Appendix 12.2. Hydrodynamic Technical Report

Mortarstown WWTP Upgrade

Proposed Outfall Pipe & Headwall

Hydrodynamic Technical Report

March 2026

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

Mortarstown WWTP Upgrade

Proposed Outfall Pipe & Headwall

Hydrodynamic Technical Report

Client: Uisce Éireann

Location: Kilkenny Road, Mortarstown, County Carlow

Date: 05th March 2026

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1. Introduction

IE Consulting was requested by AtkinsRéalis, on behalf of Uisce Éireann, to undertake a Hydrodynamic Analysis and Assessment in support of a planning application for the proposed Mortarstown Wastewater Treatment Plant (WWTP) upgrade project at Kilkenny Road, Mortarstown, Co Carlow. The primary objective of the proposed upgrade project is to deliver an upgraded WWTP to service the current and future agglomeration loading, ensuring the scheme complies with the Urban Wastewater Treatment Regulations 2001, the conditions enforced by the WWDA licence and to maintain the designation and status of the receiving waters.

This Hydrodynamic Analysis and Assessment has been undertaken specifically in relation to the proposed new outfall pipe and headwall element of the overall proposed upgrade project. In this regard it is proposed to replace the existing 600mm diameter outfall pipe with a new 900mm diameter gravity outfall pipe approximately 205m in length. The new outfall pipe will discharge to the main channel of the River Barrow Watercourse. The new outfall pipe will be constructed to the south side of the existing outfall, and a temporary cofferdam or similar structure will be required in order to construct the outfall pipe headwall within the area of the left overbank of the River Barrow. The proposed outfall pipe will enter the main channel of the River Barrow circa. 1.5m below the low water level.

The purpose of this assessment is to assess the potential short term (Construction Stage Scenario) and long-term (Operation Stage Scenario) impact of the proposed new outfall pipe and associated headwall to the existing hydrodynamic and hydrological regime of the River Barrow at this location.

The assessment and associated details presented herein includes for the following:

- Description of the River Barrow Catchment, its hydrological characteristics and physical catchment descriptors.
- Flow estimates within the River Barrow during both low flow and flood flow conditions.
- Assess and comment on the current substrate of the main channel of the River Barrow within the vicinity of the proposed outfall pipe and associated headwall.
- Development of a hydraulic model to assess the current hydrological and hydraulic conditions associated with the River Barrow at this location and assess the potential impacts of the proposed outfall pipe and associated headwall during the construction phase and operational phase.

- Assess the impact that the proposed outfall pipe and associated headwall may or may not have on the existing hydrodynamic and hydrological regime of the area, and determine if this has the potential to result in a change or alteration to the existing patterns of erosion, transport, or deposition of substrate within the River Barrow at this location.
- Quantify the minimum required height of the temporary cofferdam or other similar structure that will be required in order to construct the outfall pipe headwall within the area of the left overbank of the River Barrow.

An hydrologist from IE Consulting undertook a survey of the site area and surrounding catchment on the 25th of March 2025.

Quoted ground levels or estimated flood levels relate to Ordnance Datum (Malin) unless stated otherwise.

2. Study Area

2.1. General

The proposed outfall pipe and associated headwall is located on Kilkenny Road, Mortarstown, County Carlow, 2.2km south of Carlow Town. The site is bounded to the north and east by existing residential dwellings, to the south by Tyndall College Carlow and to the east by Kilkenny Road and the River Barrow. The proposed outfall to service the proposed WwTP development site is located in the south western corner of the site boundary, adjacent to the left hand bank of the River Barrow. The proposed outfall pipe will travel in a north western direction from the existing WwTP, underneath Kilkenny Road and will discharge into the River Barrow with a total length of approximately 210m.

The total area of the proposed WWTP development site is approximately 12.1265 ha. The location of the proposed WWTP development site is illustrated on *Figure 1* below and shown on *Drawing Number IE3120-001-A, Appendix A*.

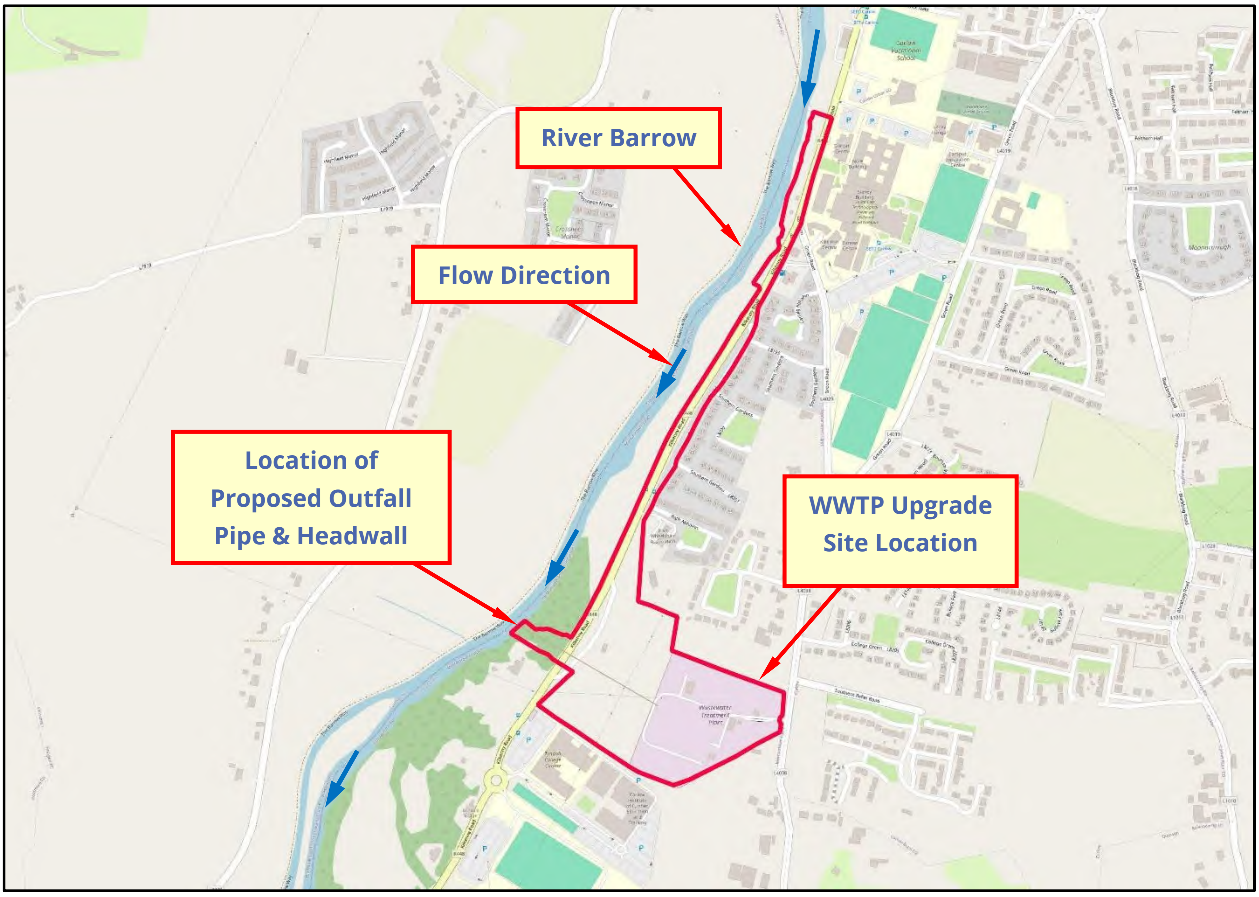

Figure 1 – Site Location

2.2. Topography

The most immediate and significant hydrological feature in the vicinity of the proposed WwTP outfall is the River Barrow located adjacent to the western boundary of the site, as illustrated in *Figure 1* above. At this location the River Barrow generally flows in a northeast to southwest direction.

The catchment area of the River Barrow was delineated and was found to be approximately 2275.88km^2 to a point located immediately downstream of the proposed WwTP outfall and as illustrated below in *Figure 2.* Assessment of the upstream catchment area indicates that the catchment is predominantly rural in nature with the urban fraction accounting for approximately 1.81% of the upstream catchment area.

The River Barrow originates in the Slieve Bloom Mountains in County Laois, initially flowing west to east through Portarlington. It then shifts direction near Monasterevin, turning to flow north to south. From there, the river continues southward through towns and villages including Athy, Carlow, Muine Bheag, and Graiguenamanagh, eventually discharging into the sea near New Ross. An assessment of the upstream catchment area shows that it is largely rural, with urban areas comprising approximately 1.8% of the total.

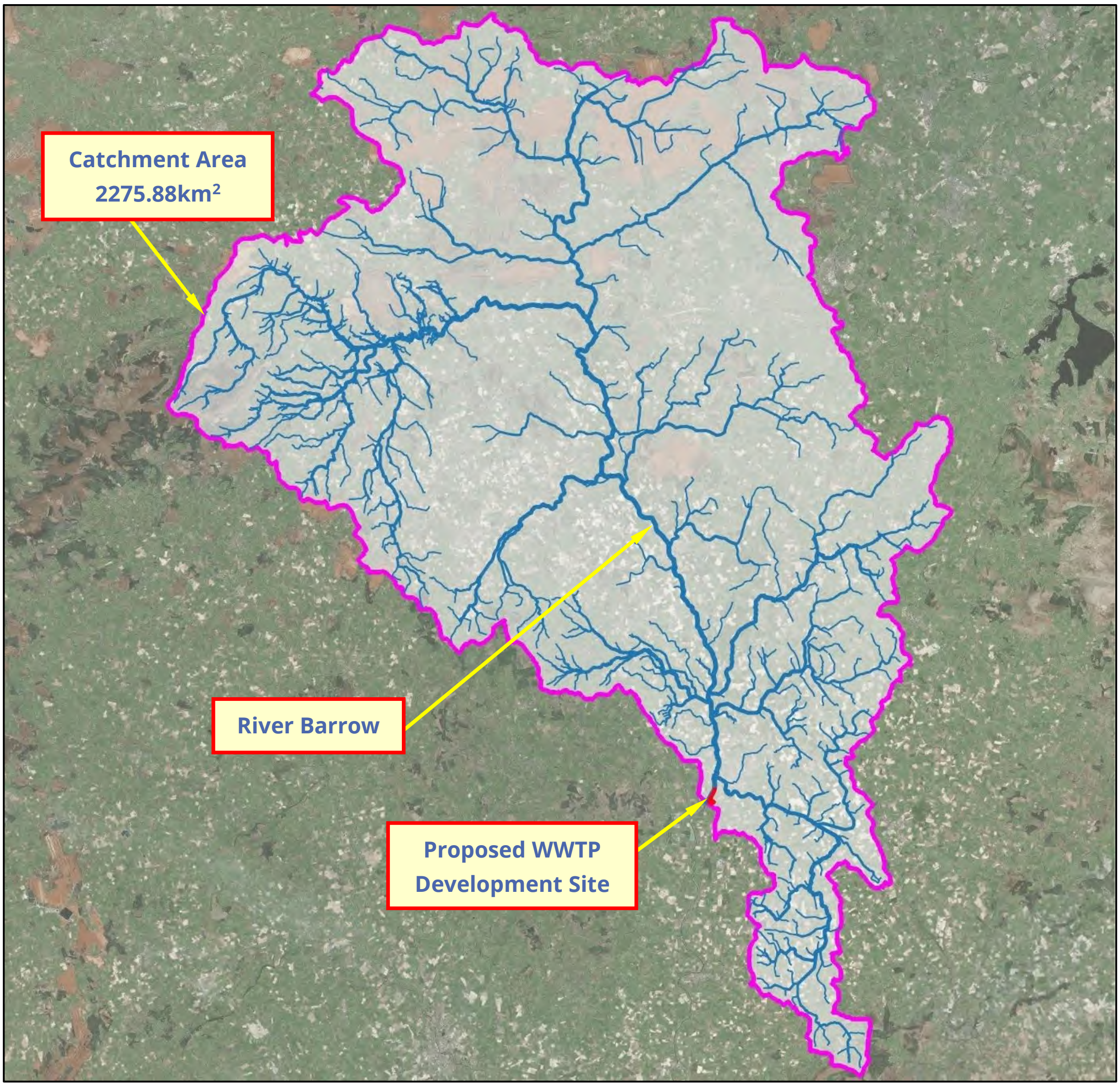

Figure 2 - River Barrow Catchment Area

The lands of the proposed WwTP development site itself slopes gently from the east to the west towards the River Barrow. The ground drops more steeply along the western boundary of the proposed WwTP development site, next to the River Barrow. Existing ground elevations range from approximately 51.7m – 48.9m OD (Malin) within the eastern area of the site to 48.4m – 41.6 OD (Malin) in the western area of the site.

3. Substrate Analysis

To assess the current substrate within the River Barrow channel bed two sediment samples were collected by Murphy Geospatial on the 13/05/2025. Significant issues were encountered when attempting to acquire sufficient sediment volume from the main watercourse channel bed due to a lack of sediment transport and deposition potential at this location.

Deposition occurs whenever a river loses energy and the velocity falls. Within the vicinity of the proposed outfall pipe and associated headwall the reach length of the River Barrow watercourse is generally straight, with no significant meanders or changes of direction. The gradient of the watercourse channel is also significantly shallow at this location. As there is little change to the watercourse topography and gradient at this location, the flow velocity of the watercourse is low and relatively constant at this location. This in turn results in a low erosion, accretion, sediment transport and sediment deposition potential at this location.

Murphy Geospatial did acquire enough sediment material to allow for a substrate analysis to be completed by collecting sediment material within the main watercourse channel, at and upstream and downstream of the location of the proposed outfall pipe and associated headwall.

The collected sediment material is generally described as a dark brown/black saturated fine silt clay with numerous twigs and a strong organic odour. Some of the material verges on being anaerobic, but only because of the fine particle size and its saturated state, rather than any contamination. It suggests a more sluggish part of the river rather than a fast flowing more aerated section.

The collected sediment material was submitted for laboratory analysis to Ground Investigation & Geotechnical Specialists (IGSL) to assess the particle size distribution. The results of the analysis are listed below in *Table 1*.

Sieve Size (mm)	Grain size Description	Sediment Sample 1 % Passing	Sediment Sample 2 % Passing
8	Pebble	100	100
6.3		97	100
5		96	99
4		93	98

Sieve Size (mm)	Grain size Description	Sediment Sample 1 % Passing	Sediment Sample 2 % Passing
2	Granule	82	96
1	Very Course Sand	70	83
0.5	Course Sand	55	69
0.25	Medium Sand	40	53
0.15	Fine sand	29	39
0.125	Very fine sand	25	35
0.063	Silt/ Clay (mud)	13	17

Table 1 - Particle Size Table

The particle size distribution grading of the collected sediment material is illustrated in *Figure 3* below.

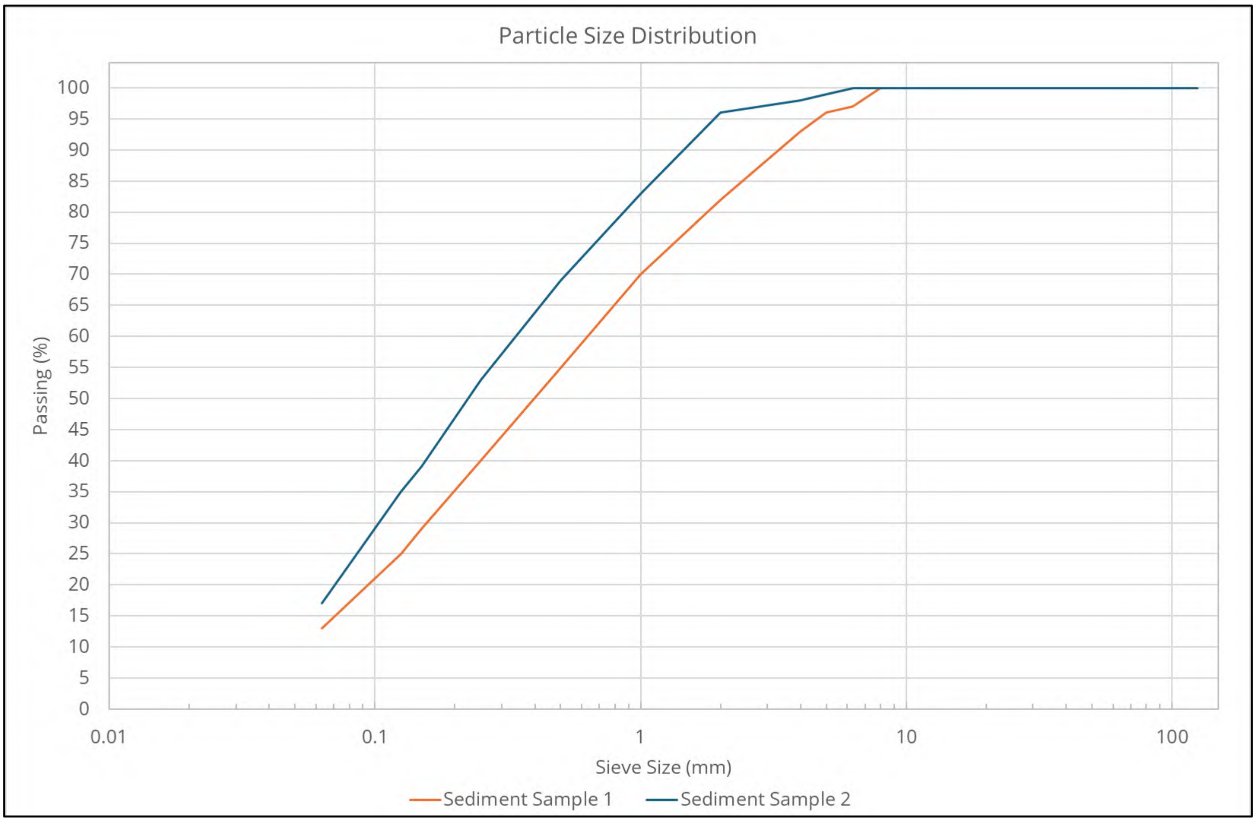

Figure 3 - Particle Size Distribution

Based on the particle size distribution analysis presented above, the sediment within the main channel of the River Barrow at this location is mostly composed of between fine grained (grain size <2mm) and medium grained (grain size 0.063mm – 2mm). A copy of the particle size analysis is included in *Appendix B*.

4. Hydrological Assessment

A hydrological assessment has been undertaken in order to provide an estimation of the low flow regime and flood flow regime of the River Barrow at the location of the proposed outfall pipe and associated headwall.

The low flow and flood flow estimations have subsequently been utilised in the hydraulic modelling and analysis presented in *Section 5* of this study report.

4.1. Low Flow Estimation

The low flow regime within the River Barrow represents the baseline hydrological conditions under non-flood scenarios, specifically those associated with flow rates below the 50% AEP (1 in 2 Year) fluvial flood event.

For the purposes of this assessment, natural flow estimates have been utilised to evaluate the potential hydraulic impact, specifically in terms of water levels and velocities, associated with the construction of the proposed outfall pipe and associated headwall. As part of this assessment, two flow exceedance scenario thresholds were identified and calculated. These are listed in *Table 2* below.

Exceedance Scenario (%)	Description
5	Flow in the River Barrow that is exceeded 5% (5%ile) of the time
50	Flow in the River Barrow that is exceeded 50% (50%ile) of the time

Table 2 - Exceedance Events

Two hydrometric gauges are situated on the River Barrow approximately 1.75 km upstream of the location of the proposed outfall pipe and associated headwall. However, a review of these gauge stations indicates that they record water level (stage) data only, with no associated flow (discharge) measurements. Consequently, they are considered unsuitable for deriving flow estimates required for this assessment.

In light of this limitation, the EPA Low Flow Duration Curve (LFDC) Tool was employed to estimate the 5%ile and 50%ile flow values. This tool generates flow percentile estimates for ungauged catchments based on catchment descriptors.

The outputs represent naturalised flow conditions and do not account for anthropogenic influences such as abstractions or effluent discharges. The location of the EPA-derived flow estimation point is illustrated below in *Figure 4.*

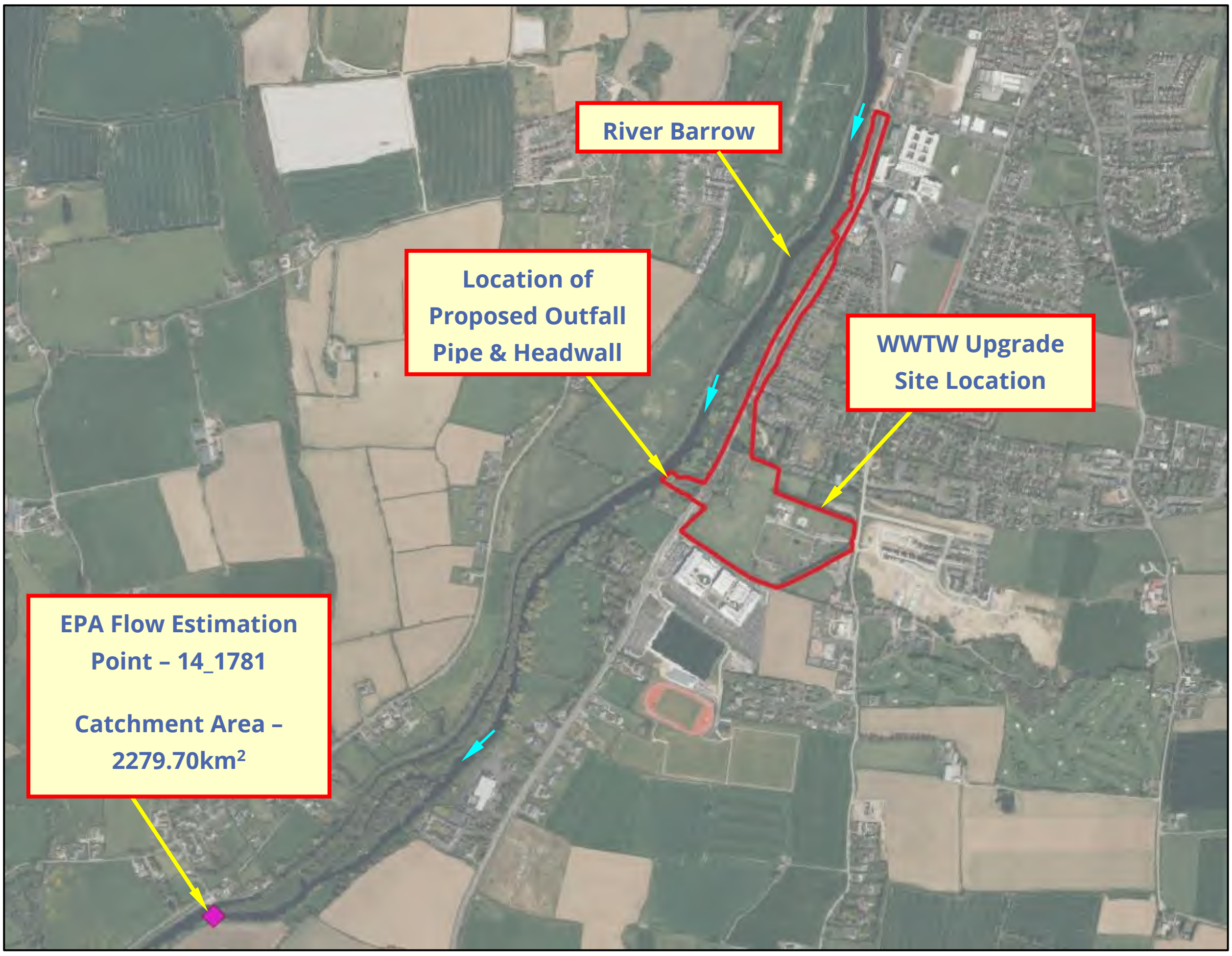

Figure 4 - EPA Flow Estimation Point

As illustrated in *Figure 4* above, the closest available flow estimation point from the EPA Low Flow Duration Curve Tool is located approximately 1.6km downstream of the location of the proposed outfall pipe and headwall. The percentage exceedance flows for the 5%ile and 50%ile events at this EPA Flow Estimation point are listed in *Table 3* below.

Percentage Exceedance (%)	Flow (m^3/s)
5%ile	97.78
50%ile	20.78

Table 3 – Natural River Flow Estimation at EPA Estimation Point 14_1781

As the EPA flow estimation point is situated downstream of the location of the proposed outfall pipe and headwall, the low flow exceedance values were area weighted to the site.

The catchment area to the location of the proposed outfall pipe and headwall is 2275.88km^2, which is 3.82km^2 less than the catchment area to the EPA flow estimation point. Therefore, the percentage exceedance values are multiplied by 0.998 to represent the minor decrease in catchment area, the values of which are listed below in *Table 4.*

Percentage Exceedance (%)	16020 gauge flow data at gauge (m^3/s)	Gauge Flow data area weighted to Weir (m^3/s)
5%	97.818	97.622
50%	20.801	20.759

Table 4 - Area Weighted Flows

In addition to the present day flows, the potential impact of climate change on the lows flows has been considered as a part of this assessment. A report issued by the EPA (Climate Change – Refining the Impacts for Ireland) states that the largest percentage increases in winter precipitation are expected to reach up to an increase of 20%. For this assessment it is assumed that the 20% increase in precipitation will correspond to a 20% increase in river flows, which is a conservative approach. The climate change low flows are listed below in *Table 5.*

HEP	5% ile Flow (m^3/s)	5% ile + CC Flow (m^3/s)	50% ile Flow (m^3/s)	50%ile + CC Flow (m^3/s)
River Barrow - HEP 14_184_4	97.622	117.146	20.759	24.9108

Table 5 - Climate Change Low Flows

4.2. Flood Flow Estimation

4.2.1. Selection of Hydrological Estimation Point (HEP)

In order to provide an estimation of extreme fluvial flood flows in the River Barrow at the location of the proposed outfall pipe and headwall, a suitable hydrological estimation point (HEP) must be selected. This assessment and analysis is undertaken in consideration of the 50% AEP (1 in 2 year) and 1% AEP (1 in 100 year) fluvial flood flow in the River Barrow at this location.

To best represent the hydrological flows in the River Barrow, an HEP was selected close to the location of the proposed outfall pipe and headwall. The location of the selected HEP was obtained from the OPW Flood Estimation Package and is illustrated below in *Figure 5.*

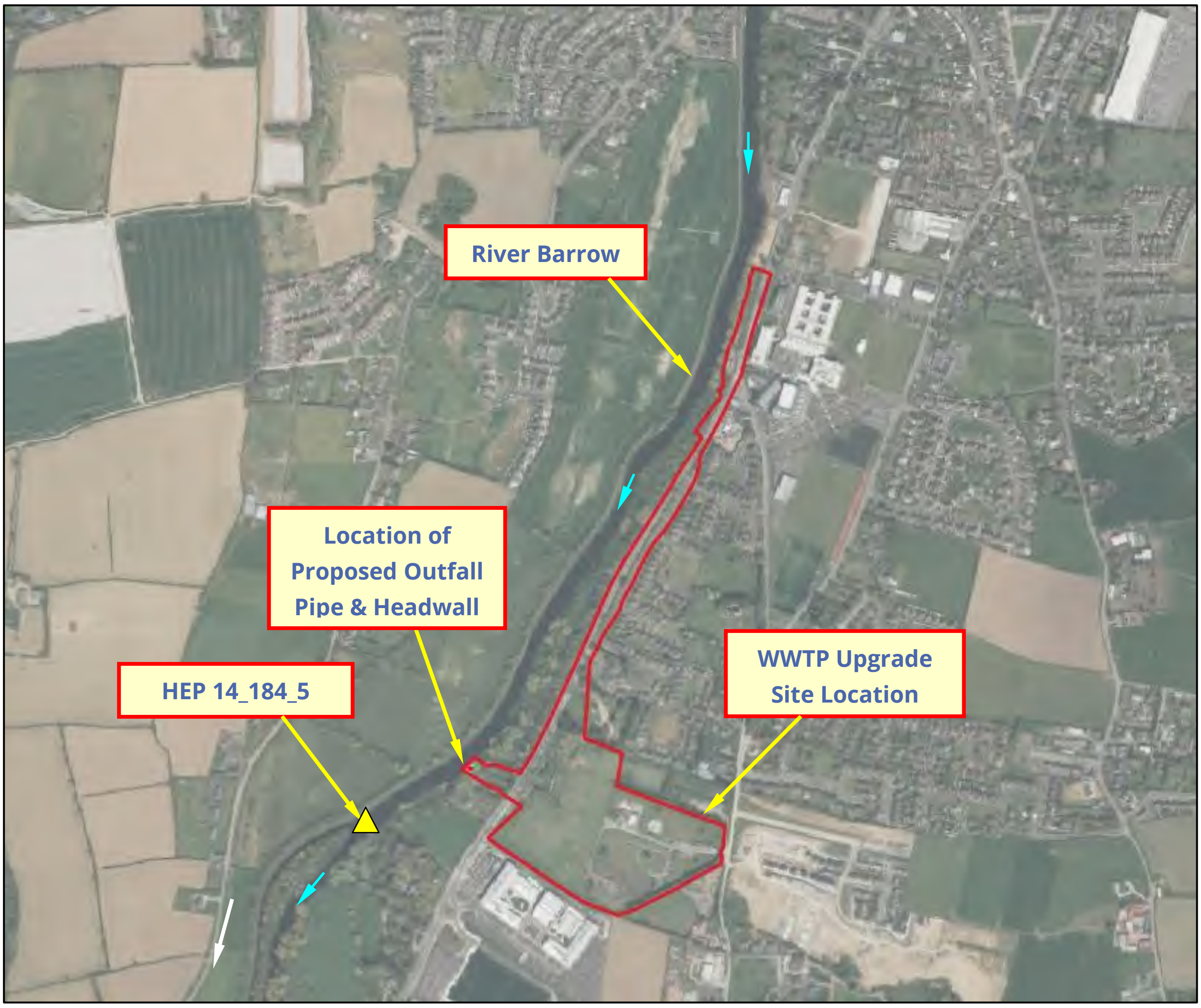

Figure 5 – Hydrological Estimation Point

4.2.1. Catchment Descriptors

Catchment descriptors for the HEP illustrated in *Figure 5* above were acquired from the OPW Flood Estimation Package and were then reviewed. The catchment descriptors for the selected HEP are listed below in *Table 6*.

Catchment Descriptor	HEP 14_184_5
Area (km^2)	2275.88
FARL	0.999
S1085 (m/km)	0.56446
DRAIND (km/km^2)	0.666
ARTDRAIN2	0
BFISOIL	0.66
SAAR (mm)	857.44
URBEXT	0.0181

Table 6 - Catchment Descriptors at HEP 14_184_5

4.2.2. Estimation of Rural Q_{MED}

The OPW South Eastern CFRAMS Hydrology Report was examined to determine the methodology used to derive the 1% AEP (1 in 100 year) flow rates associated with the River Barrow at this location.

The report states that the OPW Flood Studies Update (FSU) methodology was utilised to determine the peak flow within ungauged catchments. From this review the hydrological methods applied in the OPW South Eastern CFRAMS were deemed suitable for this hydrodynamic assessment. No suitable hydrometric gauges are located in close proximity to the location of the proposed outfall pipe and headwall and from which an estimate of flood flows can be extrapolated. Therefore the 7-parameter QMED equation was applied to the flow estimation point. This equation is listed below (*Equation 1*).

$$QMED_{rural} = 1.237 \text{x} 10^{-5}\ AREA^{0.937}\ BFIsoils^{-0.922}\ SAAR^{1.306}\ FARL^{2.217}\ DRAIND^{0.341}\ S1085^{0.185}\ (1 + ARTDRAIN2)^{0.408}$$

Equation 1 - QMED Equation

The catchment descriptors for the HEP selected are listed above in *Table 6*. The resultant QMED value is listed in *Table 7* below:

	The River Barrow Flow (m^3/s) at HEP 14_184_5
Rural QMED (m^3/s)	130.517

Table 7 - QMED values at HEP

4.2.3. Pivotal Site Selection

No suitable hydrologically similar pivotal sites lie immediately upstream or downstream of the selected HEP. Therefore, the River Barrow is treated as an ungauged catchment at this location. A pivotal site is selected from a donor catchment based on hydrological similarity utilising the OPW FSU Flood Estimation Package. Of the possible donor pivotal sites, OPW FSU Station 14022 –Barrow New Bridge gauge was chosen as the most suitable pivotal sites due to the geographical and hydrological closeness to the subject site. OPW FSU station 14022 Barrow New Bridge gauge was also selected in the OPW South Eastern CFRAM study to calculate the relevant adjustment factor. The OPW South Eastern CFRAM Study developed a catchment run-off model (NAM) to develop an updated gauged QMED value as the original gauged QMED value was deemed to have a high level of uncertainty. The NAM model (Nedbor-Afstromings Model) is a module of the modelling software MIKE 11, which is capable of simulating river flow data based on input rainfall data. As a part of the OPW South Eastern CFRAM study the NAM model simulated flow at OPW FSU Station 14022 – Barrow New Bridge gauge based on the surrounding historic rainfall data from gauges and calculated an updated gauged QMED value of 126.8m^3/s. The calculated QMED value based on catchment descriptors (Equation 1) was calculated at the OPW FSU station 14022 and was then divided by the updated gauged QMED value to determine the adjustment factor. The adjustment factor was then applied to the subject site QMED value at HEP 14_184_5 to determine the adjusted rural QMED. The adjusted rural QMED values are listed below in *Table 8*.

	The River Barrow Flow (m^3/s) at HEP 14_184_5
Unadjusted QMED (m^3/s)	130.517
Adjustment Factor	1.029
Adjusted QMED (m^3/s)	134.33

Table 8 - Adjusted Rural QMED

4.2.1. Urbanisation

The effects of urbanisation can have a major impact on flood events. An increase in urbanisation normally results in a corresponding increase in surface runoff volumes due to more impervious surfaces and an increase in the speed of response. To account for this urbanisation an Urban Adjustment Factor (UAF) was calculated using the equation listed below as *Equation 2* and which is sourced from the OPW FSU Work Package 2.2 report (OPW 2009).

$$UAF = (1 + URBEXT)^{1.482}$$

Equation 2 - Urban Adjustment Factor Equation

The UAF and the corresponding urbanised QMED is listed below in *Table 9*.

	River Barrow Flow (m³/s) at HEP 14_184_5
Rural QMED (m³/s)	134.33
UAF	1.027
Urban QMED (m³/s)	137.95

Table 9 - Urban QMED Values

4.2.2. Growth Factors

In order to estimate the 50% AEP (1 in 2 year) and 1% AEP (1 in 100 year) peak flows in the River Barrow at this location, growth factors were derived using the same values applied to the OPW South Eastern CFRAM study. The growth factors from the OPW South Eastern CFRAMS study were calculated utilising a regional pooling group method and applying the Generalised Extreme Value (GEV) statistical distribution method. The resultant growth factors for the River Barrow are listed below in *Table 10*.

Annual Exceedance Probability / AEP (%)	Growth Factors
50% (1 in 2 year)	1
1% (1 in 100 year)	2.005

Table 10 - River Barrow Growth Factors

The final peak model flows for this assessment are listed below in *Table 11.* These flows were derived by multiplying the growth factors illustrated above in *Table 10* for the River Barrow with the adjusted QMED values as listed in *Table 9* above.

HEP	Final Peak Model Flows (m^3/s)	
	AEP 50% (1 in 2 year)	AEP 1% (1 in 100 year)
HEP 14_184_4	137.95	276.59

Table 11 - River Barrow 50% AEP & 1% AEP Peak Flows

4.2.3. Climate Change

Flooding is a natural process that can occur from a range of sources at any time in a wide variety of locations. Flooding can impact on people, communities, property, infrastructure, economy, environment, and our cultural heritage. It is likely that severe weather events and sea level rise due to climate change will have a considerable impact on flooding and flood risk in Ireland.

To assess the impacts of climate change on the proposed development the Climate Change Sectoral Adaptation Plan was inspected. This Plan considers the impacts of climate change on flooding and flood risk, as well as on flood risk management and what adaptation actions are required to ensure effective and sustainable management of flood risk into the future.

There are a variety of projections which quantify the impacts of climate change in the future. For this assessment the Mid-Range Future Scenario (MRFS) was applied to the predictive 50% AEP (1 in 2 Year) and 1% AEP (1 in 100 year) fluvial flows. The MRFS represents the typical or near to the general average future climate projections. The guidelines recommend that based on the MRFS projection a 20% increase should be applied to the peak fluvial flood flow. These are listed below in *Table 12.*

HEP	50% AEP (1 in 2 year) Flow (m^3/s)	50% AEP + CC (1 in 2 year + Climate Change) Flow (m^3/s)	1% AEP (1 in 100 year) Flow (m^3/s)	1% AEP + CC (1 in 100 year + Climate Change) Flow (m^3/s)
River Barrow - HEP 14_184_4	137.95	165.54	276.59	331.91

Table 12 - Climate Change Flood Flows

4.2.4. Characteristic Hydrograph Transfer to Subject Site

The 50% AEP (1 in 2 year) and 1% AEP (1 in 100 year) peak flow hydrographs for the River Barrow at the HEP were derived utilising the OPW Flood Estimation Package.

The peak flows listed in *Table 13* below have subsequently been fitted onto the created hydrographs, as illustrated in Figure 6 below.

Watercourse	50% AEP Flow (m^3/s)	50% AEP + CC Flow (m^3/s)	1% AEP Flow (m^3/s)	1% AEP + CC Flow (m^3/s)
River Barrow - HEP 14_184_4	137.95	165.54	276.59	331.91

Table 13 - River Barrow 50% AEP & 1% AEP Peak Flows

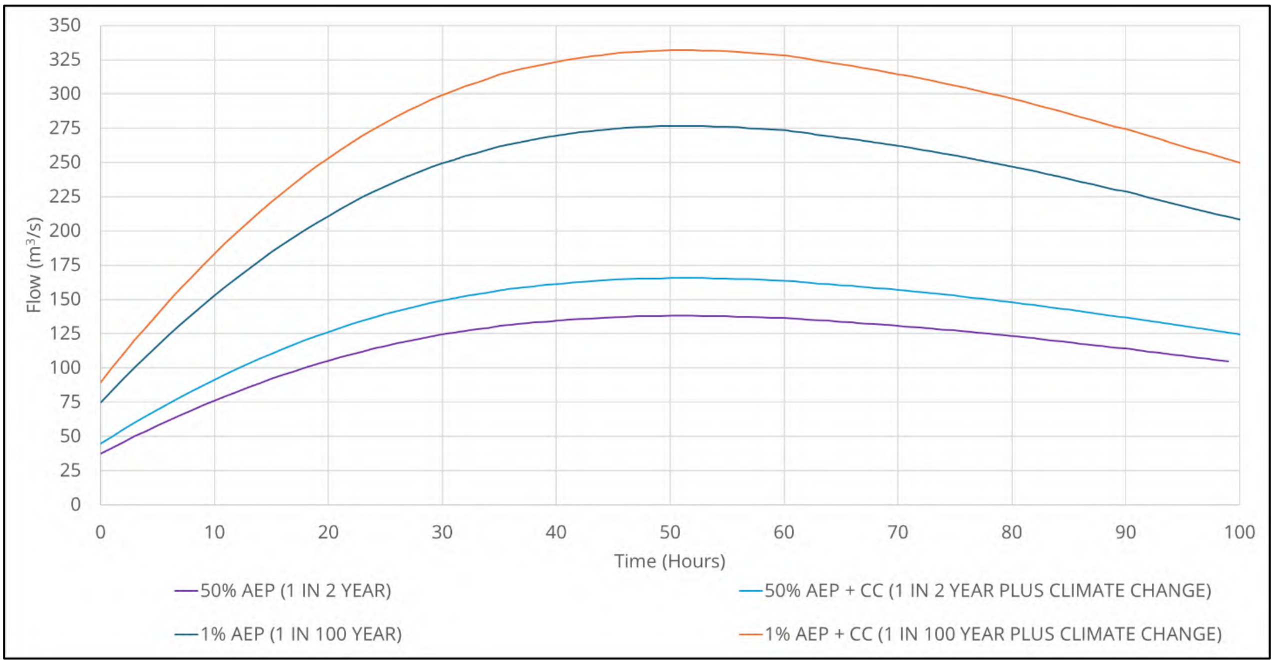

Figure 6 –River Barrow Flood Hydrographs

5. Hydraulic Modelling & Analysis

5.1. Introduction

A two dimensional (2D) hydraulic model was developed for the reach length of River Barrow at the location of the proposed outfall pipe and headwall.

The purpose of developing a hydraulic model is to estimate flood water levels and flow velocities at specific locations along the modelled reach representing the existing river channel and hydraulic structures on the River Barrow. The hydraulic model developed is based on an appropriate computer software package that utilises topographical information about the river and flood plain geometry, the hydraulic resistance characteristics (Manning's 'n') of the river and flood plain and appropriate boundary conditions at the upstream and downstream extent of the study area.

The extent of modelled watercourse reach length is illustrated in *Figure 7* below: -

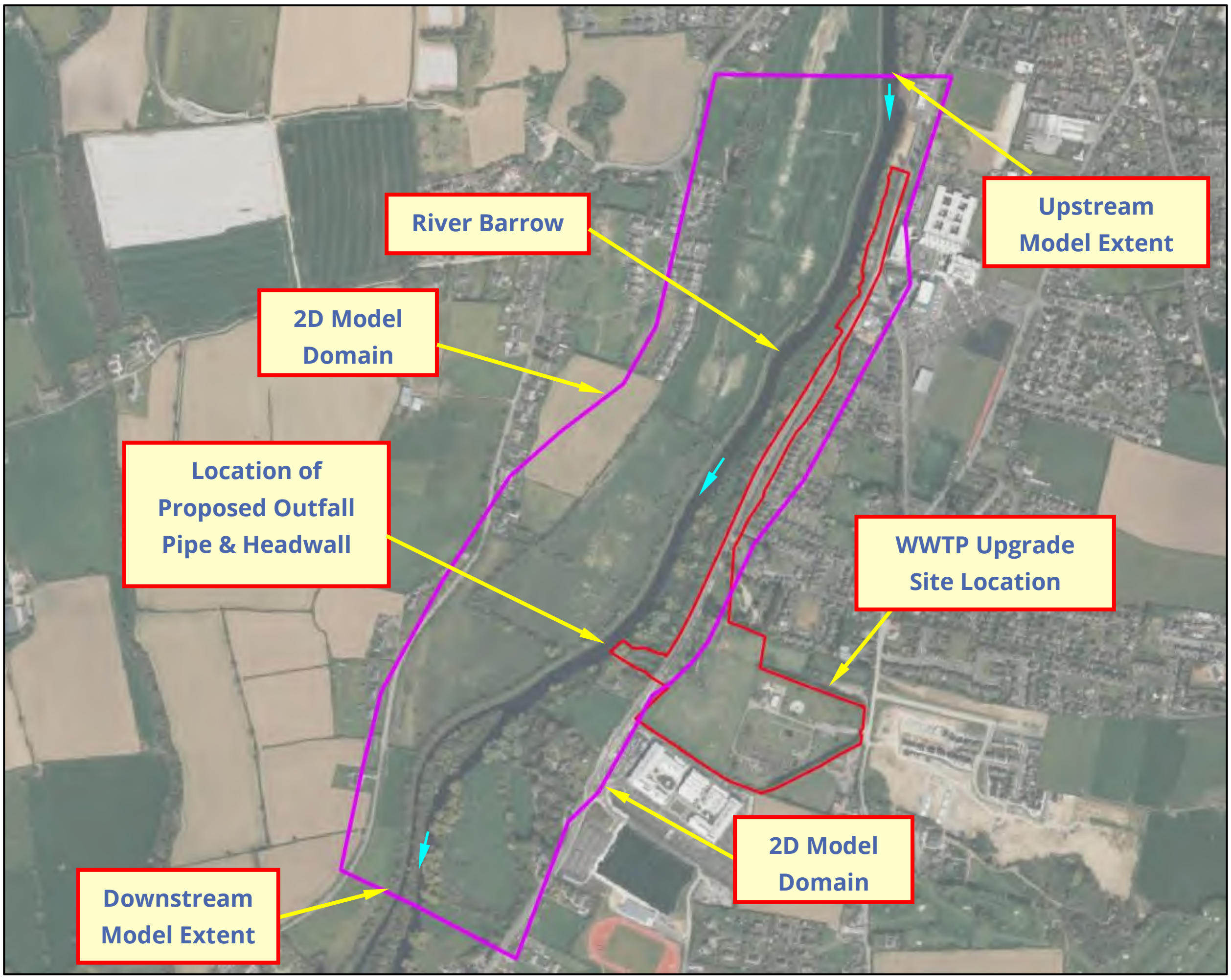

Figure 7 –River Barrow - Hydraulic Model Domain Extent

5.2. Hydraulic Model Selection

A number of hydraulic models are available which will predict flood levels for a given design flow. For this assessment the HEC-RAS hydraulic modelling package was employed. The HEC-RAS modelling package allows for one-dimensional (1D) and two-dimensional (2D) modelling of steady and unsteady state flow profiles and thematic mapping of flood plains and overland flow paths when required.

It also supports modelling of structures such as bridges, culverts, and weirs along with storage ponds. It is well regarded for use in the application of river and flood plain modelling. The model type utilised is a 2D model where the main channel of River Barrow and the left and right overbank lands is represented in the 2D domain.

5.3. Bathometric Survey Data

High-resolution site-specific survey data was acquired of the River Barrow within the vicinity of the proposed outfall pipe and associated headwall. The survey was gathered by Murphy Geospatial and consisted of detailed bed level data of the River Barrow, 130m upstream and downstream of the proposed outfall and associated headwall. The survey was completed in accordance with a survey specification written by IE Consulting and provided to Murphy Geospatial. A copy of the survey is included below in *Appendix C*.

Both a hard bed level and a soft bed level were requested to be collected, however, due to the lack of sediment on the River Bed, only a hard bed survey is available. The DTM and contour mapping developed for the modelled area is illustrated in *Figure 8* below. The hard bed survey was converted into a DTM which was then fed into the hydraulic model described in *Section 6* below. The highly detailed bathometric survey provided an extremely accurate representation of the River Barrow bed channel within the vicinity of the proposed outfall pipe and associated headwall.

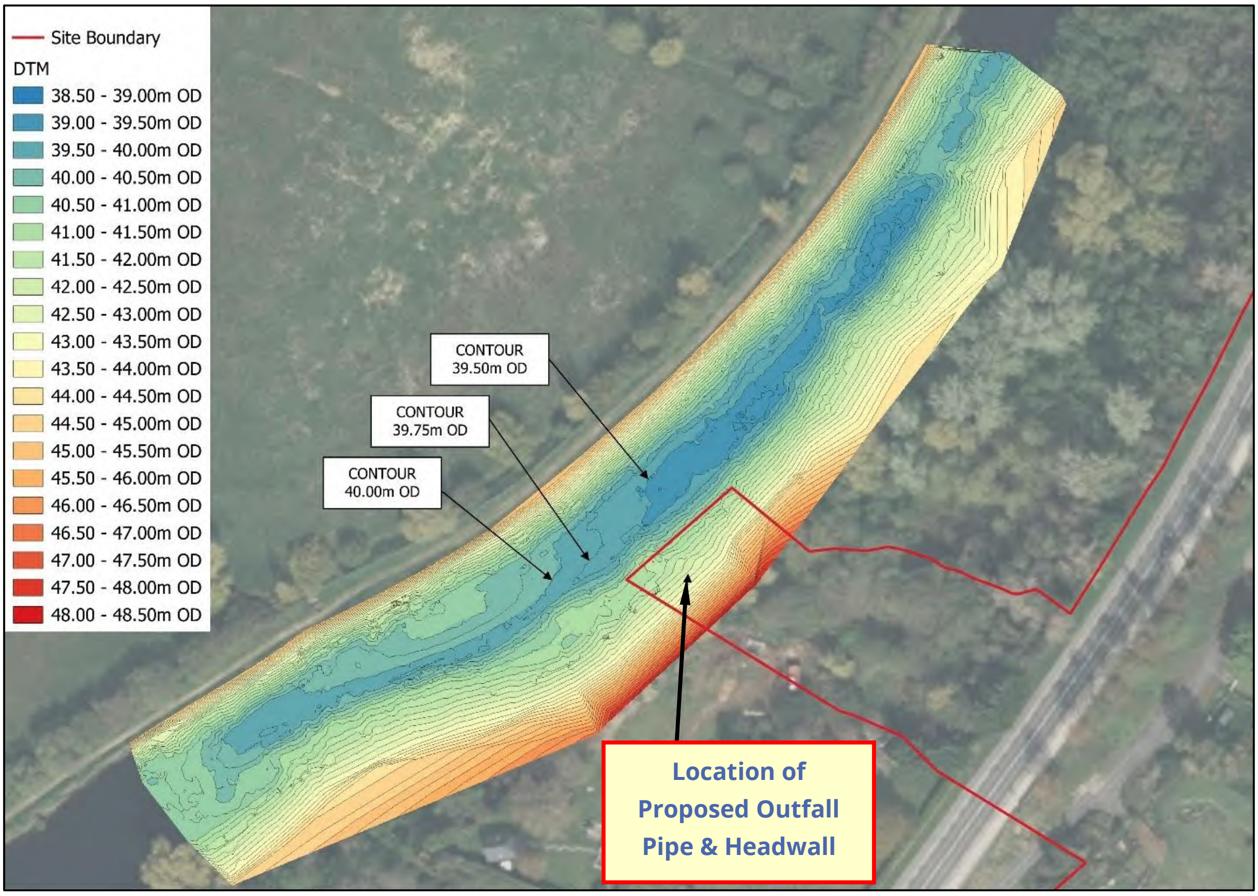

Figure 8 – River Topographic Survey - DTM and Contour Data

5.4. LiDAR Derived Digital Terrain Model & Contour Mapping

In order to assist the hydraulic modelling and analysis in the general area of the location of the proposed outfall pipe and headwall, and to enable an accurate representation of flood zone mapping and delineation to be developed, a detailed Digital Terrain Model (DTM) was developed for this location. From this data a detailed contour map was developed to encompass the area of the hydraulic model domain, including the area of the proposed outfall pipe and headwall, and surrounding lands.

The DTM and contour mapping was developed using aerial flown Light Detection & Ranging Data (LiDAR) which was commissioned by the OPW and acquired by Fugro in 2011. The LiDAR data was supplied in Irish Transverse Mercator (ITM) in TIF file format, at 2m resolution.

The DTM and contour mapping developed for the modelled area is illustrated in *Figure 9* below. The high-resolution river topographical survey discussed above in *Section 5.3* was also incorporated within this DTM.

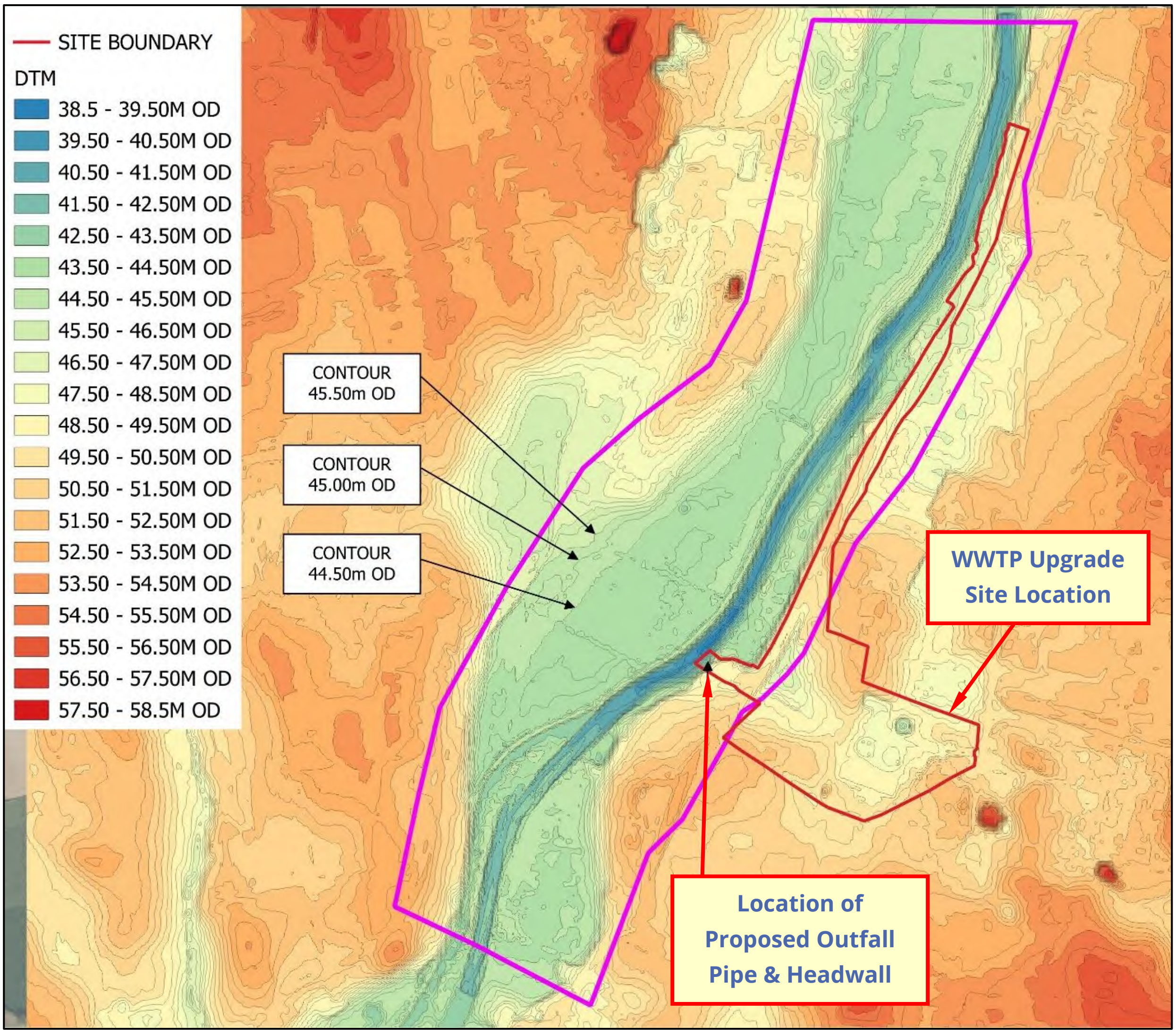

Figure 9 - DTM and Contour Data

5.5. River Channel & Flood Plain Roughness Co-Efficients

The Manning's 'n' coefficient represents the hydraulic resistance to flow of the river channel or flood plain. The Manning's 'n' coefficients chosen are estimated from a visual inspection of the river channel and associated flood plain lands. Guidance is available on selecting appropriate Manning's 'n' values (from Chow 1959, French 1986); however, the Manning's 'n' coefficients are usually subsequently refined upon the development of the model by calibrating with any historical flooding data in the area, if available.

Table 14 below lists recommended river channel overbank land roughness co-efficients for various vegetation types.

Type of Channel and Description	Minimum	Normal	Maximum
A. *Natural Streams*			
1. **Main Channels**			
a. Clean, straight, full, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. Same as "d" but more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy. deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stands of timber and brush	0.070	0.100	0.150
2. **Flood Plains**			
a. Pasture no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
2. Same as above, but heavy sprouts	0.050	0.060	0.080
3. Heavy stand of timber, few down trees, little undergrowth, flow below branches	0.080	0.100	0.120
4. Same as above, but with flow into branches	0.100	0.120	0.160
5. Dense willows, summer, straight	0.110	0.150	0.200

Table 14 - Manning's 'n' Values

With reference to *Table 14* above, varying roughness co-efficients were applied to the hydraulic model to reflect the type and form of vegetation observed during the survey of the River Barrow undertaken by a hydrological engineer from IE Consulting.

In respect of the main channel of the River Barrow an applied roughness co-efficient of 0.040 was utilised, reflecting a channel that is generally clean and straight with some limited areas of stones and weeds. An applied flood plain roughness co-efficient of 0.060 (light brush) were utilised along the left bank of the River Barrow. A roughness co-efficient of 0.045 (open fields of grass) was applied to the remainder of the model domain.

Figure 10 below illustrates the observed conditions along the modelled reach of the River Barrow.

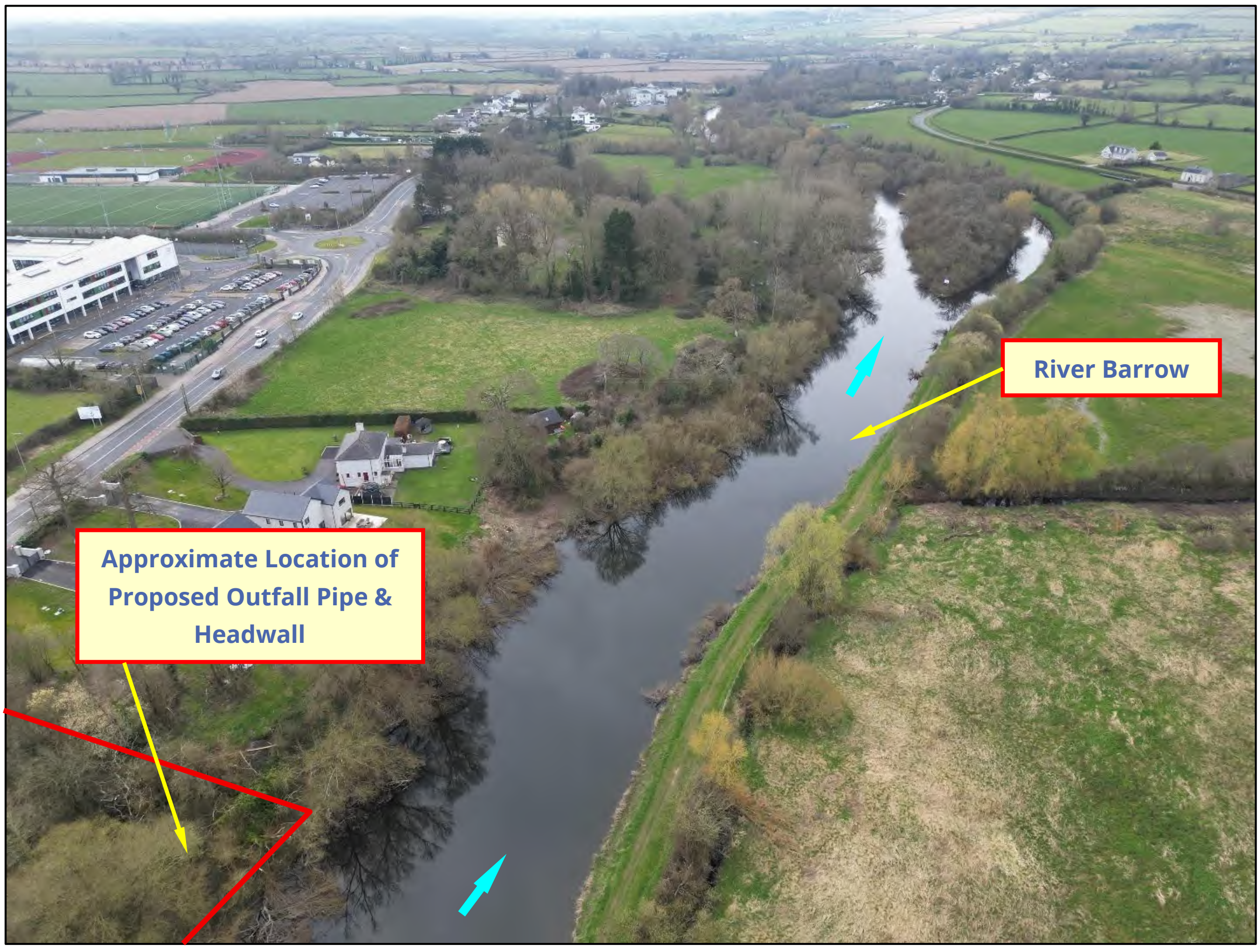

Figure 10 –River Barrow - Looking Downstream

As illustrated in *Figure 11* below, the roughness values in the 2D model domain was represented utilising a GIS shapefile. Different areas within the model domain have different roughness values based on the land use characteristic. The Geological Survey of Ireland CORINE dataset was utilised to confirm the underlying land use.

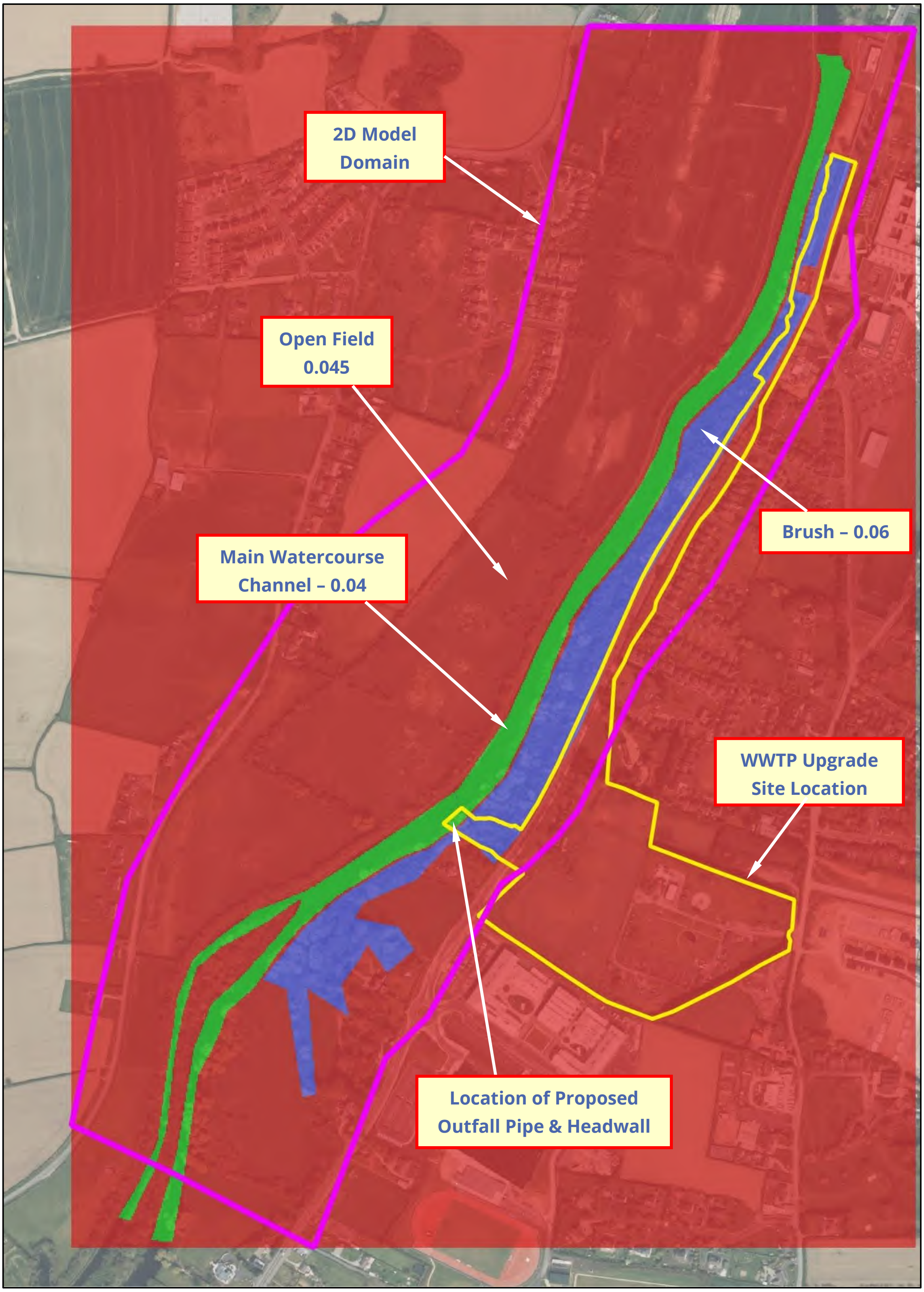

Figure 11 – 2D Roughness Values

6. Hydraulic Model Simulation Results

The hydraulic model was developed in order to provide a quantitative comparative analysis of the three phases of the proposed outfall pipe and associated headwall, these being the Existing Baseline Scenario, the Construction Stage Scenario and the Operational Stage Scenario.

- Existing Baseline Scenario – No proposed works undertaken. In this scenario the River Barrow watercourse is represented in the hydraulic model in its current configuration.
- Construction Stage Scenario – A temporary cofferdam or similar structure will be provided in order to construct the outfall pipe and headwall within the area of the left overbank of the River Barrow watercourse.
- Operation Stage Scenario – The proposed outfall pipe and associated headwall works are complete, and no further construction works are undertaken at this location.

The hydraulic simulation model was run for the Existing Baseline Scenario, the Construction Stage Scenario and the Operation Stage Scenario for the range of low flows and flood flows as listed below in *Table 15.*

Low Flows	Flood Flows
5%ile	50% AEP (1 in 2 year)
5%ile + Climate Change	50% AEP + Climate Change (1 in 2 year + climate change)
50%ile	1% AEP (1 in 100 year)
50%ile + Climate Change	1% AEP + Climate Change (1 in 100 year + climate change)

Table 15 – Hydraulic Model Simulation Flows

6.1. Existing Baseline Scenario

6.1.1. Low Flows

The 2D model domain was reduced for the low flow hydraulic model simulations in order to improve model run times. The 2D model domain utilised for the low flow model simulation is illustrated below in *Figure 12.*

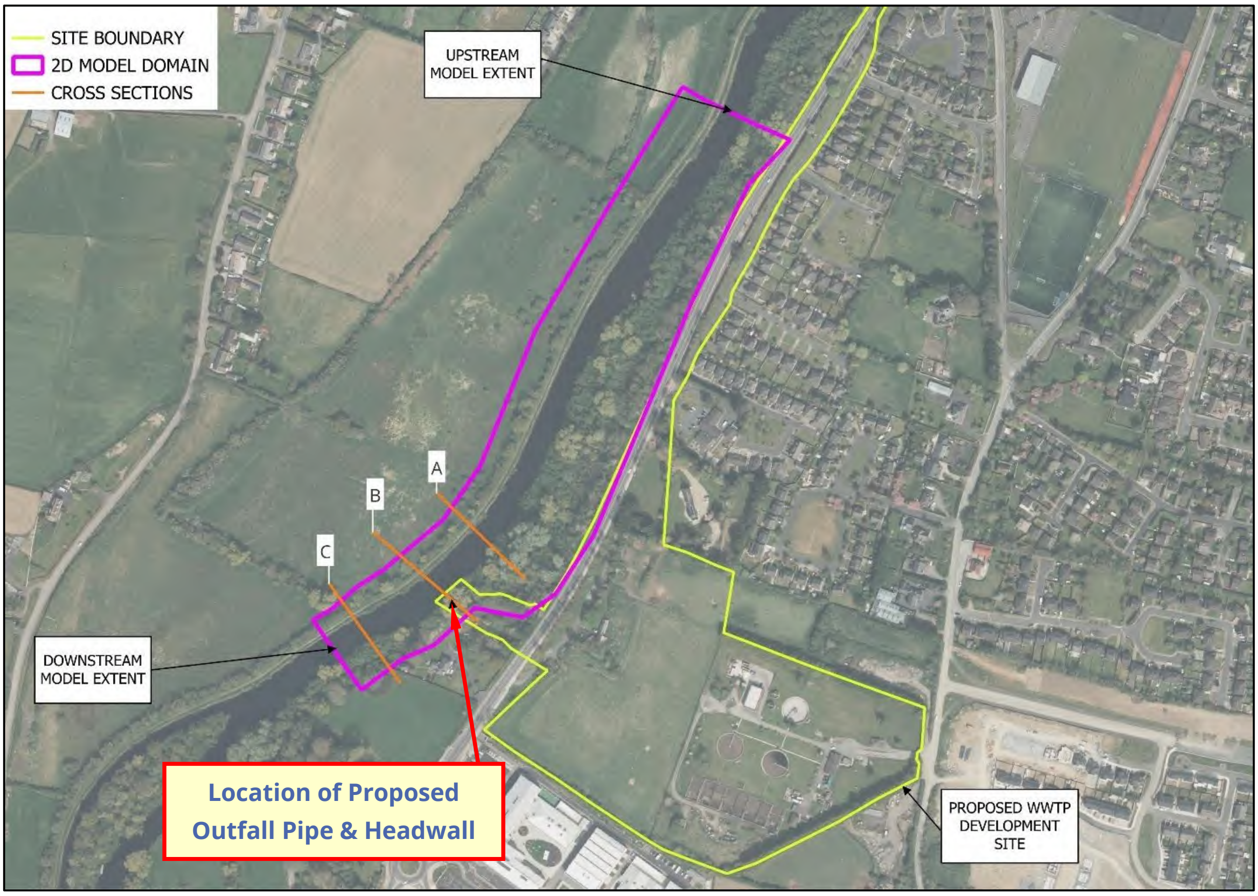

Figure 12 – Low Flow 2D Hydraulic Model Domain

As illustrated in *Figure 12* above, three model cross sections are utilised in order to quantity modelled low flow water levels and flow velocities at and in the vicinity of the proposed outfall pipe and headwall – i.e. Cross Section ‘A’ – upstream of proposed outfall pipe and headwall, Cross Section ‘B’ – at location of proposed outfall pipe and headwall, Cross Section ‘C’ – downstream of proposed outfall pipe and headwall.

Table 16 below lists the predictive Existing Baseline Scenario 5%ile, 5%ile+CC, 50%ile and 50%ile + CC peak fluvial water levels at Cross Section 'A', Cross Section 'B' and Cross Section 'C' as outputted by the hydraulic simulation model

Cross Section Label	5%ile Peak Water Level (m OD)	5%ile + CC Peak Water Level (m OD)	50%ile Peak Water Level (m OD)	50%ile + CC Peak Water Level (m OD)
A	43.47	43.74	41.87	42.00
B	43.46	43.73	41.86	41.99
C	43.36	43.63	41.79	41.92

Table 16 - Predictive 5%ile, 5%ile+ CC, 50%ile & 50%ile + CC Flood Levels – Existing Baseline Scenario

Figure 13 below illustrates the longitudinal hydraulic model profile of the predictive Existing Baseline Scenario 5%ile, 5%ile+CC, 50%ile and 50%ile + CC water levels along the modelled reach of the River Barrow.

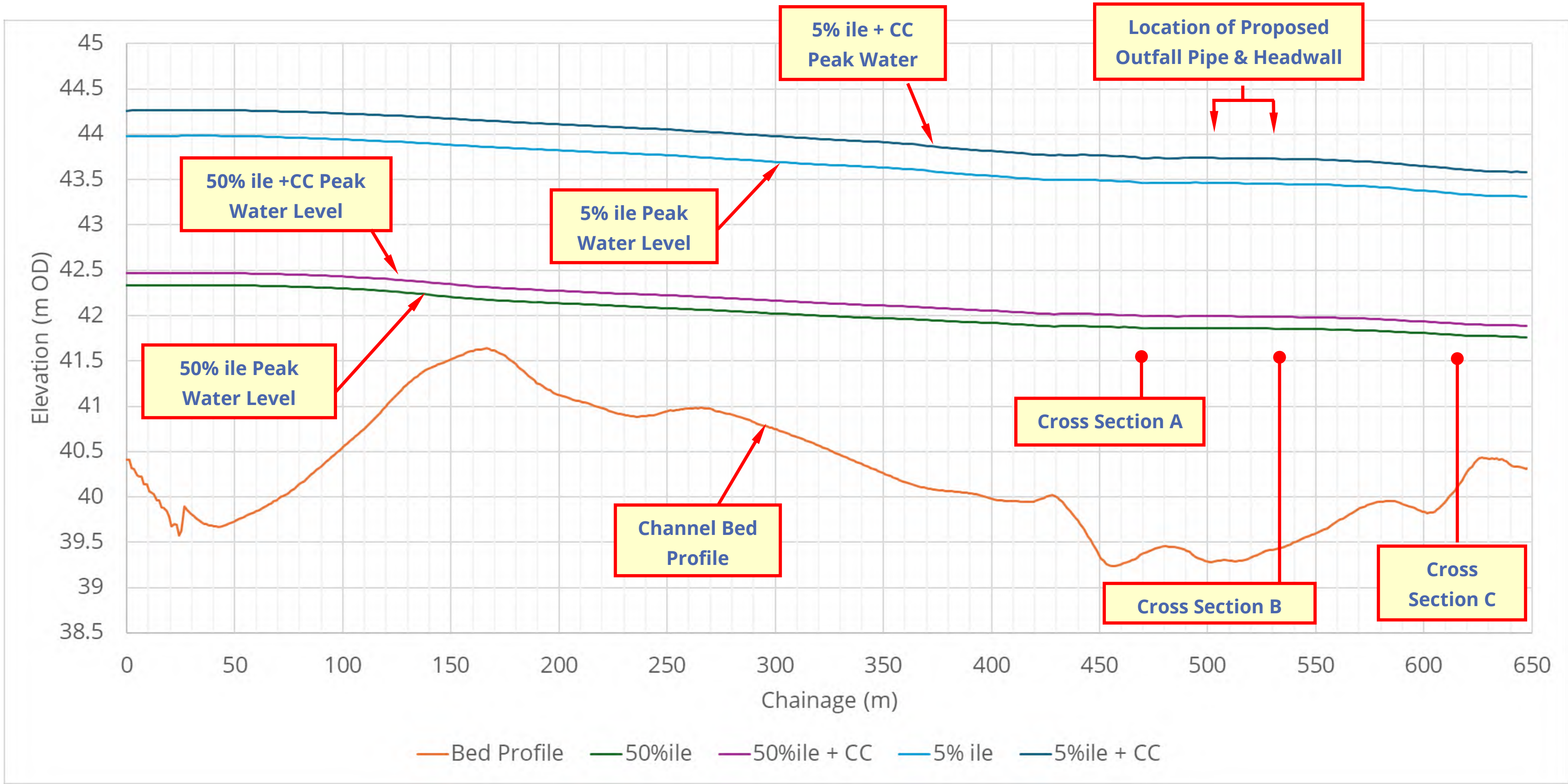

Figure 13 – River Barrow – Longitudinal Hydraulic Profile – Existing Baseline Scenario

Table 17 below list the predictive Existing Baseline Scenario 5%ile, 5%ile+CC, 50%ile, and 50%ile + CC peak flow velocities at Cross Section 'A', Cross Section 'B' and Cross Section 'C' as outputted by the hydraulic simulation model.

Cross Section Label	5%ile Peak Velocity (m/s)	5%ile + CC Peak Velocity (m/s)	50%ile Peak Velocity (m/s)	50%ile + CC Peak Velocity (m/s)
A	1.632	1.735	0.956	1.039
B	1.560	1.661	0.634	0.733
C	1.679	1.780	0.918	1.001

Table 17 - Predictive 5%ile, 5%ile+ CC, 50%ile & 50%ile + CC Peak Velocities – Existing Baseline Scenario

The 5%ile and 50%ile fluvial extents in consideration of the Existing Baseline Scenario as outputted by the hydraulic simulation model are illustrated in *Figure 14* below.

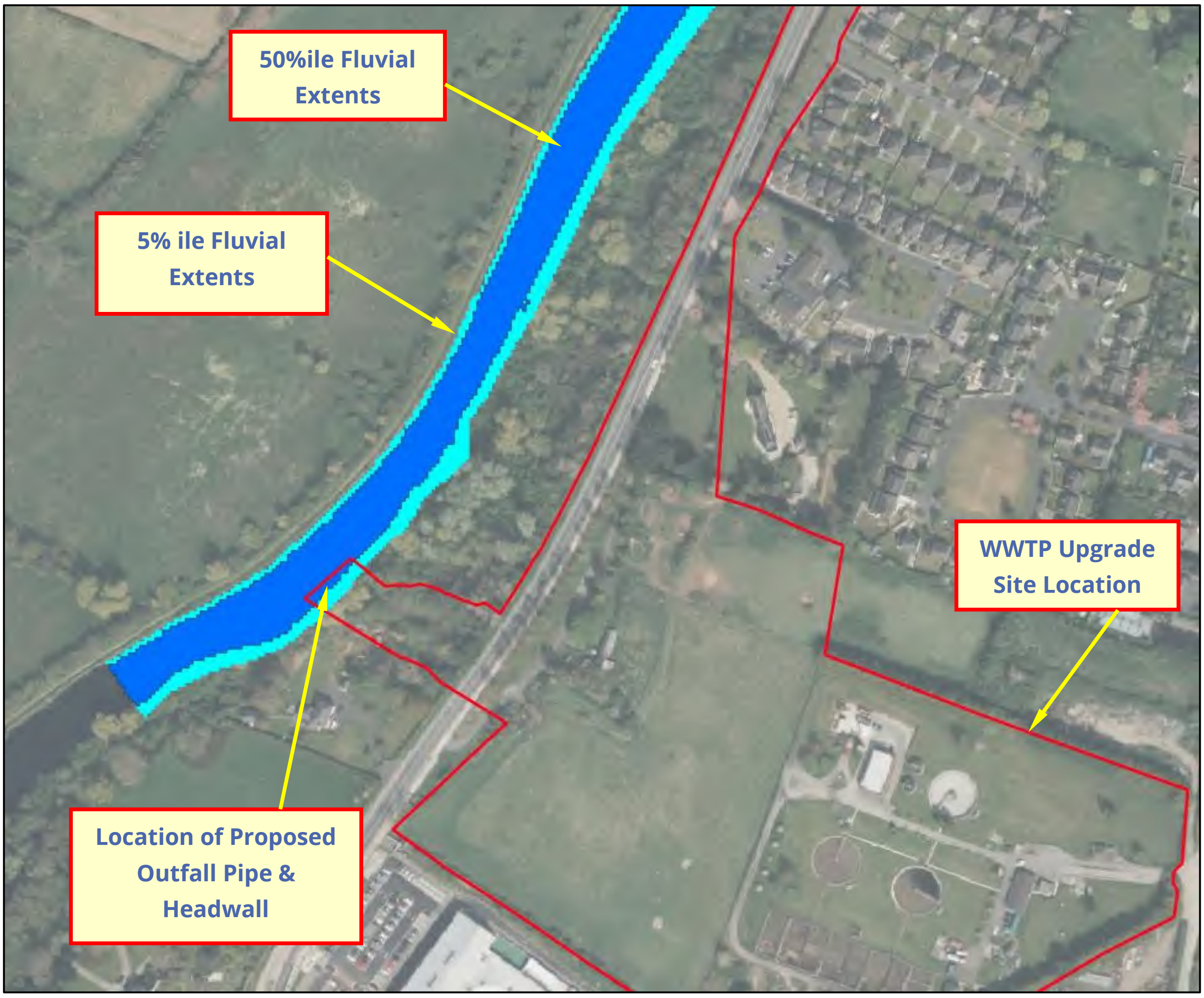

Figure 14 - 50%ile & 5%ile Fluvial Extents – Existing Baseline Scenario

The 5%ile+CC and 50%ile+CC fluvial extents in consideration of the Existing Baseline Scenario as outputted by the hydraulic simulation model are illustrated in *Figure 15* below.

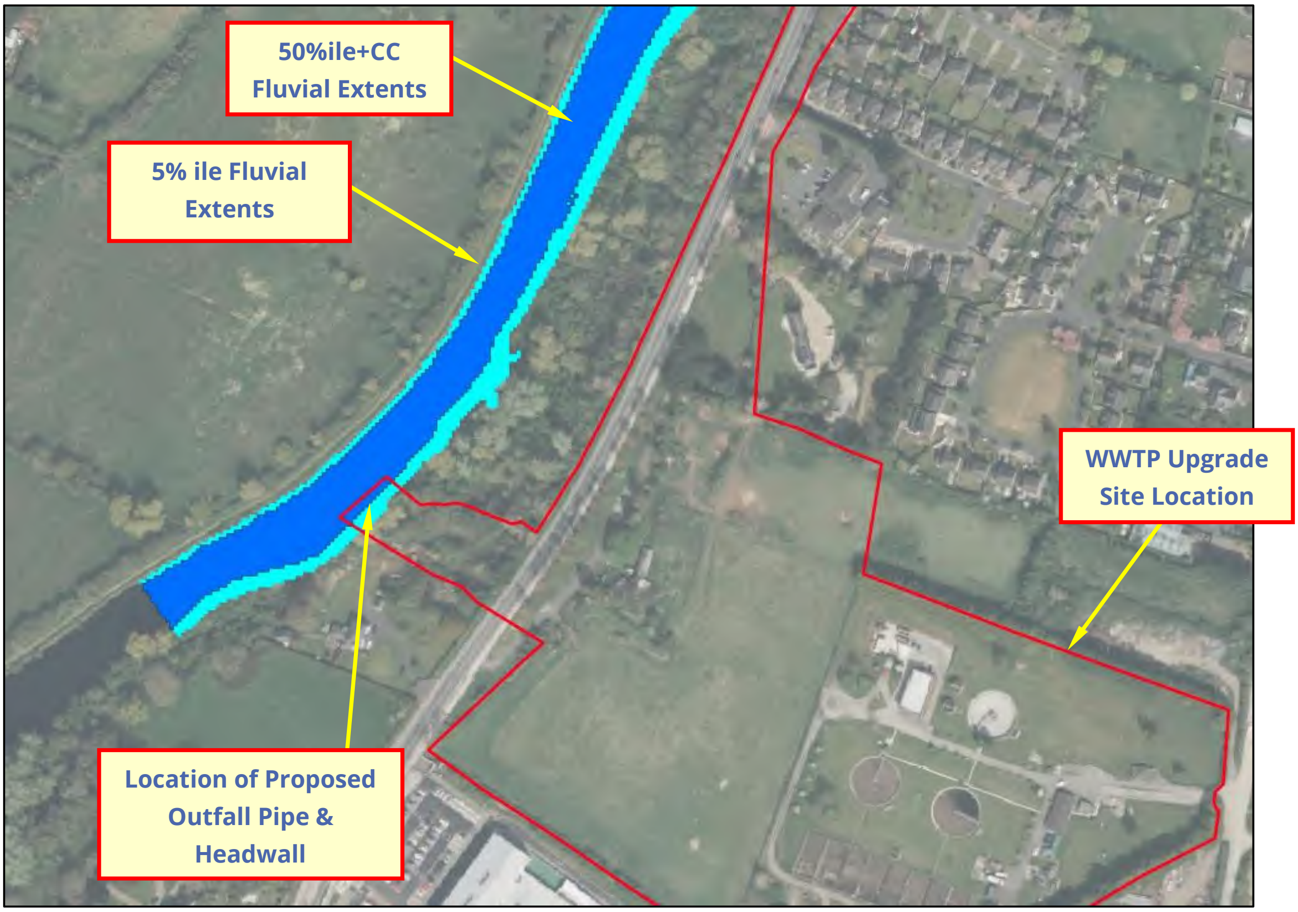

Figure 15 - 5%ile+CC & 50%ile+CC Fluvial Extents – Existing Baseline Scenario

The delineated 5%ile and 50%ile fluvial extents illustrated in *Figure 14* above are also presented on *Drawing Number IE3120-002-A, Appendix A*.

The delineated 5%ile +CC and 50%ile + CC fluvial extents illustrated in *Figure 15* above are also presented on *Drawing Number IE3120-003-A, Appendix A*.

6.1.2. Flood Flows

The full extent of the 2D model domain was utilised for the flood flow hydraulic model simulation analysis. The 2D model domain utilised for the flood flow model simulation is illustrated below in *Figure 16.*

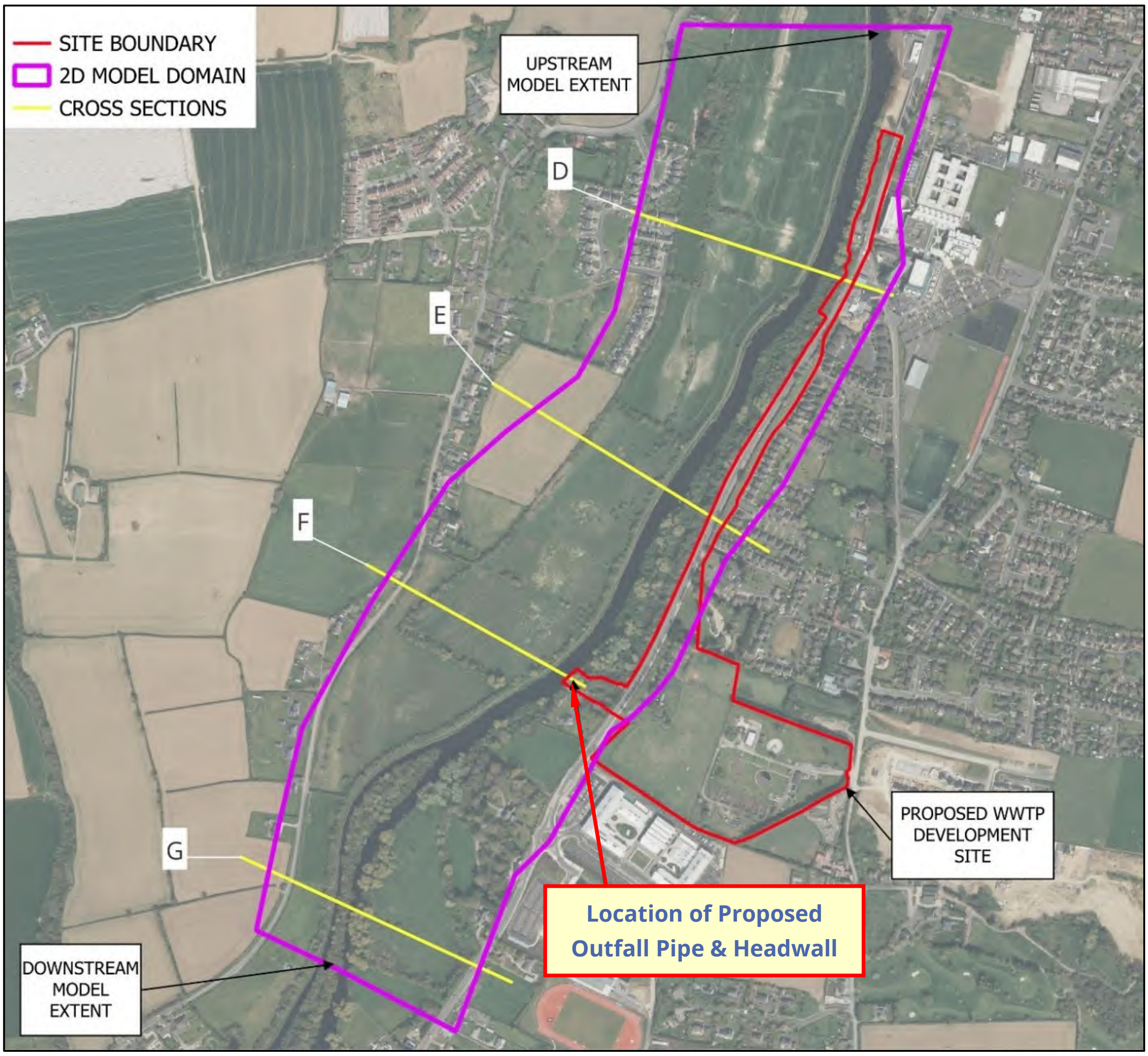

Figure 16 – Hydraulic Model Cross Section Locations

As illustrated in *Figure 16* above, four model cross sections are utilised in order to quantity modelled flood flow water levels and flow velocities at and in the vicinity of the proposed outfall pipe and headwall – i.e. Cross Section 'D' – upstream of proposed outfall pipe and headwall, Cross Section 'E' – upstream of proposed outfall pipe and headwall, Cross Section 'F' – at location of proposed outfall pipe and headwall, Cross Section 'G' – downstream of proposed outfall pipe and headwall.

Table 18 below lists the predictive Existing Baseline Scenario 50% AEP (1 in 2 year), 50% AEP+CC (1 in 2 year + climate change), 1% AEP (1 in 100 year) and 1% AEP+CC (1 in 100 year + climate change) fluvial flood levels at Cross Section 'D', Cross Section 'E', Cross Section 'F' and Cross Section 'G' as outputted by the hydraulic simulation model.

Cross Section Label	50% AEP Peak Flood Level (m OD)	50% AEP + CC Peak Flood Level (m OD)	1% AEP Peak Flood Level (m OD)	1% AEP + CC Peak Flood Level (m OD)
D	45.57	45.74	46.223	46.414
E	45.47	45.62	46.102	46.309
F	45.42	45.57	46.043	46.245
G	45.29	45.44	45.876	46.068

Table 18 – Predictive 50% AEP, 50% AEP + CC, 1% AEP & 1% AEP+CC Peak Flood Levels – Existing Baseline Scenario

Figure 17 below illustrates the longitudinal hydraulic model profile of the predictive Existing Baseline Scenario 50% AEP (1 in 2 Year), 50% AEP + CC (1 in 2 year + climate change), 1% AEP (1 in 100 year) and 1% AEP + CC (1 in 100 year + climate change) flood levels along the modelled reach of River Barrow.

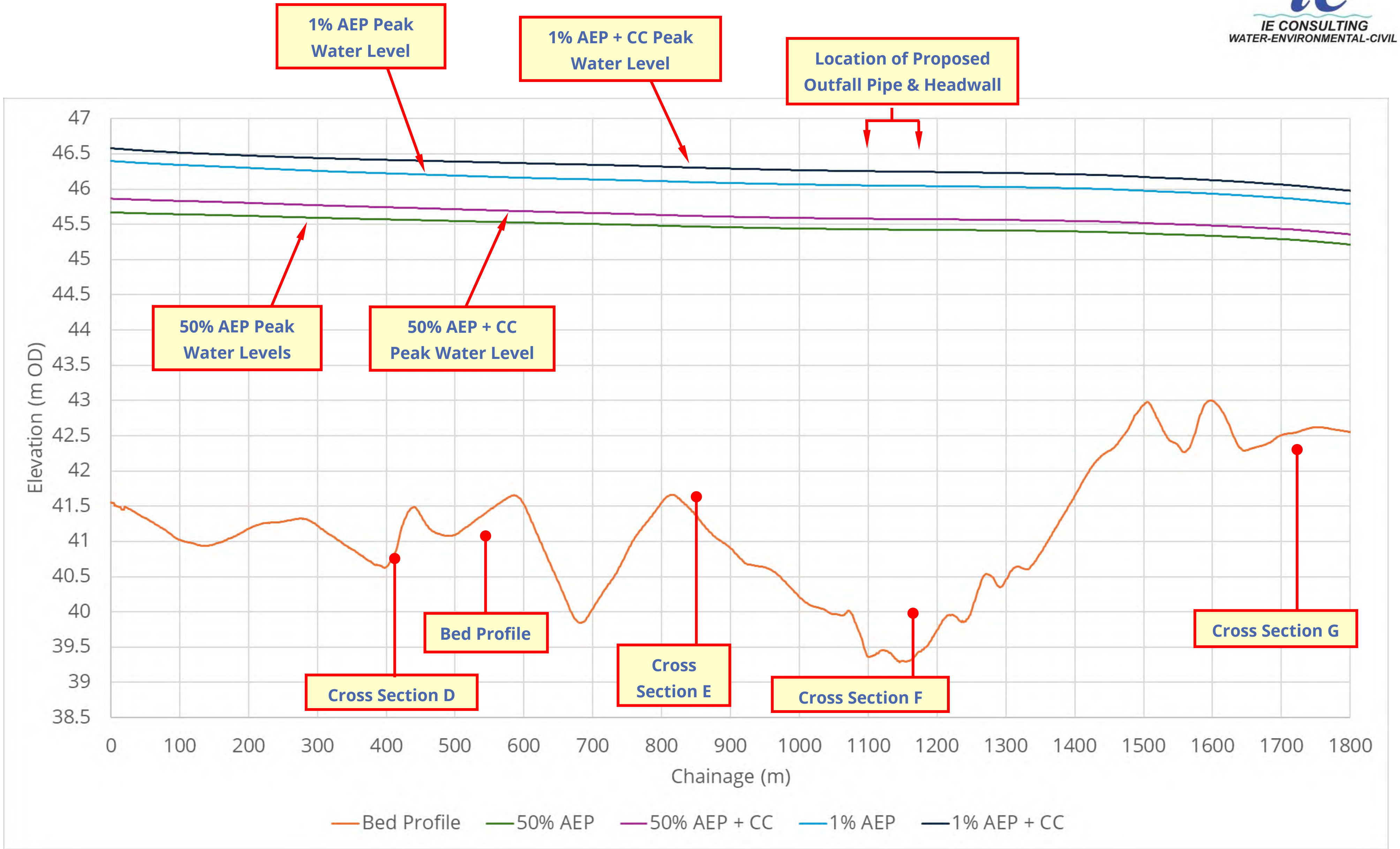

Figure 17 – River Barrow – Longitudinal Hydraulic Profile – Existing Baseline Scenario

The 50% AEP (1 in 2 year) and 1% AEP (1 in 100 year) fluvial flood extents in consideration of the Existing Baseline Scenario as outputted by the hydraulic simulation model are illustrated in *Figure 18* below.

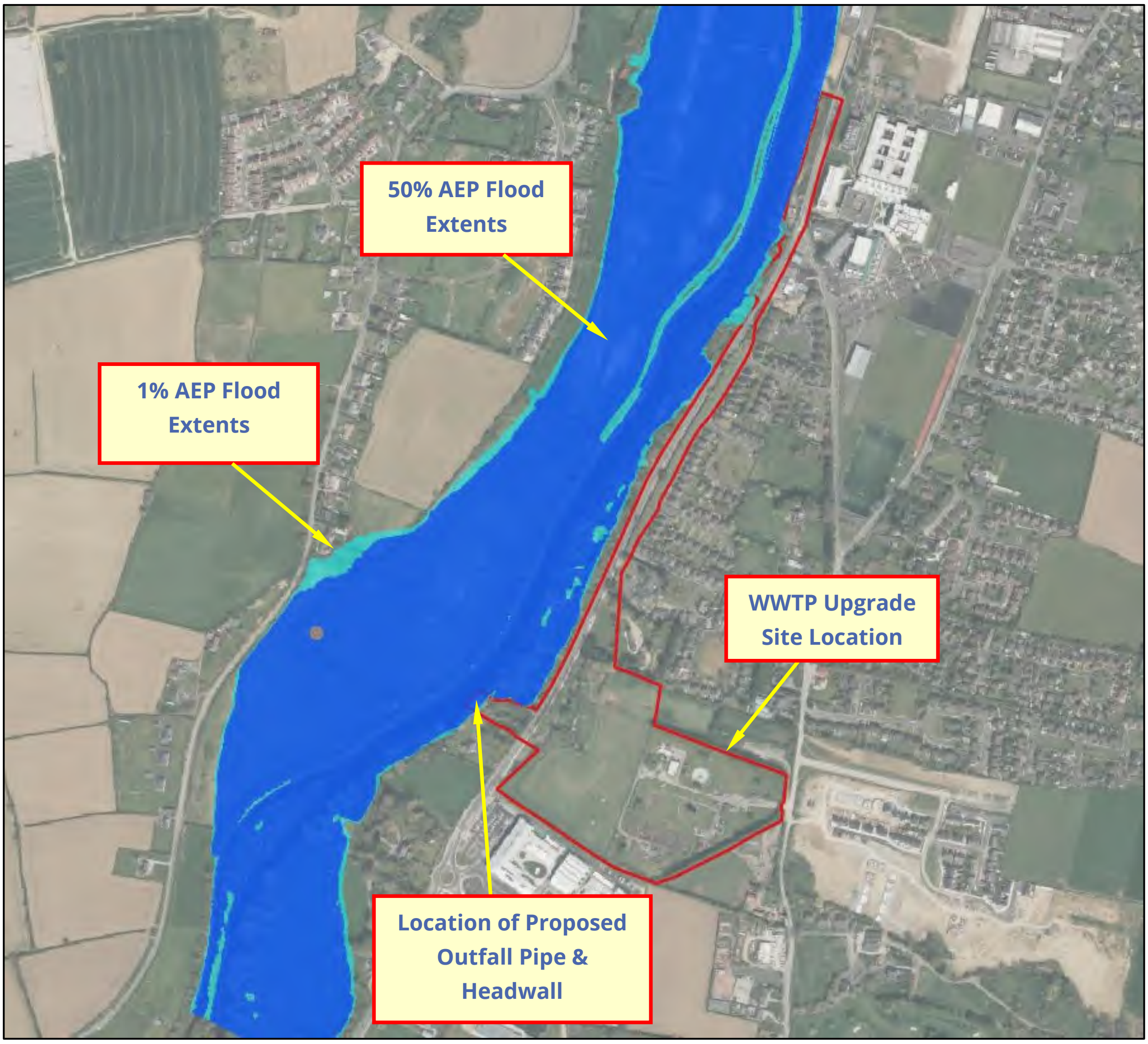

Figure 18 - 50% AEP & 1% AEP Fluvial Flood Extents – Existing Baseline Scenario

The delineated 50% AEP (1 in 2 year) and 1% AEP (1 in 100 year) fluvial flood extents illustrated in *Figure 18* above are also presented on *Drawing Number IE3120-004-A*, *Appendix A*.

As illustrated in *Figure 18* above, during the occurrence of a 50% AEP (1 in 2 year) and a 1% AEP (1 in 100 year) fluvial flood event, flood waters are predicted to overtop the right and left overbanks of the River Barrow, and within the location of the propose outfall pipe and headwall.

The 50% AEP + CC (1 in 2 year + climate change) and 1% AEP + CC (1 in 100 year + climate change) fluvial flood extents in consideration of the Existing Baseline Scenario as outputted by the hydraulic simulation model are illustrated in *Figure 19* below.

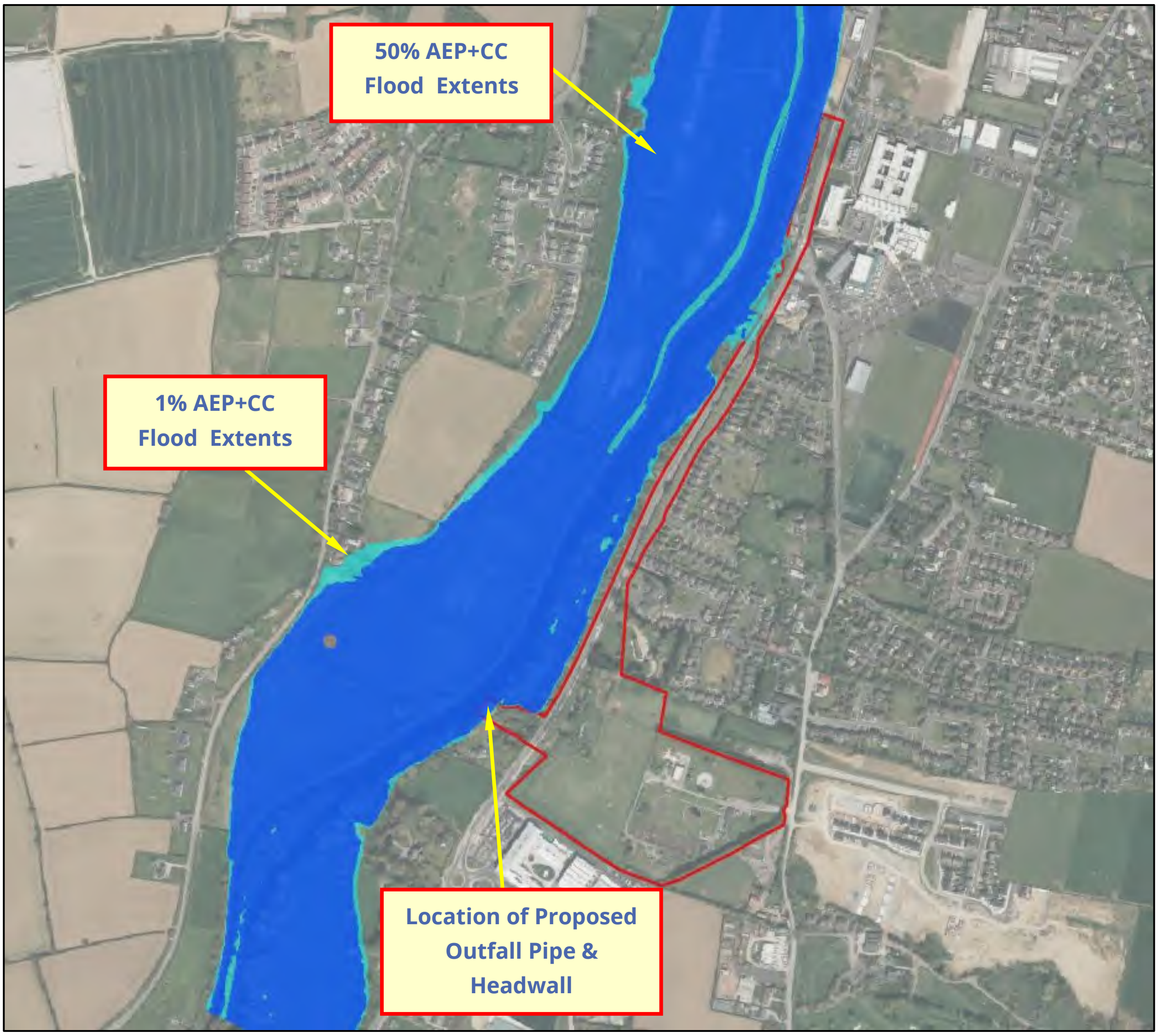

Figure 19 - 50% AEP + CC & 1% AEP + CC Fluvial Flood Extents – Existing Baseline Scenario

The delineated 50% AEP + CC (1 in 2 year + climate change) and 1% AEP + CC (1 in 100 year + climate change) fluvial flood extents illustrated in Figure 19 above are also presented on *Drawing Number IE3120-005-A, Appendix A*.

As illustrated in *Figure 19* above, during the occurrence of a 50% AEP + CC (1 in 2 year + climate change) and a 1% AEP + CC (1 in 100 year + climate change) fluvial flood event, flood waters are predicted to overtop the right and left overbanks of the River Barrow, and within the location of the propose outfall pipe and headwall.

6.2. Operation Stage Scenario

The assessment and analysis presented below considers the Operation Stage Scenario – i.e. the proposed outfall pipe and associated headwall works are complete, and no further construction works are undertaken at this location.

The assessment and analysis has been undertaken in consideration of the Low Flow and Flood Flow regime in the River Barrow at this location, and provides a comparative analysis in order to determine and quantify the impact, if any, that the proposed outfall pipe and headwall in the Operation Stage Scenario may have on the existing hydrodynamic and hydrological regime of the River Barrow at this location in comparison to the Existing Baseline Scenario presented in *Section 6.1* above.

6.2.1. Low Flows

As illustrated in *Figure 20* below, the proposed outfall pipe shall be constructed below ground to the location of the proposed outfall pipe headwall. The headwall will generally be of insitu concrete or precast concrete form of construction with wingwalls and of approximate dimensions of 1.65m high x 2.175m.

Figure 20 - Proposed Outfall

The Existing Baseline Scenario hydraulic simulation model was therefore updated and in order to include the line, level, location and geometric profile of the proposed outfall pipe and associated headwall structure as illustrated in *Figure 20* above, and the results were analysed and evaluated.

Table 19 below lists the predictive Existing Baseline Scenario versus the Operation Stage Scenario 5%ile, 5%ile + CC, 50%ile and 50%ile + CC peak fluvial water levels at Cross Section 'A', Cross Section 'B' and Cross Section 'C' as outputted by the hydraulic simulation model.

Table 20 below lists the predictive Existing Baseline Scenario versus the Operation Stage Scenario 5%ile, 5%ile + CC, 50%ile and 50%ile + CC peak flow velocities at Cross Section 'A', Cross Section 'B' and Cross Section 'C' as outputted by the hydraulic simulation model.

Cross Section Label	5%ile Peak Water Level (m OD) Baseline Scenario	5%ile + CC Peak Water Level (m OD) Baseline Scenario	50%ile Peak Water Level (m OD) Baseline Scenario	50%ile + CC Peak Water Level (m OD) Baseline Scenario	5%ile Peak Water Level (m OD) Operation Stage Scenario	5%ile + CC Peak Water Level (m OD) Operation Stage Scenario	50%ile Peak Water Level (m OD) Operation Stage Scenario	50%ile + CC Peak Water Level (m OD) Operation Stage Scenario	5%ile Peak Water Level (m) Difference	5%ile + CC Peak Water Level (m) Difference	50%ile Peak Water Level (m) Difference	50%ile + CC Peak Water Level (m) Difference
A	43.47	43.74	41.87	42.00	43.47	43.74	41.87	42.00	0	0	0	0
B	43.46	43.73	41.86	41.99	43.46	43.73	41.86	41.99	0	0	0	0
C	43.36	43.63	41.79	41.92	43.36	43.63	41.79	41.92	0	0	0	0

Table 19 - Predictive 50%ile, 50%ile+ CC, 5%ile & 5%ile + CC Fluvial Water Levels – Existing Baseline Scenario vs Operation Stage Scenario

Cross Section Label	5%ile Peak Flood Velocity (m/s) Baseline Scenario	5%ile + CC Peak Velocity (m/s) Baseline Scenario	50%ile Peak Velocity (m/s) Baseline Scenario	50%ile + CC Peak Velocity (m/s) Baseline Scenario	5%ile Peak Flood Velocity (m/s) Operation Stage Scenario	5%ile + CC Peak Velocity (m/s) Operation Stage Scenario	50%ile Peak Velocity (m/s) Operation Stage Scenario	50%ile + CC Peak Velocity (m/s) Operation Stage Scenario	5%ile Peak Flood Velocity (m/s) Difference	5%ile + CC Peak Velocity (m/s) Difference	50%ile Peak Velocity (m/s) Difference	50%ile + CC Peak Velocity (m/s) Difference
A	1.632	1.735	0.956	1.039	1.632	1.735	0.956	1.039	0	0	0	0
B	1.549	1.647	0.634	0.733	1.549	1.647	0.634	0.733	0	0	0	0
C	1.679	1.780	0.918	1.001	1.679	1.780	0.918	1.001	0	0	0	0

Table 20 - Predictive 50%ile, 50%ile+ CC, 5%ile, and 5%ile + CC Peak Velocities – Existing Baseline Scenario vs Operation Stage Scenario

As presented in *Table 19 and Table 20* above, the results of the hydraulic simulation and analysis indicates that, in the Operation Stage Scenario, the proposed outfall pipe and associated headwall are not predicted to result in an increase in peak fluvial water levels or peak flow velocities in comparison to the Existing Baseline Scenario.

6.2.2. Flood Flows

The Existing Baseline Scenario hydraulic simulation model was updated and in order to include the line, level, location and geometric profile of the proposed outfall pipe and associated headwall structure as illustrated in *Figure 20* above, and the results were analysed and evaluated.

Table 21 below lists the predictive Existing Baseline Scenario versus the Operation Stage Scenario 50% AEP (1 in 2 year), 50% AEP + CC (1 in 2 year + climate change), 1% AEP (1 in 100 year) and 1% AEP + CC (1 in 100 year + climate change) peak fluvial flood levels at Cross Section 'D', Cross Section 'E', Cross Section 'F' and Cross Section 'G' as outputted by the hydraulic simulation model.

Cross Section Label	50% AEP Peak Flood Level (m OD) Baseline Scenario	50% AEP + CC Peak Flood Level (m OD) Baseline Scenario	1% AEP Peak Flood Level (m OD) Baseline Scenario	1% AEP + CC Peak Flood Level (m OD) Baseline Scenario	50% AEP Peak Flood Level (m OD) Operation Stage Scenario	50% AEP + CC Peak Flood Level (m OD) Operation Stage Scenario	1% AEP Peak Flood Level (m OD) Operation Stage Scenario	1% AEP + CC Peak Flood Level (m OD) Operation Stage Scenario	50% AEP Peak Flood Level (m) Difference	50% AEP + CC Peak Flood Level (m) Difference	1% AEP Peak Flood Level (m) Difference	1% AEP + CC Peak Flood Level (m) Difference
D	45.57	45.74	46.223	46.414	45.57	45.74	46.223	46.414	0	0	0	0
E	45.47	45.62	46.102	46.309	45.47	45.62	46.102	46.309	0	0	0	0
F	45.42	45.57	46.043	46.245	45.42	45.57	46.043	46.245	0	0	0	0
G	45.29	45.44	45.876	46.068	45.29	45.44	45.876	46.068	0	0	0	0

Table 21 – Predictive 50% AEP, 50%AEP + CC, 1% AEP & 1% AEP + CC Flood Levels – Existing Baseline Scenario vs Operation Stage Scenario

As presented in *Table 21* above, the results of the hydraulic simulation and analysis indicates that, in the Operation Stage Scenario, the proposed outfall pipe and associated headwall are not predicted to result in an increase in peak fluvial flood level water levels in comparison to the Existing Baseline Scenario.

6.3. Construction Stage Scenario

The assessment and analysis presented below considered the Construction Stage Scenario – i.e. a temporary cofferdam or similar structure will be provided in order to construct the outfall pipe and associated headwall within the area of the left overbank of the River Barrow watercourse. The impounding structure will have a width of 4m and a length of 5m.

The assessment and analysis has been undertaken in consideration of the Low Flow regime only in the River Barrow at this location, and provides a comparative analysis in order to determine and quantify the impact, if any, that the proposed outfall pipe and headwall in the Construction Stage Scenario may have on the existing hydrodynamic and hydrological regime of the River Barrow at this location in comparison to the Existing Baseline Scenario presented in *Section 5.1* above. Flood flows have not been considered for the Construction Stage Scenario as it is envisage that no works are expected to progress in the event of an extreme weather event (I.e. Flood Flows).

As illustrated in *Figure 21* below, in order to facilitate the construction of the proposed outfall pipe and associated headwall, a temporary lower infill area and upper infill area will be formed in order to allow access to this location for construction traffic and equipment. Within this infill area a temporary cofferdam or similar structure will be provided in order allow construction of the outfall pipe and associated headwall at this location.

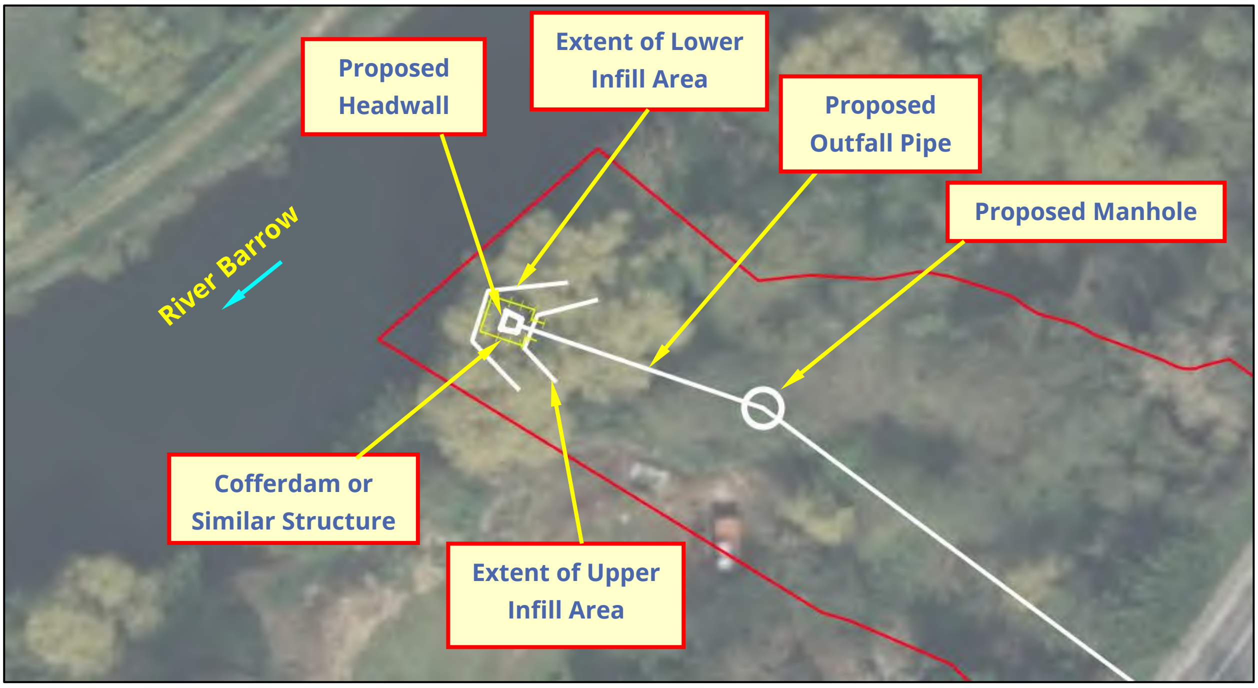

Figure 21 - Construction Stage

The Existing Baseline Scenario hydraulic simulation model was therefore updated in order to include the line, level, location and geometric profile proposed temporary lower and upper infill areas and the proposed temporary cofferdam or similar structure.

Table 22 below lists the predictive Existing Baseline Scenario versus the Construction Stage Scenario 5%ile, 5%ile + CC, 50%ile and 50%ile + CC peak fluvial water levels at Cross Section 'A', Cross Section 'B' and Cross Section 'C' as outputted by the hydraulic simulation model.

Table 23 below lists the predictive Existing Baseline Scenario versus the Construction Stage Scenario 5%ile, 5%ile + CC, 50%ile and 50%ile + CC peak flow velocities at Cross Section 'A', Cross Section 'B' and Cross Section 'C' as outputted by the hydraulic simulation model.

Cross Section Label	5%ile Peak Water Level (m OD) Baseline Scenario	5%ile + CC Peak Water Level (m OD) Baseline Scenario	50%ile Peak Water Level (m OD) Baseline Scenario	50%ile + CC Peak Water Level (m OD) Baseline Scenario	5%ile Peak Water Level (m OD) Construction Stage Scenario	5%ile + CC Peak Water Level (m OD) Construction Stage Scenario	50%ile Peak Water Level (m OD) Construction Stage Scenario	50%ile + CC Peak Water Level (m OD) Construction Stage Scenario	5%ile Peak Water Level (m) Difference	5%ile + CC Peak Water Level (m) Difference	50%ile Peak Water Level (m) Difference	50%ile + CC Peak Water Level (m) Difference
A	43.47	43.74	41.87	42.00	43.47	43.75	41.87	42.00	0	+0.01	0	0
B	43.46	43.73	41.86	41.99	43.46	43.73	41.86	41.99	0	0	0	0
C	43.36	43.63	41.79	41.92	43.36	43.63	41.79	41.92	0	0	0	0

Table 22 - Predictive 5%ile, 5%ile+ CC, 50%ile & 50%ile + CC Fluvial Water Levels – Existing Baseline Scenario vs Construction Stage Scenario

Cross Section Label	5%ile Peak Flood Velocity (m/s) Baseline Scenario	5%ile + CC Peak Velocity (m/s) Baseline Scenario	50%ile Peak Velocity (m/s) Baseline Scenario	50%ile + CC Peak Velocity (m/s) Baseline Scenario	5%ile Peak Flood Velocity (m/s) Construction Stage Scenario	5%ile + CC Peak Velocity (m/s) Construction Stage Scenario	50%ile Peak Velocity (m/s) Construction Stage Scenario	50%ile + CC Peak Velocity (m/s) Construction Stage Scenario	5%ile Peak Flood Velocity (m/s) Difference	5%ile + CC Peak Velocity (m/s) Difference	50%ile Peak Velocity (m/s) Difference	50%ile + CC Peak Velocity (m/s) Difference
A	1.632	1.735	0.956	1.039	1.632	1.735	0.956	1.039	0	0	0	0
B	1.549	1.647	0.634	0.733	1.583	1.677	0.634	0.733	+0.034	+0.03	0	0
C	1.679	1.780	0.918	1.001	1.679	1.780	0.918	1.001	0	0	0	0

Table 23 - Predictive 5%ile, 5%ile+ CC, 50% ile, and 50% ile + CC Peak Velocities – Existing Baseline Scenario vs Construction Stage Scenario

As presented in *Table 22* and *Table 23* above, the results of the hydraulic simulation and analysis indicates that, in the Construction Stage Scenario, the proposed temporary lower and upper infill areas and the proposed temporary cofferdam or similar structure are for the majority not predicted to result in an increase in peak fluvial water level or peak flow velocities in comparison to the Existing Baseline Scenario.

As listed in *Table 22* above a small minor increase of 0.01m is predicted at the location of Cross Section 'A' in consideration of the 5%ile + CC event.

As listed in *Table 23* above a small minor increase of 0.034 m/s and 0.03 m/s is predicted at the location of Cross Section 'B' in consideration of the and 5%ile and the 5%ile + CC event respectively.

The potential small minor increase of 0.01m in water levels in consideration of the 5%ile + CC event is illustrated graphically in *Figure 22* below.

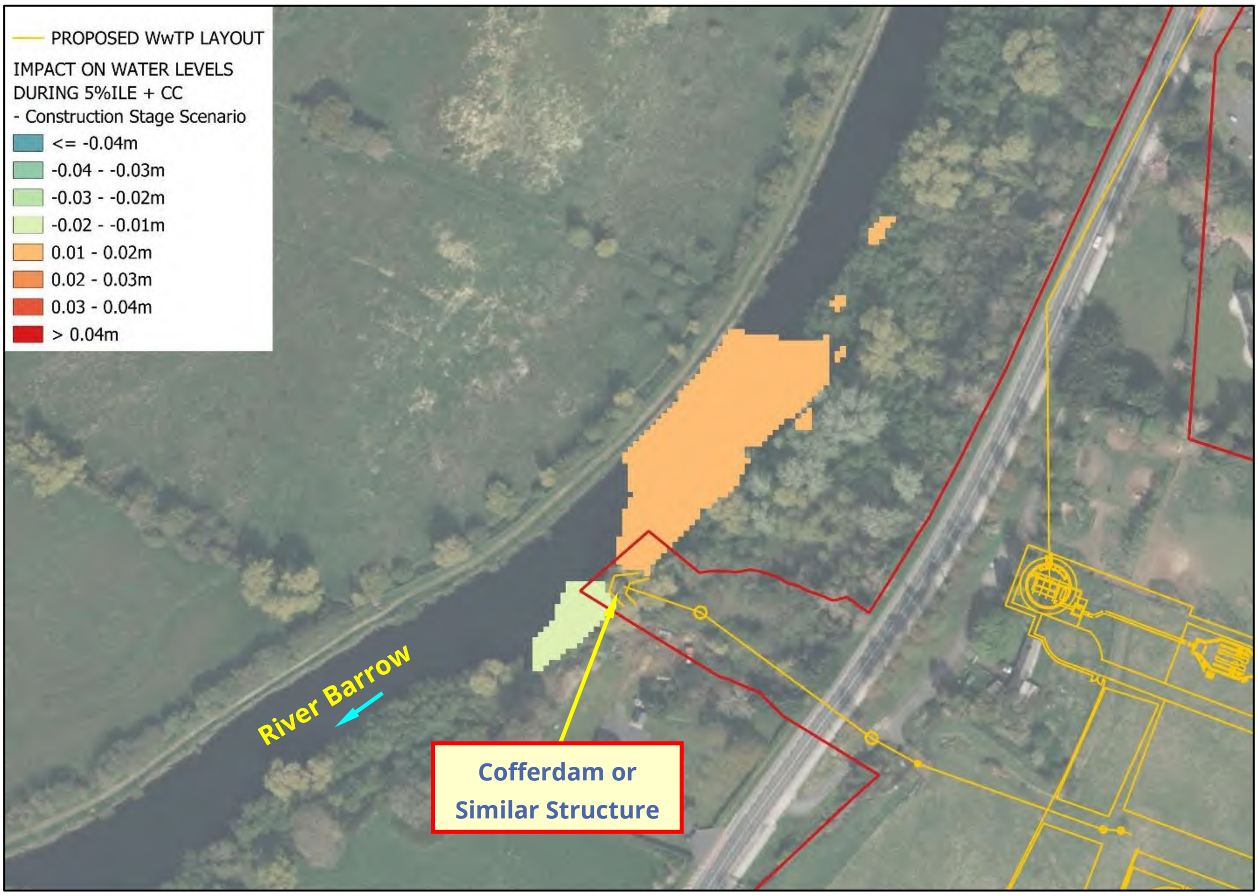

Figure 22 - 5%ile + CC Event - Construction Stage Scenario Water Levels

As illustrated in *Figure 22* above, in consideration of the 5%ile + CC event, a limited minor increase in water levels of the order of 0.01m is predicted immediately upstream of the proposed temporary cofferdam or similar structure for a distance of approximately 100m upstream, after which predictive water levels return to Existing Baseline Scenario levels. This potential small minor increase in water level is contained within the main watercourse channel of the River Barrow and does not encroach within adjacent left or right overbank lands.

A minor decrease in water levels is predicted immediately downstream of the proposed temporary cofferdam or similar structure for a distance of approximately 40m downstream, after which predictive water levels return to Existing Baseline Scenario levels.

Changes in water level mapping for the 5%ile, 5%ile+ CC, 50%ile, and 50%ile + CC are presented in *Appendix D*.

The potential small minor increase of 0.03 m/s in flow velocities in consideration of the 5%ile + CC event is illustrated graphically in *Figure 23* below.

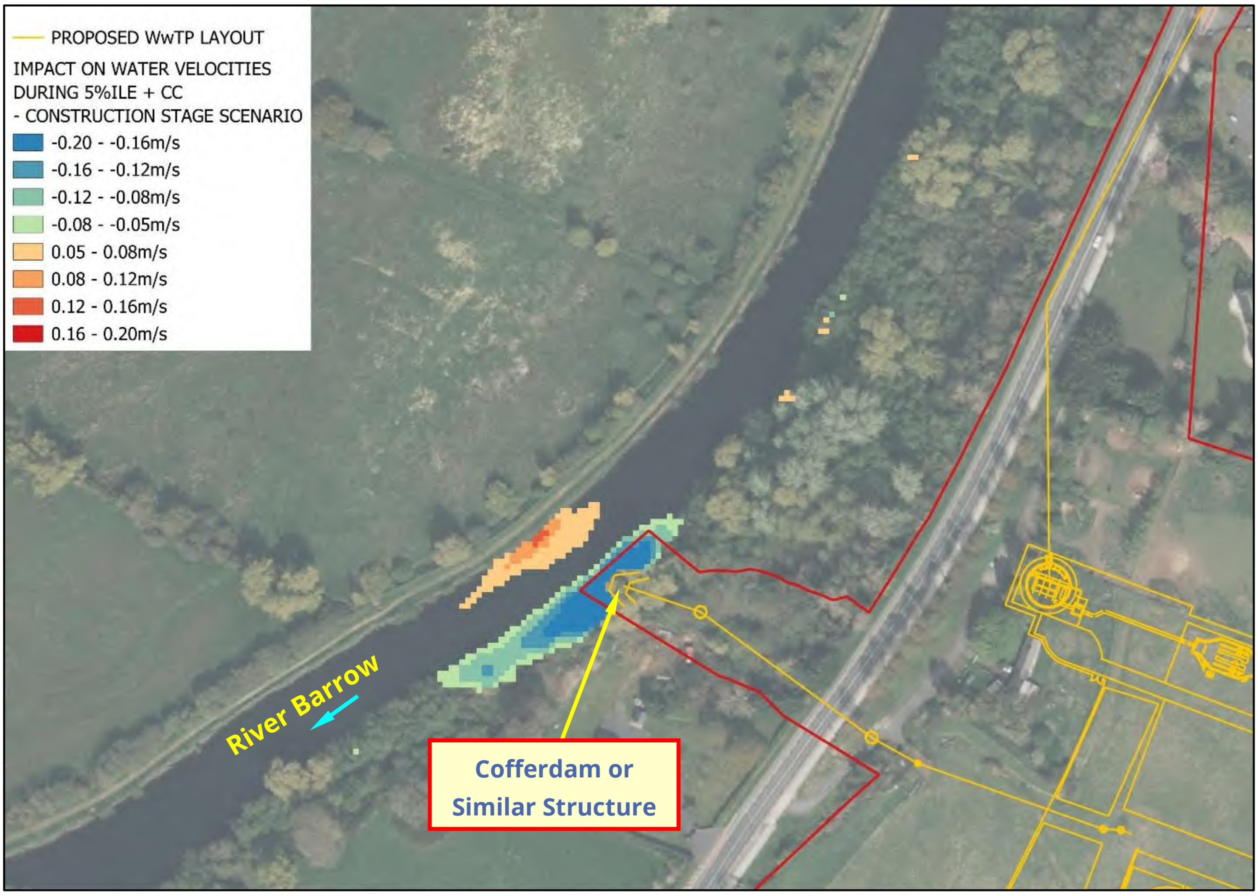

Figure 23 - 5%ile + CC Event - Construction Stage Scenario Flow Velocities

As illustrated in *Figure 23* above, in consideration of the 5%ile + CC event, a minor limited increase in flow velocities of the order of 0.03 m/s is predicted at the location of the proposed temporary cofferdam or similar structure, and primarily adjacent to a limited reach length adjacent to the right overbank of the River Barrow.

A minor limited decrease in flow velocities of the order of 0.1 m/s is predicted at the location of the proposed temporary cofferdam or similar structure, and primarily adjacent to the limited reach length adjacent to the left overbank of the River Barrow.

Predictive flow velocities return to Existing Baseline Scenario levels approximately 40m upstream and approximately 70m downstream of the location of the proposed cofferdam or similar structure.

Change in water velocity mapping for the 50%ile, 50%ile+ CC, 5%ile, and 5%ile + CC are presented in *Appendix E*.

7. Discussion

The 2D hydraulic modelling and analysis undertaken as part of this assessment indicates that in consideration of the Construction Stage Scenario and the Operation Stage Scenario, the proposed outfall pipe and associated headwall are not predicted result in an adverse impact to Existing Baseline Scenario water levels or flow velocities, and in this regard the proposed outfall pipe and associated headwall will not alter or adversely impact existing patterns of erosion, accretion, sediment transport or deposition along this reach length of the River Barrow watercourse.

This conclusion is supported by the following key factors:

1) The sediment survey conducted within the river channel revealed minimal sediment deposition in the area. This is primarily due to the relatively straight alignment of the river at the location of the proposed outfall pipe and associated headwall, with no significant watercourse meanders or change of direction at, or upstream or downstream of this location. The gradient of the River Barrow watercourse channel is also significantly shallow at this location, and no existing significant hydraulic structures such are weir or bridge structures are present at this location. In such conditions, and where river energy and flow velocities remain consistent, significant sediment transport and deposition is unlikely to occur. As the river topography at this location is stable and flow velocities remain unchanged, erosion, accretion, sediment transport or deposition is not predicted to occur along this reach length of the River Barrow watercourse.

2) The proposed outfall pipe and associated headwall will be located on the left overbank of the River Barrow, and at a location where there is a significant existing vegetative cover. This vegetative cover provides a significant erosion potential buffer. Additionally, the Mortarstown WwTP - Outfall Temporary Works and Constructability technical note – (Document Number -5161805DG0444) specifies that "Sediment and erosion control measures shall be in place at and around the embankment to mitigate negative impacts of run-off from the site into the watercourse." There is no evidence of any erosion or accretion potential at this location and mitigation measures will be implemented during the Construction Stage Scenario in order to ensure that there is no adverse impact to the Existing Baseline Scenario.

3) In consideration of the Construction Stage Scenario, a minor limited increase in water levels and flow velocities is predicted as a result of the temporary cofferdam or similar structure, however these minor limited increase in water levels and flow velocities are strictly limited to the immediate area of the temporary cofferdam or similar structure and will not result in an increase of erosion, accretion or sediment transport or deposition potential at this location. The cofferdam dam or similar structure will be a temporary structure only, and will be in place only for the duration of the construction stage works.

In consideration of the above, the proposed outfall pipe and associated headwall will not result in an adverse impact to the existing hydrodynamic and hydrological regime of the River Barrow Watercourse at this location during the Construction Stage Scenario or the Operation Stage Scenario.

It is recommended that the proposed cofferdam or similar structure should be constructed to a minimum crest level of 46.25m OD, which is 2.52m above the 5%ile + CC water level and is 0.68m above the 50% AEP + CC (1 in 2 Year + climate change) flood level.

Short term rainfall data should be acquired from MET Eireann each day before construction within the River Barrow commences. The weather should be checked by a designated person every two hours while the work is ongoing. If a significant rainfall event is forecast in the River Barrow catchment area which could result in a flood event, the works within the River Barrow should be postponed.

An automated system which records river water levels immediately upstream of the proposed WwTP outfall shall be installed before construction works begin in the River Barrow. The system should be capable of sounding a loud and clear warning once water levels within the River Barrow reach a level of 44.42m OD. The 44.42m OD water level is 1m below the peak 50% AEP (1 in 2 Year) fluvial flood event in the River Barrow and is 1.83m below the top of the recommended sheet piling level. The automated system should be checked and serviced regularly by a competent person to ensure it is calibrated and working correctly.

The contractor should determine what level of exceedance they deemed to be acceptable. It is important to consider the amount of time needed to remove the equipment located within the channel if a flood event requires the works to be abandoned. The flows applied to determine the temporary barrier height have been estimated using statistical methods. While these are the best methods available for the site at this time there is still a level of uncertainty attached to them.

8. Summary Conclusions and Recommendations

In consideration of the findings of this hydrodynamic analysis the following conclusions are made in respect of the proposed outfall pipe and associated headwall:

- A hydrodynamic assessment and analysis has been undertaken in order to assess and quantify the potential short term (Construction Stage Scenario) and long-term (Operation Stage Scenario) impact of the proposed new outfall pipe and associated headwall to the existing hydrodynamic and hydrological regime of the River Barrow watercourse at this location.
- Low flows in the River Barrow watercourse at this location were determined using the EPA's Low Flow Duration Curve (LFDC) Tool. Flows for the 5%ile and 50%ile scenarios were calculated for this assessment.
- Flood flows in the River Barrow were estimated using the 7 – Variable QMED Equation and applying the same growth factors used in the OPW South Eastern CFRAMS Hydrology Report.
- A 2D hydraulic simulation model was developed in HEC-RAS in order to provide a quantitative comparative analysis of the three phases of the proposed outfall pipe and associated headwall, these being the Existing Baseline Scenario, the Construction Stage Scenario and the Operational Stage Scenario.
- The 2D hydraulic modelling and analysis undertaken as part of this assessment indicates that in consideration of the Construction Stage Scenario and the Operation Stage Scenario, the proposed outfall pipe and associated headwall are not predicted result in an adverse impact to Existing Baseline Scenario water levels or flow velocities.
- In this regard the proposed outfall pipe and associated headwall will not alter or adversely impact existing patterns of erosion, accretion, sediment transport or deposition along this reach length of the River Barrow watercourse.
- It is recommended that the sheet piling be built to a level of 46.25m OD which is 2.52m above the 5%ile + CC and is 0.68m above the 50% AEP + CC (1 in 2 Year + climate change).
- The contractor shall ultimately determine what level of exceedance they deemed to be acceptable. It is important to consider the amount of time needed to remove the equipment located within the channel if a flood event requires the works to be abandoned.

- The flows used to determine these levels were derived using statistical methods. Local weather and flow conditions may require a change to the height of the structure.
- Short term rainfall data should be acquired from MET Eireann each day before construction within the River Barrow commences. The weather should be checked by a designated person every two hours while the work is ongoing. If a significant rainfall event is forecast in the River Barrow catchment area which could result in a flood event, the works within the River Barrow should be postponed.
- An automated system which records river water levels immediately upstream of the proposed WwTP outfall shall be installed before construction works begin in the River Barrow. The system should be capable of sounding a loud and clear warning once water levels within the River Barrow reach a level of 44.42m OD. The 44.42m OD water level is 1m below the peak 50% AEP (1 in 2 Year) fluvial flood event in the River Barrow and is 1.83m below the top of the recommended sheet piling level. The automated system should be checked and serviced regularly by a competent person to ensure it is calibrated and working correctly.
- The contractor should determine what level of exceedance they deemed to be acceptable. It is important to consider the amount of time needed to remove the equipment located within the channel if a flood event requires the works to be abandoned. The flows applied to determine the temporary barrier height have been estimated using statistical methods. While these are the best methods available for the site at this time there is still a level of uncertainty attached to them.
- While there may be localised impacts on water levels and velocities during the construction stage within the immediate vicinity of the proposed WwTP outfall when compared to the baseline, these become negligible once 100 metres upstream and downstream of the outfall.
- In summary, the hydrodynamic assessment and analysis presented in this study report indicates that the proposed outfall pipe and associated headwall will not result in an adverse impact to the existing hydrodynamic and hydrological regime of the River Barrow Watercourse at this location during the Construction Stage Scenario or the Operation Stage Scenario.

Appendices

Appendix A. Drawings

Drawing Number IE3120-001-A Site Location Map

Drawing Number IE3120-002-A 5%ile & 50%ile Fluvial Extents – Baseline Scenario

Drawing Number IE3120-003-A 5%ile + CC & 50%ile + CC Fluvial Extents – Baseline Scenario

Drawing Number IE3120-004-A 50% AEP (1 in 2 Year) & 1% AEP (1 in 100 Year) Fluvial Flood Extents – Baseline Scenario

Drawing Number IE3120-005-A 50% AEP + CC (1 in 2 Year + Climate Change) & 1% AEP + CC (1 in 100 Year + Climate Change) Fluvial Flood Extents – Baseline Scenario

LEGEND

rev.	date	amendment	drn	ckd
A	26.08.25	ISSUE	MOF	PMS

PROPOSED MORTARSTOWN WWTP UPGRADE PROJECT, CARLOW

HYDRODYNAMIC ASSESSMENT

LOCATION MAP

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

CARLOW OFFICE:
INNOVATION CENTRE
GREEN ROAD
CARLOW R95 W248

NEWRY OFFICE:
1 RDC HOUSE
WIN BUSINESS PARK
NEWRY BT35 6PH

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		drawn: MOF	
drawing no. IE3120-001	rev: A	checked: PMS	
		approved: PMS	
		date: 26/08/2025	

LEGEND

- WWTP UPGRADE SITE LOCATION
- 5%ILE FLUVIAL EXTENTS
- 50%ILE FLUVIAL EXTENTS

rev.	date	amendment	drn	ckd
A	26.08.25	ISSUE	MOF	PMS

PROPOSED MORTARSTOWN WWTP UPGRADE PROJECT, CARLOW

HYDRODYNAMIC ASSESSMENT

5%ILE & 50%ILE FLUVIAL EXTENTS
BASELINE SCENARIO

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

CARLOW OFFICE:
INNOVATION CENTRE
GREEN ROAD
CARLOW R95 W248

NEWRY OFFICE:
1 RDC HOUSE
WIN BUSINESS PARK
NEWRY BT35 6PH

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		date: 26/08/2025	

LEGEND

- WWTP UPGRADE SITE LOCATION
- 5%ILE + CC FLUVIAL EXTENTS
- 50%ILE + CC FLUVIAL EXTENTS

rev.	date	amendment	drn	ckd
A	26.08.25	ISSUE	MOF	PMS

PROPOSED MORTARSTOWN WWTP UPGRADE PROJECT, CARLOW

HYDRODYNAMIC ASSESSMENT

5%ILE + CC & 50%ILE + CC FLUVIAL EXTENTS
BASELINE SCENARIO

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

CARLOW OFFICE:
INNOVATION CENTRE
GREEN ROAD
CARLOW R95 W248

NEWRY OFFICE:
1 RDC HOUSE
WIN BUSINESS PARK
NEWRY BT35 6PH

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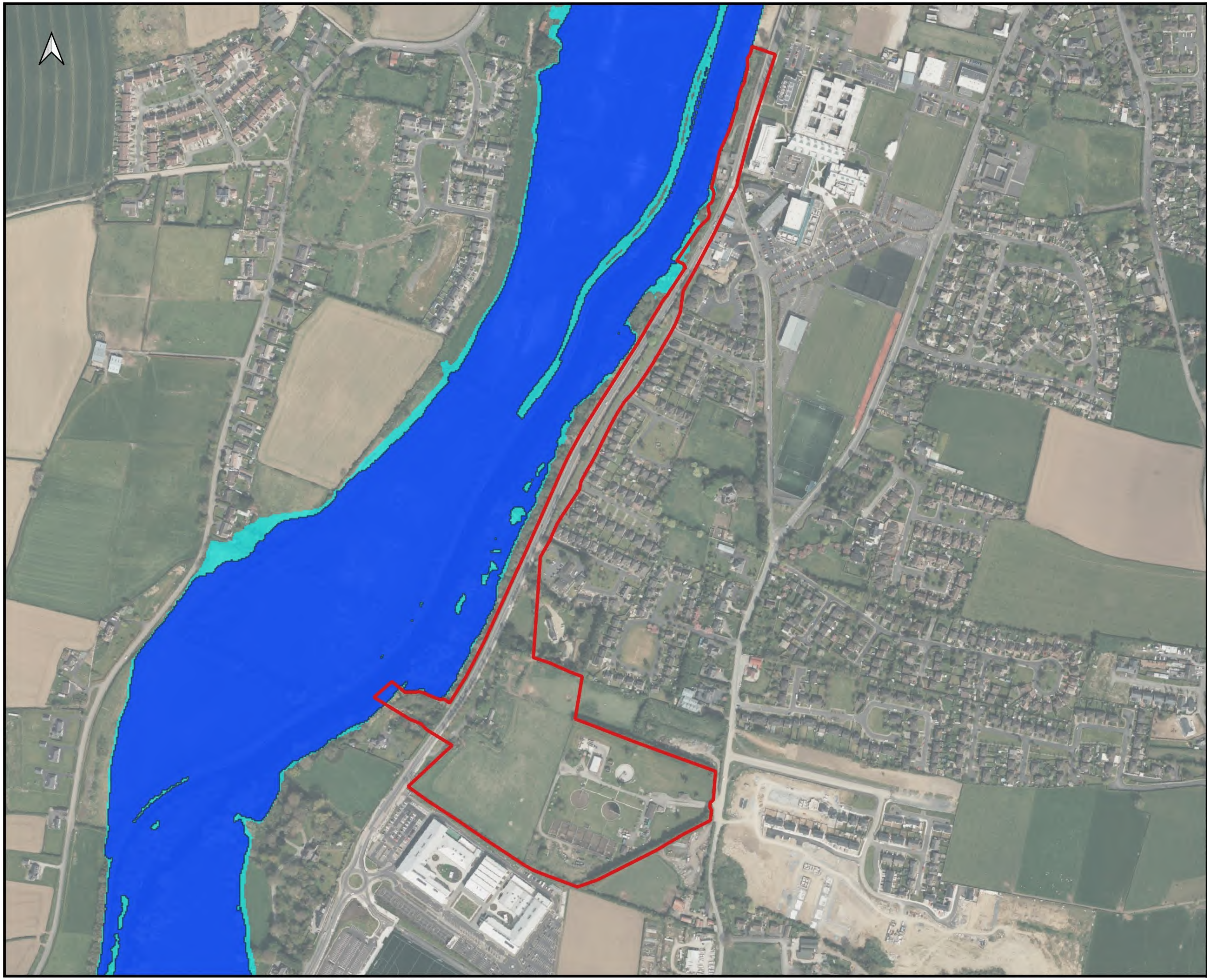

LEGEND

- WWTP UPGRADE SITE LOCATION
- 50% AEP (1 IN 2 YEAR) FLUVIAL FLOOD EXTENTS
- 1% AEP (1 IN 100 YEAR) FLUVIAL FLOOD EXTENTS

rev.	date	amendment	drn	ckd
A	26.08.25	ISSUE	MOF	PMS

PROPOSED MORTARSTOWN WWTP UPGRADE PROJECT, CARLOW

HYDRODYNAMIC ASSESSMENT

50% AEP (1 IN 2 YEAR) & 1% AEP (1 IN 100 YEAR) FLUVIAL EXTENTS
BASELINE SCENARIO

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

CARLOW OFFICE:
INNOVATION CENTRE
GREEN ROAD
CARLOW R95 W248

NEWRY OFFICE:
1 RDC HOUSE
WIN BUSINESS PARK
NEWRY BT35 6PH

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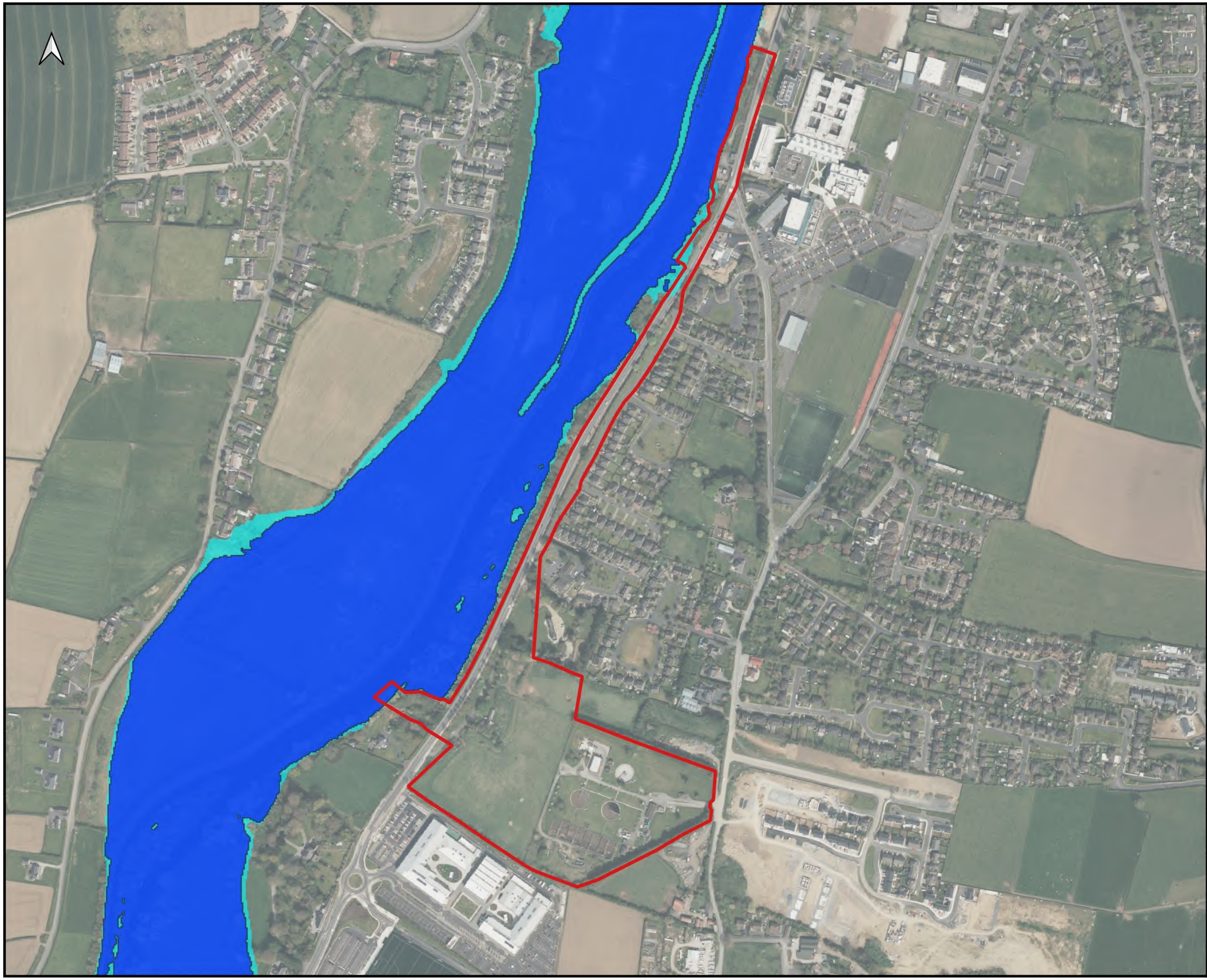

LEGEND

- WWTP UPGRADE SITE LOCATION
- 50% AEP (1 IN 2 YEAR + CLIMATE CHANGE) FLUVIAL FLOOD EXTENTS
- 1% AEP (1 IN 100 YEAR + CLIMATE CHANGE) FLUVIAL FLOOD EXTENTS

rev.	date	amendment	drn	ckd
A	26.08.25	ISSUE	MOF	PMS

PROPOSED MORTARSTOWN WWTP UPGRADE PROJECT, CARLOW

HYDRODYNAMIC ASSESSMENT

50% AEP + CC (1 IN 2 YEAR + CLIMATE CHANGE) & 1% AEP + CC (1 IN 100 YEAR + CLIMATE CHANGE) FLUVIAL EXTENTS BASELINE SCENARIO

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

CARLOW OFFICE:
INNOVATION CENTRE
GREEN ROAD
CARLOW R95 W248

NEWRY OFFICE:
1 RDC HOUSE
WIN BUSINESS PARK
NEWRY BT35 6PH

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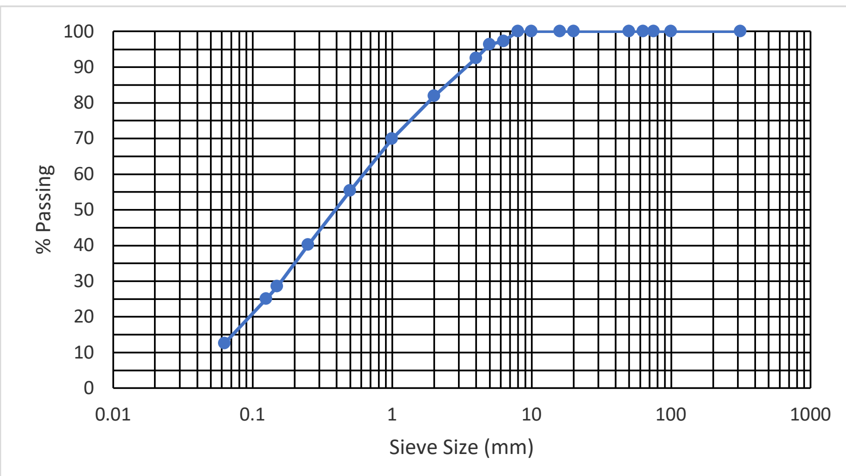
Appendix B. Particle Size Distribution

IGSL Ltd Materials Laboratory M7 Business Park Naas Co. Kildare	Test Report Determination of Particle Size Distribution Tested in accordance with BS EN ISO 17892-4:2016	ISO 17025 INAB ACCREDITED TESTING DETAILED IN SCOPE REG NO.133T

Report No.	**R168713**
Contract No.	25974
Contract Name:	River sediment Samples
Client:	IECE
Lab Sample No.	A25/1812
Client Ref*:	Sample 1
Material Type:	Soil
Sample Received:	12/05/2025
Date test started:	12/05/2025
Soil Description	Brown organic SILT/CLAY
Assumed Particle Density	2.65Mg/m^3



Sieve Size	% Passing	Sieve Size	% Passing
125	100	6.3	97
100	100	5	96
75	100	4	93
63	100	2	82
50	100	1	70
31.5	100	0.5	55
20	100	0.25	40
16	100	0.15	29
10	100	0.125	25
8	100	0.063	13

Results relate only to the specimen tested, in as received condition unless otherwise noted.
Opinions and interpretations are outside the scope of accreditation.
* denotes Customer supplied information.
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Persons authorised to approve report
J Barrett (Quality Manager)
H Byrne (Laboratory Manager)

IGSL Ltd Materials Laboratory	Approved by	Date	Page
	H Byrne	27/5/25	1 of 1

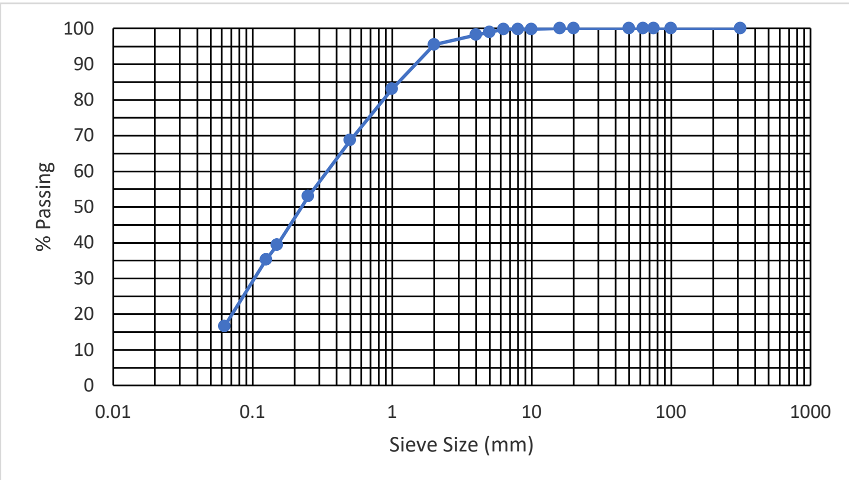
IGSL Ltd
Materials Laboratory
M7 Business Park
Naas
Co. Kildare

Test Report

Determination of Particle Size Distribution

Tested in accordance with BS EN ISO 17892-4:2016

Report No.	**R168714**
Contract No.	25974
Contract Name:	River sediment Samples
Client:	IECE
Lab Sample No.	A25/1813
Client Ref*:	Sample 2
Material Type:	Soil
Sample Received:	12/05/2025
Date test started:	12/05/2025
Soil Description	Brown organic SILT/CLAY
Assumed Particle Density	2.65Mg/m^3



Sieve Size	% Passing	Sieve Size	% Passing
125	100	6.3	100
100	100	5	99
75	100	4	98
63	100	2	96
50	100	1	83
31.5	100	0.5	69
20	100	0.25	53
16	100	0.15	39
10	100	0.125	35
8	100	0.063	17

Results relate only to the specimen tested, in as received condition unless otherwise noted.
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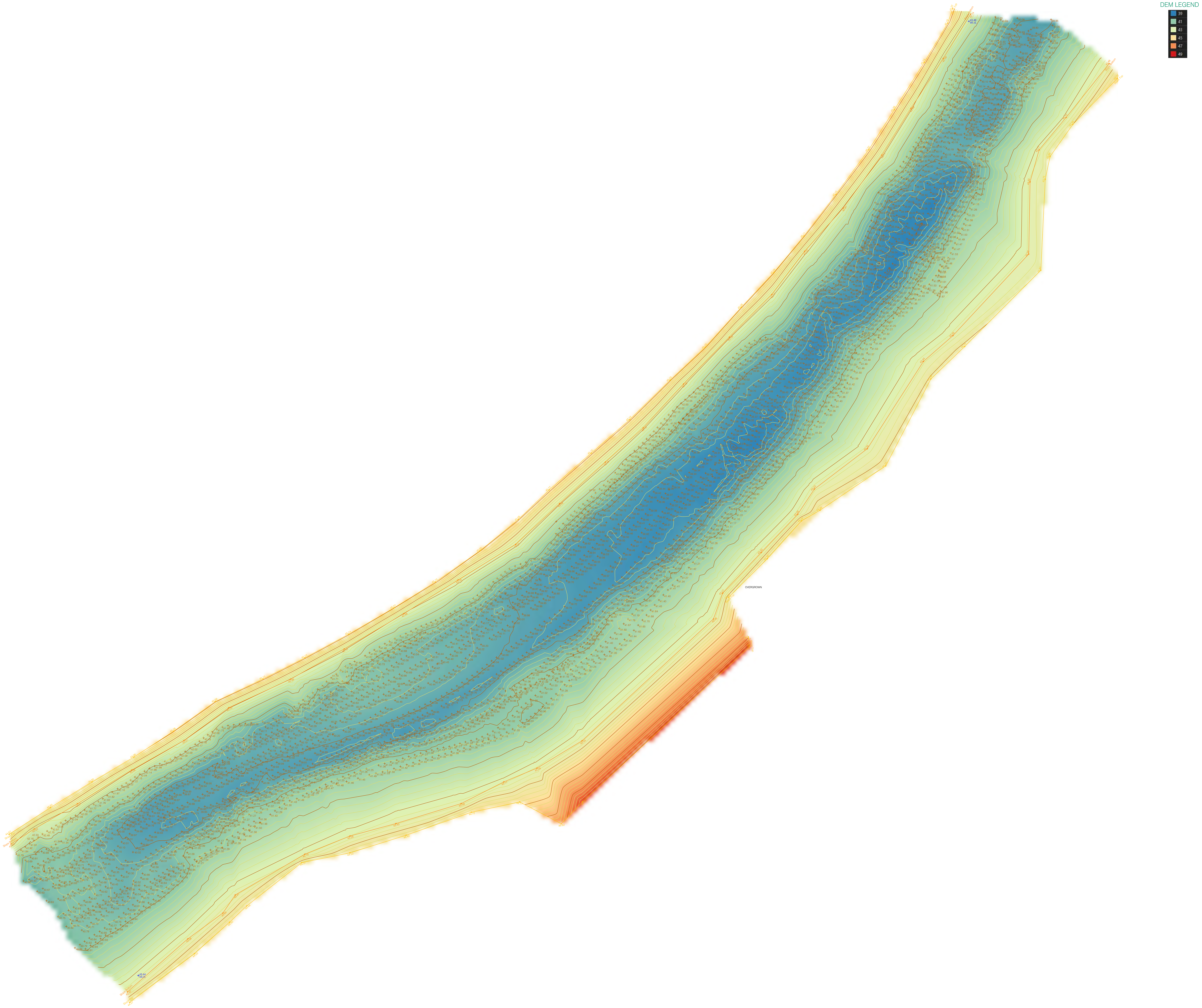
Persons authorised to approve report
J Barrett (Quality Manager)
H Byrne (Laboratory Manager)

IGSL Ltd Materials Laboratory	Approved by	Date	Page
	H Byrne	27/5/25	1 of 1

Appendix C. River Barrow Topographic Survey



DEM LEGEND

39
41
43
45
47
49

LEGEND

Street furniture & Services

Over Head Wires (LUAS) - Pylon ESB; Flowerbed; Pipe; Lift; Barrier; Pump; Trial Pit; Bus/Tram Shelter; Postbox; Valve - General; Water Valve; Gas Valve; Sluice Valve; Air Valve; Stop Cock; C P Post; Marker Post; Traffic light; Parking Meter; Plane Aerial Mark; Smart Card Validator; Unknown Valve; Bus Stop; Bollard; Beacon; Coalhole Cover; Bore Hole; Electricity Pole; Telegraph pole; OCS Pole; CCTV Camera Pole; Lamp Post; Foul Manhole; Surface Water MH; Manholes; Air Conditioning Vents; Services Inspection Cover; Traffic Inspection Cover; Cable TV Inspection Cover; ESAT Inspection Cover; NTL Inspection Cover; Eircom Inspection Cover; Rodding Eye; Road Sign; Bench Seat; Kiosk; Gully; U/G Car Park Vent; Waste Bin; Hydrant; Fire Hydrant; ESB Box; ESB Inspection Cover; Traffic Control Box; LUAS Technical Cubicle; Ticket Vending Machine; Water Meter Cover; Telecom Inspection Cover; Monument / Toilets; Tank Storage; Basement: MH. Cover & Pipe; Dished Aerial Mark; Stay for pole; Pipe Protection; Washout; Phone Box; Duct; Gas Cover; C P Box

Natural Features

Surface Change; Land Drain; Bottom of Slope; Top of Slope; Ditch; Water Edge / Lake / Pond; Hedge / Trees Drip Line / Vegetation; Tree Coniferous; Water Level; Crown Level; Invert level; Bed Level; Spotheight; Tree Deciduous; Top of Tree

Golf

Fair Way; Green; Tee Box

Other

Survey Station; Photo point

Built Features
Roads & Road Markings

Building; Edge of Road; Kerb Bottom; Kerb Top; Bridge Abutment; Bridge Deck; Bridge Parapet; Building Façade; Fence; Gate; Road Centreline; Top of Wall; Hoarding; Property Line; Road Scar; Top of Fence; Floor Level; Apex Height; Eaves Height; Parapet Height; Soffit Elevation; Step Level; Concrete Pad; Track; Footpath / Platform Train & Tram; Damp Proof Course / Verge; Bridge Pier / Wall & Gate Pillar / LUAS Trackbed; Cycleway / Private Landing Area; Wall / Retaining Wall; Railway / Tram Rail / Grating / Ramp; Building Canopy / Roof / Overhang

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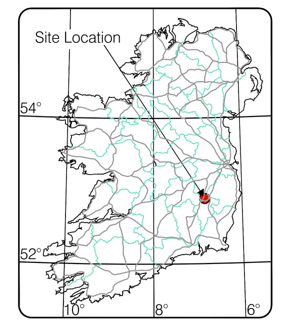
North

Site Location



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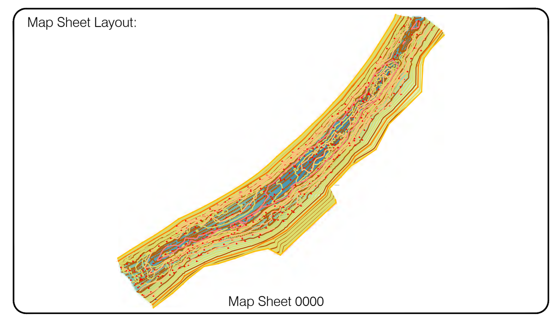

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Surveyed by : MGS Date: May 2025 Datum : Malin Hd. 15
Drawn by : CE Date: May 2025 Grid System:
Checked by : NR Date: 13.05.2025 Irish National Grid ☐ ITM ■

Revisions

No.	Date	Description
0	13.05.2025	First Drawing

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Topographic surveys, Measured Building Surveys, Setting-Out, As-Built Surveys, Hydrographic Surveys, Legal Mapping, Pipeline Surveys, Services Location, Ground Penetrating Radar, Laser Scanning, Rectified Photography

Kildare Cork Dublin Belfast Glasgow Manchester London

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Global House
Kilcullen Business Campus
Kilcullen Co. Kildare, Ireland
Phone: (+353) 045 484040
Fax: (+353) 045 484004
Email: info@murphygs.ie

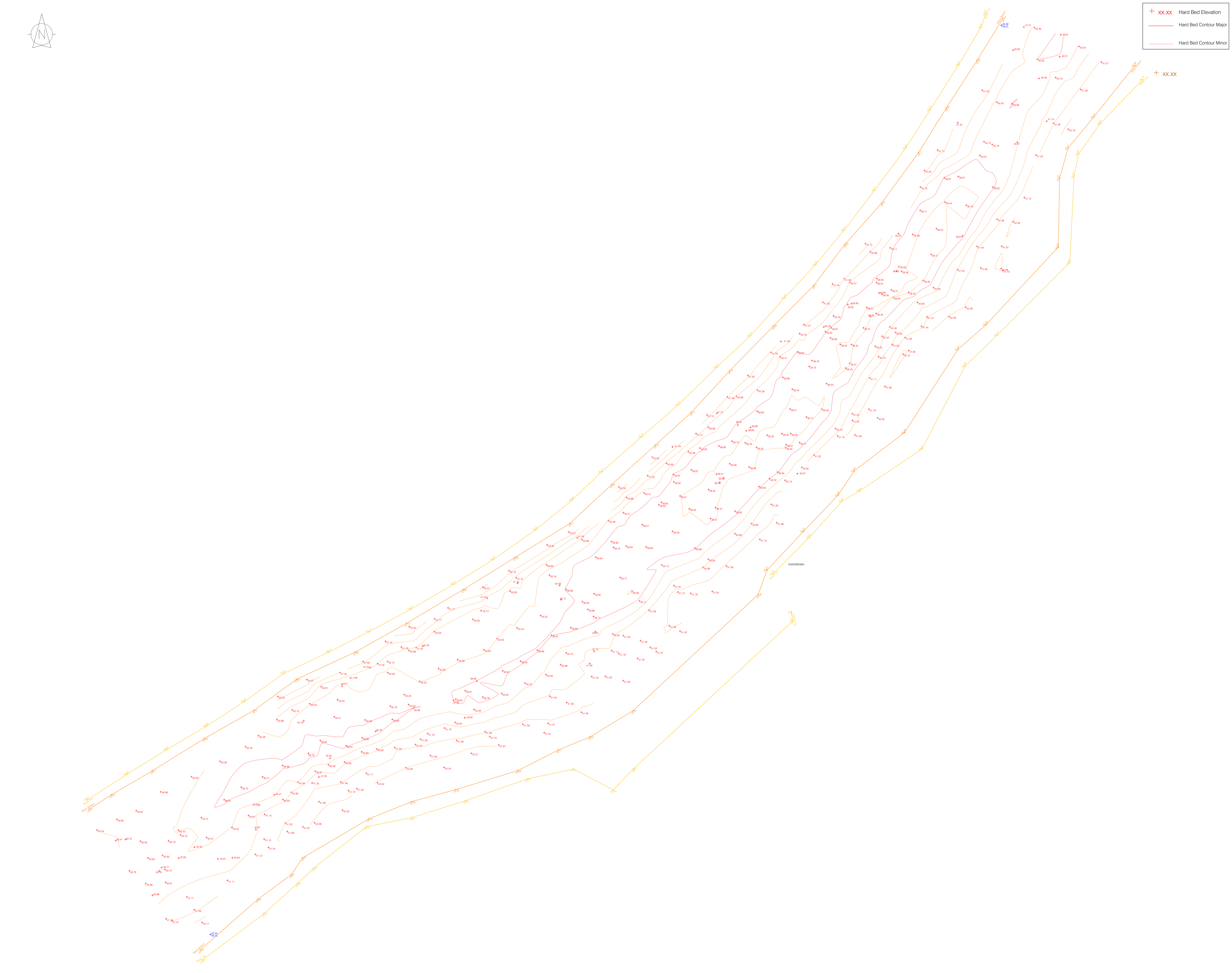
Client : IE Consulting Engineers

Project : 63112 Bathymetric Survey and Soil Sampling of River Barrow

Date : 13.05.2025 **Scale :** 1:250@A0

Description : Topographical Survey

Drawing Number : MGS63112_Barrow_Bathy_01



LEGEND

Street furniture & Services

5.12 Over Head Wires (LUAS) - Pylon ESB	Sign RS Road Sign	PBOX Phone Box
5.12 Flowerbed	Bus Stop	Bench Seat
5.12 Pipe	Bollard	Duct
5.12 Lift	BEA Beacon	Kiosk
5.12 Barrier	CH Coalhole Cover	GAS Gas Cover
5.12 Pump	BH Bore Hole	GY Gully
5.12 Trial Pit	EP Electricity Pole	CPBox C P Box
5.12 Bus/Tram Shelter	TP Telegraph pole	U/G Vent U/G Car Park Vent
5.12 Postbox	OCS OCS Pole	BIN Waste Bin
Valve - General	CP CCTV Camera Pole	HY Hydrant
WV Water Valve	LP Lamp Post	FH Fire Hydrant
GV Gas Valve	FMH or Foul Manhole	EBOX ESB Box
SV Sluice Valve	SMH or Surface Water MH	ICE ESB Inspection Cover
AV Air Valve	MH or Manholes	TFB Traffic Control Box
SC Stop Cock	AC Air Conditioning Vents	LUAS LUAS Technical Cubicle
CPP C P Post	ICU Services Inspection Cover	Ticket Vending Machine
MK Marker Post	ICTC Traffic Inspection Cover	WM Water Meter Cover
TL Traffic light	ICTV Cable TV Inspection Cover	ICT Telecom Inspection Cover
PM Parking Meter	ICES ESAT Inspection Cover	Monument / Toilets
PAM Plane Aerial Mark	ICNC NTL Inspection Cover	Tank Storage
SCV Smart Card Validator	ICEM Eircom Inspection Cover	Basement: MH, Cover & Pipe
UV Unknown Valve	RE Rodding Eye	DAM Dished Aerial Mark
		STAY Stay for pole
		PP Pipe Protection
		WO Washout

Natural Features

5.12 Surface Change	WLVL Water Level
5.12 Land Drain	CRWN Crown Level
5.12 Bottom of Slope	IL Invert level
5.12 Top of Slope	BL Bed Level
5.12 Ditch	S Spotheight
5.12 Water Edge / Lake / Pond	
Hedge / Trees Drip Line / Vegetation	
Tree Coniferous	Tree Deciduous

Golf

FWAY Fair Way
GREE Green
TBOX Tee Box

Other

S1 E: 1000.000 N: 1000.000 H: 100.00 Survey Station
Photo point
Top of Tree

Built Features
Roads & Road Markings

5.12 Building	5.12 Fence	FL 0.00 Floor Level
5.12 Edge of Road	Gate Gate	APX 0.00 Apex Height
5.12 Kerb Bottom	5.12 Road Centreline	EV 0.00 Eaves Height
5.12 Kerb Top	5.12 Top of Wall	PAR 0.00 Parapet Height
5.12 Bridge Abutment	5.12 Hoarding	SOFF 0.00 Soffit Elevation
5.12 Bridge Deck	5.12 Property Line	STPL 5.12 Step Level
5.12 Bridge Parapet	5.12 Road Scar	CONC Concrete Pad
5.12 Building Façade	5.12 Top of Fence	5.12 Track
5.12 Footpath / Platform Train & Tram	5.12 Wall / Retaining Wall	
5.12 Damp Proof Course / Verge	5.12 Railway / Tram Rail / Grating / Ramp	
5.12 Bridge Pier / Wall & Gate Pillar / LUAS Trackbed	5.12 Building Canopy / Roof / Overhang	
5.12 Cycleway / Private Landing Area		

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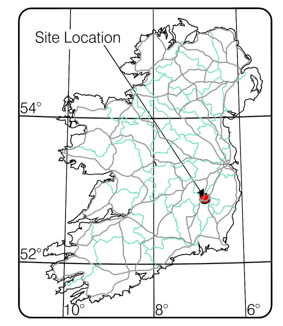
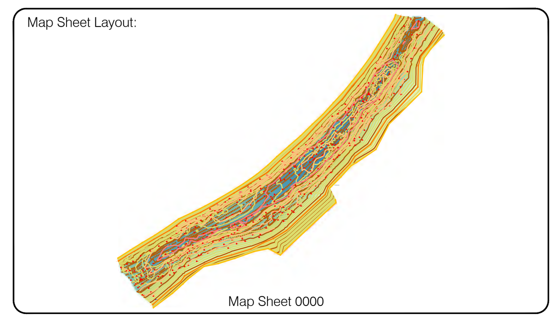
North





Surveyed by : MGS	Date: May 2025	Datum : Malin Hd. 15
Drawn by : CE	Date: May 2025	Grid System:
Checked by : NR	Date: 13.05.2025	Irish National Grid ☐ ITM ■

Revisions

No.	Date	Description
0	13.05.2025	First Drawing

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Head Office

Global House	**Phone:**	**(+353) 045 484040**
Kilcullen Business Campus	**Fax:**	**(+353) 045 484004**
Kilcullen Co. Kildare, Ireland	**Email:**	**info@murphygs.ie**

Client : IE Consulting Engineers

Project : 63112 Bathymetric Survey and Soil Sampling of River Barrow

Date : 13.05.2025 | **Scale :** 1:250@A0

Description : Topographical Survey

Drawing Number : MGS63112_Barrow_Bathy_Hard Bed_02

Appendix D. Impact of Construction Stage on River Barrow Water Levels

LEGEND

- WWTP UPGRADE SITE LOCATION
- PROPOSED WWTP LAYOUT
- SHEET PILING

<u>IMPACT ON WATER LEVELS DURING 5%ILE - CONSTRUCTION STAGE SCENARIO</u>

- <= -0.04M
- -0.04 - -0.03M
- -0.03 - -0.02M
- -0.02 - -0.01M
- 0.01 - 0.02M
- 0.02 - 0.03M
- 0.03 - 0.04M
- > 0.04M

rev.	date	amendment	drn	ckd
A	26.08.25	ISSUE	MOF	PMS

PROPOSED MORTARSTOWN WWTP UPGRADE PROJECT, CARLOW

HYDRODYNAMIC ASSESSMENT

5%ILE CHANGE IN WATER LEVELS CONSTRUCTION STAGE SCENARIO

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

CARLOW OFFICE:
INNOVATION CENTRE
GREEN ROAD
CARLOW R95 W248

NEWRY OFFICE:
1 RDC HOUSE
WIN BUSINESS PARK
NEWRY BT35 6PH

file location: N:\IE3120\DRAWINGS	scale: 1:1,500	A3
drawing status: PLANNING	datum: MALIN	
	drawn: MOF	
drawing no. IE3120-100	rev: A	checked: PMS
		approved: PMS
		date: 26/08/2025

LEGEND

- WWTP UPGRADE SITE LOCATION
- PROPOSED WWTP LAYOUT
- SHEET PILING

IMPACT ON WATER LEVELS
DURING 5%ILE + CC
- CONSTRUCTION STAGE SCENARIO

- <= -0.04M
- -0.04 - -0.03M
- -0.03 - -0.02M
- -0.02 - -0.01M
- 0.01 - 0.02M
- 0.02 - 0.03M
- 0.03 - 0.04M
- > 0.04M

rev.	date	amendment	drn	ckd
A	26.08.25	ISSUE	MOF	PMS

PROPOSED MORTARSTOWN WWTP UPGRADE PROJECT, CARLOW

HYDRODYNAMIC ASSESSMENT

5%ILE + CC CHANGE IN WATER LEVELS CONSTRUCTION STAGE SCENARIO

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

CARLOW OFFICE:
INNOVATION CENTRE
GREEN ROAD
CARLOW R95 W248

NEWRY OFFICE:
1 RDC HOUSE
WIN BUSINESS PARK
NEWRY BT35 6PH

file location: N:\IE3120\DRAWINGS

scale: 1:1,500 | A3

drawing status: PLANNING

datum: MALIN

drawn: MOF

checked: PMS

approved: PMS

drawing no. IE3120-101

rev: A

date: 26/08/2025

NOTE: THERE IS NO IMPACT ON WATER LEVELS DURING THE CONSTRUCTION STAGE SCENARIO DURING THE 50% FLUVIAL EVENT

LEGEND

- WWTP UPGRADE SITE LOCATION
- PROPOSED WWTP LAYOUT
- SHEET PILING

IMPACT ON WATER LEVELS DURING 50%ILE - CONSTRUCTION STAGE SCENARIO

- <= -0.04M
- -0.04 - -0.03M
- -0.03 - -0.02M
- -0.02 - -0.01M
- -0.01 - 0.00M
- 0.00 - 0.01M
- 0.01 - 0.02M
- 0.02 - 0.03M
- 0.03 - 0.04M
- > 0.04M

rev.	date	amendment	drn	ckd
A	26.08.25	ISSUE	MOF	PMS

PROPOSED MORTARSTOWN WWTP UPGRADE PROJECT, CARLOW

HYDRODYNAMIC ASSESSMENT

50%ILE CHANGE IN WATER LEVELS CONSTRUCTION STAGE SCENARIO

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GREEN ROAD
CARLOW R95 W248

NEWRY OFFICE:
1 RDC HOUSE
WIN BUSINESS PARK
NEWRY BT35 6PH

file location: N:\IE3120\DRAWINGS		scale: 1:1,500	A3
drawing status: PLANNING		datum: MALIN	
		drawn: MOF	
drawing no. IE3120-102	rev: A	checked: PMS	
		approved: PMS	
		date: 26/08/2025	

NOTE: THERE IS NO IMPACT ON WATER LEVELS DURING THE CONSTRUCTION STAGE SCENARIO DURING THE 50% + CC FLUVIAL EVENT

LEGEND

- WWTP UPGRADE SITE LOCATION
- PROPOSED WWTP LAYOUT
- SHEET PILING

IMPACT ON WATER LEVELS DURING 50%ILE + CC - CONSTRUCTION STAGE SCENARIO

- <= -0.04M
- -0.04 - -0.03M
- -0.03 - -0.02M
- -0.02 - -0.01M
- 0.01 - 0.02M
- 0.02 - 0.03M
- 0.03 - 0.04M
- > 0.04M

rev.	date	amendment	drn	ckd
A	26.08.25	ISSUE	MOF	PMS

PROPOSED MORTARSTOWN WWTP UPGRADE PROJECT, CARLOW

HYDRODYNAMIC ASSESSMENT

50%ILE + CC CHANGE IN WATER LEVELS CONSTRUCTION STAGE SCENARIO

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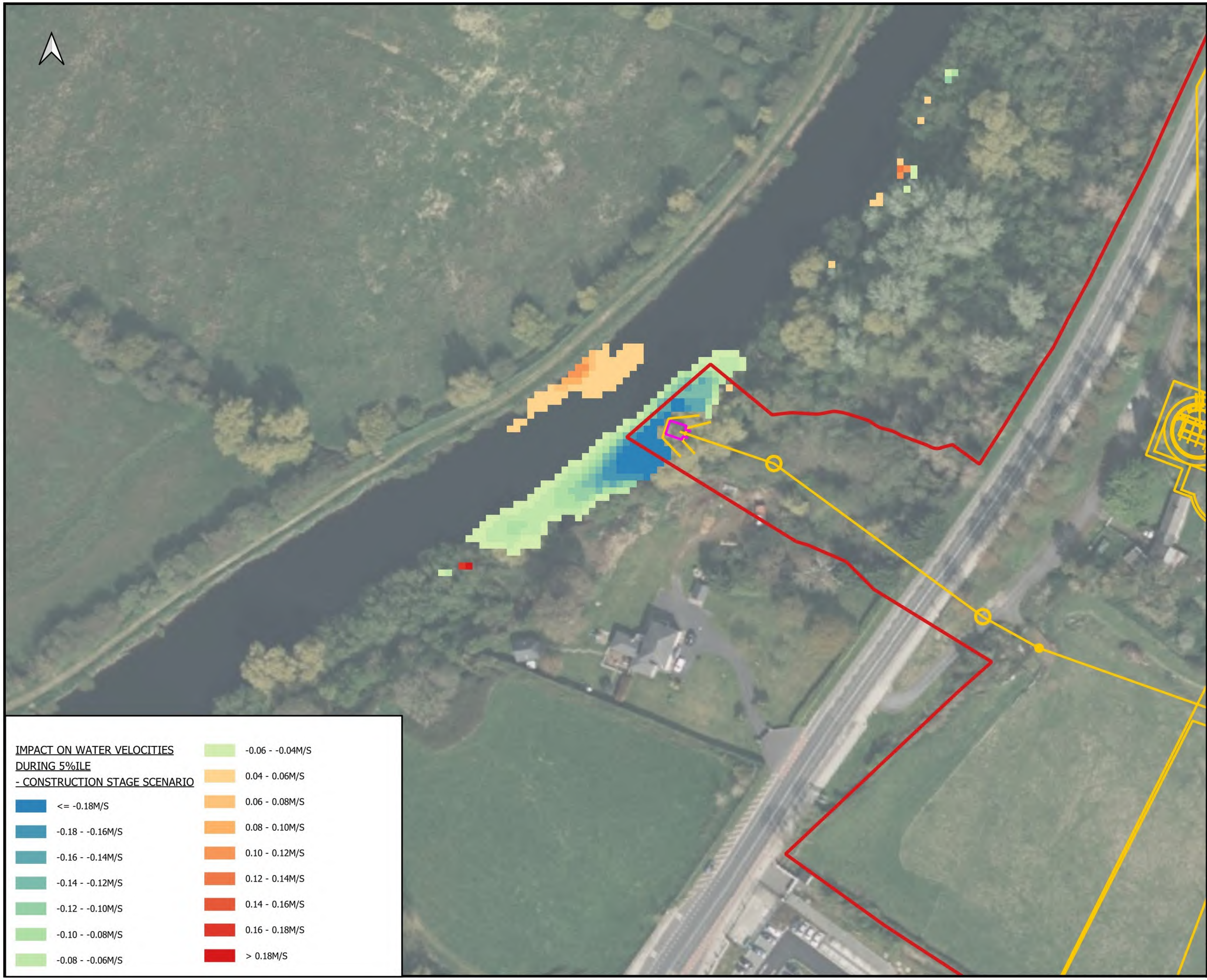
GREEN ROAD
CARLOW R95 W248

NEWRY OFFICE:
1 RDC HOUSE
WIN BUSINESS PARK
NEWRY BT35 6PH

file location: N:\IE3120\DRAWINGS		scale: 1:1,500	A3
drawing status: PLANNING		datum: MALIN	
		drawn: MOF	
drawing no. IE3120-103	rev: A	checked: PMS	
		approved: PMS	
		date: 26/08/2025	

Appendix E. Impact of Construction Stage on River Barrow Velocities



LEGEND

WWTP UPGRADE SITE LOCATION

PROPOSED WWTP LAYOUT

SHEET PILING

rev.	date	amendment	drn	ckd
A	26.08.25	ISSUE	MOF	PMS

PROPOSED MORTARSTOWN WWTP UPGRADE PROJECT, CARLOW

HYDRODYNAMIC ASSESSMENT

5%ILE CHANGE IN WATER VELOCITIES
CONSTRUCTION STAGE SCENARIO

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WATER-ENVIRONMENTAL-CIVIL

CARLOW OFFICE:
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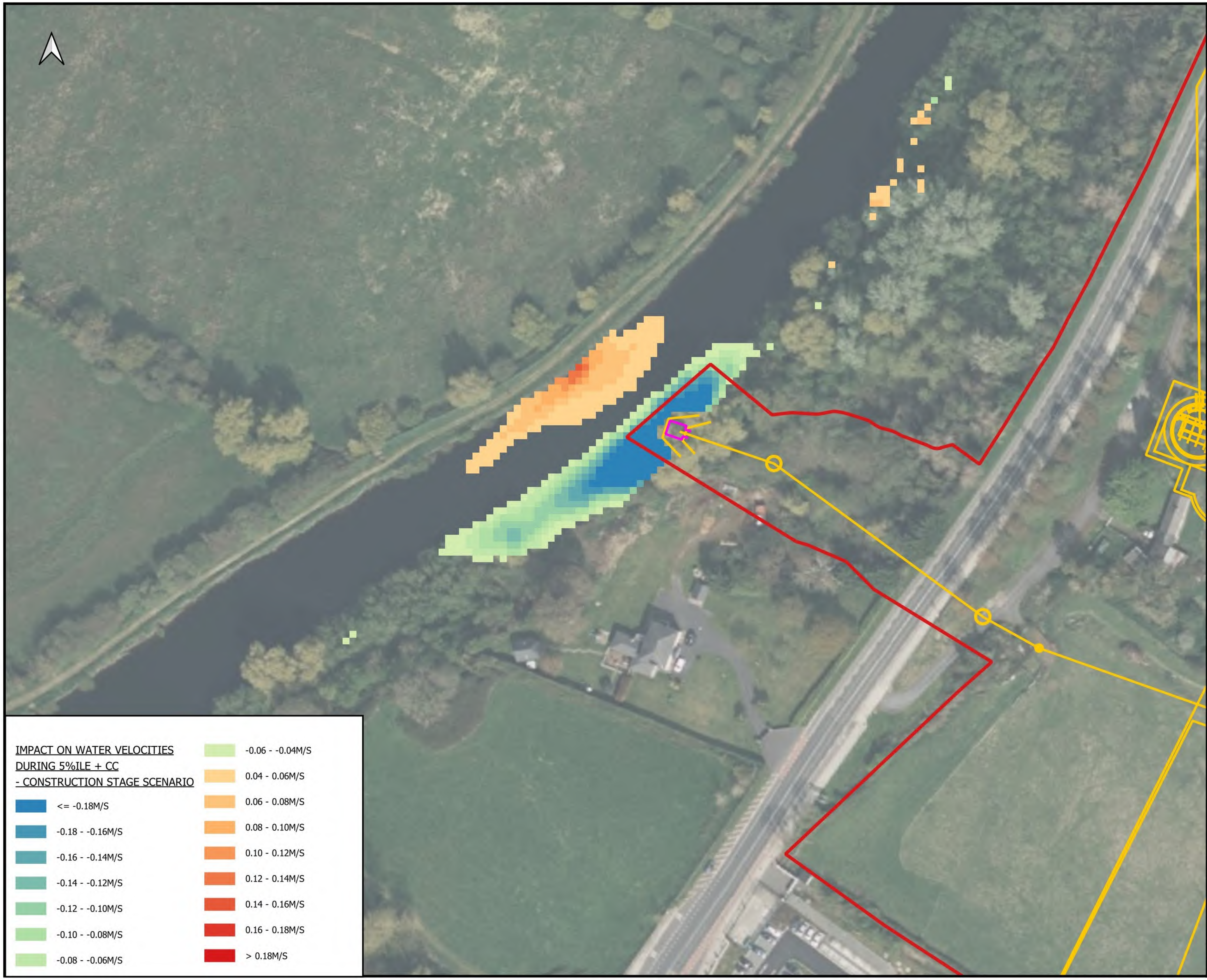
GREEN ROAD
CARLOW R95 W248

NEWRY OFFICE:
1 RDC HOUSE
WIN BUSINESS PARK
NEWRY BT35 6PH

file location: N:\IE3120\DRAWINGS		scale: 1:1,500	A3
drawing status: PLANNING		datum: MALIN	
		drawn: MOF	
drawing no. IE3120-200	rev: A	checked: PMS	
		approved: PMS	
		date: 26/08/2025	



LEGEND

- WWTP UPGRADE SITE LOCATION
- PROPOSED WWTP LAYOUT
- SHEET PILING

rev.	date	amendment	drn	ckd
A	26.08.25	ISSUE	MOF	PMS

PROPOSED MORTARSTOWN WWTP UPGRADE PROJECT, CARLOW

HYDRODYNAMIC ASSESSMENT

5%ILE + CC CHANGE IN WATER VELOCITIES CONSTRUCTION STAGE SCENARIO

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

CARLOW OFFICE:
INNOVATION CENTRE
GREEN ROAD
CARLOW R95 W248

NEWRY OFFICE:
1 RDC HOUSE
WIN BUSINESS PARK
NEWRY BT35 6PH

file location: N:\IE3120\DRAWINGS	scale: 1:1,500	A3
drawing status: PLANNING	datum: MALIN	
	drawn: MOF	
drawing no. IE3120-201	rev: A	checked: PMS
		approved: PMS
		date: 26/08/2025

LEGEND

- WWTP UPGRADE SITE LOCATION
- PROPOSED WWTP LAYOUT
- SHEET PILING

IMPACT ON WATER VELOCITIES DURING 50%ILE - CONSTRUCTION STAGE SCENARIO

- <= -0.18M/S
- -0.18 - -0.16M/S
- -0.16 - -0.14M/S
- -0.14 - -0.12M/S
- -0.12 - -0.10M/S
- -0.10 - -0.08M/S
- -0.08 - -0.06M/S
- -0.06 - -0.04M/S
- 0.04 - 0.06M/S
- 0.06 - 0.08M/S
- 0.08 - 0.10M/S
- 0.10 - 0.12M/S
- 0.12 - 0.14M/S
- 0.14 - 0.16M/S
- 0.16 - 0.18M/S
- > 0.18M/S

NOTE: THERE IS NO IMPACT ON VELOCITIES DURING THE CONSTRUCTION STAGE SCENARIO DURING THE 50% FLUVIAL EVENT

rev.	date	amendment	drn	ckd
A	26.08.25	ISSUE	MOF	PMS

PROPOSED MORTARSTOWN WWTP UPGRADE PROJECT, CARLOW

HYDRODYNAMIC ASSESSMENT

50%ILE CHANGE IN WATER VELOCITIES CONSTRUCTION STAGE SCENARIO

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

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INNOVATION CENTRE
GREEN ROAD
CARLOW R95 W248

NEWRY OFFICE:
1 RDC HOUSE
WIN BUSINESS PARK
NEWRY BT35 6PH

file location: N:\IE3120\DRAWINGS	scale: 1:1,500	A3
drawing status: PLANNING	datum: MALIN	
	drawn: MOF	
drawing no. IE3120-202	rev: A	checked: PMS
		approved: PMS
		date: 26/08/2025

IMPACT ON WATER VELOCITIES
DURING 50%ILE + CC
- CONSTRUCTION STAGE SCENARIO

- <= -0.18M/S
- -0.18 - -0.16M/S
- -0.16 - -0.14M/S
- -0.14 - -0.12M/S
- -0.12 - -0.10M/S
- -0.10 - -0.08M/S
- -0.08 - -0.06M/S
- -0.06 - -0.04M/S
- 0.04 - 0.06M/S
- 0.06 - 0.08M/S
- 0.08 - 0.10M/S
- 0.10 - 0.12M/S
- 0.12 - 0.14M/S
- 0.14 - 0.16M/S
- 0.16 - 0.18M/S
- > 0.18M/S

LEGEND

- WWTP UPGRADE SITE LOCATION
- PROPOSED WWTP LAYOUT
- SHEET PILING

rev.	date	amendment	drn	ckd
A	26.08.25	ISSUE	MOF	PMS

PROPOSED MORTARSTOWN WWTP UPGRADE PROJECT, CARLOW

HYDRODYNAMIC ASSESSMENT

50%ILE +CC CHANGE IN WATER VELOCITIES CONSTRUCTION STAGE SCENARIO

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

CARLOW OFFICE:
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GREEN ROAD
CARLOW R95 W248

NEWRY OFFICE:
1 RDC HOUSE
WIN BUSINESS PARK
NEWRY BT35 6PH

file location: N:\IE3120\DRAWINGS		scale: 1:1,500	A3
drawing status: PLANNING		datum: MALIN	
		drawn: MOF	
drawing no. IE3120-203	rev: A	checked: PMS	
		approved: PMS	
		date: 26/08/2025	