Cush Wind Farm

Environmental Impact Assessment Report

Annex 7.1: Flood Risk Assessment

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PROPOSED CUSH WIND FARM, CO. OFFALY

STAGE III FLOOD RISK ASSESSMENT

FINAL REPORT

Prepared for:
Cush Wind Limited

Prepared by:
Hydro-Environmental Services

DOCUMENT INFORMATION

Document Title:	**PROPOSED CUSH WIND FARM, CO. OFFALY - STAGE III FLOOD RISK ASSESSMENT**
Issue Date:	**20th December 2023**
Project Number:	**P1537-2**
Project Reporting History:	**P1537-0/1**
Current Revision No:	**P1537-2_FRA_FINAL_F1**
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1. INTRODUCTION

1.1 BACKGROUND

Hydro-Environmental Services (HES) were requested by Galetech Energy Services (GES) on behalf of Cush Wind Limited to prepare a Stage III Flood Risk Assessment (FRA) for the proposed Cush Wind Farm, located ~4km north of Birr, Co. Offaly. A site location map is shown below as **Figure A.**

The FRA was prepared at the early project design stage in order to investigate the extents of potential flooding at the project site and to inform the layout of turbines and associated infrastructure within the project site with regard potential flood risk. The design approach was to keep as much of wind farm infrastructure outside of fluvial flood zones where possible.

A scoping response received from the OPW as part of the EIAR was also considered during the preparation of this FRA as outlined further below.

The term ‘project site’ refers to the lands within the EIAR/planning application boundary for the proposed wind farm development. The term ‘project site’ is as defined within Chapter 1 of the EIAR.

This FRA is carried out in accordance with ‘The Planning System and Flood Risk Management Guidelines for Planning Authorities’ (DoEHLG, 2009).

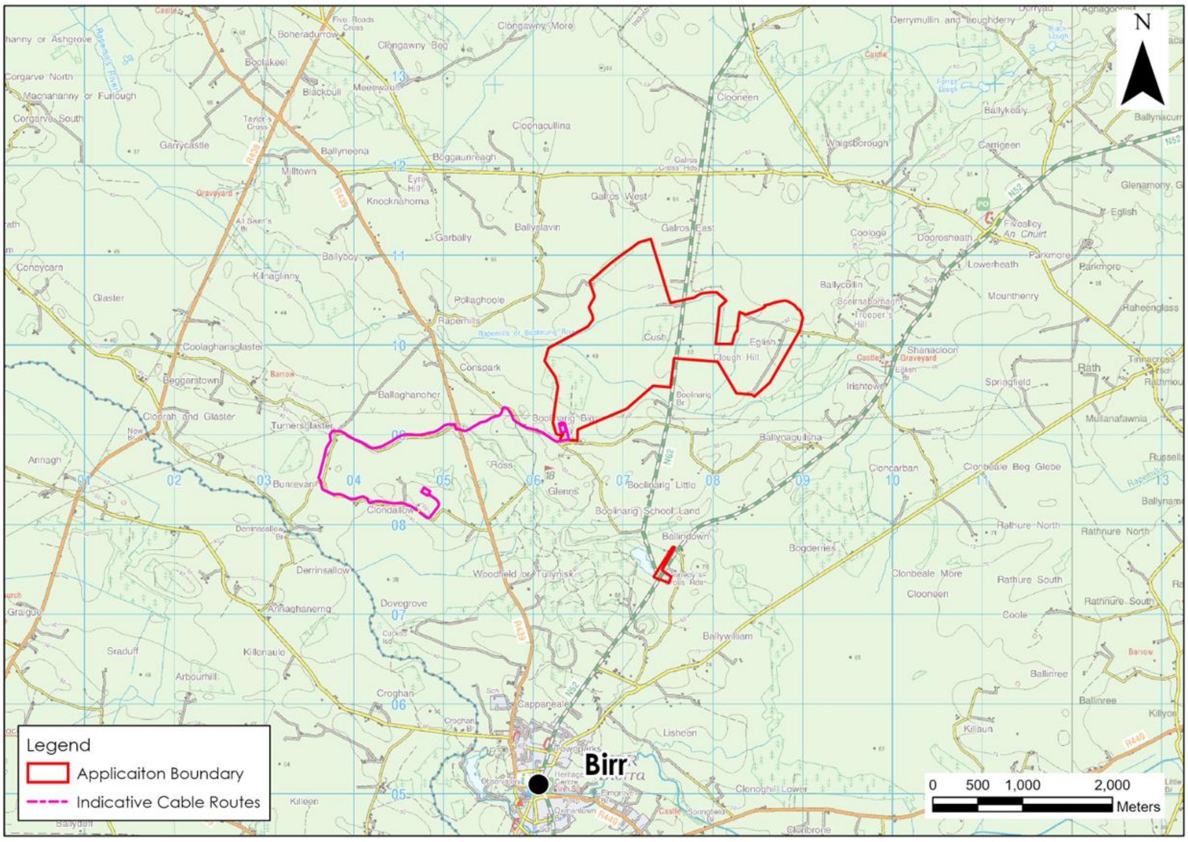

Figure A: Site Location Map

1.2 STATEMENT OF EXPERIENCE

Hydro-Environmental Services ("HES") are a specialist geological, hydrological, hydrogeological and environmental practice which delivers a range of water and environmental management consultancy services to the private and public sectors across Ireland and Northern Ireland. HES was established in 2005, and our office is located in Dungarvan, County Waterford.

Our core area of expertise and experience is hydrology and hydrogeology, including flooding assessment and surface water modelling. We routinely work on surface water monitoring and modelling, and prepare flood risk assessment reports.

Michael Gill P.Geo (BA, BAI, Dip Geol., MSc, MIEI) is an Environmental Engineer and Hydrogeologist with over 22 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments of quarries and renewable projects in Ireland, as well as accompanying Flood Risk Assessments. He has substantial experience in surface water drainage design and SUDs design and surface water/groundwater interactions.

David Broderick P.Geo (BSc, H. Dip Env Eng, MSc) is a Hydrogeologist with 17 years environmental consultancy experience in Ireland. David has completed numerous hydrological and hydrogeological assessments for various developments across Ireland. David has significant experience in surface water drainage issues, SUDs design, flood risk assessment and modelling.

Jenny Law (BSc, MSc) is an Environmental Geoscientist holding a first honours degree in Applied Environmental Geosciences from the University College Cork. Jenny has assisted in the preparation of the land, soils and geology and hydrology chapters for various environmental impact assessment reports, hydrological impact assessments, Water Framework Directive Assessment reports and Flood Risk Assessment reports for a variety of projects including wind farm developments and strategic housing developments.

1.3 REPORT LAYOUT & METHODOLOGY

This FRA report is structured as follows:

- Section 2 describes the proposed project site setting and details of the proposed development;
- Section 3 outlines the hydrological and geological characteristics of the local surface water catchments in the vicinity of the project site;
- Section 4 deals with an initial flood risk identification undertaken for the proposed development based on desk studies and walkover surveys;
- Section 5 deals with a detailed site-specific flood risk assessment (FRA) which includes stage 3 topographic surveys and flood modelling;
- Section 6 provides commentary in relation to the County Offaly Development Plan and Justification Test; and,
- Section 7 presents the FRA report conclusions.

As stated above, this FRA is carried out in accordance with 'The Planning System and Flood Risk Management Guidelines for Planning Authorities' (DoEHLG, 2009). The assessment methodology involves researching and collating flood related information from the following data sources:

- OPW Flood Studies Update (FSU) Web Portal;
- Geological Survey of Ireland (GSI) maps on superficial deposits;
- EPA hydrology maps;
- OPW National Indicative Fluvial Mapping (NIFM);

- EIAR scoping submission from OPW;
- Offaly County Development Plan 2021 – 2027 (including Strategic Flood Risk Assessment);
- Lidar data for the project site; and,
- Site walkovers and surveys conducted by HES and GES during July 2021, January and March 2023).

2. BACKGROUND INFORMATION

2.1 INTRODUCTION

This section provides details on the topographical setting of the project site along with a description of the proposed project.

2.2 SITE LOCATION AND TOPOGRAPHY

The project site, which has an area of approximately 290ha, is located c. 4km north of Birr, Co. Offaly. The N62 dissects the project site into an eastern portion and western portion. The project site setting is basin peat bogs fringed by other bogs, agricultural and forestry lands.

The western portion is mainly bordered by forestry with some agricultural land and cutover peat bog while the eastern portion its mainly agricultural land with some cutaway peat bog. Access to the proposed project site from the N62 is at various forestry/bog entrances and via private farm entrances off surrounding local roads.

Current land use within the proposed project site areas comprises mainly of mixed forestry, cutaway and cutover bogs, agricultural grassland with some areas of transitional woodland/scrub.

2 no. turbines (T1 and T3) located towards the north of the proposed project site are located on cutover bog, with some pockets of agricultural grassland. The main proposed spoil deposition area (SDA1) along with the main construction compound (CC1) is also located on cutover bogs.

4 no. turbines (T2, T4, T5 and T6) are located in mixed woodland/forestry which are also largely underlain by peat deposits at the proposed development areas. Turbines T5 and T6 are located in areas of commercial forestry. There are also proposed spoil deposition areas around turbines T5 and T6.

The remaining 2 no. turbines (T7 and T8), substation, BESS, windfarm control room, met mast and construction compound no. 2 (CC2) are located on agricultural land.

The proposed project site is low lying with topography being slightly undulating to flat and with ground elevations ranging between 47 and 63m OD (Ordnance Datum). The overall slope is to the west.

The most elevated section of the proposed project site is found along the eastern fringes where agricultural grassland rises up to 63m OD (met mast location). The ground slopes in a general westerly direction from this eastern section to the lowest point on the far west of the project site which follows the valley of the Rapemills River.

A site location map is shown as **Figure A** above.

2.3 PROPOSED DEVELOPMENT DETAILS

With regard the FRA, the following main project components were considered:

- 8 no. wind turbines;
- 110kV electricity substation, Battery Energy Storage System (BESS) and control building;
- Underground grid connection cable (5.6km) between the project site and the existing Clondallow substation to the southwest;
- 1 no. temporary construction compound;
- 3 no. permanent spoil deposition area; and,
- Windfarm drainage infrastructure (i.e. settlement ponds, drains, swales etc).

A site layout map is shown as **Figure B** below.

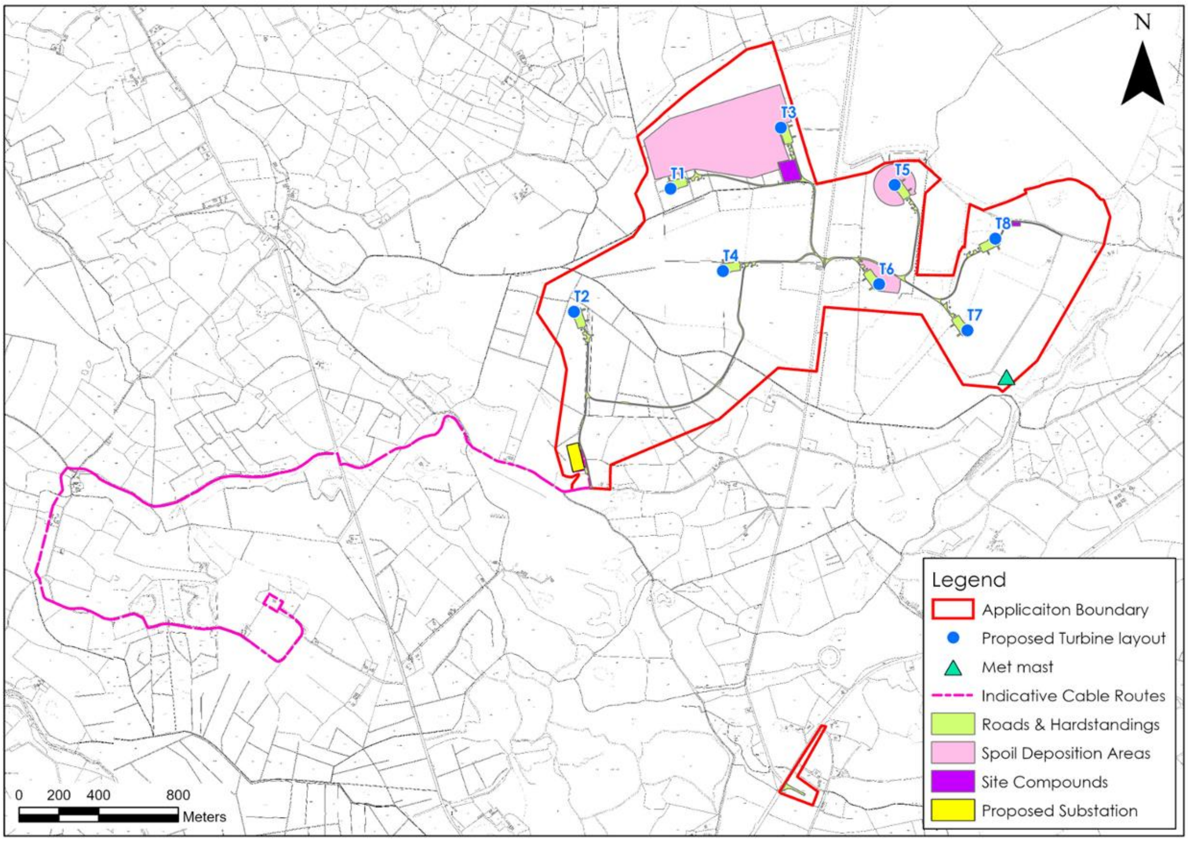

Figure B: Proposed Project Site Layout Map

3. EXISTING ENVIRONMENT AND CATCHMENT CHARACTERISTICS

3.1 INTRODUCTION

This section gives an overview of the hydrological and geological characteristics in the area of the proposed project site.

3.2 BASELINE HYDROLOGY

3.2.1 Regional and Local Hydrology

On a regional scale, the proposed project site is located within Hydrometric Area 25 (Lower Shannon Catchment) and mainly situated inside the Shannon[lower]_SC_040 sub-catchment (i.e. Rapemills River). The grid connection route extends into the Shannon[lower]_SC_060 (Little Brosna River) sub-catchment.On a local scale, the Rapemills River (Rapemills_010) rises approximately 8km to the east of the project site and then flows in westerly direction through the project site itself. The Rapemills River then flows into the River Shannon approximately 10.5km downstream of the project site.

Approximately 2.7km of the grid connection is located in the Rapemills River catchment while the other 2.9km is located in the Little Brosna River catchment. The Little Brosna River flows approximately 1km to the southwest of the existing Dallow substation, at Clondallow, before joining the River Shannon a further 12km downstream.

Refer to **Figure C** below for local hydrology map.

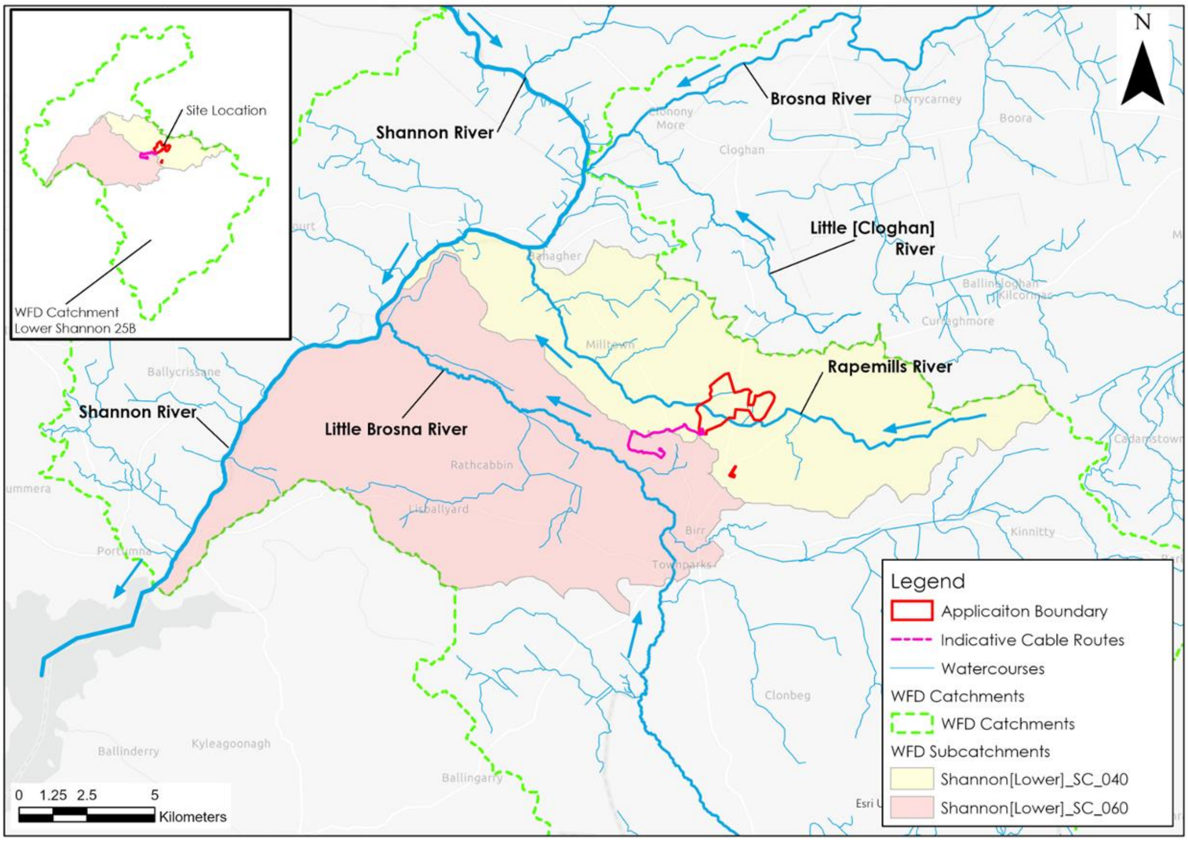

Figure C: Local Hydrology Map

3.2.2 Rainfall and Evaporation

The SAAR (Standard Average Annual Rainfall) recorded at Birr rainfall station, located ~4km southwest of the project site, is 849.7mm. The average potential evapotranspiration (PE) is also recorded at Birr and is 445m/year (www.met.ie). The actual evapotranspiration ("AE") is calculated to be 422mm (95% PE). Using the above figures, the effective rainfall ("ER")[1] for the area is calculated to be (ER = SAAR – AE) approximately 428mm/year.

Based on recharge coefficient estimates from the GSI (www.gsi.ie), an estimate of 18mm/year average annual recharge is given for basin peat in this area (recharge coefficient of ~4%). This means that the hydrology of the project site is characterised by very high surface water runoff rates and very low groundwater recharge rates.

Therefore, conservative annual recharge and runoff rates for the project site are estimated to be 18mm/year and 410mm/year respectively.

Table A below presents return period rainfall depths for the area of the project site. These data are taken from https://www.met.ie/climate/services/rainfall-return-periods and they provide rainfall depths for various storm durations and sample return periods (1-year, 5-year, 30-year, 100-year).

Table A: Rainfall return period depths for Proposed Project Site

	Return Period (Years)			
Duration	**1**	**5**	**30**	**100**
5 mins	3.8	6.6	13.9	17.1
15 mins	6.2	10.9	19.5	28.0
30 mins	7.8	12.3	22.9	32.0
1 hour	10	16.2	26.8	36.5
6 hours	18.6	27.2	40.4	51.5
12 hours	23.6	33.3	47.3	58.9
24 hours	30	40.6	55.5	67.3
2 days	37.1	48.6	63.9	75.8

3.3 EXISTING SITE DRAINAGE

The primary drainage feature within the project site is the Rapemills River which flows westerly through the southwestern section of the site for 1.2km. The Rapemills River is deep (2m) with steep banks and up to 5m in width.

A tributary stream of Rapemills River, referred to as the West Galros Stream by the EPA emerges from forestry on the eastern portion of the project site, crosses the N62 and then merges with the Rapemills River close to the western boundary of the project site.

The West Galros Stream has a modified channel appearance, up to 3m wide, c.1m deep with a high water level that's close to ground level. The stream is also heavily vegetated.

The northern half of the project site, including the cutaway/cutover private bogs on the northwest of the project site initially drain to the West Galros Stream.

The private cutaway bogs on the northwest of the project site (including turbines T1 and T3 along with the spoil deposition area and the main construction compound – SC1) drain directly into the West Galros Stream via several bog drains with outfalls into the Galros Stream west of the N62.

[1] *ER – Effective Rainfall is the excess rainfall after evaporation which produces overland flow and recharge to groundwater.*

The forestry on the east of the project site (including turbines T5 and T6) also drain to the West Galros Stream. On the western portion of the project site, the cutaway peat bog at the proposed turbine T1 and T3 locations drain southerly into the West Galros Stream via several north/south drainage channels.

The majority of the southern half of the project site drains directly into the Rapemills River, including the substation, control building and turbines T2, T4, T7 and T8.

Turbine T2 and the substation are located to the south of the Rapemills River. Drainage in this area is northwards towards the Rapemills River channel. The agricultural land to the south of the Rapemills River, referred to as callows locally are generally wet and boggy and highly susceptible to winter flooding and surface water ponding. The forestry in the area of proposed turbine T4 also drains southerly towards the Rapemills River.

The fringing grasslands on the east of the project site (including turbines T7 and T8 along with the met mast) slope westerly towards the bog. Drainage from the grasslands flows into a watercourse which flows southerly along the edge of the bog. This drain has an outfall on the Rapemills River which flows to the south of the bog in question.

Within the project site there are 3 no. proposed (new) watercourse crossings (1 no. on Rapemills, 1 no. on West Galros and 1 no. on minor watercourse west of T7/T8). There is 1 no. existing crossing proposed for upgrade on the West Galros Stream just southeast of the main construction compound.

There are no EPA mapped watercourse crossings along the proposed grid connection route. The closest EPA mapped watercourse, which is a headwater stream of the Little Brosna River, is located approximately 500m to the east of the Dallow substation.

A site drainage map is shown as **Figure D** below.

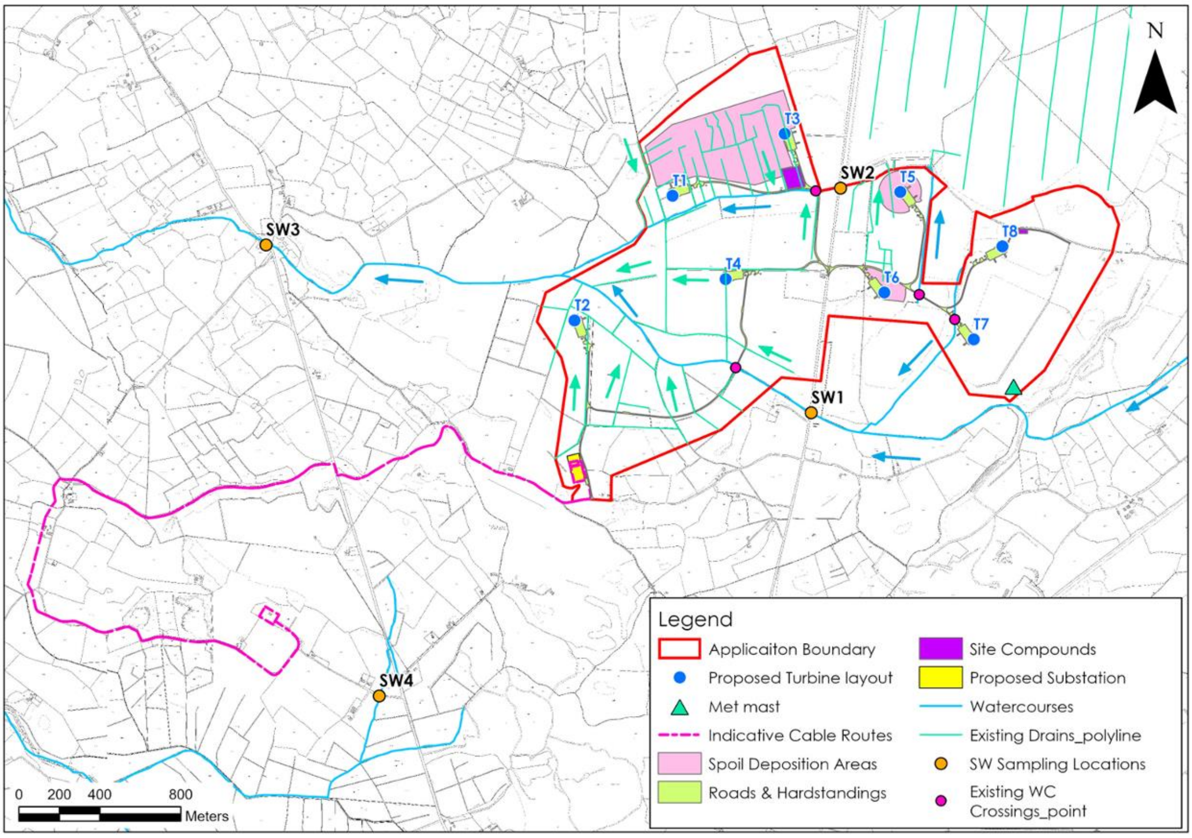

Figure D: Existing Site Drainage Map

3.4 GEOLOGY

GSI subsoils mapping (www.gsi.ie) show that the proposed project site is underlain predominantly by cutover raised peat (Cut) with Gravels derived from Limestones (GLs) mapped on the southeast and southwest of the project site and also underlying turbine locations T7 and T8. A small pocket of Till derived from Limestones (TLs) is mapped towards the centre of the proposed project site along the N62.

Peat depths recorded from peat probing across the project site ranged from 0 to 5.2m with an average depth of 2.5m. Approximately 90 percent of peat depth probes recorded peat depths of less than 4.0m.

Trial pits were excavated at all accessible turbine locations T1, T2, T3, T6, T7 and T8. Peat probes and soil gouge cores were carried out at inaccessible turbines T4 and T5 as an alternative to trial pits.

The overburden geology profile at the turbine locations on bogs typically has the following sequence – peat, shell marl and lacustrine clay. The depth to the base of the lacustrine clay exceeds 5m (maximum depth of trial pit) at all turbine locations on bogs.

Based on the GSI bedrock mapping (www.gsi.ie), Dinantian Pure Unbedded Limestones (Waulsortion Limestone) underlie the middle section of the proposed project site, Dinantian Lower Impure Limestones (Ballysteen Formation) are mapped on the west, while Dinantian Pure Bedded Limestones (Visean Limestones) are mapped on the east of the proposed project site.

3.5 DESIGNATED SITES & HABITATS

Designated sites include Natural Heritage Areas (NHAs), Proposed Natural Heritage Areas (pNHAs) Special Areas of Conservation (SACs), candidate Special Areas of Conservation (cSAC) and Special Protection Areas (SPAs). The project site is not located within any designated conservation-site.

Designated sites in close proximity to the proposed project site and grid connection include Woodville Woods pNHA (Site Code: 000927), Ross and Glens Eskers pNHA and Ridge Road, SW of Rapemills SAC/pNHA (Site Code: 000919). The junction works at the N52/N62 drains into Woodville Woods pNHA.

The proposed grid connection runs adjacent to Ross and Glens Eskers pNHA.

The abovementioned close proximity designated sites are not water dependant.

The closest SPA to the site is Dovegrove Callows SPA (Site Code: 004137) is adjacent to part of the grid connection on the public road to the south of Dallow substation.

The project site drains to the northwest via the Rapemills River, which passes the All Saints Bog and Esker SAC and pNHA (Site Code: 000566) and the All Saints Bog SPA (Site Code:004103) approximately 3.5km from the project site.

However, there is no surface water connection between the project site and All Saints Bog and Esker SAC as All Saints Bog discharges into Rapemills River and not vice versa.

Groundwater flow in the area of the project site is likely to be westerly towards All Saints Bog and Esker SAC. However, groundwater flow below All Saints Bog will be limited to the deeper glacial deposits which are separated from the overlying bog by very low permeability marl and lacustrine clay deposits which underlies the basin peat in this area.

The Rapemills River ultimately drains into the River Shannon and flows through the River Shannon Calllows SAC (Site Code: 00216) and the Middle Shannon Callows SPA (Site Code:004096), which lie approximately 6.8km northwest of the project site.

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4. FLOOD RISK IDENTIFICATION

4.1 INTRODUCTION

The following assessment is carried out in accordance with '*The Planning System and Flood Risk Management Guidelines for Planning Authorities*' (DoEHLG, 2009). The basic objectives of these guidelines are to:

- Avoid inappropriate development in areas at risk of flooding;
- Avoid new developments increasing flood risk elsewhere, including that which may arise from surface water run-off;
- Ensure effective management of residual risks for development permitted in floodplains;
- Avoid unnecessary restriction of national, regional or local economic and social growth;
- Improve the understanding of flood risk among relevant stakeholders; and,
- Ensure that the requirements of EU and national law in relation to the natural environment and nature conservation are complied with at all stages of flood risk management.

A Stage 2 assessment involves the confirmation of sources of flooding, appraising the adequacy of existing information and determining what surveys and modelling approach may be required for further assessment.

As per the guidance (DOEHLG, 2009), the stages of a flood risk assessment are:

- *Flood risk identification* – identify whether there are surface water flooding issues at a site; and,
- *Initial flood risk assessment* - confirm sources of flooding that may affect a proposed development.

Further to this, a Stage 3 FRA was previously completed which is a detailed flood risk assessment which assesses flood risk issues in sufficient detail and to provide a quantitative appraisal of potential flood risk to a proposed or existing development or land to be zoned, of its potential impact on flood risk elsewhere and of the effectiveness of any proposed mitigation measures.

As stated in the introduction section, the main purpose of the Stage 3 FRA for the project site was to inform the wind farm layout at an early stage and to keep as much of the proposed infrastructure outside of fluvial flood zones as possible.

4.2 SOILS MAPS – FLUVIAL MAPS

A review of the soil types in the vicinity of the project site was undertaken as soils can be a good indicator of past flooding in an area. Due to past flooding of rivers, deposits of transported silts/clays, referred to as alluvium build up within the floodplain and hence the presence of these soils is a good indicator of potentially flood-prone areas.

Based on the EPA/GSI soil map for the area, no regions of alluvium are mapped within the project site planning boundary. However, some alluvium (fluvial deposits) is recorded along the Rapemills River, immediately to the southeast of the site boundary and 1.3km west and downstream of the project site.

4.3 HISTORICAL MAPPING

There is no text on local available historical 6" or 25" mapping for the project site area that identify areas that are "*prone to flooding*" within the site or surrounding lands.

4.4 OPW PAST EVENT MAPPING

The OPW Past Flood Maps have no records of recurring flood incidences within the project site boundaries. The closest mapped flood event is found approximately 2.3km northeast of the project site at Fivealley where low lying land floods after heavy rain. Downstream of the project site, several recurring flood events (www.floodinfo.ie) have been recorded at Banagher associated with flooding along the River Shannon (refer to **Figure E** below).

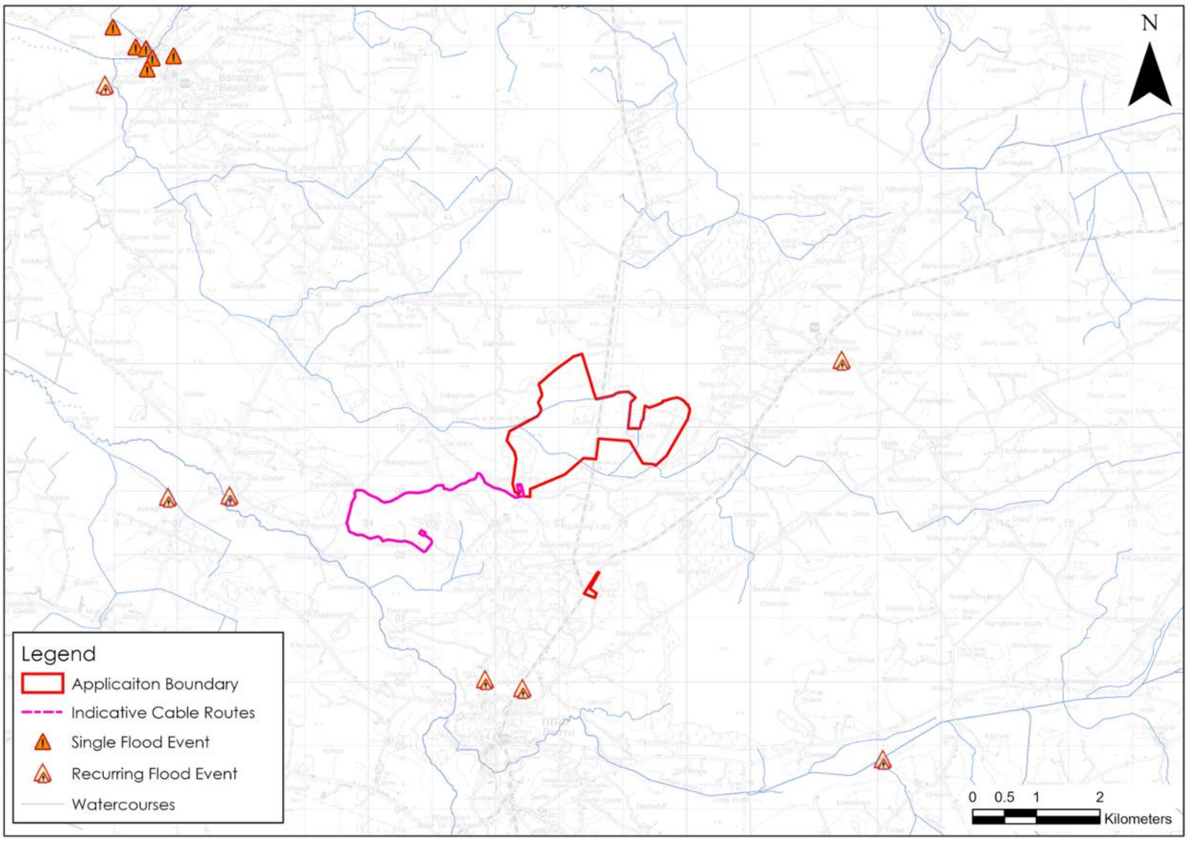

Figure E: OPW National Flood Event Mapping (Source: www.floodinfo.ie)

4.5 BENEFITING LANDS

Areas within the project site, along the Rapemills River and its tributaries are mapped within the Boolinaraig Drainage District, i.e. an area where drainage schemes to improve land for agricultural purposes were constructed or as Benefiting Lands, i.e. land identified by the OPW as potentially benefitting from the implementation of Arterial (Major) Drainage Schemes and an indicator of land subject to flooding and poor drainage.

4.6 CFRAM MAPS FLUVIAL AND COASTAL FLOODING

Where complete, the Catchment Flood Risk Assessment and Management (CFRAM)[2] OPW Flood Extent Maps are now the primary reference for flood risk planning in Ireland. This mapping is currently only available along the Rapemills River approximately 6.2km further downstream of the project site.

However, there is National Indicative Fluvial Mapping (NIFM) available for the Rapemills River at the project site as discussed below.

4.7 NATIONAL INDICATIVE FLUVIAL MAPPING (NIFM)

The National Indicative Fluvial Mapping for the present day shows the modelled extent of land that might be flooded by rivers (fluvial flooding) during a theoretical or 'design' flood event with an estimated probability of occurrence, rather than information for actual floods that have occurred in the past.

NIFM for the present day (https://www.floodinfo.ie/map/floodmaps/) shows that portions of the project site along the Rapemills River and West Galros Stream are inside the mapped 100-year and 1000-year fluvial flood zones. NIFM flood zones are mainly mapped on the western portion of the project site (i.e. west and downstream of the N62) along both the Rapemills River and West Galros Stream.

There are no NIFM flood zones mapped along the West Galros Stream on the eastern portion of the project site (i.e. upstream of the N62). There are some NIFM flood zones mapped along the Rapemills River east/upstream of the N62 but the flood zones are remote from the main proposed development areas.

According to the National Indicative Fluvial Mapping, only 1 no. turbine (T2) is located in a 100-year flood zone along with approximately 350m of its proposed connecting spur road from the south. The southern section of the temporary construction compound is also in a mapped 100-year flood zone.

In addition, approximately 370m of the proposed access road between turbines T2 and T4 is also in a mapped 100-year flood zone along with approximately 120m of the proposed access road leading to turbine T1.

All other proposed project infrastructure is located above the 1000-year flood level and therefore all infrastructure is located in Flood Zone C (Low Risk) according to the NIFM. The NIFM fluvial flood zones are shown in **Figure F**.

[2] *CFRAM is Catchment Flood Risk Assessment and Management. The national CFRAM programme commenced in Ireland in 2011,and is managed by the OPW. The CFRAM Programme is central to the medium to long-term strategy for the reduction and management of flood risk in Ireland.*

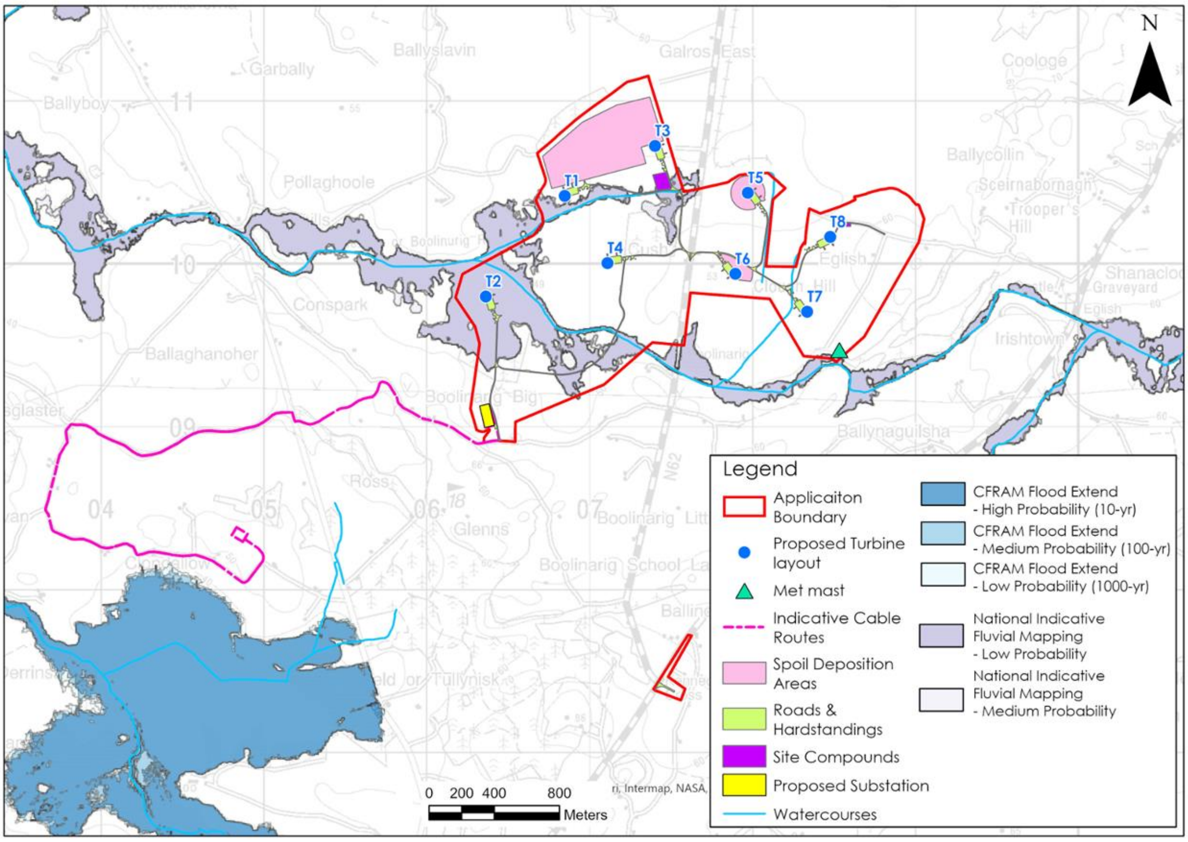

Figure F: NIFM Present Day Mapping (Source: www.floodinfo.ie)

4.8 MODELLED FLOOD SCENARIOS ASSOCIATED WITH CLIMATE CHANGE

It is likely that climate change will have significant impacts on flooding and flood risk in Ireland due to rising sea levels, increased winter rainfall and more intense rainfall. The CFRAM Programme has modelled flooding associated with potential future climate change scenarios. However as stated above no CFRAM modelling has been completed in the vicinity of the Site.

National Indicative Fluvial Mapping has been completed for catchments greater than 5km^2 for which flood maps were not produced under the CFRAM Programme. These flood zones have also been modelled for 2 no. potential future climate change scenarios, with the Mid-Range and High-End Future Scenario flood extents generated using an increase in rainfall of 20% and 30% respectively.

No significant increase in potential flood extents within the project are mapped for NIFM Mid-Range Future Scenario extents and High-End Future Scenario extents.

These NIFM modelled future flood extents do not deviate significantly from the present day scenario described in **Section 4.7** above.

4.9 GSI HISTORIC SURFACE WATER AND GROUNDWATER FLOOD MAPS

The Geological Survey of Ireland Historic Flood Maps show maximum observed extents of flooding, both groundwater and surface water, over various periods. The Maximum Historic Groundwater Flood Map shows maximum observed flood extents for locations of recurrent groundwater flooding in limestone regions. The map is primarily based on the winter 2015/2016 flood event, which in most areas represented the largest groundwater flood event on record.

Out of the 75 no. gauging stations in the reference OPW network, 37 gauges registered their highest flood levels since records began. In contrast, the flood levels of 2009 remain the highest on record in only 13 of these gauges. Therefore, the 2015/2016 flood event was also a significant fluvial flood event. Analysis of flood events in the UK and Ireland suggest return periods from 50 to 200 years.

As a complementary dataset to the Historic Groundwater Flood Map, the Winter 2015/2016 Surface Water Flooding map shows fluvial (rivers) and pluvial (rain) floods in Ireland, excluding urban areas, during the 2015/2016 flood event.

The GSI surface water flood map shows 2 no. localised areas of surface water flooding within the project site (refer to **Figure G** below). A small area of surface water flooding is mapped approximately 100m to the southwest of, but not affecting turbine T1 and surface water flooding is also mapped at the proposed works at the N62/N52 junction.

However, what is of note is that the GSI Historical 2015/2016 surface water flood map shows significantly less flood coverage than the NIFM mapping. This may be due to that the associated satellite imagery was taken after the floodwater from the Rapemills River had subsided or the NIFM mapping significantly overestimates the fluvial flood risk at the site.

The GSI Maximum Historic Groundwater Flood Map (refer to **Figure G** below) indicates groundwater flooding occurs to the south of the Rapemills River which effects the area of proposed turbine T2 and also its access road from the south.

However, what is of note here is that the area affected by the GSI mapped Historical groundwater flooding is not the lowest area of the proposed development site. The lowest area of the site is further west of T2 along the floodplain of the Rapemills River (this area is low-lying wet marsh land). If it were groundwater flooding mapped in 2015/2016 you would expect the lowest part of the project site to flood preferentially as the groundwater level rises.

The area shown affected by 2015/2016 groundwater flood is probably 0.5m higher than the marsh land area to the west. This puts doubt on whether it is actually groundwater flooding shown on the GSI Historical 2015/2016. Also, the fact that the site is covered by relatively deep peat and lacustrine clay, the groundwater table is likely to be confined below these low permeability layers.

Also, if it were fluvial flooding from the Rapemills River you would expect the same pattern of flooding as described above (i.e. the lands on the west of the site flooding preferentially as they are lower than the lands in the area of the mapped 2015/2016 groundwater flood event).

Based on the above observations it would appear that the observed flooding in 2015/2016 is pluvial/surface water in nature and not groundwater or fluvial.

It was indicated by the landowner that the grasslands in the area of T1 and T2 pond water after heavy rainfall due to the flat ground. The landowner also noted that during past flooding in the Rapemills River, the flood water level never reached the proposed location of turbine T2, which is over a 100m from the river.

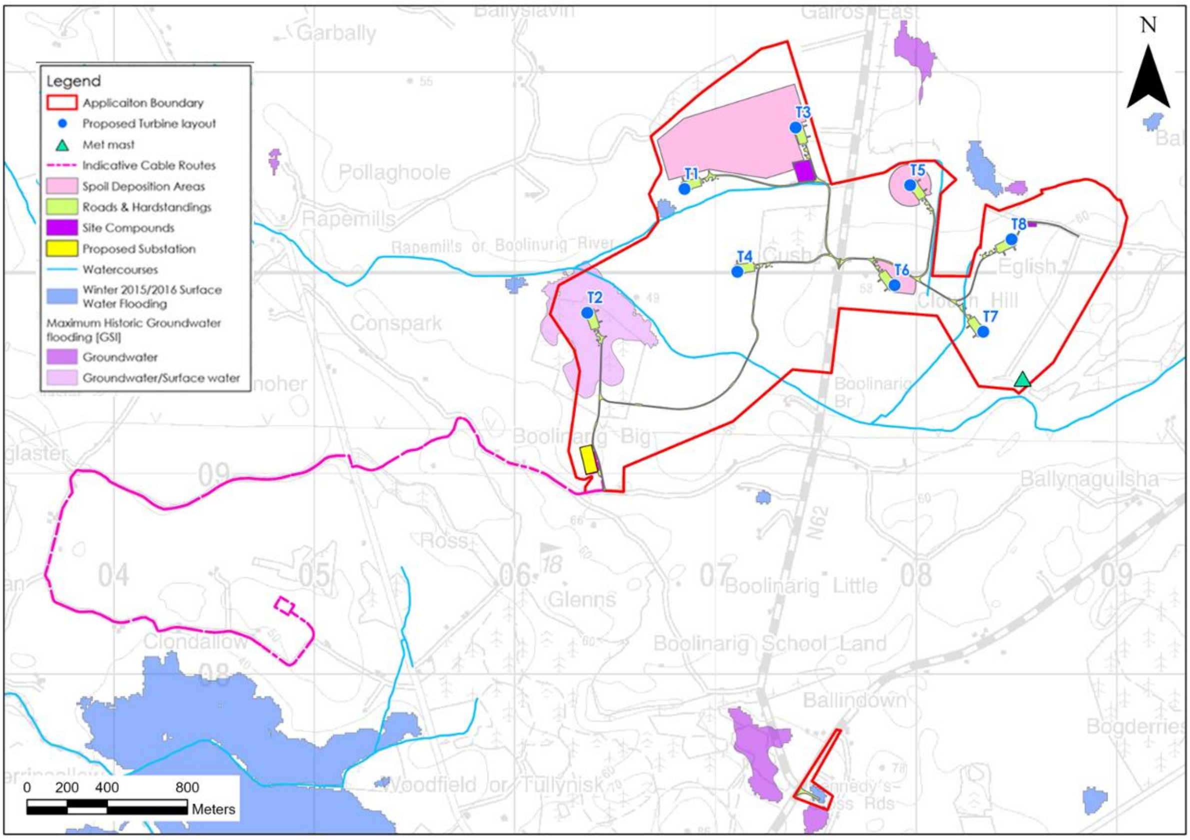

Figure G: GSI Groundwater and Surface Water Flood Mapping (Source: www.gsi.ie)

4.10 OPW EIAR SCOPING RESPONSE

The EIAR scoping response letter from OPW (dated 9th June 2022) made the following key observations:

- *"The proposed site is located in lands that benefit from the Boolinaraig Drainage District. There may be a risk of flooding at this location. The Local Authority and the developers should satisfy themselves that there is adequate level of protection against flooding at this location;*
- *Datasets prepared by the Office of Public Works identifying land that might benefit from the implementation of Arterial (Major) Drainage Schemes (under the Arterial Drainage Act 1945) and indicating areas of land subject to flooding or poor drainage;*
- *The channel in question* [at the Project Site] *is not an OPW maintainable channel; however, it is good practise that a 10-metre wide strip be retained adjacent to the channel to permit access to the local authority for maintenance. Ideally, the strip should not be fenced, paved or landscaped in a manner that would prevent access by maintenance plant; and,*
- *Further to this, please note that for the construction, replacement or alteration of any bridge or culvert over any channel which appears on a 6-inch to 1 mile map, Prior Section 50 consent must be sought under Section 50 of the Arterial Drainage Act, 1945.*

4.11 SUMMARY – FLOOD RISK IDENTIFICATION

Based on the information gained through the flood identification process it would appear that the project site can potentially be affected by fluvial and pluvial flooding.

According to the NIFM mapping, the majority of the project site and proposed infrastructure are mapped in Flood Zone C (Low Risk), including 7 no. of the 8 proposed turbines, the 110kV substation, BESS, wind farm control building and the spoil deposition areas.

1 no. proposed turbine (T2) along with a total of approximately 0.84km of proposed access roads are mapped inside a NIFM 100-year flood zone. The southern section of the temporary construction compound is also in a mapped 100-year flood zone.

The risk of groundwater flooding at the project is very low due to the fact that the groundwater table is confined below low permeability peat and clays layers which are extensive at the project site. There appears to be a risk of pluvial flooding in the area of proposed turbine T2.

4.11.1 Hydrological Flood Conceptual Model

Potential flooding in the vicinity of the site can be described using the Source – Pathway – Receptor Model ("S-P-R"). The primary potential source of flooding in this area, and the one with most consequence for the proposed wind farm development, is fluvial flooding with regard the Rapemills River.

The primary potential pathway would be fluvial overbank flooding of the Rapemills River which flows through the site during significant rainfall events. The potential receptors in the area are infrastructure and land as outlined below.

The project site is also likely to experience localised pluvial flooding along the callows of the Rapemills River and on peat bogs due to the flat topography.

4.11.2 Summary – Initial Flood Risk Assessment

Based on the information gained through the flood identification process and Initial Flood Risk Assessment process, the sources of flood risk for the project site are outlined and assessed in **Table B**.

Table B: Initial S-P-R Assessment of Flood Sources for the Site

Source	Pathway	Receptor	Comment
Tidal	Not applicable.	Land and infrastructure.	The proposed site is ~75km from the coast and therefore there is no risk of coastal flooding.
Fluvial	Overbank flooding	Land and infrastructure.	Based on the NIFM mapping, proposed turbine location T2, 0.84km of access roads and a section of the construction compound are located in a mapped 100-year flood zone. The majority of the proposed site and infrastructure are located in Flood Zone C (Low Risk).
Pluvial	Ponding of rainwater on the route right of way.	Land and infrastructure.	The site is generally low lying and flat in places and therefore localised pluvial flooding is very likely after heavy or prolonged rainfall, particularly the area around turbine T2 as indicated by the GSI

			historical flood mapping
Surface water	Surface ponding/ Overflow.	Land and infrastructure	Same as above (pluvial).
Groundwater	Rising groundwater levels.	Land and infrastructure.	Based on local geological/ hydrogeological setting (i.e. deep peat with confined groundwater table), groundwater flooding at the site is unlikely.

5. DETAILED FLOOD RISK ASSESSMENT

5.1 INTRODUCTION

A stage 3 site specific flood risk assessment including flood modelling was completed by HES for the proposed project site in July 2021. This was done at the time to assess the accuracy of the Preliminary Flood Risk Assessment (PFRA) mapping which was the only available published flood mapping for the area of the project site at that time.

The PFRA mapping, which is no longer used, was a national screening exercise, based on preliminary analysis, to identify areas where there may be a significant risk associated with flooding. The mapping was not site specific and had inherited inaccuracies.

Please note that the site specific flood risk assessment also overrides the National Indicative Fluvial Mapping in terms of its flood zone mapping accuracy at the project site. The National Indicative Fluvial Mapping is not intended to replace site specific flood risk assessments according to the OPW.

The Stage 3 FRA for the project site was done to inform the wind farm layout at an early design stage in order to keep as much of the proposed infrastructure outside of fluvial flood zones as possible.

The Stage 3 site specific flood risk assessment involved detailed site topographic surveys, use of Lidar data and flood flow modelling of the Rapemills River, West Galros Stream and associated floodplains.

5.2 SITE SPECIFIC STAGE 3 ASSESSMENT

A site-specific FRA included a detailed topographic survey of the Rapemills River and West Galros Stream channels along with the use of Lidar data (Digital Terrain Model) to determine ground elevations for the wider site and flood plain.

The river channel survey is described in **Section 5.3** below. This combined topographic data was used to create a river channel/flood plain 2-dimensional flow model for the section of Rapemills River and West Galros Stream within the project site.

Flood level modelling was undertaken using HEC-RAS™[3] open channel flow software. HEC-RAS is a 2-dimensional flow model which can calculate channel water depth/level using parameters such as flood volumes, channel dimensions, slope and friction coefficients (Mannings n number). To investigate the potential for flooding within the project site, modelling of design flood volumes (i.e. 100-yr and 1000-yr) was undertaken for the watercourses and flood plains with allowance for climate change (20%).

Apart from the NIFM, no direct CFRAM flood studies / modelling has been completed for the Rapemills River at the proposed project site location and therefore the OPW Flood Studies Update (FSU) Web Portal was used to calculate the Q_{med} (flow) for the watercourses at the site. The Q_{med} is then factored up to estimate design floods.

The design flood event growth factors applied in the River Shannon CFRAM study[4] were used to calculate the 100-year and 1000-year design flood flows in the Rapemills River and West Galros Stream (Q_{med} x Growth - Factor × Climate Change). A potential flow increase of 20% was applied to account for future climate change scenarios.

A 20% (medium end risk) is considered sufficient for the proposed wind farm life span (20 years or so) because the high end future flood scenarios risks are for a time horizon of

[3] *HEC-RAS – Hydrologic Engineering Centre – River Analysis System*

4 Shannon Catchment-Based Flood Risk Assessment and Management Study – Hydrology Report Unit of Management 25/26 (OPW, 2016.)

approximately 100-years. The design flood flows for the Rapemills River and west Galros Stream are shown in **Table C** below.

Table C: Design Flood Flows for Rapemills and West Galros Watercourses

Design Flood Return Period	Q_{med} (m^3/s)	Design Flood Flow (m^3/s) + 20%*
Rapemills 100 – Year	3.45 – 4.46	8.7 – 11.24
Rapemills 1000 – Year		11.2 – 14.45
West Galros Stream – 100 year	0.9	2.24
West Galros Stream – 1000 year		2.88

+ *Includes 20% increase for climate change allowance*

For the stretch of the Rapemills River and West Galros Stream at the location of the project site, a friction coefficient (Mannings n number) of 0.04 and 0.048 was used respectively for the channel frictional loss in the model. A coefficient of 0.035 and 0.1 was used for the surrounding grasslands and forested lands respectively.

The slope of the Rapemills River and West Galros Stream channels was determined from the detailed topographic survey and this is calculated to be approximately 0.00052.

5.3 TOPOGRAPHICAL SURVEY

A total of 10 no. open channel cross-sections (XS1 – XS10) of the Rapemills River and adjacent lands were surveyed in the vicinity of the project site. Cross-section numbering decreases in the direction of flow. 3 no. cross-sections (XS11 – XS13) of the West Galros Stream channel were survey. The survey cross-sections were extended across the floodplain and study area using Lidar data.

On both the Rapemills River and West Galros Stream, all cross-sections were surveyed downstream of the N62 as there are no NIFM flood zones mapped upstream of the N62 that's close to proposed infrastructure.

The locations of the cross-sections are shown on **Figure H** below.

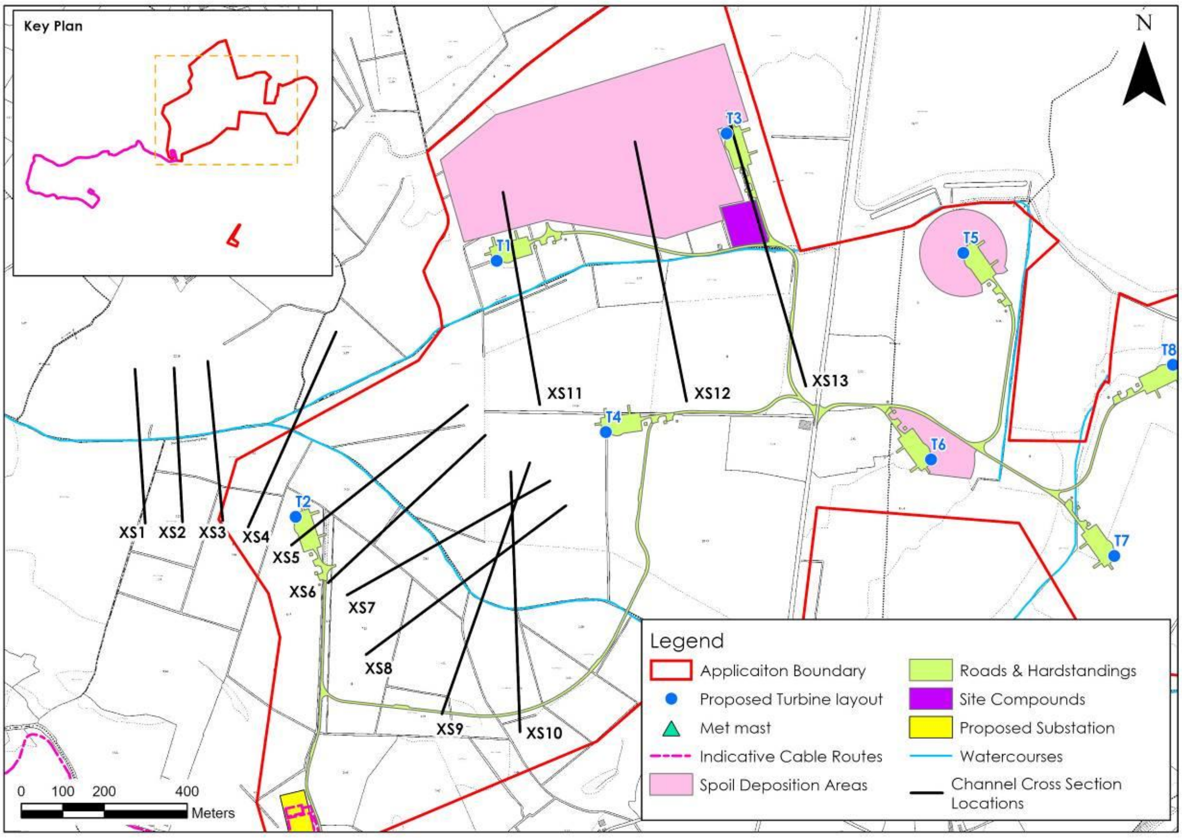

Figure H: Channel Cross Section Locations

5.4 FLOOD LEVEL MODELLING

Prior to modelling the design flood flows, the flows in the Rapemills River and West Galros Stream on the day of the topographic survey in July 2021 were run to assess the accuracy of the model. There are no historical or peak flood flows with corresponding water levels available for flood flow calibration.

The flow in the Rapemills River on 13th July 2021 was measured to be 0.67m^3/s upstream of the West Galros Stream confluence and 0.79m^3/s downstream of the confluence. The flow input from the West Galros Stream into the Rapemills River was measured to be 0.12m^3/s.

The modelled water levels compared to the measured water levels are shown in **Table D** below. Following the model calibration, there is reasonable correlation between measured and modelled water levels at the model cross-section locations.

The overall model average difference between the measured and modelled levels is 0.13m which is within acceptable tolerances according to HEC-RAS guidance[5]. (≤0.15m).

[5] HEC RAS River Analysis System – User's Manual (February 2016)

Table D: Comparison of Measured and Modelled Flows on 13/07/2021

Cross-section*	Measured Level (m OD)	Modelled Level (m OD)	Difference (m)
Rapemills River			
XS10	46.052	46.08	0.028
XS9	45.925	46.07	0.145
XS8	45.923	46.05	0.127
XS7	45.920	45.87	0.050
XS6	45.842	45.740	0.102
XS5	45.793	45.690	0.103
XS4	45.687	45.600	0.087
XS3	45.470	45.370	0.100
XS2	45.460	45.200	0.270
XS1	45.441	45.150	0.291
West Galros Stream			
XS13	45.98	46.100	0.120
XS12	45.94	46.050	0.110
XS11	45.80	45.93	0.130

*Cross-section numbering decreases from upstream to downstream

The design flood flows were then run using the calibrated model and the results are shown in **Table E** below.

HEC-RAS model output tables for the design flood modelling are attached as **Appendix I**.

Table E: Design Flood Levels

Channel Section	100 - Year (m OD)*	1000 - Year (m OD)*
Rapemills River		
XS10	46.740	46.790
XS9	46.690	46.740
XS8	46.620	46.680
XS7	46.580	46.630
XS6	46.540	46.590
XS5	46.540	46.590
XS4	46.530	46.580
XS3	46.520	46.560
XS2	46.400	46.450
XS1	46.330	46.390
West Galros Stream		
XS13	46.710	46.760
XS12	46.650	46.700
XS11	46.570	46.620

*Including 20% for climate change

The modelled 100 -year flood level for the project site ranges between 46.33m OD (furthest downstream) and 46.74m OD which is the furthest upstream location on the Rapemills River in the model. The 1000-year ranges between 46.39m OD and 46.79m OD at the respective locations.

The site specific modelled flood zones (refer to **Figure I** below) cover a much smaller area of the proposed project site compared to the NIFM flood zones.

Notable areas of the proposed development infrastructure affected according to the NIFM include the proposed turbine T2 location, a section of the main construction compound (CC1) and approximately 0.84km of access roads.

The site-specific flood zone modelling shows that proposed turbine location T2 is located outside the 100-year and 1000-year flood zones. The modelled 100-year and 1000-year flood level at the location is T2 is 46.54 and 46.59m OD respectively (refer to XS5 levels in **Table E** above) while the ground level at the proposed T2 location is between approximately 47 and 47.25m OD.

The minimum ground level at the construction compound is at approximately 47m OD whereas the site-specific modelled 100-year and 1000-year flood level is 46.71 and 46.76m OD respectively (refer to XS13 levels in **Table E** above).

Only two short sections of proposed access roads at watercourse crossing locations between turbine locations T2 and T4 (which amounts to approximately 100m of access road) are located within the site-specific modelled 100-year and 1000-year flood zone.

Therefore, with the exception of 100m of proposed access roads, the remainder proposed infrastructure is located in Flood Zone C (Low Risk).

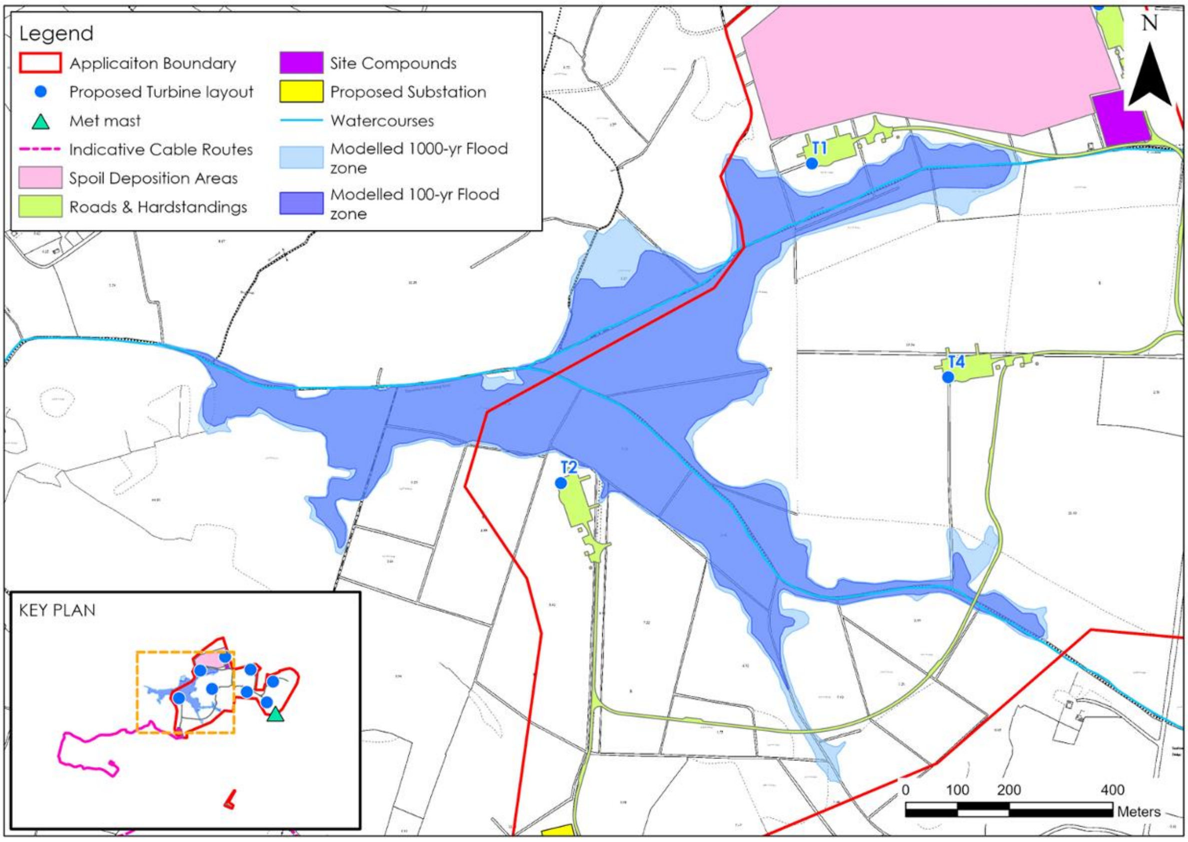

Figure I: Site Specific Modelled Flood Zones

5.5 SENSITIVITY ANALYSIS

To assess the sensitivity of the flood model to changes in design flood flow volumes, a sensitivity analysis was carried out.

The 100-year and 1000-year design flood flows (inclusive of 20% climate change) were increased by 10% and 20% and the subsequent changes in flood levels were observed and the significance noted with regard increased flood zones at the project site.

For both the 100 year and 1000 year design flood flow scenarios, a 10% increase in flow resulted in a water level increase of between 0.01 and 0.03m and with a 20% increase in flow, the water level increase was between 0.03 and 0.04m.

The water level increases with the conservative higher flows have negligible effect on the flood zone footprints as shown on **Figure I** above. All 8 no. turbines, the 110kV substation, BESS, wind farm control building, temporary construction compound and spoil deposition areas are still above the 1000 year flood level when applying the conservatively higher flows.

5.6 SUMMARY – DETAILED FLOOD RISK ASSESSMENT

Using the modelled flood levels (100-year (1% AEP) and 1000-year (0.1% AEP) flood levels) along with the site topography and Lidar data, a site-specific flood zone map for the proposed wind farm site was created and this is shown as **Figure I** above.

The site specific flood zone modelling shows that proposed turbine location T2 is located outside the 100-year and 1000-year flood zones. Two short sections of access road at watercourse crossing locations between turbine locations T2 and T4 (which amounts to approximately 100m of access road) are located within the 100-year and 1000-year flood zone.

Therefore, with the exception of 100m of proposed access road, the proposed infrastructure is located in Flood Zone C (Low Risk).

On rare occasions there is a minor risk of shallow inundation from pluvial flooding which will have no consequence for the proposed development.

5.7 PROPOSED WINDFARM DRAINAGE

The development of the project site means that there will be an increase in hardstand/roofed areas. However, the existing green areas at the project site are formed mainly from peat soils with a naturally high runoff potential. The proposed wind farm site is relatively flat, and the slope of the ground will dampen the limited potential for runoff.

Given the slope (or lack thereof) of the site, the surface water drainage, the small area of proposed development relative to the larger site area, there is limited to no potential for increase in runoff as a result of the proposed new access tracks/ hardstands areas etc (i.e. the proposed development footprint). Any potential small increase in runoff will be local to the development footprint, and any such small increases will be buffered/eliminated by the lack of gradient.

Nevertheless, the overarching objective of the proposed drainage measures is to ensure that all surface water runoff is comprehensively treated and attenuated such that no silt or sediment laden waters or deleterious material is discharged into the local drainage system. A Planning-Stage SWMP, incorporating the surface water drainage design has been prepared, see **Annex 3.4 of the EIAR**, and incorporates the principles of Sustainable Drainage Systems (SuDS) through an arrangement of surface water drainage infrastructure. The SWMP has regard to Greenfield runoff rates and is designed to mimic same and is sufficient to accommodate a 1-in-100 year rainfall event.

While the SuDS is an amalgamation of a suite of drainage infrastructure; the overall philosophy is straightforward. In summary:-

- All surface water runoff will be directed to specially constructed swales surrounding all areas of ground proposed to be disturbed (including the area for the temporary storage of material);
- The swales will direct runoff into settlement ponds/silt traps where silt/sediment will be allowed to settle;
- Following treatment, clean water will be discharged indirectly to the local drainage network via buffered outfalls thus ensuring that no scouring occurs;
- Drainage from the BnM lands also have the added benefit of the existing attenuation ponds/lagoons at the bog outfalls; and,
- All new watercourse crossings and culvert upgrades will be designed to accommodate a 100-year flood flow with allowance for at least 300m below the soffit structure.

The suite of surface water drainage infrastructure will include interception drains, collector drains swales, sedimats, flow attenuation and filtration check dams, settlement ponds/silt traps, and buffered outfalls.

The design criteria implemented as part of the SuDS are as follows:-

- To minimise alterations to the ambient site hydrology and hydrogeology;
- To provide settlement and treatment controls as close to the site footprint as possible and to replicate, where possible, the existing hydrological environment of the site;
- To minimise sediment loads resulting from the development run-off during the construction phase;

- To preserve greenfield runoff rates and volumes;
- To strictly control all surface water runoff such that no silt or other pollutants shall enter watercourses and that no artificially elevated levels of downstream siltation or no plumes of silt arise when substratum is disturbed;
- To provide settlement ponds to encourage sedimentation and storm water runoff settlement;
- To reduce stormwater runoff velocities throughout the site to prevent scouring and encourage settlement of sediment locally;
- To manage erosion and allow for the effective revegetation of bare surfaces;
- To manage and control water within the site and allow for the discharge of runoff from the site below the MAC of the relevant surface water regulation value; and,
- The high sensitivity of downstream receptors along with WFD status.

5.8 FLOOD RESILIENCE MEASURES

The site-specific flood zone modelling shows that only short sections of proposed access road at 2 no. watercourse crossing locations will potentially be affect by fluvial flooding. One crossing is on the Rapemills River itself and the second is a large land drain on the south of the site which drains into the Rapemills River.

For these new crossing works a Section 50 consent will be sought under Section 50 of the Arterial Drainage Act, 1945 to install a new culvert/bridge with the hydraulic capacity to accommodate a 100-year flood flows while maintaining at least a 300mm freeboard above the flood level.

The proposed access road surface level will be close or at the existing ground level to prevent obstruction of surface water flow paths.

6. PLANNING POLICY AND JUSTIFICATION TEST

6.1 PLANNING POLICY AND THE OFFALY COUNTY DEVELOPMENT PLAN

The following policies are defined in the Offaly CDP 2021-2027 (**Table F**) in respect of flooding, and we have outlined in the column to the right how these policies are provided for within the Proposed Development design:

Table F: Offaly County Development Plan Objectives/Policies and Project Responses

No.	Policy	Development Design Response
CAEP-67	It is Council policy to minimise and limit the extent of hard surfacing and paving and require the use of sustainable urban drainage systems (SuDs) where appropriate, for new developments or for extensions to existing developments, in order to reduce the potential impact of existing and predicted flooding risks.	The proposed development will include the use of SuDs and drainage improvement works to mitigate against any potential flooding and pollution at the project site. Refer to **Section 5.7** above.
CAEP-55	The assessments shall consider and provide information on the implications of climate change with regard to flood risk in relevant locations. The 2009 OPW Draft Guidance on Assessment of Potential Future Scenarios for Flood Risk Management (or any superseding document) and available information from the CFRAM Studies shall be consulted with to this effect."	This assessment considers the potential affect of Climate change with regard to flood risk. A 20% increase is applicable for the life time of the wind farm.
18.8.3 Flood Risk Assessment	Development proposals within these areas shall be accompanied by a detailed Flood Risk Assessment, carried out in accordance with The Planning System and Flood Risk Assessment Guidelines and Circular PL 2/2014 (or as updated), which shall assess the risks of flooding associated with the proposed development.	This FRA is consistent with the requirements for a flood risk assessment as in line with the recommendations as part of the Offaly County Development Plan 2021-2027. This FRA is consistent with the requirements of the "Planning System and Flood Risk Management – Guidelines for Planning Authorities" and the Strategic Flood Risk Assessment (SFRA).
18.8.3 Flood Risk Assessment	All development proposals within or incorporating areas at moderate to high risk of flooding will require site specific and appropriately detailed Flood Risk Assessments.	This FRA is consistent with the requirements for a flood risk assessment as in line with the recommendations as part of the Offaly County Development Plan 2021-2027. A detailed site specific assessment is fully outlined above in **Section 5.**
18.8.3 Flood Risk Assessment	All development proposals within or incorporating areas at moderate or high risk of flooding will require the application of the Development Management Justification Test in accordance with the Planning System and Flood Risk Management-Guidelines for Planning Authorities (DEHLG and OPW, 2009).	A justification test for the proposed development is completed below in **Section 6.2.**

6.2 REQUIREMENT FOR A JUSTIFICATION TEST

The matrix of vulnerability versus flood zone to illustrate appropriate development and that required to meet the Justification Test[6] is shown in **Table G** below.

Based on the stage 3 flood risk assessment and modelling exercise, only 2 no. short sections of proposed access roads at watercourse crossing locations are inside a fluvial flood zone.

The proposed access roads can be considered a 'Less Vulnerable Development' and therefore a justification test is still required. Only 1 no. proposed watercourse crossing location and less than 100m of proposed access roads are located inside Flood Zone A/100-year flood zone (i.e. below the 100-year flood level).

Table G: Matrix of Vulnerability versus Flood Zone

	Flood Zone A	Flood Zone B	Flood Zone C
Highly vulnerable development (including essential infrastructure)	Justification test	Justification test	Appropriate
Less vulnerable development	**Justification test**	**Appropriate**	**Appropriate**
Water Compatible development	Appropriate	Appropriate	Appropriate

Note: Taken from Table 3.2 (DoEHLG, 2009)
Bold: *Applies to this project.*

[6] *A 'Justification Test' is an assessment process designed to rigorously assess the appropriateness, or otherwise, of particular developments that are being considered in areas of moderate or high flood risk, (DoEHLG, 2009).*

7. JUSTIFICATION TEST

Box 5.1 (

Table H below) of "The Planning System and Flood Risk Management Guidelines" (PSFRM Guidelines) outlines the criteria required to complete the "Justification Test".

Table H: Format of Justification Test for Development Management

Box 5.1 Justification Test for Development Management (to be submitted by the applicant)
When considering proposals for development, which may be vulnerable to flooding, and that would generally be inappropriate as set out in Table 3.2, the following criteria must be satisfied: 1. The subject lands have been zoned or otherwise designated for the particular use or form of development in an operative development plan, which has been adopted or varied taking account of these Guidelines. 2. The proposal has been subject to an appropriate flood risk assessment that demonstrates: i. The development proposed will not increase flood risk elsewhere and, if practicable, will reduce overall flood risk; ii. The development proposal includes measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible; iii. The development proposed includes measures to ensure that residual risks to the area and/or development can be managed to an acceptable level as regards the adequacy of existing flood protection measures or the design, implementation and funding of any future flood risk management measures and provisions for emergency services access; and iv. The development proposed addresses the above in a manner that is also compatible with the achievement of wider planning objectives in relation to development of good urban design and vibrant and active streetscapes. The acceptability or otherwise of levels of residual risk should be made with consideration of the type and foreseen use of the development and the local development context.

Note: *this table has been adapted from Box 5.1 of "The Planning System and Flood Risk Management Guidelines", (2009).*

Referring to Point 1 and Points 2 (i) to (iv) inclusive in Figure 20 [of PSFRM guideline document]:

1. The proposed development has been deemed suitable for development by the applicant. The applicant is aware of the fluvial and pluvial flood risks associated with the proposed site, and they have included design layout responses to ensure avoidance of fluvial flood zones for the most sensitive elements of the proposed infrastructure. All proposed infrastructure with the exception of short sections of proposed access roads at 2 no. watercourse crossing locations (which are unavoidable) are located in Flood Zone C;
2. The proposal for 8 no. turbine wind farm and associated access tracks, construction compound, spoil storage areas, sub-station, BESS, control building, 1 no. met mast, cable, grid connection, and other ancillary works has been the subject of a Stage III flood risk assessment (this report) and this assessment has shown that:
   i. The development has been assessed to have no impact on flood risk elsewhere in the locality and this largely due to the avoidance of fluvial flood zones as informed by the site specific stage III assessment at the early design phase;
   ii. The proposed development will not impede the flow of surface water during extreme flood events. Drainage designs for the proposed development follows SuDS principles and adequately sized watercourse crossing structures to cope with peak floods. We conclude that the proposed development presents minimal risk to people, property, the economy and the environment.

There will be no increase in flood risk on lands upstream or downstream of the proposed development site;

iii. The flood assessment has shown that there will be no residual risks to the proposed development or the local area. Flood resilience proposals for new watercourse crossings and access roads are outlined above. All other elements of the development proposal are located outside of modelled flood zones; and,

iv. With respect to the above (flood risk management proposals) the proposed development is therefore compatible with the wider planning objectives of the area. It does not alter the flood risk upstream or downstream of the proposed application site.

With regards to the proposed development site, it will for the large part remain flood free, but on rare occasions there is a minor risk of shallow inundation from pluvial flooding which will have no consequence for the proposed development.

8. REPORT CONCLUSIONS

8.1 CONCLUSIONS

- According to the NIFM mapping, the majority of the project site and proposed infrastructure are mapped in Flood Zone C (Low Risk), including 7 no. of the 8 proposed turbines, the 110kV substation, BESS, wind farm control building, 2 no. temporary construction compound and spoil deposition areas.
- 1 no. proposed turbine (T2) along with a total of approximately 0.84km of proposed access roads are mapped inside a NIFM 100-year flood zone. The southern section of the temporary construction compound is also in a mapped 100-year flood zone.
- However, the NIFM mapping is not intended to replace a site specific flood risk assessment which was previously completed for the project site in 2021 when a Stage 3 assessment was carried out;
- The main purpose of the Stage 3 FRA for the project site was to inform the wind farm layout design at an early stage and to keep as much of the proposed infrastructure outside of fluvial flood zones as possible;
- Therefore, most of the proposed infrastructure with the exception of short sections of proposed access roads at 2 no. watercourse crossing locations (which are unavoidable) are located in Flood Zone C. These crossings are unavoidable.
- The proposed project will have no impact on flood risk elsewhere in the locality and this largely due to the avoidance of fluvial flood zones as an early design measure;
- A Planning-Stage SWMP, incorporating the surface water drainage design has been prepared for the proposed development and incorporates the principles of Sustainable Drainage Systems (SuDS); and,
- This FRA fulfils the requirements for a site specific flood risk assessment and is consistent with the recommendations made in the Offaly County Development Plan 2021-2027.

* *

9. REFERENCES

AGMET	1996	Agroclimatic Atlas of Ireland.
Offaly County Council	2021	Offaly County Development Plan 2021-2027.
DOEHLG	2009	The Planning System and Flood Risk Management.
Met Eireann	1996	Monthly and Annual Averages of Rainfall for Ireland 1961-1990.
OPW	2016	Shannon Catchment-Based Flood Risk Assessment and Management Study – Hydrology Report Unit of Management 25/26

APPENDIX I: HEC-RAS MODEL OUTPUT DATA

100-YEAR FLOOD DESIGN LEVELS FOR RAPEMILLS RIVER AND WEST GALROS STREAM

HEC-RAS Plan: Plan 16 Profile: PF 1

River	Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
Rapemills	1	1	PF 1	11.24	44.30	46.33	45.51	46.34	0.000521	0.58	39.07	185.48	0.14
Rapemills	1	2	PF 1	11.24	44.49	46.40		46.42	0.001404	0.92	23.07	106.99	0.23
Rapemills	1	3	PF 1	11.24	45.03	46.52		46.53	0.001043	0.78	29.23	138.37	0.21
Rapemills	1	4	PF 1	8.69	44.79	46.53		46.54	0.000004	0.06	215.10	413.74	0.01
Rapemills	1	5	PF 1	8.69	44.90	46.54		46.54	0.000033	0.15	109.73	361.19	0.04
Rapemills	1	6	PF 1	8.69	45.30	46.54		46.55	0.000402	0.48	33.54	127.75	0.14
Rapemills	1	7	PF 1	8.69	45.30	46.58		46.58	0.000254	0.38	40.75	157.97	0.12
Rapemills	1	8	PF 1	8.69	45.50	46.62		46.63	0.000931	0.67	26.54	145.07	0.23
Rapemills	1	9	PF 1	8.69	45.17	46.69		46.70	0.000471	0.54	35.43	183.60	0.14
Rapemills	1	10	PF 1	8.69	44.94	46.74		46.78	0.001471	0.99	12.00	31.80	0.24
Rapemills Trib	1	7	PF 1	2.24	45.77	46.57		46.57	0.000428	0.33	11.54	75.45	0.12
Rapemills Trib	1	8	PF 1	2.24	45.63	46.65		46.65	0.000560	0.38	11.27	57.20	0.14
Rapemills Trib	1	9	PF 1	2.24	45.66	46.71		46.71	0.000958	0.44	12.85	99.87	0.18

1000-YEAR FLOOD DESIGN LEVELS FOR RAPEMILLS RIVER AND WEST GALROS STREAM

Rapemills	1	1	PF 1	14.45	44.30	46.39	45.69	46.40	0.000521	0.59	49.87	199.11	0.14
Rapemills	1	2	PF 1	14.45	44.49	46.45		46.47	0.001337	0.92	29.15	110.49	0.23
Rapemills	1	3	PF 1	14.45	45.03	46.56		46.58	0.000998	0.79	36.04	142.53	0.21
Rapemills	1	4	PF 1	11.18	44.79	46.58		46.58	0.000006	0.06	234.97	417.53	0.02
Rapemills	1	5	PF 1	11.18	44.90	46.59		46.59	0.000035	0.16	127.29	366.01	0.04
Rapemills	1	6	PF 1	11.18	45.30	46.59		46.60	0.000411	0.50	39.82	130.48	0.15
Rapemills	1	7	PF 1	11.18	45.30	46.63		46.63	0.000288	0.42	49.52	193.85	0.13
Rapemills	1	8	PF 1	11.18	45.50	46.68		46.68	0.000812	0.65	34.86	161.54	0.21
Rapemills	1	9	PF 1	11.18	45.17	46.74		46.75	0.000440	0.53	45.71	210.37	0.14
Rapemills	1	10	PF 1	11.18	44.94	46.79		46.85	0.002116	1.21	14.29	58.38	0.29
Rapemills Trib	1	7	PF 1	2.88	45.77	46.62		46.63	0.000393	0.33	15.91	86.51	0.12
Rapemills Trib	1	8	PF 1	2.88	45.63	46.70		46.71	0.000613	0.42	14.77	76.71	0.15
Rapemills Trib	1	9	PF 1	2.88	45.66	46.76		46.76	0.000735	0.41	18.96	136.15	0.16

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