Site Specific Flood Risk Assessment

Strategic Housing Development
Carley's Bridge, Enniscorthy, Co. Wexford

March 2022

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

Site Specific Flood Risk Assessment

Client: Torca Developments Ltd.

Location: Carley's Bridge, Enniscorthy, Co. Wexford

Date: 25th March 2022

Document Control

PROJECT NUMBER: IE2066		DOCUMENT REF: IE2066_Report_4152			
7.0	Issue	NOM	PMS	PMS	25/03/2022
6.0	Issue	NOM	PMS	PMS	07/10/2021
5.0	Issue	NOM	PMS	PMS	24/09/2021
4.0	Draft	NOM	PMS	PMS	23/08/2021
3.0	Issue	NOM	PMS	PMS	04/06/2020
2.0	Draft	NOM	PMS	PMS	04/06/2020
1.0	Draft	NOM	PMS	PMS	02/06/2020
Revision	Purpose Description	Originated	Checked	Reviewed	Date

CARLOW OFFICE: INNOVATION CENTRE, GREEN ROAD, CARLOW, R93 W248
Tel: 059 91 33084 Email: info@iece.ie Web: www.iece.ie

NEWRY OFFICE: 1 RDC HOUSE, WIN BUSINESS PARK, NEWRY, BT35 6PH
Tel: 048 302 57974 Email: info@iece.ie Web: www.iece.ie

Contents

Appendices

1. Introduction

IE Consulting was requested by Torca Developments Limited to undertake a Site Specific Flood Risk Assessment (SSFRA) for a proposed Strategic Housing Development site at Carley's Bridge, Enniscorthy, Co. Wexford.

The proposed Strategic Housing Development will comprise a residential development of 233 no. units (53 no., 3-4 bed houses and 180 no. 1/2/3 bed duplexes/apartments). Provision of a creche. Associated car parking, bicycle parking, and open spaces/landscaping. Vehicular and pedestrian accesses provided via Carley's Bridge Road to the north west, pedestrian/cyclist access via Carley's Bridge Road to the north and Millbrook Residential Estate to the east of the site. All associated site works including boundary treatments, plant, bin stores, site services and connections to facilitate the development.

The purpose of this SSFRA is to assess the potential flood risk to the proposed development site and to assess the impact that development of the site may or may not have on the hydrological regime of the area.

A hydrological engineer from IE Consulting undertook a survey of the site area and surrounding catchment on the 12th December 2017.

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

This flood risk assessment study has been undertaken in consideration of the following guidance document:

'*The Planning System and Flood Risk Management – Guidelines for Planning Authorities*' DOEHLG 2009.

2. Proposed Site Description

2.1. General

The proposed development site is located at Carley's Bridge, Enniscorthy, Co. Wexford. The site is bounded to the north by the Carley's Bridge Road and existing residential dwellings, to the east by existing residential dwellings, to the south by a Field Drain and to the west by the River Urrin and the River Lyre. The total area of the proposed development site is approximately 8.71 hectares.

The location of the proposed development site is illustrated on *Figure 1* below and shown on *Drawing Number IE2066-001-B* in *Appendix A*.

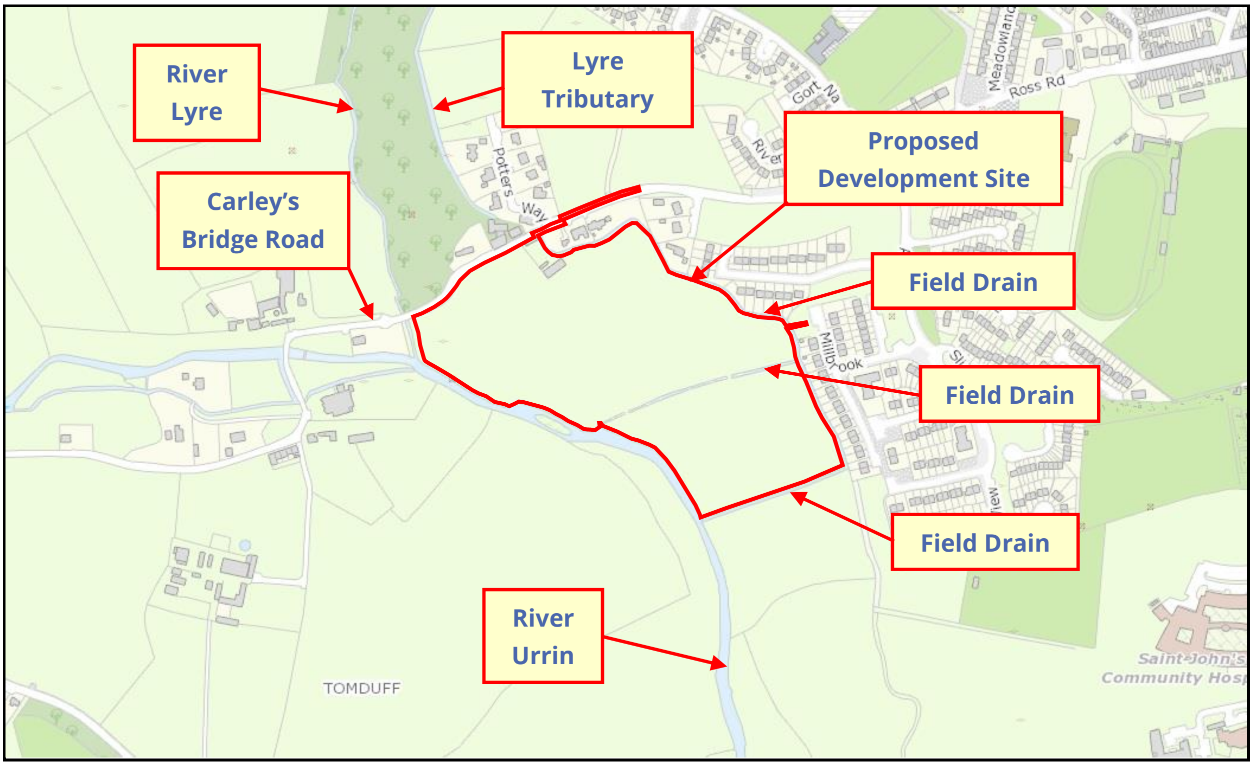


Figure 1- Site Location

2.2. Existing Topography Levels at Site

The proposed development site slopes steeply from the northern boundary of the site to the southern boundary of the site at an average gradient of approximately 7.1% (1 in 14).

Existing ground elevations range from approximately 20.313m OD (Malin) in the northern area of the site to 2.631m OD (Malin) in the southern area of the site.

2.3. Local Hydrology, Landuse & Existing Drainage

The most immediate and significant hydrological feature in the vicinity of the proposed site is the River Urrin, which flows adjacent to the south-western boundary of the proposed development site in a north-west to south-east direction. The catchment area of River Urrin was delineated and found to be approximately 114km^2 a point downstream of the site. An Assessment of the River Urrin upstream catchment area indicates that the catchment is predominantly rural in nature with urban development accounting for approximately 0.28% of the total catchment area.

3. Initial Flood Risk Assessment

The flood risk assessment for the proposed development site is undertaken in three principle stages, these being *'Step 1 – Screening'*, *'Step 2 – Scoping'* and *'Step 3 – Assessing'*.

3.1. Possible Flooding Mechanisms

Table 1 below summarises the possible flooding mechanisms in consideration of the proposed development site:

Source/Pathway	Significant?	Comment/Reason
Tidal/Coastal	No	The site is not located within a coastal region.
Fluvial	Yes	The River Urrin and the River Lyre are located adjacent to the western boundary of the site. There are field drains located around the northern and eastern boundaries and one crossing the middle of the proposed development site.
Pluvial (urban drainage)	Possible	There is existing urban drainage and water supply infrastructure located within and adjacent to the boundary of the site.
Pluvial (overland flow)	No	The site is not surrounded by significantly elevated lands and does not provide an important surface water discharge point to adjacent lands.
Blockage	Possible	There is a river bridge on the River Lyre located on Carley's Bridge Road upstream of the site.
Groundwater	No	There are no significant springs or groundwater discharges mapped or recorded in the immediate vicinity of the site

Table 1: Flooding Mechanisms

The primary potential flood risk to the proposed development site can be attributed to an extreme fluvial flood event in the River Urrin, River Lyre or in the field drains in the vicinity of the site. Secondary flood risk can be attributed to a surcharge due to blockage of the bridge located upstream of the proposed development site or from a possible surcharge of the urban drainage and water supply infrastructure in the vicinity of the site.

In accordance with '*The Planning System and Flood Risk Management – Guidelines for Planning Authorities - DOEHLG 2009*' these potential flood risks are analysed in the subsequent 'Screening Assessment' and "Scoping Assessment" section of this study report.

4. Screening Assessment

The purpose of the screening assessment is to establish the level of flooding risk that may or may not exist for a particular site and to collate and assess existing current or historical information and data which may indicate the level or extent of any flood risk.

If there is a potential flood risk issue then the flood risk assessment procedure should move to *'Step 2 – Scoping Assessment'* or if no potential flood risk is identified from the screening stage then the overall flood risk assessment can end at *'Step 1'*.

The following information and data was collated as part of the flood risk screening assessment for the proposed development site.

4.1. OPW/EPA/Local Authority Hydrometric Data

Existing sources of OPW, EPA and local authority hydrometric data were investigated. This assessment has determined that there are two existing hydrometric gauging stations located on the River Urrin, with one station located immediately upstream of the site and one downstream of the proposed site as shown in *Figure 2* below.

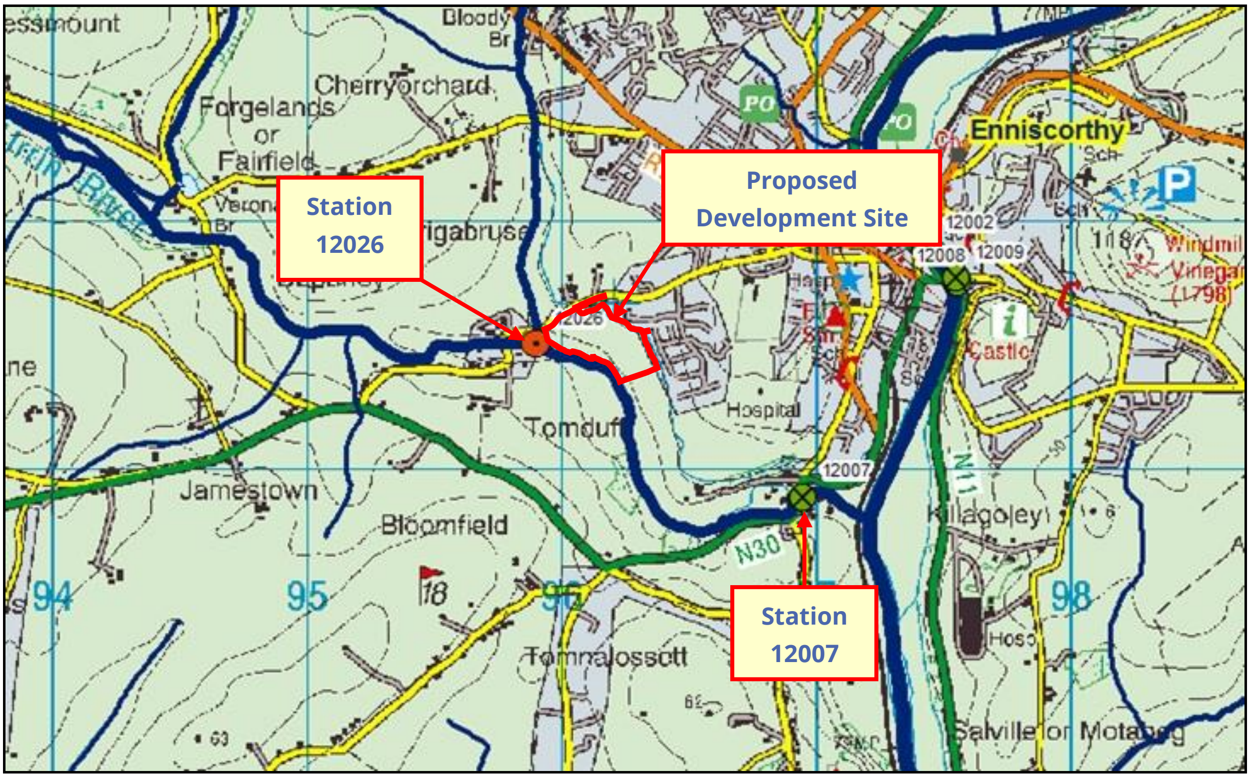


Figure 2 – Hydrometric Gauging Stations

These gauging stations are entered in the register of hydrometric gauging stations as station number 12026 (Carley's Bridge) and station number 12007 (St John's Bridge).

Station 12026 is entered into the Register of Hydrometric Stations in Ireland as an inactive staff gauge. Sixteen years of water level measurement data is available for this station for hydrometric years 1982-1998, however annual maxima data was not recorded for these years and is therefore considered to be unsuitable to assist in the prediction of extreme flood levels at the location of the proposed development site.

Station 12007 is entered into the Register of Hydrometric Stations in Ireland as an active hydrometric recorder. Fourteen years of water level measurement data is available for this station for hydrometric years 2003 to the present; however annual maxima data was not recorded for these years and is therefore not considered suitable to assist in the prediction of extreme flood levels at the location of the proposed development site.

4.2. OPW PFRA Indicative Flood Mapping

Preliminary Flood Risk Assessment (PFRA) Mapping for Ireland was produced by the OPW in 2011. OPW PFRA flood map number 2019/MAP/124/A illustrates indicative flood zones within this area of County Wexford.

Figure 3 below illustrates an extract from the above indicative flood map in the vicinity of the proposed development site. The PFRA flood mapping indicates an indicative fluvial flood zone within part of the south-western area of the proposed development site. There are no mapped indicative pluvial or groundwater flood zones within the boundary of the proposed development.

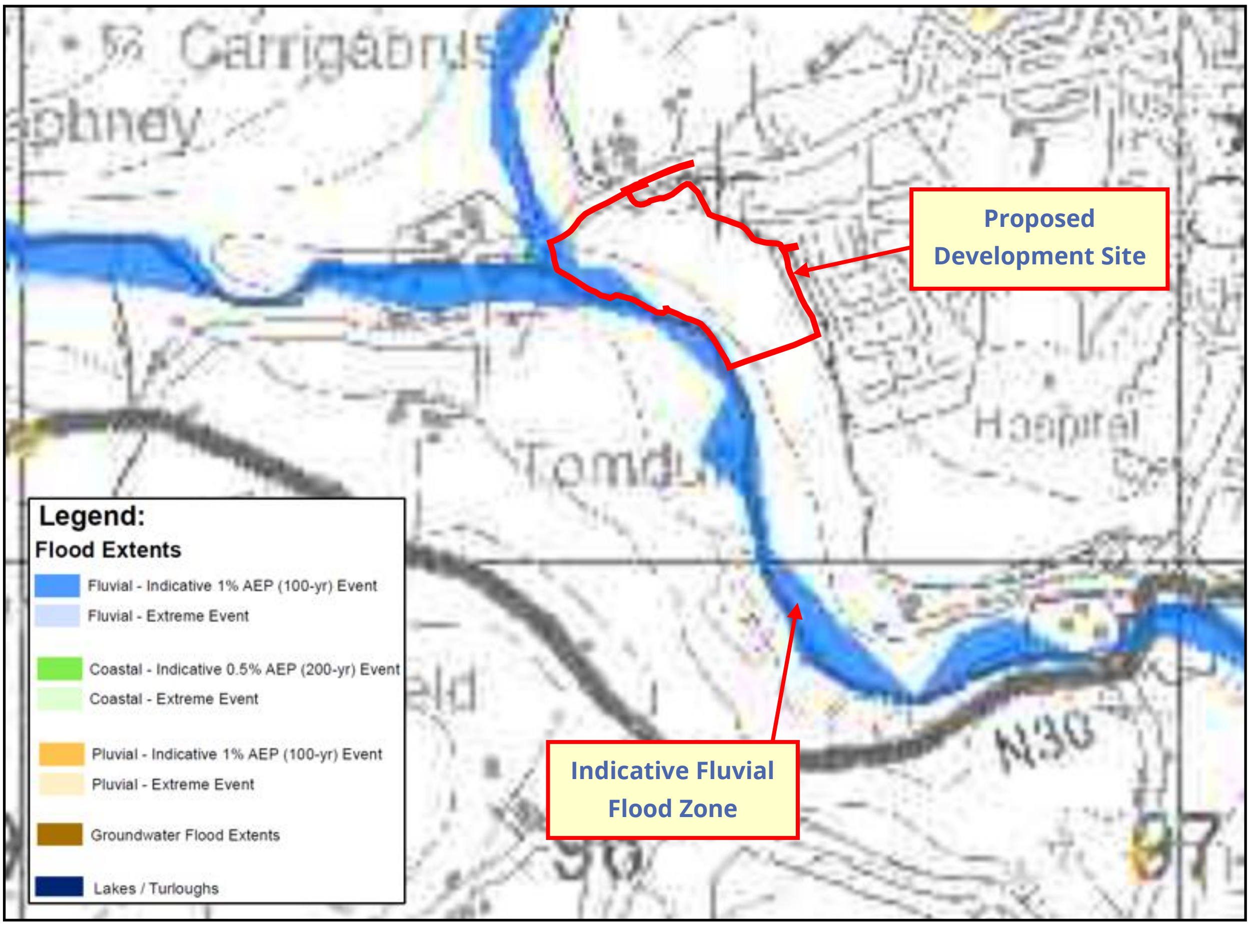


Figure 3 – PFRA Mapping

Figure 4 below illustrates the PFRA indicative flood zones from *Figure 3* overlaid onto higher resolution background mapping.

It should be noted that the indicated extent of flooding illustrated on these maps was developed using a low resolution digital terrain model (DTM) and illustrated flood extents are intended to be indicative only. The flood extents mapped on the PFRA maps are not intended to be used on a site specific basis.

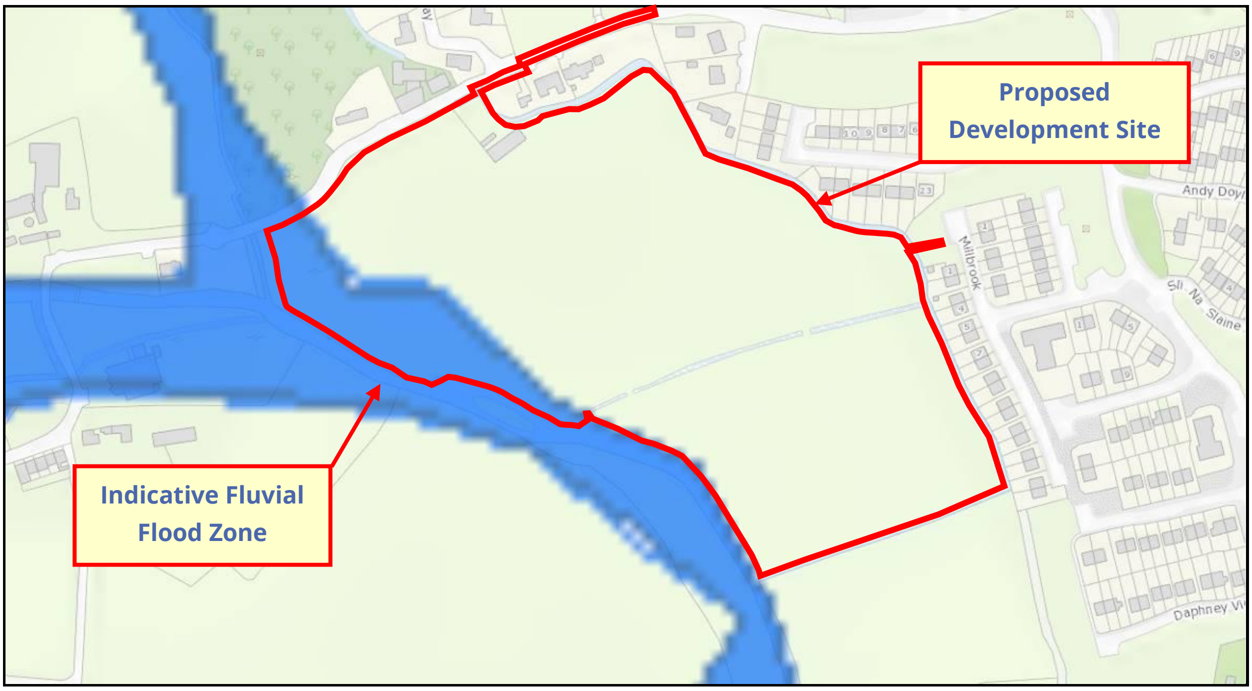


Figure 4 – PFRA Fluvial Mapping

4.3. OPW Flood Maps Website

The OPW Flood Maps Website (www.floods.ie) was consulted in relation to available historical or anecdotal information on any flooding incidences or occurrences in the vicinity of the proposed development site. *Figure 5* below illustrates mapping from the Flood Maps website in the vicinity of the site.

Figure 5 indicates that there are no recorded or anecdotal instances of flooding at or in the immediate vicinity of the proposed development site. A flood point is mapped to the west of the proposed development site, which relates to a flooding event that occurred in November 2000. There was flooding identified on the Carley's Bridge Road north-west of the proposed site, where severe damage was caused by flood waters, including road blockages as well as bridges and private property damage.

It is not known as to whether the above flood occurrence had any impact on the area of the proposed development site.

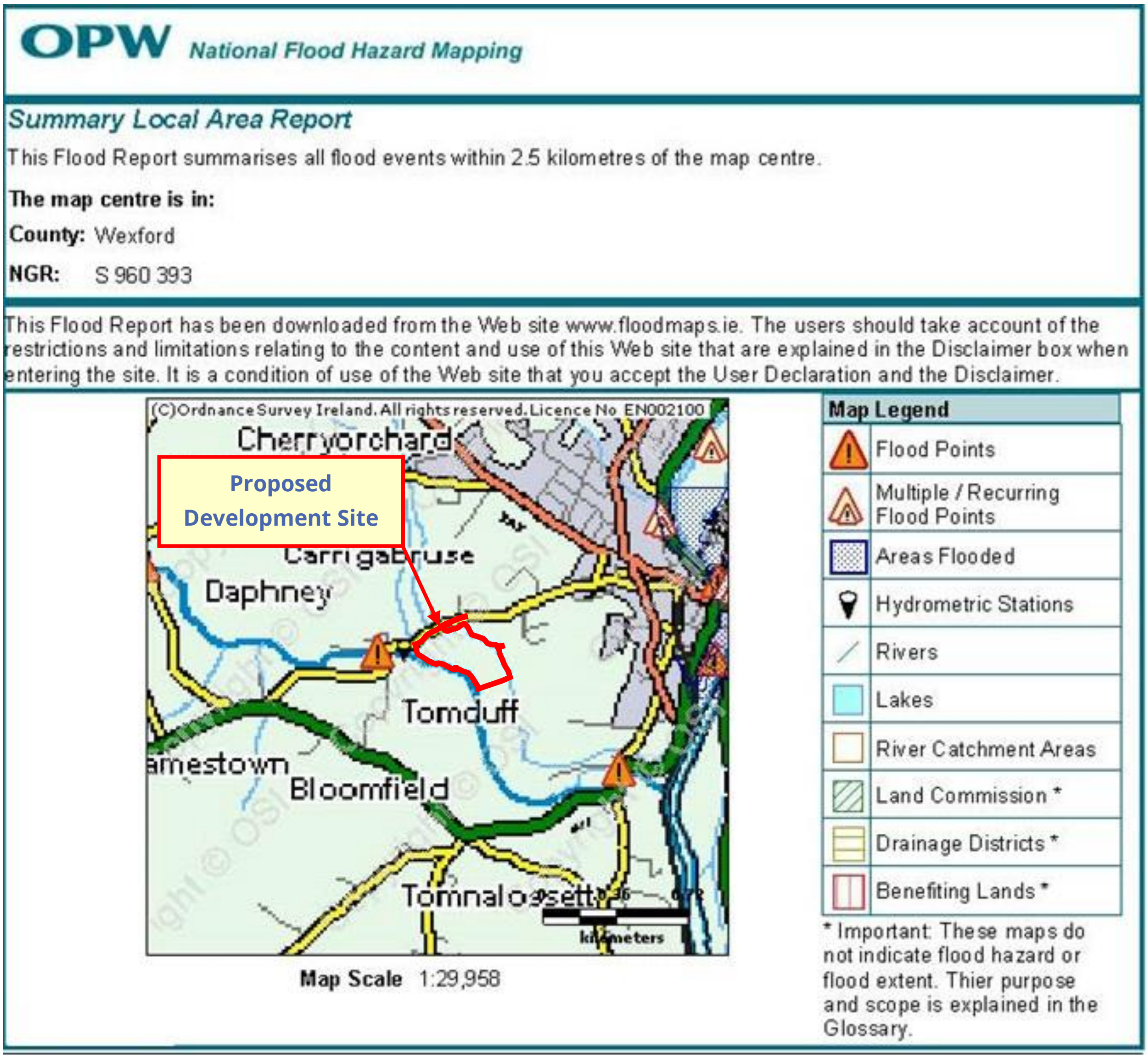


Figure 5 – OPW Flood Maps

4.4. Reported Flooding Incident in Millbrook Estate

A flooding incident occurred in the Millbrook Estate located to the east of the proposed development site in 2019. There was reported overland flow in the area of property number 32 and property number 1 in Millbrook Estate as well as the road located between these properties at the end of the cul-de-sac. Following discussions with some local residents the flooding occurred due to a new stormwater pipe connection that was made into the existing 375mm pipe that runs through the estate and into the proposed development site, as shown below in *Figure 5A*.

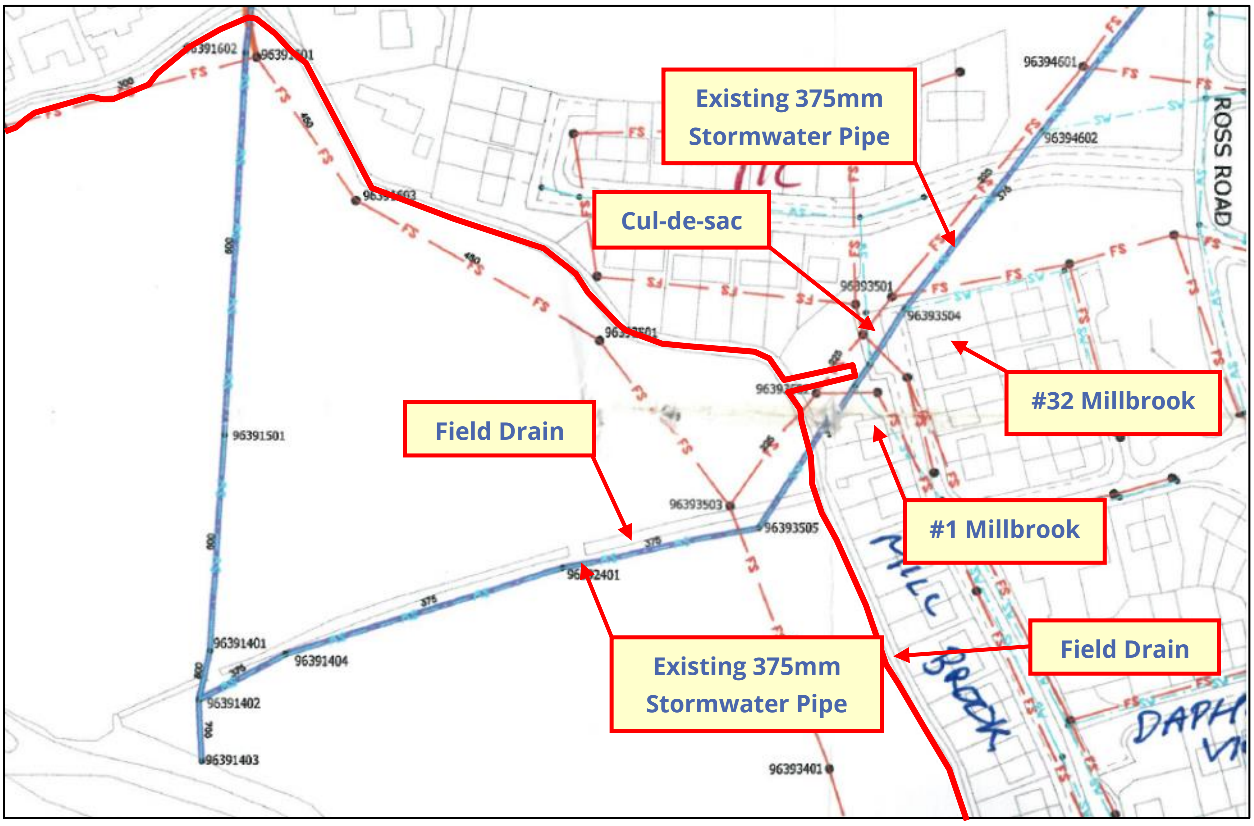


Figure 5A – Existing Drainage in Millbrook Estate and Proposed Site

Further drainage works were carried out by Wexford County Council to remediate the issue, which included diverting the new stormwater connection into a new 450mm pipe from the Millbrook Estate into the open Field Drain located within the proposed development site. According to the local residents there has been no further flooding issues within the Millbrook Estate.

4.5. Ordnance Survey Historic Mapping

Available historic mapping for the area was consulted, as this can provide evidence of historical flooding incidences or occurrences. The maps that were consulted were the historical 6-inch maps (pre-1900), and the historic 25-inch map series.

Figure 6 and *Figure 7* below show the historic mapping for the area of the proposed development site.

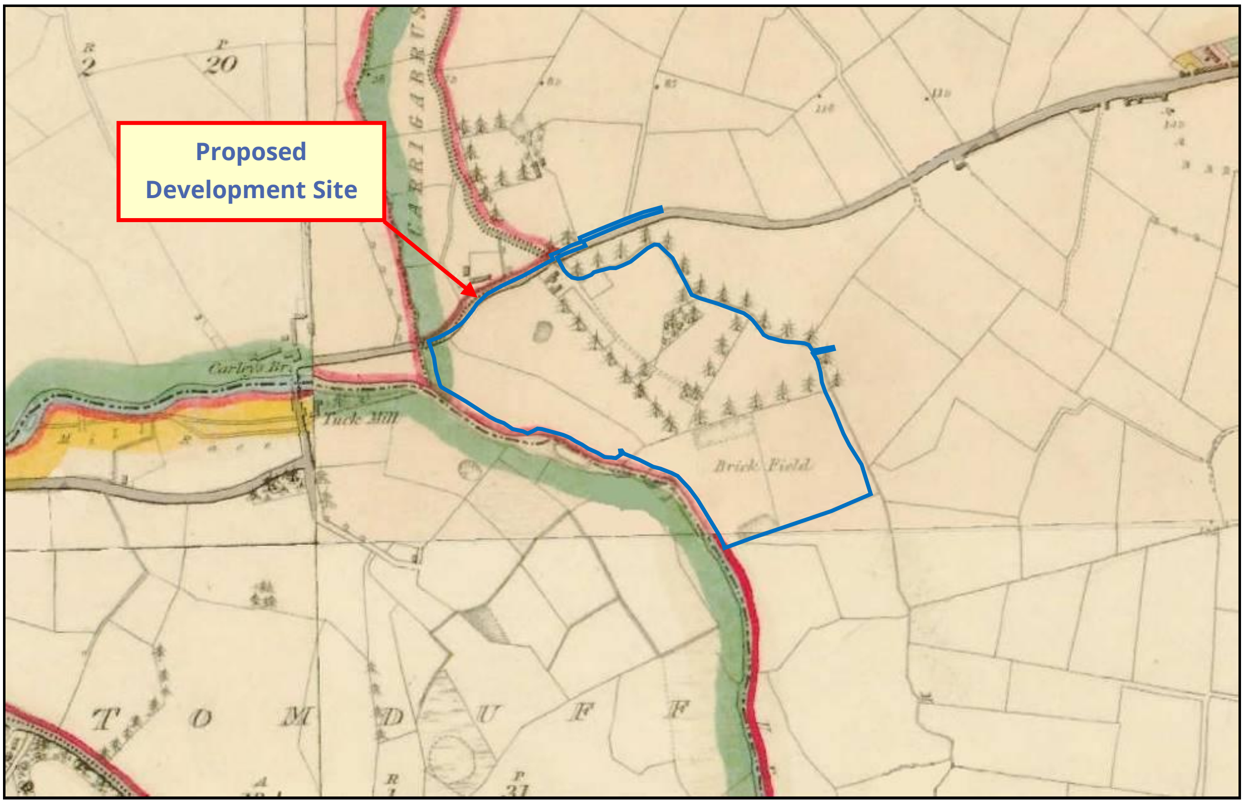


Figure 6 – Historic 6-Inch Mapping

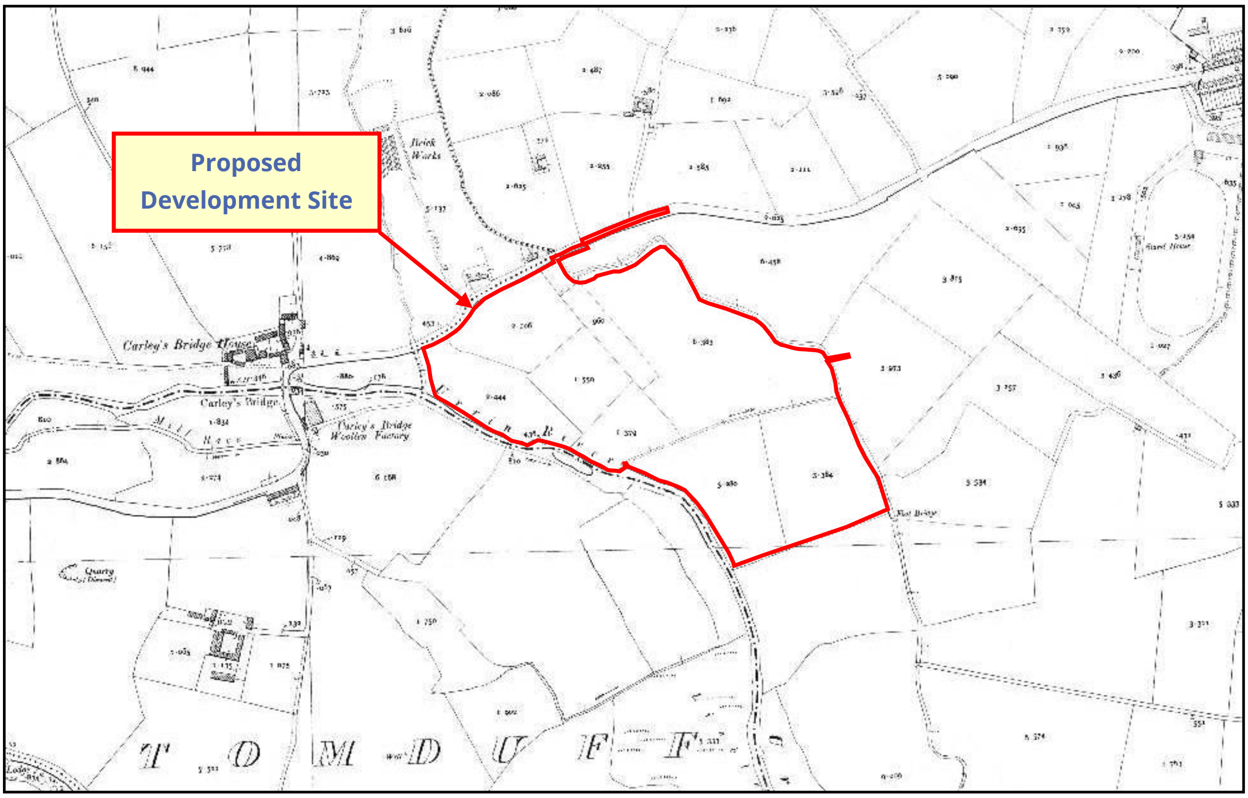


Figure 7 – Historic 25-Inch Mapping

The historic 6 inch and 25 inch mapping does not indicate any historical or anecdotal instances of flooding within or adjacent to the boundary of the proposed development site.

4.6. Geological Survey of Ireland Mapping

The alluvial deposit maps of the Geological Survey of Ireland (GSI) were consulted to assess the extent of any alluvial deposits in the vicinity of the proposed development site. Alluvial deposits can be an indicator of areas that have been subject to flooding in the recent geological past.

Figure 8 below illustrates the sub-soils mapping for the general area of the site.

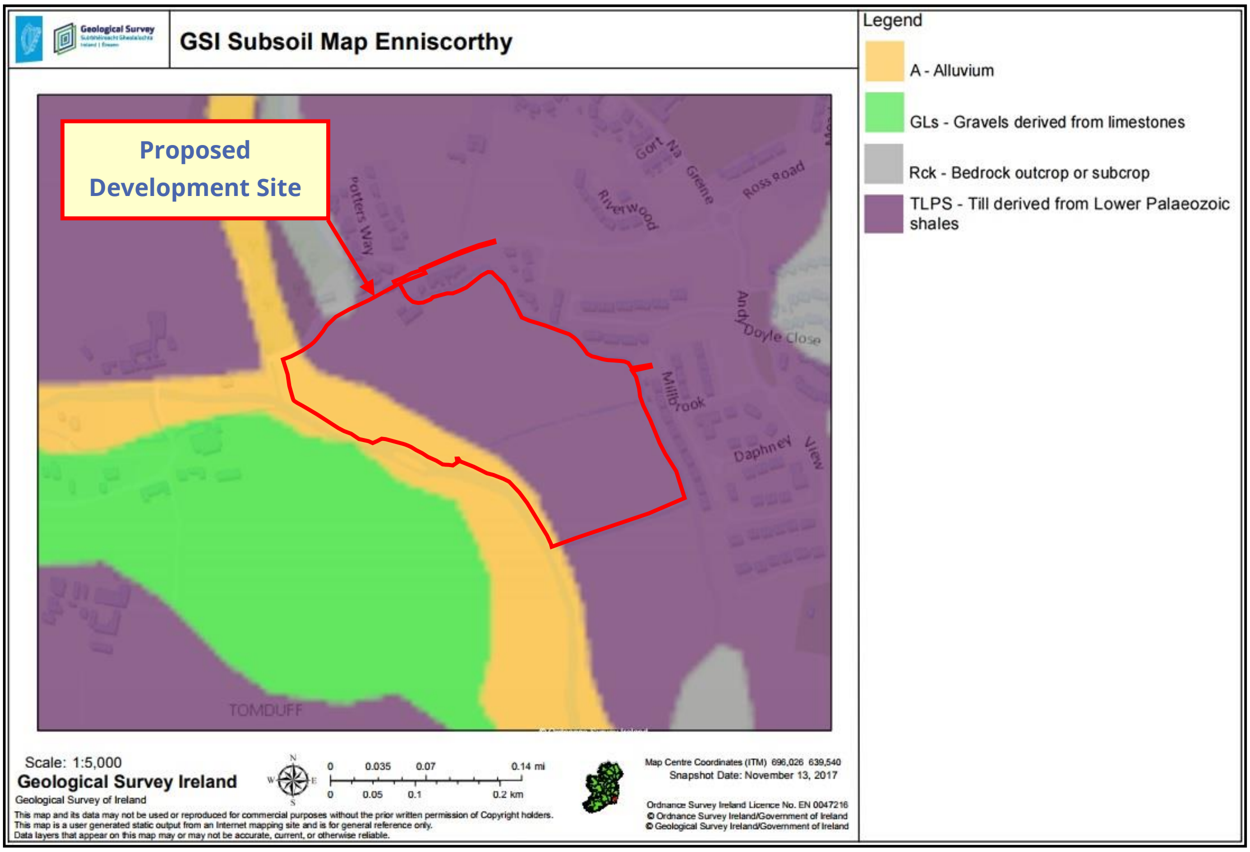


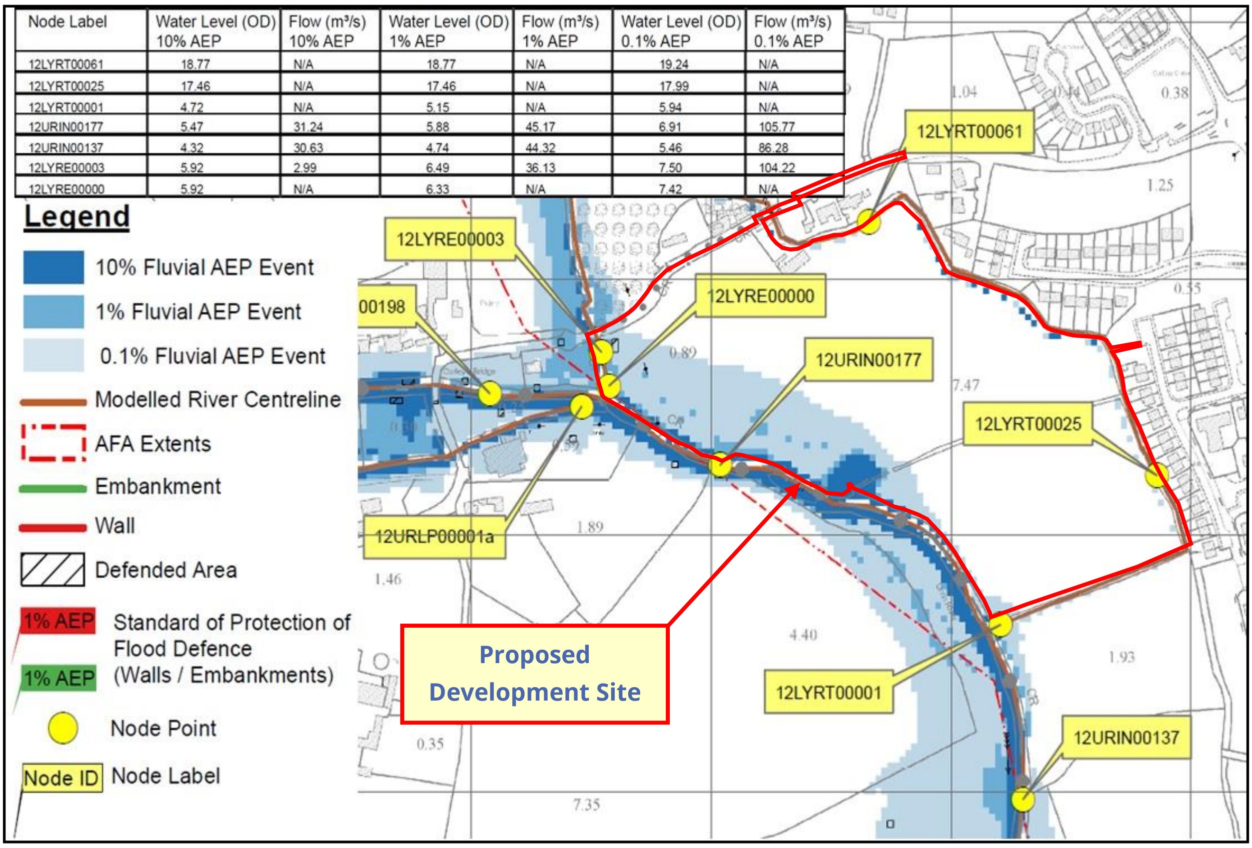
Figure 8 – GSI Subsoil Mapping

Figure 8 above indicates that the proposed development site is largely underlain by Till derived from Lower Palaeozoic shales. There are alluvium deposits mapped within the south-western area of the site, which could be indicative of the areas that have flooded in the recent geological past.

4.7. South Eastern CFRAM Study

The South Eastern Region Catchment Flood Risk & Management Study (CFRAMS) has been undertaken by the OPW and the Final version of the flood maps were issued in July 2016. Flood risk extent and depth maps for further assessment areas within Enniscorthy have also been produced. OPW CFRAMS predictive flood map number *O12ENN_EXFCD_F0_03* illustrates predictive extreme fluvial flood extent zones associated with the River Urrin, River Lyre and Lyre Tributary (actually a Field Drain – see Section 6.4 for detailed explanation) in the vicinity of the proposed development site.

Figure 9 below (extracted from CFRAMS flood map *O12ENN_EXFCD_F0_03*), illustrates the predicted extreme 10% AEP (1 in 10 year), 1% AEP (1 in 100 year) or 0.1% AEP (1 in 1000 year) flood extents in the vicinity of the proposed development site.



Node Label	Water Level (OD) 10% AEP	Flow (m³/s) 10% AEP	Water Level (OD) 1% AEP	Flow (m³/s) 1% AEP	Water Level (OD) 0.1% AEP	Flow (m³/s) 0.1% AEP
12LYRT00061	18.77	N/A	18.77	N/A	19.24	N/A
12LYRT00025	17.46	N/A	17.46	N/A	17.99	N/A
12LYRT00001	4.72	N/A	5.15	N/A	5.94	N/A
12URIN00177	5.47	31.24	5.88	45.17	6.91	105.77
12URIN00137	4.32	30.63	4.74	44.32	5.46	86.28
12LYRE00003	5.92	2.99	6.49	36.13	7.50	104.22
12LYRE00000	5.92	N/A	6.33	N/A	7.42	N/A

Figure 9 – CFRAMS Fluvial Flood Maps

The CFRAMS flood map also provides information on predicted water levels and flows for 10% AEP, 1% AEP and 0.1% AEP fluvial flood events at various node points along these watercourses. The node points closest to the proposed development site are referenced as node points *12LYRT00061,* *12LYRT00025* and *12LYRT00001* along the Lyre Tributary (Field Drain), node points *12LYRE00003, 12YRE00000, 12URIN00177,* and *12URIN00137* along the River Lyre and River Urrin as illustrated in *Figure 9* above. Details of the predicted fluvial flood levels and flows for the CFRAMS node points in the general vicinity of the proposed development site are listed in *Table 2* below, which has been extracted from CFRAMS flood map reference *O12ENN_EXFCD_F0_03.*

Node Label	Water Level (m OD) 10% AEP	Flow (m3/s) 10% AEP	Water Level (m OD) 1% AEP	Flow (m3/s) 1% AEP	Water Level (m OD) 0.1% AEP	Flow (m3/s) 0.1% AEP
12LYRT00061	18.77	N/A	18.77	N/A	19.24	N/A
12LYRT00025	17.46	N/A	17.46	N/A	17.99	N/A
12LYRT00001	4.72	N/A	5.15	N/A	5.94	N/A
12LYRE00003	5.92	2.99	6.49	36.13	7.50	104.22
12LYRE00000	5.92	N/A	6.33	N/A	7.42	N/A
12URIN00177	5.47	31.24	5.88	45.17	6.91	105.77
12URIN00137	4.32	30.63	4.74	44.32	5.46	88.28

Table 2: CFRAMS Fluvial Map - Predicted Flows & Flood Levels

4.8. Wexford County Development Plan 2013-2019 SFRA

As part of the current Wexford County Development Plan, a Strategic Flood Risk Assessment was prepared in accordance with the Guidelines for Planning Authorities 'The Planning System and Flood Risk Management'. The flood risk mapping produced as part of this assessment was collated from a number of sources and shows the delineation of Flood Zones 'A' and 'B' within the Enniscorthy area including the area of the proposed development site.

Figure 10 below illustrates the flood zone delineation mapping for the area of the proposed development site produced as part of this Strategic Flood Risk Assessment.

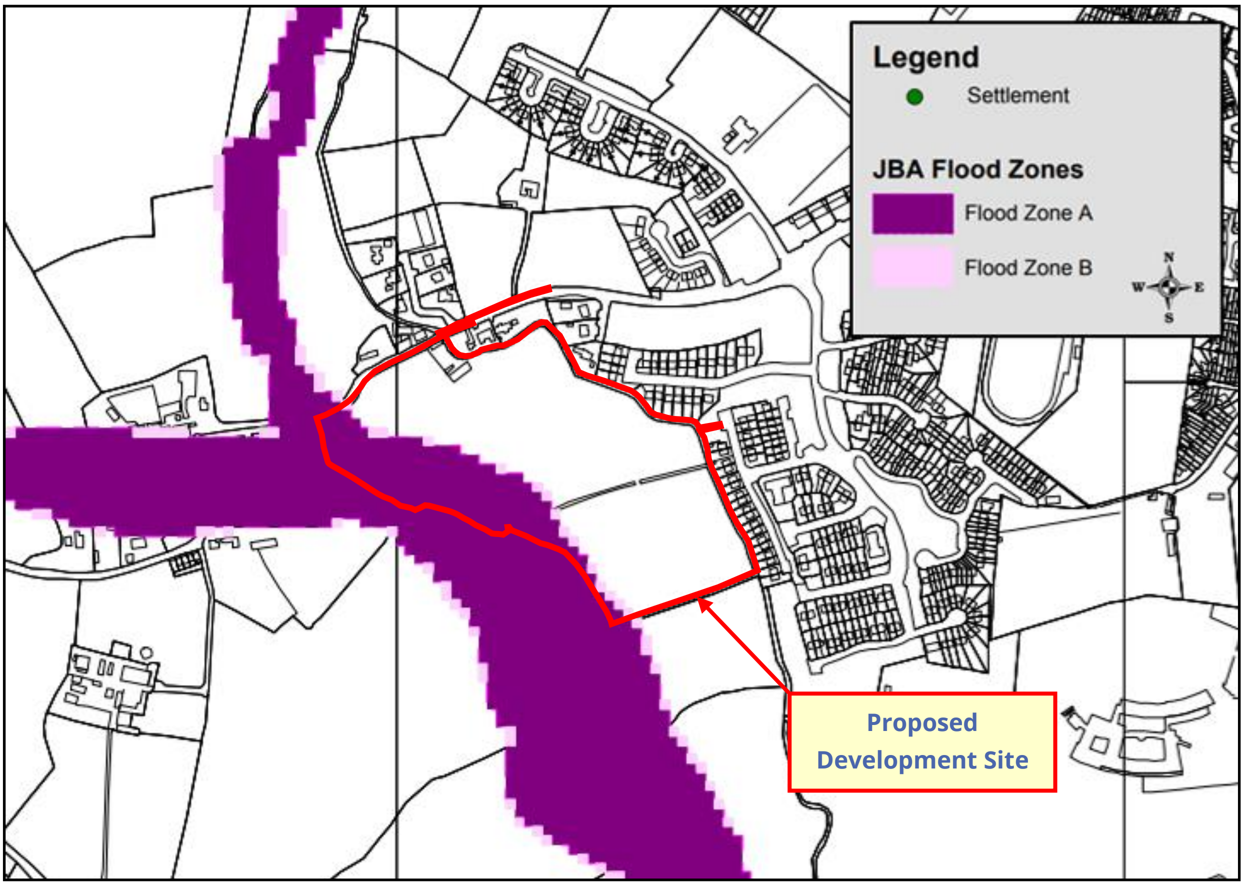


Figure 10 – Wexford County Development Plan 2013-2019 SFRA Mapping

4.9. Draft Wexford County Development Plan 2021- 2027 SFRA

As part of the Draft Wexford County Development Plan 2021-2027, a Strategic Flood Risk Assessment was prepared in accordance with the Guidelines for Planning Authorities 'The Planning System and Flood Risk Management'. The flood risk mapping produced as part of this assessment was collated from a number of sources and shows the delineation of Flood Zones 'A' and 'B' within the Enniscorthy area including the area of the proposed development site.

Figure 11 below illustrates the flood zone delineation mapping for the area of the proposed development site produced as part of this Strategic Flood Risk Assessment.

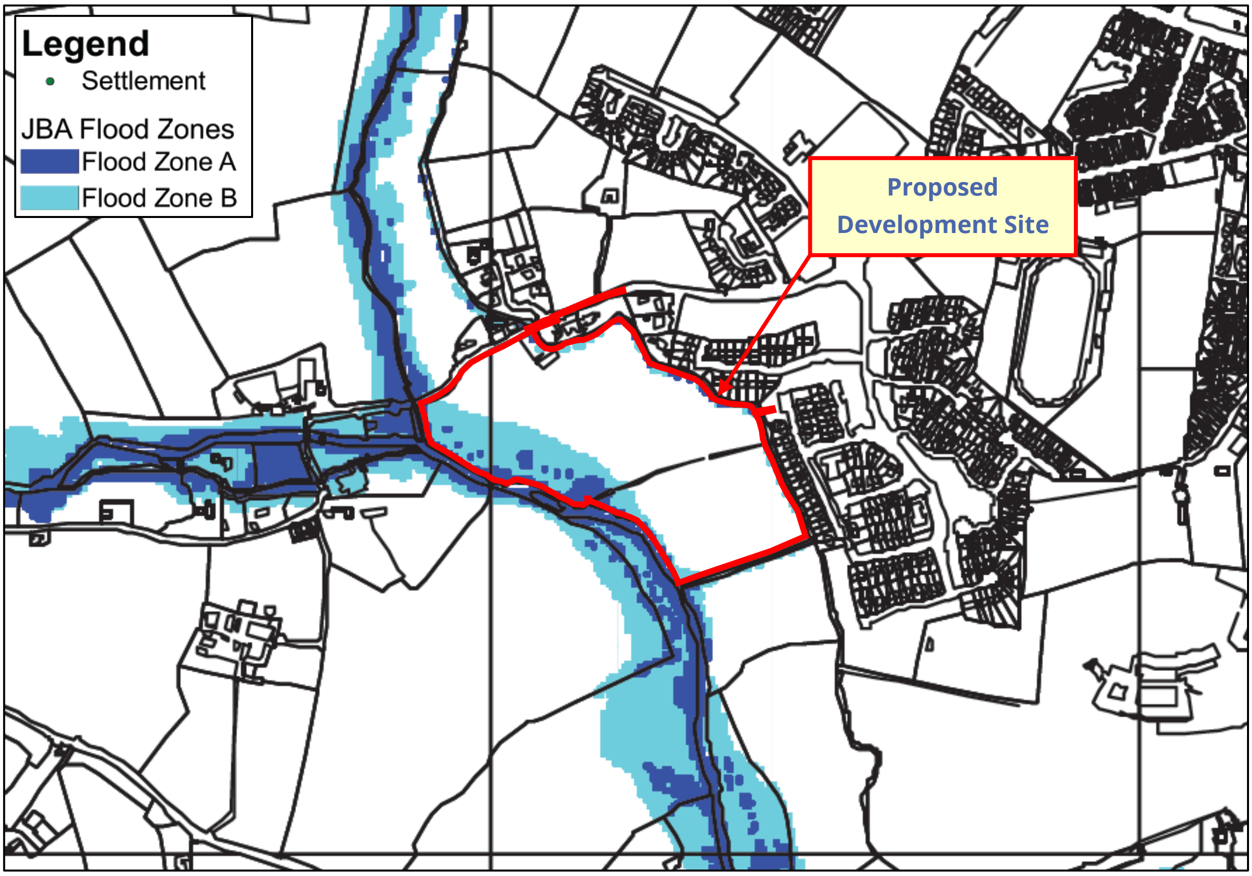


Figure 11 – Draft Wexford County Development Plan 2021-2027 SFRA Mapping

Figure 10 above indicates that the south-western area of the proposed development site may fall within an indicative Strategic Flood Zone A and Flood Zone B.

4.10. Climate Change

The delineated flood extents illustrated in *Figure 9* above are based on the current scenario 1% AEP (1 in 100 year) and 0.1% AEP (1 in 1000 year) predictive fluvial flood extent and do not account for the potential impact of climate change.

The www.myplan.ie resource was utilised to assess the potential mid-range future climate change scenario fluvial flood extents in the general location of the site of the proposed development as shown in *Figure 12* below.

Figure 12 - Mid Range Future Climate Change Scenario Mapping

'The Planning System and Flood Risk Management – Guidelines for Planning Authorities, DOEHLG 2009' Technical Appendices states that the 1 in 1000 year flood extents may be considered as a surrogate for the 1 in 100 year mid-range future climate change scenario flood extents in the absence of hydraulic modelling of such scenarios. The extent of flooding shown in *Figure 12* above is similar to that of the current 1 in 1000 year fluvial flood extents shown on the OPW CFRAMS mapping in *Figure 9* above.

5. Scoping Assessment

The purpose of the scoping stage is to identify possible flood risks and to implement the necessary level of detail and assessment to assess these possible risks, and to ensure these can be adequately addressed in the flood risk assessment. The scoping exercise should also identify that sufficient quantitative information is already available to complete a flood risk assessment appropriate to the scale and nature of the development proposed.

The above screening assessment indicates that the primary flood risk to the proposed development site with can be attributed to a potential fluvial flooding from the Urrin River, Lyre River and the Field Drains in the vicinity of the site. Secondary flood risk can be attributed to a surcharge due to a potential blockage in the river bridge on the River Lyre close to the proposed site entrance. Secondary flood risk can also be attributed to a surcharge of the urban drainage and water supply infrastructure in the vicinity if the site.

In consideration of the information collated as part of the screening exercise, and the availability of other information and data specific to the proposed site, it is considered that sufficient quantitative information to complete an appropriate flood risk assessment can be derived from the information collated as part of the screening exercise alone. In particular, the final flood extent maps dated July 2016 as part of the South Eastern CFRAM Study are based on the results of detailed hydraulic modelling undertaken along the River Urrin, River Lyre and the Field Drains and therefore provide a reasonably accurate delineation of flood zones and prediction of flood depths in the general vicinity of the proposed development site.

The specific flood risk to and from the proposed development site is assessed in the subsequent 'Assessing Flood Risk' stage of this study report.

6. Assessing Flood Risk

Flood risk from a particular watercourse is normally assessed for a 1 in 100 year and 1 in 1000 year flood event, in accordance with most county development plans and in accordance with the DOEHLG guidelines *'The Planning System and Flood Risk Management Guidelines'*.

The following sections present an analysis and assessment of the estimated 1 in 100 year (1% AEP) and 1 in 1000 year (0.1% AEP) flood levels in the River Urrin, River Lyre and the Field Drains in the vicinity of the proposed development site.

6.1. Estimation of Extreme Flood Levels

Extreme flood levels have been derived as part of the South Eastern CFRAM Study at a number of nodes along the River Lyre, River Urrin and the Field Drains (Lyre Tributary) in the vicinity of the proposed development site. Utilising this information, predicted flood levaels at the upstream and downstream end of the proposed development site have been interpolated as illustrated in *Table 3* below.

CFRAMS Node	1 in 100 Years (1% AEP)	1 in 1000 Years (0.1% AEP)
12LYRE00003	6.49	7.50
Upstream Site Boundary	6.49	7.50
12LYRE00000	6.33	7.42
12URIN00177	5.88	6.91
Downstream Site Boundary	5.15	5.94
12LYRT00001	5.15	5.94
12URIN00137	4.74	5.46

Table 3: Extreme Flood Levels

6.2. Topographical Survey & Contour Mapping

In order to assist in the assessment of any potential flooding in the general area of the proposed development site, topographical survey information was utilised to develop a Digital Terrain Model (DTM) of the proposed development site area. Development of a DTM allows the flood level predictions listed in *Table 3* above to be analysed in more detail at the location of the proposed development site. The contour mapping and DTM developed for the area is illustrated in *Figure 13* and *Figure 14* below.

Figure 13 – Contour Mapping

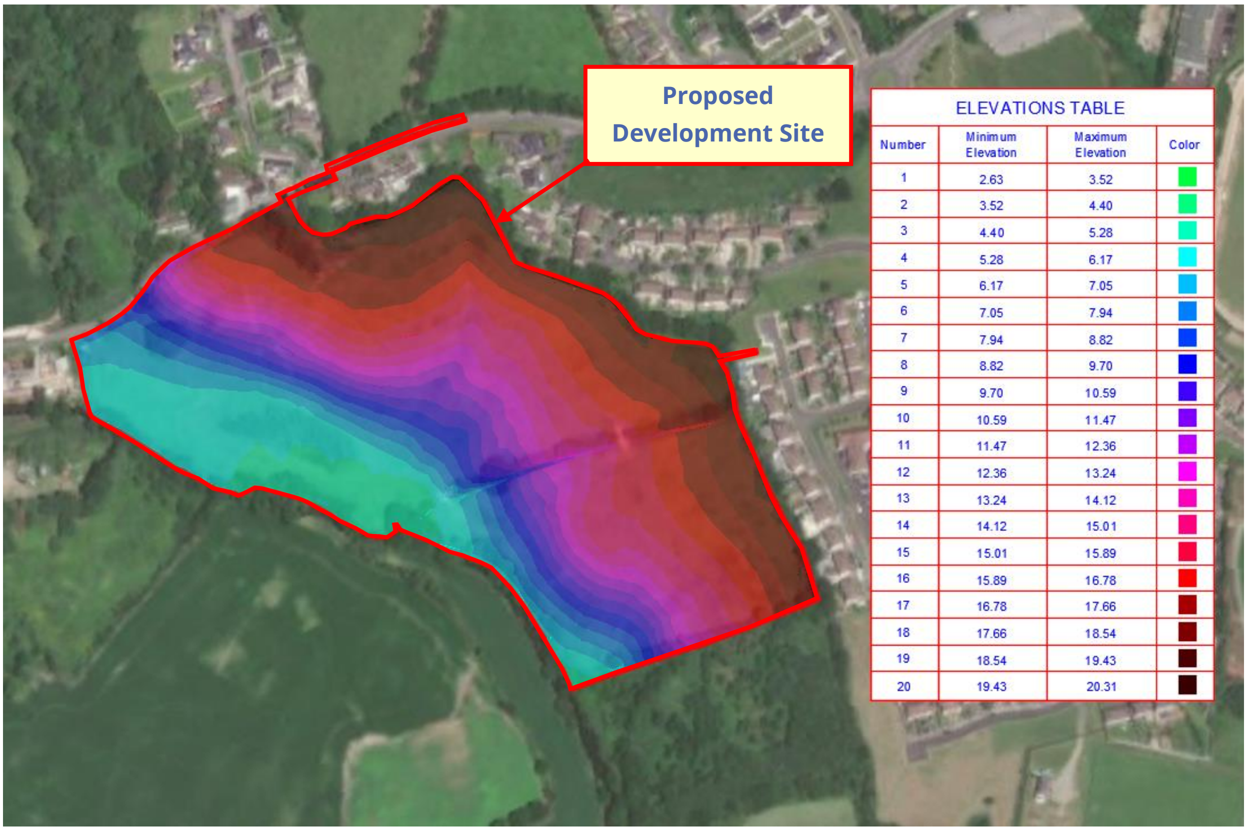


Figure 14 – Topographical Survey Derived DTM

6.3. Flood Zone Mapping & Delineation

Utilising the DTM illustrated in *Figure 13* and *Figure 14* above, and the 1 in 100 year (1% AEP) and 1 in 1000 year (0.1% AEP) extreme flood levels in the adjacent watercourses to the south of the site from the node points listed in *Table 3* above, the 1% AEP and 0.1% AEP flood zones within the boundary of the site were delineated.

The highest topographical elevation surveyed within the boundary of the proposed development site is 20.313m OD, which is located in the northern area of the site. The lowest topographical elevation within the site is 2.631m OD, which is located in the southern area of the site. The DTM illustrated in *Figure 12* above indicates that an area of the existing topography of the site is below the 0.1% AEP predicted flood level (as per *Table 3* above). *Drawing Number IE2066-002-D, Appendix A* illustrates the delineated 1 in 100 year flood extent (Flood Zone 'A') and 1 in 1000 year flood extent (Flood Zone 'B') over the full area of the proposed development site.

6.4. Lyre Tributary

The CFRAMS flood extent map illustrated in *Figure 9* above indicates a narrow line of potential fluvial flooding along the northern boundary of the site, which is referred to as the Lyre Tributary. This watercourse is elevated above the majority of the site and therefore there is potential for flood waters to overtop this channel and spill downhill into the site.

The Lyre Tributary was modelled as part of the South Eastern CFRAM Study for the Enniscorthy area. An extract from the CFRAMS Hydraulics Report (reference IBE0601Rp0014, Appendix A.2) displays a long section through the modelled reach of the Lyre Tributary adjacent to the northern boundary of the site as illustrated in *Figure 15* below. This long section shows the predicted 1 in 1000 year (0.1% AEP) flood level along this modelled reach length. A copy of the Hydraulics Report is included in *Appendix B* herein.

The long section presented also does not appear to make sense in terms of the gradient in the channel. It indicates that the Lyre Tributary flows in a southerly direction and has a negative gradient for the first 507m of channel as shown in *Figure 15* below.

The CFRAMS Hydraulics Report states in Section 4.6.6 (d) that "*The Lyre Tributary (LYRT) model was extended upstream to better represent the channel as the first cross-section at 507.235 m had a dry bed. This helped create a better representation in the model simulations as the channel link was much shorter and a more gradual slope could be applied to the rise in bed level, helping with the model run. The two cross-sections placed upstream of the original were copies of the first cross-section on the channel, with the whole section lowered to match the bed level of the linking section from the Lyre River as this was needed for the model simulations to run. This meant the first stretch of the Lyre Tributary would be able to hold water in extreme flooding events, which is more representative of the watercourse in reality. This involved adding a culvert to pass under a road at the upstream end of the branch. The culvert was input as a 0.8 m diameter pipe of length 7 m at 39.744 m. These culvert dimensions were obtained by using Google Maps and the scale provided with it*."

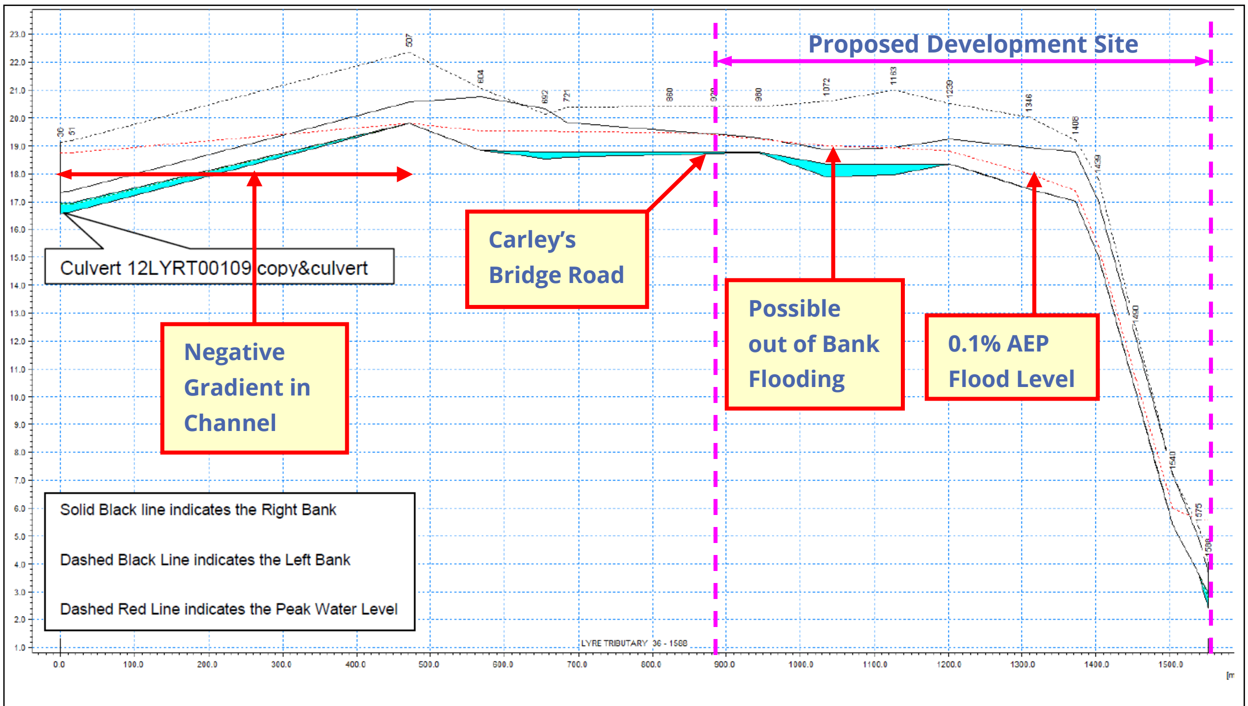


Figure 4.6.31 Lyre Tributary Watercourse 0.1% Fluvial Flow

Figure 15 – CFRAMS Model Long Section of Lyre Tributary for 0.1% AEP Event

It is unclear from the above text extracted from the CFRAMS Hydraulics Report whether in fact the 0.8m culvert at Node Point 12LYRT00109 (located 790m north of the site on the Lyre Tributary) was actually surveyed or if the diameter was assumed. It is also unclear where along the Lyre Tributary cross sections of the river channel were surveyed along its length. *Figure 16* below, which was extracted from the CFRAMS Hydraulics Report, shows the Model Schematisation for the Enniscorthy area. It does appear to show modelled cross sections along the Lyre Tributary but there is no indication if these sections were surveyed on the ground or were extracted from a LiDAR derived DTM.

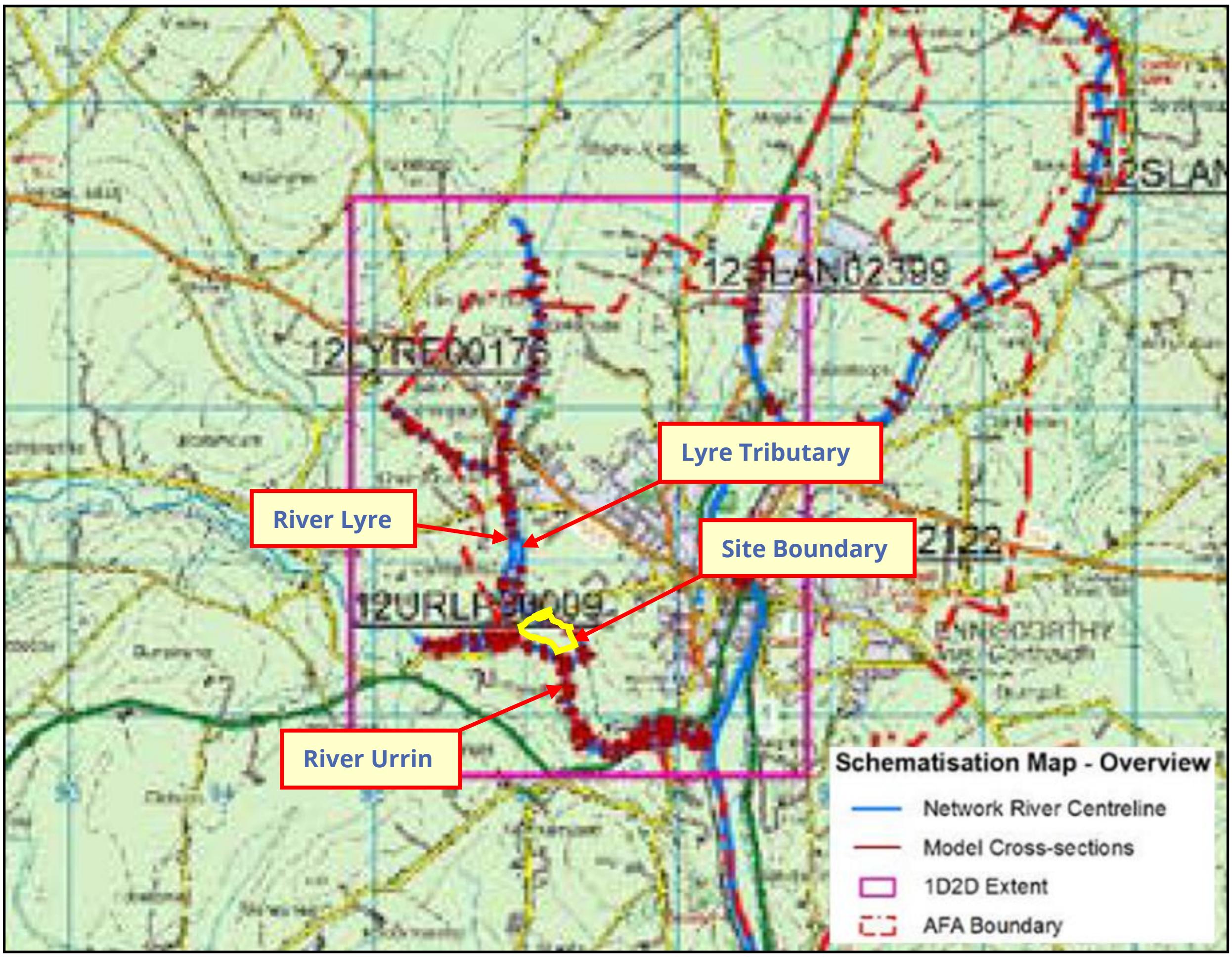


Figure 16 –CFRAMS Model Schematisation

The long section in *Figure 15* above indicates that there may be out of bank flooding along its length within the boundary of the proposed development site. However, the model does not appear to take into account of any hydraulic structure to represent a road crossing along the reach at Carley's Bridge Road adjacent to the site. There is also no mention of a culvert in this location in the CFRAMS Hydraulics Report.

The presence of a hydraulic structure under Carley's Bridge Road was investigated by a Hydrological Engineer from IE Consulting in December 2017 and no culvert or bridge was found on site. The channel representing the Lyre Tributary does not appear to cross the road at all at this location. The topographical survey of the channel also did not identify the presence of culvert or bridge traversing the site or road at this location as shown in *Figure 17* below. The channel within the site was also observed to be completely dry where the channel commences within the site, which is shown in *Figure 18* below.

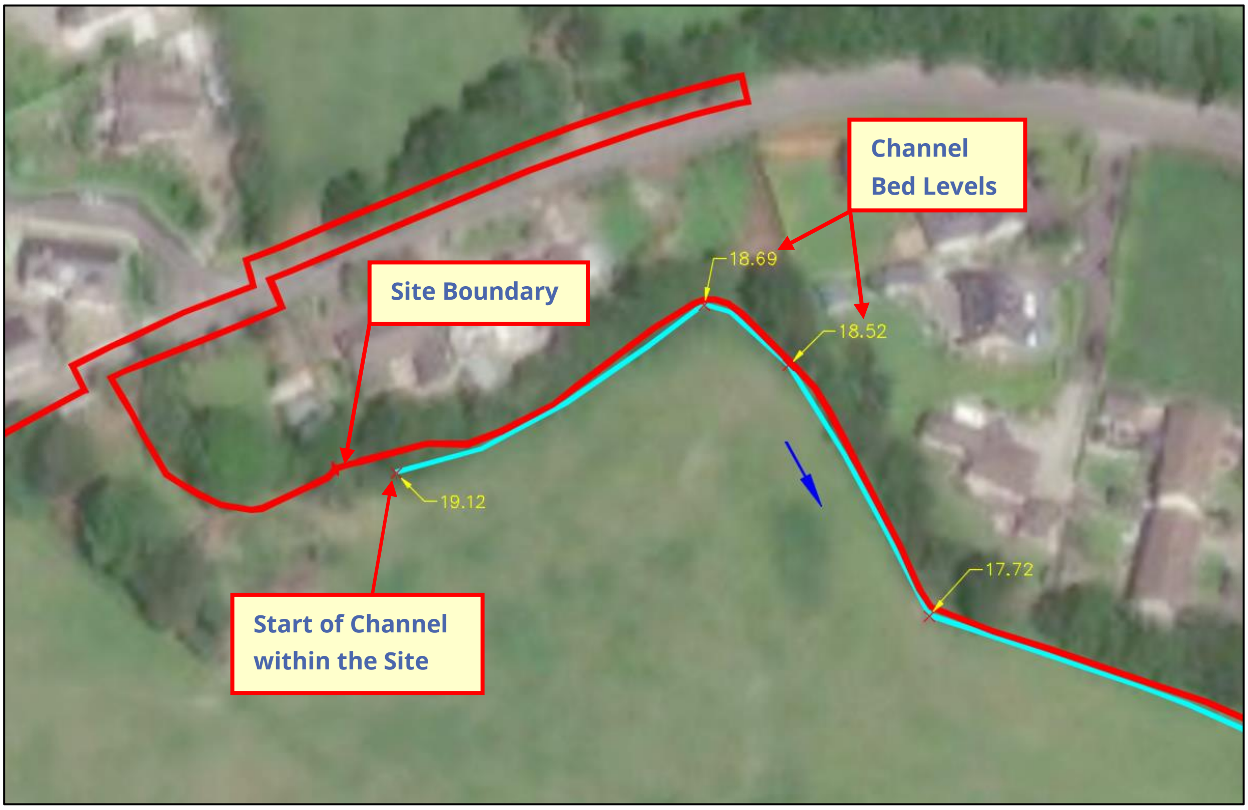


Figure 17 – Surveyed Channel Extents within the Site

Figure 18 – Start of Channel within the Site

Based on the evidence above it is more likely and reasonable to conclude that the section of the Lyre Tributary to the north of Carley's Bridge Road flows in a northerly direction based on the flood levels indicated on the node points and the overall gradient of the topography, and then discharges into the main Lyre River channel to the north of CFRAMS Node Point 12LYRT00109 as shown below in *Figure 19* below.

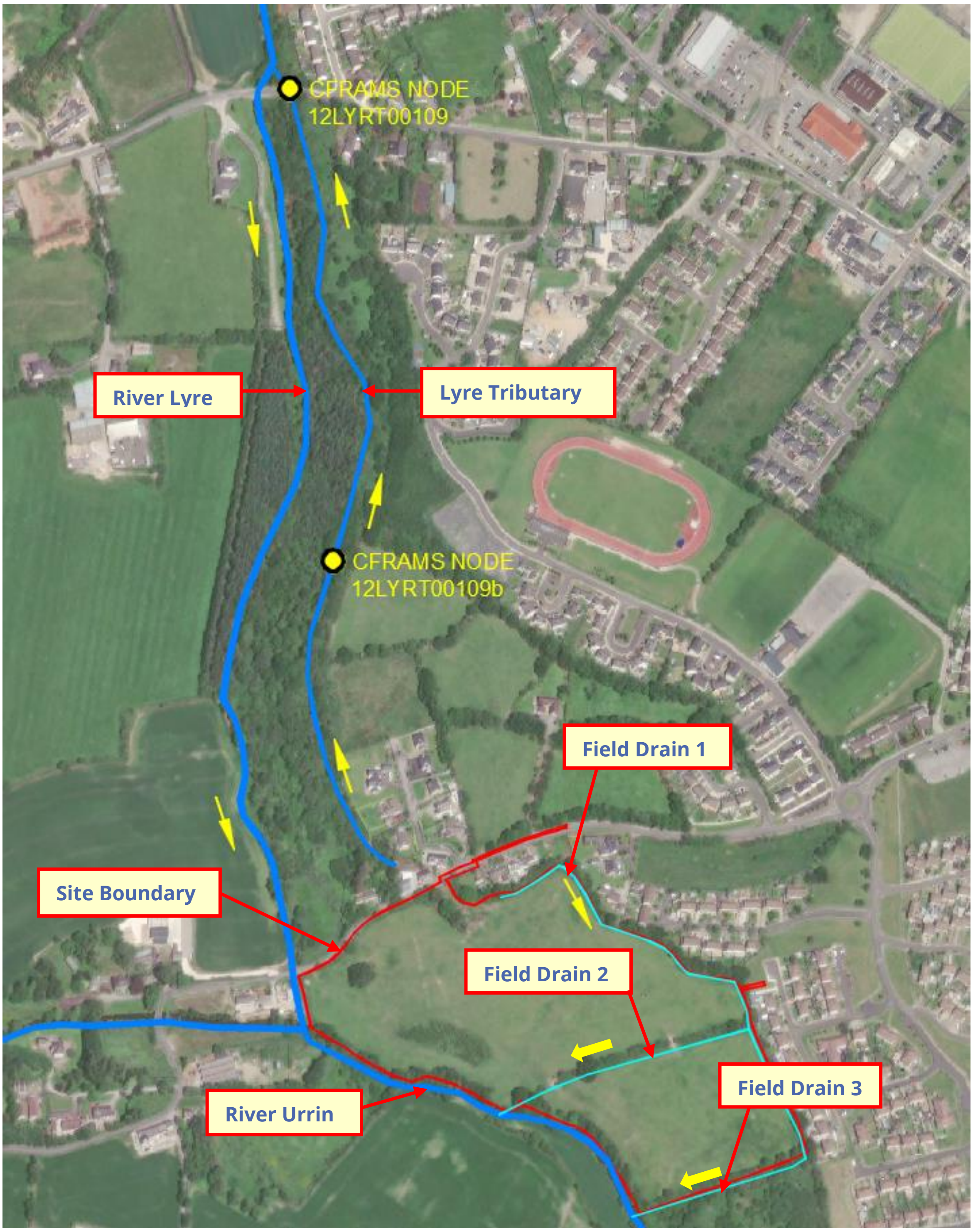


Figure 19 – Lyre Tributary Connectivity

The channels located within the site were observed to be dry along most of the channel length. It is likely that these channels acted as field drains for the lands to the north in the past prior to any development in the housing estates to the east and north of the site. The stormwater runoff from these lands is now catered for by the drainage systems in place, which discharges into the downstream section of Field Drain 2 via existing pipework, and therefore the catchment now associated with these channels is considered to be negligible. Overall, the flood risk posed to the site from this channel is considered to be LOW.

6.5. Field Drains

There is a field drain that crosses the site (Field Drain 2) and also a second drain that flows adjacent to the eastern and southern boundary of the site (Field Drain 1 & Field Drain 3), which are referred to in the CFRAM Study as the Lyre Tributary, as shown in *Figure 17* above. As discussed in *Section 6.4* above the Lyre Tributary does not cross Carley's Bridge Road and therefore these channels are field drains only.

The topographical survey indicates that the channel along the northern boundary discharges into Field Drain 2. There was little or no flow observed on site in these channels and as such these channels only drain the lands on either side of it. Overall, the flood risk posed to the site from these field drains is considered to be LOW.

6.6. Assessment of Secondary Flood Risk

6.6.1. Pluvial - Urban Drainage/Water Supply Infrastructure

Secondary pluvial flood risk can also be attributed to a potential surcharge of the urban drainage network and /or damage to the water supply infrastructure in the general vicinity of the site. An urban drainage infrastructure map was obtained from Wexford County Council, an extract of which is illustrated in *Figure 20* below. The following drainage infrastructure has been identified in the vicinity of the proposed development site:

- 375mm stormwater pipe located along the eastern boundary of the site;
- 600mm stormwater pipe crossing the centre of the site;
- 700mm stormwater pipe located along the southern boundary of the site;
- 300mm foul sewer located along northern boundary of the site; and

- 225mm & 450mm foul sewer located along the eastern boundary of the site.

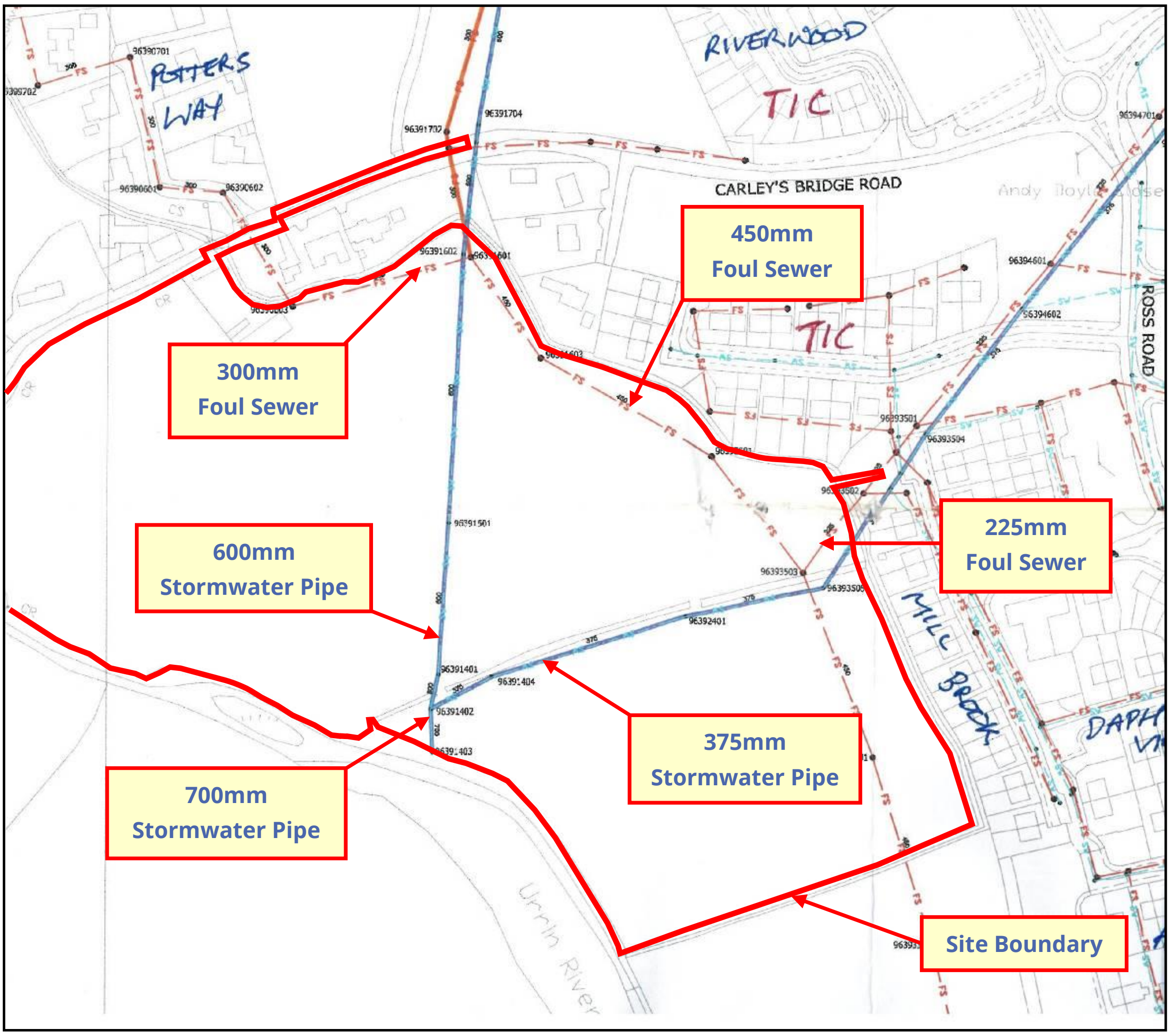


Figure 20 – Urban Drainage Records - Wexford County Council

A water supply infrastructure map was obtained from Wexford County Council, an extract of which is illustrated in *Figure 21* below. The following water supply infrastructure has been identified in the vicinity of the proposed development site:

- 150mm water main located along Carley's Bridge Road adjacent to the northern boundary of the site.
- 100mm water-main located in Urrin Valley housing estate close to the eastern boundary of the site.

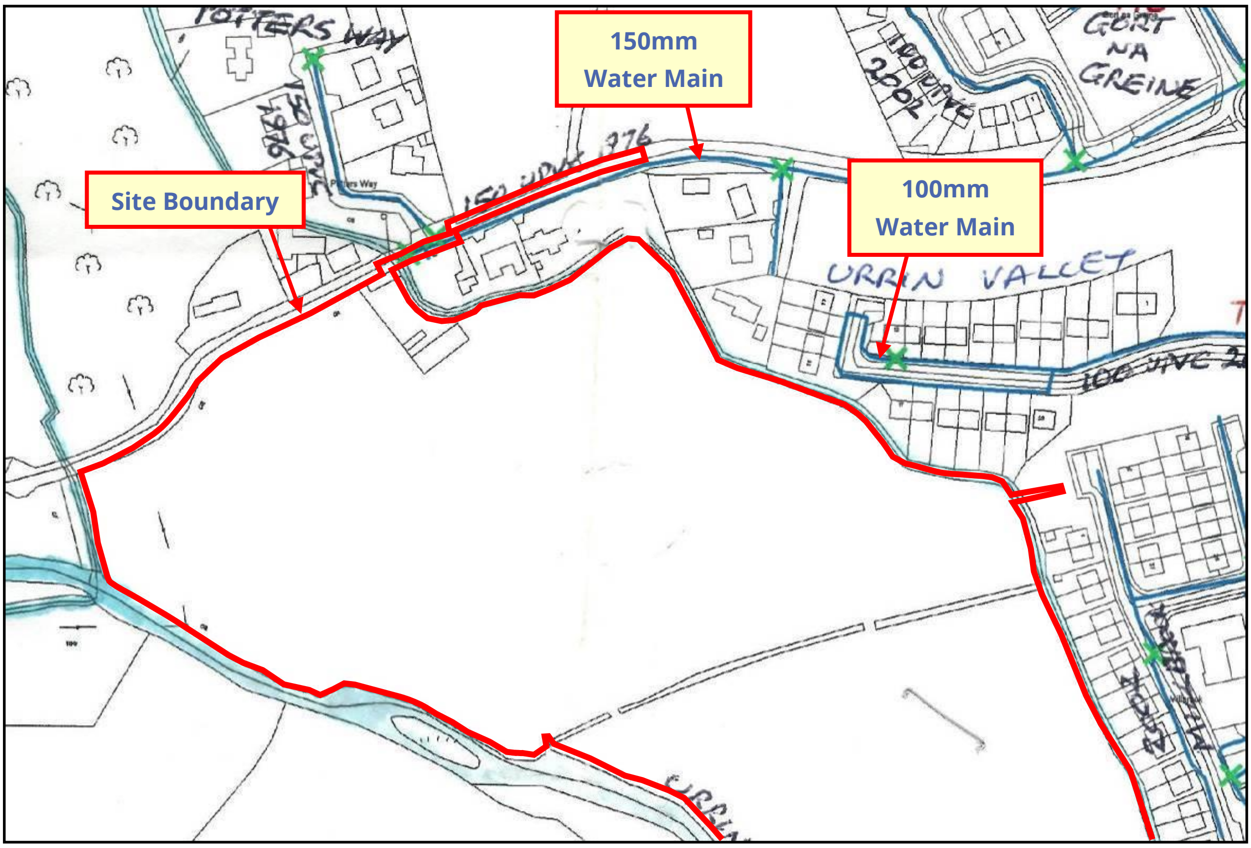


Figure 21 – Water Main Records - Wexford County Council

It is anticipated that the any flooding due to surcharge of the foul sewer located close to the northern boundary of the site would spill out onto Carley's Bridge Road. These waters would likely be picked up by existing stormwater gullies located in the road as shown in *Figure 22* and *Figure 23* below. It is not anticipated that these waters would enter the boundary of the site.

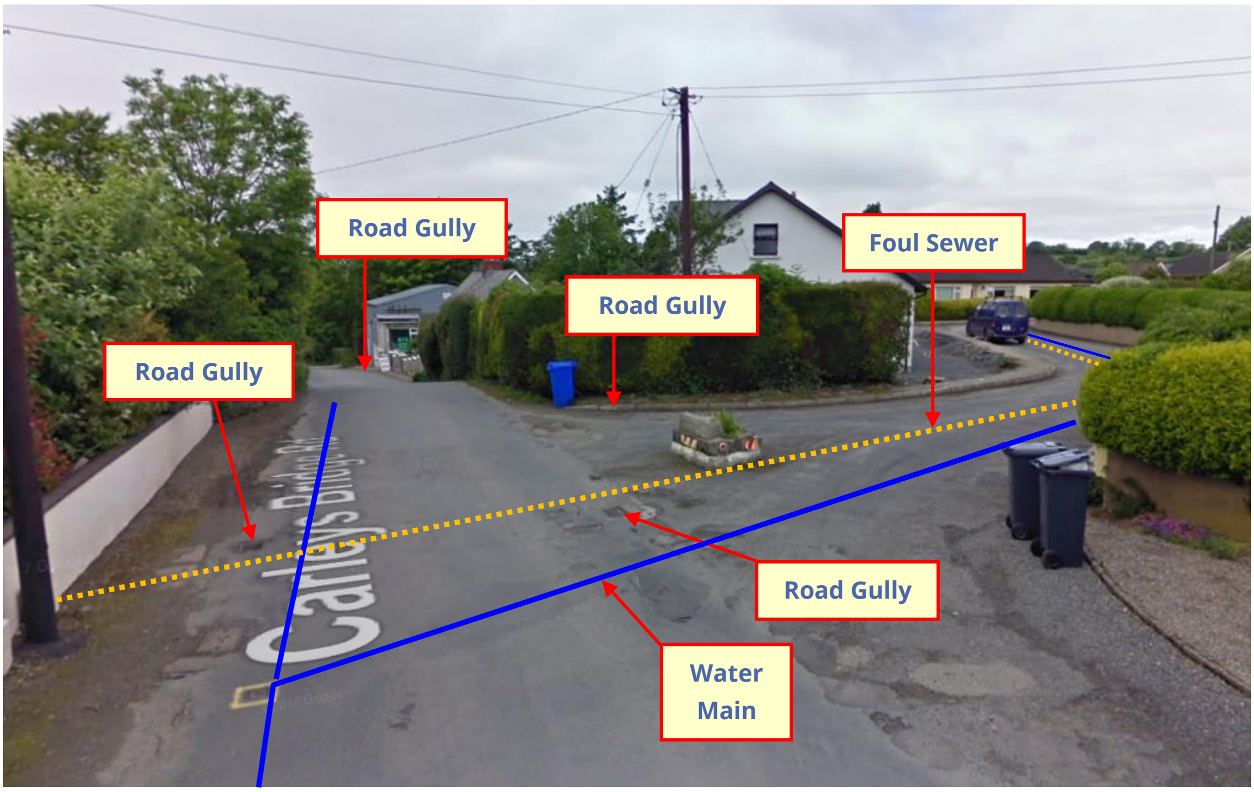


Figure 22 – Foul Sewer and Water Main Overland Flow Paths

It is also predicted that any flooding due to a surcharge of the stormwater or foul manholes within the site would likely cause these waters to spill out onto the proposed development site and flow downhill in a southerly direction toward the River Urrin, before spilling into the river and away from the site, as illustrated in *Figure 23* below. It is not anticipated that this would result in any significant ponding or flooding within the site.

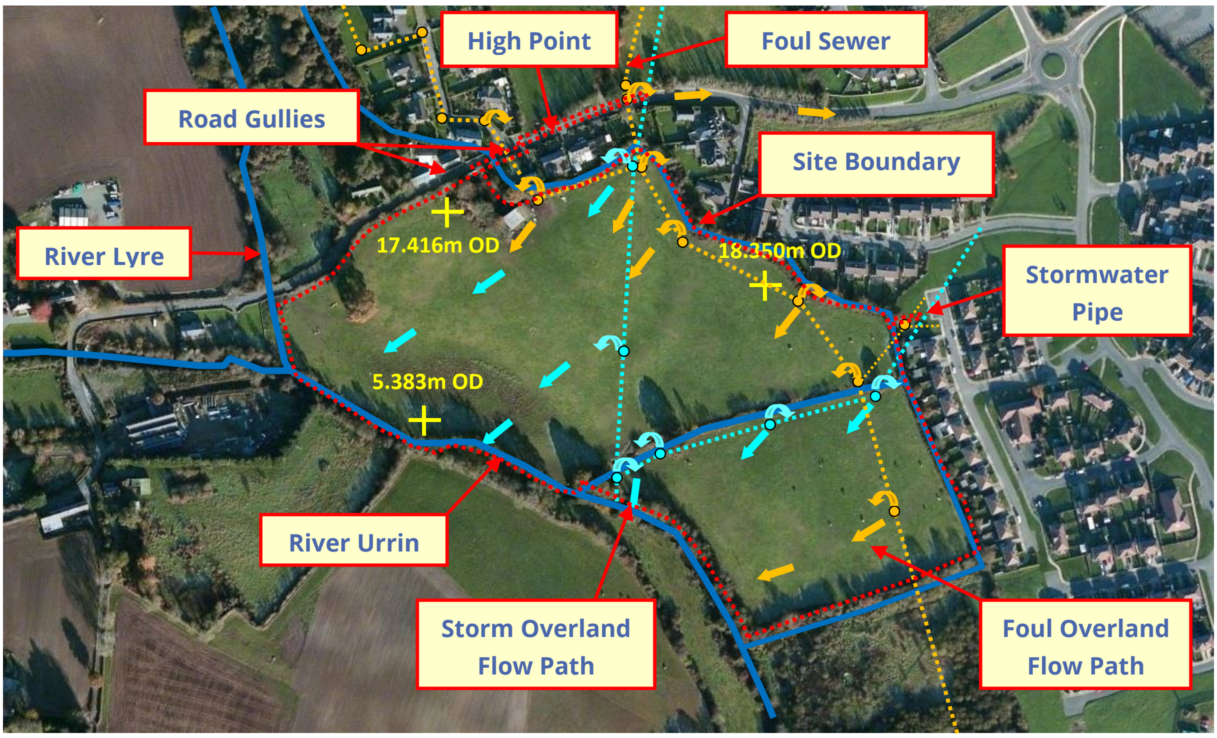


Figure 23 – Overland Flow Paths

The water mains located in Carley's Bridge Road and in the adjacent Urrin Valley housing estate are not anticipated to pose a flood risk to the site. Any potential flooding on the road that may occur as a result of damage of these water mains will likely be collected by the existing stormwater gullies in the road. Therefore, the water supply infrastructure does not pose a flood risk to the proposed development site.

6.6.2. Surcharge/Blockage – Bridge

Secondary flood risk can be attributed to a potential surcharge due to a blockage in the bridge located on the River Lyre adjacent to the north-western boundary of the proposed development site. In the event the bridge becomes blocked and begins to surcharge flood waters would surcharge/back up the River Lyre, overtop the bank and potentially spill out onto the surrounding land. Based on the existing topography, it is predicted that if the water levels continue to rise, flood waters would eventually flow in a southerly direction into the River Urrin and away from the proposed development site, as illustrated in *Figure 24* below. The bridge located on the River Urrin further to the west of the site is not predicted to pose a flood risk to the site. Therefore, the secondary flood risk to the site due to potential bridge blockage or surcharge is considered to be LOW.

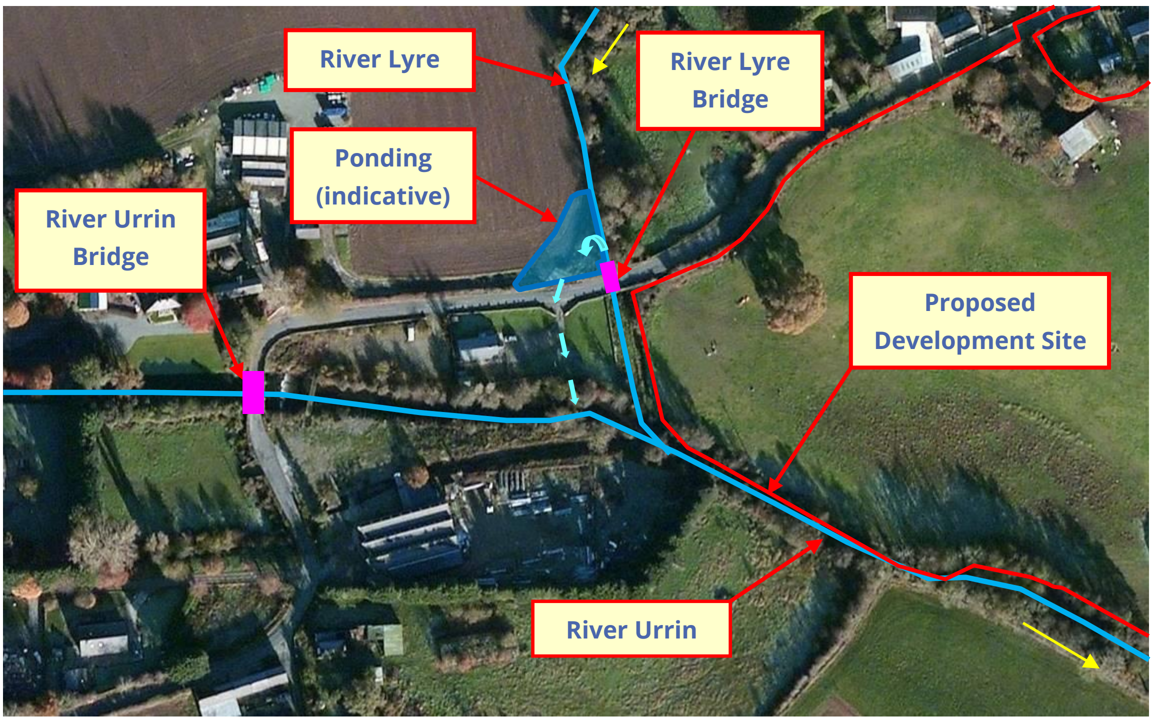


Figure 24 – Overland Flow Path - Bridge Surcharge

7. Proposed Development in the Context of the Guidelines

In the context of the *'Planning System and Flood Risk Management Guidelines, DOEHLG, 2009'* three flood zones are designated in consideration of flood risk to a particular development site.

Flood Zone 'A' – where the probability of flooding from rivers and watercourses is the highest (greater than 1% or 1 in 100 year for river and watercourse flooding and 0.5% or 1 on 200 for coastal or tidal flooding).

Flood Zone 'B' – where the probability of flooding from rivers and watercourses is moderate (between 0.1% or 1 in 1000 year for river and watercourse flooding and 0.5% or 1 on 200 for coastal or tidal flooding).

Flood Zone 'C' – where the probability of flooding from rivers and watercourses is low or negligible (less than 0.1% of 1 in 1000 year for both river and watercourse and coastal flooding). *Flood Zone 'C'* covers all areas that are not in *Zones 'A'* or '*B*'.

The *'Planning System and Flood Risk Management Guidelines'* list the planning implications for each flood zone, as summarised below:

Zone A – High Probability of Flooding. Most types of development would not be considered in this zone. Development in this zone should be only be considered in exceptional circumstances, such as in city and town centres, or in the case of essential infrastructure that cannot be located elsewhere, and where the *'Planning System and Flood Risk Management Guidelines'* justification test has been applied. Only water-compatible development, such as docks and marinas, dockside activities that require a waterside location, amenity open space and outdoor sports and reaction would be considered appropriate in this zone.

Zone B – Moderate Probability of Flooding. Highly vulnerable development such as hospitals, residential care homes, Garda, fire and ambulance stations, dwelling houses, strategic transport and essential utilities infrastructure would generally be considered inappropriate in this zone, unless the requirements of the justification test can be met. Less vulnerable development such as retail, commercial and industrial uses and recreational facilities might be considered appropriate in this zone. In general however, less vulnerable development should only be considered in this zone if adequate lands or sites are not available in *Zone 'C'* and subject to a flood risk assessment to the appropriate level of detail to demonstrate that flood risk to the development can be adequately managed and that development in this zone will not adversely affect adjacent lands and properties.

Zone C – Low to Negligible Probability of Flooding. Development in this zone is appropriate from a flood risk perspective. Developments in this zone are generally not considered at risk of fluvial flooding and would not adversely affect adjacent lands and properties from a flood risk perspective.

In the context of the *'Planning System and Flood Risk Management Guidelines, DOEHLG, 2009'* this Site Specific Flood Risk Assessment has determined that the majority of the proposed development site is located within Flood Zone 'C'. The western and south-western areas of the site fall within Flood Zone 'B', which includes the proposed access road, footpath and road embankment. Areas of the site that are designated as proposed green open space also fall within Flood Zone 'A'.

In accordance with the *'Planning System & Flood Risk Management Guidelines, DOEGLG, 2009'* development proposals for the site may be subject to the requirements of the Justification Test.

8. Flood Depth & Volume Analysis

An analysis was undertaken to assess the depths and volumes of flood waters that may potentially inundate the proposed development site during a 1 in 100 year (1% AEP) and 1 in 1000 year (0.1% AEP) extreme flood event in the watercourse. Using the hydrology module of the Autodesk Civil Design 3D software package further analysis was therefore undertaken to determine the range of flood water depths and volumes which may possibility inundate the site area.

Drawing Numbers IE2066-003-D and *IE2066-004-D, Appendix A,* illustrate the calculated depth of flood waters that may occur within the undeveloped site area in consideration of a 1% AEP and 0.1% AEP flood event in the adjacent watercourses. The possible depth of flood waters for these return periods is illustrated on the drawings via a graphical representation of flood depths within the boundary of the proposed development site and via a table of predicted flood water depths. The flood water depth table presents flood water depths over 20 separate elevation ranges within the boundary of the proposed development site.

By applying a Triangulated Irregular Network (TIN) analysis to the existing DTM surface and the predicted 1% AEP and 0.1% AEP year extreme flood levels in the River Urrin, the volume of flood waters which may inundate the site was calculated. The potential maximum and mean flood depths and flood inundation volumes are summarised in *Table 4* below.

	1% AEP Flood	0.1% AEP Flood
Maximum Flood Depth (m)	1.192	2.280
Mean Flood Depth (m)	0.454	1.210
Total Flood Water Volume (m^3)	5,776	20,549

Table 4: Site Flood Depth and Inundation Volumes

9. Discussion

The analysis undertaken as part of this Site Specific Flood Risk Assessment indicates that the south-western area of the proposed development site falls within a delineated Flood Zone 'A' and Flood Zone 'B' associated with the River Urrin and River Lyre. There is a small area of the proposed access road, footpath and road embankment that is located with Flood Zone 'A' (1 in 100 year extent) and Flood Zone 'B' (1 in 1000 year extent).

In order to enable a sustainable development of the site and to reduce the risk of flood inundation to the site it is proposed to raise the access road and footpath in the south-western area of the site above the 1 in 1000 year (0.1% AEP) flood levels in this area of the site.

An analysis was undertaken to assess the depths and volumes of flood waters that may potentially inundate the undeveloped site where development is proposed in the site during a 1 in 100 year (1% AEP) and 1 in 1000 year (0.1% AEP) extreme flood event River Urrin and River Lyre. Utilising the hydrology module of an appropriate software package further analysis was undertaken to determine the range of flood water depths and volumes which may possibility inundate the area of the site.

Drawing Number IE2066-005-D, Appendix A, illustrates the 0.1% AEP (1 in 1000 year) depth and volume of flood waters that may inundate the area of the existing site to be developed and also the post development 0.1% AEP (1 in 1000 year) flood depth and volumes within the same area adjacent to the proposed road embankment. The potential maximum and mean flood depths and flood volumes are summarised in *Table 5* below.

	Existing Site	**Proposed Site**
	0.1% AEP Flood Event	0.1% AEP Flood Event
Maximum Flood Depth (m)	1.563	1.563
Mean Flood Depth (m)	0.742	0.603
Total Flood Water Volume (m^3)	2180.75	457.40

Table 5: Pre and Post Development Site Flood Depth and Inundation Volumes

The volume of flood water that may be potentially displaced by the proposed access road, footpath and road embankment is calculated as follows:

Existing Site 0.1% AEP Flood Volume - Proposed Site 0.1% AEP Flood Volume = Volume Displaced

- 2180.75 – 457.40 = 1723.35m^3 [Volume Displaced]

9.1. Flood Storage Compensation

Although the impact of raising the access road and footpath is not predicted to have a significant impact on flooding regime in the area, it is proposed to provide flood storage compensation within the proposed development site boundary to compensate for the volume of flood water displaced by the proposed access road, footpath and road embankment. It is proposed to lower an area of the proposed green space area in the southern area of the site adjacent to the River Urrin. This flood storage area has been incorporated into the proposed landscaping plan for the development. The proposed area and levels of flood storage compensation is shown in on *Drawing Number IE2066-006-G, Appendix A.*

The volume of storage provided within the site is summarised in *Table 6* below.

	0.1% AEP Flood Event
Proposed Total Storage Compensation Volume (m^3)	1781
Proposed Flood Volume Displaced by Filling Site (m^3)	1723.35
Net Additional Volume of Storage Provided (m^3)	57.65

Table 6: Proposed Flood Storage Area Volumes

The volume of storage provided during a 1 in 1000 year (0.1% AEP) extreme flood events is greater than the volume displaced by raising the site levels for the proposed access road, footpath and road embankment and therefore the impact is considered to be low.

Considering the above it is therefore predicted that the proposed site would not result in any alteration to the existing fluvial and hydrological regime in the area and would not result in an increased flood risk elsewhere.

9.2. Proposed Drainage Works

As illustrated in *Figure 25* below, there are existing foul and stormwater pipes located within the boundary of the site. There is also an existing field drainage channel that traverses the site. It is proposed to divert the existing stormwater pipes and pipe the field drainage channel so that all pipes are located within the proposed roads as illustrated in *Figure 25* below. Please refer to the proposed drainage design details provided by Sweeney Consulting Engineers for further details.

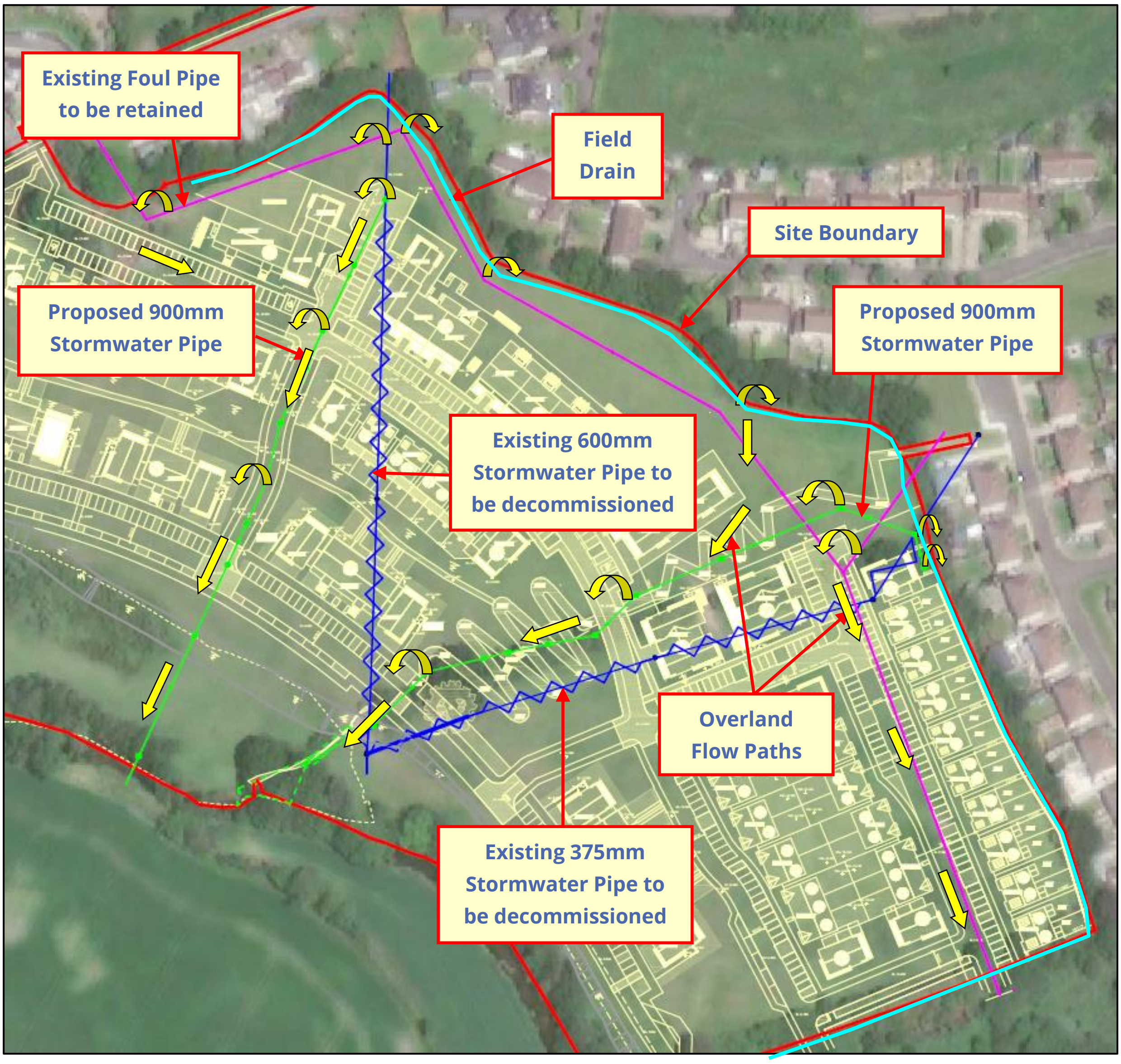


Figure 25 – Existing Drainage to be diverted

In the event that any of the diverted stormwater drainage or existing foul sewers was to surcharge any potential flood waters would spill onto the proposed roads or areas of open space. These waters would be collected by the proposed road gullies within the site or continue to flow along the road to the south-western area of the site as shown in *Figure 25* above. These waters would eventually overtop the road and spill into the proposed green open space in the south-western area of the site. The diverted stormwater pipe would likely spill directly into sections of open field drain to be retained within the site.

Overall, the potential flood risk posed by the existing drainage and proposed drainage diversions within the site is considered to be LOW.

10. Justification Test for Development Management

In the context of the '*Planning System and Flood Risk Management Guidelines, DOEHLG, 2009*' and in consideration of the scenario that the proposed development site is undefended, this Site Specific Flood Risk Assessment has determined that the southern area of the proposed development site falls within Flood Zone 'A' and Flood Zone 'B'.

Table 3.1 of the guidelines lists the vulnerability class of various types of development. The proposed development site is therefore classified as Highly Vulnerable development.

Table 3.2 of the guidelines (*duplicated below*) provides a matrix of different vulnerability classes of development in relation to Flood Zones A, B and C, and lists if development is appropriate in each Zone and where the Justification Test should be applied.

	Flood Zone A	**Flood Zone B**	**Flood Zone C**
Highly Vulnerable Development (including essential infrastructure	Justification Test	Justification Test	Appropriate
Less Vulnerable Development	Justification Test	Appropriate	Appropriate
Water-compatible development	Appropriate	Appropriate	Appropriate

Table 3.2: Matrix of vulnerability versus flood zone to illustrate appropriate development and that required to meet the Justification Test

With reference to the table above, the form of development proposed at the site is 'Highly Vulnerable Development' (i.e. residential) and the site partially falls within a delineated Flood Zone 'A' and Flood Zone 'B', therefore development proposals for the site are subject to the Justification Test. It is noted however that there are no proposed dwellings located in Flood Zone 'A' or Flood Zone 'B'.

Where 'Highly vulnerable development' is proposed within a delineated Flood Zone 'A or Flood Zone 'B', the planning authority must be satisfied that the development satisfies the criteria of the Justification Test as described in Box 5.1 of the guidelines (*duplicated below*):

Box 5.1 Justification Test for development management
(to be submitted by the applicant)

When considering proposals for development, which may be vulnerable to flooding, and that would generally be inappropriate as set out in Table 3.2, the following criteria must be satisfied:

1. The subject lands have been zoned or otherwise designated for the particular use or form of development in an operative development plan, which has been adopted or varied taking account of these Guidelines.
2. The proposal has been subject to an appropriate flood risk assessment that demonstrates:

   (i) The development proposed will not increase flood risk elsewhere and, if practicable, will reduce overall flood risk;

   (ii) The development proposal includes measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible;

   (iii) The development proposed includes measures to ensure that residual risks to the area and/or development can be managed to an acceptable level as regards the adequacy of existing flood protection measures or the design, implementation and funding of any future flood risk management measures and provisions for emergency services access; and

   (iv) The development proposed addresses the above in a manner that is compatible with the achievement of wider planning objectives in relation to development of good urban design and vibrant and active streetscapes.

The acceptability or otherwise of levels of residual risk should be made with consideration of the type and foreseen use of the development and the local development context.

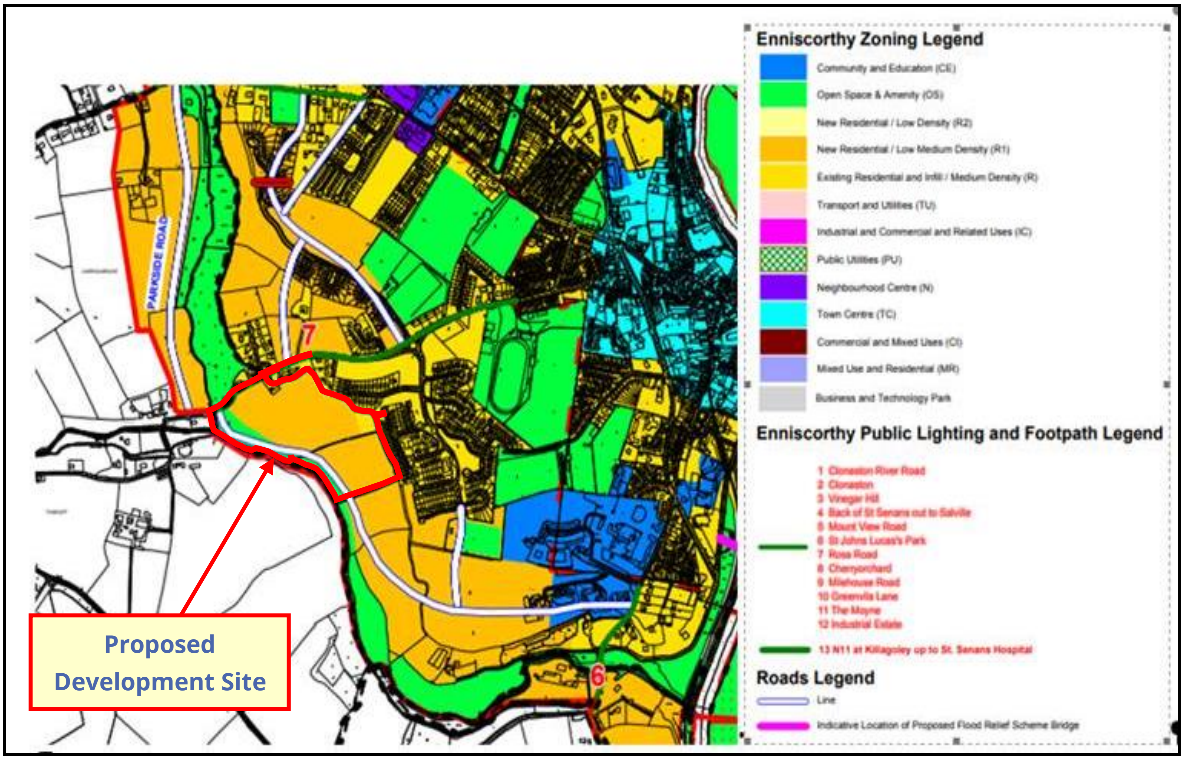
Note: See section 5.27 in relation to major development on zoned lands where sequential approach has not been applied in the operative development plan.

Refer to section 5.28 in relation to minor and infill developments.

Each of the criteria listed in Box 5.1 above are considered as follows:

1. The subject lands have been zoned or otherwise designated for the particular use or form of development in an operative development plan, which has been adopted or varied taking account of these guidelines.

   Answer – The subject site is predominantly zoned 'New Residential' under the Enniscorthy Town Plan. The area along the riverbank is zoned open space and amenity. As such the area of open space associated with the residential development is located here, in accordance with the zoning and having regard to the planning history of the site.



2. The proposal has been subject to an appropriate flood risk assessment that demonstrates:

   (i) The development proposed will not increase flood risk elsewhere and, if practical will reduce overall flood risk:

   Answer – Flood Storage Compensation shall be provided within the green open space area to reduce the overall flood risk as a result of raising grounds levels in the site including the proposed access road, footpath and road embankment. The proposed volume of flood storage provided is 1781m^3, which provides an additional storage volume of 57.65m^3 during a 1 in 1000 year (0.1% AEP) flood event in the River Urrin and River Lyre.

In consideration of the proposed flood compensation, the proposed development is not expected to result in an adverse impact to the hydrological regime of the area and is not expected to increase flood risk elsewhere.

(ii) The development proposal includes measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible:

Answer – The finished floor levels of the proposed houses shall be constructed to a minimum level of 8.65m OD, which is 1.15m above the peak 1 in 1000 year (0.1% AEP) flood level of 7.50m OD in the River Lyre at the proposed site entrance.

The access road and footpath located in the western area of the site shall be raised to a minimum level of 9.35m OD at the entrance to the site, which is 1.85m above the 1 in 1000 year flood level in this location.

The access road and footpath located in the southern area of the site shall be raised to a minimum level of 7.50m OD, which is 1.56m above the 1 in 1000 year flood level of 5.94m OD in this location.

These measures shall mitigate any residual risk associated with potential future climate change. Refer to Drawing Number *IE2066-006-G* for cross section details of the proposed ground levels relative to the 1 in 1000 year flood levels in the adjacent watercourses.

(iii) The development proposed includes measures to ensure that residual risks to the area and/or development can be managed to an acceptable level as regards the adequacy of existing flood protection measures or the design, implementation and funding or any future flood risk management measures and provisions for emergency services access:

Answer – Access to the proposed development site during an extreme flood event is provided at the proposed entrance in the western area of the site and by raising the access road and footpath above the 1 in 1000 year flood level. There is no residual risk posed to the site as the proposed ground levels are above the peak 1 in 1000 year flood adjacent to the site.

(iv) The development proposed addresses the above in a manner that is also compatible with the achievement of wider planning objectives in relation to development of good urban design and vibrant and active streetscapes:

Answer – The layout has been designed having regard to: the policies and objectives of the Town Plan and County Plan (zoning/road/urban design objectives); the planning history for the site; the context of the area including the sloping topography of the site; the adjoining residential estates/consolidation of built environment and the amenity provided by the River Urrin/Carley's Bridge etc. (apts/duplexes overlook open space and River).

The layout and design of units overlooking the main open space/smaller pockets spaces and streets creates active streetscapes and ensures passive surveillance of the public realm.

11. Summary Conclusions and Recommendations

In consideration of the findings of this site specific flood risk assessment and analysis the following conclusions and recommendations are made in respect of the proposed development site:

- A Site Specific Flood Risk (SSFRA) assessment, appropriate to the type and scale of development proposed, and in accordance with 'The Planning System and Flood Risk Management Guidelines – DoEHLG-2009' has been undertaken.
- The proposed site has been screened, scoped and assessed for flood risk in accordance with the above guidelines.
- The primary flood risk to the proposed site can be attributed to a fluvial flood event in the River Urrin and River Lyre adjacent to the western and south-western boundary of the site. The site is not at risk of groundwater flooding.
- A detailed Digital Terrain Model (DTM) has been developed for the site. Utilising the DTM, and the predicted 1 in 100 year (1% AEP) and 1 in 1000 year (0.1% AEP) flood levels, the flood extents have been delineated over the full extent of the DTM. This analysis has determined that the south-western area of the site falls within Flood Zone 'A' and Flood Zone 'B'. The majority of the area of the site where development is proposed is located in Flood Zone 'C'.
- Secondary pluvial flood risk can also be attributed to a potential surcharge of the urban drainage network and /or damage to the water supply infrastructure in the vicinity of the site. It is anticipated that the any flooding due to surcharge of the foul sewer located close to the northern boundary of the site would spill out onto Carley's Bridge Road and be picked up by existing stormwater gullies located in the road. It is not anticipated that these waters would enter the boundary of the site. It is also predicted that any flooding due to a surcharge of the stormwater or foul manholes within the site would likely cause these waters to spill out onto the proposed development site and flow downhill in a southerly direction toward the River Urrin, before spilling into the river and away from the site. It is not anticipated that this would result in any ponding or flooding within the site.
- Secondary flood risk can be attributed to a potential surcharge due to a blockage in the bridge located on the River Lyre adjacent to the north-western boundary of the proposed development site. In the event the bridge becomes blocked and begins to surcharge flood waters would surcharge/back up the River Lyre, overtop the bank and potentially spill out onto the surrounding land and would eventually flow in a southerly direction into the River

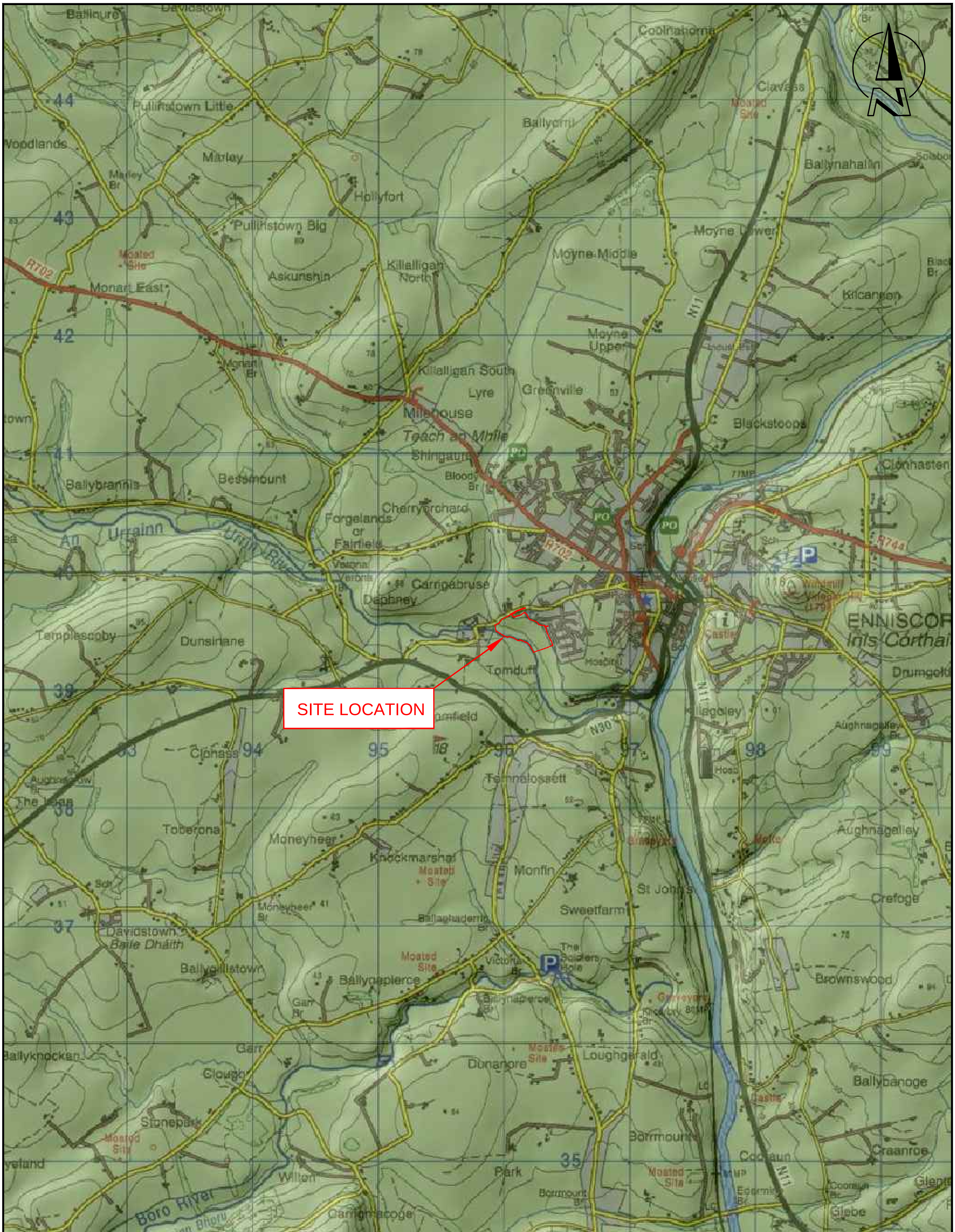
Urrin and away from the proposed development site. Therefore, this secondary flood risk to the site is considered LOW.

- The finished floor levels of the proposed houses shall be constructed to a minimum level of 8.65m OD, which is 1.15m above the peak 1 in 1000 year (0.1% AEP) flood level of 7.50m OD in the River Lyre at the proposed site entrance. This shall mitigate any residual risk associated with potential future climate change.
- The access road and footpath located in the western area of the site shall be raised to a minimum level of 9.35m OD at the entrance to the site, which is 1.85m above the 1 in 1000 year flood level in this location. The access road and footpath located in the southern area of the site shall be raised to a minimum level of 7.50m OD, which is 1.56m above the 1 in 1000 year flood level of 5.94m OD in this location. This shall mitigate any residual risk associated with potential future climate change.
- Flood storage compensation shall be provided in the proposed green open space area to account for flood waters that may be displaced as a result of raising the grounds in the southern area of the proposed development site above the 1 in 1000 year flood level.
- There are existing foul and stormwater pipes located within the site as well as an existing field drainage channel that traverses the site. It is proposed to divert the existing foul and stormwater pipes and pipe the field drainage channel so that all pipes are located within the proposed roads. In the event any of the diverted drainage was to surcharge any potential flood waters would spill onto the proposed road. These waters would be collected by the proposed road gullies within the site or continue to flow along the road to the south-western area of the site and spill into the proposed green open space in the south-western area of the site. Overall, the potential flood risk posed to the site is considered to be LOW.
- The proposed development is considered to comply with the requirements of the Justification Test for development management.
- In consideration of implementation of the recommendations of this SSFRA the flood risk to and from the proposed development site is considered to be **LOW**. Development of the site is not expected to result in an adverse impact to the hydrological regime of the area or increase flood risk elsewhere.

Appendices

Appendix A. Drawings

IE2066-001-B	Site Location
IE2066-002-D	1% AEP & 0.1% AEP Flood Extents
IE2066-003-D	1% AEP Flood Depth & Volumes
IE2066-004-D	0.1% AEP Flood Depth & Volumes
IE2066-005-D	0.1% AEP Flood Volume & Depth Displacement Analysis
IE2066-006-G	Proposed Flood Storage Compensation Area & Proposed Site Cross Sections



IE Consulting Innovation Centre, Green Road,
Carlow, R93 W248.
Ph: 059-9133084
E-mail: info@iece.ie
Web: www.iece.ie

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

Project Title:	FLOOD RISK ASSESSMENT
Project Address:	CARLEY'S BRIDGE, ENNISCORTHY, CO WEXFORD
Client:	TORCA DEVELOPMENTS LIMITED
Drg. Title:	SITE LOCATION MAP

Dwg.Scale:	Date:	Dwg.No:	Job No:	Revision:	Dwg.By:
1:50,000	19/08/21	IE2066-001	IE2066	B	NOM

LEGEND

- SITE BOUNDARY
- 100 YEAR FLOOD EXTENT (1% AEP) FLOOD ZONE 'A'
- 1000 YEAR FLOOD EXTENT (0.1% AEP) FLOOD ZONE 'B'

rev.	date	amendment	drn	ckd
D	25.03.22	PLANNING	NOM	PMS
C	24.09.21	PLANNING	NOM	PMS
B	16.08.21	PLANNING	NOM	PMS
A	03.06.20	PLANNING	NOM	PMS

STRATEGIC HOUSING DEVELOPMENT
CARLEY'S BRIDGE ROAD, ENNISCORTHY, CO. WEXFORD

SITE SPECIFIC FLOOD RISK ASSESSMENT

1 IN 100 YEAR (1% AEP) & 1 IN 1000 YEAR (0.1% AEP) FLUVIAL FLOOD EXTENTS

ie
IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

CARLOW OFFICE:
INNOVATION CENTRE
GREEN ROAD
CARLOW, R93 W248

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

file location:	N:\IE2066\DRAWINGS	scale:	1:1000 A3
drawing status:	PLANNING	datum:	MALIN
		drawn:	NOM
drawing no.	IE2066-002	checked:	PMS
rev	D	approved:	PMS
		date:	25.03.2022

1 in 100 Year Flood Depths

Number	Minimum Elevation	Maximum Elevation	Color
1	0.00	0.06	
2	0.06	0.12	
3	0.12	0.18	
4	0.18	0.24	
5	0.24	0.30	
6	0.30	0.36	
7	0.36	0.42	
8	0.42	0.48	
9	0.48	0.54	
10	0.54	0.60	
11	0.60	0.66	
12	0.66	0.72	
13	0.72	0.78	
14	0.78	0.83	
15	0.83	0.89	
16	0.89	0.95	
17	0.95	1.01	
18	1.01	1.07	
19	1.07	1.13	
20	1.13	1.19	

PROJECT NO. IE2066
CARLEY'S BRIDGE, ENNISCORTHY, CO. WEXFORD

Number of points	5805
Minimum Depth	0.000 m
Maximum Depth	1.192 m
Mean Depth	0.454 m

1: 100 YEAR FLUVIAL FLOOD VOLUME

Base Surface:	Existing Site
Comparison Surface:	1:100 Year Fluvial Water Level

Flood volume = 5,776 m^3

LEGEND

SITE BOUNDARY

rev.	date	amendment	drn	ckd
D	25.03.22	PLANNING	NOM	PMS
C	24.09.21	PLANNING	NOM	PMS
B	16.08.21	PLANNING	NOM	PMS
A	03.06.20	PLANNING	NOM	PMS

STRATEGIC HOUSING DEVELOPMENT
CARLEY'S BRIDGE ROAD, ENNISCORTHY, CO. WEXFORD

SITE SPECIFIC FLOOD RISK ASSESSMENT

1 IN 100 YEAR (1% AEP) FLUVIAL FLOOD VOLUME & DEPTH ANALYSIS

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

CARLOW OFFICE:
INNOVATION CENTRE
GREEN ROAD
CARLOW, R93 W248

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

file location: N:\IE2066\DRAWINGS	scale: 1:1000	A3
drawing status: PLANNING	datum: MALIN	
	drawn: NOM	
drawing no. IE2066-003	checked: PMS	
rev D	approved: PMS	
	date: 25.03.2022	

1 in 1000 Year Flood Depths

Number	Minimum Elevation	Maximum Elevation	Color
1	0.00	0.11	
2	0.11	0.23	
3	0.23	0.34	
4	0.34	0.46	
5	0.46	0.57	
6	0.57	0.68	
7	0.68	0.80	
8	0.80	0.91	
9	0.91	1.03	
10	1.03	1.14	
11	1.14	1.25	
12	1.25	1.37	
13	1.37	1.48	
14	1.48	1.60	
15	1.60	1.71	
16	1.71	1.82	
17	1.82	1.94	
18	1.94	2.05	
19	2.05	2.17	
20	2.17	2.28	

PROJECT NO. IE2066
CARLEY'S BRIDGE, ENNISCORTHY, CO. WEXFORD

Number of points	5693
Minimum Depth	0.000 m
Maximum Depth	2.280 m
Mean Depth	1.210 m

1: 1000 YEAR FLUVIAL FLOOD VOLUME

Base Surface:	Existing Site
Comparison Surface:	1:1000 Year Fluvial Water Level

Flood volume = 20,549 m^3

LEGEND

SITE BOUNDARY

rev.	date	amendment	drn	ckd
D	25.03.22	PLANNING	NOM	PMS
C	24.09.21	PLANNING	NOM	PMS
B	16.08.21	PLANNING	NOM	PMS
A	03.06.20	PLANNING	NOM	PMS

STRATEGIC HOUSING DEVELOPMENT
CARLEY'S BRIDGE ROAD, ENNISCORTHY,
CO. WEXFORD

SITE SPECIFIC FLOOD
RISK ASSESSMENT

1 IN 1000 YEAR (0.1% AEP) FLUVIAL FLOOD
VOLUME & DEPTH ANALYSIS

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

CARLOW OFFICE:
INNOVATION CENTRE
GREEN ROAD
CARLOW, R93 W248

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

file location: N:\IE2066\DRAWINGS		scale: 1:1000	A3
drawing status: PLANNING		datum: MALIN	
		drawn: NOM	
drawing no. IE2066-004	rev D	checked: PMS	
		approved: PMS	
		date: 25.03.2022	

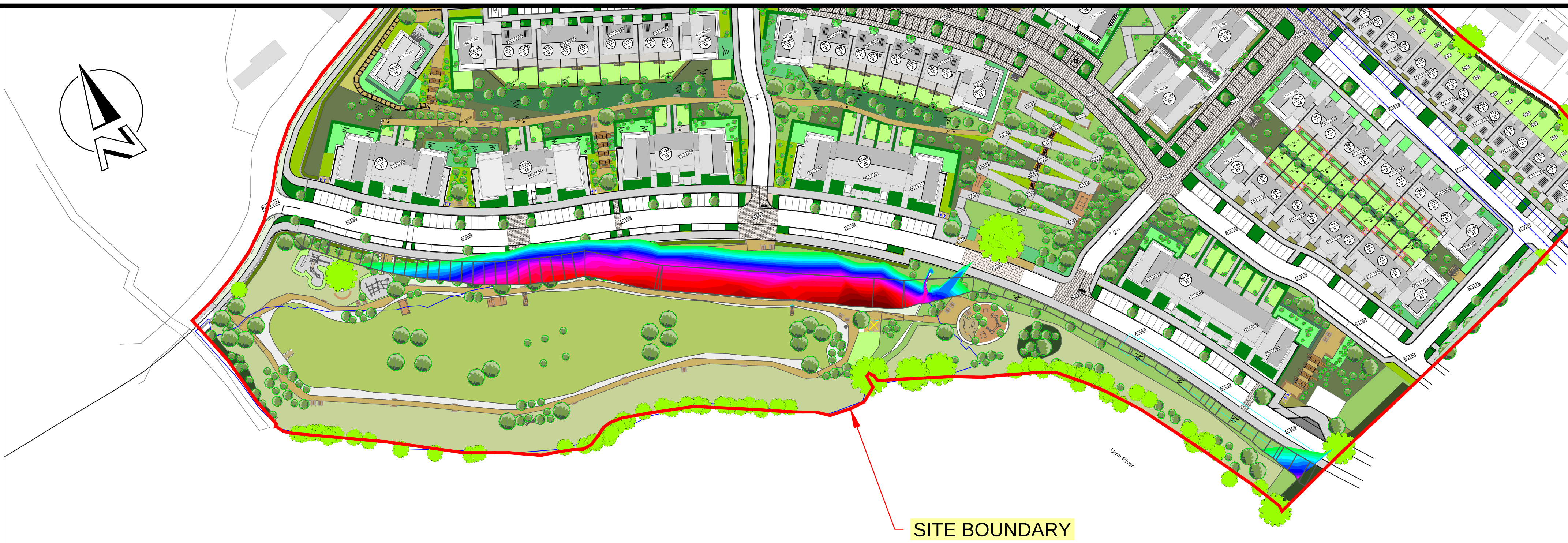
1 in 1000 Year Flood Depths			
Number	Minimum Elevation	Maximum Elevation	Color
1	0.00	0.08	
2	0.08	0.16	
3	0.16	0.23	
4	0.23	0.31	
5	0.31	0.39	
6	0.39	0.47	
7	0.47	0.55	
8	0.55	0.63	
9	0.63	0.70	
10	0.70	0.78	
11	0.78	0.86	
12	0.86	0.94	
13	0.94	1.02	
14	1.02	1.09	
15	1.09	1.17	
16	1.17	1.25	
17	1.25	1.33	
18	1.33	1.41	
19	1.41	1.49	
20	1.49	1.56	

PROJECT NO. IE2066
CARLEY'S BRIDGE, ENNISCORTHY, CO. WEXFORD

EXISTING SITE FLOOD VOLUME: 2180.75m^3

PROPOSED SITE FLOOD VOLUME: 457.40m^3

FLOOD VOLUME DISPLACED: 1723.35m^3



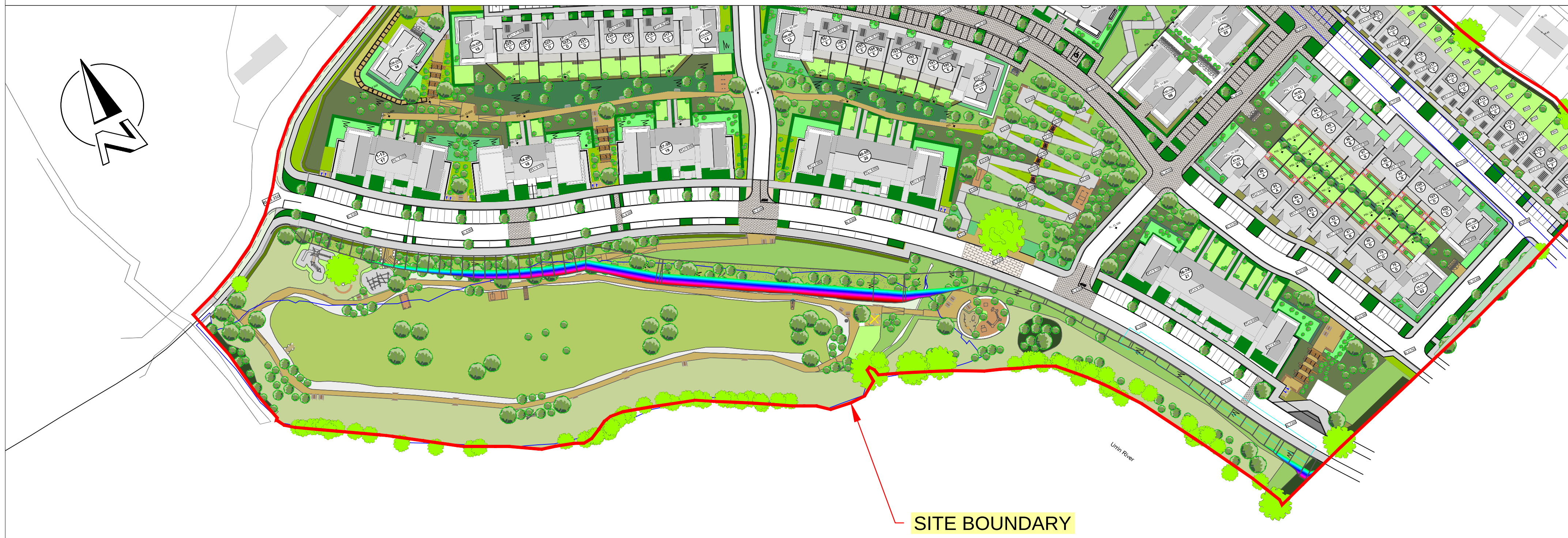
EXISTING SITE 0.1% AEP FLOOD INUNDATION VOLUME

PROJECT NO. IE2066
CARLEY'S BRIDGE, ENNISCORTHY, CO. WEXFORD

1: 1000 YEAR FLUVIAL FLOOD VOLUME

Base Surface: Existing Site
Comparison Surface: 1:1000 Year Fluvial Water Level

Flood volume = 2180.75 m^3



PROPOSED SITE 0.1% AEP FLOOD INUNDATION VOLUME

PROJECT NO. IE2066
CARLEY'S BRIDGE, ENNISCORTHY, CO. WEXFORD

1: 1000 YEAR FLUVIAL FLOOD VOLUME

Base Surface: Proposed Site
Comparison Surface: 1:1000 Year Fluvial Water Level

Flood volume = 457.40 m^3

LEGEND

SITE BOUNDARY

rev.	date	amendment	drn	ckd
D	25.03.22	PLANNING	NOM	PMS
C	24.09.21	PLANNING	NOM	PMS
B	16.08.21	PLANNING	NOM	PMS
A	03.06.20	PLANNING	NOM	PMS

STRATEGIC HOUSING DEVELOPMENT
CARLEY'S BRIDGE ROAD, ENNISCORTHY,
CO. WEXFORD

SITE SPECIFIC FLOOD
RISK ASSESSMENT

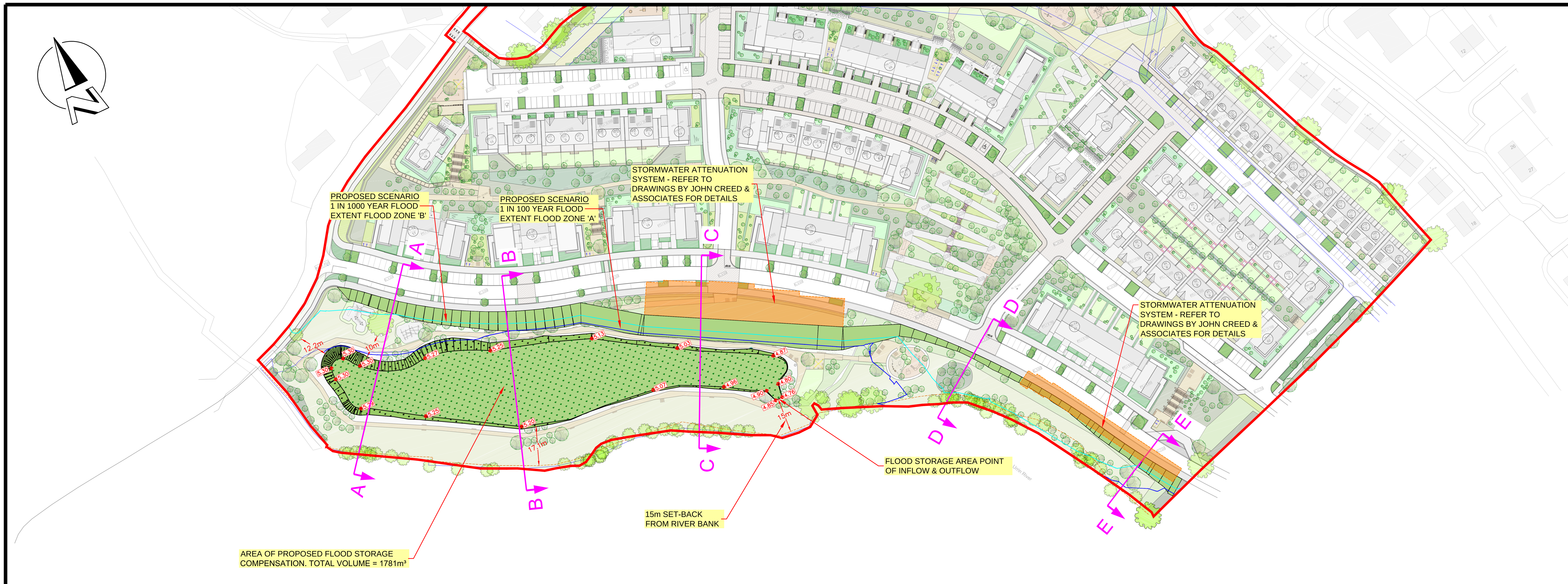
1 IN 1000 YEAR (0.1% AEP)
FLOOD VOLUME & DEPTH
DISPLACEMENT ANALYSIS

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

CARLOW OFFICE:
INNOVATION CENTRE
GREEN ROAD
CARLOW, R93 W248

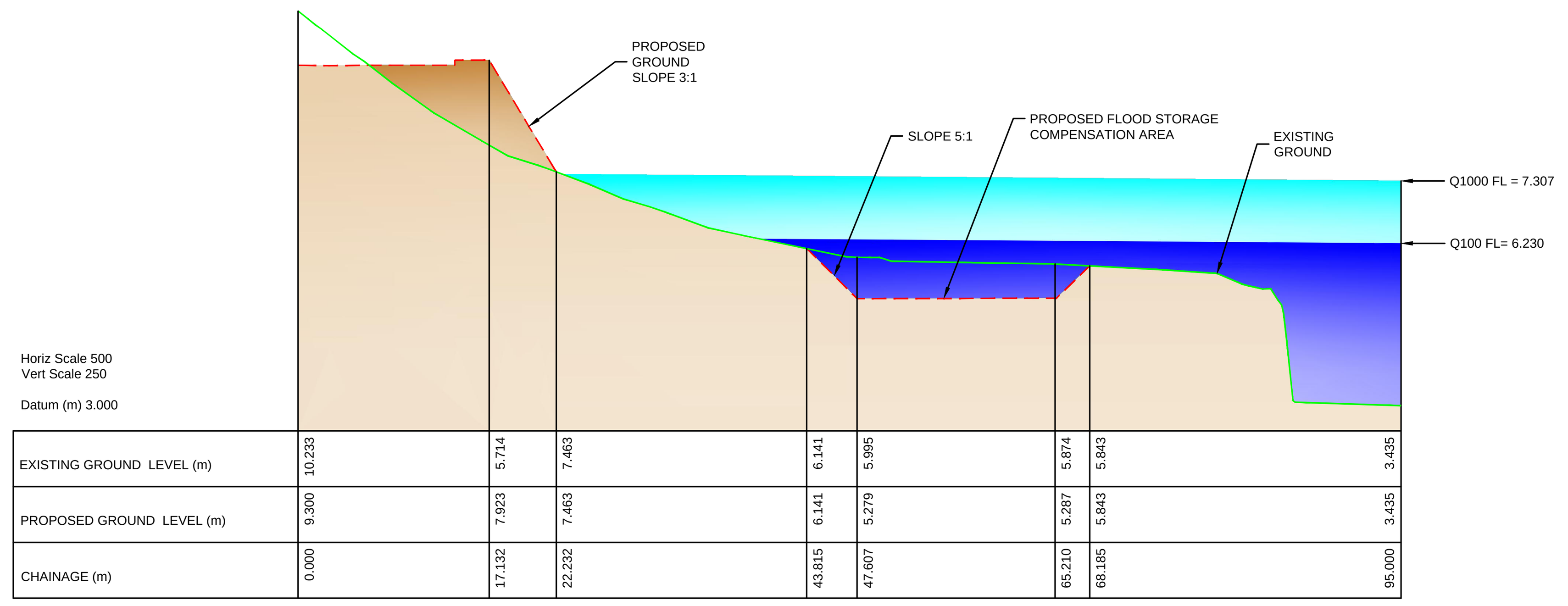
NEWRY OFFICE:
1 RDC HOUSE
WIN BUSINESS PARK
NEWRY, BT35 6PH

file location:	N:\IE2066\DRAWINGS		scale: 1:1000	A3
drawing status:	PLANNING		datum: MALIN	
			drawn: NOM	
drawing no.	IE2066-005	rev D	checked: PMS	
			approved: PMS	
			date: 25.03.2022	

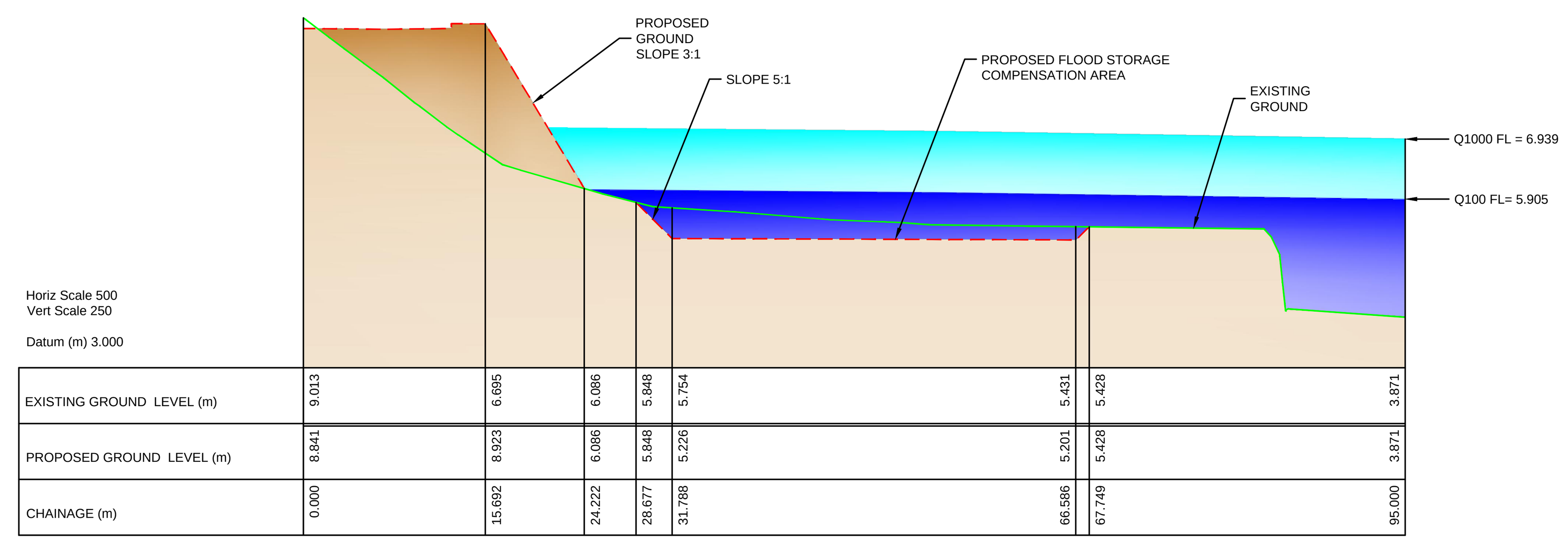


LAYOUT PLAN

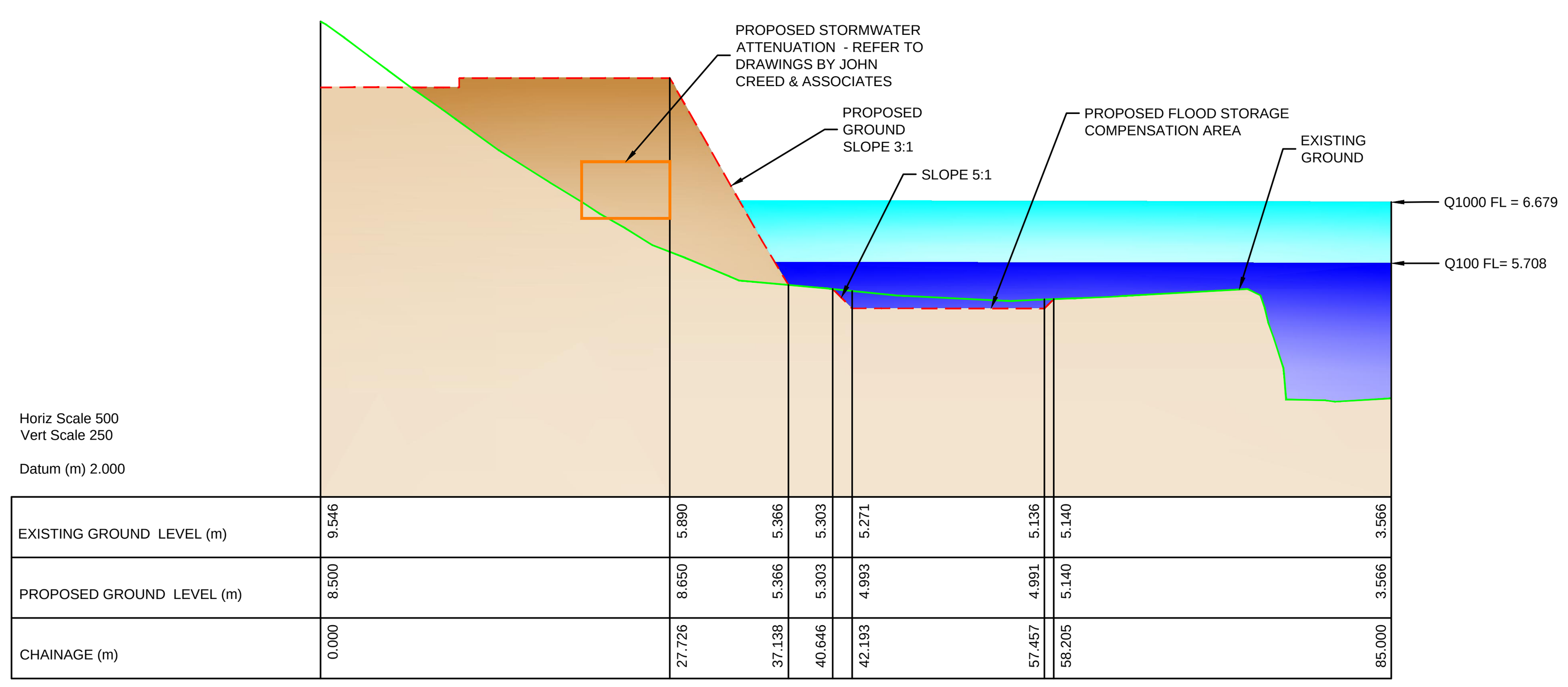
SCALE 1:1000



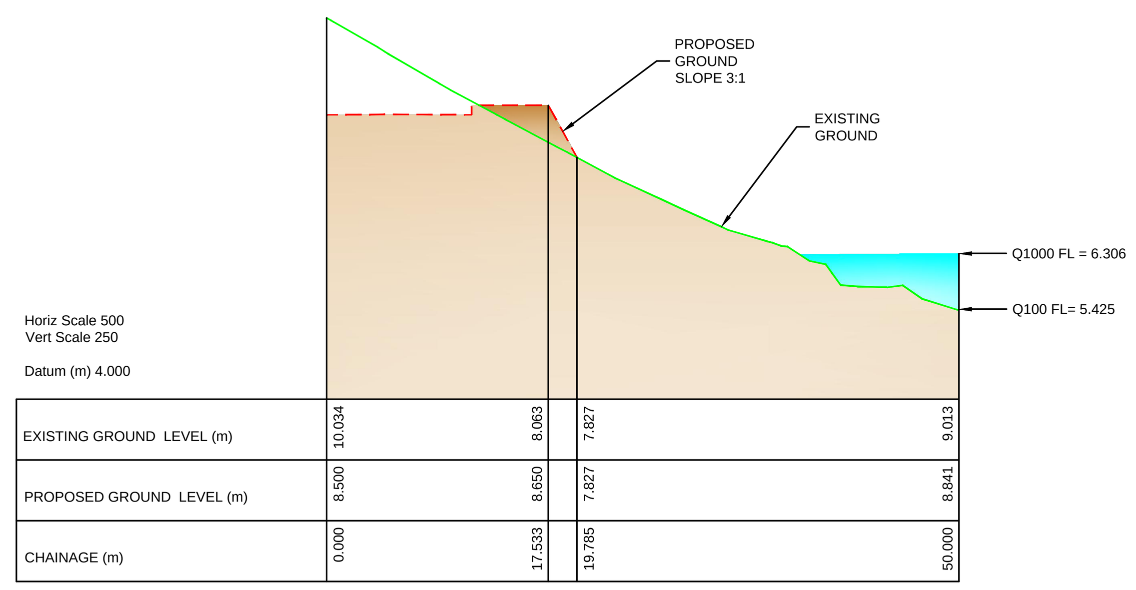
SECTION A-A
Horiz Scale 1:1000
Vert Scale 1:500



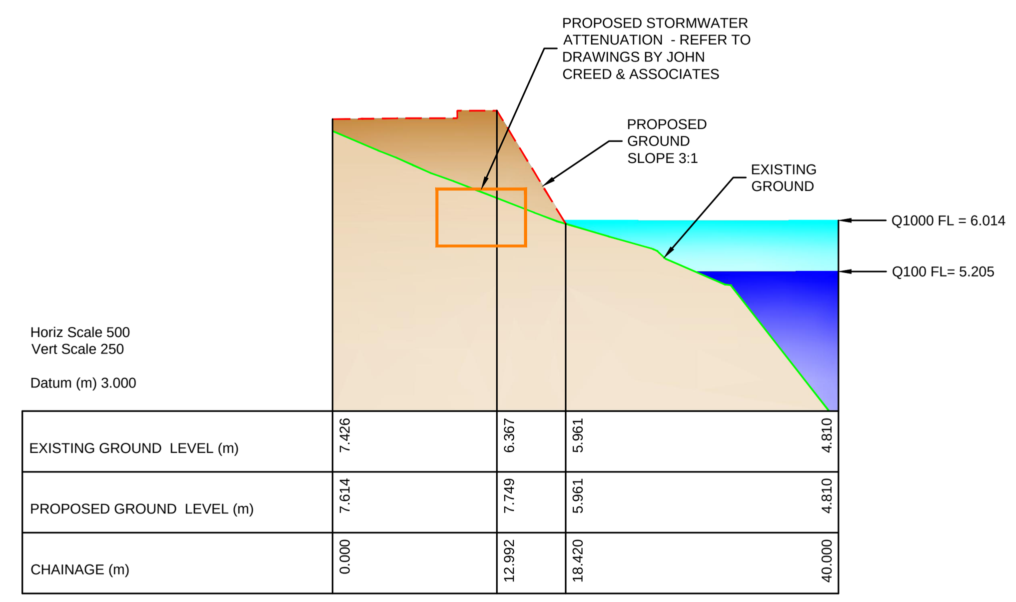
SECTION B-B
Horiz Scale 1:1000
Vert Scale 1:500



SECTION C-C
Horiz Scale 1:1000
Vert Scale 1:500



SECTION D-D
Horiz Scale 1:1000
Vert Scale 1:500



SECTION E-E
Horiz Scale 1:1000
Vert Scale 1:500

LEGEND

SITE BOUNDARY

rev.	date	amendment	drn	ckd
G	25.03.22	PLANNING	NOM	PMS
F	24.09.21	PLANNING	NOM	PMS
E	25.08.21	PLANNING	NOM	PMS
D	16.08.21	PLANNING	NOM	PMS
C	24.06.21	PLANNING	NOM	PMS
B	11.05.21	PLANNING	NOM	PMS
A	04.06.20	PLANNING	NOM	PMS

STRATEGIC HOUSING DEVELOPMENT
CARLEY'S BRIDGE ROAD, ENNISCORTHY,
CO. WEXFORD

SITE SPECIFIC FLOOD
RISK ASSESSMENT

PROPOSED FLOOD STORAGE
COMPENSATION AREA
& PROPOSED SITE CROSS SECTIONS

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL
CARLOW OFFICE:
INNOVATION CENTRE
GREEN ROAD
CARLOW, R93 W248
NEWRY OFFICE:
1 RDC HOUSE
WIN BUSINESS PARK
NEWRY, BT35 6PH

file location: N:\IE2066\DRAWINGS		scale:	AS SHOWN A1
drawing status: PLANNING		datum:	MALIN
		drawn:	NOM
drawing no. IE2066-006	rev G	checked:	PMS
		approved:	PMS
		date:	25.03.2022

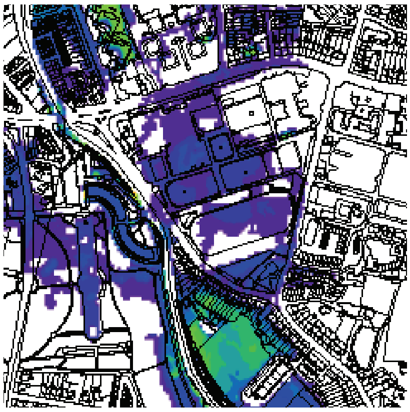
Appendix B. CFRAMS Hydraulics Report

South Eastern CFRAM Study

HA 11, 12 and 13 Hydraulics Report
4.6 Enniscorthy

IBE0601Rp0014




South Eastern CFRAM Study

HA12 Hydraulics Report

Enniscorthy (Fairfield/ Cherryorchard) Model

DOCUMENT CONTROL SHEET

Client	OPW
Project Title	South Eastern CFRAM Study
Document Title	IBE0601Rp0014_HA12 Hydraulics Report_F01
Model Name	Enniscorthy (Fairfield / Cherryorchard)

Rev.	Status	Author(s)	Modeller	Reviewed by	Approved By	Office of Origin	Issue Date
D01	Draft	T. Carberry	M. Nixon	I. Bentley	G. Glasgow	Limerick/Belfast	05/06/2014
F01	Draft Final	M. Nixon	M. Nixon	K. Smart	G. Glasgow	Belfast	23.12.2014
F02	Draft Final	M. Nixon	M. Nixon	K. Smart	G. Glasgow	Belfast	13/08/2015
F03	Draft Final	M. Nixon	M. Nixon	S. Patterson	G. Glasgow	Belfast	30/06/2016

Table of Reference Reports

Report	Issue Date	Report Reference	Relevant Section
South Eastern CFRAM Study Flood Risk Review	**November 2011**	**IBE0601 Rp0001_Flood Risk Review**	**3.10.9** **3.10.10**
South Eastern CFRAM Study Inception Report UoM11, 12 & 13	**July 2012**	**IBE0601Rp0007_HA 11, 12 and 13 Inception Report**	**4.3.2**
South Eastern CFRAM Study Hydrology Report UoM11, 12 & 13	**February 2014**	**IBE0601Rp0012_HA11, 12 & 13_Hydrology Report**	**4.7**
South Eastern CFRAM Study HA11-17 SC4 Survey Contract Report	**January 2014**	**IBE0601Rp0016_South Eastern CFRAMS Survey Contract Report**	**1.9**

4 HYDRAULIC MODEL DETAILS

4.6 ENNISCORTHY (FAIRFIELD / CHERRYORCHARD) MODEL

4.6.1 General Hydraulic Model Information

(1) Introduction:
The South Eastern CFRAM Study Flood Risk Review report (IBE0601 Rp0001_Flood Risk Review_F01) highlighted Enniscorthy in the Slaney catchment as an AFA for fluvial flooding based on a review of historic flooding and the extents of flood risk determined during the PFRA. As a flood alleviation scheme is being progressed on the main River Slaney through Enniscorthy, this section of the report focuses on the flooding within the Fairfield / Cherryorchard portions of the AFA. To this end, there is no requirement to produce flood maps for the River Slaney through Enniscorthy. However, flood risk to Fairfield and Cherryorchard was identified by Wexford County Council arising from the River Urrin. This, and any backwater effects from the Slaney, is assessed by South Eastern CFRAM Study hydraulic modelling. With flood maps not required for the River Slaney through Enniscorthy and Enniscorthy itself, the Drumgold, Ballycourcy, Killcannon, Kilpierce, Killagoley and Clonnasten watercourses have all been excluded from the model in model simulations. Despite not being hydraulically modelled, the hydrology for these watercourses has been modelled. HA12 Model 4 represents the Enniscorthy AFA, including Fairfield and Cherryorchard. It is hereafter referred to as the Enniscorthy model. It encompasses the River Slaney as it flows through the AFA, becoming tidally influenced as it makes the transition to Upper Slaney Estuary. The model also includes the River Urrin flowing from the west as it enters the AFA which joins the River Slaney south of the town after passing beneath the N30 roadway. There are also several tributaries of the Slaney and Urrin within the Enniscorthy model including those at Ballycoory, Killagoley, Kilpierce and Blackstoops, all of which directly affect the AFA. The total contributing area at the downstream limit of the model is 1,646 km^2. The catchment area of the River Urrin is 115 km^2. The Bann River enters the model near the upstream limit and accounts for 182 km^2 of the contributing area and, although it has not been hydraulically modelled, the hydrology for the watercourse has been modelled. There are six gauging stations located within the model extents but only one of them provides data that can be used for calibration as summarised below. Further information can be found in Section 4.6.5(4). Scarawalsh Gauging Station (12001) is located on the River Slaney. The Q_{med} for the model is 152.1 m^3/s based on a flow data AMAX series of 55 years (1955-2011). It was rated under FSU as an A2 station where flows can be calibrated on flow values up to 1.3 times Q_{med}. A CFRAM Study rating review was undertaken at this gauging station, refer to section 4.6.5(4) for further details. Enniscorthy Gauging Station (12002) is located on the River Slaney. The Q_{med} for the model is 203.1 m^3/s

based on a flow data AMAX series of 31 years. This station was not rated under FSU. This gauging station records both water level and flow; however it is tidal and therefore unsuitable for calibration in this fluvial only model.

St. John's Bridge Gauging Station (12007) is a tidal station located on the Urrin River. It records water level only so it is therefore unsuitable for calibration. Gauging stations Rafter Bridge (downstream) (12008) and Rafter Bridge (upstream) (12009) are both located on the River Slaney. They record water level only and so are not suitable for use in calibration of this model. Carley's Bridge (12026) on the Urrin River is inactive with a staff gauge only reading, making it unsuitable for model calibration.

Q_{med} estimates at the various HEPs were adjusted based on the gauge at Scarawalsh (12001). It is also noted that a rating review station (Station 12015, Ferns – OPW) is located on the Bann River which enters the model near the upstream limit. The rating review brings this station into play with respect to its use as a pivotal site for adjustment of the initial Q_{med} estimates at the relevant Tributary HEP (12_943_2_RPS).

Q_{med} values for HEPs 12_2604_2_RPS and 12007_RPS on the River Urrin are identical. These are intermediate HEPs located on the River Urrin main channel with no tributaries joining between these two HEP points. Initial Q_{med} estimates using FSU regression equation resulted in Q_{med} values that decreased in a downstream direction. This is not hydrologically correct and was found to be a function of the SAAR value used in the FSU regression equation. It tends to decrease in a southerly direction and was reducing Q_{med} values as a consequence. In reality, flow will not decrease for this reason and as such the higher Q_{med} values from upstream are held constant moving downstream until they begin to rise again. These are not input flows to the model.

The River Slaney is identified as an MPW for the upstream end of the reach from 12SLAN03172 to 12SLAN02903, with much of the remainder identified as a HPW. The watercourses in the Fairfield and Cherryorchard area are modelled in 1D-2D using the MIKE suite software, as is the stretch of the River Slaney between the Blackstoops River and Urrin River (01ENNI00649-01ENNI00450). The remainder of the River Slaney is modelled in 1D, to convey flood flows, as it is included in the Enniscorthy Flood Defence scheme.

The Enniscorthy model has been extended for modelling purposes by 1.07 km upstream into the Bunclody model, incorporating four additional cross-sections. It has also been extended by 1.1 km downstream into the Wexford model, incorporating two additional cross-sections. There is nothing to note from either of these models that will affect the Enniscorthy model.

(2) Model Reference:	HA12_ENNI4
(3) AFAs included in the model:	ENNISCORTHY (FAIRFIELD / CHERRYORCHARD)

(4) Primary Watercourses / Water Bodies (including local names):

Reach ID	**Name**
12DRUM	DRUMGOLD
12BRCY	BALLYCOURCY

12SLAN SLANEY 2 12CANN KILCANNON 12KILP KILPIERCE 12LYRE LYRE 12MONA MONART STREAM 12OLEY KILLAGOLEY 12OOPS BLACKSTOOPS 12STEN CLONNASTEN 12URIN URRIN RIVER 12URLP ENNISCORTHY 12URMI URRIN MILL 12LYRT LYRE TRIB		
(5) Software Type (and version):		
(a) 1D Domain: MIKE 11 (2012)	**(b) 2D Domain:** MIKE 21 – Rectangular Mesh (2012)	**(c) Other model elements:** MIKE FLOOD (2012)

4.6.2 Hydraulic Model Schematisation

(1) Map of Model Extents:

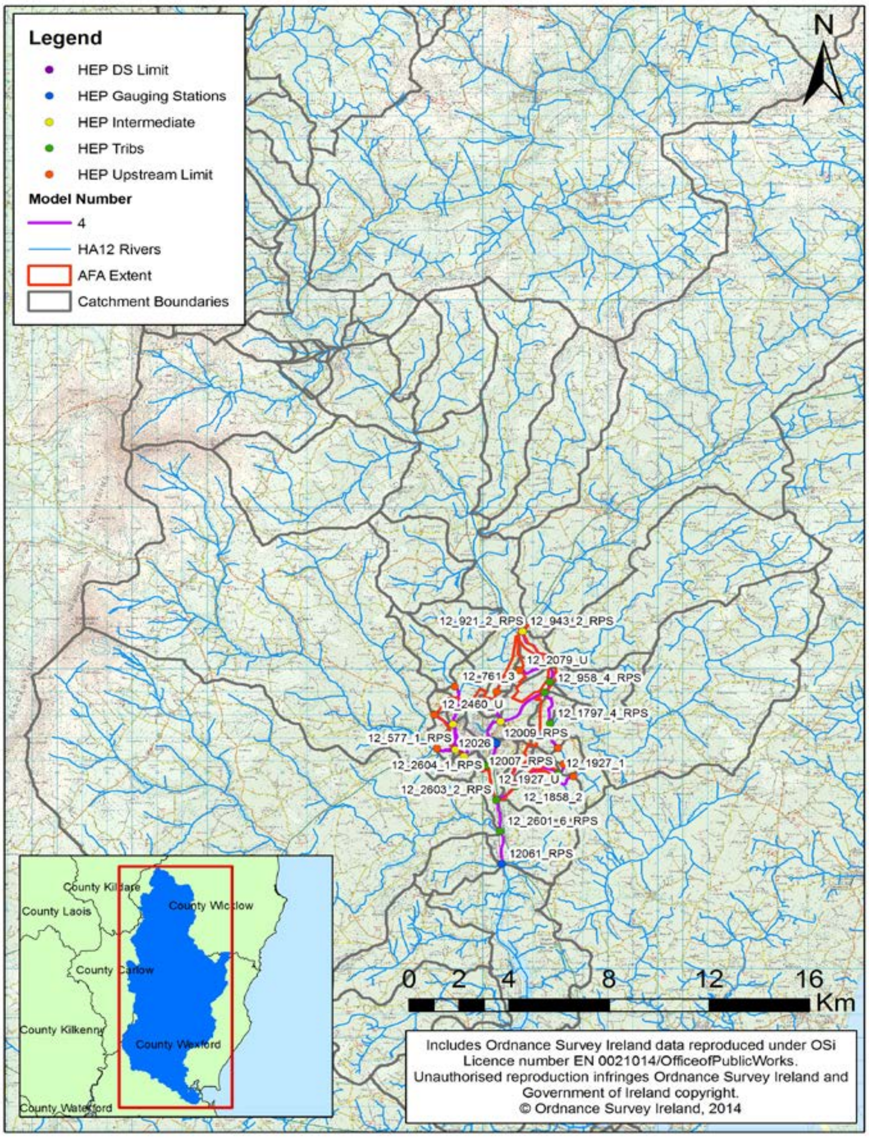


Figure 4.6.1 Map of Model Extents

Figure 4.6.1 and Figure 4.6.2 illustrate the extent of the modelled catchment, river centre line, HEP locations and AFA extents. Figure 4.6.2 is focused on the AFA extent. The Enniscorthy catchment includes 6 Gauging Station HEPs (12001_RPS, 12002_RPS, 12007_RPS, 12008_RPS, 12009_RPS and 12026_RPS), 5 Upstream Limit HEPs, 1 Downstream Limit HEP, 5 Intermediate HEPs and 7 Tributary HEPs.

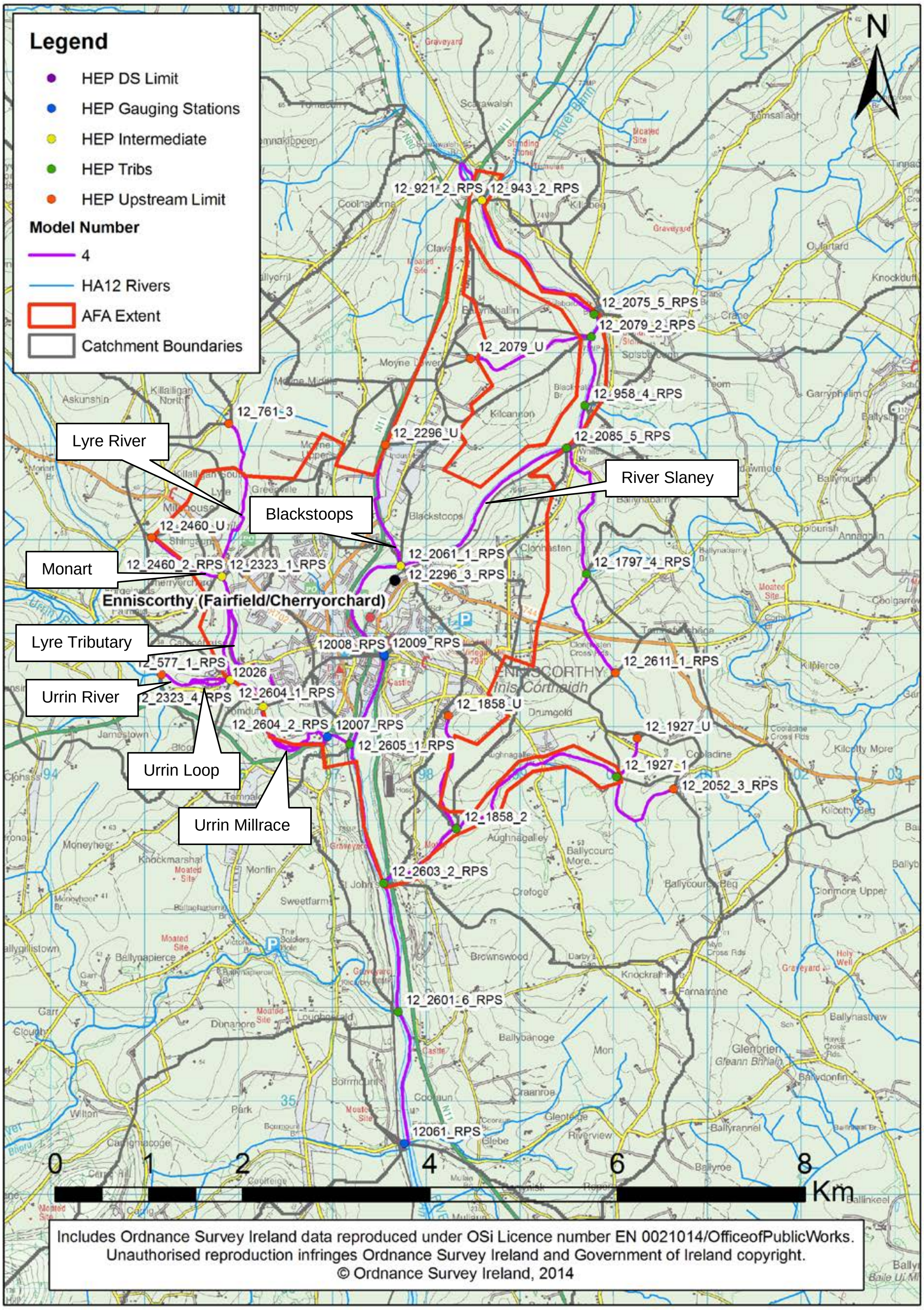


Figure 4.6.2 Detail of AFA Extent

(2) x-y Coordinates of River (Upstream extent):

River Name		x	y
12DRUM	DRUMGOLD	N/A	N/A
12BRCY	BALLYCOURCY	N/A	N/A
12SLAN	SLANEY 1	296823.47	147530.91
12CANN	KILCANNON	N/A	N/A
12KILP	KILPIERCE	N/A	N/A
12LYRE	LYRE	295907.69	142227.47
12MONA	MONART STREAM	295073.26	141023.98
12OLEY	KILLAGOLEY	N/A	N/A
12OOPS	BLACKSTOOPS	297555.57	141991.06
12STEN	CLONNASTEN	N/A	N/A
12URIN	URRIN RIVER	295274.98	139506.22
12URLP	URRIN LOOP	295512.38	139472.05
12URMI	URRIN MILL	296333.2	138910.04
12LYRT	LYRE TRIB	295898.96	140408.06
12SLAM	SLANEY RIVER MILLRACE	298407.58	144995.89

Reaches with no upstream co-ordinates (stated as N/A) are those excluded from the hydraulic model. See 4.6.1(1) for details.

(3) Total Modelled Watercourse Length:		26.5 km (approx)	
(4) 1D Domain only Watercourse Length:	15.5 km (approx.)	**(5) 1D-2D Domain Watercourse Length:**	11 km (approx.)
(6) 2D Domain Mesh Type / Resolution / Area:		Rectangular / 5 metres / 14.9 km^2 (approx.)	

(7) 2D Domain Model Extent:

Figure 4.6.4 shows an overview drawing of the model schematisation. Figures 4.6.5 and 4.6.6 show detailed views. The overview diagram covers the model extents, showing the surveyed cross-section locations, AFA boundary and river centreline. It also shows the area covered by the 2D model domain. The detailed areas are provided where there is the most significant risk of flooding. These diagrams include the surveyed cross-section locations, AFA boundary and river centreline. They also show the location of the critical structures as discussed in 4.6.3(1), along with the location and extent of the links between the 1D and 2D models. Buildings are excluded from the mesh and therefore represented as red spaces. For details of the approach to modelling buildings in the 2D area, please refer to section 3.3.2 of this report.

Check guidance document for details of what maps to add.

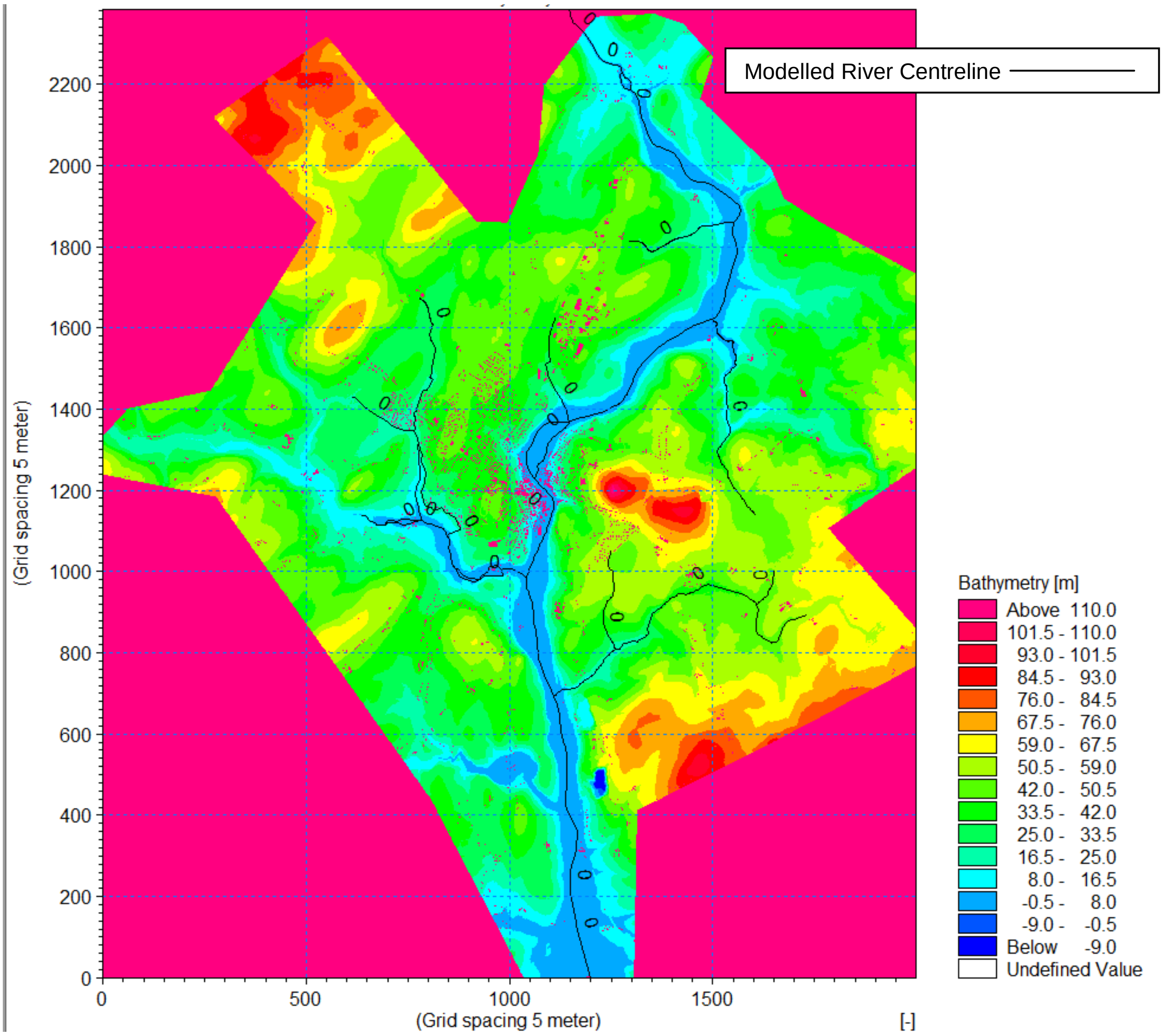


Figure 4.6.3 2D Domain Model Extent

Figure 4.6.3 shows clearly the LiDAR data extent, marked clearly with the boundary of the pink area marked as 'Above 110m'. This area inside of the pink boundary is covered by the 2D model domain. Also included is the river centreline for the model and the model extent.

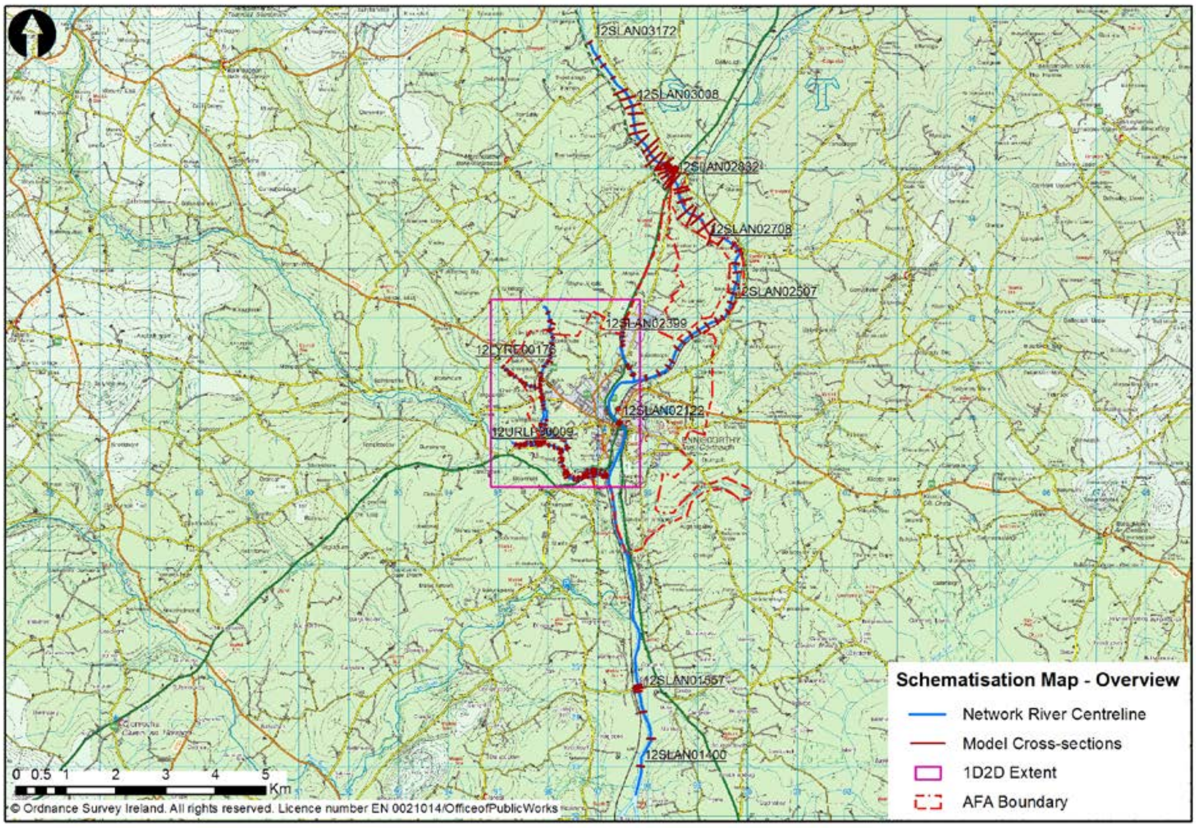


Figure 4.6.4 Model Schematisation Overview

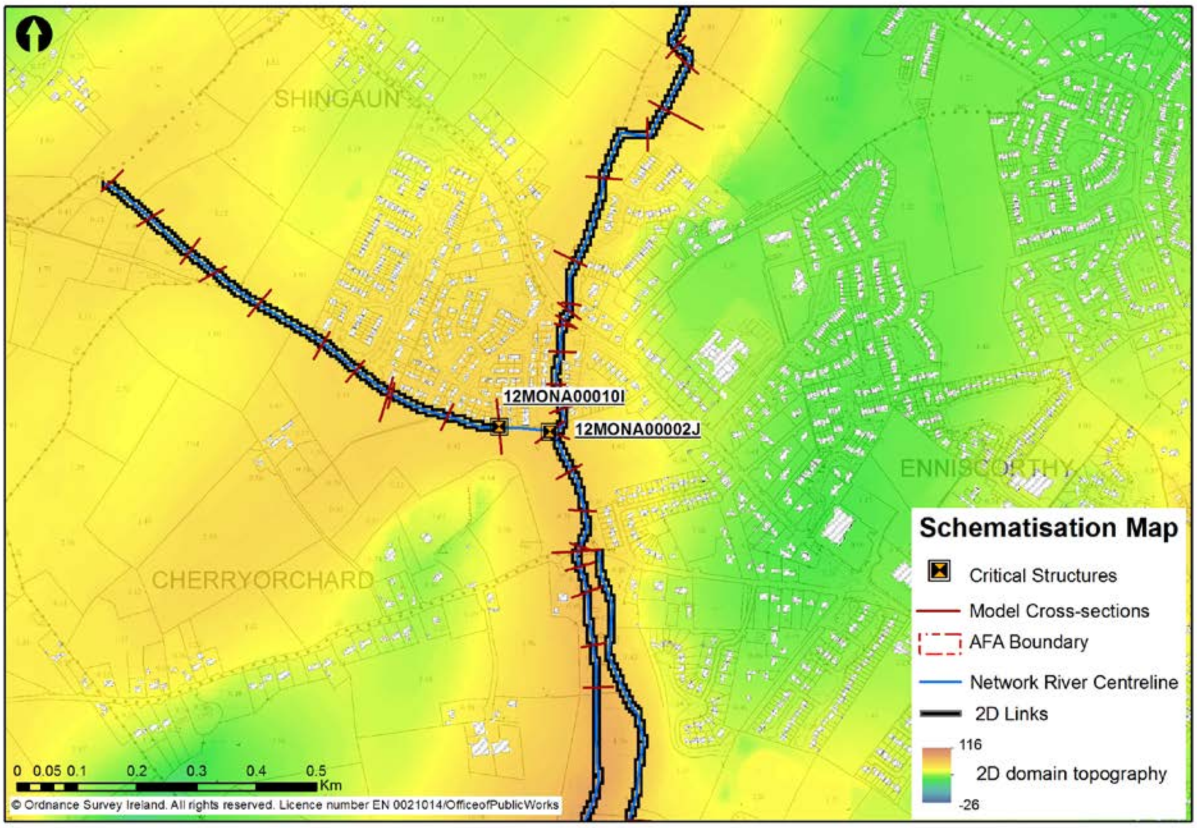


Figure 4.6.5 Location of 1D Model Cross-section and Critical Structure Location (1)

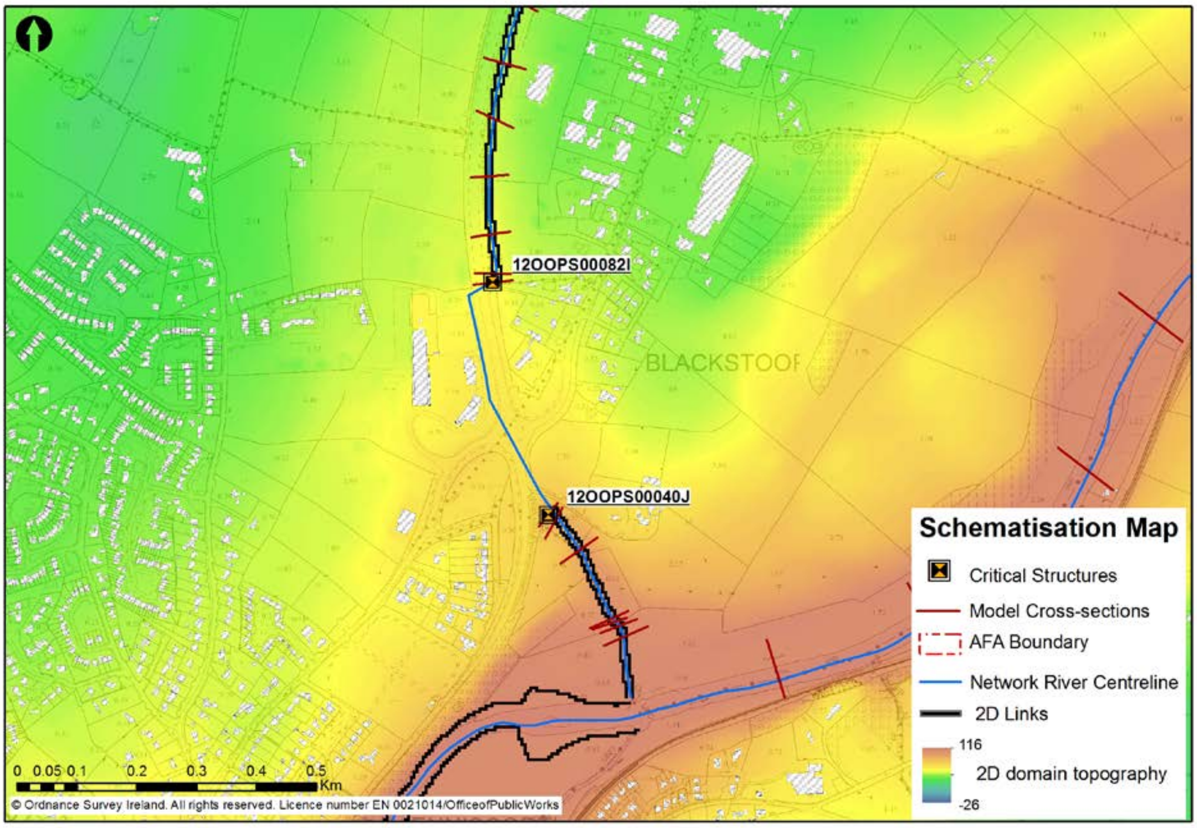


Figure 4.6.6 Location of 1D Model Cross-section and Critical Structure Location (2)

(8) Survey Information

(a) Survey Folder Structure:

First Level Folder	**Second Level Folder**	**Third Level Folder**
CCS_S12_M04_12BRCY_Final_WP3_130321 Enniscorthy CCS: Surveyor Name S12: South Eastern CFRAM Study Area, Hydrometric Area 12 M04: Model Number 04 12BRCY: River Reference WP3: Work Package 3 Final: Version 130321: Date Issued (21st MAR 2013)	12BRCY_Data Files	
	12BRCY_Drawings	
	12BRCY_GIS	
	Photos *(Naming convention is in the format of Cross-Section ID and orientation - upstream, downstream, left bank or right bank)*	

(b) Survey Folder References:

Reach ID	Name	File Ref.
12DRUM	DRUMGOLD	CCS_S12_M04_12DRUM_ Final_WP3_130321
12BRCY	BALLYCOURCY	CCS_S12_M04_12BRCY_Final_WP3_130321
12SLAN	SLANEY 2	CCS_S12_M03_12SLAN2_Final_WP3_130321
12CANN	KILCANNON	CCS_S12_M04_12CANN_Final_WP3_130321
12KILP	KILPIERCE	CCS_S12_M04_12KILP_Final_WP3_130321
12LYRE	LYRE	CCS_S12_M04_12LYRE_Final_WP3_130321
12MONA	MONART STREAM	CCS_S12_M04_12MONA_Final_WP3_130321
12OLEY	KILLAGOLEY	CCS_S12_M04_12OLEY_Final_WP3_130321
12OOPS	BLACKSTOOPS	CCS_S12_M04_12OOPS_Final_WP3_130321
12STEN	CLONNASTEN	CCS_S12_M04_12STEN_Final_WP3_130321
12URIN	URRIN RIVER	CCS_S12_M04_12URIN_Final_WP3_130321
12URLP	URRIN LOOP	CCS_S12_M04_12URLP_Final_WP3_130424
12URMI	URRIN MILL	CCS_S12_M04_12URMI_Final_WP3_130321
12LYRT	LYRE TRIB	CCS_S12_M04_12LYRT_Final_WP3_130321
12SLAN1	RIVER SLANEY	CCS_S12_M05_12SLAN1_Final_WP3_130321
12SLAN3	RIVER SLANEY	CCS_S12_M03_12SLAN3_Final_WP3_130321
12001	SCARAWALSH	CCS_S12_M03_04_Scarwalsh_12001_Final_WP1_13012
01ENNI	ENNISCORTHY	Murphy_S12_M04_01ENNI_V1_SFRT_131212

(9) Survey Issues:

No survey issues or queries.

4.6.3 Hydraulic Model Construction

(1) 1D Structures (in-channel along modelled watercourses):	See Appendix A.1 Number of bridges and culverts: 24 Number of weirs: 2

The survey information recorded includes a photograph of each structure, which has been used to determine the Manning's n value. Further details are included in Chapter 3.5.1. A discussion on the way structures have been modelled is included in Chapter 3.3.4.

There are 18 bridges, 6 culverts and 2 weirs in the model. No structures have been excluded from the model.

On the Blackstoops reach, the long culvert (located from cross-sections 12OOPS00082I to 12OOPS00040J) causes some back up of water, particularly in the 1% AEP and 0.1% AEP flood event. Inside the square opening shown in Figure 4.6.4 is a 0.5 m diameter pipe which was used as the upstream section as it exerted the greatest amount of hydraulic effect on the flow. The pipe increases to 1 m diameter downstream (Figure 4.6.5).

Figure 4.6.7 12OOPS00082I CULVERT

Figure 4.6.8 12OOPS00040J CULVERT

Also, on the Monart River, the long culvert (located from cross-sections 12MONA00010I_DS to

12MONA00002J_US) causes flow to back up, again having more effect in holding back the water during the 1% AEP and 0.1% AEP flood events. The channel around the culvert is heavily vegetated and overgrown across the culvert slightly, but would be at high risk of blockage and under these conditions has the possibility of causing flooding during less extreme events (Figure 4.6.7 and Figure 4.6.8).

Figure 4.6.9 12MONA00010I_DS

Figure 4.6.10 12MONA0002J_US

(2) 1D Structures in the 2D domain (beyond the modelled watercourses):	Number of Bridges and Culverts: 0 Number of Weirs: 0
(3) 2D Model structures:	Number of Bridges and Culverts: 0 Number of Weirs: 0

(4) Defences:

Type	Watercourse	Bank	Model Start Chainage (approx.)	Model End Chainage (approx.)
None				

The flood defence scheme in Enniscorthy is not included in the model as flood maps are not required for the Slaney through Enniscorthy. Detailed in 4.6.1(1).

(5) Model Boundaries - Inflows:

Full details of the flow estimates are provided in the Hydrology Report (**IBE0601Rp0012_HA11 12 13 Hydrology Report**, Section 4.7 and Appendix D). The boundary conditions implemented in the model are shown in Figure 4.6.8.

	Boundary Description	Boundary Type	Branch Name	Chainage	Chainage	Gate ID	Boundary ID
1	Open	Inflow	RIVER SLANEY	30909.474	0		12001_RPS
2	Point Source	Inflow	RIVER SLANEY	34507.5	0		12_921_2_RPS
3	Point Source	Inflow	RIVER SLANEY	36362.635	0		12_2075_5_RPS
4	Point Source	Inflow	RIVER SLANEY	36665.352	0		12_2079_2_RPS
5	Point Source	Inflow	RIVER SLANEY	37290.535	0		12_958_4_RPS
6	Point Source	Inflow	RIVER SLANEY	37837.587	0		12_2085_5_RPS
7	Open	Inflow	BLACKSTOOP	27.691	0		12_2296_U
8	Distributed Source	Inflow	BLACKSTOOP	27.691	1371.18		Top-up between 12_2296_U & 12_2296_3_RPS
9	Open	Inflow	URRIN	114.411	0		12_577_1_RPS
10	Distributed Source	Inflow	LYRE RIVER	2049.041	2953.51		12_2323_4_RPS
11	Open	Inflow	LYRE RIVER	20.631	0		12_761_3
12	Open	Inflow	MONART	0	0		12_2460_U
13	Distributed Source	Inflow	MONART	0	877.987		Top-up between 12_2460_U & 12_2460_2_RPS
14	Distributed Source	Inflow	LYRE RIVER	20.631	1841.17		Top-up between 12_761_3 & 12_2323_1_RPS
15	Distributed Source	Inflow	URRIN	1323.085	1611.323		Top-up between 12_2604_2_RPS & 12007_RPS
16	Point Source	Inflow	RIVER SLANEY	44075.529	0		12_2603_2_RPS
17	Point Source	Inflow	RIVER SLANEY	46650.085	0		12_2601_6_RPS
18	Open	Q-h	RIVER SLANEY	49211.659	0		Slaney d/s boundary
19	Distributed Source	Inflow	RIVER SLANEY	34017.317	34507.502		Top-up between 12001_RPS & 12_943_2_RPS
20	Distributed Source	Inflow	RIVER SLANEY	34507.502	39888.332		Top-up between 12_943_2_RPS & 12_2061_1_RPS
21	Distributed Source	Inflow	RIVER SLANEY	39888.332	41406.996		Top-up between 12_2061_1_RPS & 12008_RPS
22	Distributed Source	Inflow	RIVER SLANEY	41406.996	46949.018		Top-up between 12008_RPS & 12061_RPS
23	Distributed Source	Inflow	LYRE TRIBUTA	507.235	1575.441		Top-up between 12_2323_1_RPS & 12_2604_2_RPS (lateral, but u/s input assumed)

Figure 4.6.11 Boundary Information

The upstream boundary of the Enniscorthy catchment is located at HEP 12001_RPS, the model node ID at this location is 12SLAN03172, an open point inflow was therefore applied at this node to account for flow entering the Slaney River upstream of this location.

The top-up flows between 12_2296_U and 12_2296_3_RPS on the Blackstoops reach was increased by 10% to achieve model calibration. All of the hydrology was delayed by 2.5 hours, with an extended time at the beginning for the Hotstart file to run. The top-up flow between 12_2604_2_RPS & 12007_RPS on the Urrin River was brought forward by 2.5 hours. A half hour change was applied for calibration to bring the peak of 12_577_1_RPS on the River Urrin forward in the 1%AEP and 0.1%AEP simulations. These hydrograph timing changes were implemented to achieve optimal flows at further downstream HEP points.

The point source inflow 12_921_2_RPS into the River Slaney was moved one cross-section downstream as the original location was in close proximity to other inputs and resulting in a steady state error.

The following Figures, 4.6.12, 4.6.13 and 4.6.14, show the 0.1% AEP inflow hydrographs of the five upstream modelled boundaries - River Slaney (12001_RPS), Blackstoops (12_2296_U), Monart (12_2460_U), Urrin River (12_577_1_RPS) and Lyre River (12_761_3).

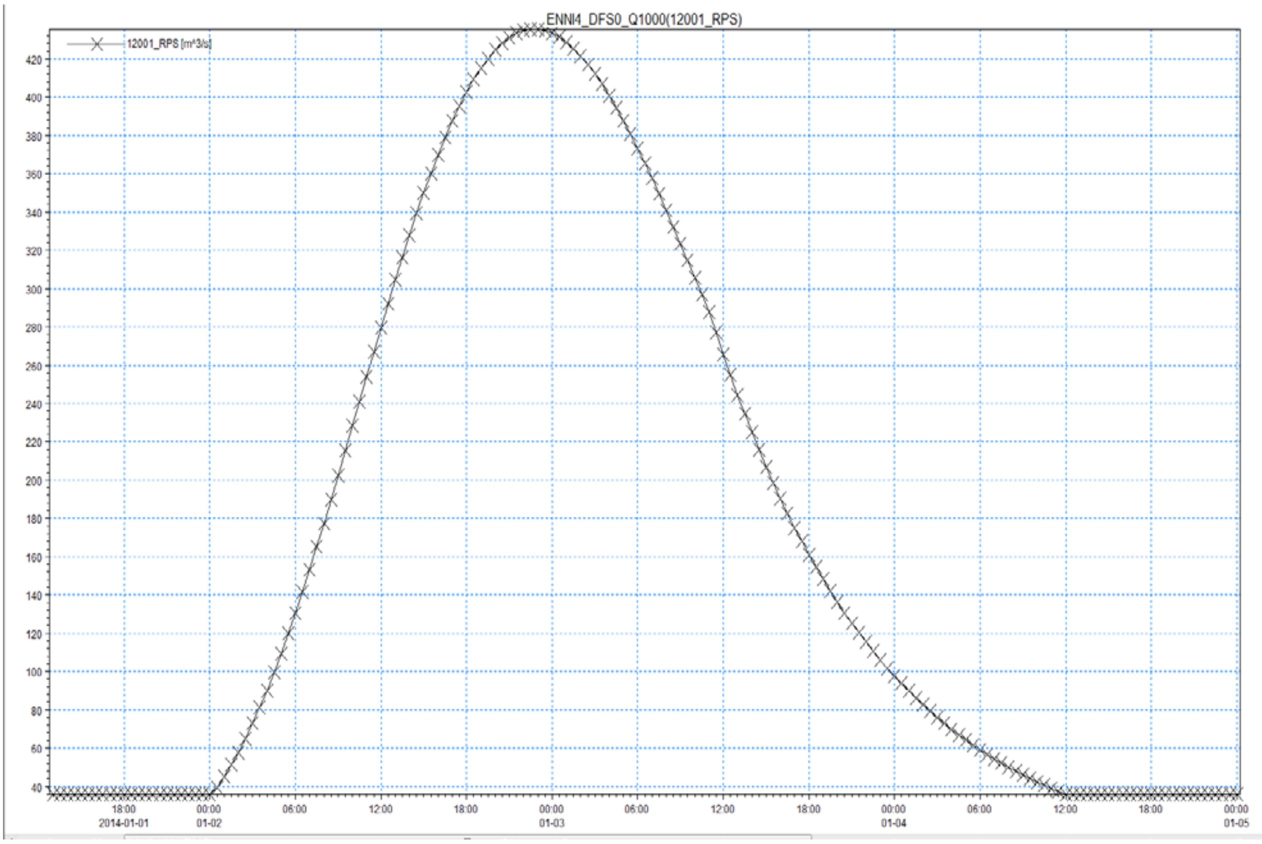


Figure 4.6.12 Upstream Inflow (HEP 12001_RPS)

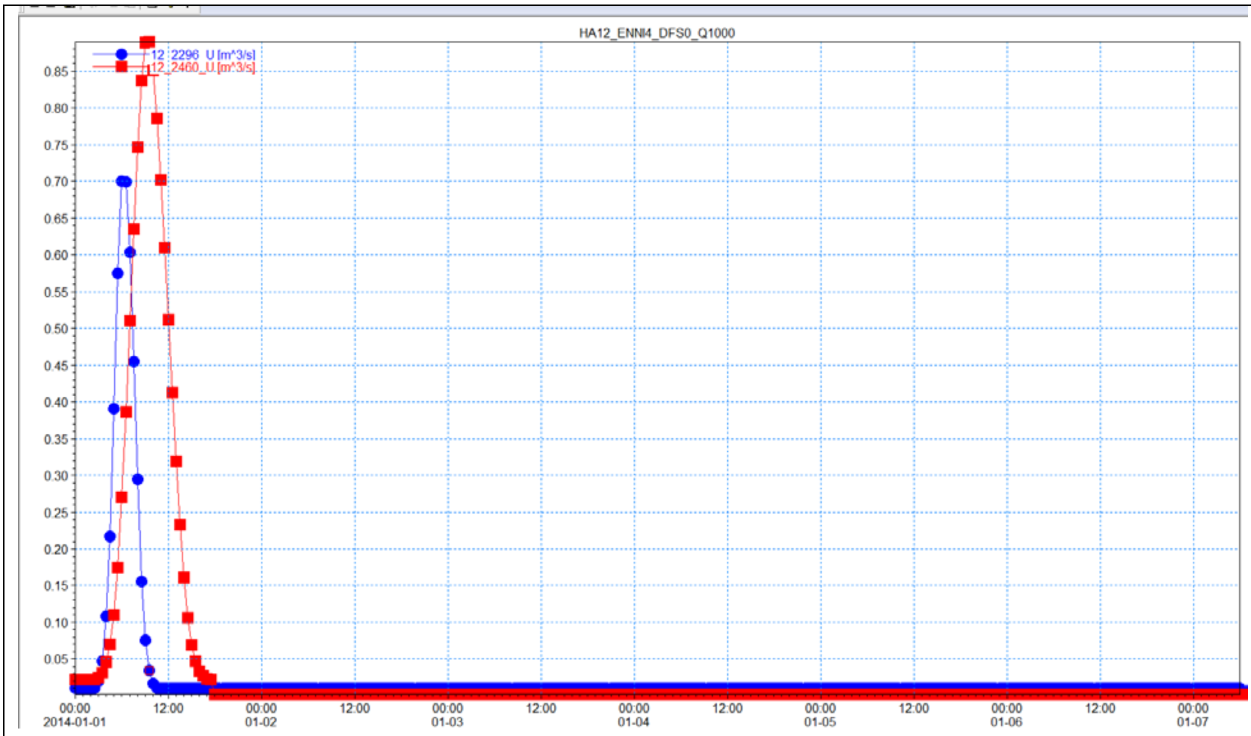


Figure 4.6.13 Upstream Inflow (HEPs 12_2296_U and 12_2460_U)

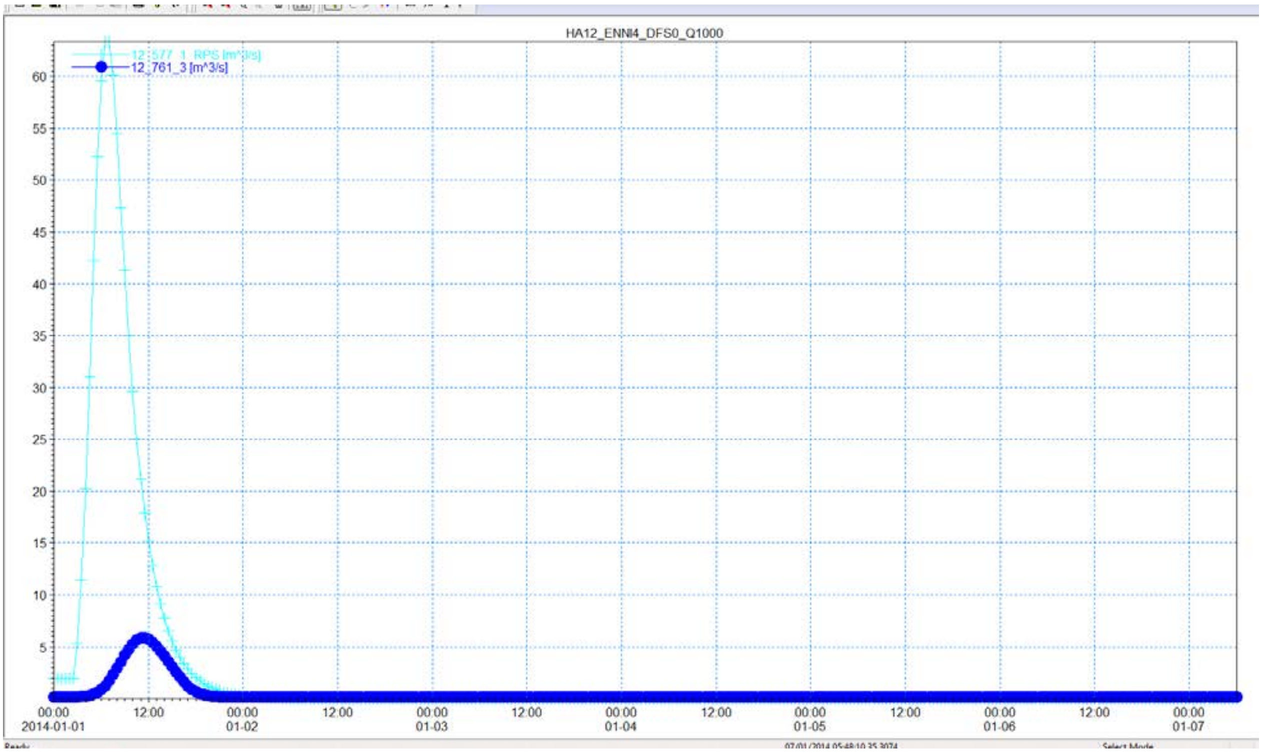


Figure 4.6.14 Upstream Inflow (HEPs 12_577_1_RPS and 12_761_3)

An open inflow point has been applied at the relevant Upper Limit HEP for each of the main watercourses within the model (River Slaney, Blackstoops, Urrin, Lyre River and Monart).

A distributed source has been applied along the nodes downstream of the Upper Limit HEPs to account

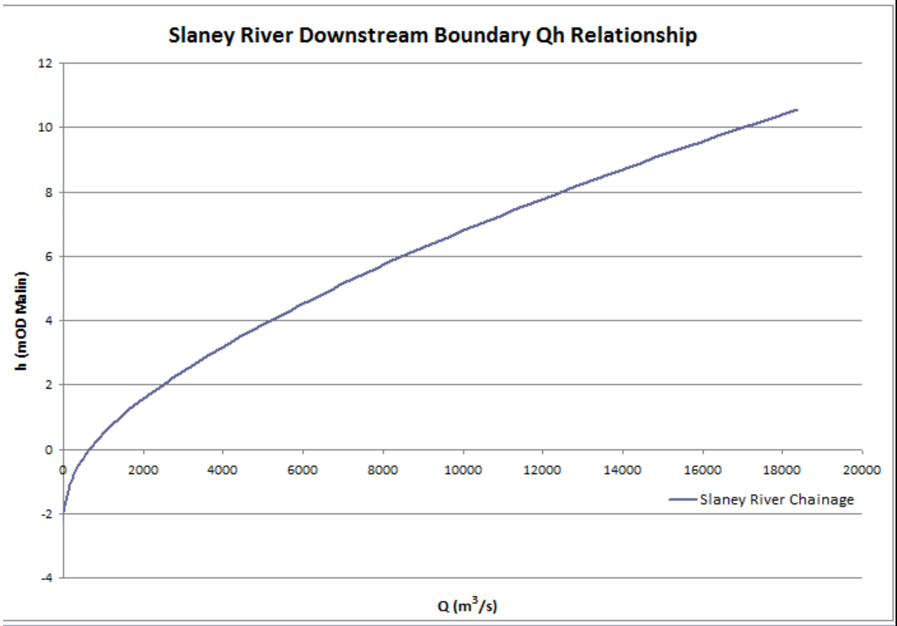
<table>
<tr><td colspan="3">for flow entering the watercourses further downstream.
Finally, point flows were added at specific nodes to account for flow entering from main tributaries that are not directly included in the model.</td></tr>
<tr><td>(6) Model Boundaries – Downstream Conditions:</td><td colspan="2">Crictical flow conditions were used to derive a Q-h relationship boundary as plotted in Figure 4.6.15 at the downstream model extent of the River Slaney (chainage 49211.659).
The downstream boundary is a Q-h relationship, generated based on the cross-section at the downstream extent of the model. This is located on the River Slaney at chainage 49211.659. Although the Ennsicorthy model is stated as being tidally influenced, it is modelled as fluvial only. The reason for this is, as stated in 4.6.1(1), the River Slaney through Enniscorthy does not need flood maps produced and the area to be mapped is Fairfield and Cherryorchard. Tidal levels will have no effect on this area and so a Q-h boundary was applied and deemed appropriate. The model has been extended by approximately 1.07 km further upstream and approximately 1.1 km downstream. This incorporated four extra sections and two extra sections, upstream and downstream respectively


Figure 4.6.15 Q-h Relationship at River Slaney Chainage 49211.659</td></tr>
<tr><td colspan="3">(7) Model Roughness:</td></tr>
<tr><td>(a) In-Bank (1D Domain)</td><td>Minimum 'n' value: 0.035</td><td>Maximum 'n' value: 0.050</td></tr>
<tr><td>(b) MPW Out-of-Bank (1D)</td><td>Minimum 'n' value: 0.035</td><td>Maximum 'n' value: 0.050</td></tr>
<tr><td>(c) MPW/HPW Out-of-Bank (2D)</td><td>Minimum 'n' value: 0.011
(Inverse of Manning’s ‘M’)</td><td>Maximum 'n' value: 0.071
(Inverse of Manning’s ‘M’)</td></tr>
</table>

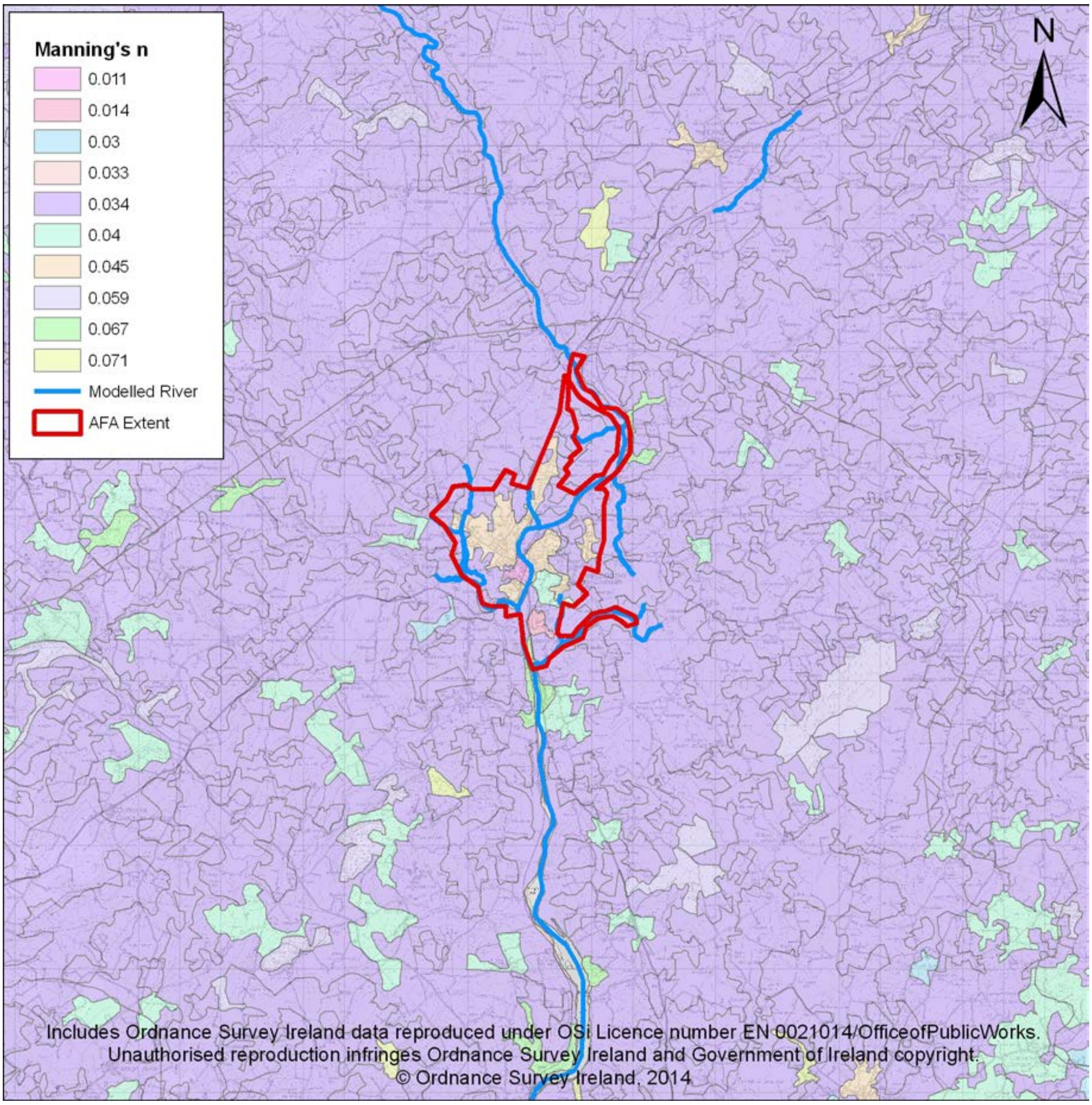


Figure 4.6.16 Map of 2D Roughness (Manning's n)

Figure 4.6.10 illustrates the roughness values applied within the 2D domain of the model. Roughness in the 2D domain was applied based on land type areas defined in the Corine Land Cover Map with representative roughness values associated with each of the land cover classes in the dataset. Null Manning's M values on inland water bodies were corrected to Manning's n of 0.033.

(d) Examples of In-Bank Roughness Coefficients

Figure 4.6.17 River Slaney - 12SLAN02271_DS

Manning's n = 0.035

Standard natural channel or river in stable condition

Figure 4.6.18 River Slaney - 12SLAN02827D_DS

Manning's n = 0.035

Standard natural channel or river in stable condition

Figure 4.6.19 Lyre River - 12LYRE00099_DS

Manning's n = 0.050

Small channel in stable condition, bed partially vegetated and some stones on bed

Figure 4.6.20 Lyre River - 12LYRE00244D

Manning's n = 0.050

Small channel, some cobbles and heavily vegetated

Figure 4.6.21 Monart - 12MONA00052_US

Manning's n = 0.050

Small channel, heavily vegetated

Figure 4.6.22 Urrin - 12URIN00052_US

Manning's n = 0.040

Standard channel, cobbles and stones on bed

Figure 4.6.23 Urrin Loop - 12URLP00010_US

Manning's n = 0.050

Channel heavily vegetated with some stones and cobbles on bed

Figure 4.6.24 Urrin Mill - 12URMI00025_US

Manning's n = 0.050

Channel heavily vegetated with some stones and cobbles on bed

4.6.4 Sensitivity Analysis

To be completed in final version of report.

4.6.5 Hydraulic Model Calibration and Verification

(1) Key Historical Floods (From IBE0601Rp0002_ HA11, 12&13 Inception Report unless otherwise specified):	
(a) NOV 2009	Information sourced from www.enniscorthyecho.ie and www.wexfordecho.ie indicated that flooding occurred in Enniscorthy, Wexford and Gorey in late November 2009 following a period of heavy and prolonged rainfall. The water level in the River Slaney was reported to be extremely high; however no confirmation is available of the river bursting it banks. In Enniscorthy, properties in the area avoided serious damage as the expected levels of water failed to materialise. Minor damage occurred, however, and the cost of this flooding was estimated to be in the region of €100,000. This event related mainly to flooding from the River Slaney which is being addressed by a flood alleviation scheme, there are no specific references to the Fairfield or Cherryorchard areas.
(b) OCT 2004	Flooding occurred in Enniscorthy, Wexford and Tullow on 28th and 29th October 2004. Photos were available on www.floodmaps.ie which provided information on the event. In Enniscorthy, the River Slaney burst its banks causing flooding of the N11 roadway within the town. Riverside roads were also closed for a period and both quays were blocked to traffic. Many businesses were affected by the flooding. A mean daily flood level of 8.3 mOD (Malin) and a corresponding daily mean flow of 1,738 m^3/s was recorded for the River Slaney at Enniscorthy Hydrometric Station on 29th October 2004 (http://www.opw.ie/hydro). However, it was noted on the OPW website that this flood level and flow data is above the prescribed data range and must be used with caution. As it was reported that rainfall played an insignificant role in the flood event, it is likely that high tides caused the River Slaney to back up and overflow in Enniscorthy; therefore the estimated flow of 1,738 m^3/s for the corresponding flood level may not have occurred. This event also related mainly to flooding from the River Slaney itself which is being addressed by a flood alleviation scheme, there are no specific references to the Fairfield or Cherryorchard areas.

(c) NOV 2002	Information was found for a flood event which occurred in Enniscorthy, Gorey, Blackwater and Tullow on 21st November 2002 following a series of rainfall events. Press articles from the Irish Times, Irish Independent and Evening Herald were found on www.floodmaps.ie detailing this event. Information for Enniscorthy is available within the OPW Feasibility Report on the Enniscorthy Flooding Problem in the section 'Enniscorthy Flooding Appendices'. A mean daily flood level of 2.17 mOD (Malin), and a corresponding daily mean flow of 204 m^3/s, was recorded for the River Slaney at Enniscorthy Hydrometric Station on 21st November 2002 (http://www.opw.ie/hydro). However, it was mentioned on the OPW website that the reliability of this flow data is unknown and it should therefore be treated with caution. Again this event related mainly to flooding from the River Slaney itself which is being addressed by a flood alleviation scheme, there are no specific references to the Fairfield or Cherryorchard areas.
(d) NOV 2000	Information was found on www.floodmaps.ie for a flood event that occurred in Baltinglass, Bunclody, Enniscorthy, Wexford, South Slobs/Rosslare Port, Tullow and Gorey in November 2000. The information included photographs, OPW reports, Carlow County Council reports, Wexford County Council reports and press articles from the Nationalist & Leinster Times, Irish Times, Irish Independent, Irish Examiner, Enniscorthy Echo and the Evening Herald. The flooding was caused by excessive rainfall on the 5th and 6th November 2000, which varied in intensity from 40 mm to 100 mm over a 24 hour period. In Enniscorthy, the River Slaney burst its banks causing widespread flooding. Island Road and adjoining premises were flooded to a depth of 1.2 m. The North and South Quays were flooded to a depth of 2 m. The Templeshannon area was also flooded. The new bridge was flooded to a depth of 0.6 m and the N11 was impassable at Enniscorthy Quays. Rail services were affected with the Dublin - Rosslare line closing due to a mud slide near Enniscorthy. Two men were trapped in a vehicle near the Riverside Park Hotel. Strong gales also had an effect with more than 750 homes left without power. The OPW Report entitled "Tullow Pre-Feasibility Flood Relief Study" reported an AEP of approximately 2.9%. Flood levels at various locations in Enniscorthy are available on OPW Report entitled OPW Feasibility Report on the Enniscorthy Flooding Problem in the section 'Enniscorthy Flooding Appendices'" and also the OPW Report "Flooding event of 5-7 Nov 2000 - Wexford". A mean daily flood level of 4 mOD (Malin), and a corresponding daily mean flow of 555 m^3/s, was recorded for the River Slaney at Enniscorthy Hydrometric Station on 6th November 2000 (http://www.opw.ie/hydro). However, it was mentioned on the OPW website that the reliability of this flow data is unknown and it should therefore be treated with

	caution. This event related mainly to flooding from the River Slaney itself which is being addressed by a flood alleviation scheme, there are no specific references to the Fairfield or Cherryorchard areas.
(e) AUG 1997	Information was found for a flood event which occurred in Enniscorthy, Wexford, Rosslare and Blackwater Village in early August 1997. Details of the event were obtained from press articles in the Irish Times, Irish Independent, Munster Express and the Examiner (Cork), as well as photographs and a Wexford County Council memo (dated 7th February 2001), downloaded from www.floodmaps.ie. In Enniscorthy, a daily mean flow of 63.9 m^3/s was recorded for the River Slaney at Enniscorthy Hydrometric Station on 4th August 1997 (http://www.opw.ie/hydro). However, it was mentioned on the OPW website that the reliability of this flow data is unknown and it should therefore be treated with caution. This event related mainly to flooding from the River Slaney itself which is being addressed by a flood alleviation scheme, there are no specific references to the Fairfield or Cherryorchard areas.
(f) AUG 1986	Information from OPW and Wexford County Council sources was found on www.floodmaps.ie for a flood event which occurred in Enniscorthy, Courtown and Gorey in August 1986. The flooding was caused by heavy and prolonged rainfall. The August 1986 storm event, more commonly referred to as Hurricane Charlie, caused Island Road to flood. A mean daily flood level of 1.97 mOD (Malin), and a corresponding daily mean flow of 139 m^3/s, was recorded at Enniscorthy Hydrometric Station on 26th August 1986 (http://www.opw.ie/hydro). However, as with the November 2000 flood event, it was mentioned on the OPW website that the reliability of this flow data is unknown and it should therefore be treated with caution. This event related mainly to flooding from the River Slaney itself which is being addressed by a flood alleviation scheme, there are no specific references to the Fairfield or Cherryorchard areas.
(g) DEC 1978	The historical data indicated that flooding occurred in Bunclody and Enniscorthy at the end of December 1978 following three days of heavy rain and strong winds. Details were available in an Enniscorthy Echo press article, downloaded from www.floodmaps.ie. In Enniscorthy, a licenced premises at Templeshannon was flooded to a significant depth (reported as several feet) and the fire brigade spent three hours pumping the premises. A residence at Aidan Villas was also extensively damaged causing the

	family to evacuate. Further flooding occurred of the main Enniscorthy/Bunclody road. This event related mainly to flooding from the River Slaney itself which is being addressed by a flood alleviation scheme, there are no specific references to the Fairfield or Cherryorchard areas.
(h) NOV 1965	A flood event occurred in Baltinglass, Bunclody, Enniscorthy, Tullow, Courtown and Gorey in November 1965 following three days of persistent rainfall. Information on the event was available from various press articles, including those published in the Enniscorthy Echo, Wicklow People, Wexford People, Leinster Leader, Cork Examiner, Irish Independent, and also from Wexford County Council and OPW information on www.floodmaps.ie. In the early morning of Thursday 18th November 1965, flood waters rose in the Slaney and the town of Enniscorthy experienced its worst ever flooding in living memory with damage amounting to thousands of pounds. From anecdotal accounts, the 1965 flood was worsened by debris partially blocking the arches of Enniscorthy Bridge. Flooding was particularly severe in the areas of Island Road, Templeshannon, and Abbey Square and rising to a height of over 2.7 metres in some parts. The Railway Bridge over the Slaney was severely damaged and at one stage it was feared that the Road Bridge over the Slaney might be in danger of collapse. Three rowing boats were brought in from Wexford for rescue purposes. Places of note that were affected by the floods included the ESB station, the Co-operative Stores, Enniscorthy Gas Company and the railway station. The Garda Barracks and County Council Machinery Yard were also severely flooded to a depth of over 1 metre in some places. Buttles Barley Fed Bacon Factory was also affected where two sows and seven pigs were lost. The OPW Report entitled OPW Feasibility Report on the Enniscorthy Flooding reported that the flood event yielded an AEP of approximately 1%. This event related mainly to flooding from the River Slaney itself which is being addressed by a flood alleviation scheme, there are no specific references to the Fairfield or Cherryorchard areas.
(i) NOV 1954	Press articles were found in the Wexford People and Enniscorthy Echo which reported that the River Slaney burst its banks in Enniscorthy following torrential rain and storm conditions on 8th November 1954. Premises at Templeshannon Quay, Abbey Quay and Island Road were flooded. At Island Road, Doherty's garage and shop were flooded to a depth of approximately 300 mm. The road at Templeshannon Quay was flooded to a depth of 1 to 1.2 m. Floodwaters poured into the ESB station at Abbey Quay, the premises of Enniscorthy Gas Company, and the County Council Machinery Yard. The extent of the flooding at Island Road, the Railway Bridge,

	Templeshannon and Shannon Quay can be seen in a series of photographs. This event related mainly to flooding from the River Slaney itself which is being addressed by a flood alleviation scheme, there are no specific references to the Fairfield or Cherryorchard areas.
(j) MAR 1947	The OPW Report entitled OPW Feasibility Report on the Enniscorthy Flooding Problem contains a photograph that depicts the extent of the flooding of Island Street in Enniscorthy during March 1947. Information from The Enniscorthy Echo press article indicates that flooding was caused by snow melt which caused the already swollen river to burst its banks. Flooding occurred at residential parts of Island Road and at commercial businesses on Templeshannon Quay. This event related mainly to flooding from the River Slaney itself which is being addressed by a flood alleviation scheme, there are no specific references to the Fairfield or Cherryorchard areas.
(k) NOV 1924	The OPW Report entitled "Feasibility Report on the Enniscorthy Flooding Problem" includes a photograph illustrating the extent of the flooding in Enniscorthy in late November 1924. The photograph is of the town downstream of Enniscorthy Bridge and shows similar flood levels to those recorded for the November 2000 flood event. The same report estimates an AEP of between 2% and 3.33% for the flood event. This event related mainly to flooding from the River Slaney itself which is being addressed by a flood alleviation scheme, there are no specific references to the Fairfield or Cherryorchard areas.
Summary of Calibration The available information provides details of flooding at Enniscorthy rather than the Fairfield and Cherryorchard areas. Enniscorthy is modelled in 1D form for the purpose of completing the lower end of the Fairfield and Cherryorchard extents. The flooding depicted in the maps for this area matches the records of past flooding so the model appears to be consistent here. The mass balance check has been carried out on the model to make sure that the total volume of water entering and leaving the model at the upstream and downstream boundaries balances the quantity of water remaining in the model domain at the end of a simulation. Refer to Chapter 3.11 for details of acceptable limits. This ensures the model schematisation is robust. The mass error in the 1% AEP design run was found to be -1.5178% which is within acceptable limits. A minor instability shows at the first cross-section on the River Slaney (the location of HEP 12001_RPS). The instability shows only between flows of 100-150m^3/s. This instability causes the water levels to flicker as they reach the peak. Attempts were made to stabilise this during the model development process but as this is the upstream cross-section of the River Slaney, there were limited options for addressing the issue. Attempts at altering markers or moving the next cross-section further from it had no positive effect	

and so the current level of stabilisation shown was the maximum achieved. However, as this is the first cross-section on the River Slaney and it has little effect on the peak water level, it is considered to be of little significance to the Fairfield and Cherryorchard area which is much further downstream. This is also proven in the overall mass balance error of the model, supporting the conclusion that this instability has a minor impact upon the model results.

(2) Post Public Consultation Updates

On the Urrin River, two interpolated sections were added at Chainages 750 and 2593 to further stabilise the model. Following informal public consultation and formal S.I. public consultation periods in 2015, general model updates were applied to refine model resolution and improve model stability, mapping issued as Final reflects these changes.

(3) Standard of Protection of Existing Formal Defences:

Defence Reference	Type	Watercourse	Bank	Modelled Standard of Protection (AEP)
None				

(4) Gauging Stations:

There are six gauging stations located along the model extent with 1 gauging station with fluvial water level and flow data, 1 with tidal data, 3 with water level data only and 1 inactive. The 3 stations with water level data were used for comparison of modelled water levels against observed data where possible.

(a) Station 12001_RPS, Scarawalsh, River Slaney

This gauging station is subject to a rating review, as detailed in the Hydrology Report for UoMs 11, 12 and 13 (IBE0601Rp00012_HA11 12 13 Hydrology Report). The gauging station rating was given an FSU classification under FSU, suggesting there is confidence in the rating up to 1.3 times Q_{med}. The existing rating data was analysed during model calibration and the results are shown on the graph below. The RPS rating curve envelops the OPW curve with the rising limb falling mostly below the OPW rating curve and the falling limb above the OPW curve. A hysteresis effect can be observed and it is considered that this is due to the attenuating effect of the restrictive bridge cross-section immediately upstream of the gauging station. The RPS curve follows very well at initial flows right up to the Q_{med} of 156.27 m^3/s; with only a low level of variance ranging to a maximum of approximately 0.2 m. This relates to a close relationship up to a depth of 2.95 m; however the large degree of variance can be seen from 2.95 m to 5 m where hysteresis causes a very different relationship to be shown from the extrapolated values for this range on the OPW curve. There may be multiple flow values possible for any given stage height at flows above 35 m^3/s when hysteresis develops. Therefore, it was found that this gauge station data is suitable for model calibration flood flows. However, the model will only be seen to follow the reported flows at low levels and a large degree of variance will be observed at flood flows.

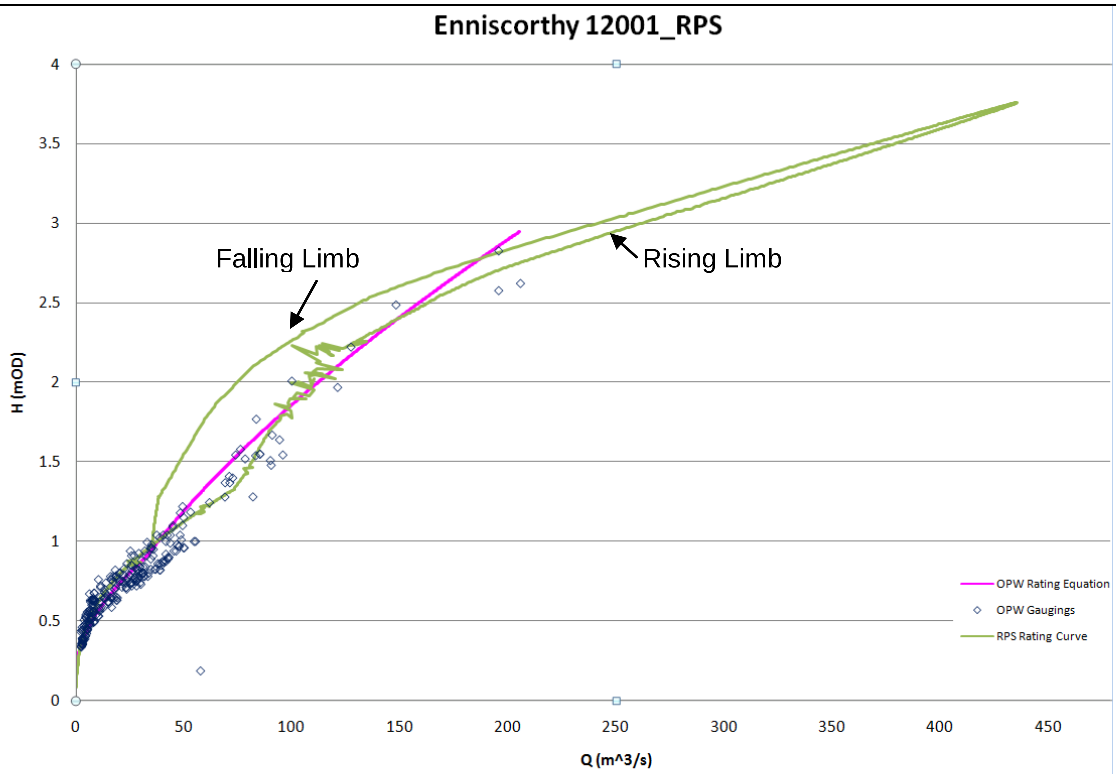


Figure 4.6.25 12001_RPS Q-h Relationship

(b) 12002_RPS, Enniscorthy, River Slaney

This station is tidal with the model being a fluvial only model which makes it unsuitable for calibration.

(c) 12007_RPS, St. John's Bridge, Urrin River

This station is currently active but only records water level information which makes it unsuitable for model calibration.

(d) 12008_RPS, Rafter Bridge (downstream), River Slaney

This station is currently active but only records water level information which makes it unsuitable for model calibration.

(e) 12009_RPS, Rafter Bridge (upstream), River Slaney

This station is currently active but only records water level information which makes it unsuitable for model calibration.

(f) 12026, Carley's Bridge, Urrin River

This station is inactive with a staff gauge only reading making it unsuitable for model calibration.

(5) Other Information:

Some comments were made at the Local Authority Workshop pointing out that at points along the River Slaney, more extensive flooding occurs. To further emphasise, the River Slaney through Enniscorthy does not require mapping as it is not hydraulically modelled although the hydrology is modelled. It is included for purposes of its effect on the Fairfield and Cherryorchard area. Further details are provided in Section 4.6.1.

4.6.6 Hydraulic Model Assumptions, Limitations and Handover Notes

(1) Hydraulic Model Assumptions:
(a) The in-channel roughness coefficients were selected by viewing photographs provided by surveyors and it is considered that the final selected values are representative.
(b) The time-to-peak of inflow fluvial hydrographs generated during the hydrological analysis have been reviewed during the calibration process. The hydrographs in the original time series files were delayed to provide more time for the hotstart file to run. Further changes were made to time-to-peak of upstream inflows and top-up flows. (See section 4.6.3(5) for more details).
(c) For all simulations it has been assumed that all culverts and screens are free of debris and sediment.
(d) Lyre Tributary (LYRT) model was extended upstream to better represent the channel as the first cross-section had originally been at 507.235 m as the upstream section of the channel is a dry bed. This helped create a better representation in the model simulations as the channel link was much shorter and a more gradual slope could be applied to the rise in bed level, helping with the model run. The two cross-sections placed upstream of the original were copies of the first cross-section on the channel, with the whole section lowered to match the bed level of the linking section from the Lyre River as this is needed for the model simulations to run. This meant the first stretch of the Lyre Tributary would be able to hold water in extreme flooding events, which is more representative of the watercourse in reality. This involved adding a culvert to pass under a road at the upstream end of the branch. The culvert was input as a 0.8 m diameter pipe of length 7 m at 39.744 m. These culvert dimensions were obtained by using Google Maps and the scale provided with it.
(e) Culvert at LYRT00109_CULVERT was created and assumed to have a Manning's n value of 0.013.
(f) On Lyre Tributary, the hydrological input top-up between 12_2323_1_RPS and 12_2604_2_RPS was a lateral input noted as entering the channel as one specific cross-section. It was entered along the full length of the surveyed channel (507.235 to 1587.981) to match flows at further downstream points.
(g) On the Blackstoops reach, the long culvert (located at cross-sections 12OOPS00082I to 12OOPS00040J) had differing upstream and downstream sections, beginning as a 0.5 m diameter pipe set 1.3 m metres into a square opening and ending with a 1 m diameter. For the upstream section, the 0.5 m diameter pipe was chosen with the square opening ignored as the circular pipe is the more critical section having more effect on the flow. No information was provided on where in the culvert the dimensions change or how so an assumption was made with the first two sections kept as 0.5 m and the remainder of the closed sections being 1 m, which also helped the model run better than in some other scenarios.
(h) After review, Manning's n values for all culverts were kept at 0.013.
(2) Hydraulic Model Limitations and Parameters:
(a) The Zeta Min factor is set at 0.2.
(b) An initial Water Depth and Initial Discharge were both set at 0.2m.
(c) The Inter1Max factor is set to 10.

(d) A hotstart file is running until 01/01/2014 05:30:00 with initial flows. (e) Stability at the original extents is improved by extending the model, in this case by approximately 1.07 km further upstream and approximately 1.1 km downstream. This incorporated four extra sections and two extra sections, upstream and downstream respectively. (f) The River Slaney is represented in 1D and not included within the current scope of flood mapping.	
Hydraulic Model Parameters:	
MIKE 11	
Timestep (seconds)	2
Wave Approximation	High Order Fully Dynamic
Delta	0.85
MIKE 21	
Timestep (seconds)	2
Drying / Flooding depths (metres)	0.02/0.03
Eddy Viscosity (and type)	0.2 (Constant value, Flux based)
MIKE FLOOD	
Link Exponential Smoothing Factor (where non-default value used)	0.8
Lateral Length Depth Tolerance (m) (where non-default value used)	0.4
(3) Design Event Runs & Hydraulic Model Handover Notes:	
This model is influenced by fluvial sources for the modelling of the Fairfield and Cherryorchard area. The 10% AEP, 1% AEP and 0.1% AEP fluvial events were simulated to determine the flood risk throughout the Enniscorthy AFA. The flooding along the Slaney and through Enniscorthy is not a consideration for this model as the Enniscorthy Flood Scheme has already been produced. However, it does give a good indication that flood extents are accurate and so the model is likely to be consistent throughout, providing some confidence in the flooding occurring in the Fairfield and Cherryorchard area even though no historic data is available. The 0.1% AEP flood extents show a small number of properties and their land being flooded at the downstream end of Urrin River. However, there is the possibility of the flood defence scheme having slightly altered or addressed this. The remainder of the flooding affects agricultural land only. The culvert located at cross-sections 12OOPS00082I to 12OOPS00040J on the Blackstoops reach, as previously mentioned, is a critical structure which causes the hold up of water, particularly in the 1% and 0.1% AEP flood events. On the Monart River, culvert located at cross-sections 12MONA00010I_DS to 12MONA00002J_US also	

causes a build up of water, particularly in the 1% and 0.1% AEP flood events but there is some overgrowth across the pipe and the area is heavily vegetated, meaning there is a risk of flooding due to blockage at less extreme flood events. The close proximity of two large bridges (202D and 200D) on the Urrin River has caused a slight instability in the model runs with some flickering. However, overall flow and model run is not affected.	
(4) Hydraulic Model Deliverables:	
Please see Appendix A.4 for a list of all model files provided with this report.	
(5) Quality Assurance:	
Model Constructed by:	Maria Nixon
Model Reviewed by:	Stephen Patterson
Model Approved by:	Malcolm Brian

APPENDIX A.1

MODELLED STRUCTURES

Structure Details – Bridges & Culverts								
RIVER BRANCH	**CHAINAGE**	**ID**	**LENGTH (m)**	**OPENING SHAPE**	**HEIGHT (m)**	**WIDTH (m)**	**SPRING HEIGHT FROM INVERT (m)**	**MANNING'S N**
Bridges								
BLACKSTOOPS	1246.649	12OOPS00017D_bridge	0.8	Irregular	0.968	1.17	N/A	0.013
LYRE RIVER	550.769	12LYRE00244D_bridge	3.75	Irregular	2.007	2.267	N/A	0.013
LYRE RIVER	1634.147	12LYRE00136D_bridge	18.8	Arch	1.786	3.509	0.815	0.013
LYRE RIVER	2054.606	12LYRE00092D_bridge	7.13	Arch	2.138	2.34	1.528	0.013
LYRE RIVER	2938.638	12LYRE00005D_bridge	8.09	Irregular	1.349	2.62	N/A	0.013
URRIN	656.39	12URIN00202D_bridge	6.1	Arch x 3	2.881,3.218,2.76	3.79,4.79,4.18	0.981,0.809,0.94	0.013
URRIN	677.531	12URIN00200D_bridge	1.87	Irregular	3.006	15.157	N/A	0.013
URRIN	2402.262	12URIN00028D_bridge	8.77	Arch x 3	3.807,4.032,3.736	5.407,5.413,5.51	1.517,1.852,1.596	0.013
URRIN	2652.029	12URIN00003D_bridge	4.83	Irregular	6.334	13.293	N/A	0.013
URRIN	2667.413	12URIN00000D_bridge	2.8	Irregular	5.947	33.02	N/A	0.013
URRIN LOOP	320.285	12URLP00014D_bridge	5.17	Arch	2.141	3.47	0.841	0.013
URRIN LOOP	346.386	12URLP00010D_bridge	3.75	Irregular	1.374	5.16	N/A	0.013
RIVER SLANEY	33962.973	12SLAN02863D_bridge	10	Arch x 6	Ranging from 6.296-4.898	Ranging from 7.85-5.42	Ranging from 2.79-2.407	0.013
RIVER SLANEY	34285.186	12SLAN02827D_bridge	15.3	Irregular	5.584	34.59	N/A	0.013
RIVER SLANEY	41257.383	01ENNI00555D_bridge	5.1	Irregular x 7	Ranging from 4.121-3.577	Ranging from 9.35-9.66	N/A	0.013
RIVER SLANEY	41367.153	12SLAN02121D_bridge	9.48	Arch x 6	Ranging from 5.128-2.387	Ranging from 10.4-7.9	Ranging from 2.411-0.607	0.013
RIVER SLANEY	41571.347	01ENNI00524D_bridge	17	Arch x 3	4.764,4.919,4.064	14.23,19.9,18.2	3.404,2.998,2.993	0.013
RIVER SLANEY	46950.918	12SLAN01565D_bridge	3.8	Irregular x 13	Ranging from 5.506-1.421	Ranging from 9.21-0.52	N/A	0.013

Structure Details – Bridges & Culverts								
RIVER BRANCH	**CHAINAGE**	**ID**	**LENGTH (m)**	**OPENING SHAPE**	**HEIGHT (m)**	**WIDTH (m)**	**SPRING HEIGHT FROM INVERT (m)**	**MANNING'S N**
Culverts								
MONART	594.636	12MONA00027I_culvert	6.1	Circular	0.36	N/A	N/A	0.013
URRIN LOOP	338.774	12URLP00012I_culvert	5.87	Irregular	0.826	1.77	N/A	0.013
URRIN LOOP	363.882	12URLP00009I_culvert	2.67	Irregular	2.052	3.44	N/A	0.013
LYRE TRIBUTARY*	40.244	12LYRT00109_culvert	8	Circular	0.8	N/A	N/A	0.013
BLACKSTOOPS**	803.892	12OOPS00082I	432.494	Circular	1	N/A	N/A	0.013
MONART**	829.362	12MONA00010I	88.18	Circular	0.68	N/A	N/A	0.013

*Structure created (further information in Section 4.6.6(1)).

**Denotes structures incorporated as closed cross-sections only (and are therefore not included in the Network file).

Structure Details - Weirs			
RIVER BRANCH	**CHAINAGE**	**ID**	**Type**
URRIN RIVER	302.966	12URIN00237W_weir	Broad Crested Weir
SLANEY	40340.041	01ENNI00648_WEIR	Broad Crested Weir

***Structure ID Key:

D - Bridge Upstream Face

I - Culvert Upstream Face

W - Crest of Weir

APPENDIX A.2

RIVER LONG SECTION PROFILES

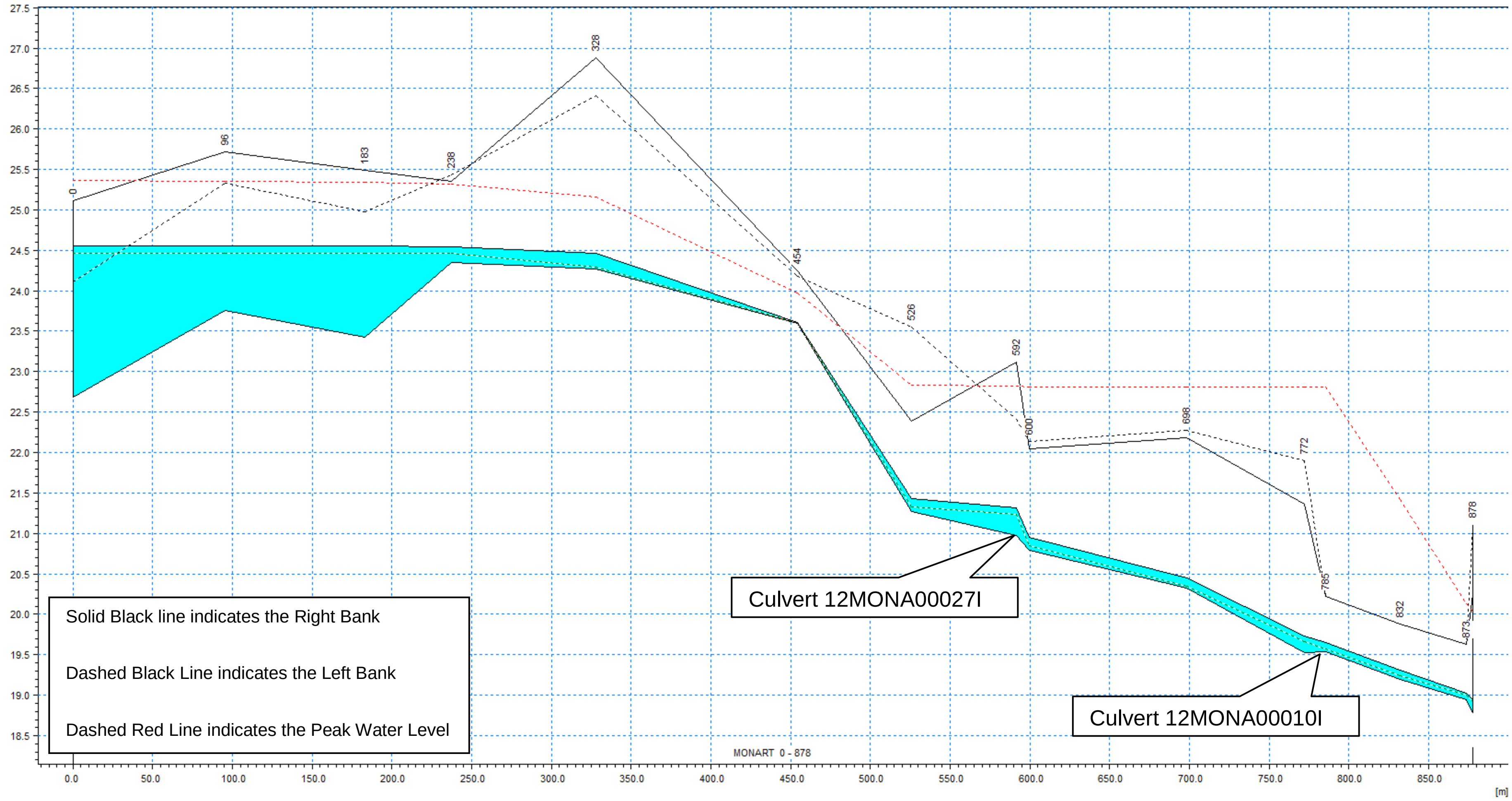


Figure 4.6.26 Monart Watercourse 0.1% fluvial flow

The Monart reach is a tributary of the Lyre River and has upstream flooding and a critical structure (12MONA00010I-12MONA00002J) which holds back water and has an effect on peak flows. This is discussed further in Appendix A.3.

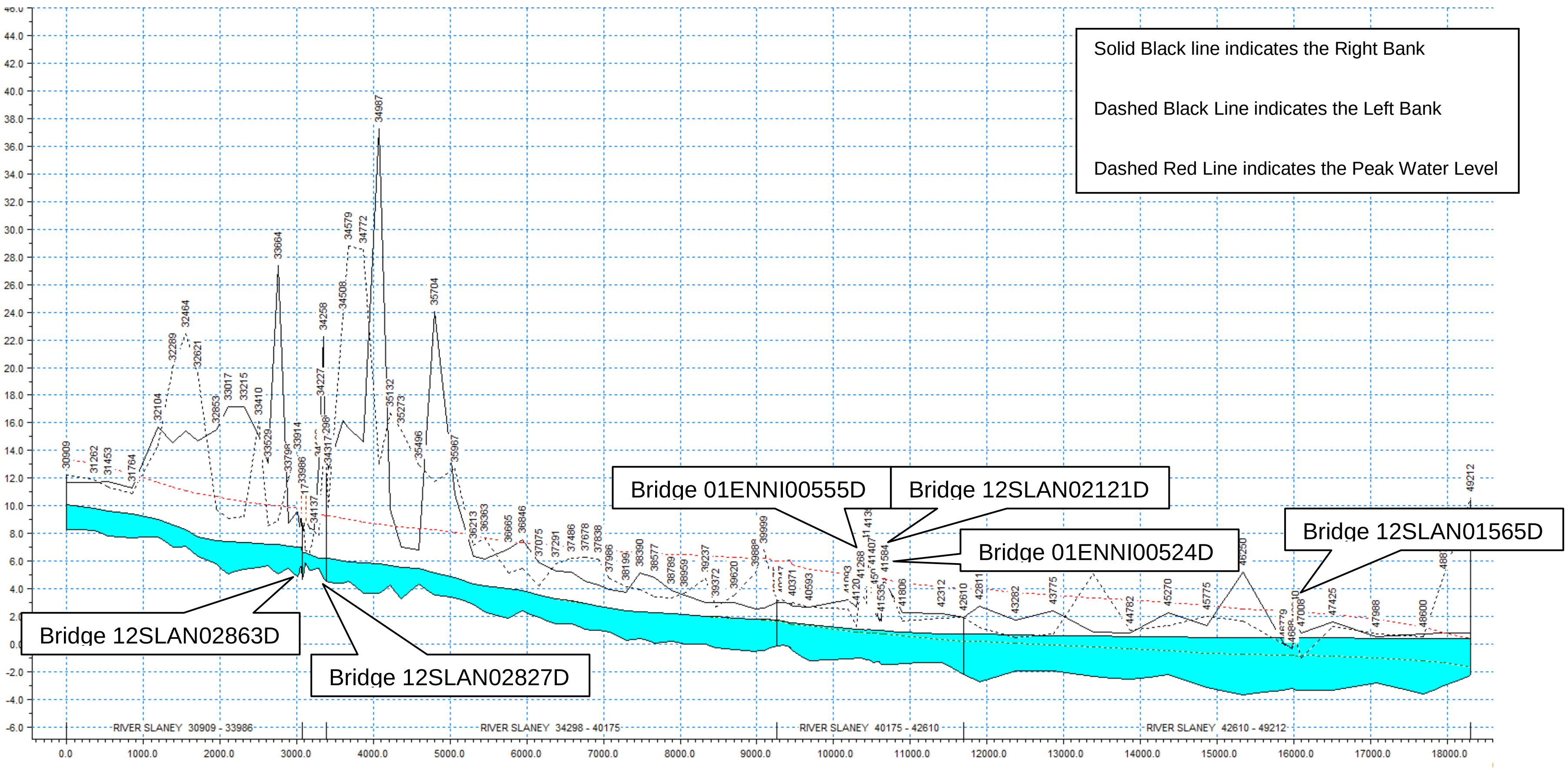


Figure 4.6.27 River Slaney Watercourse 0.1% Fluvial Flow

The River Slaney is the main reach running through Ennsicorthy. There is a slight instability at the first cross-section which causes some flickering, however, as discussed in '4.6.5.1, Summary of Calibration' this has little impact on the model as proven by the mass-balance calculation. A Q-h boundary is applied to the most downstream point of the model. For this section and a few sections directly upstream of it, water levels are extremely low but as it is a significant distance from the Fairfield and Cherryorchard area, the mapping of these areas will remain unaffected.

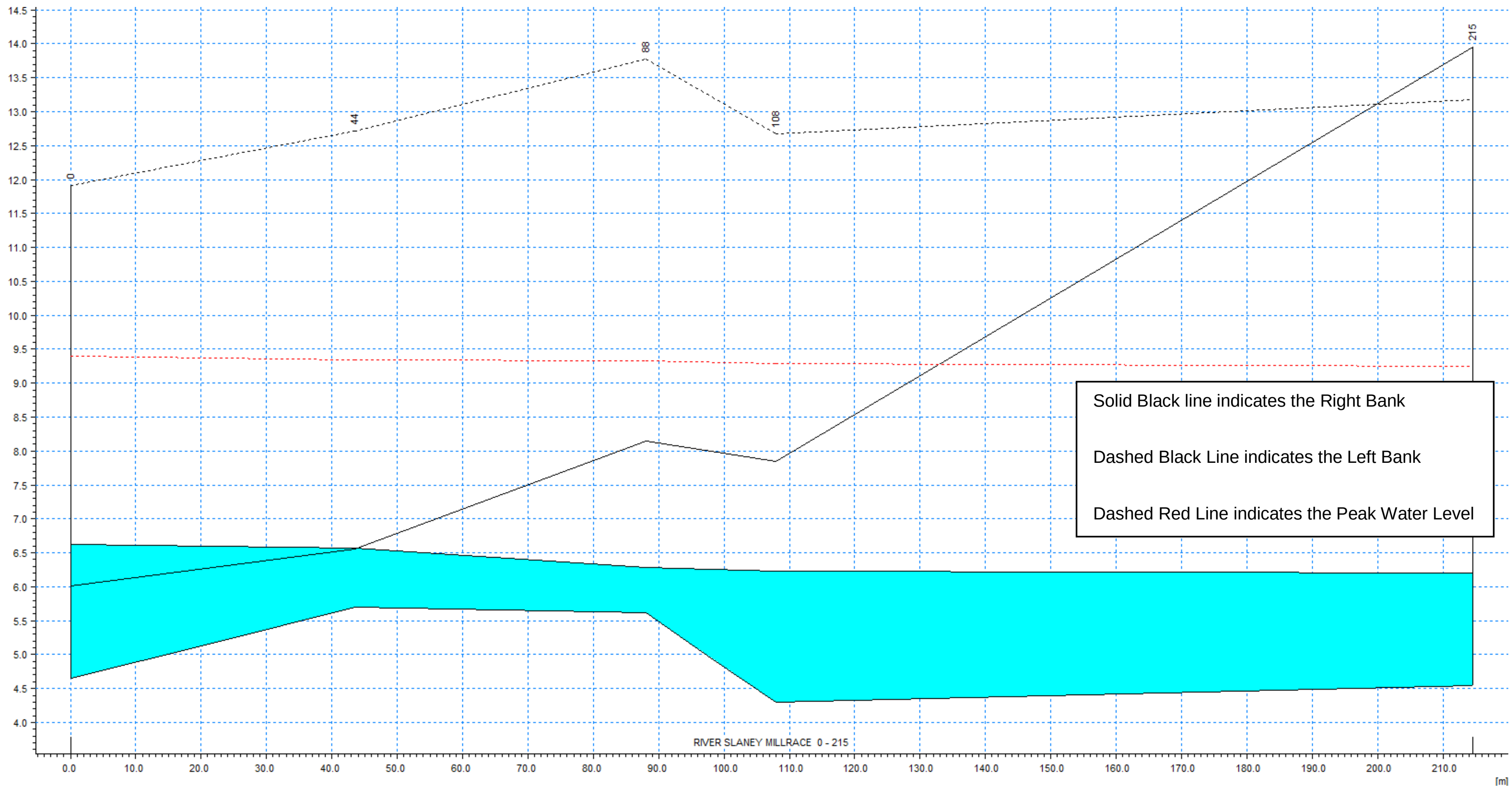


Figure 4.6.28 River Slaney Millrace Watercourse 0.1% Fluvial Flow

This reach was created for model run purposes from already given cross-sections for the River Slaney. There are no instabilities on this reach, supported by the mass-balance assessment in '4.6.5.1, Summary of Calibration'.

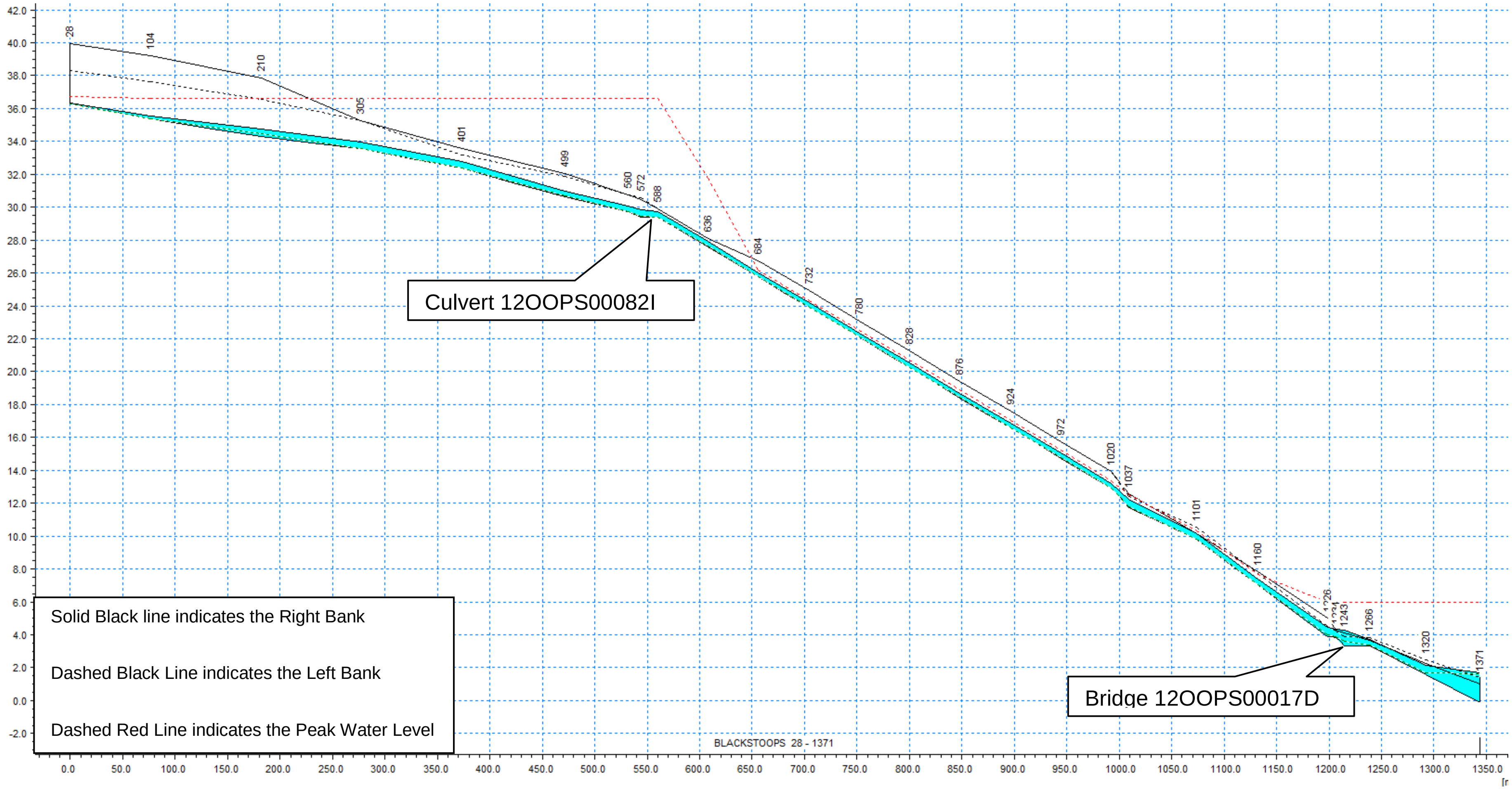


Figure 4.6.29 Blackstoops Watercourse 0.1% Fluvial Flow

The Blackstoops watercourse is a tributary of the River Slaney. It contains a critical structure, culvert 12OOPS00082I-12OOPS00040J which holds back water, affecting peak water levels. The mass balance was calculated to be -1.5178% which shows an accurate representation of flow throughout the model has been achieved.

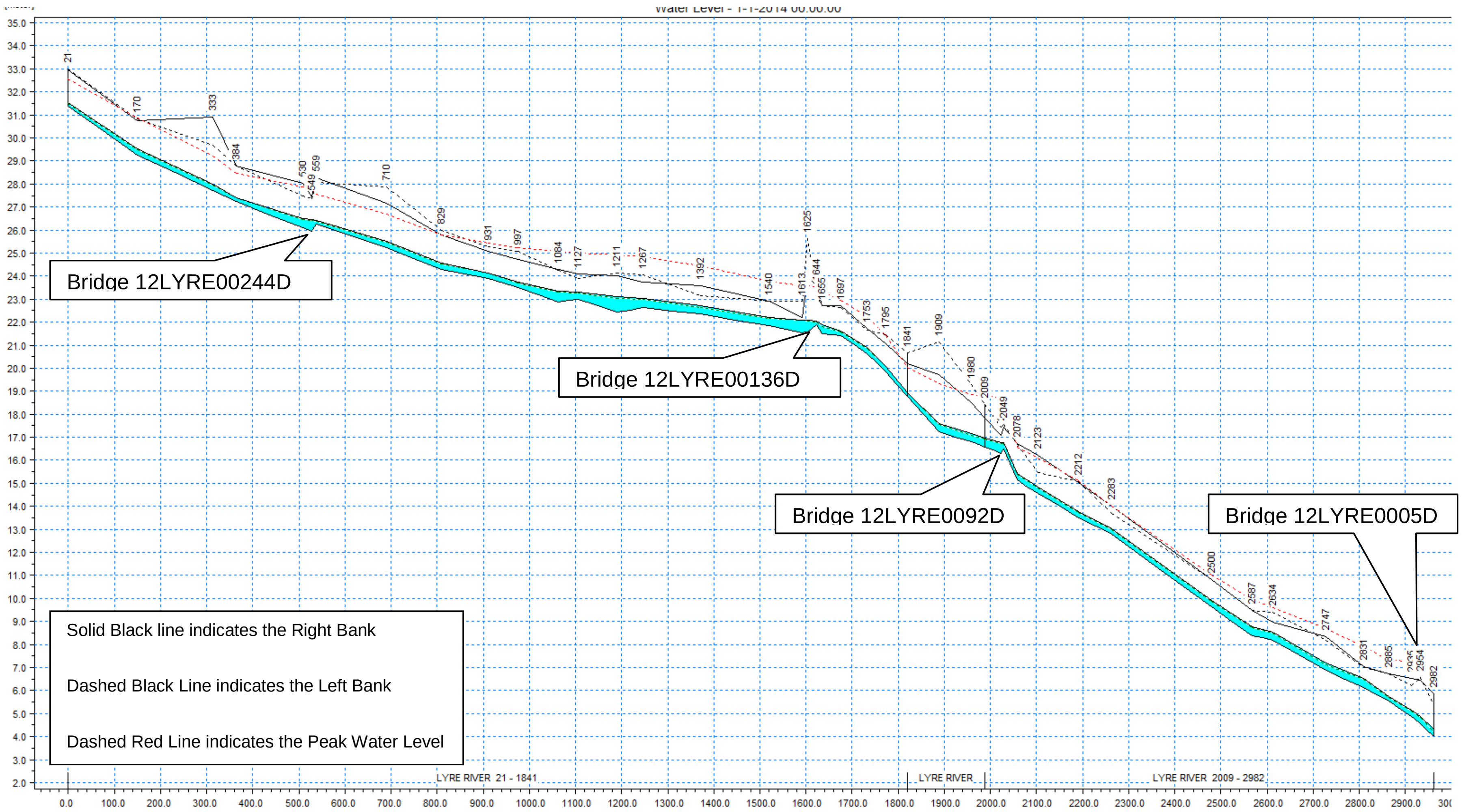


Figure 4.6.30 Lyre River Watercourse 0.1% Fluvial Flow

The Lyre River flows to join the Urrin River and is one of the main rivers runnign thrugh the Fairfield and Cherryorchard area. There are no instabilities on this reach, supported by the mass-balance assessment in '4.6.5.1, Summary of Calibration'.

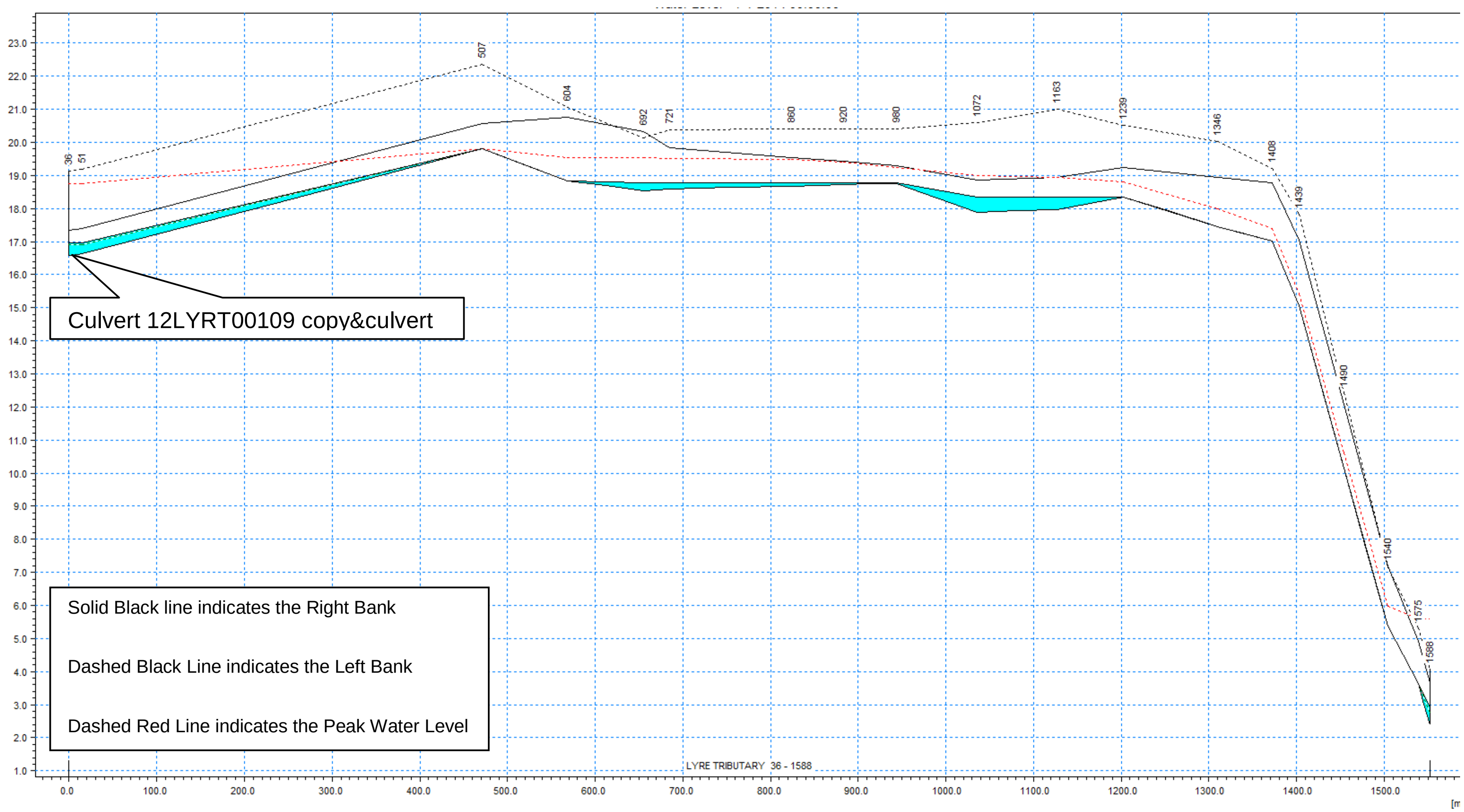


Figure 4.6.31 Lyre Tributary Watercourse 0.1% Fluvial Flow

The Lyre Tributary is a narrow watercourse. There are no instabilities, supported by the mass-balance assessment in '4.6.5.1, Summary of Calibration'.

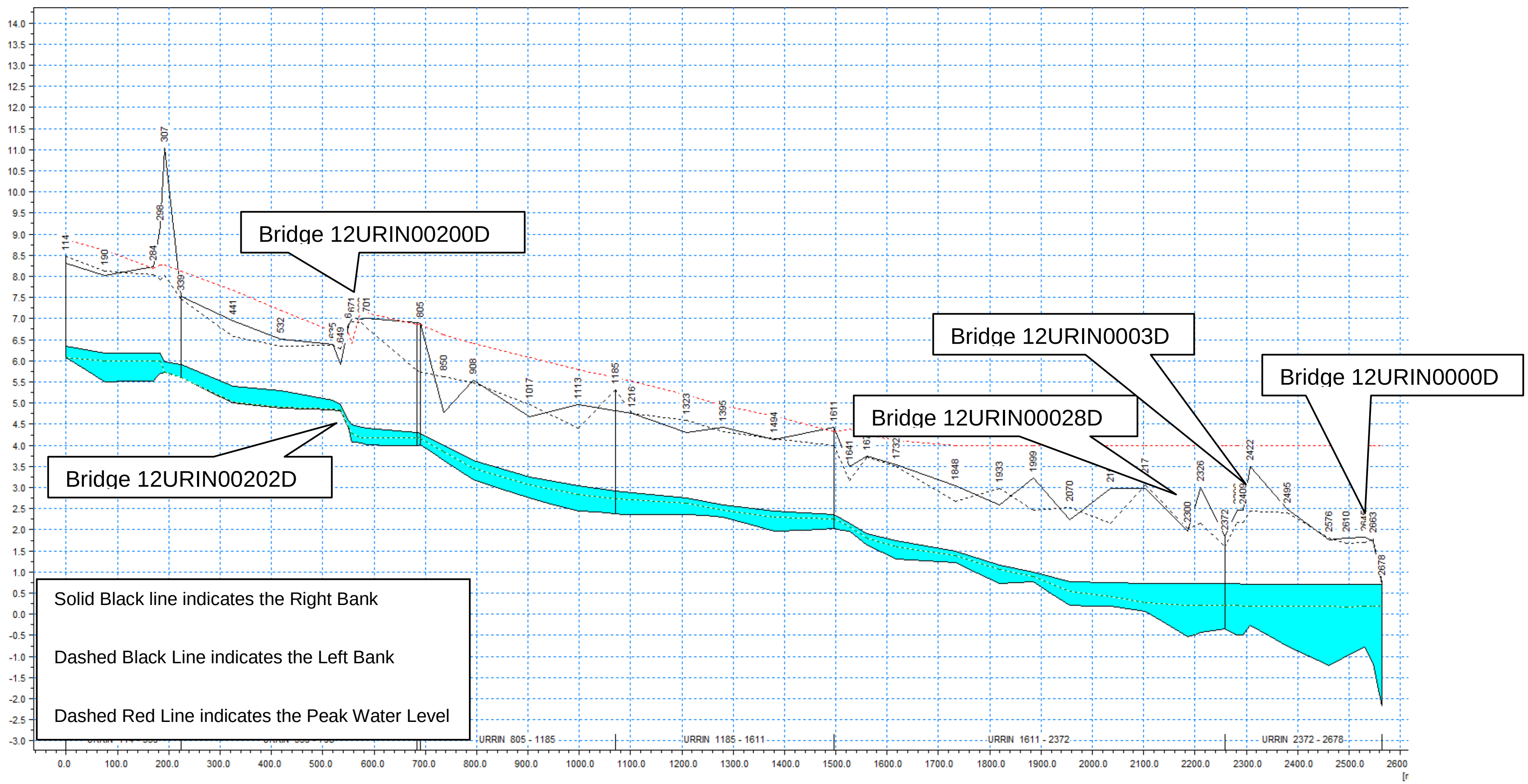


Figure 4.6.32 Urrin River Watercourse 0.1% Fluvial Flow

The Urrin River is the other main river, along with the Lyre, that runs through the Fairfield and Cherryorchard area. The close proximity of two large bridges (202D and 200D) has caused a slight instability in the model with some flickering. Overall flow and model run is not affected, proven by the mass-balance assessment in '4.6.5.1, Summary of Calibration'.

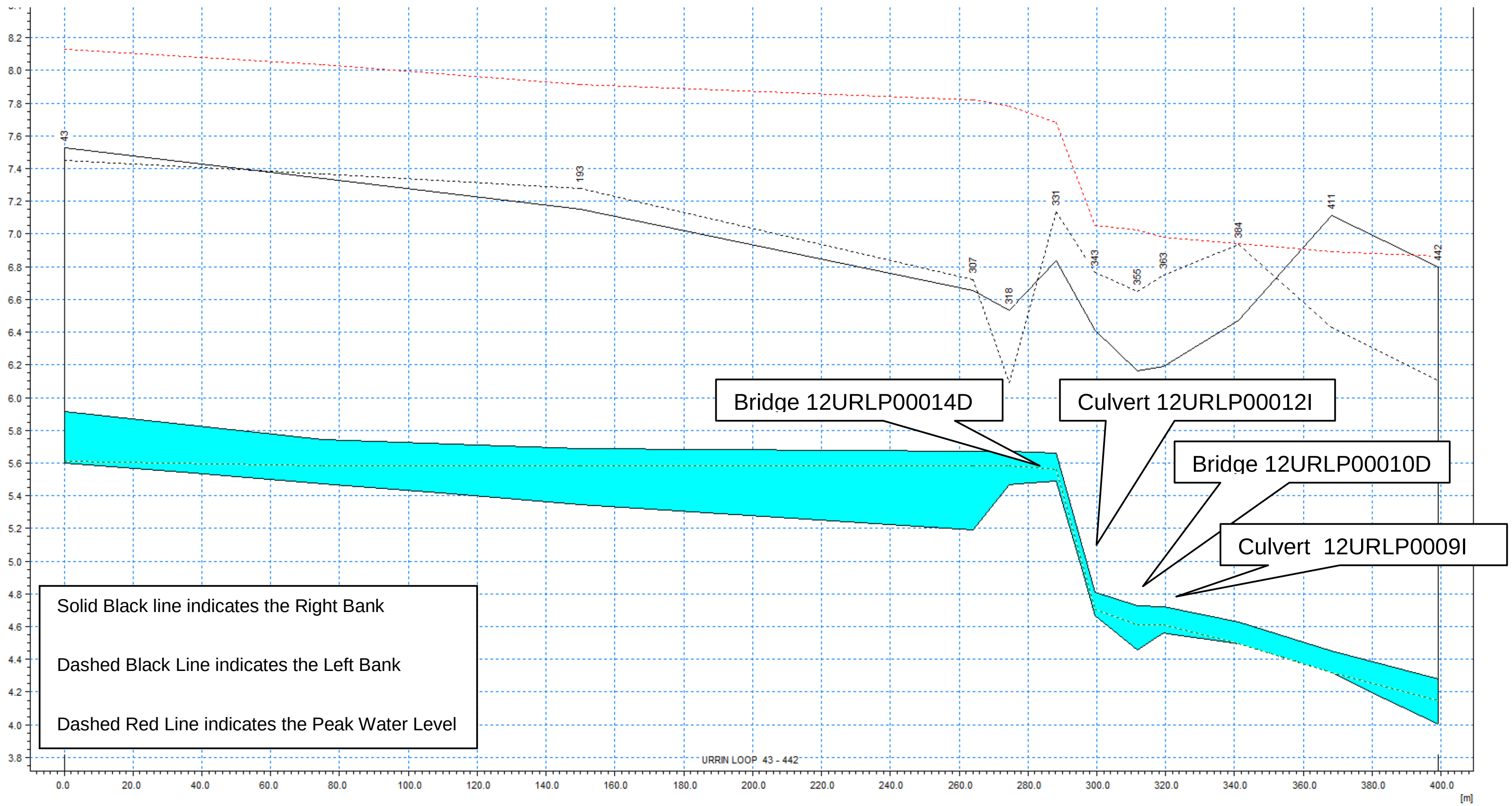


Figure 4.6.33 Urrin Loop Watercourse 0.1% Fluvial Flow

Urrin Loop is the first of two tributaries that split off from the Urrin River and rejoin further downstream in the Fairfield and Cherryorchard area. There is one flicker around the area where the three structures are located at the downstream end but this has no effect on the peak water levels, confirmed by the mass-balance assessment in '4.6.5.1, Summary of Calibration'.

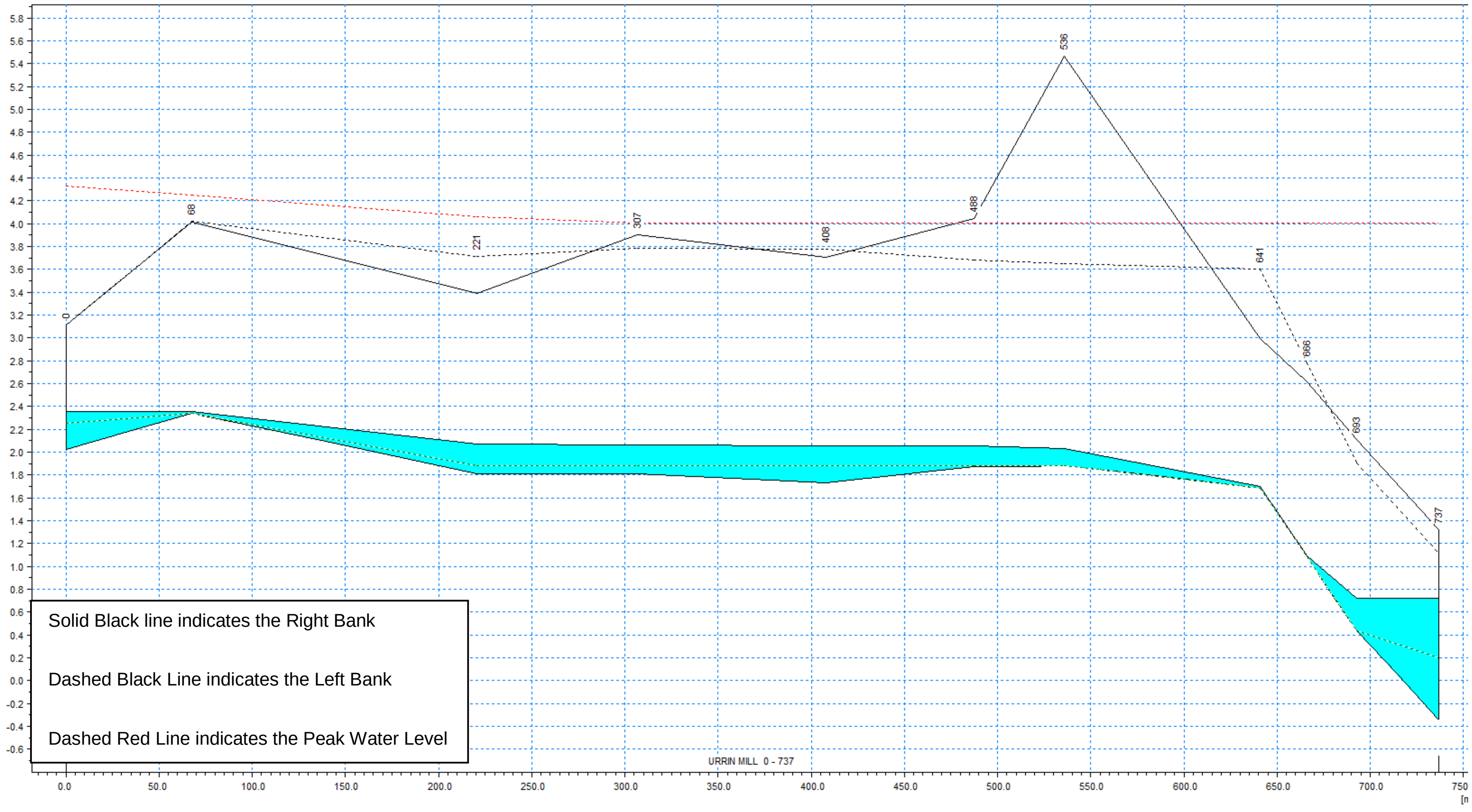


Figure 4.6.34 Urrin Mill Watercourse 0.1% Fluvial Flow

This is the second tributary along the Urrin that splits off and then rejoins further downstream. There are no instabilities, supported by the mass-balance assessment in '4.6.5.1, Summary of Calibration'. Water levels can be seen to be very low at points. This is due to the raised bed level of Urrin Mill compared to that of the Urrin River.

APPENDIX A.3

ESTIMATED PEAK FLOW AND MODEL FLOW COMPARISON

	Peak Water Flows			
River Name & Chainage	**AEP**	**Check Flow (m^3/s)**	**Model Flow (m^3/s)**	**Diff (%)**
MONART 735.19	10%	0.52	0.29	-43.85
12_2460_2_RPS	1%	0.93	0.45	-51.83
	0.1%	1.61	0.87	-46.27
BLACKSTOOPS 1230.14	10%	1.36	1.26	-7.50
12_2296_3_RPS	1%	2.44	1.87	-23.44
	0.1%	4.24	2.64	-37.74
RIVER SLANEY 34543.08	10%	252.07	251.70	0.15
12_921_2_RPS & 12_943_2_RPS	1%	358.01	358.23	0.06
	0.1%	505.75	491.74	2.77
RIVER SLANEY 40210.8	10%	260.62	267.50	2.64
12_2061_1_RPS & 12_2296_3_RPS_DS	1%	370.15	381.53	3.07
	0.1%	505.75	522.88	3.39
RIVER SLANEY 41695.2	10%	262.06	262.48	0.16
12008_RPS	1%	372.20	369.07	0.84
	0.1%	508.54	536.13	5.43
RIVER SLANEY 46950.92	10%	313.64	301.00	-4.03
12061_RPS	1%	445.45	442.57	-0.65
	0.1%	608.63	600.32	-1.37
URRIN 152.37	10%	32.32	31.03	-3.99
12_2605_1_RPS	1%	46.58	44.71	-4.01
	0.1%	65.97	63.35	-3.97
URRIN 1359.13	10%	32.29	30.62	5.16
12_2604_2_RPS	1%	46.55	47.43	1.88
	0.1%	51.72	57.26	10.71
URRIN 2384.09	10%	32.28	29.86	7.50
12007_RPS	1%	46.53	49.53	6.44
	0.1%	65.90	62.58	5.04
URRIN 2652.03	10%	32.32	35.01	8.31
12_2605_1_RPS	1%	46.58	44.34	4.81
	0.1%	65.97	62.65	5.03
LYRE RIVER 1874.98	10%	3.43	2.82	17.67
12_2323_1_RPS & 12_2460_2_RPS_DS	1%	6.15	5.75	6.50
	0.1%	10.68	9.44	11.60

The table above provides details of the flow in the model at every HEP intermediate check point, modelled tributary and gauging station. These flows have been compared with the hydrology flow estimation and a percentage difference provided.

The estimated and modelled flows downstream of the Monart River for the 10%, 1% and 0.1% AEP events show differences of 44% to 52%. This has been attributed to the fact that the culvert 12MONA00010I-12MONA00002J is holding back water. This has slowed the flow and created a delay in the water reaching the bottom of the channel. However, it may be noted that although the difference is high, this is relative to flows being small and so a variance of only 0.23m^3/s is the cause of a -44% difference.

Check point 12_2323_1_RPS is located at the confluence of the Monart and Lyre River and represents the total flow in both watercourses. The difference in percentage here is largely due to the flow that is restricted by the culvert on the Monart River (discussed above). Without this loss of flow on the minor watercourse the differences could be shown to be much smaller therefore demonstrating much improved anchoring of the modelled flows to the hydrological estimates.

The percentage difference can be seen to progressively increase for the greater return periods at 12_2296_3_RPS on the Blackstoops reach. This can be explained by the presence of flooding in this section of the model. There is very little flooding in the 10% AEP modelled event, which can be seen to be well anchored to the hydrological estimates (difference less than 10%). However the difference increases with the greater return periods, which correlates with the fact that out of bank flooding increases throughout these different model runs. As such it is considered that the localised flood attenuation effects demonstrated in the model are not represented within the hydrological estimates.

For all other check points, it can be seen model flows and estimated flows are within 11% of the hydrological estimates. This indicates the model is well anchored to hydrological estimates.

APPENDIX A.4

DELIVERABLE MODEL AND GIS FILES

MIKE FLOOD	MIKE 21	MIKE 21 RESULTS
HA12_ENNI4_MF_DES_1_Q10	HA12_ENNI4_M21_DES_1_Q10	HA12_ENNI4_M21_DES_1_Q10.dfs2
HA12_ENNI4_MF_DES_1_Q100	HA12_ENNI4_M21_DES_1_Q100	HA12_ENNI4_M21_DES_1_Q100.dfs2
HA12_ENNI4_MF_DES_1_Q1000	HA12_ENNI4_M21_DES_1_Q1000 HA12_ENNI4_Bafs_Rec_10.dfs2 HA12_ENNI4_Bafs_Rec_Corine_1.dfs2	HA12_ENNI4_M21_DES_2_Q1000.dfs2

MIKE 11 - SIM FILE & RESULTS FILE	MIKE 11 - NETWORK FILE	MIKE 11 - CROSS-SECTION FILE	MIKE 11 - BOUNDARY FILE
HA12_ENNI4_M11_DES_1_Q10 HA12_ENNISCORTHY_4_MF_DES_1_Q10.res11 HA12_ENNI4_M11_DES_1_Q100 HA12_ENNISCORTHY_4_MF_DES_1_Q100.res11 HA12_ENNI4_M11_DES_1_Q1000 HA12_ENNISCORTHY_4_MF_DES_2_Q1000.res11	HA12_ENNI4_NWK_DES_1	HA12_ENNI4_XNS_DES_1	HA12_ENNI4_BND_Q10 HA12_ENNI4_BND_Q100 HA12_ENNI4_BND_Q1000
MIKE 11 - DFS0 FILE		**MIKE 11 - HD FILE & RESULTS FILE**	
HA12_ENNI4_DFS0_Q10 HA12_ENNI4_DFS0_Q100 HA12_ENNI4_DFS0_Q1000 HA12_ENNI4_DFS0_DsBnd		HA12_ENNI4_HD_DES_1_Q10 HA12_ENNISCORTHY_4_M11_DES_1_Q10_HDmaps.dfs2 HA12_ENNI4_HD_DES_1_Q100 HA12_ENNISCORTHY_4_M11_DES_1_Q100_HDmaps.dfs2 HA12_ENNISCORTHY_4_M11_DES_2_Q1000_HDmaps.dfs2	

GIS Deliverables - Hazard		
Flood Extent Files (Shapefiles)	**Flood Depth Files (Raster)**	**Water Level and Flows (Shapefiles)**
Fluvial o16exfcd001F0 o16exfcd010F0 o16exfcd100F0	Fluvial o16dpfcd001F0 o16dpfcd010F0 o16dpfcd100F0	Fluvial O16NFCDF0_SPJoin
Flood Zone Files (Shapefiles)	**Flood Velocity Files (Raster)**	
Fluvial o16zna_fcdF0 o16znb_fcdF0	o16VLfcd001F0 o16VLfcd010F0 o16VLfcd100F0	

GIS Deliverables - Risk		
Specific Risk - Inhabitants (Raster)	**General Risk - Economic (Shapefiles)**	**General Risk-Environmental (Shapefiles)**
Fluvial o16rifcd001F0 o16rifcd010F0 o16rifcd100F0		