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APPENDIX 10

Hydrology and Water Quality

Appendix 10.1 – Bridge and Culvert Report

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APPENDIX 10.1

Bridge and Culvert Report

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P22-242 DREHID WIND FARM AND SUBSTATION SID

Preliminary Technical Report for Proposed Bridges and Culverts

Prepared for:

North Kildare Wind Farm Ltd

Date: May 2025

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PRELIMINARY TECHNICAL REPORT FOR PROPOSED CULVERTS AND BRIDGES

REVISION CONTROL TABLE, CLIENT, KEYWORDS AND ABSTRACT

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Abstract: Fehily Timoney and Company is pleased to submit this Preliminary Technical Report for the Proposed Bridges and Culverts for Drehid Wind Farm SID.

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1. INTRODUCTION

1.1 Proposed Development

This Preliminary Technical Report has been prepared by Fehily Timoney and Company (FT) on behalf of North Kildare Wind Farm Ltd. The report outlines the preliminary design and location of proposed culverts and structures to minimize the impacts of the Proposed Development access tracks and hardstanding areas on the hydrology of the local environment.

The Proposed Development Site includes lands in the townlands of Ballynamullagh, Kilmurry, Killyon, Coolree, Mulgeeth, Drehid, and Dunfierth, covering a footprint of 79 ha. The site is 3.7 km southwest from the town of Enfield and 12.4 km southwest from the town of Kilcock. Access to the site is via the M4 motorway until Enfield, then along the R402 for approximately 7.7 km and finally along the local road (L5025) to the entrance of the site. The site lies approximately 2.8 km south of the motorway M4 at Enfield and 1.2km southeast of the regional road R402 linking the M4 to the R420 east of Tullamore in County Offaly.

The Proposed Development access tracks and hardstanding areas will intersect several watercourses and land drains. These include:

- Three watercourse crossings over the Fear English River (EPA Name: Ballynamullagh), which are part of the Arterial Drainage Scheme.
- Four additional crossings over channels that are part of the Arterial Drainage Scheme.
- Several land drain crossings.

These crossings are proposed with culverts and structures, such as bridges, to ensure uninterrupted river flow. They are designed to maintain natural hydrological conditions while supporting the development infrastructure.

The location of the Proposed Development site is shown in Figure 1.1

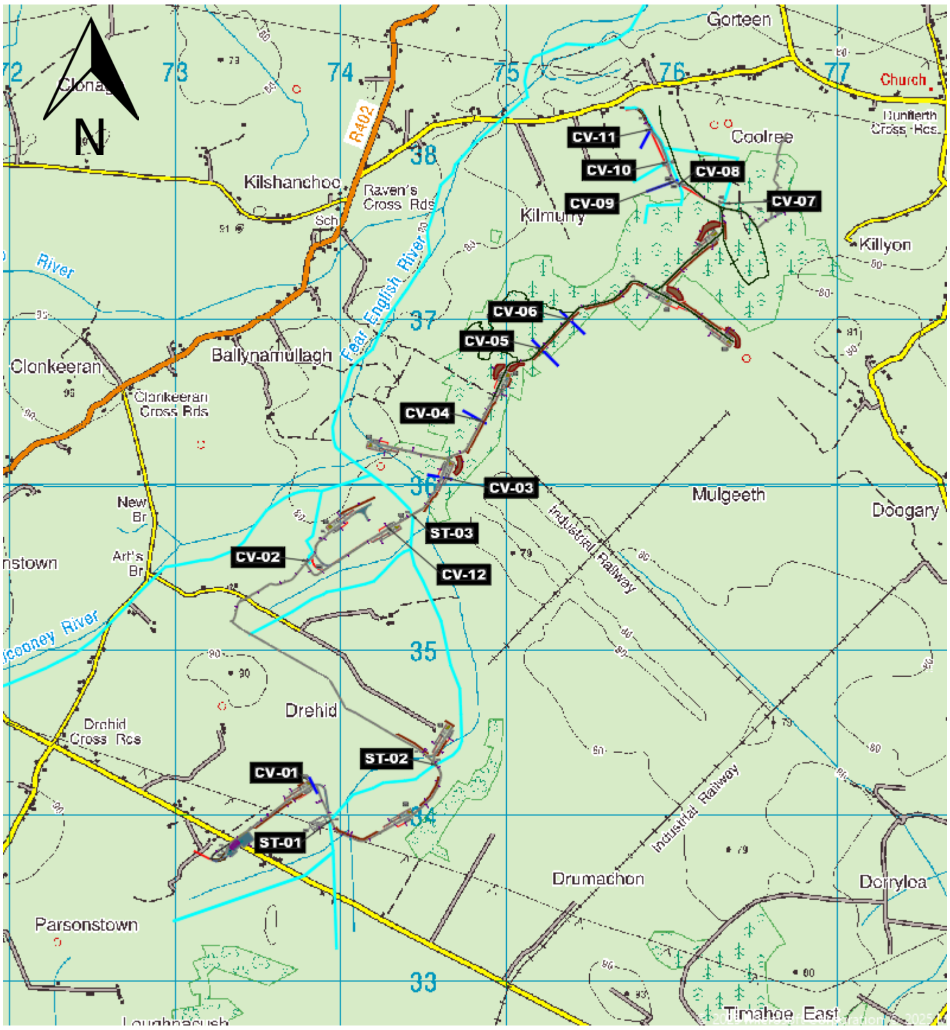

Figure 1-1: Proposed Scheme

1.2 Existing Streams and Proposed Culverts and Structures

The Fear English River flows through the site, also referred to by the EPA as Ballynamullagh (River waterbody code - IE_EA_07B020100). This waterbody is a tributary of the River Blackwater, which in turn is a tributary of the River Boyne. The river originates approximately northeast of Parsonstown and flows further north through, Drehid, Ballynamullagh, Kilmurry, Gorteen and joins the River Blackwater.

The Kilcooney River, referred to by the EPA as Coolree 07 (River waterbody code - IE_EA_07B020100) is a tributary of the Fear English River and it flows in a northeastern direction. A small tributary of this river intersects with the site.

The proposed structures in the scheme include 3 bridges (ST-01, ST-02, ST-03) and 12 culverts/temporary crossing structures to accommodate the river crossings, arterial drainage scheme and land drain crossings. CV-08 and CV-10 will be temporary crossing structures which will be installed only during the construction phase and removed when the construction activity is completed.

1.2.1 Crossing - ST-01

The crossing is located approximately 200 m southeast of proposed Turbine 1. The catchment size of the river at the location of the proposed bridge is 2.25 km2, obtained using the Ordnance Survey 1:50,000 scale Discovery Series Maps and LIDAR

Figure 1-2 below shows the existing conditions of the river at the crossing point.

The proposed structure layout is shown on drawing No. P22-242-0300-0021.

Table 1-1: Proposed Bridge ST- 01

Bridge Name	Bridge Width (m)	Bridge Span (m)	Bridge Height (m)	Bridge Coordinates	
				Easting (ITM)	Northing (ITM)
ST -01	5	8.50	0.60*	673974.665	734133.343

*From top of riverbank and flood plain to bridge soffit

Figure 1-2: Existing Stream looking upstream

1.2.2 Crossing - ST-02

The crossing is located downstream of ST-01, approximately 700 m away. It crosses the same river, the Fear English River, and it is next to Turbine 3. The catchment size of the river at the location of the proposed structure is 3.46 km2, obtained using the Ordnance Survey 1:50,000 scale Discovery Series Maps and LIDAR.

Figure 1-3 below shows the existing conditions of the river at the crossing point. Currently, there is a culvert for the existing access track that intersects the river. ST-02 will provide a new clear span bridge immediately adjacent to this existing culvert.

The proposed structure layout is shown on drawing No. P22-242-0300-0022.

Table 1-2: Proposed Bridge ST-02

Bridge Name	Bridge Width (m)	Bridge Span (m)	Bridge Height (m)	Bridge Coordinates	
				Easting (ITM)	Northing (ITM)
ST-02	4.50	8.50	0.55*	674610.717	734467.701

* From top of riverbank and flood plain to bridge soffit

Figure 1-3: Existing Stream Culvert looking upstream

1.2.3 Crossing - ST-03

The crossing is located downstream of ST-01 and ST-02 and approximately 100 m northeast of proposed Turbine 4. The catchment size of the river at the location of the proposed structure is 5.016 km2, obtained using the Ordnance Survey 1:50,000 scale Discovery Series Maps and LIDAR.

Figure 1-4 below shows the existing conditions of the river at the crossing point.

The proposed structure layout is shown on drawing No. P22-242-0300-0023.

Table 1-3: Proposed Bridge ST - 03

Bridge Name	Bridge Width (m)	Bridge Span (m)	Bridge Height (m)	Bridge Coordinates	
				Easting (ITM)	Northing (ITM)
ST-03	4.50	8.70	0.85*	674467.038	735976.277

* From top of riverbank and flood plain to bridge soffit

Figure 1-4: Existing Stream looking upstream

1.2.4 Proposed Culverts/Temporary Crossings

Access tracks and hardstanding areas pass through multiple land drains and Arterial Drainage Scheme Channels that connect or discharge to the Fear English River (River waterbody code - IE_EA_07B020100). The following table shows the list of proposed culverts, their sizes, and the associated catchments.

Table 1-4: Proposed Culverts

Culvert/ Structure Name	Culvert Type	Catchment Area (km2)	Culvert Length (m)	Culvert Diameter (mm)	Culvert Coordinates	
					Easting (ITM)	Northing (ITM)
CV-01	Circular	0.140	10.50	1050	673870.087	734342.270
CV-02	Circular	0.050	10.50	900	673844.294	735701.550
CV-03	Circular	0.060	54.13	1050	674670.598	736201.296
CV-04	Circular	0.012	10.50	900	674892.787	736543.629
CV-05	Circular	0.265	10.50	1200	675250.928	736980.500
CV-06	Circular	0.428	10.50	1500	675417.454	737158.857
CV-07	Circular	0.047	58.00	1350	676347.116	737844.516
CV-08*	Temp.	0.138	12.70	1200	676084.970	737970.987
CV-09	Circular	0.028	10.80	1050	676049.766	737993.457
CV-10*	Temp.	0.059	10.50	1050	675993.515	738103.549
CV-11	Circular	0.026	13.00	900	675904.469	738301.134
CV-12	Circular	0.176	36.00	1200	674336.666	735914.252

*Temporary Crossings

2. HYDROLOGYCAL ANALYSIS

2.1 Contribute Catchment

The hydrology of a catchment is significantly influenced by its physical characteristics, such as the size of the catchment, length of the stream, steepness of the terrain and average annual rainfall. The following table lists the parameters used for the hydrological calculations. The parameters were obtained from different sources including UK SuDS web portal, discovery mapping and site survey LIDAR; specifically calculated for the subject catchments.

Table 2-1: Catchment Characteristics

Catchment Reference	Standard Average Annual Rainfall	Soil index	Catchment Area	Max. Catchment Width	Average Height of Catchment Divide in metres
	SAAR	SOIL	Area	W	Z
	(mm)	-	Km2	m	m
	Source: https://www.uksuds.com/		Source: Catchment Analysis - Discovery mapping and Lidar Survey		
CAT-A	822	0.47	2.250	2448.00	6.50
CAT-B	822	0.47	3.460	3085.71	5.50
CAT-C	822	0.47	5.016	3494.00	11.77
CAT-D	822	0.47	0.140	821.00	5.50
CAT-E	822	0.47	0.050	799.00	9.50
CAT-F	822	0.47	0.060	340.72	1.00
CAT-G	822	0.47	0.012	139.05	1.19
CAT-H	822	0.47	0.265	1164.21	4.31
CAT-I	822	0.47	0.428	1169.86	5.02
CAT-J	822	0.47	0.025	167.40	3.00
CAT-K	822	0.47	0.138	457.85	2.97
CAT-L	822	0.47	0.028	323.71	1.10
CAT-M	822	0.47	0.059	339.94	4.00
CAT-N	822	0.47	0.026	245.00	1.87
CAT-O	822	0.47	0.176	1305.00	10.00

2.2 Estimated Peak Flow

In accordance with the OPW guidelines on hydrology, several methods were considered for estimating the peak flow of the various watercourses at the locations of the proposed bridges and culverts for the annual exceedance probability (AEP) of 1%.

The following methods have been selected for the catchments presented in order to estimate the peak flow of the streams:

- ADAS Method.
- Institute of Hydrology Report 124 Method (IoH124).
- FSSR 6, 3 Variable Method.

The ADAS method equation is designed to yield a design flow for a return period of 75 years, while the other two methods provide the mean annual flood (a return period of approximately 1:2.3 years). Therefore, different growth factors have been applied to estimate the design flow for a return period of 100 years. These are 1.05 for the ADAS Method and 1.96 for the other two methods.

The flow estimates are all subject to a 20% climate change allowance. To account for potential errors in the flow estimates, different factors have been applied to each method, such as the FSE (Factorial Standard Error). Where there are no properties with the potential to be at flood risk, this FSE has been applied with a 65 % CI.

The different methods have been applied, but the selection of the final design flow takes into account the adequacy of each method for the size of the catchment. The ADAS method is more appropriate for very small catchments (<0.4 km2) and yields very conservative results while the IoH 124 and the FSSR 6, 3 Variable Method are more adequate for catchments larger than 0.4 km2.

The following table provides the different methods and factors used, as well as the final design flow chosen for the 100-years return period.

For Bridge crossings ST-01, ST-02, ST-03, and culvert CV-06, the catchment is >0.4 km2, therefore, IoH 124 and FSSR 6, 3 Variable Method would be more appropriate.

Table 2-2: Comparison of estimated design flows for Catchments >0.4 km2

Catchment Reference	Method	Qbar (m3/s)	Factorial Standard Error (FSE)	Q100 (100 Years)	Q100 with 20% of climate change (m3/s)
CAT-A	IoH 124	1.833	1.65	3.593	4.311
	FSSR 6, 3 Variable Method	1.748	1.58	3.426	4.111
CAT-B	IoH 124	2.688	1.65	5.269	6.322
	FSSR 6, 3 Variable Method	2.597	1.58	5.090	6.108
CAT-C	IoH 124	3.741	1.65	7.333	8.796
	FSSR 6, 3 Variable Method	3.655	1.58	7.163	8.595

Catchment Reference	Method	Qbar (m3/s)	Factorial Standard Error (FSE)	Q100 (100 Years)	Q100 with 20% of climate change (m3/s)
CAT-I	IoH 124	0.419	1.65	0.821	0.985
	FSSR 6, 3 Variable Method	0.380	1.43	0.745	0.894

When comparing the results, the IoH 124 method provides the highest flow; therefore, this method has been selected for the design flow.

For the remaining culvert crossings, the catchments are <0.4 km2, so the ADAS method would be more appropriate.

Table 2-3: Estimated design flows for Catchments <0.4 km2

Catchment Reference	Method	Catchment Area (km2)	Q75 (m3/s)	Q100 (m3/s)	Q100 with 20% of climate change (m3/s)
CAT-D	ADAS	0.140	0.193	0.202	0.243
CAT-E	ADAS	0.050	0.081	0.085	0.102
CAT-F	ADAS	0.060	0.084	0.089	0.106
CAT-G	ADAS	0.012	0.029	0.031	0.037
CAT-H	ADAS	0.265	0.280	0.294	0.352
CAT-J	ADAS	0.047	0.071	0.074	0.117
CAT-K	ADAS	0.138	0.222	0.233	0.280
CAT-L	ADAS	0.028	0.041	0.043	0.051
CAT-M	ADAS	0.059	0.121	0.128	0.153
CAT-N	ADAS	0.026	0.051	0.054	0.064
CAT-O	ADAS	0.176	0.220	0.232	0.278

3. HYDRAULIC ANALYSIS

3.1 Hydraulic Design

The hydraulic design of the proposed bridges was conducted using Manning's equation for open channels. For the culverts, the hydraulic design was carried out using Culvert Master software. These designs followed the main requirements and parameters established in the OPW Guidelines, though they are at a preliminary design stage and based on the available information.

The proposed culverts and bridges have been designed to provide a freeboard of at least 300mm, both upstream and downstream, for the design peak flow. This design accounts for a 100-year return period and 20% climate change impact.

The Manning's equation and Culvert Master software have been used for preliminary sizing of proposed bridges and culverts, which will need to be re-analysed at detailed design stage with a detailed topographical survey.

The hydraulic capacity of the channel and a section of the floodplain were used to estimate the approximate span and soffit of the proposed bridges ST-01, ST-02, and ST-03, ensuring they can convey the design flow with a minimum freeboard of 300mm. This estimation also considered that the abutments would be set back at least 2.5 meters from the banks for environmental purposes.

The proposed culverts were designed as circular culverts with an embedment of 300 mm, ensuring that they can convey the design flow with a minimum freeboard of 300 mm.

The design parameters used such as the Manning's values for the river channel were estimated based on the site visit and on the proposed manning's values from the Hec-Ras Reference Manual.

Table 3-1: Design Parameters used in the hydraulic design

Structure	Manning's Value (n)	Source
Bridges for streams	Stream bed = 0.045	HEC-RAS Manual -Table 3-1 Manning's Values
Culverts for land drains	Culvert bed = Stream bed= 0.045 Culvert walls = 0.013 Average = 0.029	HEC-RAS Manual -Table 3-1 Manning's Values

The hydraulic design of the proposed bridges and culverts was based on the topographic survey (LIDAR) provided by Bluesky International Ltd and a site visit conducted by FT on 14/10/2024 and 15/10/2024.

4. RESULTS AND CONCLUSION

A hydraulic analysis was carried out for the design of 3 bridges, 2 temporary crossings and 10 permanent culverts for the construction of Drehid Wind Farm access tracks and hardstanding areas to cross the existing watercourses and land drains.

Three calculation methods were applied to determine the design flow for the 100 years return period with an allowance of 20 % for climate change. The most adequate method was selected in accordance with the catchment characteristics.

The proposed bridges ST-01, ST-02, and ST-03 were sized using Manning's Equation to determine the minimum span and height. Additionally, a minimum setback of 2.5 meters for the abutments from the riverbanks was established for environmental and ecological considerations. These structures were designed to convey a design flow for a 100-years return period with a minimum freeboard of 300 mm.

The proposed culverts were designed in Culvert Master as circular pipe culverts following the estimated bed levels of the streams and land drains, with a minimum 300 mm of embedment and 300 mm freeboard. The temporary crossings (CV-08 and CV-10) will be removed following the completion of Drehid Wind Farm construction.

In conclusion, the design of the proposed bridges and culverts provides an estimation or preliminary sizing for the required watercourse and land drain crossings. However, detailed design analysis, including a detailed topographical survey of the waterbodies, will be required to optimize the structural dimensions and assess potential impacts on water levels and flooding.

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APPENDIX 1

HYDROLOGIC ANALYSIS

Catchment Flow Calculator

Stream Reference	Chainage Range	Road/String Name	Road Side
CAT-A	N/A	N/A	N/A

Author	Checked	Approved
PW	SH	PD

Description	Inputs Parameters								
	Rainfall	Soil Index	Catchment Area	Max. Catchment Width	Average Height of Catchment Divide in metres	IH124 Method		FSSR 6, 3-Variable Method	Climate Change
						Growth Factor	FSE	FSE	Climate Change (%)
Parameters	SAAR	SOIL	AREA	W	Z	F	FSE	FSE	CC
Units	(mm)	-	km2	m	m	-	-	-	(%)
Info Source	UK SUDS	UK SUDS	Catchment Analysis- Drawings	Catchment Analysis- Drawings	Catchment Analysis- Drawings	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	FSU WP 2.3	OPW Guidelines
Inputs	822	0.47	2.250	2448	6.5	1.96	1.65	1.58	20%

Description	Outputs				
	IH124 Method		FSSR 6, 3-Variable Method		Design Peak Flow + CC for permeable areas
	IH124 Annual Flow	IH124 100Yr Flow	FSSR Annual Flow	FSSR 100Yr Flow	
Parameter	Q_a	$Q100_{IH124}$	Q_a	$Q100_{FSSR}$	Q
Units	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)
Formula	Q = 0.00108 * $AREA^{0.89}$ * $SAAR^{1.17}$ * $SOIL^{2.17}$* FSE	$Q = F\,Q_a$	Q = 0.00066 * $AREA^{0.92}$ * $SAAR^{1.22}$ * $SOIL^{2.0}$* FSE	$Q = F\,Q_a$	Q_{75} * 1.2
Info Source	Formula 1 of HA 106	Formula 3 of HA 106			Vol 3 of 5 Pt 2, 4.2.5.5 (vii)
Outputs	1.833	3.593	1.748	**3.426**	**4.312**

Notes

	Cells to fill
	Calculation
	Result

Catchment Flow Calculator

Stream Reference	Chainage Range	Road/String Name	Road Side
CAT-B	N/A	N/A	N/A

Author	Checked	Approved
PW	SH	PD

Description	Inputs Parameters								
	Rainfall	Soil Index	Catchment Area	Max. Catchment Width	Average Height of Catchment Divide in metres	IH124 Method		FSSR 6, 3-Variable Method	Climate Change
						Growth Factor	FSE	FSE	Climate Change (%)
Parameters	SAAR	SOIL	AREA	W	Z	F	FSE	FSE	CC
Units	(mm)	-	km2	m	m	-	-	-	(%)
Info Source	UK SUDS	UK SUDS	Catchment Analysis- Drawings	Catchment Analysis- Drawings	Catchment Analysis- Drawings	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	FSU WP 2.3	OPW Guidelines
Inputs	822	0.47	3.460	3085.71	5.5	1.96	1.65	1.58	20%

Description	Outputs				
	IH124 Method		FSSR 6, 3-Variable Method		Design Peak Flow + CC for permeable areas
	IH124 Annual Flow	IH124 100Yr Flow	FSSR Annual Flow	FSSR 100Yr Flow	
Parameter	Q_a	$Q100_{IH124}$	Q_a	$Q100_{FSSR}$	Q
Units	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)
Formula	$Q = 0.00108 * AREA^{0.89} * SAAR^{1.17} * SOIL^{2.17} * FSE$	$Q = F\,Q_a$	$Q = 0.00066 * AREA^{0.92} * SAAR^{1.22} * SOIL^{2.0} * FSE$	$Q = F\,Q_a$	$Q_{75} * 1.2$
Info Source	Formula 1 of HA 106	Formula 3 of HA 106			Vol 3 of 5 Pt 2, 4.2.5.5 (vii)
Outputs	2.688	5.269	2.597	**5.090**	**6.323**

Notes

	Cells to fill
	Calculation
	Result

Catchment Flow Calculator

Stream Reference	Chainage Range	Road/String Name	Road Side
CAT-C	N/A	N/A	N/A

Author	Checked	Approved
PW	SH	PD

Description	Inputs Parameters								
	Rainfall	Soil Index	Catchment Area	Max. Catchment Width	Average Height of Catchment Divide in metres	IH124 Method		FSSR 6, 3-Variable Method	Climate Change
						Growth Factor	FSE	FSE	Climate Change (%)
Parameters	SAAR	SOIL	AREA	W	Z	F	FSE	FSE	CC
Units	(mm)	-	km2	m	m	-	-	-	(%)
Info Source	UK SUDS	UK SUDS	Catchment Analysis-Drawings	Catchment Analysis- Drawings	Catchment Analysis-Drawings	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	FSU WP 2.3	OPW Guidelines
Inputs	822	0.47	5.016	3494	11.77	1.96	1.65	1.58	20%

Description	Outputs				
	IH124 Method		FSSR 6, 3-Variable Method		Design Peak Flow + CC for permeable areas
	IH124 Annual Flow	IH124 100Yr Flow	FSSR Annual Flow	FSSR 100Yr Flow	
Parameter	Q_a	$Q100_{IH124}$	Q_a	$Q100_{FSSR}$	Q
Units	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)
Formula	Q = 0.00108 * $AREA^{0.89}$ * $SAAR^{1.17}$ * $SOIL^{2.17}$* FSE	$Q = F\,Q_a$	Q = 0.00066 * $AREA^{0.92}$ * $SAAR^{1.22}$ * $SOIL^{2.0}$* FSE	$Q = F\,Q_a$	Q_{75} * 1.2
Info Source	Formula 1 of HA 106	Formula 3 of HA 106			Vol 3 of 5 Pt 2, 4.2.5.5 (vii)
Outputs	3.741	7.333	3.655	**7.163**	**8.800**

Notes

	Cells to fill
	Calculation
	Result

Catchment Flow Calculator

Stream Reference	Chainage Range	Road/String Name	Road Side
CAT-I	N/A	N/A	N/A

Author	Checked	Approved
PW	SH	PD

Description	Inputs Parameters								
	Rainfall	Soil Index	Catchment Area	Max. Catchment Width	Average Height of Catchment Divide in metres	IH124 Method		FSSR 6, 3-Variable Method	Climate Change
						Growth Factor	FSE	FSE	Climate Change (%)
Parameters	SAAR	SOIL	AREA	W	Z	F	FSE	FSE	CC
Units	(mm)	-	km2	m	m	-	-	-	(%)
Info Source	UK SUDS	UK SUDS	Catchment Analysis- Drawings	Catchment Analysis- Drawings	Catchment Analysis- Drawings	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	FSU WP 2.3	OPW Guidelines
Inputs	822	0.47	0.428	1169.86	5.02	1.96	1.65	1.58	20%

Description	Outputs				
	IH124 Method		FSSR 6, 3-Variable Method		Design Peak Flow + CC for permeable areas
	IH124 Annual Flow	IH124 100Yr Flow	FSSR Annual Flow	FSSR 100Yr Flow	
Parameter	Q_a	$Q100_{IH124}$	Q_a	$Q100_{FSSR}$	Q
Units	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)
Formula	$Q = 0.00108 * AREA^{0.89} * SAAR^{1.17} * SOIL^{2.17} * FSE$	$Q = F\,Q_a$	$Q = 0.00066 * AREA^{0.92} * SAAR^{1.22} * SOIL^{2.0} * FSE$	$Q = F\,Q_a$	$Q_{75} * 1.2$
Info Source	Formula 1 of HA 106	Formula 3 of HA 106			Vol 3 of 5 Pt 2, 4.2.5.5 (vii)
Outputs	0.419	0.821	0.380	**0.745**	**0.985**

Notes

	Cells to fill
	Calculation
	Result

Catchment Flow Calculator

Stream Reference	Chainage Range	Road/String Name	Road Side
CAT-D	N/A	N/A	N/A

Author	Checked	Approved
PW	SH	PD

Description	Inputs Parameters								
	Rainfall	Soil Index	Catchment Area	Max. Catchment Width	Average Height of Catchment Divide in metres	IH124 Method		ADAS Method	Climate Change
						Growth Factor	FSE	Growth Factor	Climate Change (%)
Parameters	SAAR	SOIL	AREA	W	Z	F	FSE	F_1	CC
Units	(mm)	-	km2	m	m	-	-	-	(%)
Info Source	UK SUDS	UK SUDS	Catchment Analysis- Drawings	Catchment Analysis- Drawings	Catchment Analysis- Drawings	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	OPW Guidelines
Inputs	822	0.47	0.140	821	5.5	1.96	1.65	1.050	20%

Description	Outputs					
	IH124 Method		ADAS Method			Design Peak Flow + CC for permeable areas
	IH124 Annual Flow	IH124 100Yr Flow	Time of Concentration	ADAS 75 Yr Flow	ADAS 100 Yr Flow	
Parameter	Q_a	$Q100_{IH124}$	T	$Q_{75\ ADAS}$	$Q100_{ADAS}$	Q
Units	(m3/s)	(m3/s)	Hours	(m3/s)	(m3/s)100 s)	(m3/s)
Formula	Q = 0.00108 * $AREA^{0.89}$ * $SAAR^{1.17}$ * $SOIL^{2.17}$	$Q = F\,Q_a$	$T = 0.1677 \frac{W^{0.78}}{Z^{0.39}}$	$Q = AREA\,(0.0443\,SAAR - 11.19)\,SOIL^{2.0} * \left[\frac{18.79T^{0.28}-1}{10T}\right]$	$Q=F_1 * Q_{75\ ADAS}$	Q_{75} * 1.2
Info Source	Formula 1 of HA 106	Formula 3 of HA 106	Formula 6 of HA 106	Formula 4 of HA 106	-	Vol 3 of 5 Pt 2, 4.2.5.5 (vii)
Outputs	0.155	0.303	16.18	0.1927	0.202	**0.243**

Notes

1. As per paragraph 5.6 of Ha 106, Design Flow, Q, is calculated using IH124 for catchments > 0.4 km2 and ADAS method for catchments < 0.4km2
2. If catchments are larger than 0.4 km2, input parameters W and Z are not required.
3. Template has been tested against Worked Examples in Chapters 7 of HA 106

(yellow)	Cells to fill
(white)	Calculation
(green)	Result

Catchment Flow Calculator

Stream Reference	Chainage Range	Road/String Name	Road Side
CAT-E	N/A	N/A	N/A

Author	Checked	Approved
PW	SH	PD

Description	Inputs Parameters								
	Rainfall	Soil Index	Catchment Area	Max. Catchment Width	Average Height of Catchment Divide in metres	IH124 Method		ADAS Method	Climate Change
						Growth Factor	FSE	Growth Factor	Climate Change (%)
Parameters	SAAR	SOIL	AREA	W	Z	F	FSE	F_1	CC
Units	(mm)	-	km2	m	m	-	-	-	(%)
Info Source	UK SUDS	UK SUDS	Catchment Analysis- Drawings	Catchment Analysis- Drawings	Catchment Analysis- Drawings	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	OPW Guidelines
Inputs	822	0.47	0.050	799	9.5	1.96	1.65	1.050	20%

Description	Outputs					
	IH124 Method		ADAS Method			Design Peak Flow + CC for permeable areas
	IH124 Annual Flow	IH124 100Yr Flow	Time of Concentration	ADAS 75 Yr Flow	ADAS 100 Yr Flow	
Parameter	Q_a	$Q100_{IH124}$	T	$Q_{75\ ADAS}$	$Q100_{ADAS}$	Q
Units	(m3/s)	(m3/s)	Hours	(m3/s)	(m3/s)100 s)	(m3/s)
Formula	Q = 0.00108 * $AREA^{0.89}$ * $SAAR^{1.17}$ * $SOIL^{2.17}$	$Q = F\,Q_a$	$T = 0.1677 \frac{W^{0.78}}{Z^{0.39}}$	$Q = AREA\,(0.0443\,SAAR - 11.19)\,SOIL^{2.0} * \left[\frac{18.79T^{0.28} - 1}{10T}\right]$	$Q=F_1 * Q_{75\ ADAS}$	Q_{75} * 1.2
Info Source	Formula 1 of HA 106	Formula 3 of HA 106	Formula 6 of HA 106	Formula 4 of HA 106	-	Vol 3 of 5 Pt 2, 4.2.5.5 (vii)
Outputs	0.062	0.121	12.80	0.0813	0.085	**0.102**

Notes

1. As per paragraph 5.6 of Ha 106, Design Flow, Q, is calculated using IH124 for catchments > 0.4 km2 and ADAS method for catchments < 0.4km2
2. If catchments are larger than 0.4 km2, input parameters W and Z are not required.
3. Template has been tested against Worked Examples in Chapters 7 of HA 106

(yellow)	Cells to fill
(white)	Calculation
(green)	Result

Catchment Flow Calculator

Stream Reference	Chainage Range	Road/String Name	Road Side
CAT-F	N/A	N/A	N/A

Author	Checked	Approved
PW	SH	PD

Description	Inputs Parameters								
						IH124 Method		ADAS Method	Climate Change
	Rainfall	Soil Index	Catchment Area	Max. Catchment Width	Avergae Height of Catchment Divide in metres	Growth Factor	FSE	Growth Factor	Climate Change (%)
Parameters	SAAR	SOIL	AREA	W	Z	F	FSE	F_1	CC
Units	(mm)	-	km2	m	m	-	-	-	(%)
Info Source	UK SUDS	UK SUDS	Catchment Analysis-Drawings	Catchment Analysis- Drawings	Catchment Analysis-Drawings	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	OPW Guidelines
Inputs	822	0.47	0.060	340.72	1	1.96	1.65	1.050	20%

Description	Outputs					
	IH124 Method		ADAS Method			Design Peak Flow + CC for permeable areas
	IH124 Annual Flow	IH124 100Yr Flow	Time of Concentration	ADAS 75 Yr Flow	ADAS 100 Yr Flow	
Parameter	Q_a	$Q100_{IH124}$	T	$Q_{75\ ADAS}$	$Q100_{ADAS}$	Q
Units	(m3/s)	(m3/s)	Hours	(m3/s)	(m3/s)100 s)	(m3/s)
Formula	Q = 0.00108 * $AREA^{0.89}$ * $SAAR^{1.17}$ * $SOIL^{2.17}$	$Q = F\,Q_a$	$T = 0.1677 \frac{W^{0.78}}{Z^{0.39}}$	$Q = AREA\,(0.0443\,SAAR - 11.19)\,SOIL^{2.0} * \left[\frac{18.79T^{0.28} - 1}{10T}\right]$	$Q=F_1*Q_{75\ ADAS}$	Q_{75} * 1.2
Info Source	Formula 1 of HA 106	Formula 3 of HA 106	Formula 6 of HA 106	Formula 4 of HA 106	-	Vol 3 of 5 Pt 2, 4.2.5.5 (vii)
Outputs	0.073	0.144	15.84	0.0845	0.089	**0.106**

Notes

1. As per paragraph 5.6 of Ha 106, Design Flow, Q, is calculated using IH124 for catchments > 0.4 km2 and ADAS method for catchments < 0.4km2
2. If catchments are larger than 0.4 km2, input parameters W and Z are not required.
3. Template has been tested against Worked Examples in Chapters 7 of HA 106

	Cells to fill
	Calculation
	Result

Catchment Flow Calculator

Stream Reference	Chainage Range	Road/String Name	Road Side
CAT-G	N/A	N/A	N/A

Author	Checked	Approved
PW	SH	PD

Description	Inputs Parameters								
	Rainfall	Soil Index	Catchment Area	Max. Catchment Width	Avergae Height of Catchment Divide in metres	IH124 Method		ADAS Method	Climate Change
						Growth Factor	FSE	Growth Factor	Climate Change (%)
Parameters	SAAR	SOIL	AREA	W	Z	F	FSE	F_1	CC
Units	(mm)	-	km2	m	m	-	-	-	(%)
Info Source	DBS	DBS	Catchment Analysis- Drawings	Catchment Analysis- Drawings	Catchment Analysis- Drawings	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	OPW Guidelines
Inputs	822	0.47	0.012	139.05	1.19	1.96	1.65	1.050	20%

Description	Outputs					
	IH124 Method		ADAS Method			Design Peak Flow + CC for permeable areas
	IH124 Annual Flow	IH124 100Yr Flow	Time of Concentration	ADAS 75 Yr Flow	ADAS 100 Yr Flow	
Parameter	Q_a	$Q100_{IH124}$	T	$Q_{75\ ADAS}$	$Q100_{ADAS}$	Q
Units	(m3/s)	(m3/s)	Hours	(m3/s)	(m3/s)100 s)	(m3/s)
Formula	$Q = 0.00108 * AREA^{0.89} * SAAR^{1.17} * SOIL^{2.17}$	$Q = F\,Q_a$	$T = 0.1677 \frac{W^{0.78}}{Z^{0.39}}$	$Q = AREA\,(0.0443\,SAAR - 11.19)\,SOIL^{2.0} * \left[\frac{18.79T^{0.28} - 1}{10T}\right]$	$Q=F_1*Q_{75\ ADAS}$	$Q_{75} * 1.2$
Info Source	Formula 1 of HA 106	Formula 3 of HA 106	Formula 6 of HA 106	Formula 4 of HA 106	-	Vol 3 of 5 Pt 2, 4.2.5.5 (vii)
Outputs	0.018	0.035	7.36	0.0295	0.031	**0.037**

Notes

1. As per paragraph 5.6 of Ha 106, Design Flow, Q, is calculated using IH124 for catchments > 0.4 km2 and ADAS method for catchments < 0.4km2
2. If catchments are larger than 0.4 km2, input parameters W and Z are not required.
3. Template has been tested against Worked Examples in Chapters 7 of HA 106

	Cells to fill
	Calculation
	Result

Catchment Flow Calculator

Stream Reference	Chainage Range	Road/String Name	Road Side
CAT-H	N/A	N/A	N/A

Author	Checked	Approved
PW	SH	PD

Description	Inputs Parameters								
	Rainfall	Soil Index	Catchment Area	Max. Catchment Width	Average Height of Catchment Divide in metres	IH124 Method		ADAS Method	Climate Change
						Growth Factor	FSE	Growth Factor	Climate Change (%)
Parameters	SAAR	SOIL	AREA	W	Z	F	FSE	F_1	CC
Units	(mm)	-	km2	m	m	-	-	-	(%)
Info Source	UK SUDS	UK SUDS	Catchment Analysis- Drawings	Catchment Analysis- Drawings	Catchment Analysis- Drawings	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	OPW Guidelines
Inputs	822	0.47	0.265	1164.21	4.31	1.96	1.65	1.050	20%

Description	Outputs					
	IH124 Method		ADAS Method			Design Peak Flow + CC for permeable areas
	IH124 Annual Flow	IH124 100Yr Flow	Time of Concentration	ADAS 75 Yr Flow	ADAS 100 Yr Flow	
Parameter	Q_a	$Q100_{IH124}$	T	$Q_{75\ ADAS}$	$Q100_{ADAS}$	Q
Units	(m3/s)	(m3/s)	Hours	(m3/s)	(m3/s)100 s)	(m3/s)
Formula	Q = 0.00108 * $AREA^{0.89}$ * $SAAR^{1.17}$ * $SOIL^{2.17}$	$Q = F\,Q_a$	$T = 0.1677 \frac{W^{0.78}}{Z^{0.39}}$	$Q = AREA\,(0.0443\,SAAR - 11.19)\,SOIL^{2.0} * \left[\frac{18.79T^{0.28} - 1}{10T}\right]$	$Q=F_1*Q_{75\ ADAS}$	Q_{75} * 1.2
Info Source	Formula 1 of HA 106	Formula 3 of HA 106	Formula 6 of HA 106	Formula 4 of HA 106	-	Vol 3 of 5 Pt 2, 4.2.5.5 (vii)
Outputs	0.273	0.535	23.37	0.2803	0.294	**0.353**

Notes

1. As per paragraph 5.6 of Ha 106, Design Flow, Q, is calculated using IH124 for catchments > 0.4 km2 and ADAS method for catchments < 0.4km2
2. If catchments are larger than 0.4 km2, input parameters W and Z are not required.
3. Template has been tested against Worked Examples in Chapters 7 of HA 106

	Cells to fill
	Calculation
	Result

Catchment Flow Calculator

Stream Reference	Chainage Range	Road/String Name	Road Side
CAT-J	N/A	N/A	N/A

Author	Checked	Approved
PW	SH	PD

Description	Inputs Parameters								
	Rainfall	Soil Index	Catchment Area	Max. Catchment Width	Average Height of Catchment Divide in metres	IH124 Method		ADAS Method	Climate Change
						Growth Factor	FSE	Growth Factor	Climate Change (%)
Parameters	SAAR	SOIL	AREA	W	Z	F	FSE	F_1	CC
Units	(mm)	-	km2	m	m	-	-	-	(%)
Info Source	UK SUDS	UK SUDS	Catchment Analysis- Drawings	Catchment Analysis- Drawings	Catchment Analysis- Drawings	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	OPW Guidelines
Inputs	822	0.47	0.047	287.82	2.5	1.96	1.65	1.050	20%

Description	Outputs					
	IH124 Method		ADAS Method			Design Peak Flow + CC for permeable areas
	IH124 Annual Flow	IH124 100Yr Flow	Time of Concentration	ADAS 75 Yr Flow	ADAS 100 Yr Flow	
Parameter	Q_a	$Q100_{IH124}$	T	$Q_{75\ ADAS}$	$Q100_{ADAS}$	Q
Units	(m3/s)	(m3/s)	Hours	(m3/s)	(m3/s)100 s)	(m3/s)
Formula	Q = 0.00108 * $AREA^{0.89}$ * $SAAR^{1.17}$ * $SOIL^{2.17}$	$Q = F\,Q_a$	$T = 0.1677 \frac{W^{0.78}}{Z^{0.39}}$	$Q = AREA(0.0443\,SAAR - 11.19)\,SOIL^{2.0} * \left[\frac{18.79T^{0.28}-1}{10T}\right]$	$Q=F_1*Q_{75\ ADAS}$	Q_{75} * 1.2
Info Source	Formula 1 of HA 106	Formula 3 of HA 106	Formula 6 of HA 106	Formula 4 of HA 106	-	Vol 3 of 5 Pt 2, 4.2.5.5 (vii)
Outputs	0.059	0.115	9.72	0.0930	0.098	**0.117**

Notes

1. As per paragraph 5.6 of Ha 106, Design Flow, Q, is calculated using IH124 for catchments > 0.4 km2 and ADAS method for catchments < 0.4km2
2. If catchments are larger than 0.4 km2, input parameters W and Z are not required.
3. Template has been tested against Worked Examples in Chapters 7 of HA 106

	Cells to fill
	Calculation
	Result

Catchment Flow Calculator

Stream Reference	Chainage Range	Road/String Name	Road Side
CAT-K	N/A	N/A	N/A

Author	Checked	Approved
PW	SH	PD

Description	Inputs Parameters								
	Rainfall	Soil Index	Catchment Area	Max. Catchment Width	Average Height of Catchment Divide in metres	IH124 Method		ADAS Method	Climate Change
						Growth Factor	FSE	Growth Factor	Climate Change (%)
Parameters	SAAR	SOIL	AREA	W	Z	F	FSE	F_1	CC
Units	(mm)	-	km2	m	m	-	-	-	(%)
Info Source	UK SUDS	UK SUDS	Catchment Analysis- Drawings	Catchment Analysis- Drawings	Catchment Analysis- Drawings	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	OPW Guidelines
Inputs	822	0.47	0.138	457.85	2.97	1.96	1.65	1.050	20%

Description	Outputs					
	IH124 Method		ADAS Method			Design Peak Flow + CC for permeable areas
	IH124 Annual Flow	IH124 100Yr Flow	Time of Concentration	ADAS 75 Yr Flow	ADAS 100 Yr Flow	
Parameter	Q_a	$Q100_{IH124}$	T	$Q_{75\ ADAS}$	$Q100_{ADAS}$	Q
Units	(m3/s)	(m3/s)	Hours	(m3/s)	(m3/s)100 s)	(m3/s)
Formula	Q = 0.00108 * $AREA^{0.89}$ * $SAAR^{1.17}$ * $SOIL^{2.17}$	$Q = F\,Q_a$	$T = 0.1677 \frac{W^{0.78}}{Z^{0.39}}$	$Q = AREA\,(0.0443\,SAAR - 11.19)\,SOIL^{2.0} * \left[\frac{18.79T^{0.28} - 1}{10T}\right]$	$Q = F_1 * Q_{75\ ADAS}$	Q_{75} * 1.2
Info Source	Formula 1 of HA 106	Formula 3 of HA 106	Formula 6 of HA 106	Formula 4 of HA 106	-	Vol 3 of 5 Pt 2, 4.2.5.5 (vii)
Outputs	0.153	0.300	13.05	0.2221	0.233	**0.280**

Notes

1. As per paragraph 5.6 of Ha 106, Design Flow, Q, is calculated using IH124 for catchments > 0.4 km2 and ADAS method for catchments < 0.4km2
2. If catchments are larger than 0.4 km2, input parameters W and Z are not required.
3. Template has been tested against Worked Examples in Chapters 7 of HA 106

(yellow)	Cells to fill
(white)	Calculation
(green)	Result

Catchment Flow Calculator

Stream Reference	Chainage Range	Road/String Name	Road Side
CAT-L	N/A	N/A	N/A

Author	Checked	Approved
PW	SH	PD

Description	Inputs Parameters								
	Rainfall	Soil Index	Catchment Area	Max. Catchment Width	Average Height of Catchment Divide in metres	IH124 Method		ADAS Method	Climate Change
						Growth Factor	FSE	Growth Factor	Climate Change (%)
Parameters	SAAR	SOIL	AREA	W	Z	F	FSE	F_1	CC
Units	(mm)	-	km2	m	m	-	-	-	(%)
Info Source	UK SUDS	UK SUDS	Catchment Analysis- Drawings	Catchment Analysis- Drawings	Catchment Analysis- Drawings	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	OPW Guidelines
Inputs	822	0.47	0.028	323.71	1.1	1.96	1.65	1.050	20%

Description	Outputs					
	IH124 Method		ADAS Method			Design Peak Flow + CC for permeable areas
	IH124 Annual Flow	IH124 100Yr Flow	Time of Concentration	ADAS 75 Yr Flow	ADAS 100 Yr Flow	
Parameter	Q_a	$Q100_{IH124}$	T	$Q_{75\ ADAS}$	$Q100_{ADAS}$	Q
Units	(m3/s)	(m3/s)	Hours	(m3/s)	(m3/s)100 s)	(m3/s)
Formula	Q = 0.00108 * $AREA^{0.89}$ * $SAAR^{1.17}$ * $SOIL^{2.17}$	$Q = F\,Q_a$	$T = 0.1677 \dfrac{W^{0.78}}{Z^{0.39}}$	$Q = AREA\,(0.0443\,SAAR - 11.19)\,SOIL^{2.0} * \left[\dfrac{18.79T^{0.28} - 1}{10T}\right]$	$Q = F_1 * Q_{75\ ADAS}$	Q_{75} * 1.2
Info Source	Formula 1 of HA 106	Formula 3 of HA 106	Formula 6 of HA 106	Formula 4 of HA 106	-	Vol 3 of 5 Pt 2, 4.2.5.5 (vii)
Outputs	0.037	0.072	14.67	0.0413	0.043	**0.052**

Notes

1. As per paragraph 5.6 of Ha 106, Design Flow, Q, is calculated using IH124 for catchments > 0.4 km2 and ADAS method for catchments < 0.4km2
2. If catchments are larger than 0.4 km2, input parameters W and Z are not required.
3. Template has been tested against Worked Examples in Chapters 7 of HA 106

	Cells to fill
	Calculation
	Result

Catchment Flow Calculator

Stream Reference	Chainage Range	Road/String Name	Road Side
CAT-M	N/A	N/A	N/A

Author	Checked	Approved
PW	SH	PD

Description	Inputs Parameters								
	Rainfall	Soil Index	Catchment Area	Max. Catchment Width	Average Height of Catchment Divide in metres	IH124 Method		ADAS Method	Climate Change
						Growth Factor	FSE	Growth Factor	Climate Change (%)
Parameters	SAAR	SOIL	AREA	W	Z	F	FSE	F_1	CC
Units	(mm)	-	km2	m	m	-	-	-	(%)
Info Source	UK SUDS	UK SUDS	Catchment Analysis-Drawings	Catchment Analysis- Drawings	Catchment Analysis-Drawings	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	OPW Guidelines
Inputs	822	0.47	0.059	339.94	4	1.96	1.65	1.050	20%

Description	Outputs					
	IH124 Method		ADAS Method			Design Peak Flow + CC for permeable areas
	IH124 Annual Flow	IH124 100Yr Flow	Time of Concentration	ADAS 75 Yr Flow	ADAS 100 Yr Flow	
Parameter	Q_a	$Q100_{IH124}$	T	$Q_{75\ ADAS}$	$Q100_{ADAS}$	Q
Units	(m3/s)	(m3/s)	Hours	(m3/s)	(m3/s)100 s)	(m3/s)
Formula	Q = 0.00108 * $AREA^{0.89}$ * $SAAR^{1.17}$ * $SOIL^{2.17}$	$Q = F\,Q_a$	$T = 0.1677\frac{W^{0.78}}{Z^{0.39}}$	$Q = AREA\,(0.0443\,SAAR - 11.19)\,SOIL^{2.0} * \left[\frac{18.79T^{0.28} - 1}{10T}\right]$	$Q=F_1*Q_{75\ ADAS}$	Q_{75} * 1.2
Info Source	Formula 1 of HA 106	Formula 3 of HA 106	Formula 6 of HA 106	Formula 4 of HA 106	-	Vol 3 of 5 Pt 2, 4.2.5.5 (vii)
Outputs	0.072	0.141	9.21	0.1218	0.128	**0.153**

Notes

1. As per paragraph 5.6 of Ha 106, Design Flow, Q, is calculated using IH124 for catchments > 0.4 km2 and ADAS method for catchments < 0.4km2
2. If catchments are larger than 0.4 km2, input parameters W and Z are not required.
3. Template has been tested against Worked Examples in Chapters 7 of HA 106

	Cells to fill
	Calculation
	Result

Catchment Flow Calculator

Stream Reference	Chainage Range	Road/String Name	Road Side
CAT-N	N/A	N/A	N/A

Author	Checked	Approved
PW	SH	PD

Description	Inputs Parameters								
						IH124 Method		ADAS Method	Climate Change
	Rainfall	Soil Index	Catchment Area	Max. Catchment Width	Average Height of Catchment Divide in metres	Growth Factor	FSE	Growth Factor	Climate Change (%)
Parameters	SAAR	SOIL	AREA	W	Z	F	FSE	F_1	CC
Units	(mm)	-	km2	m	m	-	-	-	(%)
Info Source	UK SUDS	UK SUDS	Catchment Analysis- Drawings	Catchment Analysis- Drawings	Catchment Analysis- Drawings	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	OPW Guidelines
Inputs	822	0.47	0.026	245	1.87	1.96	1.65	1.050	20%

Description	Outputs					
	IH124 Method		ADAS Method			Design Peak Flow + CC for permeable areas
	IH124 Annual Flow	IH124 100Yr Flow	Time of Concentration	ADAS 75 Yr Flow	ADAS 100 Yr Flow	
Parameter	Q_a	$Q100_{IH124}$	T	$Q_{75\ ADAS}$	$Q100_{ADAS}$	Q
Units	(m3/s)	(m3/s)	Hours	(m3/s)	(m3/s)100 s)	(m3/s)
Formula	Q = 0.00108 * $AREA^{0.89}$ * $SAAR^{1.17}$ * $SOIL^{2.17}$	$Q = F\,Q_a$	$T = 0.1677 \frac{W^{0.78}}{Z^{0.39}}$	$Q = AREA\,(0.0443\,SAAR - 11.19)\,SOIL^{2.0} * \left[\frac{18.79T^{0.28} - 1}{10T}\right]$	$Q=F_1*Q_{75\ ADAS}$	Q_{75} * 1.2
Info Source	Formula 1 of HA 106	Formula 3 of HA 106	Formula 6 of HA 106	Formula 4 of HA 106	-	Vol 3 of 5 Pt 2, 4.2.5.5 (vii)
Outputs	0.034	0.067	9.60	0.0514	0.054	**0.065**

Notes

1. As per paragraph 5.6 of Ha 106, Design Flow, Q, is calculated using IH124 for catchments > 0.4 km2 and ADAS method for catchments < 0.4km2
2. If catchments are larger than 0.4 km2, input parameters W and Z are not required.
3. Template has been tested against Worked Examples in Chapters 7 of HA 106

	Cells to fill
	Calculation
	Result

Catchment Flow Calculator

Stream Reference	Chainage Range	Road/String Name	Road Side
CAT-O	N/A	N/A	N/A

Author	Checked	Approved
PW	SH	PD

Description	Inputs Parameters								
						IH124 Method		ADAS Method	Climate Change
	Rainfall	Soil Index	Catchment Area	Max. Catchment Width	Average Height of Catchment Divide in metres	Growth Factor	FSE	Growth Factor	Climate Change (%)
Parameters	SAAR	SOIL	AREA	W	Z	F	FSE	F_1	CC
Units	(mm)	-	km2	m	m	-	-	-	(%)
Info Source	UK SUDS	UK SUDS	Catchment Analysis-Drawings	Catchment Analysis- Drawings	Catchment Analysis-Drawings	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	DN-DNG-03064 (HD 106)	OPW Guidelines
Inputs	822	0.47	0.176	1305	10	1.96	1.65	1.050	20%

Description	Outputs					
	IH124 Method		ADAS Method			Design Peak Flow + CC for permeable areas
	IH124 Annual Flow	IH124 100Yr Flow	Time of Concentration	ADAS 75 Yr Flow	ADAS 100 Yr Flow	
Parameter	Q_a	$Q100_{IH124}$	T	$Q_{75\ ADAS}$	$Q100_{ADAS}$	Q
Units	(m3/s)	(m3/s)	Hours	(m3/s)	(m3/s)100 s)	(m3/s)
Formula	Q = 0.00108 * $AREA^{0.89}$ * $SAAR^{1.17}$ * $SOIL^{2.17}$	$Q = F\,Q_a$	$T = 0.1677\dfrac{W^{0.78}}{Z^{0.39}}$	$Q = AREA(0.0443\,SAAR - 11.19)\,SOIL^{2.0} * \left[\dfrac{18.79T^{0.28}-1}{10T}\right]$	$Q=F_1*Q_{75\ ADAS}$	Q_{75} * 1.2
Info Source	Formula 1 of HA 106	Formula 3 of HA 106	Formula 6 of HA 106	Formula 4 of HA 106	-	Vol 3 of 5 Pt 2, 4.2.5.5 (vii)
Outputs	0.190	0.372	18.40	0.2207	0.232	**0.278**

Notes

1. As per paragraph 5.6 of Ha 106, Design Flow, Q, is calculated using IH124 for catchments > 0.4 km2 and ADAS method for catchments < 0.4km2
2. If catchments are larger than 0.4 km2, input parameters W and Z are not required.
3. Template has been tested against Worked Examples in Chapters 7 of HA 106

(yellow)	Cells to fill
(white)	Calculation
(green)	Result

DESIGNING AND DELIVERING
A SUSTAINABLE FUTURE

APPENDIX 2

HYDRAULIC ANALYSIS

Composite Stream Calculator

Stream Reference	Chainage Range	Road/String Name	Road Side
CAT-A	N/A	N/A	N/A

Author	Checked	Approved
SH	PD	PD

Description	Inputs Parameters										Design flow	Design flow Depth
	Channel/Stream Parameters					Floodplain Parameter						
	Base Width of Channel	Channel Side Slopes (1V:?H)	Channel Depth	Channel Long Gradient	Channel/Stream Manning's Roughness	Right Hand Side Floodplain Width	Left Hand Side Floodplain Width	Floodplain Side Slopes (1V:?H)	Floodplain Long Gradient	Floodplain Manning's Roughness		
Parameters	b1	Z1	y1	J1	n1	RHSfpw	LHSfpw	Z2	J2	n2	Qd	Yd
Units	m	-	m	m/m	-	m	m	-	m/m	-	m3/s	m
Info Source	Manual Input	Manual Input	Manual Input	Minimum design gradient = 1/500 Paragraph 6.6, page 11, HD	Appendix C of HA 106	Manual Input	Manual Input	Manual Input	Minimum design gradient = 1/500 Paragraph 6.6, page 11, HD 116	Appendix C of HA 106	Manual Input	Iterations
Inputs	2.2	0.27	1.700	0.002	0.045	2.50	2.50	0.00	0.002	0.045	4.310	1.890

Description	Calculations											Checker
	Channel outputs				Floodplain outputs						Total Flow	
	Channel Area	Wet Perimeter	Hydraulic Radius	Channel Flow	Base Width of the Floodplain	Floodplain Depth	Floodplain Area	Wet Perimeter	Hydraulic Radius	Channel Flow		
Parameter	A1	W1	Rh1	Q1	b2	Y2	A2	W2	Rh2	Q2	Qt	
Units	m2	m	m	m3/s	Manning	m	m2	m	m	m3/s	m3/s	
Formula	A1 = (b1+Z1*Y1)*Y1	W1 = b1+2*y1*(1+Z1^2)^1/2	RH1 = A1/W1	Manning	b2 = b1+2*Z1*Y1+ RHSfpw + LHSfpw	Y2 = Yd-Y1	A2 = (b2+Z2*Y2)*Y2	W2 = b2+2*y2*(1+Z2^2)^1/2	RH2 = A2/W2	Manning	Qt = Q1 + Q2	
Info Source												
Outputs	4.52	5.72	0.790020517	3.839	8.118	0.19	1.54	8.50	0.18	0.491	4.3305	OK

Notes

1. Cells highlighted in yellow vary with each length of ditch. Minimum longitudinal gradient should only be changed to check against actual gradient prior to upsizing ditch.
2. Minimum Streamgradient is 1 in 500 (0.2%) as per Paragraph 6.7 of HA 106
3. Template has been tested against Worked Examples in Chatpers 7 of HA 106

Floodplain Water depth	Freeboard	Soffit Depth
FPwd	FB	SD
m	m	m
FPwd = Yd - Y1		
0.190	0.3	2.190

	Cells to fill
	Calculations
	Results

Composite Stream Calculator

Stream Reference	Chainage Range	Road/String Name	Road Side
CAT-B	N/A	N/A	N/A

Author	Checked	Approved
SH	PD	PD

Description	Inputs Parameters										Design flow	Design flow Depth
	Channel/Stream Parameters					Floodplain Parameter						
	Base Width of Channel	Channel Side Slopes (1V:?H)	Channel Depth	Channel Long Gradient	Channel/Stream Manning's Roughness	Right Hand Side Floodplain Width	Left Hand Side Floodplain Width	Floodplain Side Slopes (1V:?H)	Floodplain Long Gradient	Floodplain Manning's Roughness		
Parameters	b1	Z1	y1	J1	n1	RHSfpw	LHSfpw	Z2	J2	n2	Qd	Yd
Units	m	-	m	m/m	-	m	m	-	m/m	-	m3/s	m
Info Source	Manual Input	Manual Input	Manual Input	Minimum design gradient = 1/500 Paragraph 6.6, page 11, HD 116	Appendix C of HA 106	Manual Input	Manual Input	Manual Input	Minimum design gradient = 1/500 Paragraph 6.6, page 11, HD 116	Appendix C of HA 106	Manual Input	Iterations
Inputs	2	0.27	2.300	0.002	0.045	2.50	2.50	0.00	0.002	0.045	6.323	2.550

Description	Calculations											
	Channel outputs				Floodplain outputs							Checker
	Channel Area	Wet Perimeter	Hydraulic Radius	Channel Flow	Base Width of the Floodplain	Floodplain Depth	Floodplain Area	Wet Perimeter	Hydraulic Radius	Channel Flow	Total Flow	
Parameter	A1	W1	Rh1	Q1	b2	Y2	A2	W2	Rh2	Q2	Qt	
Units	m2	m	m	m3/s	Manning	m	m2	m	m	m3/s	m3/s	
Formula	A1 = (b1+Z1*Y1)*Y1	W1 = b1+2*y1*(1+Z1^2)^1/2	RH1 = A1/W1	Manning	b2 = b1+2*Z1*Y1+ RHSfpw + LHSfpw	Y2 = Yd-Y1	A2 = (b2+Z2*Y2)*Y2	W2 = b2+2*y2*(1+Z2^2)^1/2	RH2 = A2/W2	Manning	Qt = Q1 + Q2	
Info Source												
Outputs	6.03	6.76	0.891138039	5.548	8.242	0.25	2.06	8.74	0.24	0.781	6.3292	OK

Notes

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2. Minimum Streamgradient is 1 in 500 (0.2%) as per Paragraph 6.7 of HA 106
3. Template has been tested against Worked Examples in Chatpers 7 of HA 106

Floodplain Water depth	Freeboard	Soffit Depth
FPwd	FB	SD
m	m	m
FPwd = Yd - Y1		
0.250	0.3	2.850

	Cells to fill
	Calculations
	Results

Composite Stream Calculator

Stream Reference	Chainage Range	Road/String Name	Road Side
CAT-C	N/A	N/A	N/A

Author	Checked	Approved
SH	PD	PD

Description	Inputs Parameters										Design flow	Design flow Depth
	Channel/Stream Parameters					Floodplain Parameter						
	Base Width of Channel	Channel Side Slopes (1V:?H)	Channel Depth	Channel Long Gradient	Channel/Stream Manning's Roughness	Right Hand Side Floodplain Width	Left Hand Side Floodplain Width	Floodplain Side Slopes (1V:?H)	Floodplain Long Gradient	Floodplain Manning's Roughness		
Parameters	b1	Z1	y1	J1	n1	RHSfpw	LHSfpw	Z2	J2	n2	Qd	Yd
Units	m	-	m	m/m	-	m	m	-	m/m	-	m3/s	m
Info Source	Manual Input	Manual Input	Manual Input	Minimum design gradient = 1/500 Paragraph 6.6, page 11, HD 116	Appendix C of HA 106	Manual Input	Manual Input	Manual Input	Minimum design gradient = 1/500 Paragraph 6.6, page 11, HD 116	Appendix C of HA 106	Manual Input	Iterations
Inputs	2.84	0.27	1.550	0.003	0.045	2.50	2.50	0.00	0.003	0.045	8.800	2.100

Description	Calculations											Checker
	Channel outputs				Floodplain outputs						Total Flow	
	Channel Area	Wet Perimeter	Hydraulic Radius	Channel Flow	Base Width of the Floodplain	Floodplain Depth	Floodplain Area	Wet Perimeter	Hydraulic Radius	Channel Flow		
Parameter	A1	W1	Rh1	Q1	b2	Y2	A2	W2	Rh2	Q2	Qt	
Units	m2	m	m	m3/s	Manning	m	m2	m	m	m3/s	m3/s	
Formula	A1 = (b1+Z1*Y1)*Y1	W1 = b1+2*y1*(1+Z1^2)^1/2	RH1 = A1/W1	Manning	b2 = b1+2*Z1*Y1+ RHSfpw + LHSfpw	Y2 = Yd-Y1	A2 = (b2+Z2*Y2)*Y2	W2 = b2+2*y2*(1+Z2^2)^1/2	RH2 = A2/W2	Manning	Qt = Q1 + Q2	
Info Source												
Outputs	5.05	6.05	0.834683319	5.450	8.677	0.55	4.77	9.78	0.49	3.601	9.0508	OK

Notes

1. Cells highlighted in yellow vary with each length of ditch. Minimum longitudinal gradient should only be changed to check against actual gradient prior to upsizing ditch.
2. Minimum Streamgradient is 1 in 500 (0.2%) as per Paragraph 6.7 of HA 106
3. Template has been tested against Worked Examples in Chatpers 7 of HA 106

Floodplain Water depth	Freeboard	Soffit Depth
FPwd	FB	SD
m	m	m
FPwd = Yd - Y1		
0.550	0.3	2.400

	Cells to fill
	Calculations
	Results

Culvert Designer/Analyzer Report
CV-01

Peak Discharge Method: User-Specified					
Design Discharge	0.2430	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	83.69	m	Invert Downstream	83.65	m
Length	10.50	m	Slope	0.003810	m/m
Drop	0.04	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	0.2430	m³/s	Bottom Elevation	83.65	m
Depth	0.22	m	Velocity	0.49	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-1050 mm Circular	0.2430 m³/s	84.12 m	1.37 m/s

Culvert Designer/Analyzer Report
CV-01

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Eleva	84.12	m	Discharge	0.2430	m³/s
Headwater Depth/Height	0.40		Tailwater Elevation	83.87	m
Inlet Control HW Elev.	84.06	m	Control Type	Outlet Control	
Outlet Control HW Elev.	84.12	m			

Grades					
Upstream Invert	83.69	m	Downstream Invert	83.65	m
Length	10.50	m	Constructed Slope	0.003810	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.27	m
Slope Type	Mild		Normal Depth	0.41	m
Flow Regime	Subcritical		Critical Depth	0.27	m
Velocity Downstream	1.37	m/s	Critical Slope	0.018507	m/m

Section					
Section Shape	Circular		Mannings Coefficient	0.029	
Section Material	Concrete		Span	1.07	m
Section Size	1050 mm		Rise	1.07	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	84.12	m	Upstream Velocity Head	0.04	m
Ke	0.50		Entrance Loss	0.02	m

Inlet Control Properties					
Inlet Control HW Elev.	84.06	m	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	0.9	m²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Culvert Designer/Analyzer Report
CV-02

Peak Discharge Method: User-Specified					
Design Discharge	0.1020	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	78.64	m	Invert Downstream	78.60	m
Length	10.50	m	Slope	0.003810	m/m
Drop	0.04	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	0.1020	m³/s	Bottom Elevation	78.60	m
Depth	0.20	m	Velocity	0.36	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-900 mm Circular	0.1020 m³/s	78.93 m	0.94 m/s

Culvert Designer/Analyzer Report
CV-02

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Eleva	78.93	m	Discharge	0.1020	m³/s
Headwater Depth/Height	0.32		Tailwater Elevation	78.80	m
Inlet Control HW Elev.	78.88	m	Control Type	Outlet Control	
Outlet Control HW Elev.	78.93	m			

Grades

Upstream Invert	78.64	m	Downstream Invert	78.60	m
Length	10.50	m	Constructed Slope	0.003810	m/m

Hydraulic Profile

Profile	M2		Depth, Downstream	0.20	m
Slope Type	Mild		Normal Depth	0.27	m
Flow Regime	Subcritical		Critical Depth	0.18	m
Velocity Downstream	0.94	m/s	Critical Slope	0.019969	m/m

Section

Section Shape	Circular		Mannings Coefficient	0.029	
Section Material	Concrete		Span	0.91	m
Section Size	900 mm		Rise	0.91	m
Number Sections	1				

Outlet Control Properties

Outlet Control HW Elev.	78.93	m	Upstream Velocity Head	0.02	m
Ke	0.50		Entrance Loss	0.01	m

Inlet Control Properties

Inlet Control HW Elev.	78.88	m	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	0.7	m²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Culvert Designer/Analyzer Report
CV-03

Peak Discharge Method: User-Specified					
Design Discharge	0.1060	m^3/s	Check Discharge	0.0000	m^3/s

Grades Model: Inverts					
Invert Upstream	79.50	m	Invert Downstream	79.35	m
Length	54.13	m	Slope	0.002845	m/m
Drop	0.15	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	0.1060	m^3/s	Bottom Elevation	79.35	m
Depth	0.15	m	Velocity	0.36	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-3	1-1050 mm Circular	0.1060 m^3/s	79.81 m	1.09 m/s

Culvert Designer/Analyzer Report
CV-03

Design:Trial-3

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Eleva	79.81	m	Discharge	0.1060	m³/s
Headwater Depth/Height	0.29		Tailwater Elevation	79.50	m
Inlet Control HW Elev.	79.74	m	Control Type	Outlet Control	
Outlet Control HW Elev.	79.81	m			

Grades

Upstream Invert	79.50	m	Downstream Invert	79.35	m
Length	54.13	m	Constructed Slope	0.002845	m/m

Hydraulic Profile

Profile	M2		Depth, Downstream	0.18	m
Slope Type	Mild		Normal Depth	0.28	m
Flow Regime	Subcritical		Critical Depth	0.18	m
Velocity Downstream	1.09	m/s	Critical Slope	0.019497	m/m

Section

Section Shape	Circular		Mannings Coefficient	0.029	
Section Material	Concrete		Span	1.07	m
Section Size	1050 mm		Rise	1.07	m
Number Sections	1				

Outlet Control Properties

Outlet Control HW Elev.	79.81	m	Upstream Velocity Head	0.02	m
Ke	0.50		Entrance Loss	0.01	m

Inlet Control Properties

Inlet Control HW Elev.	79.74	m	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	0.9	m²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Culvert Designer/Analyzer Report
CV-04

Peak Discharge Method: User-Specified					
Design Discharge	0.0370	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	79.55	m	Invert Downstream	79.51	m
Length	10.50	m	Slope	0.003810	m/m
Drop	0.04	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	0.0370	m³/s	Bottom Elevation	79.50	m
Depth	0.08	m	Velocity	0.21	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-900 mm Circular	0.0370 m³/s	79.73 m	0.85 m/s

Culvert Designer/Analyzer Report
CV-04

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Eleva	79.73	m	Discharge	0.0370	m³/s
Headwater Depth/Height	0.19		Tailwater Elevation	79.58	m
Inlet Control HW Elev.	79.69	m	Control Type	Outlet Control	
Outlet Control HW Elev.	79.73	m			

Grades					
Upstream Invert	79.55	m	Downstream Invert	79.51	m
Length	10.50	m	Constructed Slope	0.003810	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.11	m
Slope Type	Mild		Normal Depth	0.16	m
Flow Regime	Subcritical		Critical Depth	0.11	m
Velocity Downstream	0.85	m/s	Critical Slope	0.021922	m/m

Section					
Section Shape	Circular		Mannings Coefficient	0.029	
Section Material	Concrete		Span	0.91	m
Section Size	900 mm		Rise	0.91	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	79.73	m	Upstream Velocity Head	0.01	m
Ke	0.50		Entrance Loss	0.01	m

Inlet Control Properties					
Inlet Control HW Elev.	79.69	m	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	0.7	m²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Culvert Designer/Analyzer Report
CV-05

Peak Discharge Method: User-Specified					
Design Discharge	0.3530	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	80.69	m	Invert Downstream	80.63	m
Length	10.50	m	Slope	0.005714	m/m
Drop	0.06	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	0.3530	m³/s	Bottom Elevation	80.63	m
Depth	0.18	m	Velocity	0.39	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-3	1-1200 mm Circular	0.3530 m³/s	81.18 m	1.48 m/s

Culvert Designer/Analyzer Report
CV-05

Design:Trial-3

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Eleva	81.18	m	Discharge	0.3530	m³/s
Headwater Depth/Height	0.40		Tailwater Elevation	80.81	m
Inlet Control HW Elev.	81.12	m	Control Type	Outlet Control	
Outlet Control HW Elev.	81.18	m			

Grades

Upstream Invert	80.69	m	Downstream Invert	80.63	m
Length	10.50	m	Constructed Slope	0.005714	m/m

Hydraulic Profile

Profile	M2		Depth, Downstream	0.31	m
Slope Type	Mild		Normal Depth	0.42	m
Flow Regime	Subcritical		Critical Depth	0.31	m
Velocity Downstream	1.48	m/s	Critical Slope	0.017683	m/m

Section

Section Shape	Circular		Mannings Coefficient	0.029	
Section Material	Concrete		Span	1.22	m
Section Size	1200 mm		Rise	1.22	m
Number Sections	1				

Outlet Control Properties

Outlet Control HW Elev.	81.18	m	Upstream Velocity Head	0.06	m
Ke	0.50		Entrance Loss	0.03	m

Inlet Control Properties

Inlet Control HW Elev.	81.12	m	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	1.2	m²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Culvert Designer/Analyzer Report
CV-06

Peak Discharge Method: User-Specified					
Design Discharge	0.9850	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	80.00	m	Invert Downstream	79.97	m
Length	10.50	m	Slope	0.002857	m/m
Drop	0.03	m			

Headwater Model: Unspecified

Tailwater properties: Rectangular Channel

Tailwater conditions for Design Storm.					
Discharge	0.9850	m³/s	Bottom Elevation	79.97	m
Depth	0.21	m	Velocity	0.68	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-1500 mm Circular	0.9850 m³/s	80.79 m	1.89 m/s

Culvert Designer/Analyzer Report
CV-06

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Eleva	80.79	m	Discharge	0.9850	m³/s
Headwater Depth/Height	0.52		Tailwater Elevation	80.18	m
Inlet Control HW Elev.	80.69	m	Control Type	Outlet Control	
Outlet Control HW Elev.	80.79	m			

Grades

Upstream Invert	80.00	m	Downstream Invert	79.97	m
Length	10.50	m	Constructed Slope	0.002857	m/m

Hydraulic Profile

Profile	M2		Depth, Downstream	0.50	m
Slope Type	Mild		Normal Depth	0.81	m
Flow Regime	Subcritical		Critical Depth	0.50	m
Velocity Downstream	1.89	m/s	Critical Slope	0.016376	m/m

Section

Section Shape	Circular		Mannings Coefficient	0.029	
Section Material	Concrete		Span	1.52	m
Section Size	1500 mm		Rise	1.52	m
Number Sections	1				

Outlet Control Properties

Outlet Control HW Elev.	80.79	m	Upstream Velocity Head	0.09	m
Ke	0.50		Entrance Loss	0.04	m

Inlet Control Properties

Inlet Control HW Elev.	80.69	m	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	1.8	m²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Culvert Designer/Analyzer Report
CV-07

Peak Discharge Method: User-Specified					
Design Discharge	0.1170	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	79.50	m	Invert Downstream	79.30	m
Length	58.00	m	Slope	0.003448	m/m
Drop	0.20	m			

Headwater Model: Unspecified

Tailwater properties: Triangular Channel

Tailwater conditions for Design Storm.					
Discharge	0.1170	m³/s	Bottom Elevation	79.30	m
Depth	0.71	m	Velocity	0.40	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-2	1-1350 mm Circular	0.1170 m³/s	80.02 m	0.15 m/s

Culvert Designer/Analyzer Report
CV-07

Design:Trial-2

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Eleva	80.02	m	Discharge	0.1170	m³/s
Headwater Depth/Height	0.38		Tailwater Elevation	80.01	m
Inlet Control HW Elev.	80.01	m	Control Type	Outlet Control	
Outlet Control HW Elev.	80.02	m			

Grades

Upstream Invert	79.50	m	Downstream Invert	79.30	m
Length	58.00	m	Constructed Slope	0.003448	m/m

Hydraulic Profile

Profile	M1		Depth, Downstream	0.71	m
Slope Type	Mild		Normal Depth	0.26	m
Flow Regime	Subcritical		Critical Depth	0.17	m
Velocity Downstream	0.15	m/s	Critical Slope	0.018906	m/m

Section

Section Shape	Circular		Mannings Coefficient	0.029	
Section Material	Concrete		Span	1.37	m
Section Size	1350 mm		Rise	1.37	m
Number Sections	1				

Outlet Control Properties

Outlet Control HW Elev.	80.02	m	Upstream Velocity Head	0.00	m
Ke	0.50		Entrance Loss	0.00	m

Inlet Control Properties

Inlet Control HW Elev.	80.01	m	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	1.5	m²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Culvert Designer/Analyzer Report
CV-08

Peak Discharge Method: User-Specified					
Design Discharge	0.2800	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	79.00	m	Invert Downstream	78.95	m
Length	12.70	m	Slope	0.003937	m/m
Drop	0.05	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	0.2800	m³/s	Bottom Elevation	78.95	m
Depth	0.36	m	Velocity	0.49	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-1200 mm Circular	0.2800 m³/s	79.45 m	0.98 m/s

Culvert Designer/Analyzer Report
CV-08

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Eleva	79.45	m	Discharge	0.2800	m³/s
Headwater Depth/Height	0.37		Tailwater Elevation	79.31	m
Inlet Control HW Elev.	79.38	m	Control Type	Outlet Control	
Outlet Control HW Elev.	79.45	m			

Grades

Upstream Invert	79.00	m	Downstream Invert	78.95	m
Length	12.70	m	Constructed Slope	0.003937	m/m

Hydraulic Profile

Profile	M2		Depth, Downstream	0.36	m
Slope Type	Mild		Normal Depth	0.41	m
Flow Regime	Subcritical		Critical Depth	0.28	m
Velocity Downstream	0.98	m/s	Critical Slope	0.017833	m/m

Section

Section Shape	Circular		Mannings Coefficient	0.029	
Section Material	Concrete		Span	1.22	m
Section Size	1200 mm		Rise	1.22	m
Number Sections	1				

Outlet Control Properties

Outlet Control HW Elev.	79.45	m	Upstream Velocity Head	0.04	m
Ke	0.50		Entrance Loss	0.02	m

Inlet Control Properties

Inlet Control HW Elev.	79.38	m	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	1.2	m²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Culvert Designer/Analyzer Report
CV-09

Peak Discharge Method: User-Specified					
Design Discharge	0.0520	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	79.22	m	Invert Downstream	78.99	m
Length	10.80	m	Slope	0.021296	m/m
Drop	0.23	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	0.0520	m³/s	Bottom Elevation	78.99	m
Depth	0.07	m	Velocity	0.67	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-1050 mm Circular	0.0520 m³/s	79.41 m	0.91 m/s

Culvert Designer/Analyzer Report
CV-09

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Eleva	79.41	m	Discharge	0.0520	m³/s
Headwater Depth/Height	0.17		Tailwater Elevation	79.06	m
Inlet Control HW Elev.	79.37	m	Control Type	Entrance Control	
Outlet Control HW Elev.	79.41	m			

Grades					
Upstream Invert	79.22	m	Downstream Invert	78.99	m
Length	10.80	m	Constructed Slope	0.021296	m/m

Hydraulic Profile					
Profile	S2		Depth, Downstream	0.12	m
Slope Type	Steep		Normal Depth	0.12	m
Flow Regime	Supercritical		Critical Depth	0.12	m
Velocity Downstream	0.91	m/s	Critical Slope	0.021023	m/m

Section					
Section Shape	Circular		Mannings Coefficient	0.029	
Section Material	Concrete		Span	1.07	m
Section Size	1050 mm		Rise	1.07	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	79.41	m	Upstream Velocity Head	0.04	m
Ke	0.50		Entrance Loss	0.02	m

Inlet Control Properties					
Inlet Control HW Elev.	79.37	m	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	0.9	m²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Culvert Designer/Analyzer Report
CV-10

Peak Discharge Method: User-Specified					
Design Discharge	0.1530	m^3/s	Check Discharge	0.0000	m^3/s

Grades Model: Inverts					
Invert Upstream	80.10	m	Invert Downstream	79.90	m
Length	10.50	m	Slope	0.019048	m/m
Drop	0.20	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	0.1530	m^3/s	Bottom Elevation	79.90	m
Depth	0.08	m	Velocity	0.92	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-1050 mm Circular	0.1530 m^3/s	80.42 m	1.21 m/s

Culvert Designer/Analyzer Report
CV-10

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Eleva	80.42	m	Discharge	0.1530	m³/s
Headwater Depth/Height	0.30		Tailwater Elevation	79.98	m
Inlet Control HW Elev.	80.38	m	Control Type	Entrance Control	
Outlet Control HW Elev.	80.42	m			

Grades

Upstream Invert	80.10	m	Downstream Invert	79.90	m
Length	10.50	m	Constructed Slope	0.019048	m/m

Hydraulic Profile

Profile	S2		Depth, Downstream	0.21	m
Slope Type	Steep		Normal Depth	0.21	m
Flow Regime	Supercritical		Critical Depth	0.21	m
Velocity Downstream	1.21	m/s	Critical Slope	0.018943	m/m

Section

Section Shape	Circular		Mannings Coefficient	0.029	
Section Material	Concrete		Span	1.07	m
Section Size	1050 mm		Rise	1.07	m
Number Sections	1				

Outlet Control Properties

Outlet Control HW Elev.	80.42	m	Upstream Velocity Head	0.07	m
Ke	0.50		Entrance Loss	0.04	m

Inlet Control Properties

Inlet Control HW Elev.	80.38	m	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	0.9	m²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Culvert Designer/Analyzer Report
CV-11

Peak Discharge Method: User-Specified					
Design Discharge	0.0650	m^3/s	Check Discharge	0.0000	m^3/s

Grades Model: Inverts					
Invert Upstream	80.00	m	Invert Downstream	79.89	m
Length	13.00	m	Slope	0.008462	m/m
Drop	0.11	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	0.0650	m^3/s	Bottom Elevation	79.89	m
Depth	0.05	m	Velocity	0.87	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-900 mm Circular	0.0650 m^3/s	80.22 m	0.99 m/s

Culvert Designer/Analyzer Report
CV-11

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Eleva	80.22	m	Discharge	0.0650	m³/s
Headwater Depth/Height	0.24		Tailwater Elevation	79.94	m
Inlet Control HW Elev.	80.19	m	Control Type	Outlet Control	
Outlet Control HW Elev.	80.22	m			

Grades					
Upstream Invert	80.00	m	Downstream Invert	79.89	m
Length	13.00	m	Constructed Slope	0.008462	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.14	m
Slope Type	Mild		Normal Depth	0.18	m
Flow Regime	Subcritical		Critical Depth	0.14	m
Velocity Downstream	0.99	m/s	Critical Slope	0.020716	m/m

Section					
Section Shape	Circular		Mannings Coefficient	0.029	
Section Material	Concrete		Span	0.91	m
Section Size	900 mm		Rise	0.91	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	80.22	m	Upstream Velocity Head	0.03	m
Ke	0.50		Entrance Loss	0.01	m

Inlet Control Properties					
Inlet Control HW Elev.	80.19	m	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	0.7	m²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Culvert Designer/Analyzer Report
CV-12

Peak Discharge Method: User-Specified					
Design Discharge	0.2780	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	80.00	m	Invert Downstream	79.79	m
Length	36.00	m	Slope	0.005833	m/m
Drop	0.21	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	0.2780	m³/s	Bottom Elevation	79.79	m
Depth	0.27	m	Velocity	0.55	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-900 mm Circular	0.2780 m³/s	84.27 m	1.47 m/s
	Trial-2	1-1200 mm Circular	0.2780 m³/s	80.44 m	1.39 m/s

Culvert Designer/Analyzer Report
CV-12

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Eleva	84.27	m	Discharge	0.2780	m^3/s
Headwater Depth/Height	4.67		Tailwater Elevation	80.06	m
Inlet Control HW Elev.	80.42	m	Control Type	Outlet Control	
Outlet Control HW Elev.	84.27	m			

Grades					
Upstream Invert	80.00	m	Downstream Invert	79.79	m
Length	36.00	m	Constructed Slope	0.005833	m/m

Hydraulic Profile					
Profile	CompositeM2PressureProfile		Depth, Downstream	0.30	m
Slope Type	Mild		Normal Depth	N/A	m
Flow Regime	Subcritical		Critical Depth	0.30	m
Velocity Downstream	1.47	m/s	Critical Slope	1.942215	m/m

Section					
Section Shape	Circular		Mannings Coefficient	0.290	
Section Material	Concrete		Span	0.91	m
Section Size	900 mm		Rise	0.91	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	84.27	m	Upstream Velocity Head	0.01	m
Ke	0.50		Entrance Loss	0.00	m

Inlet Control Properties					
Inlet Control HW Elev.	80.42	m	Flow Control	Unsubmerged	
Inlet Type	Square edge w/headwall		Area Full	0.7	m^2
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Culvert Designer/Analyzer Report
CV-12

Design:Trial-2

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Eleva	80.44	m	Discharge	0.2780	m^3/s
Headwater Depth/Height	0.36		Tailwater Elevation	80.06	m
Inlet Control HW Elev.	80.37	m	Control Type	Outlet Control	
Outlet Control HW Elev.	80.44	m			

Grades					
Upstream Invert	80.00	m	Downstream Invert	79.79	m
Length	36.00	m	Constructed Slope	0.005833	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.28	m
Slope Type	Mild		Normal Depth	0.37	m
Flow Regime	Subcritical		Critical Depth	0.28	m
Velocity Downstream	1.39	m/s	Critical Slope	0.017839	m/m

Section					
Section Shape	Circular		Mannings Coefficient	0.029	
Section Material	Concrete		Span	1.22	m
Section Size	1200 mm		Rise	1.22	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	80.44	m	Upstream Velocity Head	0.04	m
Ke	0.50		Entrance Loss	0.02	m

Inlet Control Properties					
Inlet Control HW Elev.	80.37	m	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	1.2	m^2
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

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APPENDIX 3

SITE PHOTOS


53°21'58", -6°53'26", 141,3m, 46°
14/10/2024 10:56:09


53°22'6", -6°52'55", 137,4m, 225°
14/10/2024 11:51:36


53°22'8", -6°52'52", 140,3m, 78°
14/10/2024 11:53:27


53°21'18", -6°52'45", 139,2m, 4°
14/10/2024 13:12:13


53°23'18", -6°51'24", 148,6m, 288°
14/10/2024 16:35:30


53°23'18", -6°51'24", 148,6m, 288°
14/10/2024 16:35:30


53°23'18", -6°51'24", 140.9m, 148°
14/10/2024 16:36:04


53°23'6", -6°51'9", 141.0m, 310°
14/10/2024 16:50:46


53°22'47", -6°51'58", 141,8m, 322°
15/10/2024 12:22:16


53°22'50", -6°51'30", 137,1m, 326°
14/10/2024 17:14:51


53°23'18", -6°51'24", 140,9m, 148°
14/10/2024 16:36:04


53°22'53", -6°52'1", 135,4m, 338°
15/10/2024 12:55:32


53°22'46", -6°52'1", 146,4m, 161°
15/10/2024 12:31:41

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APPENDIX 10.2

Hydrology Report

CONSULTANTS IN ENGINEERING, ENVIRONMENTAL SCIENCE & PLANNING

HYDROLOGY REPORT FOR THE PROPOSED DREHID WIND FARM AND SUBSTATION, CO. KILDARE

VOLUME 3 – Appendices

Appendix 10.2 – Hydrology report

Prepared for: North Kildare Wind Farm Ltd.

Date: **May 2025**

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10. HYDROLOGY REPORT

10.1 Introduction

This Hydrology Report has been prepared to examine any potential flooding impacts associated with the Proposed Development, which comprises the Proposed Wind Farm, Proposed Substation and turbine delivery route as described in the main EIAR report (Volume 2).

The report considers the potential increase in run-off due to the hard surfaces being introduced as part of the development. The report then considers the potential for the Proposed Development to increase flooding at locations downstream of the site. It also considers the potential for flooding to impact on-site at the location of the Proposed Development.

10.2 Methodology

The following sources of information were considered in this assessment:

- The design layout of the Proposed Development.
- A desk-based assessment of the surface water hydrology in the catchments relevant to the Proposed Development, including an assessment of the watercourses which will be intercepted by the layout of the Proposed Development and those which will receive surface water run-off from the Proposed Development. The desk-based assessment included a review of the OPW flood maps available online at www.floodinfo.ie, and a collection of rainfall data from Met Eireann.
- A field assessment was undertaken of the existing hydrological environment, to both verify desk-based assessment and record all significant hydrological features.
- Additional flow due the surfaces of the Proposed Development was estimated using the Modified Rational Method and a flood model was created using HEC-RAS software to model the flood regime downstream of the Proposed Development.

10.3 Existing Environment

10.3.1 Site in Context

The Proposed Development predominantly drains to the River Boyne and its tributaries. The main tributary of the River Boyne is the River Blackwater and a number of its small tributaries.

The Fear English River and the Kilcooney River, both tributaries draining to the River Blackwater flow through the site. The Kilcooney River rises near Carbury at approximately 95mOD and flows in a north-easterly direction through the site for approximately 1km before its confluence with the Fear English River. It joins the Fear English River to the south of Ballynamullagh. It should be noted that the Fear English, the Kilcooney, and a number of drains in the area which drain into these rivers are part of the OPW's Arterial Drainage Network.

The Fear English River rises in Parsonstown at approximately 88mOD and flows in a northerly to north-easterly direction along the eastern boundary of the site. After the confluence with the Kilcooney River, the Fear English

River continues in a north easterly direction for 3km to Johnstown Bridge, where it converges with the River Blackwater.

From Johnstown Bridge the River Blackwater flows in a north-westerly to northerly direction for approximately 12.5 km, crossing the Royal Canal and the Blackwater Bridge at Kilmurry after which it converges with the River Boyne at Rourkestown.

The River Boyne then flows on for 12 km in a north easterly direction towards Trim in County Meath. At Trim the River Boyne turns northwards and flows for 18 km to Navan Town. From Navan Town, the River Boyne veers in an easterly direction, flowing for 30 km towards Drogheda. The River Boyne discharges to the Irish Sea 6 km to the east of Drogheda.

The site is situated in a relatively flat landscape, with elevations of between 79m OD and 87 mOD (elevations derived from high-resolution data terrain model [DTM] obtained in 2023). The site is a mix of agricultural land with a number of forestry plots in various stages of their lifecycle within the site boundary.

The soil on the Proposed Development site is a diverse mix of subsoil types but predominantly comprises limestone tills, peat, and limestone sands and gravels. There are also significant deposits of lake sediment to the north of the site.

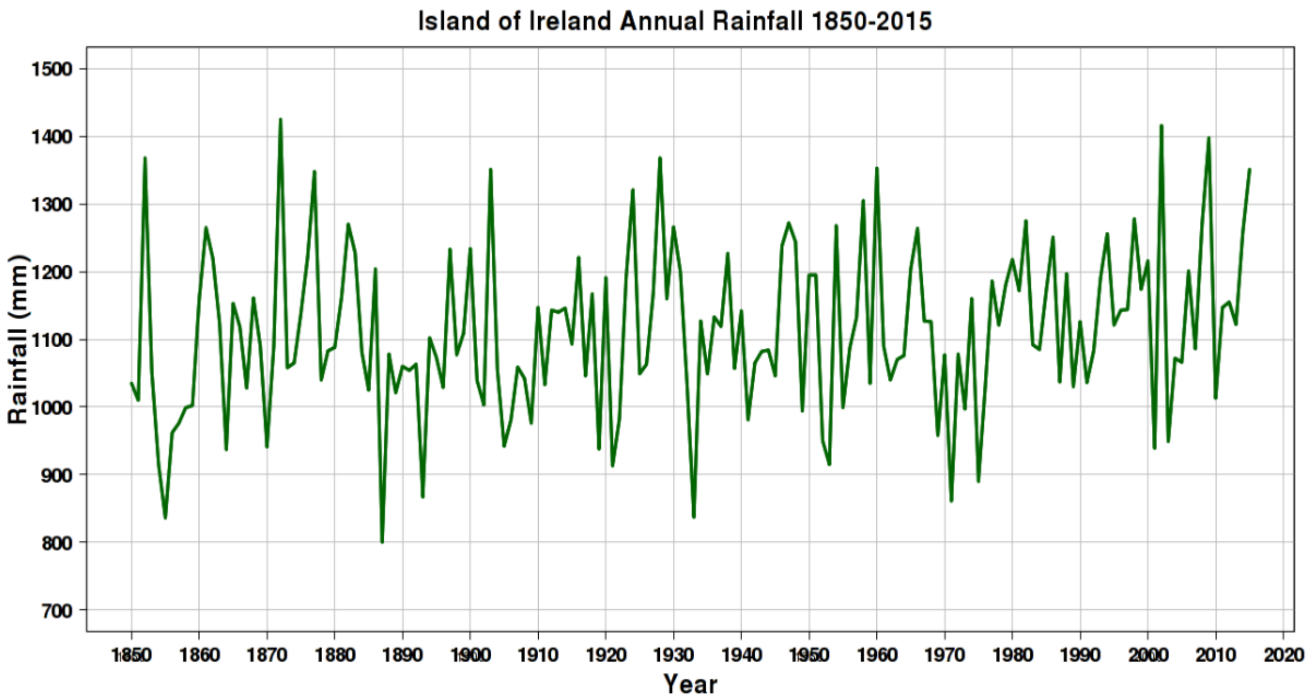
There is evidence of alluvium deposits downstream of the site, within 1km of the site boundary, in the River Blackwater.

10.3.2 Meteorology

The location of the Proposed Development receives on average 834mm of rainfall per year which is in line with the east of Ireland. The east of Ireland typically gets between 750mm and 1000mm of rain per annum, while west of Ireland receives between 1000mm and 1400mm. Table 10-1 details the annual average rainfall data recorded at Met Éireann rain gauges in the vicinity of the study area.

Table 10-1: Local Rainfall Data

Station No.	Station Name	Year Range	Annual Average Rainfall (mm)
-	All Ireland Combined	1850-2010	1089mm
0875	Mullingar	1850-2010	834mm
0175	Phoenix Park	1850-2010	754mm
6414	Athy	1981-2010	830mm
6314	Edenderry	1981-2010	874mm
3431	Derrygrenagh	1981-2010	923mm
3731	Dunsany	1981-2010	870mm
3723	Casement	1981-2010	754mm



10.4 Field Assessment

A site walk over was carried out on the 10th August 2018 to assess the existing drainage conditions and any significant hydrological features in the vicinity of the Proposed Development. Following some amendments to the layout of the Proposed Development, another site walkover was carried out on the 14th and 15th October 2024.

10.5 Flood Risk Identification And Assessment

10.5.1 Historic Flooding

Two records of historical flooding, where recurring flood incidents have been recorded within 2.5km downstream of the site, are as follows:

- At Thomastown to the west of the site, where the stream overflows its banks after significant rain
- Downstream at Knocknally, to the north of the site, in the flood plain of tributaries of the River Blackwater

Areas known as 'benefitting lands' as defined in the OPW flood hazard mapping website have been identified. The turbines and the substation, located in areas identified as 'benefitting lands' are the following:

- Turbines T6, T7, T8, T9, T10, and T11
- Substation

Historically these lands were bogland, subject to flooding or poor drainage. From the site walkover undertaken, it was observed that these lands have now been artificially drained by agricultural or forestry drainage or artificial bog drainage, therefore the mapping presented on the OPW website for these zones, while worthy of note, requires updating to reflect the current situation on these lands.

10.5.2 Existing Flood Risk in the Locality of the Proposed Development

The OPW has produced indicative flood mapping to assist with flood risk identification as listed below:

- Preliminary Flood Risk Assessment (PFRA) [no longer available]
- Catchment Flood Risk Assessment and Management (CFRAM)
- National Indicative Fluvial Maps (NIFM)

The PFRA mapping was prepared to inform the CFRAM mapping, and is now considered to be obsolete. The CFRAM mapping targeted a selection of the most important parts of the country for modelling flood extents, but left vast swaths of the country without flood maps. As such, the National Indicative Fluvial Maps were created, which provide indicative mapping for those parts of the country that weren't covered in the CFRAM. Areas that could be subject to pluvial flooding are also covered on the OPW flood maps.

It should be noted that the proposed wind turbines T1, T2, T3, T4, T5, T7, T8, T9, T10, and T11 and associated infrastructure works and the Proposed Substation do not fall within an indicative, predictive, anecdotal or historical fluvial flood zone and are therefore classed as falling within Flood Zone C. As such, there is no requirement to proceed to Stage 2 – Initial Flood Risk Assessment for these elements of the Proposed Development. However, T6 is located within an indicative Flood Zone A under the National Indicative Fluvial Mapping (NIFM).

The indicative flood zones in the area of T6 are associated with the Fear English River as illustrated on the NIFM flood maps for the area. T6 is located within zones A and B.

- Flood Zone A – where the probability of flooding from rivers and the sea is highest (greater than 1% or 1 in 100 for river flooding or 0.5% or 1 in 200 for coastal flooding);
- Flood Zone B – where the probability of flooding from rivers and the sea is moderate (between 0.1% or 1 in 1000 and 1% or 1 in 100 for river flooding and between 0.1% or 1 in 1000 year and 0.5% or 1 in 200 for coastal flooding);
- Flood Zone C –where the probability of flooding from rivers and the sea is low (less than 0.1% or 1 in 1000 for both river and coastal flooding). Flood Zone C covers all areas not in Flood Zone A or B.

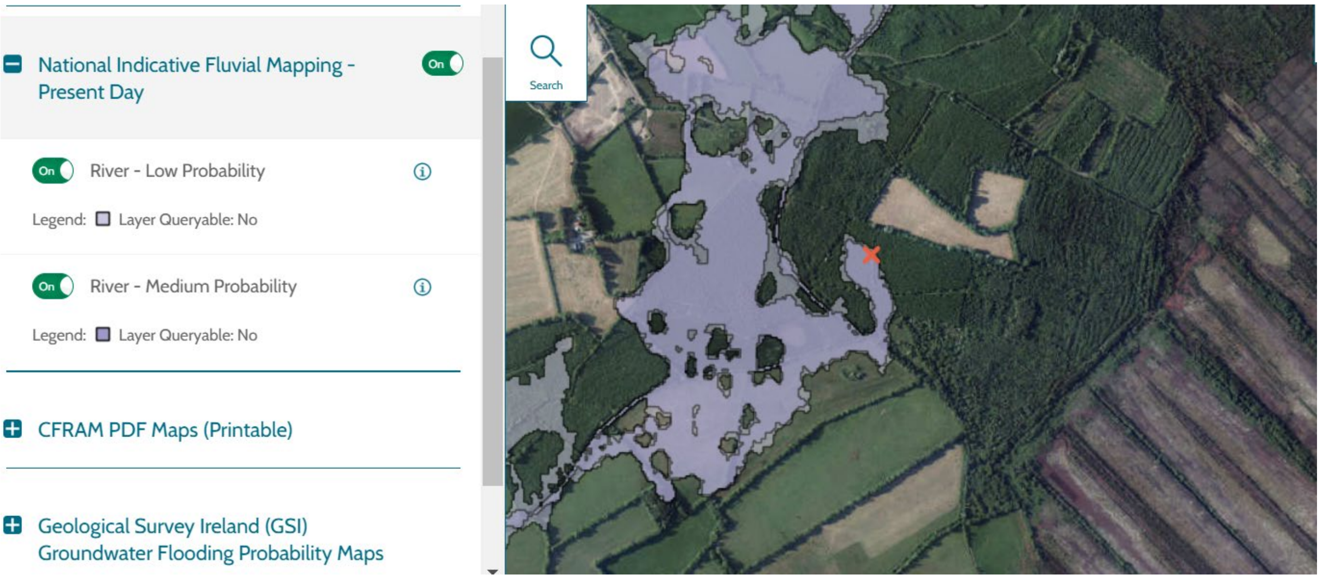


Figure 10-1: T6 location (red x) within flood zones A and B

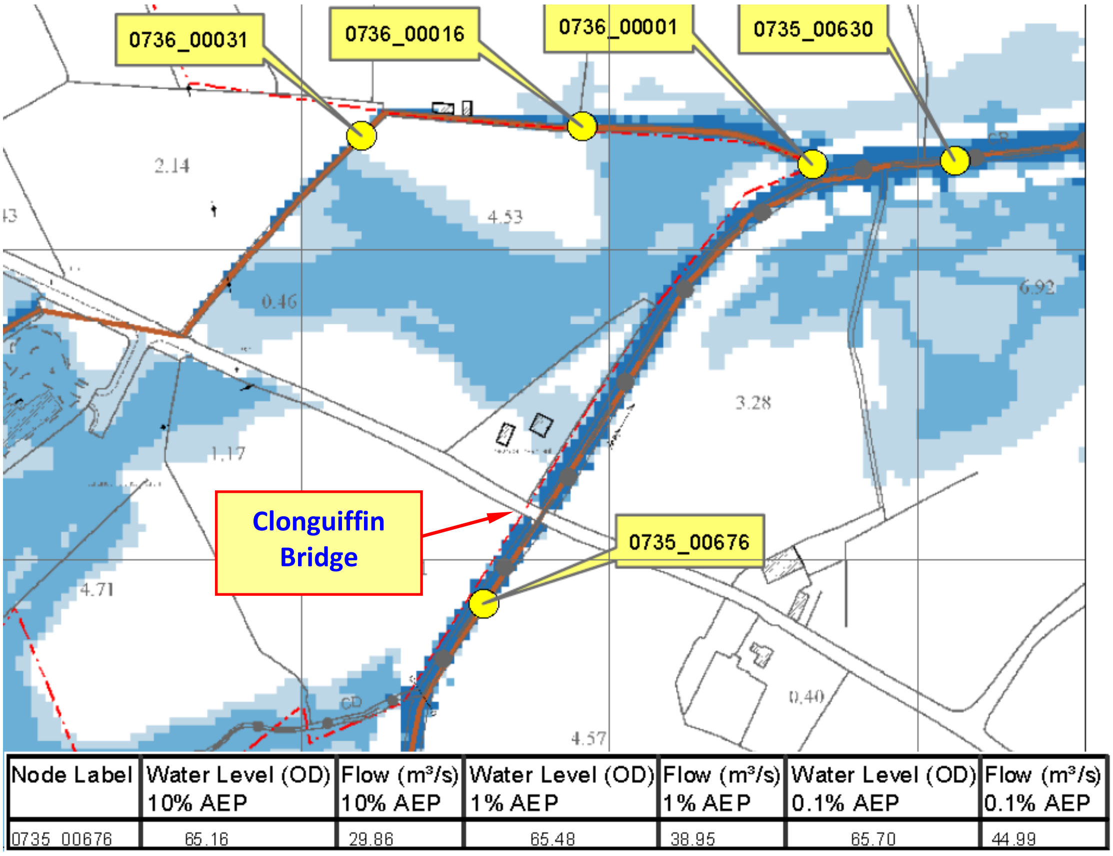
Due to its location within indicative flood zones, a 2-D flood model was run for the area using HEC-RAS flood modelling software, and a high-resolution data terrain model (DTM) acquired in 2023. The flood model confirmed that flood extents for a 1-in-100 year flood event would extend over the T6 location, as shown in the illustration from the model below:

The flood model revealed that the flood level at T6 would be 79.11 mOD; marginally above grade for the existing ground level in the area which is ca. 79 m.

10.5.3 Existing Flooding Downstream of the Proposed Development

The Eastern Catchment Flood Risk and Management Study (CFRAMS) has been undertaken by the OPW and the final version of the flood maps were issued in June 2016. Flood risk extent and depth maps for further assessment areas within Longwood village have also been produced. OPW CFRAMS predictive flood map number E07LON_EXFCD_F2_02 illustrates predictive extreme fluvial flood extent zones associated with the River Blackwater in the vicinity of Clonguiffin Bridge, located at ITM coordinates 672092, 745252, approximately 8.4 km northwest of the Proposed Development site.

Figure 10-2 below (extracted from CFRAMS flood map E07LON_EXFCD_F2_02), illustrates the predicted extreme 10% AEP (1 in 10 year), 1% AEP (1 in 100 year) and 0.1% AEP (1 in 1000 year) fluvial 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
0735_00676	65.16	29.86	65.48	38.95	65.70	44.99

Figure 10-2: Extract from the CFRAM Study Flood Extent Map

The CFRAMS flood map also provides information on predicted flood levels and flood volumes for 10% AEP, 1% AEP and 0.1% AEP fluvial flood events at various node points along the River Blackwater. As illustrated in Figure 10-9 above, the node point closest to the proposed development site is referenced as node point 0735_00676 (13.25km by hydraulic link to the site). Details of the predicted extreme fluvial flood levels and flood volumes for this CFRAMS node point is listed in Table 10-2 below, which has been extracted from CFRAMS flood map reference E07LON_EXFCD_F2_02. The table is a direct copy of the CFRAM table above, which shows water level and flow at Clonguiffin Bridge for three potential scenarios (10%, 1% and 0.1% AEP). This data will be used for the calculations in the following sections.

Table 10-2: CFRAMS Fluvial Map – Predicted Flood Volumes and Levels

Node Label	Flood Level (mOD) 10% AEP	Flow (m3/s) 10% AEP	Flood Level (mOD) 1% AEP	Flow (m3/s) 1% AEP	Flood Level (mOD) 0.1% AEP	Flow (m3/s) 0.1% AEP
0735_00676	65.16	29.86	65.48	38.95	65.70	44.99

10.5.3.1 Climate Change

It is generally acknowledged that future climate change will cumulate in decreases in summer rainfall amounts and increases in winter rainfall amounts. The levels or percentages of increase or decrease are still subjective and dependant on future studies and analysis.

The Greater Dublin Strategic Drainage Study (GDSDS) suggests that by the year 2100 summer rainfall depths will have decreased by 35-45%, with a corresponding increase in winter rainfall depths by 20%. The suggested increases in winter rainfall depth will inevitably result in higher catchment run-off and therefore greater flood peaks. It is therefore prudent to include a climate change factor in any estimation of flood peak volumes. In this instance a 20% increase in estimated flood peaks is provided for in this assessment.

Therefore, the 100-year and 1000-year flood peak flows taken from the Eastern CFRAMS has been increased to reflect the climate change factor:

$\Rightarrow$ $Q_{100} = 38.95\ m^3/s$

$\Rightarrow$ ***Design*** $\boldsymbol{Q_{100} = 38.95 \times 1.20 = \underline{46.74\ m^3/s}}$

$\Rightarrow$ $Q_{1000} = 44.99\ m^3/s$

$\Rightarrow$ ***Design*** $\boldsymbol{Q_{1000} = 44.99 \times 1.20 = \underline{53.99\ m^3/s}}$

10.5.3.2 Additional Runoff

The additional flow due the proposed works was estimated using the Modified Rational Method equation listed below:

Q = 2.78 x (Rainfall Intensity) x (Contributing Impervious Area) x (Impermeability Factor)

Where:

- Rainfall Intensity = 53.2 mm for a 1-in-100 year event, and 77.40 for a 1-in-1000 year event (from Met Eireann [Rainfall Return Period])
- Additional Contributing Impervious Area = 6.87 hectares for the Proposed Wind Farm, 3.52 hectares for the Proposed Substation
- Impermeability Factor = 0.75

Therefore, for the Proposed Wind Farm for a 1-in-100 year event:

Q = 2.78 x 53.2 x 6.87 x 0.75 = 762.03 m3/hr
Q = 0.21 m3/s

For the Proposed Substation for a 1-in-100 year event:

Q = 2.78 x 53.2 x 3.52 x 0.75 = 390.45 m3/hr
Q = 0.11 m3/s

Table 10-3: Increase in flow at Clonguiffin Bridge for the 1-in-100 year event (1% AEP)

	Existing flow (m3/s)	Plus allowance for climate change (x 1.2)	Increase in flow due to development (m3/s)	New flow (m3/s)
Existing Scenario	38.95	46.74	0.00	46.74
Proposed Wind Farm	38.95	46.74	0.21	46.95
Proposed Substation	38.95	46.74	0.11	46.85
Proposed Development	38.95	46.74	0.32	47.06

For the Proposed Wind Farm for a 1-in-1000 year event (0.1% AEP):

Q = 2.78 x 77.4 x 6.87 x 0.75 = 1108.7 m3/hr
Q = 0.31 m3/s

For the Proposed Substation for a 1-in-1000 year event (0.1% AEP):

Q = 2.78 x 77.4 x 3.52 x 0.75 = 568.05 m3/hr
Q = 0.16 m3/s

Table 10-4: Increase in flow at Clonguiffin Bridge for the 1-in-1000 year event (0.1% AEP)

	Existing flow (m3/s)	Plus allowance for climate change (x 1.2)	Increase in flow due to development (m3/s)	New flow (m3/s)
Existing Scenario	44.99	53.99	0.00	53.99
Proposed Wind Farm	44.99	53.99	0.31	54.30
Proposed Substation	44.99	53.99	0.16	54.15
Proposed Development	44.99	53.99	0.47	54.45

10.5.3.3 Hydraulic Analysis of the Clonguiffin Bridge

The Clonguiffin Bridge passes over the River Blackwater which flows as an open watercourse in the vicinity of the bridge.

A hydraulic model was developed for the Clonguiffin Bridge, using an upstream and downstream river cross section, along a short channel reach length of approximately 12.43 m. The purpose of developing a hydraulic model is to estimate extreme flood water levels at specific locations along the modelled reach.

A number of computer based hydraulic models are available which will predict flood levels for a given design flow. For this particular assessment the HEC-RAS V6.3.1 computer model was employed. HEC-RAS was developed by the Hydrologic Engineering Centre of the US Army Corps of Engineers and is a one-dimensional hydraulic model that computes both steady and unsteady flow profiles for specified upstream and downstream flow conditions. HEC-RAS is a robust and well-regarded application and is in wide spread use by engineering consultants, hydrologists and relevant authorities throughout the world. The program also supports hydraulic structures such as bridges, culverts, and weirs and can also analyse floodplain storage. It is well regarded for use in the application of watercourses and flood plain modelling.

The following are the main assumptions used in the development of the HEC-RAS hydraulic model:

- The openings of the culverts and the reach modelled were assumed to be free from blockages or debris in all events.

10.5.3.3.1 Initial Boundary Conditions

A normal depth boundary condition requiring a friction slope value (approximated to the actual main channel bed slope value) is typically used as the initial boundary condition in the hydraulic model. This value was taken to be 0.002, representing a shallow average downstream gradient of the River Blackwater downstream of the modelled bridge.

10.5.3.3.2 Watercourse Channel Roughness Coefficients

The Manning's 'n' coefficient represents the hydraulic resistance to flow of the stream channel or flood plain. The Manning's 'n' coefficients chosen are estimated from a visual inspection of the stream channel and associated flood plain lands.

Guidance is available on selecting appropriate Manning's 'n' values (from Chow 1959, French 1986), however the Manning's 'n' coefficients are usually subsequently refined upon the development of the model by calibrating with any historical flooding data in the area, but only if available.

Figure 10-3 below lists recommended watercourse channel overbank land roughness co-efficient for various vegetation types.

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

Figure 10-3: Manning's 'n' Values for Channels and Flood Plains

With reference to Figure 10-3 above, varying roughness co-efficients were applied to the hydraulic model to reflect the type and form of vegetation observed during the survey of the watercourse undertaken by a hydrological engineer from IE Consulting. In respect of the main channel of the River Blackwater an applied roughness co-efficent of 0.04 was utilised, reflecting the moderately clean, winding nature of the channel between river cross-sections with some weeds and stones. An applied flood plain roughness co-efficent of 0.035 was utilised reflecting a flood plain consisting of tall grass.

Manning's values have been determined based on the stream characteristics as illustrated in Figure 10-4.

Figure 10-4: River Blackwater Looking Upstream

10.5.3.4 Hydraulic Model Simulation Results

For the existing scenario, the flow rate of

For the **Proposed Wind Farm**, the flow rate of 46.95m³/s (1 in 100 year (1% AEP) return period flow rate of 46.74 m³/s plus the additional flow of 0.21 m3/s) was used as the critical flow parameter in the HEC-RAS hydraulic model. For the purposes of flood zone delineation a peak flow of 54.30 m³/s was used (1 in 1000 year (0.1% AEP) return period flow rate of 53.99 m³/s plus the additional flow of 0.31m3/s).

For the **Proposed Substation**, the flow rate of 46.85 m³/s (1 in 100 year (1% AEP) return period flow rate of 46.74 m³/s plus the additional flow of 0.11 m3/s) was used as the critical flow parameter in the HEC-RAS hydraulic model. For the purposes of flood zone delineation a peak flow of 54.15 m³/s was used (1 in 1000 year (0.1% AEP) return period flow rate of 53.99 m³/s plus the additional flow of 0.16 m3/s).

For the **Proposed Development** (wind farm and substation combined), the flow rate of 47.06 m³/s (1 in 100 year (1% AEP) return period flow rate of 46.74 m³/s plus the additional flow of 0.32 m3/s) was used as the critical flow parameter in the HEC-RAS hydraulic model. For the purposes of flood zone delineation a peak flow of 54.45 m³/s was used (1 in 1000 year (0.1% AEP) return period flow rate of 53.99 m³/s plus the additional flow of 0.47 m3/s).

The model simulation is represented by a longitudinal profile through the reach modelled. Figure 10-5, Figure 10-6, Figure 10-7 and Figure 10-8below illustrate the longitudinal profile of the predicted 100-year and 1000-year flood levels along the modeled reach of the River Blackwater for the existing and proposed scenarios.

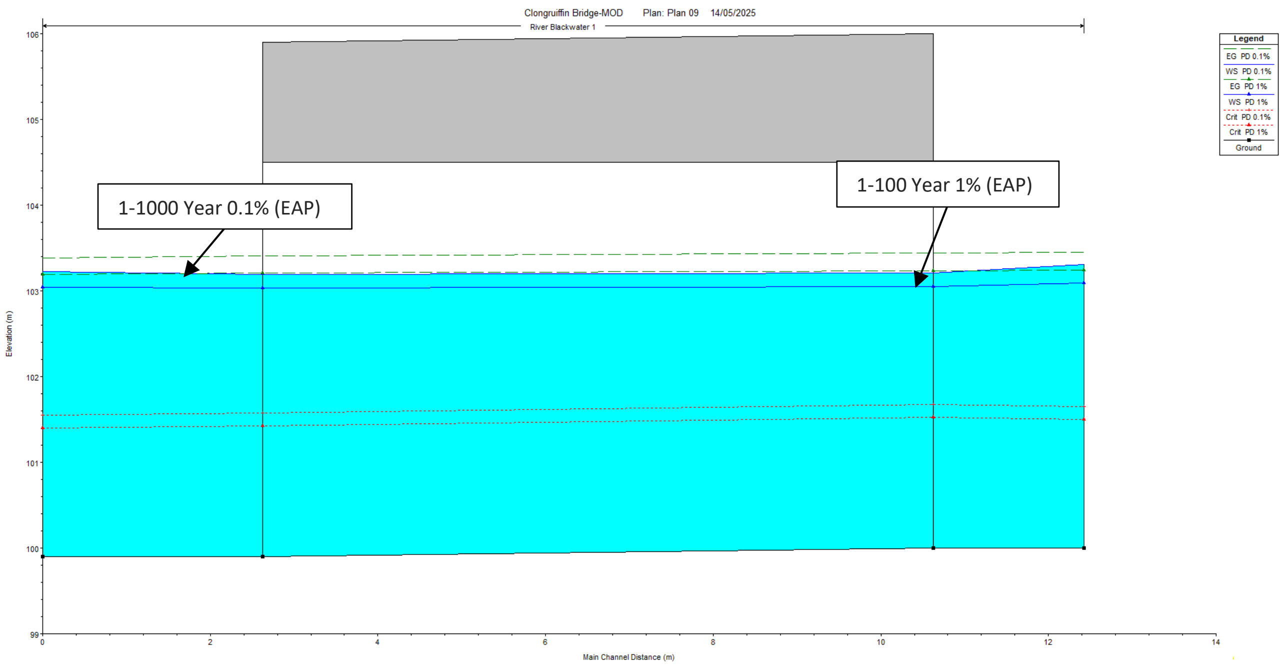


Figure 10-5: Existing Scenario

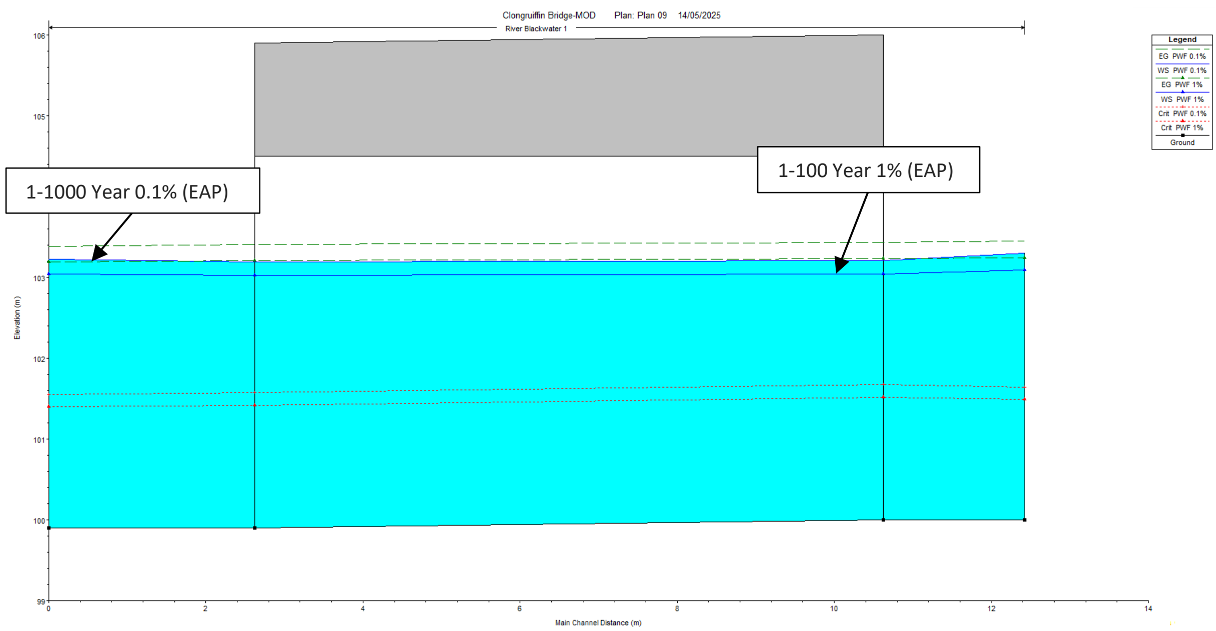


Figure 10-6: Proposed Wind Farm

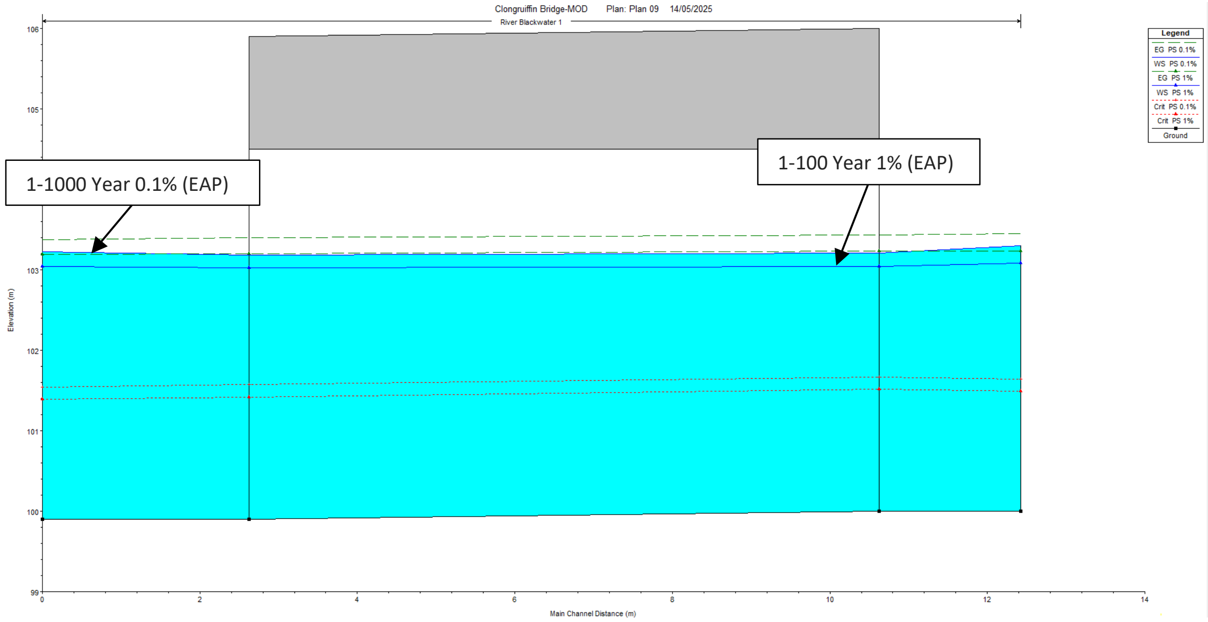


Figure 10-7: Proposed Substation

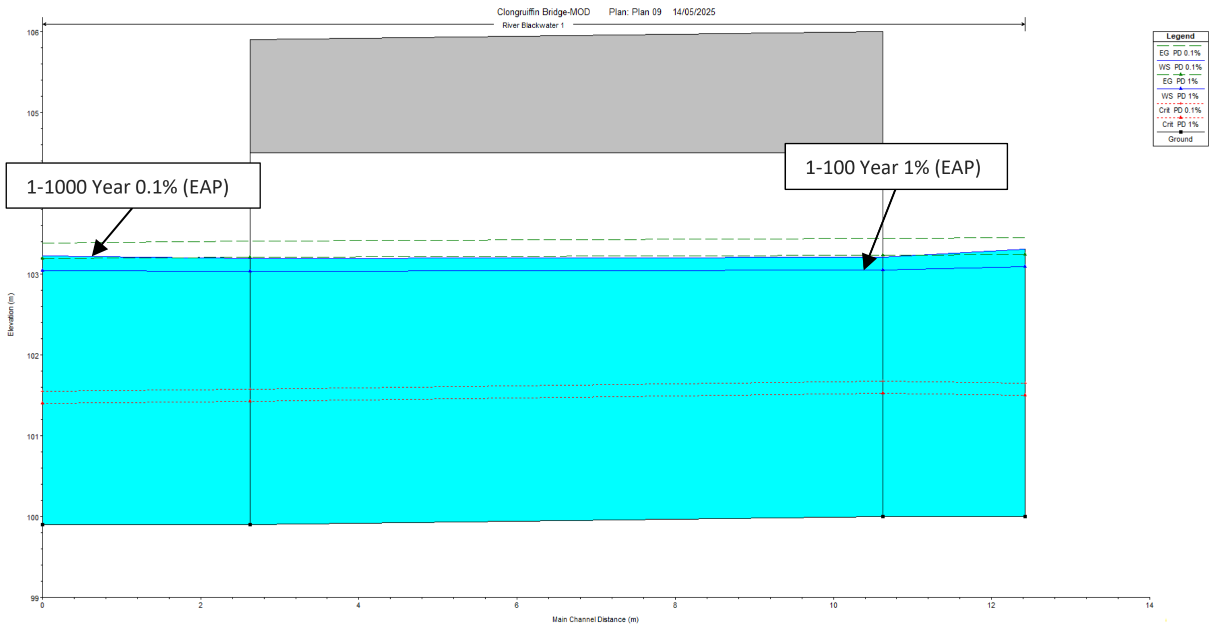


Figure 10-8: Proposed Development

Table 10-5 summarises the predicted 100-year (1% AEP) and 1000-year (0.1% AEP) flood levels upstream and downstream of the Clonguiffin Bridge for the existing and proposed scenarios.

Table 10-5: Predicted 1% and 0.1% AEP Flood Levels

		1 in 100 Year (1% AEP) Existing Scenario	1 in 100 Year (1% AEP) Proposed Scenario	1 in 1000 Year (0.1% AEP) Existing Scenario	1 in 1000 Year (0.1% AEP) Proposed Scenario
Proposed Wind Farm	Upstream	103.08	103.09	103.30	103.30
	Downstream	103.04	103.04	103.22	103.23
Proposed Substation	Upstream	103.08	103.09	103.30	103.30
	Downstream	103.04	103.04	103.22	103.22
Proposed Development	Upstream	103.08	103.09	103.30	103.31
	Downstream	103.04	103.05	103.22	103.23

The hydraulic model indicates that some out of bank flooding may occur upstream and downstream of Clonguiffin Bridge during the 1 in 100 year (1% AEP) and 1 in 1000 year (0.1% AEP) flood events for the existing and proposed scenarios but that the bridge has sufficient capacity to convey all estimated flows.

In addition, the hydraulic model predicts an increase of 0.01m for the 1 in 100 year event on the upstream face of the bridge for each of the potential scenarios (where the Proposed Wind Farm is completed, where the Proposed Substation is completed, and where the entire Proposed Development is completed). The bridge has the capacity to convey these flows.

10.6 Potential Cumulative Impacts

The increase in the rate of surface water run-off due to the increase in hard surface areas as a result of the development within the waterbody catchments, in addition to development in other waterbody catchments upstream in this site, together with any additional adjacent developments, could lead to a minor cumulative risk of flooding downstream.

The potential cumulative hydrological impact was examined in relation to current proposed TII road schemes. There are no such schemes planned or currently under construction in the vicinity of the site for the Proposed Development.

There are a number of significant developments in the vicinity of the Proposed Development including a number of large housing developments, mixed use developments, solar farms, landscaping developments and the extension of the existing Drehid Landfill. Details of these cumulative developments are presented in Table 10-6:

Table 10-6: Cumulative developments within 5 km of the Proposed Development

Development	Direction from Proposed Development site	Distance from Proposed Development site (km)	Status
Timahoe North Solar Farm	**E**	**Adjoining eastern boundary**	**In construction/nearing completion**
The consented development comprises (a) the construction and operation of 2 areas of solar photovoltaic arrays mounted on metal frames over an area of approximately 200ha, and having a maximum overall height of 3 metres over ground level; (b) Internal solar farm underground cabling; (c) 2 no. temporary construction compounds; (d) recreation and amenity works, including looped walk (upgrade of existing tracks and provision of new tracks, car parking and vehicular access); (e) 1 no. Battery Storage compound; (f) upgrade of existing tracks and provision of new site access roads; (g) site drainage; (h) forestry felling and replanting; (i) permanent signage; and (j) all associated site development and ancillary works. The proposed renewable energy development will have an operational life of 35 years from the date of commissioning. The solar farm has been in construction since 2022 and is exporting power to the grid since September 2024. Construction is nearing completion at the time of writing this EIAR and is expected to be minor works at this time such as snagging.			
Mulgeeth Solar Farm	**NE**	**Adjoining eastern boundary**	**Refused Feb 2025 – may be appealed**
Kildare planning reference 2460568. Consent is for a period of 10 years to construct and complete a solar PV energy development with a total site area of 80.9 hectares, comprising of the construction of PV panels mounted on metal frames, transformer stations, GRP units, internal access tracks, perimeter fencing with CCTV cameras and access gates, electrical cabling and ducting, temporary construction compounds, widening of an existing entrance, landscaping and all ancillary infrastructure and associated works. The solar farm would be operational for 35 years. The export capacity to grid is estimated to be c. 56MW MEC.			
Coolcarrigan Solar Farm	**SE**	**3.7 km**	**Granted consent**
Kildare planning reference 2360073. Consent for a 10-year permission, for the construction and operation of a renewable energy development within a site boundary of c. 114 ha. The proposed development will consist of a development area of circa 71.7 ha including solar on fixed on ground mounted frames with a maximum height of 3 metres, 1 No. battery storage compound, 1 No. customer switchgear container, 1 No. 110kv grid connected single storey substation, 1 No. single storey customer substation and all associated electrical plant, inverter units, electrical transformers, battery units, cooling equipment, underground cabling and ducting, boundary fencing, security entrance gates, CCTV, upgrading of existing access road and new internal access roads and all associated ancillary activities. The proposed development will have a 35-year operational life from the date of commissioning. Revised by significant further information which consists of Provision of quantum of energy export (of up to 80MW) in the proposed development and storage capacity of proposed battery compound (of up to 80MWh).			
Hortland Solar Farm	**E**	**3.9 km**	**Operational since 2022**
An existing solar farm with a total site area of 38.08 hectares. The consented development included two electrical substation buildings, six electrical transformer and inverter station modules, solar PV panels ground mounted on support structures, vehicular access, access gates and internal access tracks, one spare parts container, security fencing, electrical cabling and ducting, CCTV cameras and other ancillary infrastructure, drainage, temporary construction compound, landscaping and habitat enhancement as required and associated site development works and services.			
Dysart Solar Farm	**NE**	**2.5 km**	**Granted consent**

Development	Direction from Proposed Development site	Distance from Proposed Development site (km)	Status
10 year permission for the construction of an up to 25 MW solar PV farm comprising approximately 86,200 no. photovoltaic panels on ground mounted frames within a site area of 35.6 hectares and associated ancillary development including 20 no. transformer stations, 20 no. auxiliary transformer stations, 20 no. inverters, 1 no. client side substation, 1 no. single storey storage building, 1 no. single storey communications building, 1 no. single storey DNO building, 6 no. CCTV security cameras mounted on 4 metre high poles and perimeter security fencing (2 metres high) and localized improvements to an existing agricultural access from the adjoining L1004 road to the south.			
A number of residential developments	**N**	**2.8 km**	**Granted consent**
There are a number of consented large residential developments in Enfield which have been integrated into one large project. The planning references are Meath Co. Co. Reg Ref. 21/1449, 21/1461, 21/1462, 23/272. The consents include 99 residential units (21/1449), 67 residential units (21/1461) 77 residential units (21/1462) and a further 77 residential units (23/272); all with ancilliary infrastructure such as public open space, car parking, bicycle parking etc.			
Johnstown Estate Renovations	**N**	**2 km**	**Granted consent**
Kildare planning reference 23/613. The proposed works are principally to the existing banquet hall and conference centre located to the south of the main hotel building and associated external landscaped areas. The proposed external works comprise: (i) the provision of a new 210 sq.m. store room extension (5.450m in height) over existing service yard to the rear (east) of the building; (ii) a 136 sq.m. extension to the south east corner of the building to provide a new glazed orangery bar; (iii) demolition of existing single storey draught lobby (30 sq.m.) and construction of a new 60 sq.m. extension (4.050m in height) on the northern side of the building to provide for a bar area (44 sq.m.) and 2 no. store rooms (8sq.m. each); (iv) a new 20 sq.m. entrance lobby with an external canopy to the southern side of the building; (v) 2 no. new external seating areas to the east and west of the proposed entrance lobby; (vi) a new vehicular circulation layout with roundabout and water feature to the front of the proposed entrance lobby, loading bay, access ramp, external stair case, footpaths; (vii) relocation of the approved bike store located in the service yard (Reg. Ref. 22/1089) underneath proposed store building; and, (viii) the provision of a landscaped seating deck to the south of the building. Proposed internal works comprise reconfiguration of existing conference and banqueting accommodation to provide (a) 2 no. conference banqueting suites (320sq.m. and 280 sq.m.), (b) 2 no. meeting rooms (180 sq.m. and 110 sq.m.). (c) reception lobby (135 sq.m.) and (d) associated toilets, storage, cloakrooms and staff areas. Retention permission is sought for 4 no. accessible car parking spaces provided to the front of the hotel (southwest facade) and existing landscaping works comprising an existing timber pergola structure to south of the hotel development. The development also includes all other associated engineering works, landscaping, and ancillary works necessary to facilitate the development.			
Restoration of 5 ha of agricultural land	**N**	**3.2 km**	**Granted Consent**
Meath planning reference TA200121. The development comprises: a) use of existing stockpiles for site restoration (b) importation of inert excavation spoil comprising natural materials of clay, silt, sand, gravel or stone for the purposes of restoration of a previously extracted area (QY/54) to restore the site to a beneficial agricultural and ecological afteruse (5.85 hectares) (c) Temporary Portacabin Offices and Staff Facilities 100sqm. (d) Wheel Wash and weighbridge 134m2 (e) Site entrance and access road (f) Lockable access gate at the pit entrance (g) All other ancillary buildings, plant and facilities for the restoration, and all ancillary site works. The application is accompanied by an Environmental Impact Statement (Environmental Impact Assessment Report) and associated documents.			

Development	Direction from Proposed Development site	Distance from Proposed Development site (km)	Status
The application relates to a restoration development for the purpose of an activity requiring a Waste Permit to be issued by the Meath County Council. Significant further information/revised plans submitted on this application			
Blackwood Equestrian Centre	**SE**	**2.5 km**	**Granted consent**
Kildare planning reference 191031. Proposed two storey stable block, consisting of 6 no. horse stables & 7 no. pony stables, a wheelchair accessible toilet & two no. stairwells at ground floor level, tack room, kitchen/dining/lounge area for refreshment purposes (for staff and patrons of the livery centre only), male and female changing rooms and toilets and an office at first floor level (total floor area 494.6 sq.m), proposed horse walker (305.8 sq.m) and horse lunge (305.8sq.m) with proposed dungheap/effluent tank (18.5 sq.m). Existing concrete slab to be demolished and removed off site to authorised waste facility and to install proposed exercise area (1732 sq.m) to include 6 no. floodlights & equine fencing along the existing driveway and proposed exercise area. Permission is sought to install a septic tank and percolation area, 8 no. car parking spaces, gravel pathway to forest, proposed signage (2m sq) at existing gate and all associated site works at the above address. Permission is also sought to retain existing storage shed (24sq.m) and existing driveway.			
Drehid Land Fill Extension	**S**	**0.5 km**	**Granted consent**
ABP reference 317292. Increase in waste material at disposal facility at Drehid Waste Management Facility to accept 440,000 tonnes per annum of non-hazardsous waste material.			
Mixed Use Development in Enfield	**N**	**3.9 km**	**Granted consent**
The development will consist of: The construction of a mixed-use development including a 4 storey over ground floor level mixed use building (c.7,953 sq. m) comprising ground floor lobby (c.169 sq. m), bulky goods retail at ground (c.1,062sq,m) and first floor (c.l,219sq.m), ground floor cafe (c.304 sq. m), ground floor gym (c.352sq. m), first floor health centre (c.822 sq. m), second, third and fourth floor office and conference space (c.2,733 sq. m), core, circulation and plant facilities across all levels (c.1,292 sq.m) and 227 no. car and 80 no. cycle parking spaces to serve the building; 80 no. residential units comprising 1 3 no. 2 storey four-bedroom terraced housing units, 67 no. 2 storey three- bedroom terraced housing units with associated private open space in the form of rear gardens and terraces, 164 no. car and 320 no. cycle residential parking spaces plus 60 visitor cycle parking spaces; c.4,224 sq. m of landscaped public open space; a 2 storey creche facility (c.400 sq. m) with 12 no. car parking spaces; green roofs; solar panels; a two-lane access road linking the development to the roundabout where the R148 meets Dublin Road, providing 2 no. multimodal, priority-controlled junctions and segregated pedestrian and cyclist facilities with a controlled crossing; provision of roadway to access the development from the south via the existing roundabout on the Dublin Road; an internal road and shared surface network, including walkways and its associated infrastructure; watermain, foul and surface water drainage, extension to the proposed foul network and connection to the pump station (permitted under ABP-308357- 20), extension to the proposed watermain, connecting to the existing DN 300 HDPE adjacent to the R148 roundabout, an attenuation pond at the north east of the site (1770 sq.m); and all other ancillary site development works including hard and soft landscaping, boundary treatments, lighting, SuDs, and above and below ground services to facilitate the development.			
Royal Oaks Residential Development	**N**	**3.9 km**	**Granted consent**
Meath planning reference 2492, which is an extension of duration of reference SH304296. Construction of 133 no. dwelling units, creche and associated site works.			

Development	Direction from Proposed Development site	Distance from Proposed Development site (km)	Status
68 residential units in Johnstown Bridge	N	1.8 km	Granted consent
Kildare planning reference 22488. Development of 68 No residential units comprising 59 No houses (10 No. 2 bed, 31 No. 3 bed and 18 No. 4 bed) and 9 No. maisonette apartments (8 No. 1 bed and 1 No. 2 bed) and a retail unit/cafe measuring 77.2 sq m, with heights ranging from two storeys to two storeys with attic accommodation over. The development also proposes a new vehicular entrance off Johnstown Road, ancillary car-parking; cycle parking; a pump station; hard and soft landscaping; lighting ;balconies; solar panels; boundary treatments; bin storage; ESB substation and all associated site works above and below ground.			

The projects listed in Table 10-6 were examined for potential cumulative hydrological impacts. The proposed residential developments are mostly situated in the Enfield area, approximately 3 km north of the Proposed Development, as well as one large residential development in Johnstown. All of these developments are located within the same catchment and sub-catchment as the Proposed Development. It is noted from reviewing the planning reports for these developments that SuDS development requires that post development run-off is maintained as equivalent or lower levels than pre-development run-off for the site. As such, it is not expected that any of the proposed housing developments in the surrounding area will act cumulatively with the Proposed Development in terms of flood risk.

There are a number of existing and proposed solar farms within 5km of the Proposed Development. However, due to the insignificant increase in potential run-off from solar farm developments, it is not expected that the cumulative impact with the other permitted developments will give rise to any significant increase in flood risk.

Drehid landfill is located within a separate catchment to the Proposed Development and as such the two projects will not act cumulatively on flood risk.

The works at Johnstown Estate and the Blackwood Equestrian Centre are of a significantly smaller scale than the other cumulative projects and are of a nature which does not represent much risk of increasing run-off.

Other developments are located at significant distances from the Proposed Development and/or drain into different tributaries of the main rivers running through the site (Carbury is located in Boyne_010 sub-catchment) and it is therefore not expected that they will have any significant potential cumulative hydrological impact with the Proposed Development, in particular given the small increase in surface water run-off expected in these catchments from the Proposed Development.

10.7 Mitigation Measures and Conclusion

10.7.1 Flood risk to on-site infrastructure

As mentioned earlier, T6 is located within an area of indicative flood risk (Flood Zone A and B) according to the NIFM mapping, and has been confirmed as being within the flood extent for a 1-in-100 year flood event through a 2-D HEC-RAS model, utilising high-resolution DTM. To mitigate against the potential for flood events impacting on the T6 turbine, the ground will be raised locally at the T6 location, so that the turbine foundation and hardstanding has a finished level that is 300 mm above the modelled flood level.

Raising the ground locally to elevate the T6 foundation and hardstanding will displace a volume from the flood capacity in the area, and therefore flood “compensation” must be provided to return the flood capacity to the same as pre-development. This will be achieved by providing a “flood compensation area” immediately adjacent to the T6 hardstanding, as shown on planning drawing P22-242-0101-0033. The flood compensation area will comprise a depression in the local ground, excavated to 1.5 m below existing ground level, to cover an area as shown in the planning drawing P22-242-0101-0033 which will provide a compensation of flood capacity to cancel the volume displaced by raising the T6 foundation and hardstanding. The result of this is that flood extents in the local area are unchanged for a given flood event, as the capacity for the land to absorb flood water remains the same post-development.

There are no other turbines located within the indicative floodplain i.e. ‘Flood Zone A’ of ‘Flood Zone B’. The Proposed Substation is not located in the indicative floodplain either. This is a result of avoidance by design which aimed to locate the site infrastructure outside of flood zones. In addition, all seals on turbine towers will be designed and built to ensure no water ingress to the tower; the ducts in the foundation will be sealed to ensure no ingress of water; and the foundation will be designed and built to take account that the foundations could be exposed to water. There is no flood risk therefore to the turbines during a flood event.

There will be no appreciable obstruction to flood flows in the floodplain as a result of new access roads and turbine hardstanding areas, which have been located outside of floodplain area.

In addition, any potential impacts due to the obstruction of flow in the Fear English River will be avoided by design as follows; any stream crossings will be conveyed in culverts, sized to take the 1 in 100-year flood flow with a 20% allowance for climate change plus freeboard.

No construction personnel, operation or maintenance personnel will be permitted on site during extreme flood events.

Landowners will carry on their normal activities in the vicinity of the wind farm and will take the usual precautionary measures as far as practicable during flood events.

10.7.2 Flood risk downstream of the Proposed Development

A flood risk assessment was undertaken in 2025 for the proposed development which concludes that the proposed development has a minimal impact on flooding risk in the surrounding area. As part of the FRA, the increase in surface water run-off due to the proposed development was estimated within the catchments upstream of the bridge at Clonguiffin. The bridge at Clongruiffin has the capacity to convey the flows modelled.

The CFRAM Flood Maps have been published detailing the flood risk in Johnstown Bridge are from the Fear English River. This flood risk has been considered, and the impact of the post development surface runoff to the flood risk in this area is considered negligible.