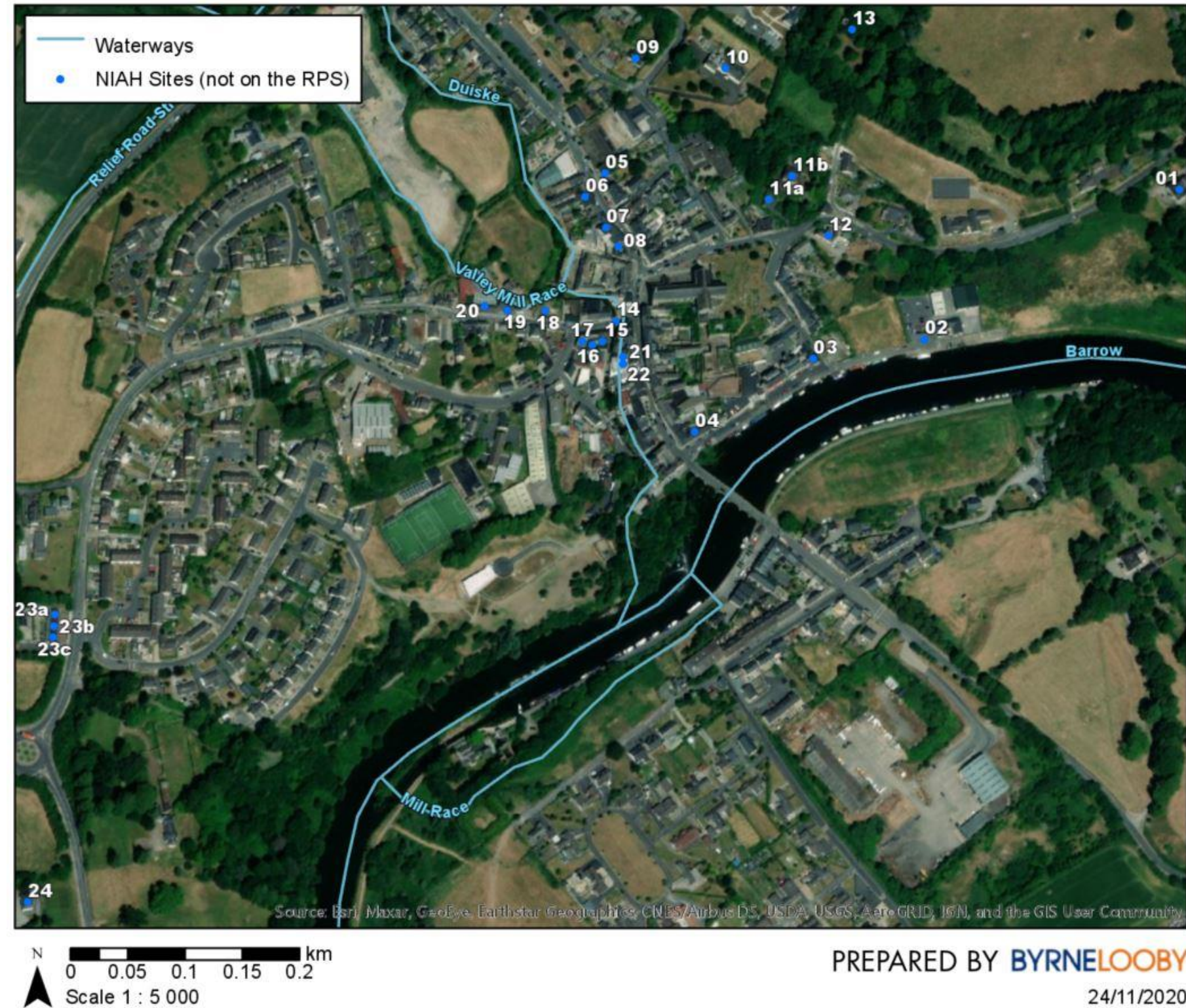
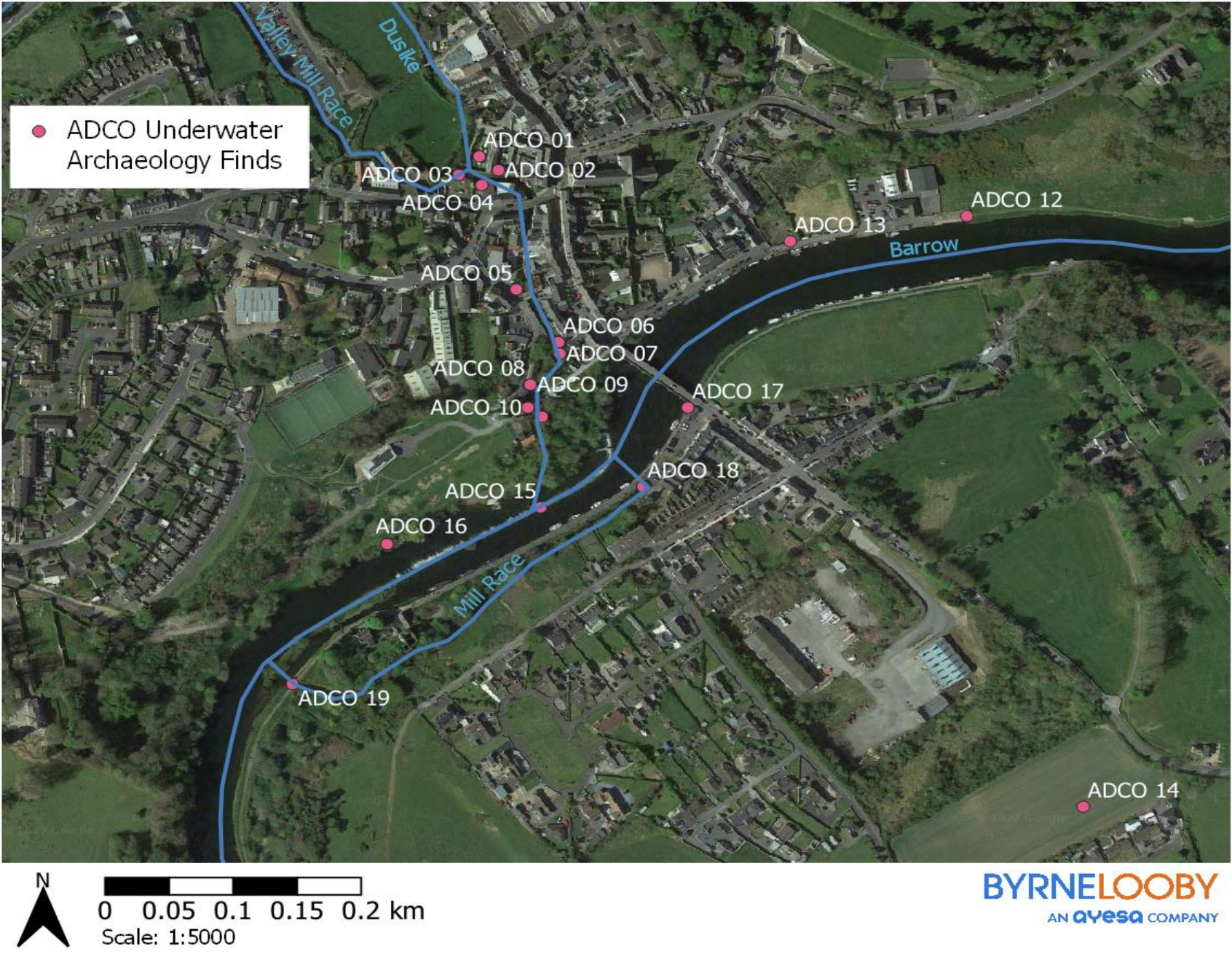




Given that Graiguenamanagh town is an Architectural Conservation Area (ACA), encompassing the medieval core of the town, the Turf Market, the bridge and the historic quay, cultural heritage and archaeological considerations must be included in the development of the scheme. The Duiske Abbey is listed as a National Monument and subsequently is under a preservation order. It can be seen in the adjacent images, which also show other key cultural heritage and archaeological considerations.



There are a significant number of industrial heritage features recorded in the Record of Monuments and Places (RMP) and Record of Protected Structures (RPS) in the study area. These are largely associated with a legacy of milling and transport. There are thirty-five protected structures listed in the RPS in the study area boundary as seen in the image on the bottom-right. The properties recorded in the study area by the National Inventory of Architectural Heritage (NIAH, as shown in the image below) are considered as being buildings and structures of conspicuous historical, archaeological, artistic, scientific, social or technical interest and are recorded by this survey as having a 'Regional' rating. Structures that are considered of regional significance are recommended by the Minister to the relevant planning authority for inclusion in their RPS. Additionally, survey work carried out in preparation for this scheme found items of archaeological significance underwater in the River barrow and the River Duiske. The figure to the right shows the location of these finds. These designations impact all the options and will be taken on board in the final scheme selection.

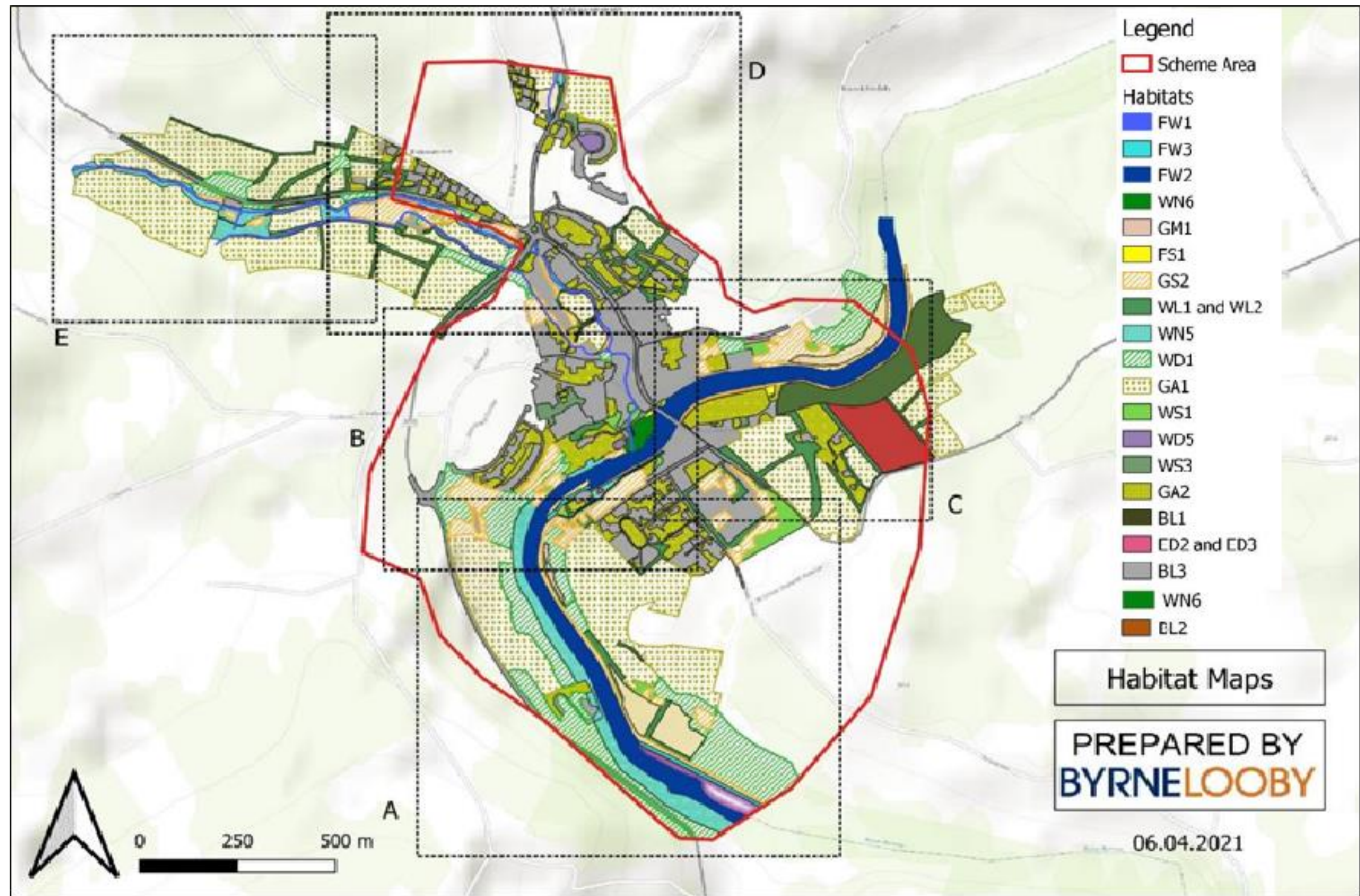


Environment - Biodiversity

The most significant ecological constraints in the Graiguenamanagh-Tinnahinch Scheme Area are the River Barrow and the River Duiske given their status as a Special Area of Conservation (SAC). The figure below shows this SAC in relation to the proposed scheme area. Once an option has been chosen for the GTFRS, a Screening for Appropriate Assessment and Natura Impact Statement will be completed in accordance with Irish legislation to determine the extent of the impact of the proposed scheme on the River Barrow and River Nore SAC pending decision on the emerging preferred option. The NIS will include recommendations to minimise and mitigate any potential impacts and ideally result in a new positive contribution to biodiversity.



The river corridors (including the rivers themselves) potentially support numerous protected species including two species of lamprey, salmon, sea and brown trout, otter, bats, badger, and potentially red squirrel, pine marten, white-clawed crayfish and the common frog. However, surveys carried out showed no signs of otter, badger, red squirrel or pine marten in the proposed scheme areas. Survey work has taken place to determine the presence of other species including aquatic and bat species. The figures below and the accompanying table describe the habitats encountered in the scheme area. The distribution of habitats, as outlined below, has been considered as much as possible in the development of the proposed options to reduce impact. The full impact of the options will be assessed as part of an Appropriate Assessment and Environmental Impacts Assessment following the selection of the preferred option.



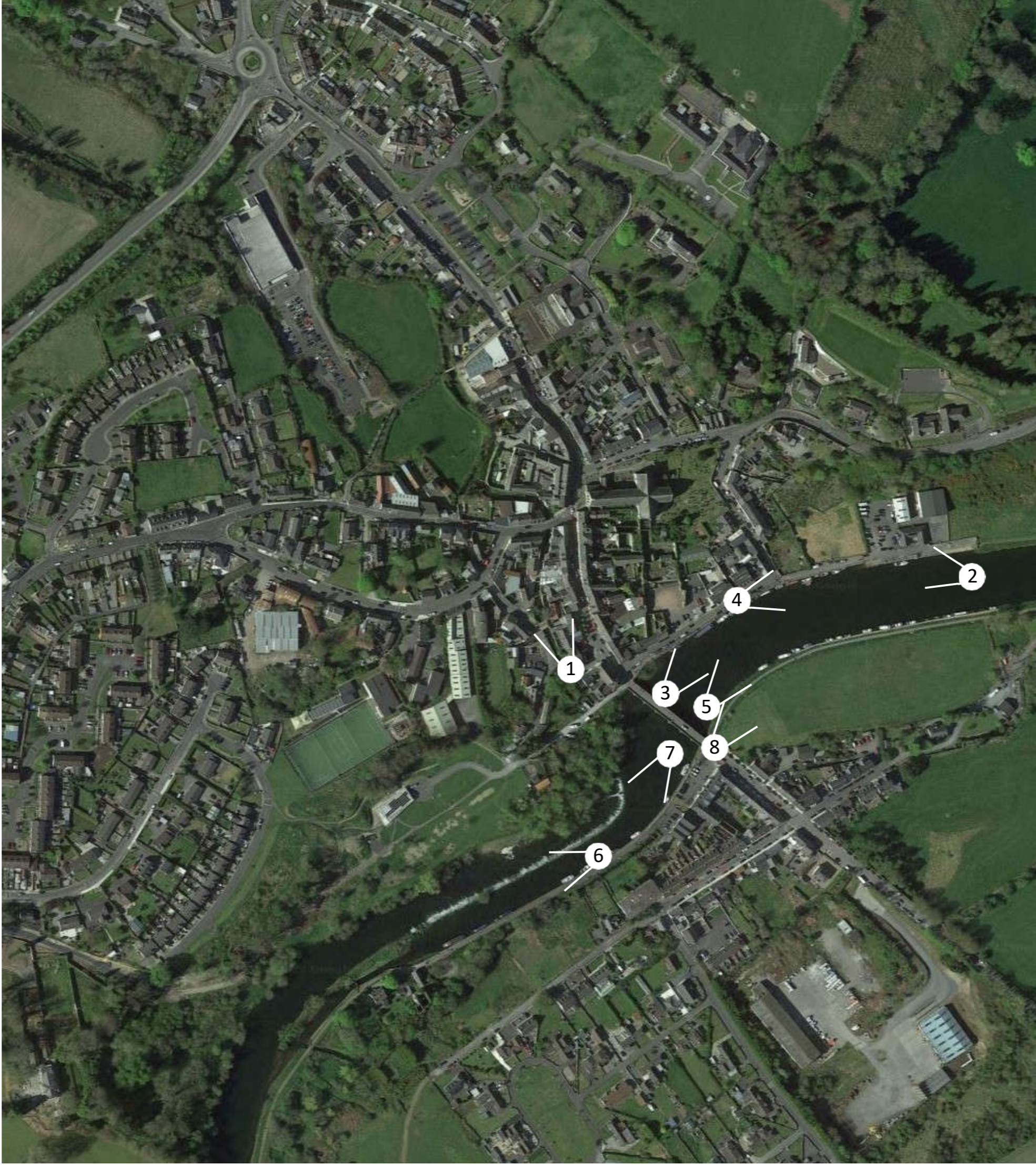
Habitat Name	Habitat Code (as per Fossitt, 2000)
Eroding/Depositing Rivers	FW1/FW2
Canals	FW3
Reed and Large Sedge Swamp	FS1
Improved Agricultural Grassland	GA1
Amenity Grassland	GA2
Dry Meadows and Grassy Verges	GS2
Wet Grassland	GS4
Oak-birch-holly Woodland	WN1
Riparian Woodland	WN5
Wet Willow-alder-ash Woodland	WN6
Mixed Broadleaved Woodland	WD1
Scattered Trees and Parkland	WD5
Scrub	WS1
Ornamental/Non-native Scrub	WS3
Hedgerows/Treelines	WL1/WL2
Spoil and Bare Ground / Recolonising Bare Ground	ED2/ED3
Arable Crops	BC1
Stone Walls and Other Stonework	BL1
Earth Banks	BL2
Buildings and Artificial Surfaces	BL3

# Graiguenamanagh–Tinnahinch Flood Relief Scheme

## Landscape Views, Design & Intent



1. Graiguenamanagh- west



5. Tinnahinch – west



2. Graiguenamanagh-east



6. Tinnahinch – west



3. Graiguenamanagh-east



7. Tinnahinch – west



4. Graiguenamanagh-east



8. Tinnahinch – east

## Hard Flood Defence - Examples

**Set back defence** – flood barrier between roads/ car parking & river edge, maintaining function of the quays & enhance public realm e.g. seating, planting



Source: ByrneLooby



Source: ByrneLooby



Source: ByrneLooby

**Flood Wall & Glass Barriers** – provide flood protection while maintaining visual link between the town & the river



Source: Waterford Flood Relief Barrier



Source: ByrneLooby

## Soft Flood Defence - Examples

**Planted embankment** - Flood embankments and planting where space allows – minimise visual impact and provide an attractive visual and recreational amenity and biodiversity benefits



Source: South Waterfront Greenway, Portland



Source: Broadland Flood Alleviation Project & UK Environment Agency



Source: Burton-upon-Trent



Source: South Waterfront Greenway, Portland

## Design Intent

- Enhance public realm
- Provide flood protection
- Maintain physical and visual access to the river & quays
- Minimise visual impact of flood protection measures
- Enhance visual & recreational amenity & biodiversity benefits

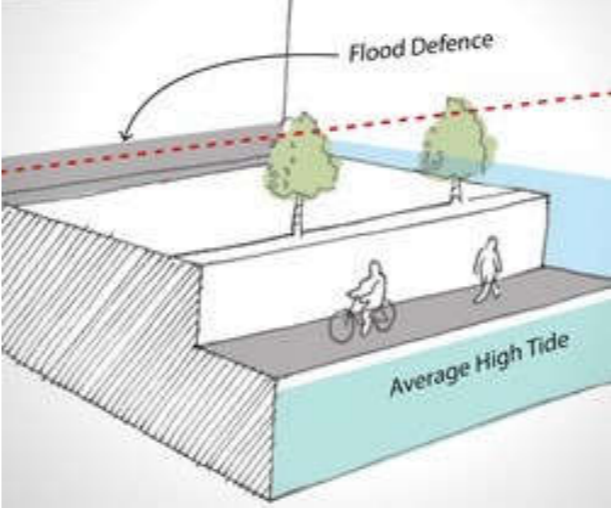
## Controlled Flow

Flow regulation to be controlled and localised pumps placed

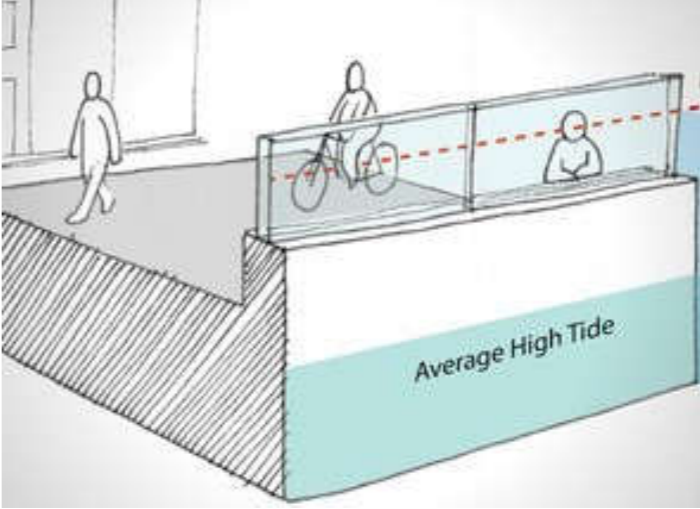


Small Number of flood gates

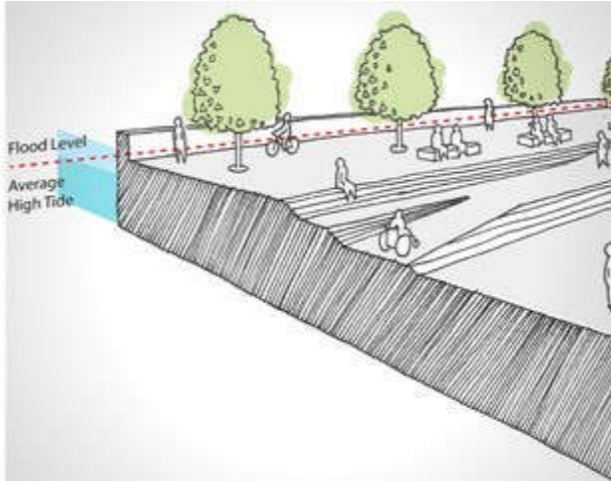
## Defence Solutions



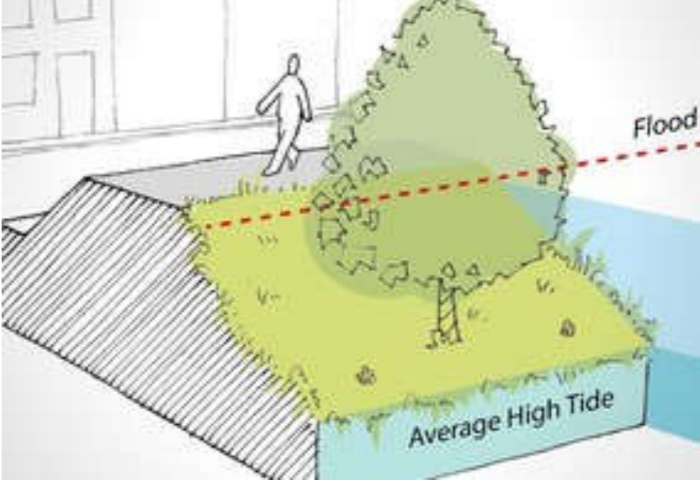
Levelled Edges



Flood walls with visual connection



Stepped Edges



Flood Embankments

## Soft Defence Solutions

- In stream structures for example woody debris
- Blocking of moorland drainage channels
- Woodland Planting
- Land and soil management practices, cover crops, hedgerows, suitable crops
- River morphology and floodplain restoration as removal of embankments and re-meandering
- Inland storage ponds and wetlands
- Protecting riverbanks for example stock fencing
- Sustainable urban drainage systems for example swales, wetlands in urban areas, green roofs, permeable pavements, detention ponds, filter strips
- Saltmarsh restoration
- Coastal managed realignment
- Coastal change management



Source: National Flood & Coastal Erosion Risk Management Strategy For England

Preliminary Options

INITIAL OPTIONS

LIST OF MEASURES CONSIDERED

As part of the GTFRS, a long list of measures was initially considered. The purpose of this screening exercise was to establish which measures would be effective for Graiguenamanagh-Tinnahinch as well as those that would be suitable.

A summary of the outcome is provided in the table below. Viable measures were then further assessed to determine their effectiveness and ultimately combined with other measures to form Options.

Number	Measures	Outcome of Initial Assessment
1	Do nothing	Baseline measure only for comparison.
2	Non-structural measures	
2a	Flood warning	Potential on the Barrow, not on the Duiske due to short advanced warning time.
2b	Individual property protection	Potential, but screen out due to increased risk of failure by having more components in the flood protection measure.
2c	Development management	Continue to implement under the Kilkenny/Carlow County Council Development Plans.
3	Properties or infrastructure relocation	Not considered socially acceptable on a large scale. Potential on a localised//individual scale.
4	Properties or infrastructure reconstruction to a higher level	Not viable in town centre areas
5	Flow diversion	
5a	Diversion of entire river	Not viable given the environmental sensitivity and protections afforded to River Barrow and River Duiske.
5b	Flood flow bypass channel	Not viable given the environmental sensitivity and protections afforded to River Barrow given the scale required. Potential on the River Duiske.
6	Flow reduction	
6a	Upstream catchment management	Not viable to achieve the scheme SOP.
6b	Upstream flood storage	Not viable to achieve the Scheme SOP on the River Barrow or Duiske, but potential to reduce flows on the River Duiske is considerable.
7	Flood containment	
7a	Walls or Embankments (Hard Defences)	Viable to contain the flow within the channel, but increases flood levels
7b	Demountable defences	Possible to include where necessary
8	Increased conveyance	
8a	Channel upgrade (channel or floodplain section and/or grade)	Not viable given the environmental sensitivity and protections afforded to the River Barrow and River Duiske.
8b	Channel maintenance (channel or floodplain roughness improve)	Not viable to achieve the scheme SOP.
8c	Removal of local constraints	Not viable to achieve the scheme SOP, but considered in combination with other measures as necessary for scheme maintenance.
9	Sediment management	Not viable to achieve the scheme SOP.
10	Storm water pumping behind defences	Typically required as part of any scheme.

Storage, hard defences and flow diversion (or combinations of each) were assessed as being likely to provide the required SOP. From these, the following options were then developed for further assessment. The relative benefits and constraints associated with these Options are presented in Boards 8-12

Option No.	Option Description
Option No. 1	Raised Defences Only
Option No. 2	Raised Defences & River Duiske Diversion
Option No. 3	Raised Defences & River Duiske Storage
Option No. 4	Raised Defences & River Duiske Storage and Diversion
Option No. 5	Raised Defences & River Duiske Culvert



Example – Riverside Flood Defence Wall



Example – Riverside Flood Defence Embankment (under construction)



Example – Flood Defence in tight/restricted spaces



Example – Glass Flood Defences in high value scenic areas



Example – Flood Defence Swing Gate



Example – Flood Storage Area (in use)



Example – Flow Diversion Culvert (under construction)



Example – High Quality Public Realm Finishes

Graigenamanagh–Tinnahinch Flood Relief Scheme

OPTION 1 – Raised Defences

Flood Defence embankments and walls form the defences on the River Barrow as shown below. A sluice gate is provided on the Mill Race to Tinnahinch Castle at the upper and lower ends to control flows in this channel during flood events. Flood gates are required along Graigenamanagh Quay and Tinnahinch Quay to retain access to water activities. Additionally, some local land-raising areas are required to maintain access to properties. Back-of-wall stormwater drainage is also required along Graigenamanagh Quay, and pumping stations are required on both quays as shown.

Flood defence walls are required on both banks of the River Duiske but primarily on the eastern side. Wall improvement to existing structures/walls are required upstream of High Street Bridge, as well as a replacement pedestrian access bridge and some local land raising. A debris trap is located adjacent to Well Lane.

At Turf Market, walls are required on the eastern bank at two locations as shown in the image below. Replacement bridges are also required at these locations to prevent flooding over the existing bridges.

Walls are required downstream of Turf Market Bridge on both banks where the influence of the River Barrow dominates.

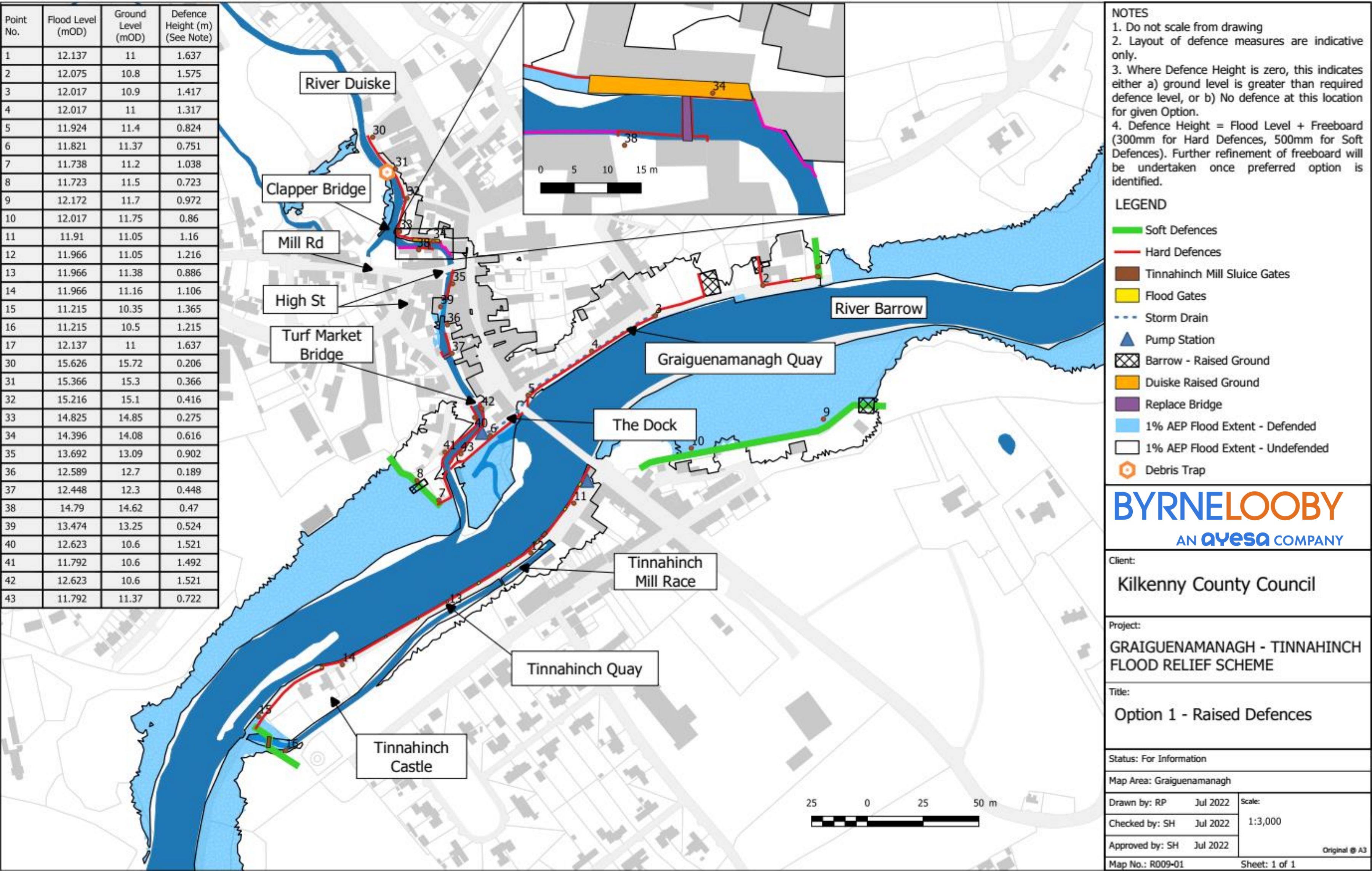
Flood defence heights are based on the 1% AEP flood event, plus an allowance for freeboard – typically 300mm for walls and 500mm for embankments where settlement can occur over time.

The option would include the following defences. More precise wall heights for specific areas can be found in the drawing below.

River Barrow	Heights	Length
Flood Walls on Left Bank	0.9 – 1.2m	390m
Flood Embankments on Left Bank	0.8 – 1.4m	280m
Flood Walls on Right Bank	0.8 – 1.6m	372m
Flood Embankments on Right Bank	0.7 – 1.6m	101m
River Duiske		
Flood Walls on Left Bank	0.2 – 2.3m	271m
Wall Improvements on Left Bank	0.2 – 2.3m	16m
Flood Walls on Right Bank	0.2 – 2.3m	106m
Wall Improvements on Right Bank	0.2 – 2.3m	16m
Bridge Replacements	3no.	<10m

Left Bank = Left bank when looking downstream on the watercourse  
Right Bank = Right bank when looking downstream on the watercourse

BENEFITS	CONSTRAINTS
<ul style="list-style-type: none"><li>Properties previously flooded are protected.</li><li>A key transport route from Carlow to Kilkenny is protected.</li><li>The option is economically viable.</li><li>Hard defence walls typically replace existing walls or man-made banks where possible.</li><li>The option avoids permanent alterations to the watercourses and avoids all instream works in the River Barrow.</li><li>Almost no loss of biodiversity except some minor felling of trees at Turf Market etc. with this option.</li><li>Opportunity to enhance public areas of Graigenamanagh Quay if works are integrated with Public Realm works.</li><li>Defences do not impose an overbearing solution on any particular property/landowner or group.</li></ul>	<ul style="list-style-type: none"><li>The number of cultural heritage features potentially affected is large and within the Archaeological Zone of Notification.</li><li>Space for construction of defences on the left bank of the River Duiske at Turf Market is extremely limited. The technical complexity design and construction of defences is significant.</li><li>Defences are required within the SAC, particularly on the River Duiske.</li><li>Mitigation of temporary in-stream construction impacts on the SAC’s Qualifying Interests is needed.</li><li>There is a recognised preference among some members of the public to avoid raised defences in public areas such as Graigenamanagh Quay.</li><li>Flood gates are unavoidable at the access to Tinnahinch Castle and to the Rowing Club. These measures require a warning and deployment plan.</li><li>Many properties have drains to the River Duiske which require non-return valves to prevent backflows to the properties.</li></ul>



OPTION 2 - Raised Defences & River Duiske Diversion

Flood Defence embankments and walls form the defences on the River Barrow as shown below. A sluice gate is provided on the Mill Race to Tinnahinch Castle at the upper and lower ends to control flows in this channel during flood events. Flood gates are required along Graiguenamanagh Quay and Tinnahinch Quay to retain access to water activities. Additionally, some local land-raising areas are required to maintain access to properties. Back-of-wall stormwater drainage is also required along Graiguenamanagh Quay, and pumping stations are required on both quays as shown.

Flood defence walls are required on only one bank of the River Duiske at Well Lane, extending down to Clapper Bridge. At Clapper Bridge, diverted flows will be conveyed by means of an 1800mm diameter culvert to The Hub where an open channel will convey flows to the River Barrow. An instream weir/structure will be required to regulate flows into the culvert. A debris trap is located adjacent to Well Lane.

Walls are required downstream of Turf Market Bridge on both banks where the influence of the River Barrow dominates.

Flood defence heights are based on the 1% AEP flood event, plus an allowance for freeboard – typically 300mm for walls and 500mm for embankments where settlement can occur over time.

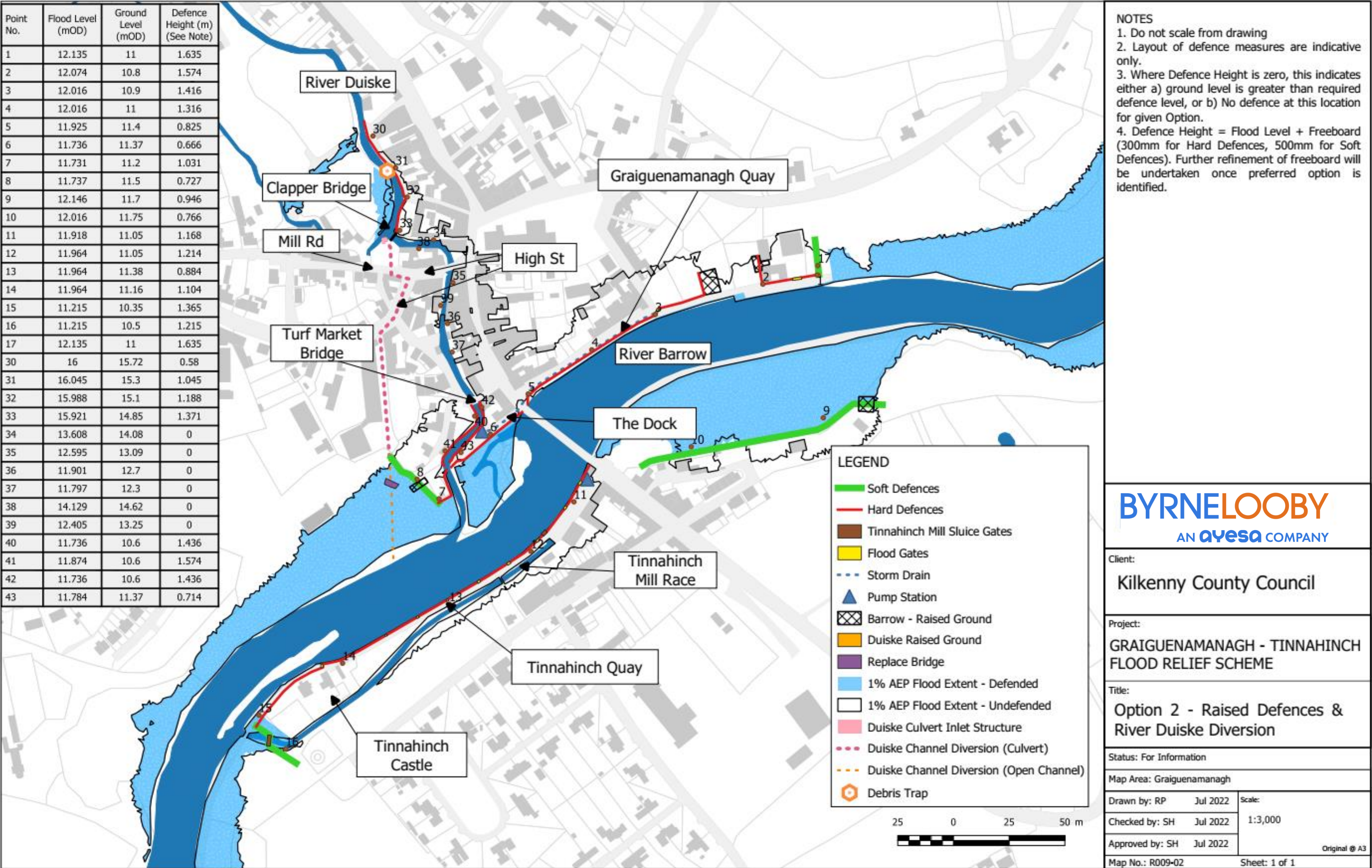
The option would include the following defences. More precise wall heights for specific areas can be found on the drawing below.

River Barrow	Heights	Length
Flood Walls on Left Bank	0.9 – 1.2m	390m
Flood Embankments on Left Bank	0.8 – 1.4m	280m
Flood Walls on Right Bank	0.8 – 1.6m	372m
Flood Embankments on Right Bank	0.7 – 1.6m	101m
River Duiske		
Flood Walls on Left Bank	0.2 – 1.0m	182m
Flood Walls on Right Bank	0.7 – 2.3m	106m
Diversion Weir	-	<10m
Flow Diversion - Culvert	-	219m
Flow Diversion – Open Channel	-	94m
Pedestrian/Vehicular Bridge	1no.	<10m

Left Bank = Left bank when looking downstream on the watercourse

Right Bank = Right bank when looking downstream on the watercourse

BENEFITS	CONSTRAINTS
<ul style="list-style-type: none"><li>Properties that previously flooded are protected.</li><li>A key transport route from Carlow to Kilkenny is protected.</li><li>The Option is economically viable.</li><li>The option avoids permanent alterations to the watercourses and avoids all instream works in the River Barrow.</li><li>Hard defence walls typically replace existing walls where possible.</li><li>Almost no loss of biodiversity, with this option.</li><li>Tree felling limited to lower reaches of the Duiske and some other small pockets</li><li>Opportunity to enhance public areas of Graiguenamanagh Quay if works are integrated with Public Realm works.</li><li>Defences do not impose overbearing solutions on any particular property/landowner.</li><li>Works at Turf Market are avoided.</li></ul>	<ul style="list-style-type: none"><li>The number of cultural heritage features potentially affected is large and within the Archaeological Zone of Notification.</li><li>The defences do not protect the camping park at The Hub</li><li>Defences are required within the SAC, particularly on the River Duiske. Consultation with NPWS is needed.</li><li>Mitigation of temporary in-stream construction impacts on SAC’s Qualifying Interests is needed.</li><li>There is a recognised preference among some members of the public to avoid hard defences in public areas such as Graiguenamanagh Quay.</li><li>A flow control structure is required near Clapper Bridge, which impacts on archaeology and ecology.</li><li>Deep excavations for the flow diversion culvert may necessitate diversion/ interference of the existing services.</li><li>Long-duration road closures required at High St., Tinnahinch Quay, Graiguenamanagh Quay and The Dock.</li></ul>



OPTION 3 – Raised Defences and River Duiske Storage

Flood Defence embankments and walls form the defences on the River Barrow as shown below. A sluice gate is provided on the Mill Race to Tinnahinch Castle at the upper and lower ends to control flows in this channel during flood events. Flood gates are required along Graiguenamanagh Quay and Tinnahinch Quay to retain access to water activities. Additionally, some local land-raising areas are required to maintain access to properties. Back-of-wall stormwater drainage is also required along Graiguenamanagh Quay, and pumping stations are required on both quays as shown.

Flood defence walls are required on only one bank of the River Duiske from Clapper Bridge downstream to the Turf Market area. A bridge replacement is required at Turf Market, immediately downstream of High St. Bridge to maintain property access. Wall improvements are also required upstream of High St. Bridge. A debris trap is located adjacent to Well Lane.

Walls are required downstream of Turf Market Bridge on both banks where the influence of the River Barrow dominates.

Upstream of Graiguenamanagh an area is provided for storage. To create the storage area, an embankment must be built across the River Duiske that ties into the high ground with a flow control structure to control the flow in the event of a flood.

Flood defence heights are based on the 1% AEP flood event, plus an allowance for freeboard – typically 300mm for walls and 500mm for embankments where settlement can occur over time.

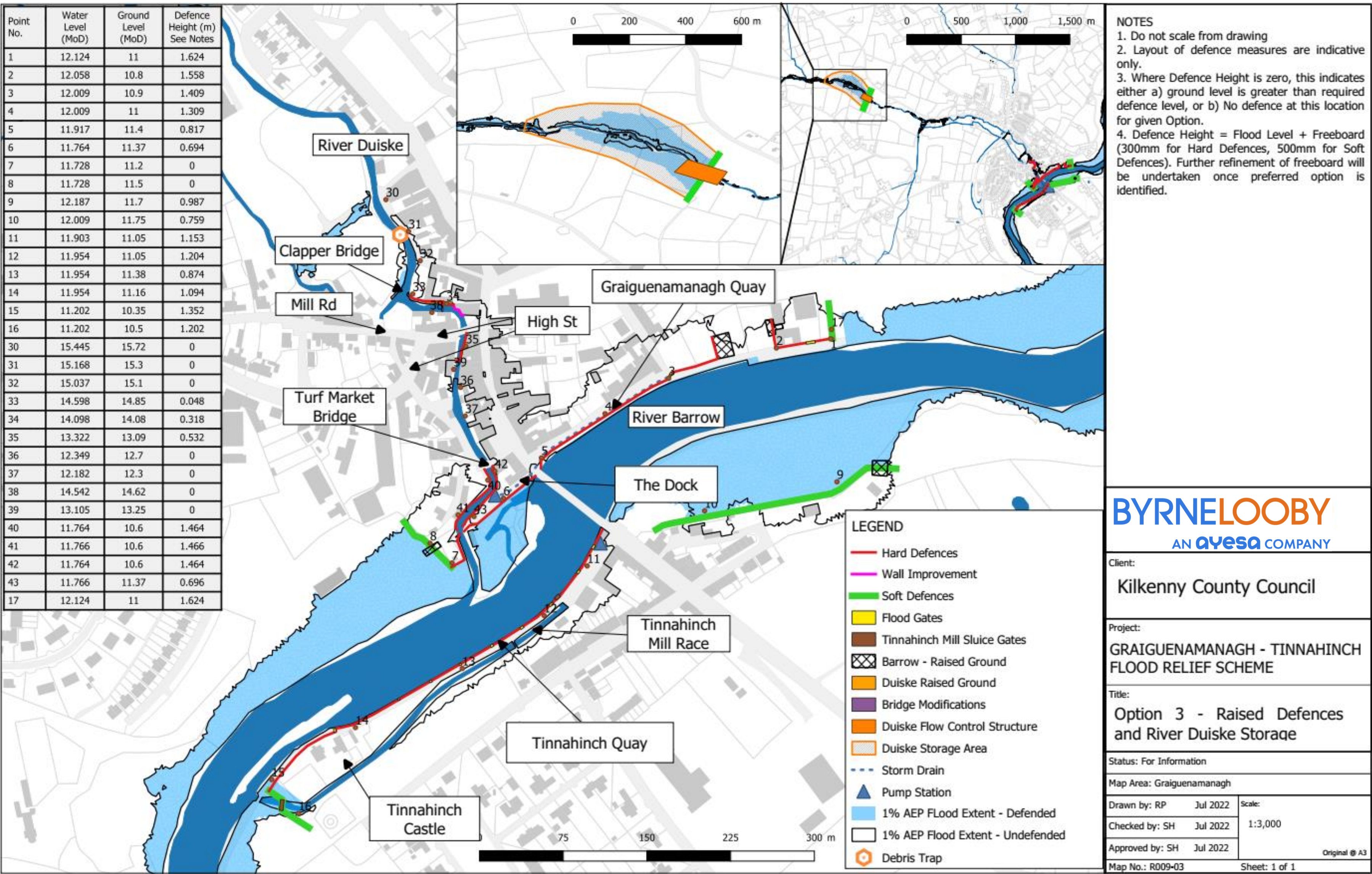
The option would include the following defences. More precise wall heights for specific areas can be found in the drawing below.

River Barrow	Heights	Length
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Flood Embankments on Left Bank	0.8 – 1.4m	280m
Flood Walls on Right Bank	0.8 – 1.6m	372m
Flood Embankments on Right Bank	0.7 – 1.6m	101m
River Duiske		
Flood Walls on Left Bank	0.2 – 2.3m	138m
Wall Improvements on Left Bank	0.2 – 2.3m	16m
Flood Walls on Right Bank	0.2 – 2.3m	106m
Bridge Replacement	1no.	<5m
Storage Embankment	1.0 - 7.0m	152m

Left Bank = Left bank when looking downstream on the watercourse

Right Bank = Right bank when looking downstream on the watercourse

BENEFITS	CONSTRAINTS
<ul style="list-style-type: none"><li>Properties that previously flooded are protected.</li><li>A key transport route from Carlow to Kilkenny is protected.</li><li>The option is economically viable.</li><li>The option avoids all instream works in the River Barrow.</li><li>Hard defence walls typically replace existing walls where possible.</li><li>Opportunity to enhance public areas of Graiguenamanagh Quay if works are integrated with Public Realm works.</li></ul>	<ul style="list-style-type: none"><li>The number of cultural heritage features potentially affected is large and within the Archaeological Zone of Notification.</li><li>Defences are required within the SAC, particular on the River Duiske.</li><li>Mitigation of temporary in-stream construction impacts on SAC QIs will likely be needed.</li><li>There is a known preference among some members of the public to avoid hard defences in public areas such as Graiguenamanagh Quay.</li><li>Flood gates are unavoidable at the access to Tinnahinch Castle and to the Rowing Club. These measures will require a warning and deployment plan.</li><li>Many properties have drains to the River Duiske which will need to have non-return valves fitted to prevent backflows to the properties.</li><li>Requires a large amount of land acquisition for storage area.</li><li>Permanent in-stream works required in the River Duiske have the potential to impact Water Framework Directive objectives.</li><li>Changes to habitats at location of storage area</li></ul>



OPTION 4 – Raised Defences and River Duiske Storage and Diversion

Flood Defence embankments and walls form the defences on the River Barrow as shown below. A sluice gate would be installed on the Mill Race to Tinnahinch Castle at the upper and lower ends to control flows in this channel during flood events. Flood gates will be required along Graiguenamanagh Quay and Tinnahinch Quay to retain access to water activities. Additionally, some local land raising areas are required to maintain access to properties. Back-of-wall stormwater drainage is also required along Graiguenamanagh Quay, and a pumping station will be required on both quays as shown.

On the River Duiske, walls are required downstream of Turf Market Bridge on both banks where the influence of the River Barrow dominates. No walls are required upstream of Turf Market Bridge.

Upstream of Graiguenamanagh, an area is provided for storage. To create the storage area, an embankment must be built across the River Duiske to tie into high ground with a flow control structure to control the flow in the event of a flood.

At Clapper Bridge, diverted flows will be conveyed by means of an 1800mm diameter culvert to The Hub where an open channel will convey flows to the River Barrow. An instream weir/structure will be required to regulate flows into the culvert. A debris trap is located adjacent to Well Lane.

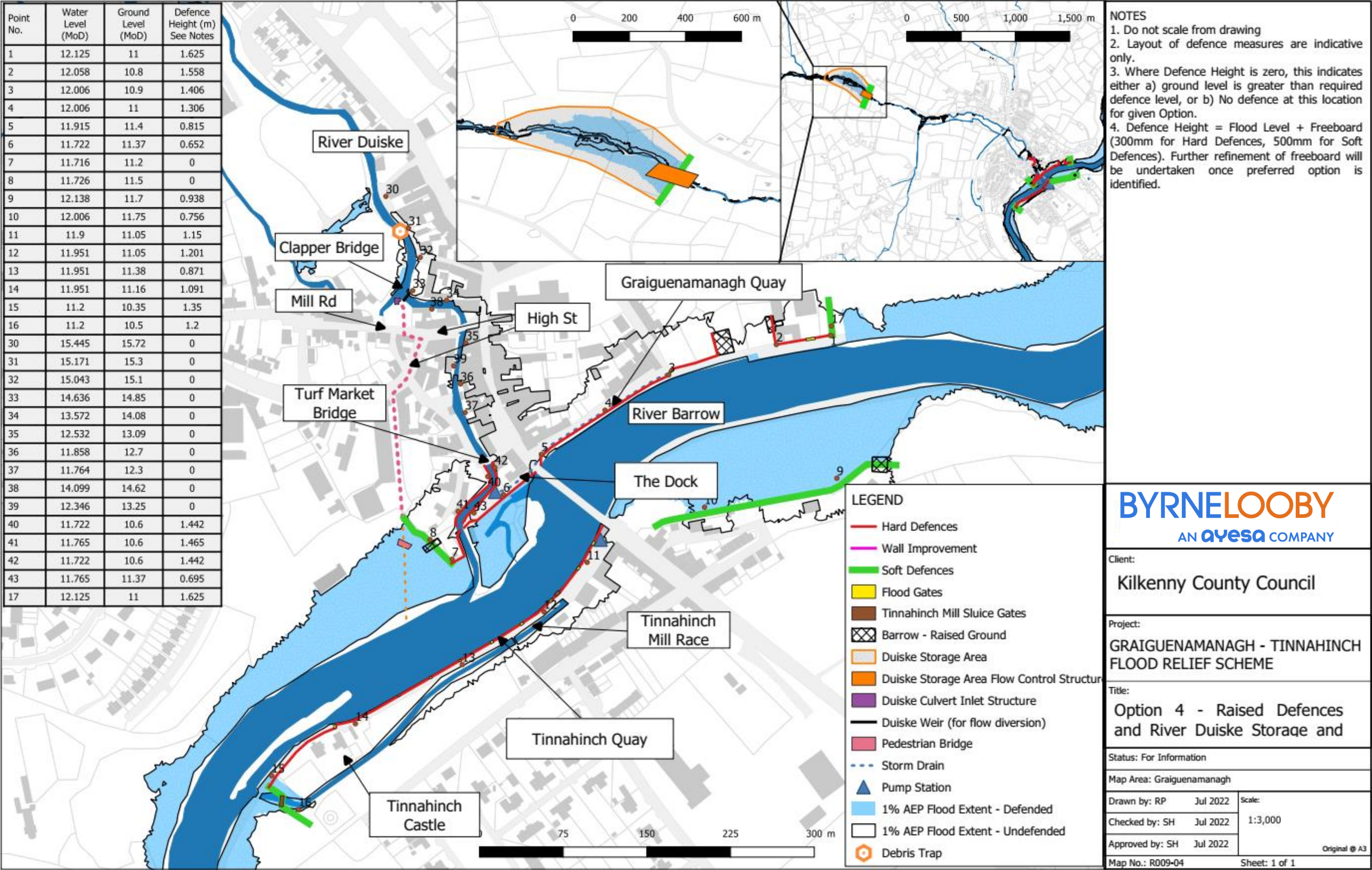
Flood defence heights are based on the 1% AEP flood event, plus an allowance for freeboard – typically 300mm for walls and 500mm for embankments where settlement can occur over time.

The option would include the following defences. More precise wall heights for specific areas can be found in the drawing below.

River Barrow	Heights	Length
Flood Walls on Left Bank	0.9 – 1.2m	390m
Flood Embankments on Left Bank	0.8 – 1.4m	280m
Flood Walls on Right Bank	0.8 – 1.6m	372m
Flood Embankments on Right Bank	0.7 – 1.6m	101m
River Duiske		
Flood Walls on Left Bank	0.2 – 1.0m	68m
Flood Walls on Right Bank	0.7 – 2.3m	106m
Diversion Weir	-	<10m
Flow Diversion – Culvert	-	219m
Flow Diversion – Open Channel	-	94m
Pedestrian Bridge	1no.	<10m
Storage Embankment	1.0 - 7.0m	152m

Left Bank = Left bank when looking downstream on the watercourse  
Right Bank = Right bank when looking downstream on the watercourse

BENEFITS	CONSTRAINTS
<ul style="list-style-type: none"><li>Properties that previously flooded are protected.</li><li>A key transport route from Carlow to Kilkenny is protected.</li><li>The option is economically viable.</li><li>The option avoids permanent alterations to the watercourses and avoids all instream works in the River Barrow.</li><li>Hard defence walls are largely avoid on the Duiske, except below Turf Market Bridge.</li><li>Opportunity to enhance public areas of Graiguenamanagh Quay if works are integrated with Public Realm works.</li><li>Reduced lengths and heights of defences required on the Duiske.</li></ul>	<ul style="list-style-type: none"><li>The density of cultural heritage features potentially affected is large and within the Archaeological Zone of Notification.</li><li>Defences are required within the SAC, particular on the River Duiske.</li><li>There is a recognised preference among some members of the public to avoid hard defences in public areas such as Graiguenamanagh Quay.</li><li>Flood gates are unavoidable at the access to Tinnahinch Castle and to the Rowing Club. These measures require a warning and deployment plan.</li><li>Requires a large amount of land acquisition for the storage area.</li><li>In-stream works are required in the River Duiske. Mitigation of temporary in-stream construction impacts on SAC’s Qualifying Interests will likely be needed.</li><li>Permanent in-stream works required in the River Duiske have the potential to impact Water Framework Directive objectives.</li><li>Changes to habitat at location of storage area</li></ul>



OPTION 5 - Raised Defences with River Duiske Culvert

Flood Defence embankments and walls form the defences on the River Barrow as shown below. A sluice gate would be installed on the Mill Race to Tinnahinch Castle at the upper and lower ends to control flows in this channel during flood events. Flood gates will be required along Graiguenamanagh Quay and Tinnahinch Quay to retain access to water activities. Additionally, some local land-raising areas are required to maintain access to properties. Back-of-wall stormwater drainage is also required along Graiguenamanagh Quay, and pumping stations will be required on both quays as shown.

Flood defence walls are required on both banks of the River Duiske but primarily on the eastern side. Wall improvement to existing structures/walls is required upstream of High Street Bridge, as well as a replacement pedestrian access bridge and some local land raising. A debris trap is located adjacent to Well Lane.

At Turf Market, walls are avoided downstream of High St. Bridge by installing a lid/culvert on the watercourse. A wall is required on the eastern bank opposite the old mill and a replacement bridge is required at this location also to prevent flooding over the bridge parapet.

Walls are required downstream of Turf Market Bridge on both banks where the influence of the River Barrow dominates.

Flood defence heights are based on the 1% AEP flood event, plus an allowance for freeboard – typically 300mm for walls and 500mm for embankments where settlement can occur over time.

The option would include the following defences. More precise wall heights for specific areas can be found in the drawing below.

River Barrow	Heights	Length
Flood Walls on Left Bank	0.9 – 1.2m	390m
Flood Embankments on Left Bank	0.8 – 1.4m	280m
Flood Walls on Right Bank	0.8 – 1.6m	372m
Flood Embankments on Right Bank	0.7 – 1.6m	101m
River Duiske		
Flood Walls on Left Bank	0.2 – 2.3m	264m
Wall Improvements on Left Bank	0.2 – 2.3m	16m
Flood Walls on Right Bank	0.2 – 2.3m	106m
Wall Improvements on Right Bank	0.2 – 2.3m	16m
Bridge Replacements	2no.	<10m
Culvert		47m

Left Bank = Left bank when looking downstream on the watercourse

Right Bank = Right bank when looking downstream on the watercourse

BENEFITS	CONSTRAINTS
<ul style="list-style-type: none"><li>• Properties that previously flooded are protected.</li><li>• A key transport route from Carlow to Kilkenny is protected.</li><li>• The option is economically viable.</li><li>• Hard defence walls typically replace existing walls or man-made banks where possible.</li><li>• The option avoids permanent alterations to the watercourses and avoids all instream works in the River Barrow.</li><li>• Opportunity to enhance public areas of Graiguenamanagh Quay if works are integrated with Public Realm works.</li><li>• Defences do not impose overbearing solution on any particular property/landowner or group.</li><li>• Access to properties at Turf Market is readily achieved.</li></ul>	<ul style="list-style-type: none"><li>• Density of cultural heritage features potentially affected is large and within the Archaeological Zone of Notification.</li><li>• Space for construction of culvert on left bank of Duiske at Turf Market is extremely limited.</li><li>• Defences are required within the SAC, particularly on the River Duiske.</li><li>• Mitigation of temporary in-stream construction impacts on SAC’s Qualifying Interests is needed.</li><li>• There is a recognised preference among some members of the public to avoid raised defences in public areas such as Graiguenamanagh Quay.</li><li>• Flood gates are unavoidable at the access to Tinnahinch Castle and to the Rowing Club. These measures require a warning and deployment plan.</li><li>• Many properties have drains to the River Duiske which need non-return valves to prevent backflows to the properties.</li></ul>

