APPENDIX 9-1

FLOOD RISK ASSESSMENT

DOCUMENT INFORMATION

Document Title:	**PROPOSED BALLIVOR WIND FARM, CO. WESTMEATH/MEATH – FLOOD RISK ASSESSMENT**
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Author(s):	**MICHAEL GILL ADAM KEEGAN CONOR MCGETTIGAN**
Signed:	 **Michael Gill B.A., B.A.I., M.Sc., MIEI Managing Director – Hydro-Environmental Services**

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This report has been prepared by HES with all reasonable skill, care and diligence within the terms of the contract with the client, incorporating our terms and conditions and taking account of the resources devoted to it by agreement with the client. We disclaim any responsibility to the client and others in respect of any matters outside the scope of the above. The flood risk assessment undertaken as part of this study is site-specific and the report findings cannot be applied to other sites outside of the survey area which is defined by the site boundary. This report is confidential to the client and we accept no responsibility of whatsoever nature to third parties to whom this report, or any part thereof, is made known. Any such party relies upon the report at their own risk.

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1. INTRODUCTION

1.1 BACKGROUND

Hydro-Environmental Services (HES) were requested by MKO Ireland (MKO), on behalf of Bord Na Móna Powergen Ltd, to undertake a Flood Risk Assessment (FRA) for the proposed Ballivor wind farm, Co. Meath and Co. Westmeath.

The Ballivor Wind Farm site ("the proposed site") forms part of the Ballivor Bog Sub-Group situated between the towns of Kinnegad and Delvin, Co. Westmeath. The proposed site comprises of 4 no. Bord na Móna bogs (Ballivor, Bracklin, Lisclogher and the western portion of Carranstown bog). The proposed site is a Bord na Móna peat bog, and as such the site is extensively modified, cutover and drained.

The proposed site boundary map is presented as **Figure A** below.

The Proposed Development comprises 26 no. turbines and associated access tracks, construction compounds, sub-station, cable trench route, grid connection, amenity pathways, carpark and other ancillary works.

The following assessment is carried out in accordance with '*The Planning System and Flood Risk Management Guidelines for Planning Authorities*' (DoEHLG, 2009).

1.2 STATEMENT OF QUALIFICATIONS

Hydro-Environmental Services ("HES") are a specialist hydrological, hydrogeological and environmental practice that 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 in 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 PGeo (BA, BAI, MSc, MIEI) is an Environmental Engineer and Hydrogeologist with 22' years of environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological assessments for various developments across Ireland. Michael has significant experience in surface water drainage issues, SUDs design, and flood risk assessment.

Adam Keegan (BSc, MSc) is a junior hydrogeologist with 5 years of experience in the environmental/engineering sector. Adam has assisted in the preparation of several flood risk assessments for various proposed developments, including wind energy developments.

Conor McGettigan (BSc, MSc) is an Environmental Scientist with 3 years' experience in the environmental sector in Ireland. Conor holds an M.Sc. in Applied Environmental Science and a B.Sc. in Geology. Conor routinely prepares flood risk assessments for a wide variety of proposed developments including wind farm developments on peatlands.

1.3 REPORT LAYOUT

This FRA report has the following format:

- Section 2 describes the proposed site setting and details of the Proposed Development;
- Section 3 outlines the hydrological and geological characteristics of the proposed site and downstream surface water catchments and the existing and proposed site drainage;

- Section 4 presents a site-specific flood risk assessment (FRA) undertaken for the Proposed Development which was carried out in accordance with the above-mentioned guidelines;
- Section 5 assesses the Proposed Development in terms of local planning policies and presents a Justification Test for parts of the Proposed Development; and,
- Section 6 presents the FRA report conclusions.

2. BACKGROUND INFORMATION

2.1 INTRODUCTION

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

2.2 SITE LOCATION AND TOPOGRAPHY

The Ballivor Wind Farm site ("the proposed site") comprises 4 no. Bord na Móna bogs which form part of the larger Derrygreenagh Bog Group situated between the towns of Kinnegad and Delvin, Co. Westmeath. The bogs comprising the proposed site include Ballivor Bog to the south, Carranstown and Bracklin Bogs towards the centre and Lisclogher Bog at the northern end of the proposed site. Lisclogher West Bog exists to the west of Lisclogher Bog and forms part of the Ballivor Sub-Group of bogs (a sub-group of the Derrygreenagh Group), however this bog does not form part of the proposed site. In addition, the western section of Bracklin Bog (Bracklin West) and the eastern section of Carranstown bog are omitted from the proposed site. The total area of the proposed site is 1,770ha (17.70km^2).

The Meath-Westmeath county boundary runs through the centre of Lisclogher Bog, along the eastern boundary of Bracklin Bog and through the centre of both Carranstown and Ballivor Bogs. The proposed site is located approximately 3.7km west of the village of Raharney, 4.5km south of Delvin town, Co. Westmeath and 2.5km east of Ballivor village, Co. Meath.

The south of the proposed site is dissected by the R156 which joins the villages of Ballivor in the east to Raharney in the west. Ballivor Bog lies to the south of this regional road with the other 4 no. bogs which comprise the Ballivor Bog Sub-Group lying to the north. A Bord na Móna works area lies in the northwest of Ballivor Bog, in the townland of Grange More and contains offices, storage sheds, roads and a peat loading area. The remainder of Ballivor Bog is located in the townlands of Robinstown and Clonycavan in the east and Riverdale, Clondalee More and Derryconor in the west. Ballivor Bog has a total area of 635ha, all of which is included within the proposed site, and it was served by a Bord na Móna railway network which still extends from the loading area into the bog.

To the north of the R156, Carranstown Bog has an area of 306ha and lies in the townlands of Grangemore in the West and Carranstown Great, Carranstown Little and Killaconnigan in the east. Approximately 79ha in the west of Carranstown Bog forms part of the proposed site. The Bord na Móna railway links Carranstown Bog to Ballivor Bog to the south and Bracklin Bog to the north. Towards the centre of the proposed site, Bracklin Bog has an area of 620ha, all of which is included within the proposed site. Bracklin Bog lies in the townlands of Coolronan in the east, Craddanstown and Bracklin in the centre and Ballynaskeagh, Mucklin and Killagh in the west. An extension of Bracklin Bog, referred to as Bracklin West is not included within the proposed site. A small bogland (~22ha) referred to as the Hill of Down lies to the east of Bracklin Bog in the townlands of Coolronan and Bracklin. Lisclogher Bog is located to the northeast of Bracklin Bog, approximately 4.3km southeast of the town of Delvin and has an area of 484ha, of which 436ha is included within the proposed site. This bog is located in the townlands of Lisclogher Great, Coolronan, Bracklin, Cockstown and Clonleame.

The current topography of the proposed site is relatively flat with an elevation range of between approximately 70 and 70mOD (metres above Ordnance Datum). Topography at the proposed site has been modified through the previous peat extraction activities and associated drainage. The highest elevations are found at headlands and remnant peat banks which create elevated boundary berms, forming a basin effect within the former extraction areas of the bogs.

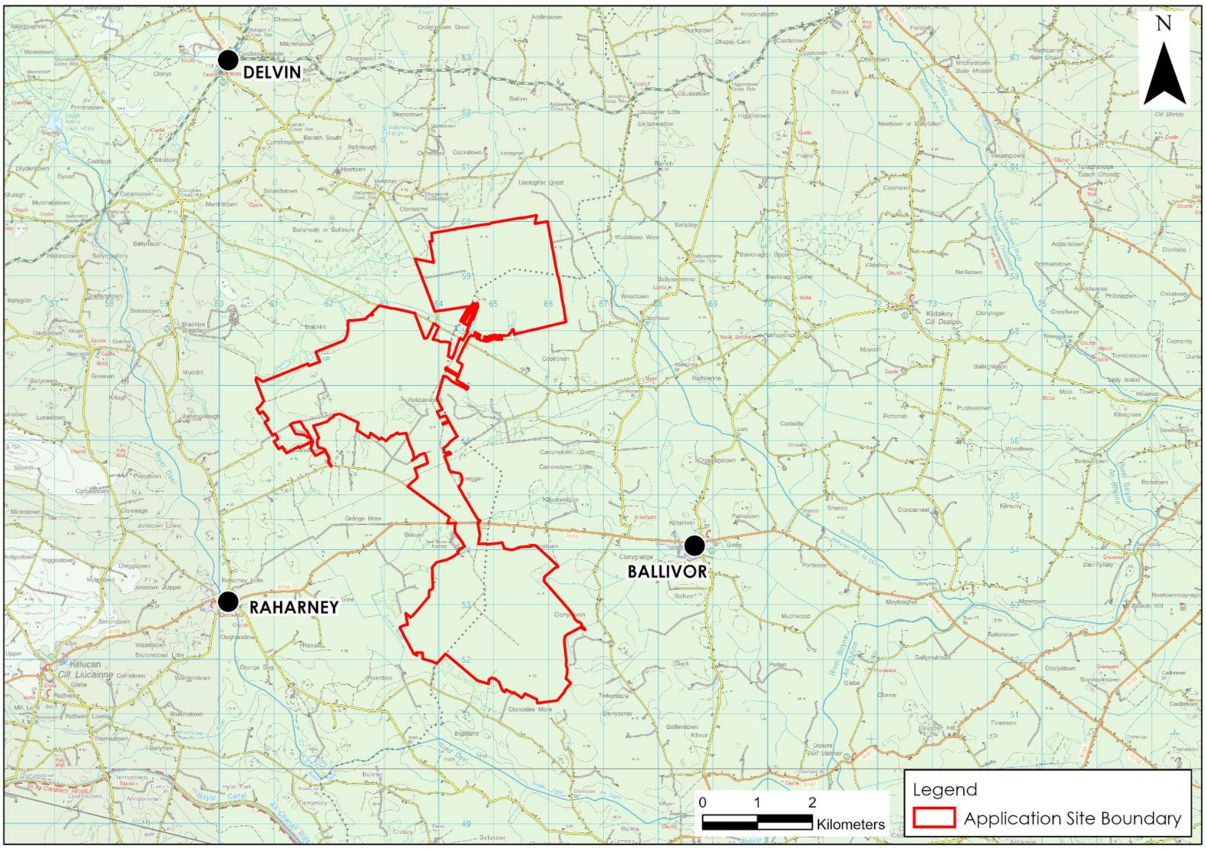

Figure A: Site Location Map

2.3 PROPOSED DEVELOPMENT DETAILS

The Proposed Development comprises of the following:

- Construction of 26 no. wind turbines;
- Turbine hardstand areas;
- Provision of 2 no. permanent meteorological masts;
- 4 no. temporary construction compounds;
- 2 no. borrow pits;
- 1 onsite 110kV substation, control building and plant, groundwater well and associated security fencing;
- 3 no. permanent amenity carparks;
- Upgrade of existing roads and access junctions;
- Provision of new site entrances, roads and hardstand areas;
- All site drainage works;
- All associated underground electrical and communication cabling connecting the turbines to the proposed on-site substation; and,
- All ancillary site and ground works, apparatus and signage.

3. EXISTING ENVIRONMENT AND CATCHMENT CHARACTERISTICS

3.1 INTRODUCTION

This section gives an overview of the hydrological and geological characteristics of the region and the proposed site.

3.2 HYDROLOGY

3.2.1 Regional and Local Hydrology

Hydrometric Area 7[1] of the Eastern River Basin District.

The River Boyne surface water catchment has a total area of 2,694km^2 and includes all areas drained by the River Boyne. The source of the Boyne is the Trinity Well, southeast of Carbury, Co. Kildare approximately 18km southeast of the proposed site. The Boyne flows west from the Trinity Well, turning north at Edenderry, passing through the raised bog landscape of north Kildare, after which it is joined by the Yellow River. The River Boyne continues to flow towards the northeast and the town of Trim, flowing approximately 5km east of the proposed site. In the vicinity of the proposed site, the main tributaries which discharge into the Boyne include the Deel (Raharney) and Stoneyford rivers. Further downstream the Athboy River confluences with the Boyne before flowing to the east through the town of Trim. The Boyne then flows towards Navan after which it continues eastwards before becoming tidal to the west of my M1 motorway. The Boyne then flows through Drogheda and out to the Irish Sea between Haven and Mornington Point.

A regional hydrology map of the is shown in **Figure B** below.

On a local scale, the majority of the proposed site is located in the River Boyne_SC_050 sub-catchment. Meanwhile, the southwest of the proposed site, including much of Ballivor Bog and small areas of Carranstown and Bracklin bogs, is located in the River Boyne_SC_040 sub-catchment. The west of Bracklin Bog (i.e. Bracklin West), which is not included in the proposed site is situated in the Deel[Raharney]_SC_010 sub-catchment.

The Deel River (EPA Code: 07D01) flows southwards approximately 2.1km west of the proposed site. The Deel River flows southwards through the town of Raharney and confluences with several small streams which drain the southwest of the proposed site. While these watercourses are largely unnamed, the Curris River is located immediately to the west of Ballivor Bog and flows to the south before discharging into the Deel River approximately 1.4km south of the proposed site. The Deel then continues to the southeast and confluence with the River Boyne (EPA Code: 07B04) approximately 4.5km south of Ballivor village.

The eastern section of the proposed site is drained by the Stonyford River (EPA Code: 07S02). The Stonyford River flowing to the southeast, approximately 700m east of Lisclogher Bog and continues to the southeast before it discharges into the River Boyne approximately 7km east of proposed site (Ballivor Bog). The proposed site is drained by several small 1st and 2nd order streams which flow to the east and discharge into the Stonyford River.

[1] *Ireland's hydrometric areas are used as management units for hydrological areas (EPA, OPW, ESBI, Local Authorities etc) and they are made up of an amalgamation of large river basins.*

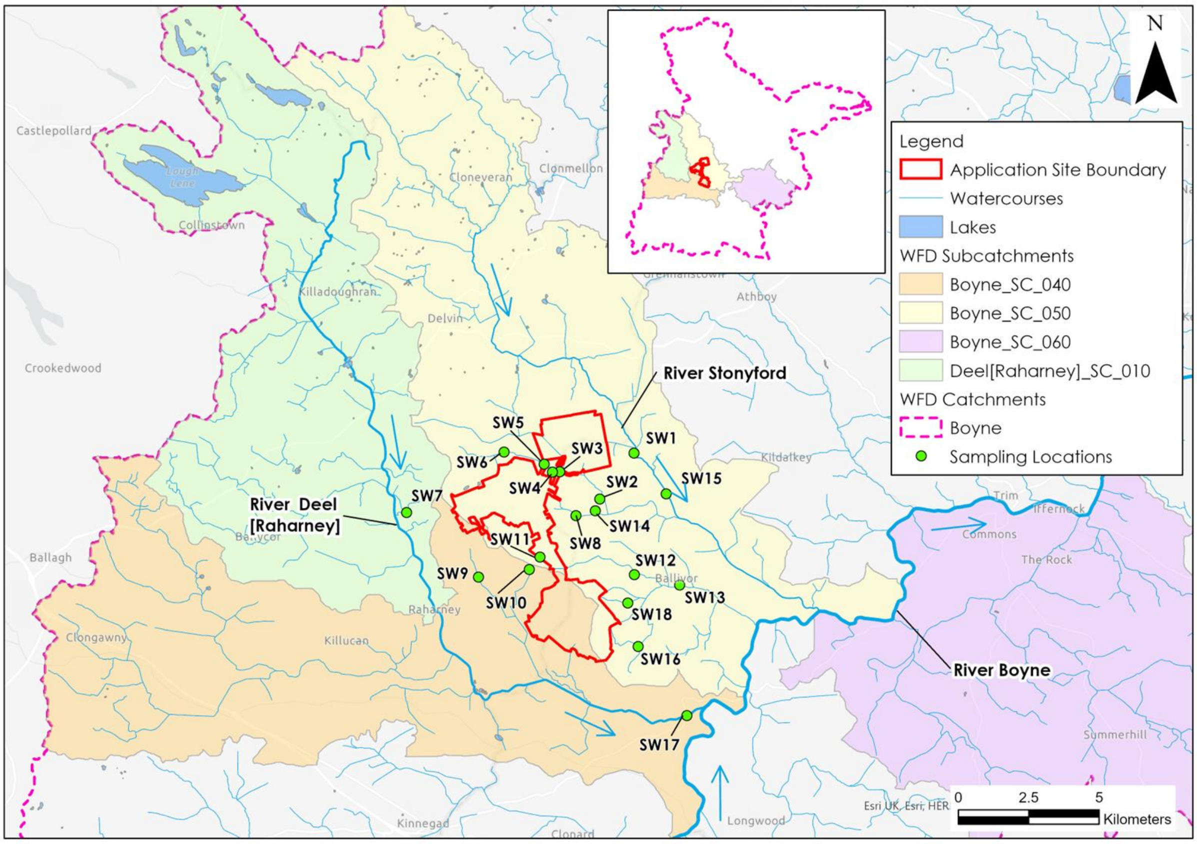

Figure B: Regional Hydrology Map

3.2.2 Rainfall and Evaporation

The SAAR (Standard Average Annual Rainfall) recorded at Ballivor (~4.5km to the east), the closest rainfall station to the proposed site with long term SAAR data, is 839mm (www.met.ie). The average potential evapotranspiration (PE) at Mullingar, approximately 17km west of the proposed site is taken to be 445mm (www.met.ie). The actual evapotranspiration (AE) is calculated to be 423mm (95% PE). Using the above values, the effective rainfall (ER)[2] for the area is calculated to be (ER = SAAR – AE) ~416mm/yr.

Based on recharge coefficient estimates from the GSI (www.gsi.ie), an estimate of 4% recharge is taken for the proposed site as an overall average. This value is for “Peat” with a “Low” to “Moderate” vulnerability rating. Areas, where peat is absent, may have slightly higher recharge rates, but on this proposed site, these areas are generally very small and localised. The high drainage density in the area would also suggest that recharge rates are very low.

The lowest value in the available range was chosen to reflect the large coverage of blanket peat and high drainage density. Therefore, annual recharge and runoff rates for the proposed site are estimated to be 17mm/year and 399mm/year respectively.

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

Table A below presents return period rainfall depths for the area of the proposed 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). These extreme rainfall depths will be the basis of the proposed wind farm drainage hydraulic design as described further below.

Table A. Ballivor WF Site Rainfall Return Period Depths (mm)

	Return Period (Years)			
Duration	**1**	**5**	**30**	**100**
5 mins	3.5	5.5	9.0	12.1
15 mins	5.7	9.1	14.7	19.9
30 mins	7.4	11.6	18.5	24.7
1 hours	9.6	14.8	23.1	30.4
6 hours	19.1	28.0	41.3	52.6
12 hours	25.0	35.8	51.8	65.1
24 hours	32.6	45.7	64.8	80.5
2 days	38.5	52.8	73.2	89.5

**Estimated using growth factors as data not available from (www.met.ie)*

3.3 GEOLOGY

The published soils map (www.epa.ie) for the area shows that cutover/cutaway peat is mapped almost exclusively over the proposed site. Soils in the surrounding lands are predominantly basic deep well drained mineral soils (BminDW) with smaller areas of basic deep poorly drained mineral soils (BminPD), poorly drained soils with a peaty topsoil (BminPDPT) and basic shallow well drained soils (BminSW). Mineral alluvium (AlluvMin) is mapped along local watercourses surrounding the proposed site.

The published subsoils map (www.gsi.ie) shows cut over raised peat (Cut) underlies the proposed site. Other subsoil types mapped in the wider area include Glacial Tills derived from Limestone (TLs) and Gravels derived from Limestone (GLs). An area of Till derived from cherts (TCh) is mapped to the southeast of Lisclogher Bog. The borrow pit (BP2) to the south of Bracklin Bog is mapped on limestone derived gravels.

The soils and subsoils present at the proposed site have been verified during site walkover surveys and intrusive site investigations. A total of 457 no. peat probes completed at the proposed site reveal a peat depth range of 0.4 to 5.7m with an average of 1.93m. Subsoils encountered during the peat probing investigations and 78 no. trial pits consisted of glacial tills comprising slightly sandy gravelly silt/clay and/or silty sands and gravels with come cobbles and boulders. A local subsoils map is attached below as **Figure C**.

The underlying bedrock geology at the proposed site is mapped by the GSI as being Dinantian Pure Unbedded Limestones (DPUL, comprising Waulsortion Limestone) and Dinantian Upper Impure Limestones (DUIL) (comprising the Lucan Formation and the Tober Colleen Formation) (refer to **Figure D** below). These types of rocks are classified as Locally Important Aquifer - bedrock which is Moderately Productive only in Local Zones – and as a Poor Aquifer – bedrock which is generally unproductive except for Local Zones – respectively by the GSI (www.gsi.ie).

The Waulsortian Limestones, of lower Visean age, underlie the majority of the proposed site and consist of dominantly grey, crudely bedded or massive limestones. Meanwhile, the northeast of Bracklin Bog and the west of Lisclogher Bog are underlain by the limestone shales of the Lucan Formation and calcareous shale and limestone conglomerates of the Tober Colleen Formation which are Dinantian in age. No bedrock exposures were noted during the walkover surveys.

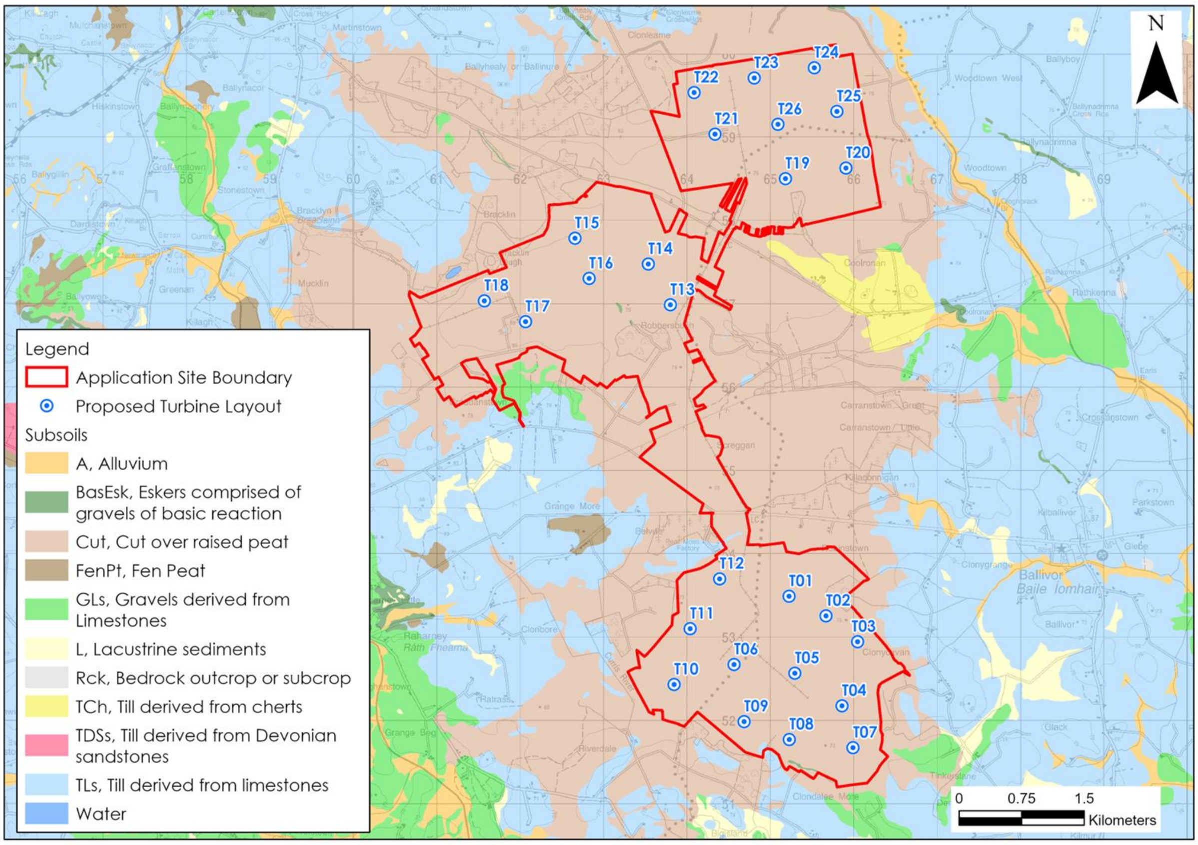

Figure C: Local Subsoils Map

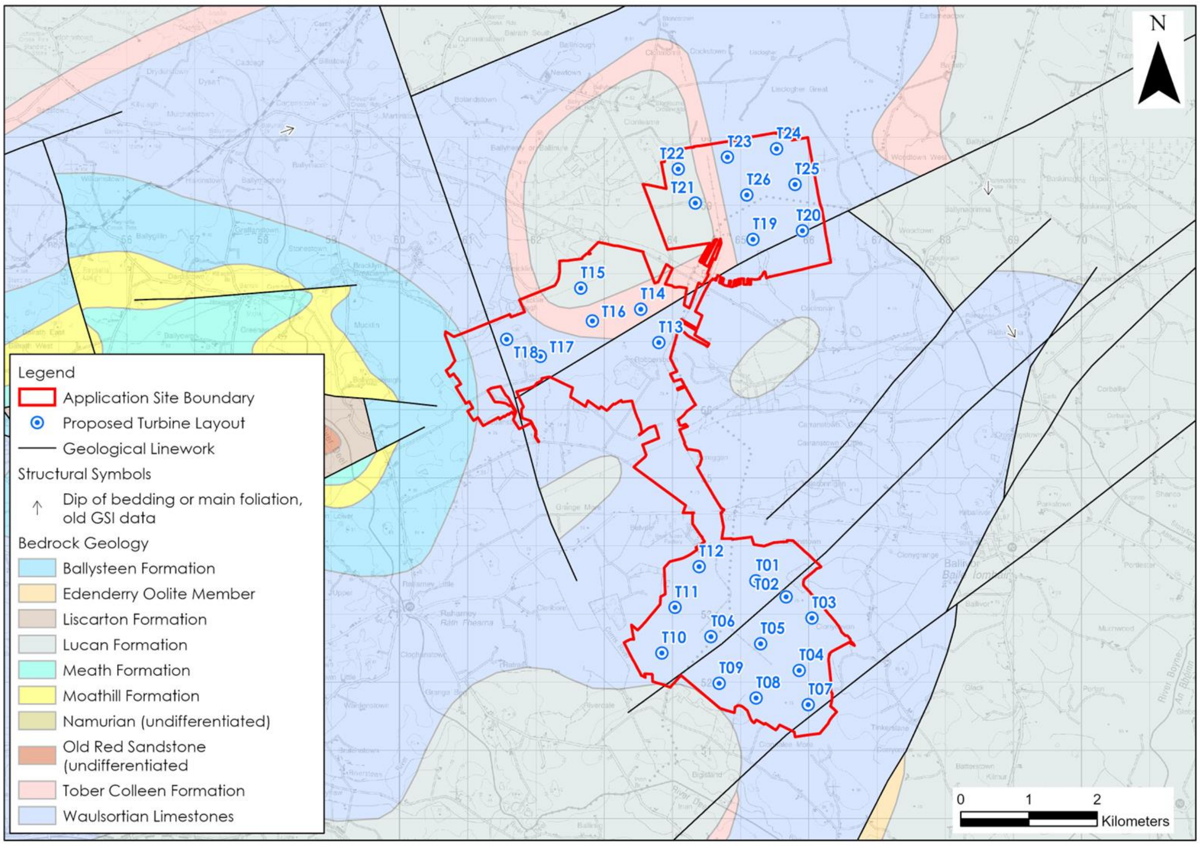

Figure D: Bedrock Geology Map

3.4 SITE DRAINAGE

3.4.1 Existing Site Drainage

Surface water is drained from the proposed site via a network of field drains typically spaced at 15 to 20m intervals, piped drained drains, main drains, headland drains, and silt ponds. These drains discharge to collector/headland drains along the perimeter of the bog, which eventually discharges to a series of large silt (settlement) ponds. Drainage is then discharged to off-site drainage channels which flow into the local river network. The proposed site is primarily drained by gravity however historical records do indicate that pumps have been used in the past to facilitate the drainage of Ballivor bog. They are no longer in operation.

A flow diagram for the existing drainage system is shown as **Figure E** below.

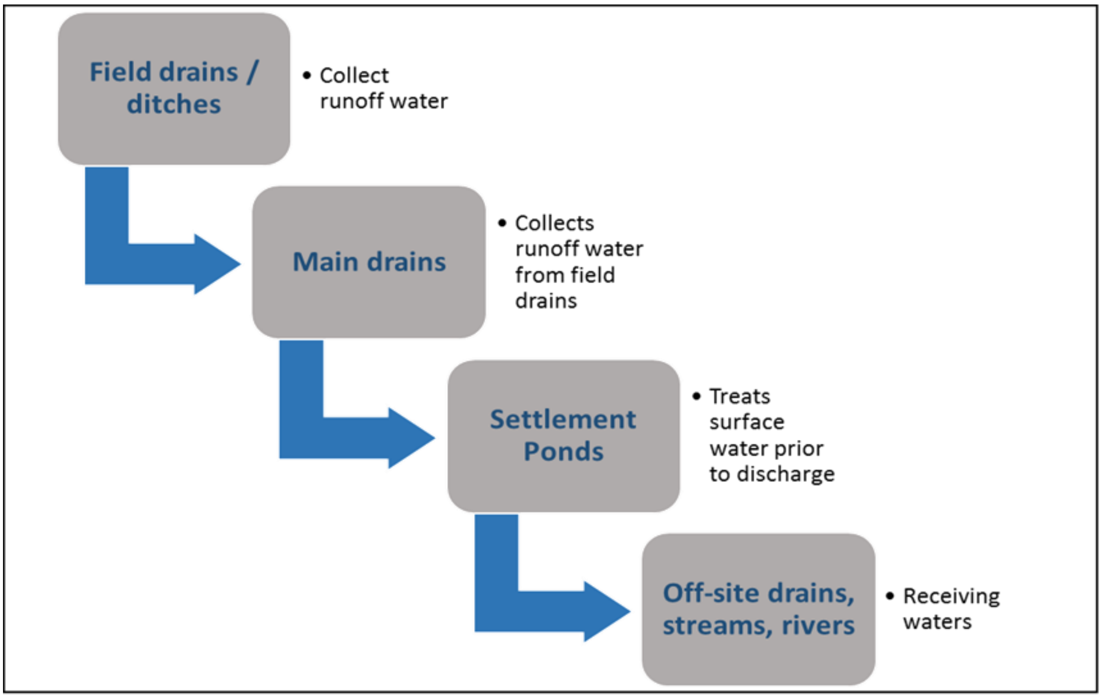

Figure E: Process Flow Diagram for the Existing Site Drainage System

A detailed hydrological audit of flowpaths from each bog to its eventual discharge point at the regional catchment scale was conducted for the 4 no. bogs comprising the proposed site. The flowpaths are shown as **Figure F** to **Figure I**.

The surface of Ballivor Bog is drained by a network of northwest/ southeast orientated drains that are typically spaced every 15 to 20m.. All 7 no. settlement ponds which form part of the drainage system for Ballivor Bog are located within the proposed site. Drainage from Ballivor Bog discharges through 6 no. outfalls (SW35, SW38, SW39, SW40, SW41 and SW41A) which discharge to off site drains and small local watercourses. Several of these watercourse have been named by the EPA (www.EPA.ie). In the southwest of Ballivor Bog, SW41A discharges to Clondalee_More stream which discharges to the Deel River. These waterbodies are mapped by the WFD as the Deel(Raharney)_060 surface waterbody (SWB). Further downstream, the Deel River discharges into the Boyne_050 SWB. The SW35, SW38 and SW39 outfalls, located in the northeast of the bog, discharge to several unnamed drains/streams, which then discharge to the Ballivor River. In the southeast of the bog outfalls SW40 and SW41 outfall to the Derryconor stream, which then discharges to the Ballivor River. The Ballivor River at this location is mapped as the Boyne_060 SWB by the WFD. Further downstream the Ballivor River confluences with the River Boyne (i.e Boyne_060 SWB). The River Boyne then continues through segments Boyne_070 to Boyne_180 before becoming tidal in the Boyne Estuary to the west of Drogheda.

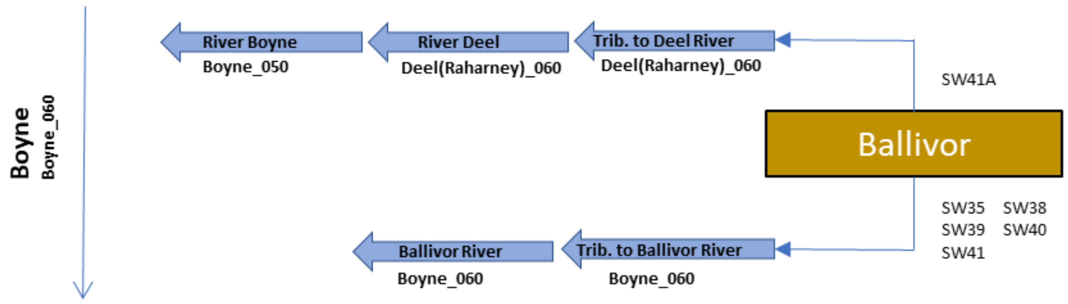

Figure F: Existing Drainage Within Ballivor Bog

The surface of Carranstown Bog is drained by a network of northwest-southeast oriented drains, typically spaced at 15m intervals. Drainage from Carranstown Bog discharges via 4 no. outfalls (SW31, SW32, SW33 and SW34). In the west, SW31 discharges to the Grange More stream which in turn discharges to the Craddanstown stream before discharging into the Deel River to the southwest of Ballivor Bog. These waterbodies are mapped within the Deel(Raharney)_060 SWB. Downstream, the Deel River discharges into the Boyne_050 SWB. In the southeast of Carranstown Bog, and outside of the proposed site boundary, the SW34 outfall discharges to the Killaconnigan stream, which in turn discharges to the Ballivor River southwest of Ballivor village. Here the Ballivor River is mapped within the Boyne_060 SWB. In the northeast of the bog, and outside of the proposed site boundary, SW32 outfalls to the Craddanstown Little stream which discharges into the Cartenstown stream and eventually into the Stonyford River to the east of the Carranstown Bog. These waterbodies are mapped within the Stoneyford_040 SWB. Further downstream the Stoneyford River reaches a confluence with the River Boyne (Boyne_070 SWB). The river Boyne then continues through segments Boyne_080 to Boyne_180 before becoming tidal to the west of Drogheda.

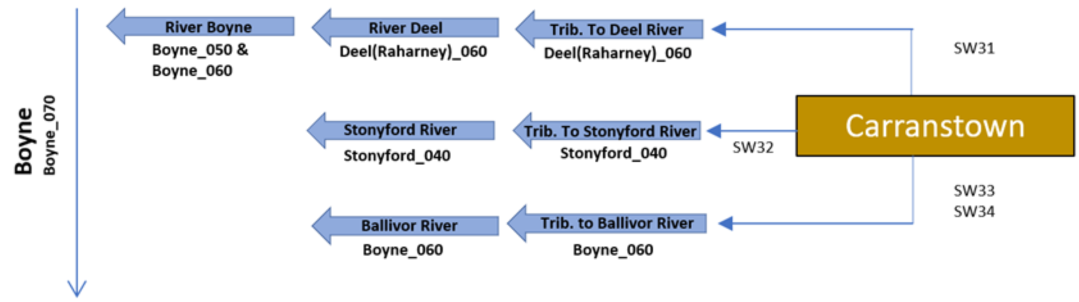

Figure G: Existing Drainage Within Carranstown Bog

Bracklin Bog is drained by a series of drains spaced at approximately 15m intervals. These drains have become overgrown since production stopped within this bog. Mineral soil can be observed from aerial photographs, indicating the peat has been essentially stripped. The western portion of Bracklin Bog (i.e. Bracklin West) contains east-west oriented drains. Drainage from Bracklin Bog discharges via 5 no. outfalls (SW26, SW27, SW28, SW29 and SW30), with all outfalls being located in Bracklin West and outside of the proposed site boundary. SW28, SW29 and SW30 discharge to the Greenan stream and the Ballynaskeagh stream respectively before discharging into the Deel River. These waterbodies are mapped in the Deel(Raharney)_030 SWB. The Deel River continues through segments Deel(Raharney)_040 and Deel(Raharney)_050. SW26 and SW27 outfall to the Craddanstown stream which forms part of the Deel(Raharney)_060 SWB. Downstream the Deel River discharges into the Boyne_050 SWB.

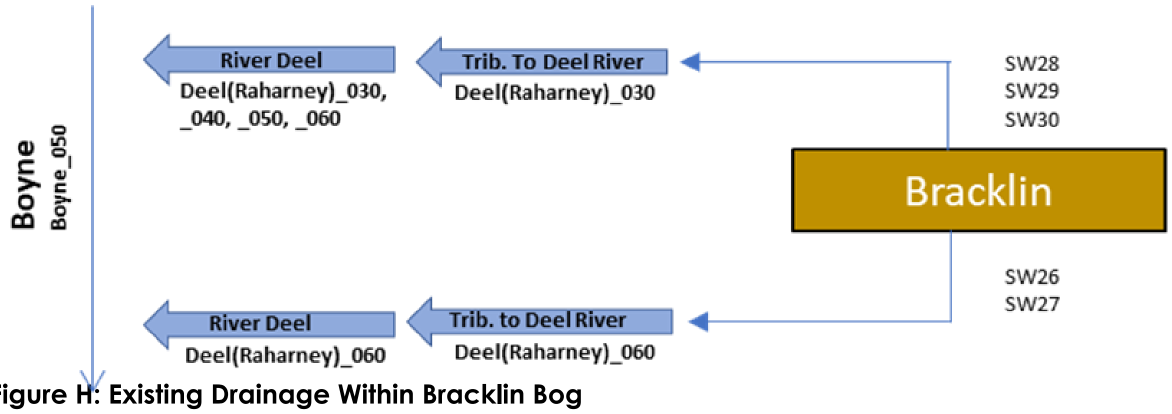

Figure H: Existing Drainage Within Bracklin Bog

Lisclogher Bog is drained by east-west oriented drains, spaced at approximately 15m intervals. There are larger arterial drains running east-west also, but much of the drainage channels have become overgrown since production ceased in the 1990s. The Bord na Móna Decommissioning and Rehabilitation Plan for Lisclogher Bog (2022) states that the drainage system is beginning to break down with many drains becoming blocked and filling with water. Drainage from Lisclogher Bog discharges via 1 no. outfall (SW25) located in the northeast of the bog. SW25 discharges to an unnamed stream which in turn discharges to the Stoneyford River. These waterbodies are mapped in the Stoneyford_030 SWB. The Stoneyford River continues through the Stoneyford_040 waterbody before discharging into the Boyne_070 SWB.

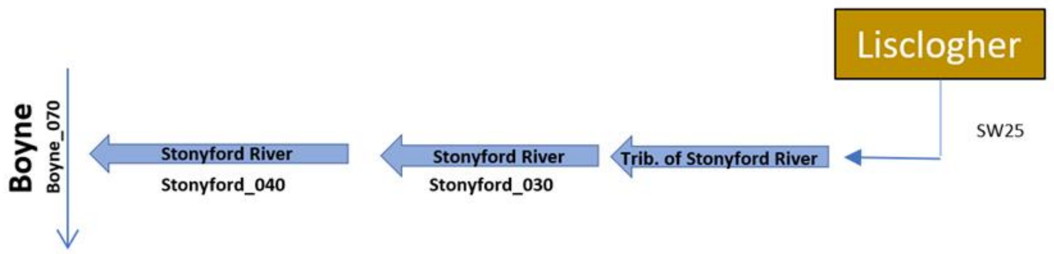

Figure I: Existing Drainage Within Lisclogher Bog

Additional, Bord na Móna drainage mapping is available for 3 of the 4 no. bogs comprising the proposed site (Ballivor, Bracklin and Carranstown bogs). The respective settlement ponds and their outfall pipe elevations are presented in **Table B** below.

Outfall pipe elevations range from 66.99 – 79.13m OD (metres above Ordnance Datum) with the greatest outfall elevations recorded in Bracklin bog. Outfalls generally discharge to nearby surface water bodies as mapped by the EPA or into smaller drains that flow towards these mapped watercourses.

Table B: Bord na Móna outfall elevations

Settlement Pond ID	Easting	Northing	Bog Name	Outfall Pipe Elevation (m OD)	Nearby Surface Waterbody
BR262	264995	251803	Ballivor	68.36	Clondalee More Stream
BR47	266375	251586	Ballivor	66.77	Ballivor River
BR48	266361	251599	Ballivor	66.99	Ballivor River
BR46	265879	253460	Ballivor	71.59	Unnamed waterbody which discharges into Ballivor River
BR45	265867	253506	Ballivor	71.47	Unnamed waterbody which discharges into Ballivor River
BR42	265139	254113	Ballivor	N/A	N/A
BN35&36	259502	257627	Bracklin	77.26	Graffasntown Stream

Settlement Pond ID	Easting	Northing	Bog Name	Outfall Pipe Elevation (m OD)	Nearby Surface Waterbody
BN33	259429	256879	Bracklin	77.95	Ballynaskeagh Stream
BN34	259437	256862	Bracklin	77.64	Ballynaskeagh Stream
BN31&32	260577	256515	Bracklin	79.13	N/A
BN39	260945	256769	Bracklin	N/A	N/A
CN38&39	265306	255941	Carranstown	67.97	N/A
CN40	265648	254796	Carranstown	70.08	Killaconnigan Stream
CN41	265874	254978	Carranstown	N/A	Killaconnigan Stream

3.4.2 Proposed Site Drainage

The proposed wind farm drainage will not significantly alter the existing drainage regime at the proposed site. Moreover, the proposed drainage system will be fully integrated into the existing bog drainage systems.

Existing field drains and main drains will be routed under/around proposed wind farm access tracks using culverts as required.

Runoff from access tracks, turbine bases, and developed areas (construction compounds, sub-station, met masts etc) will be collected and treated in local (proposed) silt traps and settlement ponds and then discharged to existing local peat field drains. From there this water will flow towards the proposed site boundaries in field drains and main drains) and be treated further in the existing main settlement ponds prior to discharge from the proposed site.

3.5 DEVELOPMENT WATER BALANCE

There are existing surface water control measures at the bog which comprise field drains, main drains, and settlement (silt) ponds. All these existing drainage measures offer some surface water attenuation during rainfall events.

However, as part of the proposed wind farm drainage, it is proposed that runoff from the proposed infrastructure will be collected locally in new proposed collector drains and settlement ponds prior to release into the existing bog drainage networks. The new proposed drainage measures will then in effect create additional attenuation to what is already present across each of the bog units. The net effect of this will be a reduction in the overall runoff coefficient of the bogs as demonstrated by the use of the Rational Method in

Table C below.

Based on a conservative reduction in the runoff coefficient from 0.96 to 0.85 for the overall proposed site, there will be a potential 11% reduction in runoff volumes from the proposed site. This assessment demonstrates that there will be no risk of exacerbated flooding down-gradient of the proposed site as a result of the Proposed Development.

Table C. Ballivor – Water Balance Assessment

Site Area	C[1]	Area (m^2)	Rc[2]	Rainfall Intensity (mm/hr)	Runoff Rate (m^3/s)	Total Site Runoff Rate (m^3/s)
Without Wind Farm Drainage Control						
Undeveloped Area	2.78	17,178,300	0.96	0.0526	867,435	894,876
Proposed Development Footprint	2.78	521,700	1.00	0.0526	27,441	
With Wind Farm Drainage Control						
Undeveloped Area	2.78	17,178,300	0.85	0.0526	768,041	794,110
Proposed Development Footprint	2.78	521,700	0.95	0.0526	26,069	
Estimated Potential Reduction in Site Runoff Rate						**11%**

Notes: 1 – Constant, 2- Runoff Coefficient

4. SITE-SPECIFIC FLOOD RISK ASSESSMENT

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.

4.2 FLOOD RISK ASSESSMENT PROCEDURE

This section of the report details the site-specific flood risk assessment carried out for the proposed site and surrounding area. The primary aim of the assessment is to consider all types of flood risks and the potential impact on the development. As per the relevant 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;
- *Initial flood risk assessment* - confirm sources of flooding that may affect a proposed development; and,
- *Detailed flood risk assessment* – quantitative appraisal of the potential risk to a proposed development.

As per the Guidelines, there are essentially two major causes of flooding:

Coastal flooding, which is caused by higher sea levels than normal, largely as a result of storm surges, resulting in the sea overflowing onto the land. Coastal flooding is influenced by the following three factors, which often work in combination:

- High tide level;
- Storm surges caused by low barometric pressure exacerbated by high winds (the highest surges can develop from hurricanes); and,
- Wave action, which is dependent on wind speed and direction, local topography and exposure.

Coastal Flooding is not applicable to the proposed site.

Inland flooding which is caused by prolonged and/or intense rainfall. Inland flooding can include a number of different types:

- Overland flow occurs when the amount of rainfall exceeds the infiltration capacity of the ground to absorb it. This excess water flows overland, ponding in natural hollows and low-lying areas or behind obstructions. This occurs as a rapid response to intense rainfall and eventually enters a piped or natural drainage system.

- River flooding occurs when the capacity of a watercourse is exceeded or the channel is blocked or restricted, and excess water spills out from the channel onto adjacent low-lying areas (the floodplain). This can occur rapidly in short steep rivers or after some time and some distance from where the rain fell in rivers with a gentler gradient.

- Flooding from artificial drainage systems results when flow entering a system, such as an urban stormwater drainage system, exceeds its discharge capacity and the system becomes blocked, and/or cannot discharge due to a high-water level in the receiving watercourse. This mostly occurs as a rapid response to intense rainfall. Together with overland flow, it is often known as pluvial flooding. Flooding arising from a lack of capacity in the urban drainage network has become an important source of flood risk, as evidenced during recent summers.

- Groundwater flooding occurs when the level of water stored in the ground rises as a result of prolonged rainfall to meet the ground surface and flows out over it, i.e. when the capacity of this underground reservoir is exceeded. Groundwater flooding tends to be very local and results from interactions of site-specific factors such as tidal variations. While water levels may rise slowly, they may be in place for extended periods. Hence, such flooding may often result in significant damage to property rather than be a potential risk to life.

- Estuarial flooding may occur due to a combination of tidal and fluvial flows, i.e., the interaction between rivers and the sea, with tidal levels being dominant in most cases. A combination of high flow in rivers and a high tide will prevent water flowing out to sea, tending to increase water levels inland, which may flood over riverbanks.

The Flood Risk Management Guidelines (DoEHLG, 2009) provide direction on flood risk and development. The guidelines recommend a precautionary approach when considering flood risk management and the core principle of the guidelines is to adopt a risk-based sequential approach to managing flood risk and to avoid development in areas that are at risk. The sequential approach is based on the identification of flood zones for inland and coastal flooding.

Flood zones are geographical areas within which the likelihood of flooding is in a particular range, and they are a key tool in flood risk management within the planning process as well as in flood warning and emergency planning.

There are three types or levels of flood zones defined within the guidelines:

Flood Zone A – where the probability of flooding from rivers and the sea is highest(greater than 1% (AEP)[3] or 1 in 100 for river flooding or 0.5% (AEP) 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% (AEP) or 1 in 1000 and 1% (AEP) or 1 in 100 for river flooding and between 0.1% (AEP) or 1 in 1000 year and 0.5% (AEP) or 1 in 200 for coastal flooding); and,

Flood Zone C – where the probability of flooding from rivers and the sea is low (less than 0.1% (AEP) or 1 in 1000 for both river and coastal flooding). Flood Zone C covers all areas of the plan which are not in zones A or B.

Once a flood zone has been identified for a site, the guidelines set out the different types of development appropriate to each identified zone (pg. 25, Table 3.1 of the Guidelines). Exceptions to the restriction of development due to potential flood risks are provided for

3 *AEP – Annual Exceedance Probability*

through the application of a Justification Test (JT), where the planning need and the sustainable management of flood risk to an acceptable level must be demonstrated by the applicant.

The Justification Test (JT) has been designed to rigorously assess the appropriateness, or otherwise, of particular developments that, for the reasons outlined above, are being considered in areas of moderate or high flood risk. The test is comprised of two processes.

- The first is the **Plan-making Justification Test** described in chapter 4 of the Guidelines and used at the plan preparation and adoption stage where it is intended to zone or otherwise designate land which is at moderate or high risk of flooding. Plan making Justification Tests are made at Plan/Policy development stage such as County Development Plans, or Local Area Plans.

- The second is the **Development Management Justification Test** described in chapter 5 of the Guidelines and used at the planning application stage where it is intended to develop land at moderate or high risk of flooding for uses or development vulnerable to flooding that would generally be inappropriate for that land. For example, application of Development Management Justification Test would be required at a site-specific level, such as for this FRA assessment, if a Justification Test is required.

4.3 FLOOD RISK IDENTIFICATION

4.3.1 Historical Mapping

To identify those areas as being at risk of flooding, historical mapping was consulted and reviewed. There is no text on local available historical 6" or 25" mapping that identify areas that are "*prone to flooding*" within the proposed site.

4.3.2 Soils Maps - Fluvial Maps

A review of the soil types in the vicinity of the proposed 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 proposed site. Alluvium (fluvial deposits) is recorded along the Stoneyford River, to the east of the proposed site and the Deel River to the west. Alluvium is also mapped locally on many of the tributaries of these rivers which drain the wider bog group. In general, however, there is no significant alluvium deposition that would be associated with a flood plain or a large geographical area prone to flooding.

The EPA/GSI soil map for the area and on-site investigations reveal that the proposed site is underlain by poorly draining, waterlogged peaty soils. This would indicate that the area is historically prone to high water table levels. However, extensive drainage has occurred in the area for peat production and extraction and has lowered the local water table.

4.3.3 OPW National Flood Hazard Mapping

The OPW National Flood Hazard Maps have no records of any recurring or historic flood incidences within the proposed site (www.floodinfo.ie).

The closest mapped historic flood event is found approximately 300m east of Ballivor Bog at Cloneycavan (Flood ID: 10583). This flood event dates from 14th August 2008 and is described in as follows: "*After very heavy and prolonged rainfall in the Boyne Catchment area flooding occurred in several parts of the catchment*". A photograph taken of this flood event on 16th

August 2008 in Cloneycavan is included below as **Figure J**. A second historic flood event (Flood ID: 10586) dating from August 2008 is reported on the River Deel south of Raharney in the Anadruce area, approximately 3km southwest of Ballivor.

Several recurring flooding incidences (Flood ID: 2714, 2715, 2716) are mapped to the southwest of Raharney village along the R156 and in the vicinity of Kilucan (refer to **Figure K**) . A report from the Mullingar Area Engineer states that some of these recurring flood incidents are due to annual flooding of low-lying land after heavy rain (Flood ID: 2715 and 2716). While a stream to the east of Kilucan overflows its banks following heavy rainfall (Flood ID: 2714).

Meanwhile downstream of the proposed site a historic flood event (Flood ID: 1954) dating from November 2002 is mapped on the Boyne at Derrindaly Bridge. Further downstream several historic and recurring flood incidents on the Boyne are recorded at Trim.

Figure J: Flooding in the Cloneycavan area, to the east of Ballivor Bog on 16th August 2008 (www.floodmaps.ie).

According to the OPW (www.floodmaps.ie), sections of the proposed site are classified as "*Benefiting Lands*". Benefiting lands are defined as a dataset 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. These lands tend to be located around the main rivers and streams which drain the individual bog basins.

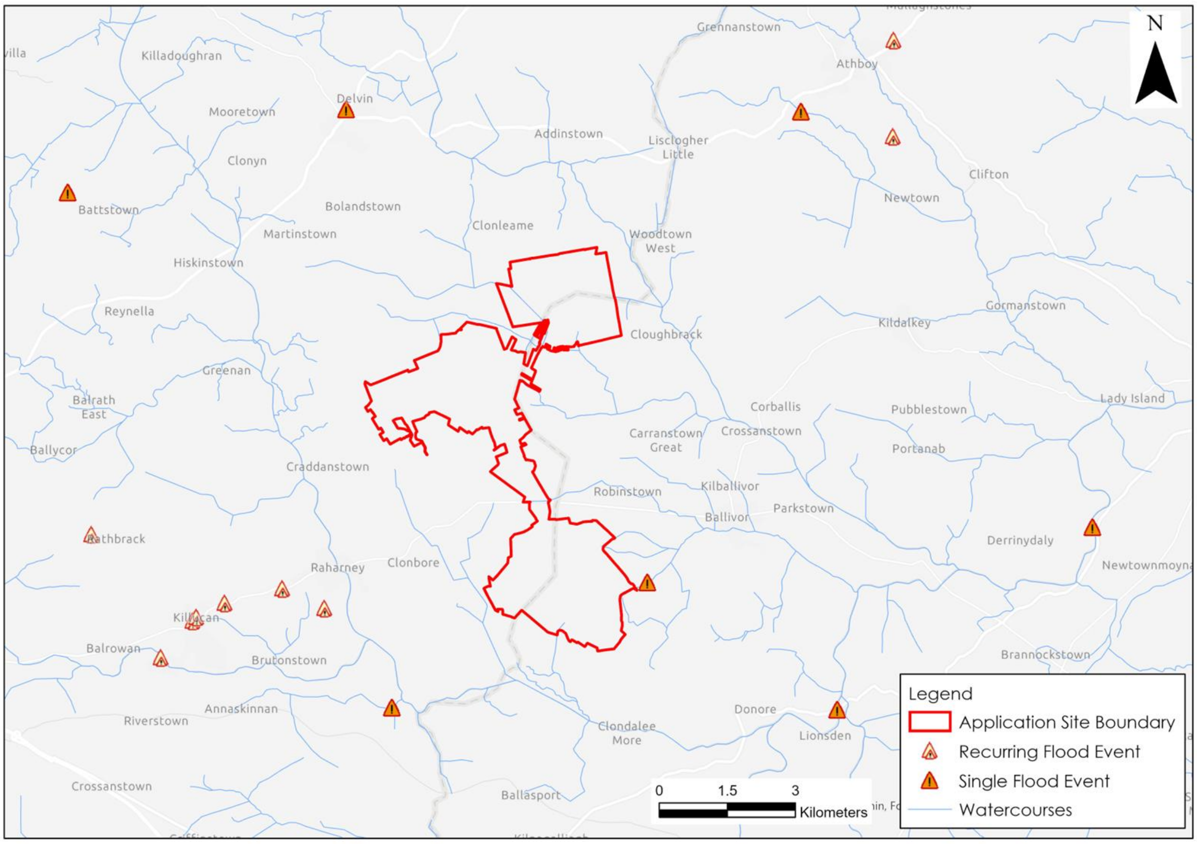

Figure K: OPW Indicative Flood Map (www.floods.ie)

4.3.4 OPW National Indicative Fluvial Flood Mapping

The OPW National Indicative Flood Maps (available at www.Floodinfo.ie) shows the modelled extent of land that might be flooded by rivers during a flood event with an estimated probability of occurrence. These flood maps have been produced for catchments greater than 5km^2 in areas for which flood maps were not produced under the National CFRAM Programme.

For the present day scenario, which does not consider the effects of climate change, the OPW have mapped potential flood extents for waterbodies draining the proposed site. The low (1,000-year flood event) and medium (100-year flood event) probability fluvial flood zones are recorded along the Stonyford and Deel (Raharney) Rivers to the east and west of the proposed site respectively. These modelled fluvial flood zones along these rivers remain largely localised to the immediate vicinity of the river channel. The vast majority of the proposed site is not mapped within the 100-year and 1,000-year flood zones and is therefore located in Flood Zone C and is at Low Risk of fluvial flooding.

However, fluvial flood zones however are also mapped along the Cartenstown stream, a tributary of the Stonyford River. These modelled flood extents encroach upon the proposed site, with areas towards the centre of Lisclogher Bog mapped within the medium probability fluvial flood zone. However site walkovers have revealed that Cartenstown Stream, mapped by the EPA to flow south-eastwards across Lisclogher Bog, does not exist. Such small local errors are infrequent in EPA mapping; however they do exist especially where manmade drainage has been imposed upon natural drainage regimes. This error casts doubt on the validity of the mapped flood zones as the modelling assumes the presence of the Cartenstown stream in this area of the proposed site.

No fluvial flood zones are mapped within Bracklin, Carranstown or Ballivor Bogs. The closest mapped fluvial flood zones to the west of Bracklin Bog are found along the Greenan stream to the northwest of the proposed site. Meanwhile, widespread fluvial Flood Zone A is mapped to the southwest of Ballivor Bog along the Craddanstown stream and the River Deel further south.

4.3.5 CFRAM Fluvial Flood Mapping

Catchment Flood Risk Assessment and Management (CFRAM)[4] OPW Flood Risk Assessment Maps are now the primary reference for flood risk planning in Ireland.

CFRAM mapping has been completed downstream of the proposed site near Ballivor Village. CFRAM mapping has also been completed on the Stoneyford and Boyne Rivers further to the southeast and downstream of the proposed site.

The modelled CFRAM flood extents at Ballivor show flood levels of 64.19 to 65.34m OD for the 10-year and 100-year flood events respectively (refer to **Table D** below). Note these flood elevations are well below the pipe outfall elevations in **Table B**.

Table D: CFRAM Modelled Fluvial Water Levels (www.floodmaps.ie)

Node Label	Location Description	10% AEP WL (mOD)	1% AEP WL (mOD)	0.1% AEP WL (mOD)
00069	Ballivor River, ~1.4km east of Ballivor Bog	64.64	65.28	65.64
00023	Ballivor River, ~1.7km east of Ballivor Bog	64.19	64.77	65.11
00425	Stoneyford River, ~2km southeast of Carranstown Bog	64.82	65.34	65.66

4 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.

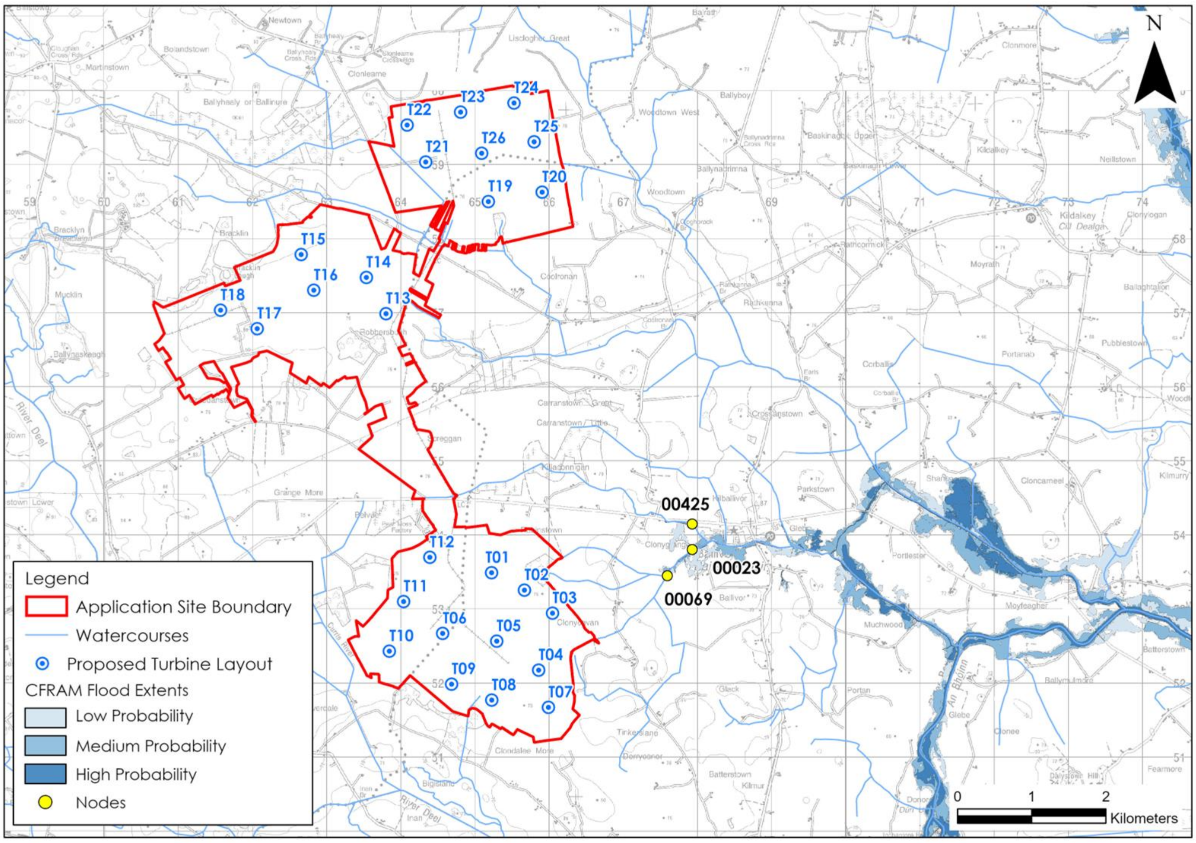

Figure L: CFRAM Fluvial Flood Mapping (www.floodinfo.ie)

4.3.6 GSI Historical Surface Water Flood Mapping

The GSI Historical 2015/2016 surface water flood map[5] does not record any mapped flood areas within the proposed site. A small area of surface water flooding is recorded to the northwest of Bracklin Bog and is associated with Bracklin Lough. No development infrastructure is located within 300m of this existing lake waterbody.

4.3.7 Local Authority SFRA Flood Mapping

Local Authority Strategic Flood Risk Assessment (SFRA) mapping obtained from Meath and Westmeath County Councils (www.westmeathcoco.maps.arcgis.com and www.meath.maps.arcgis.com) is shown below in **Figure M**.

Within County Meath, no significant fluvial flood zones are found to encroach onto the proposed site. SFRA mapping indicates flooding to the south of Lisclogher Bog on the Cartenstown stream and to the east of Bracklin and northeast of Carranstown bogs. These flood zones do not encroach upon the proposed site apart from a small area in the northeast of Carranstown Bog. Further south flood zones are also mapped along the Ballivor River to the east of Ballivor Bog at Cloneycavan and to the southwest along the Deel River in the townland of Clondalee More.

Within County Westmeath a significant portion of Lisclogher Bog is mapped as Fluvial Flood Zone A (100-yr event). Mapped flooding here is associated with the Stonestown stream. No fluvial flood zones are mapped within Bracklin Bog or the western region of Ballivor Bog. The closest mapped fluvial flood zones to the west of Bracklin Bog are found along the Greenan stream to the northwest of the proposed site. Meanwhile, widespread fluvial Flood Zone A is

5 GSI Historical flood mapping principally developed using Sentinel-1 Satellite Imagery from the European Space Agency Copernicus Programme as well as any available historic records (from winter 2015/2016 or otherwise).

mapped to the southwest of Ballivor Bog along the Craddanstown stream and the River Deel further south.

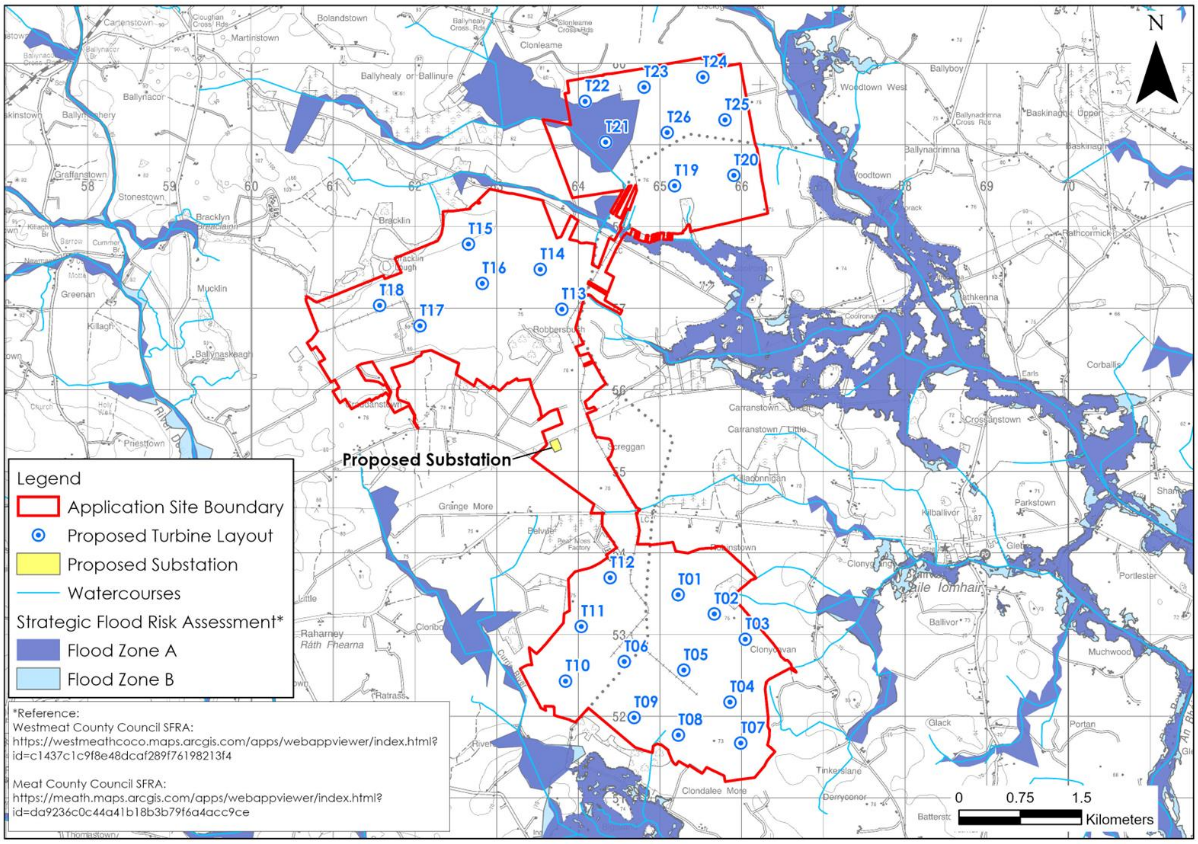

Figure M: Local Authority SFRA flood mapping

4.3.8 Groundwater Flooding

The GSI Historical 2015/2016 groundwater flood map does not record any groundwater flooding within the area of the proposed site. Areas of historic groundwater flooding are mapped in the surrounding lands, the closest of which is found approximately 200m to the south of the Bracklin Bog.

Other areas of groundwater flooding are mapped approximately 1km to the southeast of Ballivor Bog and approximately 1km to the northwest of Lisclogher Bog. These are small-localised areas of groundwater flooding and will not be impacted by the Proposed Development.

In addition the GSI predictive groundwater flood maps do not record any zones of groundwater flooding within the proposed site.

4.3.9 Climate Change

National Indicative Fluvial Flood Mapping has also been completed for several climate change scenarios which assesses the potential changes in fluvial flood extents associated with climate change. Fluvial flood modelling has been completed for 2 no. future scenarios, a Mid-Range Scenario and a High-End Future Scenario. The flood extents for the Mid-Range Future Scenario were modelled using a 20% increase in rainfall. Meanwhile the High-End Future Scenario was modelled using a 30% increase in rainfall and a sea level rise of 1,000mm.

For these future scenarios the modelled fluvial extents do not differ significantly from those described in **Section 4.3.4**. Fluvial flood zones associated with the High-End Future Scenario are shown in **Figure N** below.

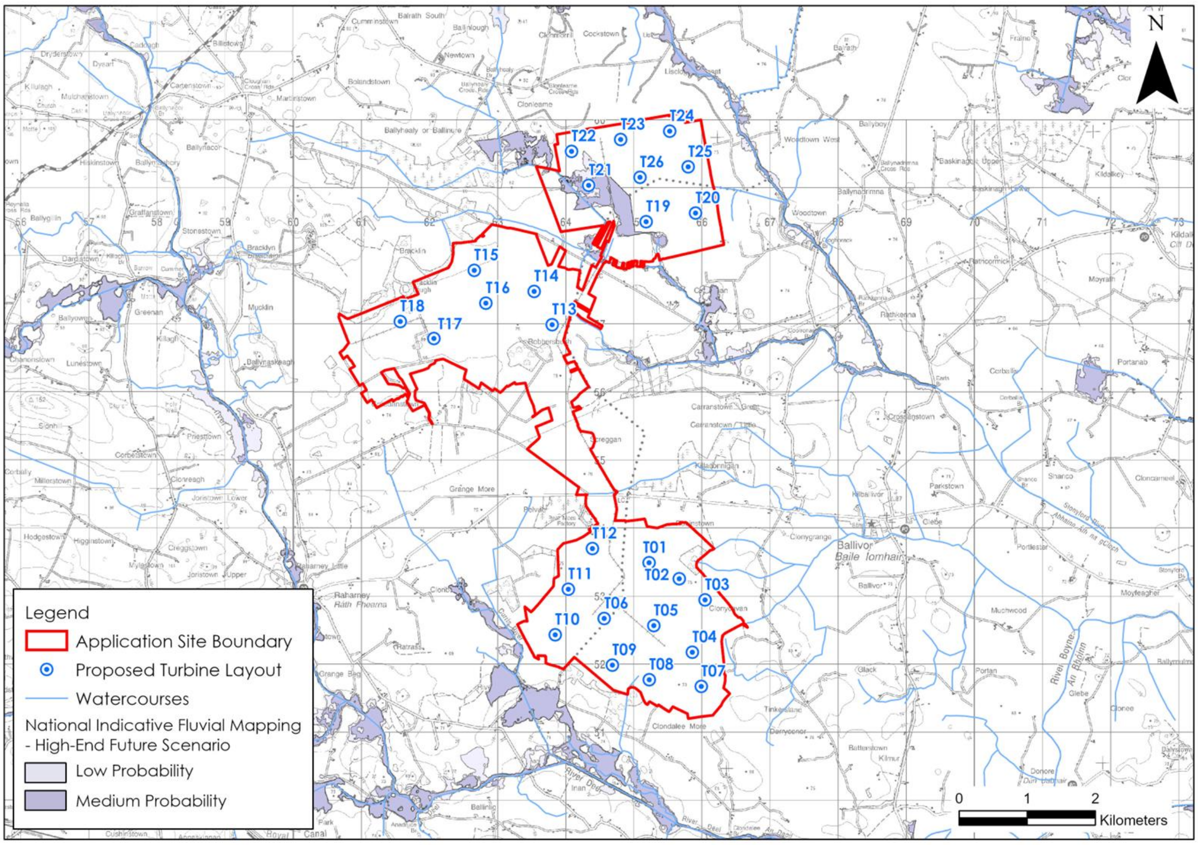

Figure N: High-End Future Scenario Fluvial Flood Zones

4.3.10 Summary – Flood Risk Identification

Based on the information gained through the flood identification process, it appears that part of the proposed site can be affected by fluvial flooding.

While the majority of the proposed site is mapped as Flood Zone C, areas in the northwest of Lisclogher Bog have a mapped high probability of flooding and are mapped within Fluvial Flood
Zone A.

4.4 INITIAL FLOOD RISK ASSESSMENT

4.4.1 Site Walkover Survey

Hydrological walkover surveys and observations on the site drainage patterns were undertaken by HES on 18th May 2020, 15th – 17th September 2020, 05th October 2020, 01st December 2020, 22nd March 2021, 01st April 2021, 20th September 2021, 28th October 2021, 19th January 2022 and 22nd February 2023.

During the site walkover surveys landuse across much of the proposed site was noted as comprising of cutover bog where peat extraction has recently occurred. Note that peat extraction formally ceased at the Ballivor Bog Group in September 2021. The bogs were noted to be drained by regularly spaced field drains which drain towards larger arterial drains. Meanwhile certain areas of the proposed site have become overgrown, with peat production ceasing in these areas some time ago allowing vegetation to recover and recolonise the bare peat fields. At the boundaries of the bogs surface water draining from the site is routed via large settlement ponds prior to discharge to off-site drainage channels which flow into the local rivers and streams.

During the site walkover, an error was observed in the EPA map of local rivers. The EPA map shows the Cartenstown stream to flow to the southeast across Lisclogher Bog. However, site walkover surveys have revealed that this section of mapped river does not exist. Such small (local) errors are infrequent in the digitised EPA river database, but they do exist, especially where manmade drainage has been imposed upon natural drainage patterns. This error also indicates that the SFRA flood zones mapped in this region are incorrect as they assume the presence of a surface watercourse.

Low lying areas within the proposed site were observed to hold surface water following heavy rainfall, but ponding only occurs to very shallow depths, (<0.2m) and only in certain areas does ponding persist in drier periods.

Monitoring of stream discharge in the main streams downstream of the proposed site was undertaken on several occasions at 18 no. monitoring locations on 1st April 2021, 28th October 2021 and 19th January 2021. These data are presented in **Table E** below. The monitoring locations are shown on **Figure B** above.

Table E: Surface Water Flow Monitoring

Location/Date	01/04/2021	28/10/2021	19/01/2022
	Flow(L/sec)	Flow (L/sec)	Flow (L/sec)
SW1	20	5	5
SW2	250	500	400
SW3	40	200	150
SW4	3	15	No flow
SW5	150	500	500
SW6	150	200	200
SW7	75	150	60
SW8	100	300	300
SW9	50	156	50
SW10	20	50	30
SW11	-	0	0
SW12	180	50	30
SW13	240	500	300
SW14	-	20	No Flow
SW15	5000	5000	5000
SW16	250	50	50
SW17	5000	5000	5000
SW18	15	75	40

4.4.2 Hydrological Flood Conceptual Model

Potential flooding in the vicinity of the proposed 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 the most consequence for the proposed site, is pluvial flooding.

During winter conditions the proposed site holds/retains rainwater following heavy rain. The depth of intermittent ponding is shallow (<0.2m). This retention of water on the bogs during such events will reduce downstream flooding risk. Potential receptors in the area are infrastructure, people, land and other private property.

4.4.3 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 site are outlined and assessed in **Table F.**

Table F. S-P-R Assessment of Flood Sources for the Proposed Site.

Source	Pathway	Receptor	Comment
Fluvial	Overbank flooding of the Cartenstown Stream	Land, People, property, infrastructure, River Shannon Callows SAC	According to SFRA mapping and OPW Flood Mapping, areas of Lisclogher Bog are mapped in Fluvial Flood Zone A. However, we have surveyed this area of the proposed site, and we confirm there are no watercourses in this area, and therefore conclude the SFRA mapping is incorrect. This area of the proposed site was noted to contain a high density of surface water drains and should be included in Flood Zone C. The proposed site is located in Fluvial Flood Zone C (Low Risk).
Pluvial	Ponding of rainwater on-site	Land and infrastructure.	The proposed site is generally low lying and flat in places and therefore localised pluvial flood is very likely after heavy or prolonged rainfall.
Surface water	Surface ponding/ Overflow	Land and infrastructure.	Same as above (pluvial)
Groundwater	Rising groundwater levels	Land and infrastructure.	Based on the local hydrogeological regime and GSI groundwater flood mapping, no apparent risk from groundwater flooding.
Coastal/tidal	Not applicable	Land and infrastructure	The proposed site is >50km from the coast and there is no risk of coastal flooding.

4.5 REQUIREMENT FOR A JUSTIFICATION TEST

A matrix of vulnerability versus flood zone is shown in **Table G**. This table is used to illustrate appropriate development types or indicate when a Justification Test[6] is required.

It may be considered that the proposed wind farm can be categorised as "Highly Vulnerable Development". The key development infrastructures including turbines, access roads and the proposed substation location are situated in Flood Zone C. Consequently, the Proposed Development is potentially not at risk of flooding and would not require further justification from a planning perspective.

However, in order to be conservative, and given the risk of pluvial flooding at the proposed site, the sensitivity of the substation and the level of the proposed turbine bases, we have completed a Justification test below in **Section 5.2**. A detailed site-specific flood risk assessment is also completed below (**Section 4.6**) for the proposed substation location.

[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).*

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.*

4.6 DETAILED FLOOD RISK ASSESSMENT FOR PROPOSED SUBSTATION

Due to the sensitivity of the proposed substation, we have completed a detailed assessment to determine a proposed floor level (or formation level) that is above the predicted 1-1000yr pluvial flood level.

The proposed substation is located in the western section of Carranstown Bog. The existing ground levels at the proposed substation location varies between 72.27 to 79.61mOD.

No part of Carranstown West is mapped in any available flood mapping (National Indicative Flood Mapping, CFRAM, Local Authority SFRA mapping, GSI Groundwater flood mapping).

In order to determine if the proposed substation location is above the 1-1000 year flood level (Low Probability) we modelled flood levels by applying 1,000-yr rainfall depths (including a climate change factor of +20%) to the western surface water catchment within Carranstown Bog. Based on available topography and the existing drainage regime at Carranstown Bog, the area to the west of the railway line is the only catchment that can contribute to flooding of the proposed substation location. The area of this catchment is ~0.62km^2. The western portion of Carranstown Bog outfalls to the north, and to the west, and the existing drainage outfalls have been surveyed by BnM and are recorded at elevations >74.12mOD.

For a catchment area of 0.62km^2, the mean annual flood (Using Institute of Hydrology Report 124) discharge from Carranstown West catchment is calculated at 0.15m^3/sec. The estimated 100-yr and 1000-yr flood flows (using growth factors and applying a climate change factor of 1.2) from the north-eastern catchment are (Q100) 0.48m^3/sec and (Q1000) 0.65m^3/sec respectively.

Extreme rainfall depths for the proposed site were determined using the Met Eireann 20 km by 20 km model of rainfall depth-duration-frequency model (www.met.ie). The rainfall totals at different durations and return periods are presented in

Table A.

A lidar survey at a 2m grid interval of the entire Carranstown Bog unit was used to determine the flood volume available in the western catchment of the bog (0.62km^2 catchment) at various water elevations. This information is presented in **Table H**.

Table H shows that significant storage is available within Carranstown West, and this is due to the expanse of the open bog area (0.62km^2), the flat nature of the ground (small increases in water level requires large volumes of water), and the shallow bowl that has been created by previous peat extraction works.
As a preliminary assessment, a conservative volumetric (catchment area × rainfall depth for each return period and storm duration) and flood storage calculation with Q_{100} and Q_{1000} discharges from the catchment was undertaken for various rainfall durations. Under this scenario, the peak storage occurs for a 1-day duration rainfall events in both return periods (T_{100} and T_{1000}), with the storage required for longer duration events being exceeded by the discharge from the catchment over time. A summary of these volumetric calculations is provided in **Table I**.

Using the stage-volume relationship presented in **Table H**, it is possible to calculate the flood elevation for each return period. These are shown in **Table J.**

Table H: Carranstown West – Storage-Volume Relationship

Stage mOD (Malin)	Volume (m^3)
73.25	0
73.50	2.9
73.75	176
74.00	2,175
74.25	9,757
74.5	27,171
74.75.	58,656
75.0	107,342

Table I: Carranstown West - Storage Volumes in T_{100} and T_{1000} rainfall events

Rainfall Event Duration	T_{100} Residual Storage Volume (m^3)	T_{1000} Residual Storage Volume (m^3)
24hrs (1 day)	11,258	28,698
2 days	Discharge > Storage	Discharge > Storage
3 days	Discharge > Storage	Discharge > Storage
4 days	Discharge > Storage	Discharge > Storage
25 days	Discharge > Storage	Discharge > Storage

Table J: Carranstown West – Estimated Flood Levels for T_{100} and T_{1000} rainfall events

Rainfall Event	Estimated Peak Flood Level (mOD Malin)
T_{100}	74.3
T_{1000}	74.6

Summary – Detailed Flood Risk Assessment for Proposed Substation

As outlined above a very conservative volumetric analysis has determined the peak flood levels at the proposed substation site for 100-yr and 1000-yr rainfall events.

The overriding factor in the analysis is the expanse of the bog to the east and southeast substation which has to be filled with pluvial flood water before the substation site can flood.

In addition to the above analysis, a freeboard of 0.3m is added to the determined flood levels to define the required floor/formation level for the substation. Applying this to the T_{1000} flood level gives a required substation floor/formation level of **>74.9mOD**. At this elevation the risk of flooding at the substation site is negligible.

4.7 FLOOD RISK IMPLICATIONS ASSOCIATED WITH THE PROPOSED DECOMMISSIONING AND REHABILITATION PLANS FOR THE BALLIVOR BOG GROUP

Now that peat extraction activity has ceased across the Ballivor Bog Group, including the 4 no. bogs which comprise the proposed site, Bord na Móna's Decommissioning and Rehabilitation Plans will be implemented in in order to fulfil the requirements of Condition 10.2 of the IPC licence No. P0501.

Bord na Móna have devised rehabilitation plans to stabilise and rehabilitate the peat bogs within the Ballivor Bog Group. The plans use bespoke interventions designed to first stabilise the environment and secondly to rehabilitate the proposed site as much as possible by placing the existing peatland environments on a path towards naturally functioning peatlands. Rehabilitation allows a site to naturally colonise with vegetation to stabilise the bare peat production fields and minimise potential downstream water pollution and surface water runoff.

Decommissioning and rehabilitation plans for each bogs comprising the wider Ballivor Bog Group, including proposed site drainage, have been prepared and are summarised below in **Table K**.

Improvements in flow and water quality can be achieved through bog rehabilitation and rewetting at the Ballivor Bog Group. The plans will generally involve the rewetting and revegetation of the drained cutover bogs. The greatest hydrological/hydrogeological effects would be experienced in those areas selected for rewetting following ecological surveying. Rewetting would be achieved through measures such as drain blocking. These plans will likely have a positive effect on hydrogeology within the proposed site where groundwater tables in the peat bogs are stabilised and closer to the bog surface. Water storage capacity within the site will therefore improve and reducing the risk of flooding within the vicinity and downstream of the proposed site. Elsewhere, where rewetting is not suitable the drainage regimes will remain relatively unchanged.

In addition to the standard rehabilitation required by the IPC licence, enhanced rehabilitation measures will be implemented in certain areas of the Ballivor Bog Group (Carranstown East and Bracklin West). The enhanced decommissioning, rehabilitation and restoration measures, referred to as the Peatlands Climate Action Scheme (PCAS), are designed both to exceed/meet the standard requirements as defined by the IPC licence and to enhance ecosystem services by optimising climate action benefits. We note that work associated with PCAS has already begun in Carranstown East. The enhanced restoration, which will include more intensive drain blocking and ground re-profiling, will optimise hydrological conditions and will have benefits for water quality and storage attenuation as well as increased carbon storage and reduced emissions.

With the implementation of the rehabilitation plans and PCAS activities, surface water runoff from the Ballivor Bog Group will be reduced, thereby decreasing the downstream flood risk.

Furthermore the Proposed Development will be constructed with its own drainage system which will provide additional surface water attenuation.

The cumulative effect of the Proposed Development and the Decommissioning and Rehabilitation Plans is that there will be a reduced risk of fluvial flooding downstream of the proposed site.

Table K: Types of Rehabilitation Measures at the Ballivor Bog Group

Bog	Type	Description	Area (Ha)
Lisclogher	Deep Peat Cutover Bog	Regular drain blocking (3 per100 m) and blocking outfalls and managing water levels with overflow pipes	305.7
	Dry Cutaway	Blocking outfalls and managing water levels with overflow pipes	148.7
	Marginal Land	No Work Required	65.5
	Other	Silt Ponds	0.36
Carranstown	Deep peat	More intensive drain blocking (max 7 per 100m), blocking outfalls and Sphagnum inoculation. Berms and field re-profiling (45x60m cell), blocking outfalls and managing overflows & drainage channels for excess water & Sphagnum Inoculation	207.91
	Dry Cutaway 2	Regular drain blocking (3 per 100m) + blocking outfalls and managing water levels with overflow pipes + targeted fertiliser treatment	26.62
	Wetland	Turn off or reduce pumping to re-wet cutaway + blocking outfalls and managing water levels with overflow pipes + Targeted blocking of outfalls within a proposed site + constructing larger berms to re-wet cutaway + transplanting Reeds and other rhizomes. More intensive drain blocking (max 7 per 100m), + blocking outfalls and managing overflows + transplanting Reeds and other rhizomes	9.57
	Marginal Land	No Work Required	45.46
	Other	Silt Ponds, Other Constraints (ROW)	16.1
Lisclogher West	Deep peat	More intensive drain blocking (max 7 per 100m), modifying outfalls	132.6
	Additional Works	Targeted Drain Blocking, where possible	22.2
	Marginal Land	No Work Required	58.1
	Other	Silt ponds, constrained areas	25.4
Ballivor	Deep Peat Cutover Bog	Regular drain blocking (3 per100m) and blocking outfalls and managing water levels with overflow pipes	537.9
	Dry Cutaway	Blocking outfalls and managing water levels with overflow pipes	19.1
	Marginal Land	No Work Required	82.4
	Other	Silt ponds	5.79
Bracklin	Deep Peat Cutover Bog	Regular drain blocking (3 per 100m) and blocking outfalls and managing water levels with overflow pipes	362.4
	Dry Cutaway	Modifying outfalls and managing water levels with overflow pipes	169.9
	Wetland	Modifying outfalls and managing water levels with overflow pipes	12.3
	Marginal Land	No Work Required	221.2
	Other	Silt pond	2.07

5. PLANNING POLICY AND JUSTIFICATION TEST

5.1 PLANNING POLICY AND CDP

The following policies are defined in the Westmeath County Council Development Plan (2021-2027) (**Table L**) and the Meath County Council Development Plan 2021-2027 (**Table M**) 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 L: Westmeath CDP Policy on flooding and reference to relevant sections of this FRA report

No.	Policy	Development Design Response
CPO-10.105	Have regard to the "Guidelines for Planning Authorities on the Planning System and Flood Risk Management" (DoEHLG/OPW 2009) and Circular PL2/2014, through the use of the sequential approach and application of the Justification Tests in Development Management.	As outlined in this FRA, and **Section 4.5**
CPO 10.106	Ensure that a flood risk assessment is carried out for any development proposal within 200m of a watercourse and at risk of flooding, in accordance with the "Guidelines for Planning Authorities on the Planning System and Flood Risk Management" (DoEHLG/OPW 2009). This assessment shall be appropriate to the scale and nature of risk to the potential development.	As outlined in this FRA.
CPO 10.118	Ensure new development is adequately serviced with surface water drainage infrastructure which meets the requirements of the Water Framework Directive, associated River Basin Management Plans and CFRAM Management Plans.	As outlined in this FRA.
CPO 10.119	Require that planning applications are accompanied by a comprehensive SUDs assessment that addresses run-off quantity, run-off quality and its impact on the existing habitat and water quality.	The WF drainage proposals incorporate numerous SuDS elements that reflect the requirements of this policy.

Table M: Meath CDP Policy on flooding and reference to relevant sections of this FRA report

No.	Policy	Development Design Response
INF POL-18	To implement the "Planning System and Flood Risk Management – Guidelines for Planning Authorities" (DoEHLG/OPW, 2009) through the use of the sequential approach and application of the Justification Tests for Development Management and Development Plans, during the period of this Plan.	As outlined in this FRA, and **Section 4.5**
INF POL 30	To implement the findings and recommendations of the Strategic Flood risk Assessment prepared in conjunction with the County Development Plan review, ensuring that climate change is taken into account.	SFRA mapping described in **Section 4.3.7**. Flooding associated with climate change described in **Section 4.3.9**
INF POL 20	To require that a flood risk assessment is carried out for any development proposal, where flood risk may be an issue in accordance with the "Planning System and Flood Risk Management – Guidelines for Planning Authorities" (DoECLG/OPW, 2009). This assessment shall be appropriate to the scale and nature of risk to the potential development.	As outlined within this FRA. Flood zone types defined within **Section 4.3**.

5.2 JUSTIFICATION TEST

Box 5.1 (**Table N** below) of "The Planning System and Flood Risk Management Guidelines" (PSFRM Guidelines) outlines the criteria required to complete the "Justification Test".

Table N: 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 PSFRMG guideline document]:

1. The Proposed Development is currently in the planning process and has been deemed suitable for development by the applicant.
2. The proposal for 26 no. turbine wind farm and associated access tracks, construction compounds, sub-station, cable trench route, grid connection, amenity pathways, carpark and other ancillary works have been the subject of Stage II and Stage III flood risk assessment (this report) and this assessment has shown that:
   i. The Proposed Development has been assessed to have no impact on flood risk elsewhere in the locality.
   ii. The Proposed Development will not impede the flow of surface water during extreme flood events. Drainage designs for the Proposed Development follow SuDS principles and will restrict discharge rates. It is therefore estimated that the development presents minimal risk to people, property, the economy and the environment. In addition, volumetric modelling has demonstrated that the proposed substation site is above the 1000-yr flood level (proposed floor level >74.9mOD). There will be no increase in flood risk on lands upstream or downstream of the proposed site;
   iii. The assessment has shown that there will be no residual risks to the Proposed Development or local area; 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 site.

With regards to the proposed site, it will for the large part remain flood free, but on very rare occasions there is a risk of shallow inundation from pluvial flooding. Surface water discharges from the proposed site are attenuated and will be slowed down below greenfield runoff rates. All drainage from the 4 no. bogs comprising the proposed site is by gravity. There are no operational pumping stations at the site.

Surface water will be held on-site, behind access tracks, in shallow wet areas (as described in **Section 3.4.2**), in low lying areas, in silt traps, in settlement ponds.

Given the large area of the Ballivor Bog Group, the bogs have an enormous capacity to store water following rainfall events, even if storage is only a couple of centimetres in depth, the volume of stored water will be very large.

Overall, during the wind farm operation phase of Proposed Development, water is more likely to be held on-site, and this will have a positive impact on downstream flooding events.

No part of the proposed wind farm infrastructure will flood, and all access roads and turbine bases will be designed to be above known pluvial flood levels.

The proposed substation will be raised to be above the 1 in 1000-year flood level as outlined above (i.e. >74.9mOD).

6. REPORT CONCLUSIONS

- A flood risk identification study was undertaken to identify existing potential flood risks associated with the proposed Ballivor wind farm development in Co. Meath and Co. Westmeath. From this study:
  - No instances of historical flooding were identified in historic OS maps;
  - No instances of recurring flooding were identified on OPW maps within the proposed site;
  - The GSI Historical 2015/2016 flood map does not record any areas of surface water flooding within the proposed site;
  - The GSI Groundwater flood mapping does not record any flood zones within the proposed site;
  - CFRAM maps, for Ballivor village and the surrounding areas, do not show any flood zones within the proposed site; and,
  - Areas of the proposed site were identified within Local Authority SFRA flood zones as described below.
- The Local Authority Strategic Flood Risk Assessment (SFRA) mapping indicates that there are areas of the proposed site are located in Fluvial Flood Zone A. The remainder of the proposed site is mapped in Flood Zone C (Low Risk);
  - However, site surveys reveal that the EPA incorrectly mapped a watercourse (the Cartenstown stream) to cross Lisclogher Bog from the west and this indicates that the SFRA mapping in this area is inaccurate;
  - We conclude, based on site observation, lack of flooding in winter 2015/2016, and the high drainage density within the bog at this location, that the actual flood risk in this area is the same for the entire Lisclogher bog, and it should be mapped in Flood Zone C;
- CFRAM mapping includes modelled flood levels for the 10-year and 100-year flood events. These levels, modelled near Ballivor village, range from 64.19 – 65.34m OD and are well above the current outfall pipe elevations of the proposed site (67.97 – 79.13m OD). Therefore, the risk of fluvial flooding along the Ballivor River, located to the east of the proposed site, backing up into the site drainage network is very low;
- The main risk of flooding across much of the proposed site is via pluvial flooding due to the low permeability of peat soils and subsoils;
- Site walkover indicates the surface of the cutover bog contains an extensive network of peat drains with surface water outflows from the bogs. This existing drainage network has been reduced the risk of pluvial flooding across much of the site. However, following periods of intense and prolonged rainfall events localised surface water ponding is still likely to occur in places across each of the bogs. Therefore, a freeboard (~0.3m) will be included in the design of each turbine base and along access roads;
- The proposed substation is particularly sensitive to flooding. Conservative volumetric analysis has determined the peak flood levels at the proposed substation site for 100-yr and 1000-yr rainfall events to be 74.3 and 74.6m OD respectively. The primary control in the analysis is the expanse of the bog in Carranstown West which needs to fill with pluvial flood water before the substation site can flood. It is therefore recommended to give the substation a floor level of >74.9mOD (74.6mOD + 0.3m freeboard). At this elevation the risk of flooding at the substation site is negligible;
- It may be considered that the proposed wind farm can be categorised as "Highly Vulnerable Development". A justification test has been completed in Section 5.2 and

concludes that the Proposed Development is designed and laid out in a manner that reduces flood risk, and that there is negligible potential for an increase in flood risk downstream of the Proposed Development;

- In addition, the risk of the wind farm contributing to downstream flooding is also very low, as the long-term plan is to implement Bord na Móna's decommissioning and rehabilitation plans at the proposed site. These plans aim to stabilise and rehabilitate the peat bogs by placing the existing peatland environments on a path towards naturally functioning peatlands. With the implementation of the rehabilitation plans, surface water runoff from the Ballivor Bog Group will be reduced, thereby decreasing the downstream flood risk. Furthermore the proposed wind farm development will be constructed with its own drainage system which will provide additional surface water attenuation. The cumulative effect of the Proposed Development and the Decommissioning and Rehabilitation Plans is that there will be a reduced risk of fluvial flooding downstream of the proposed site; and,
- The overall risk of flooding posed at the proposed site is assessed to be low, and all proposed infrastructure will be located at or above Flood Zone C elevations.

* *

7. REFERENCES

DOEHLG	2009	The Planning System and Flood Risk Management.
Natural Environment Research Council	1975	Flood Studies Report (& maps).
Cunnane & Lynn	1975	Flood Estimated Following the Flood Studies Report
CIRIA	2004	Development and Flood Risk – Guidance for the Construction Industry.
OPW	Not Dated	Construction, Replacement or Alteration of Bridges and Culverts. A Guide to Applying for Consent under Section 50 of the Arterial Act, 1945.
Institute of Hydrology	1994	Flood Estimation in Small Catchments (IH 124).
Fitzgerald & Forrestal	1996	Month and Annual Averages of Rainfall for Ireland 1961 – 1990.
Met Eireann	1996	Monthly and Annual Averages of Rainfall for Ireland 1961-1990.
Meath County Council	2021	Meath County Development Plan 2021-2027
Westmeath County Council	2021	Westmeath County Development Plan 2021-2027