Appendix 8-2

Flood Risk Assessment

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PROPOSED WINDFARM DEVELOPMENT AT CARROWNAGOWAN, CO. CLARE

SITE SPECIFIC FLOOD RISK ASSESSMENT

FINAL REPORT

Prepared for:
Coillte

Prepared by:
Hydro-Environmental Services

DOCUMENT INFORMATION

DOCUMENT TITLE:	**PROPOSED WINDFARM DEVELOPMENT AT CARROWNAGOWAN WF, CO. CLARE – SITE SPECIFIC FLOOD RISK ASSESSMENT**
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1. INTRODUCTION

1.1 BACKGROUND

Hydro-Environmental Services (HES) were requested by Malachy Walsh & Partners on behalf of Coillte, to undertake a site specific, Stage II Flood Risk Assessment (FRA) for a proposed windfarm development at Carrownagowan WF, Co. Clare. A site location map is shown below as **Figure A.**

The proposed development at the site is a 19 no. turbine wind farm and associated access tracks, construction compounds, substation, cable trench route, grid connection, and other ancillary works.

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

1.2 STATEMENT OF EXPERIENCE

Hydro-Environmental Services ("HES") are a specialist 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 is an Environmental Engineer with 15 years 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.

David Broderick is a hydrogeologist with over 12 years environmental consultancy experience across Ireland. David has completed numerous Flood Risk Assessments for all types of developments, and he regularly uses HEC-RAS and FlowMaster modelling software.

Adam Keegan is a junior hydrogeologist with 2 years' experience in the environmental/engineering sector.

1.3 REPORT LAYOUT & METHODOLOGY

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 local surface water catchment in the vicinity of the proposed development site;
- Section 4 deals with 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 completes a Justification Test for the development; and,
- Section 6 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:

- Base maps – Ordnance Survey of Ireland;
- Flood Hazard Maps and flooding information for Ireland, www.floodmaps.ie;
- Office of Public Works (OPW);
- Geological Survey of Ireland (GSI) maps on superficial deposits;
- EPA hydrology maps;
- Preliminary Flood Risk Assessment Maps; and,
- Site Walkover and drainage mapping.

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 development.

2.2 SITE LOCATION AND TOPOGRAPHY

The proposed wind farm site is located approximately 9km northwest of Killaloe and ~3km southwest of the village of Bodyke, Co. Clare on the north-western slopes of Slieve Bearnagh mountains. The total study area is approximately 853 hectares (~ 8.5 km^2). The site is roughly ovaloid in shape, ~ 4.7 km long along a northeast-southwest axis and approximately 2.2 km wide. A small spur ~ 1.2 km x 0.3 km juts out at the northern edge of the site. This spur meets an unnamed road which runs east-west through the townlands of Ballydonaghan and Caherhurly. Access to the site is along this road, via a smaller road which runs south from the crossroads at Caherhurly.

The southern half of the site slopes steeply in a north-westerly direction from the summit of Slieve Bearnagh. Elevation ranges from 370m OD on the southern boundary of the site to 120m OD at its most northerly border. Two river valleys run in a north-westerly direction through the site, which provide the main drainage routes for site runoff. The majority of the site is covered in blanket bog which has been planted over with coniferous forests.

The land use within the site areas comprises of mainly commercial coniferous forestry. A site location map is shown as **Figure A** below.

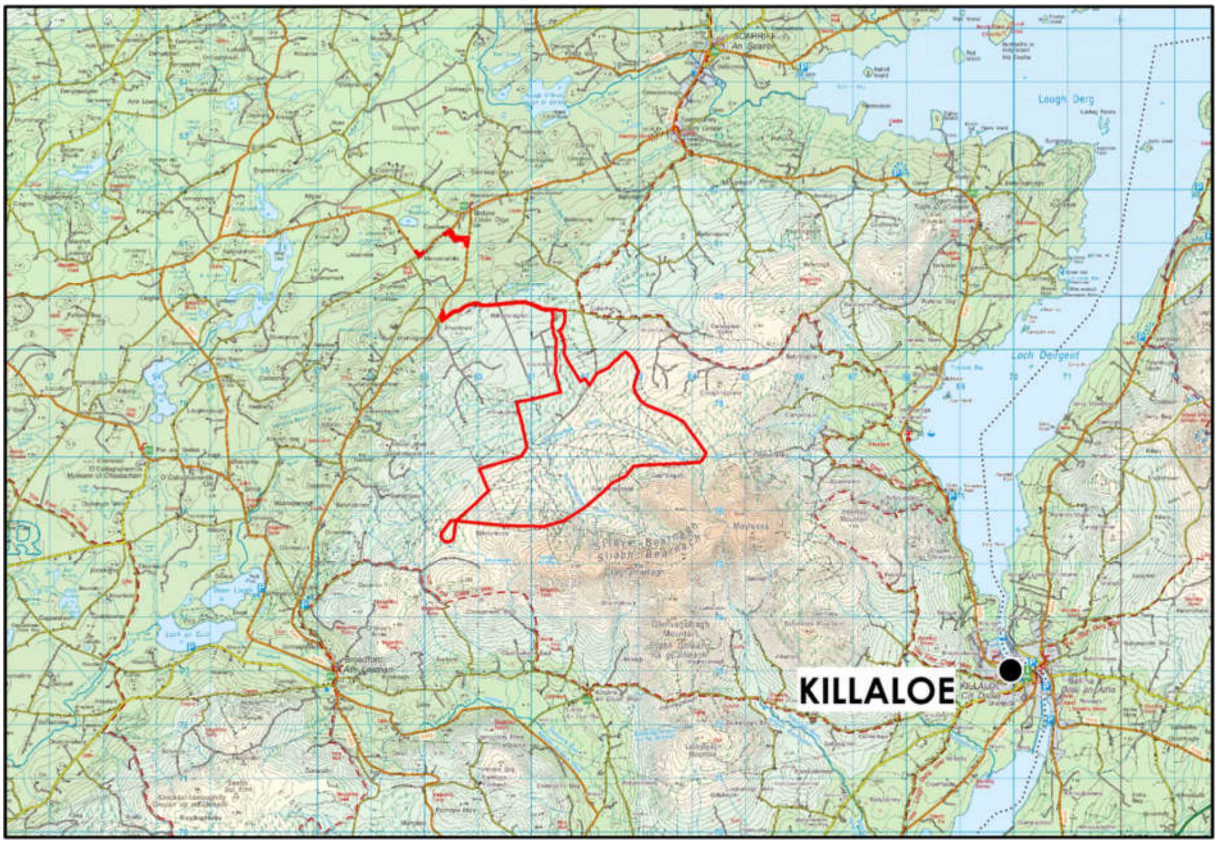

Figure A: Site Location Map

2.3 PROPOSED DEVELOPMENT DETAILS

The proposal consists of a windfarm with 19 no. turbines and associated access roads and infrastructure. It is proposed that the road construction will utilise the cut and fill construction method. Scour protection, which is detailed further below, will be provided along sections of the route as an erosion protection measure from fluvial flooding. There will also be a requirement to construct bridges and culverts at the streams that are intersected by any proposed new wind farm access track alignment.

3. EXISTING ENVIRONMENT AND CATCHMENT CHARACTERISTIC

3.1 INTRODUCTION

This section gives an overview of the hydrological and geological characteristics in the area of the proposed wind farm development.

3.2 BASELINE HYDROLOGY

3.2.1 Regional Hydrology

The majority of the proposed wind farm site is located in the Bunratty-Ballymacdonnell River Sub-Catchment, while the western edge of the site is located within the Bunratty-Killuran sub catchment. The Bunratty-Ballymacdonnell and the Bunratty-Killuran are sub-catchments of Owenogarney (Ratty) River within the regional Shannon Estuary North catchment.

The northeastern edge of the site (~ 2.5km^2) near Croaghnagower is located within the Graney-Anamullaghaun subcatchment, within the regional Lower Shannon catchment. A regional hydrology map is shown as **Figure B**. The main first order streams within the site are the Coumnagun River, the Carrownagowan River, and the Killuran River.

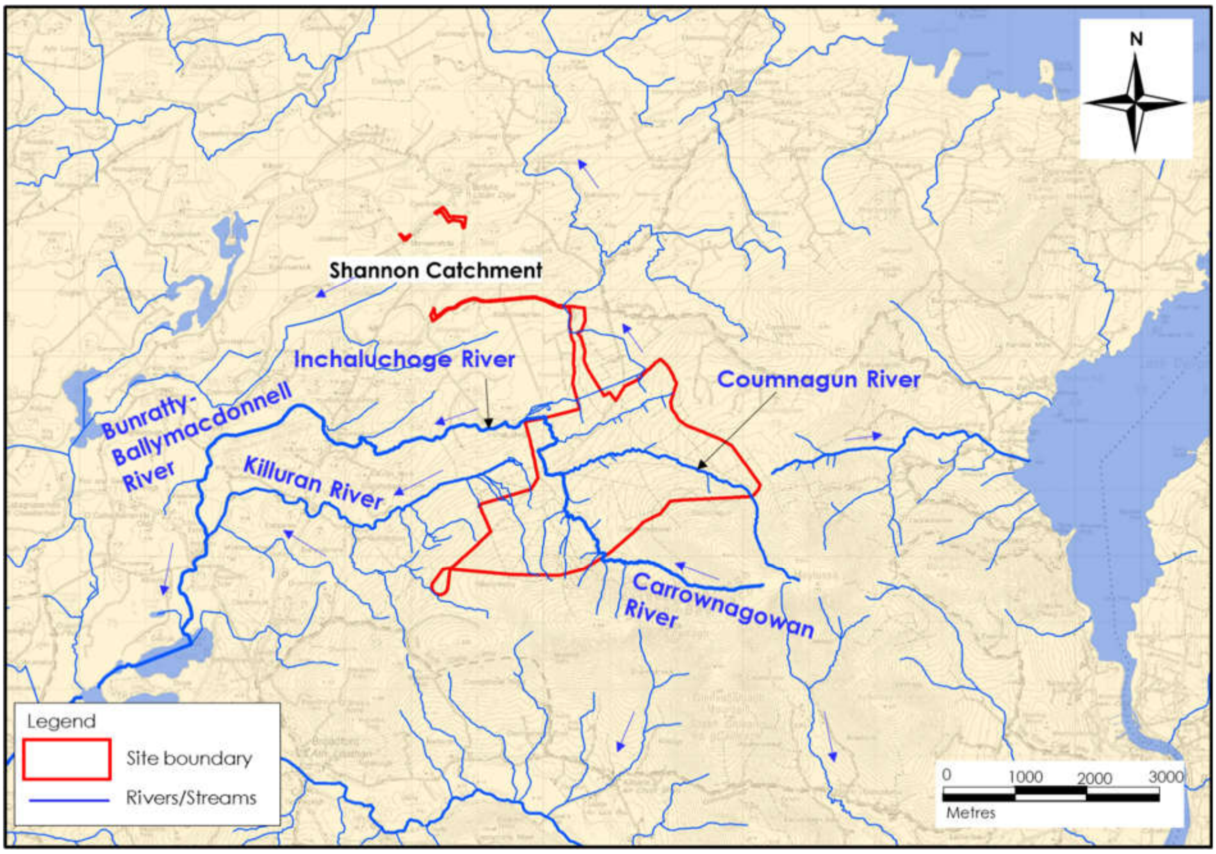

Figure B: Regional Hydrology Map

In terms of proposed wind farm infrastructure, there are 4 no. turbines located in the Bunratty-Killuran subcatchment, and the remaining 15 no. turbines are located within the Bunratty-Ballymacdonnell subcatchment.

A summary of the local hydrology with respect the proposed windfarm infrastructure is shown in **Table A** below.

Table A: Summary of Local Hydrology and proposed Infrastructure

Regional Catchment	Sub-catchment	Main Development Infrastructure	Primary Drainage Features
Shannon Estuary North	Bunratty-Killuran	4 no. turbines, section of grid route 1 no. Borrow Pit	Killuran River
	Bunratty-Ballymacdonnell	15 no turbines Substation Site compound 1 no. Borrow Pit	Carrownagowan/Inchaluchoge Rivers
Shannon Lower	Graney_Anamullaghaun	1 no. Borrow Pit	Anamullaghaun River

3.2.2 Local & Site Drainage

There are two main rivers which flow northwards through the site, namely the Carrownagowan River and the Coumnagun River, which converge at the centre of the site to form the Inchaluchoge River. A local hydrology map is shown as **Figure C**. Both the Carrownagowan River and Coumnagun River, as well as the downstream Inchaluchoge River, drain into the Bunratty-Ballymacdonnell River sub basin as delineated by the WFD. The Carrownagowan River and Inchaluchoge River are referred to as the singular Owenogarney River by the EPA.

The Carrownagowan River originates approximately 3 km east of the southern site boundary on Sliabh Bearnagh. It flows generally westward towards the southern site boundary then changes direction northwards. It flows north for ~ 1.4km through the site before joining the Inchaluchoge River. Six tributaries flow north feeding the Carrownagowan river. These tributaries range from approximately 0.6 - 1.2 km long and all drain from the summit of Sliabh Bearnagh.

The Coumnagun river also originates from the slopes of Sliabh Bearnagh, approximately 1.5 km south of the south-eastern boundary of the site. It flows north through a narrow valley towards the south-eastern corner of the site, before changing course westward through the site. The Coumnagun River, along with the Carrownagowan River, converge to form the Inchaluchoge River in the central area of the site. The Inchaluchoge River flows west for some 3km before joining the Ballymacdonnell River near Ballymacdonnell Bridge.

The far west of the site drains westward towards the Killuran River within the associated Bunratty-Killuran sub basin. Four tributaries of the Killuran river emerge within the boundary of the site and these flow west towards the Killuran River.

The Killuran River and the Ballymacdonnell River eventually merge before flowing into Doon Lough which is situated approximately 3.5 km southwest of the site.

The Anamullaghaun River and associated Graney-Anamullaghaun subcatchment, located within the Shannon Lower subcatchment is mapped as draining the north-eastern edge of the site. However, drainage mapping on the 6" OSI map indicate two streams which flow towards the Inchaluchoge River from the north-eastern area of the site. It is likely that the north-eastern section of the site actually drains into the Bunratty-Ballymacdonnell catchment, rather than discharging into Graney Anamullaghaun catchment as mapped by the EPA.

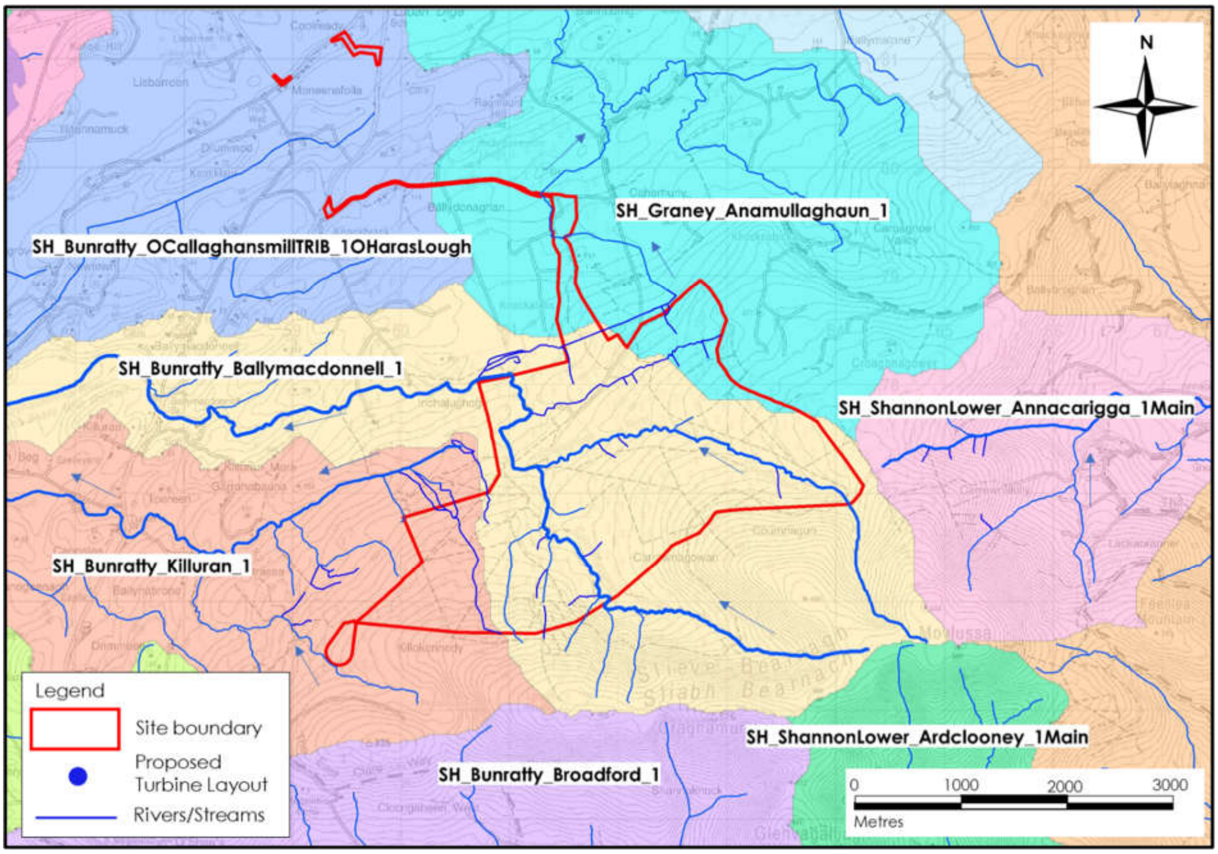

Figure C: Local Hydrology Map

3.3 RAINFALL AND EVAPORATION

The SAAR (Standard Average Annual Rainfall) recorded at Scarriff (Fossabeg) (ING: 163875, 184453), which is located approximately 6.5km north of the proposed site, is 972mm (**www.met.ie**). The average potential evapotranspiration (PE) at Shannon Airport, approximately 30km southwest of the proposed site, is taken to be 543mm (**www.met.ie**). The actual evapotranspiration ("AE") is calculated to be 516mm (95% PE). Using the above figures the effective rainfall ("ER")[1] for the area is calculated to be (ER = SAAR – AE) 456mm.

Table B below presents return period rainfall depths for the area of the proposed Carrownagowan wind farm 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 B: Rainfall return periods for the Carrownagowan site

	Return Period (Years)			
Duration	**1**	**5**	**30**	**100**
5 mins	3.5	5.7	9.5	12.9
15 mins	5.7	9.4	15.5	21.2
1 hour	9.8	15.1	23.4	30.8
6 hours	19.6	27.9	39.9	49.9
12 hours	25.7	35.3	49.1	60.1

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

24 hours	33.6	44.8	60.3	72.4
2 days	42.2	55.2	72.6	86.0

3.4 GEOLOGY

3.4.1 Soils & Subsoils

Blanket peat (BktPt) is the dominant soils type on the northern lower lying section of the site and also on the more elevated eastern and western sections of the site, along with pockets of deep poorly drained mineral soils derived from acidic parent material (AminPD). Poorly draining peaty soils are mapped in the central and south-central area of the site (towards the summit of Slieve Bearnagh), along with pockets of predominantly shallow soils derived from non-calcareous rock or gravels with/without peaty surface horizon and alluvial soil.

Mapped subsoils at the site are a mixture of blanket peat (as described above) and Tills derived from Devonian Sandstone parent material (TDSs). The sandstone tills are mapped in the central southern area of the site. Areas of rock outcrop are mapped close to the Coumnagaun River channel, as well as at the western and northern edge of the site. Alluvium is also mapped along the route of the Coumnagaun River.

Peat depths across the site vary between 0 to 4m, with average depths in the order of 1.31m. Depths will likely be shallower on the more elevated areas of the site and potentially deeper on lower lying flatters areas such as the north of the site. The blanket peat has been planted over with conifer trees throughout the site and there is little indication that the peat was cut for turf in the past. Local Subsoils map is included as

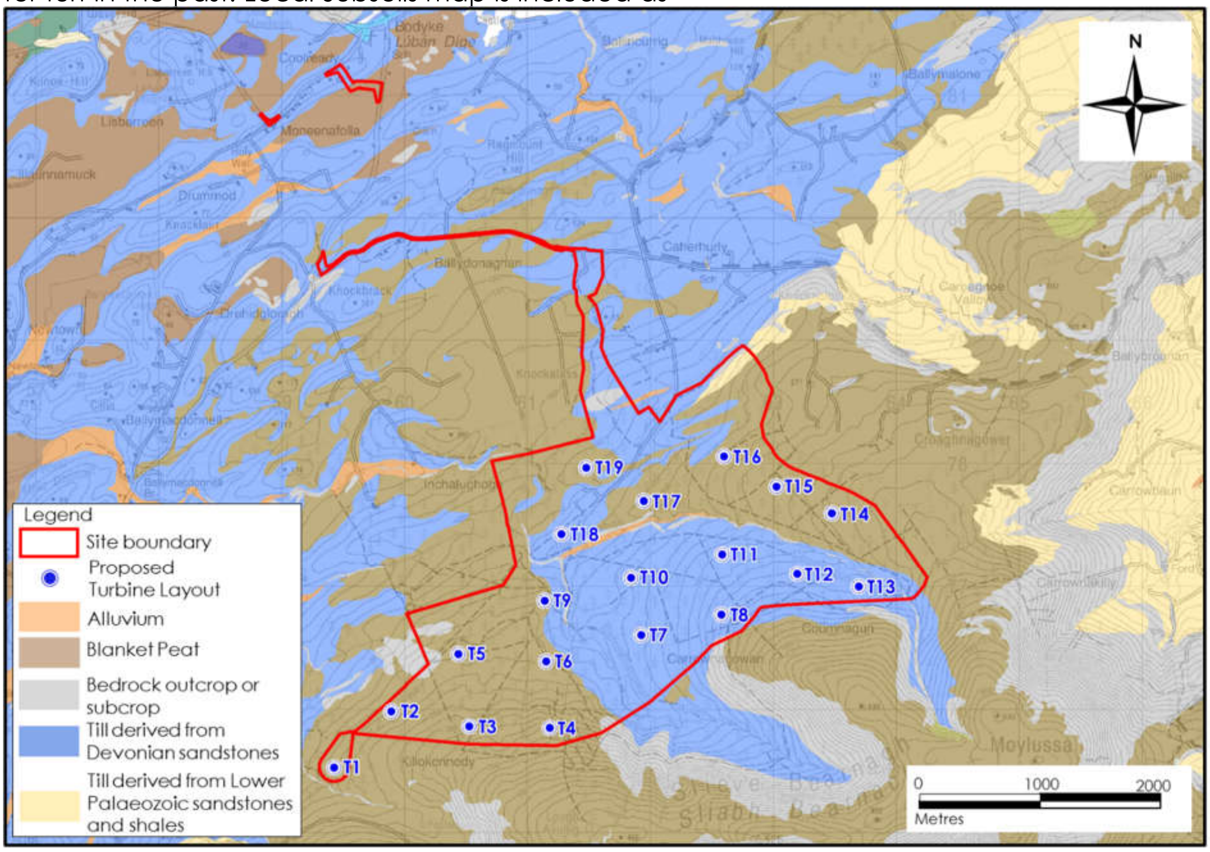

Figure D.

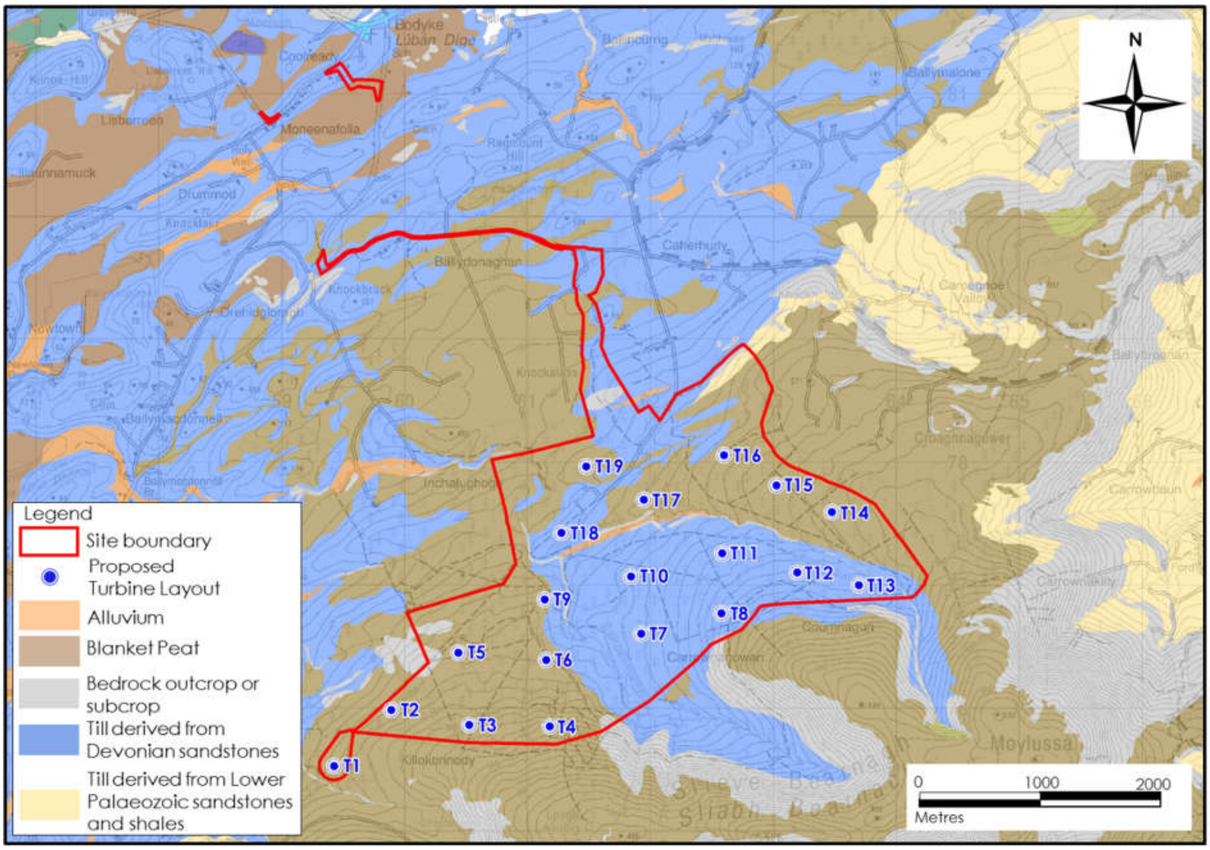

Figure D: Local subsoils map

3.4.2 Bedrock Geology

According to the GSI, the northern half of the site is mapped to be underlain by Devonian Old Red Sandstone (ORS) consisting of sandstone, conglomerate and siltstone. The southern half of the site is mapped to be underlain by Silurian meta-sediments which are comprised locally of mainly greywacke. Outcrop is sparse throughout the site, given the cover of the peat and mineral subsoils.

A regional northeast – southwest trending fault is mapped to intercept the eastern section of the site. A bedrock geology map is included as **Figure E**.

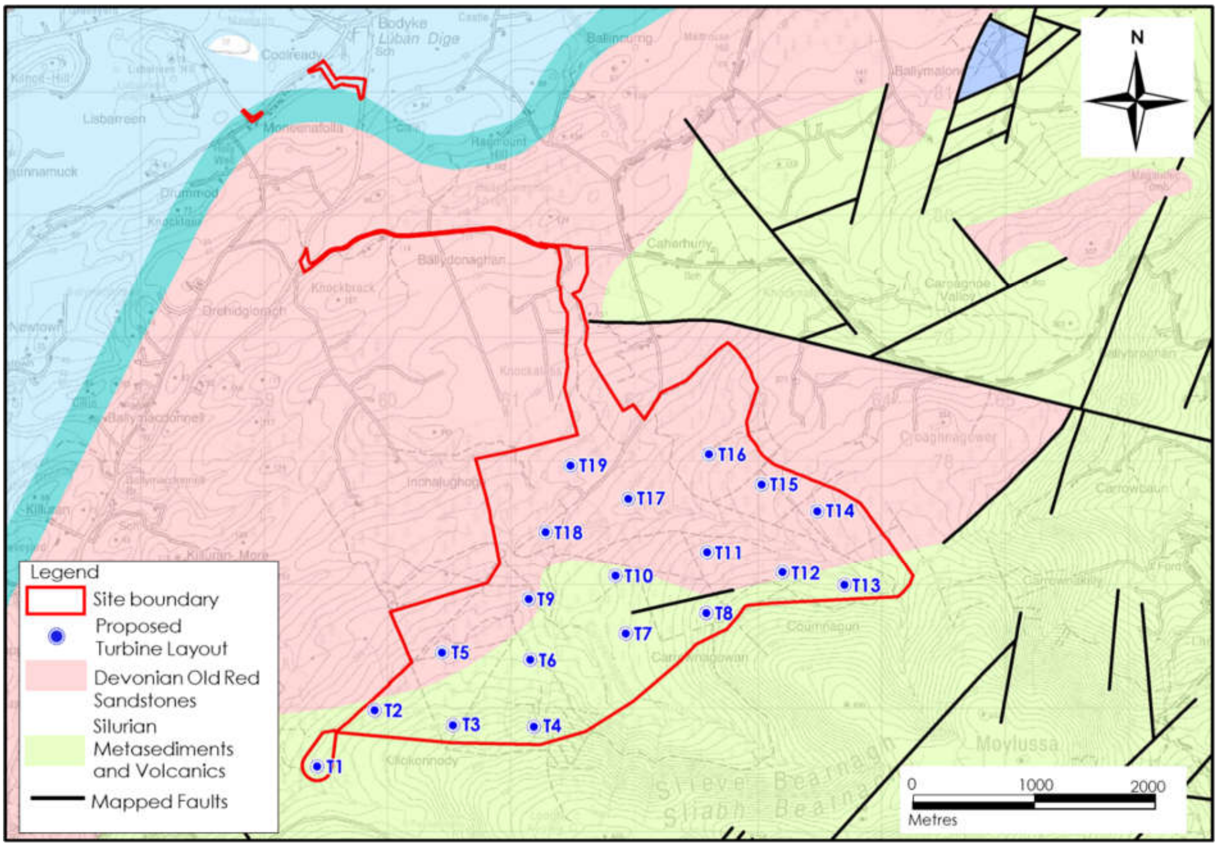

Figure E: Local Bedrock Geology map

3.5 DESIGNATED SITES & HABITATS

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

The site borders the Slieve Bearnagh SAC which extends both north and south of the site. The southern part of the Slieve Bearnagh bog is at a higher elevation (up-gradient) than the proposed windfarm site; therefore no part of the site will drain towards this section of the bog. The northern part of Slieve Bearnagh bog is situated at a lower elevation (down-gradient) than the proposed windfarm, and part of the site will drain towards this area.

The Lough Derg (Shannon) SPA is located ~ 2km east of the site.

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.

A stage 1 assessment of flood risk requires an understanding of where the water comes from (*i.e.* the source), how and where it flows (*i.e.* the pathways) and the people and assets affected by it (*i.e*. the receptors). It is necessary to identify whether there may be any flooding or surface water management issues related to the proposed site that may warrant further detailed investigation.

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 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.

4.2 FLOOD ZONE MAPPING

Flood zones are geographical areas within which the likelihood of flooding is in a particular range. There are three types or levels of flood zones defined according to OPW guidelines:

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

4.3 FLOOD RISK IDENTIFICATION

4.3.1 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 it appears that there are areas of mineral alluvium soils (fluvial deposits) mapped along various rivers/streams discussed above. The most abundant deposition of Alluvium is mapped along the Coumnagun river, with areas of between ~40-50m wide mapped across the river channel/s.

In general, however there does not appear to be any significant Alluvium deposition that would be associated with a flood plain or a large geographical area prone to flooding.

4.3.2 Historical Mapping

There is no text on local available historical 6" or 25" mapping for the proposed site that identify areas that are "*liable to flooding*".

4.3.3 OPW National Flood Hazard Mapping

No recurring flood events within the EIAR site boundary were noted from the OPW's river and coastal flood map. A recurring flood event is mapped near Bodyke, approximately 2.3 km north of the site. This recurring flood event is caused by the Anamullaghaun River which flows northwest towards Bodyke. At its closest, it is approximately 1 km north of the site (refer to **Figure F** below).

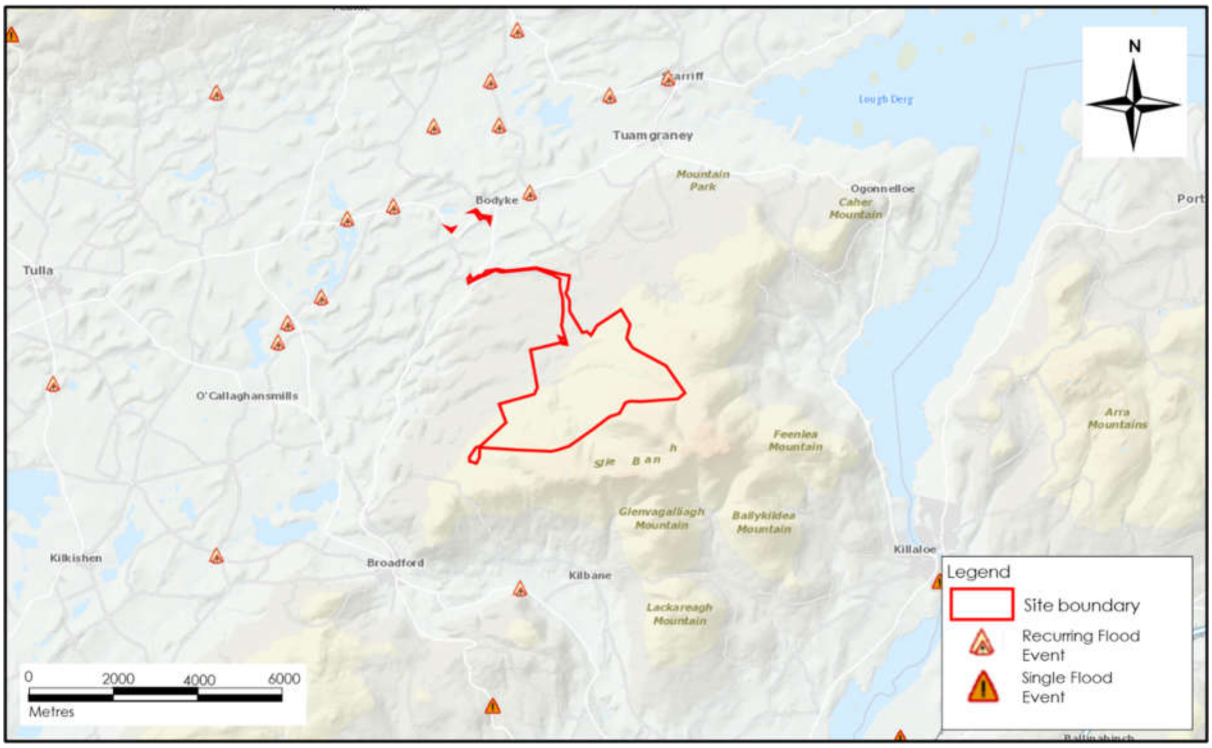

Figure F: OPW Indicative Floods Map (www.floods.ie)

4.3.4 Preliminary Flood Risk Assessment Maps – Fluvial and Pluvial Flooding

The OPW PFRA map for the area, indicates that sections of the Carrownagowan, Coumnagun, Ballymacdonnell and Killuran Rivers, within the proposed development site, are mapped within the 100-year fluvial flood event areas. These areas however are within an acceptable distance (50m) of any proposed turbine locations.

Small areas of pluvial flooding are mapped within the site within areas of low relief and/or relatively impermeable soils/subsoils.

An area of 1% AEP Pluvial flooding is mapped by OPW at the northern boundary of the site, approximately 1km south of Caherhurly cross, however as noted by the OPW, the maps offer only an indication and may not be accurate at a local scale. Observations on site during field surveys suggest that the topography and general drainage pattern is unlikely to be susceptible to pluvial flooding. A PFRA map is included as **Figure G** below.

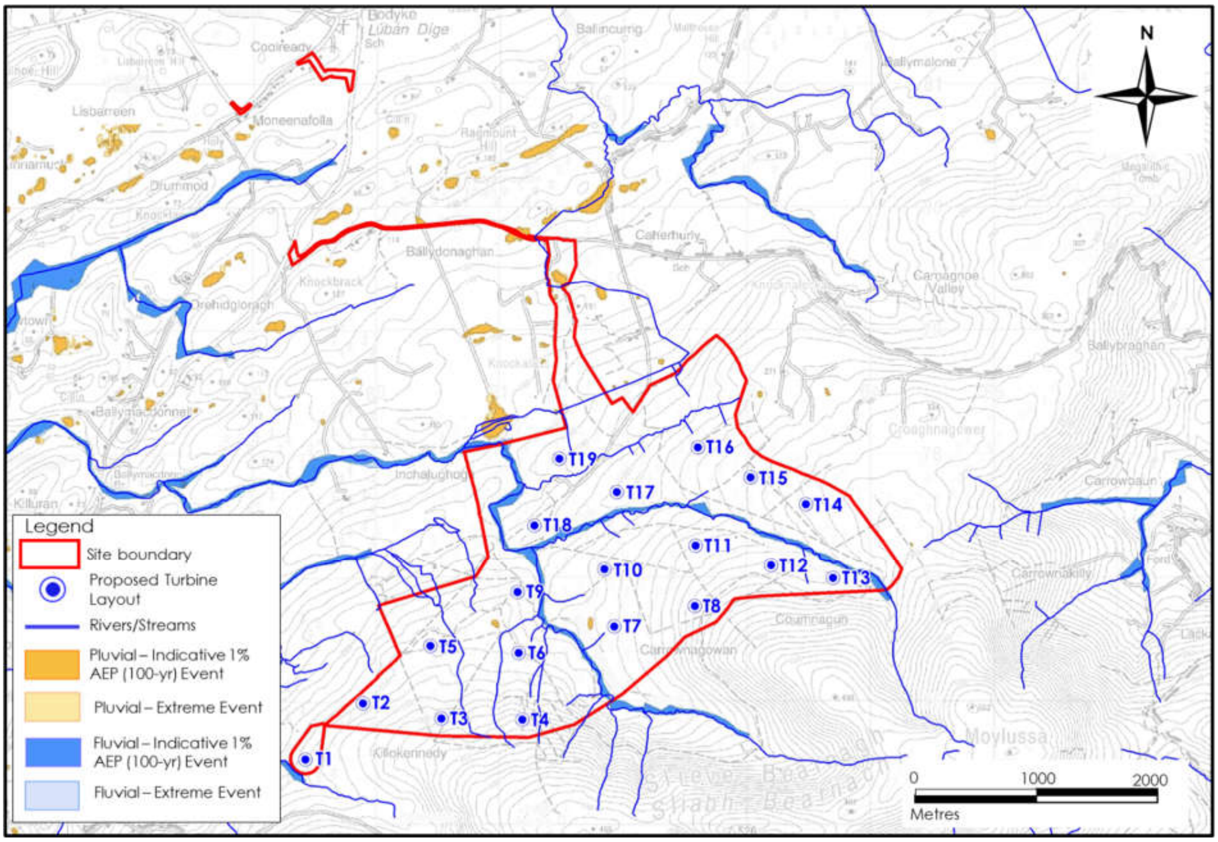

Figure G: PFRA Fluvial Flood Zone Mapping CFRAM Maps – Fluvial and Coastal Flooding

4.3.5 Summary – Flood Risk Identification

Based on the information gained through the flood identification process it would appear that parts of the site immediately surrounding the various river channels are within 1 in 100 year fluvial flood zones (Flood Zone A); however these mapped zones are limited in extent and do not coincide with areas of development (e.g. access roads/turbines). No infrastructure is mapped within 50m of an area designated as Flood Zone A.

4.4 INITIAL FLOOD RISK ASSESSMENT

4.4.1 Site Survey

A detailed walkover survey of the proposed route and the surrounding area was undertaken by HES between 18/06/2018 to 30/01/2019.

Monitoring of stream discharge in the main streams downstream of the site was undertaken on several occasions at 12 no. monitoring locations (SW1 – SW12) between August 2018 and January 2019 and these data are presented in **Table C** below.

All the higher flows measured between November 2018 and January 2019 were in bank flows (i.e. contained within the channel).

Table C: Surface Water Flow Monitoring

Location/ Date	30/08/2018	24/09/2018	19/10/2018	26/11/2018	30/01/2019	13/06/2019
	Flow (l/sec)	Flow (l/sec)	Flow (l/sec)	Flow (l/sec)	Flow (l/sec)	Flow (l/sec)
SW3	15	10	15	30		15
SW4	200	150		150	800	300
SW6	10		7	15	20	10
SW7	120	155	150	150	300	100
SW8	70		40	50	-	-
SW10	6		10	10	15	6
SW11	12	15	20	-	-	-

As discussed above, several rivers have their upper reaches within the proposed development site, and flow predominantly within either the Bunratty-Ballymacdonnell or Bunratty-Killuran subcatchments. Sections of the proposed development site are located within the 100-year fluvial flood zone; however no turbines, substations, roads or other infrastructure are located within this zone.

During the walkover survey of the route there was little evidence of past out-of-bank flow from within the various river channels. During visits following considerable rainfall in the prior day/s, high flows were observed within the rivers, with many estimated to be multiples of the typical dry weather flow. No localized or regional flooding was observed during these site visits; all flow was contained within the channels.

4.4.2 Existing Site Drainage

The forestry drains are the primary drainage routes towards the natural streams on the development site, but the flows in these drains are generally very low. The integration of the existing main drains with the proposed wind farm drainage is a key component of the drainage design.

Within the Proposed Development site there are numerous manmade drains that are in place predominately to drain the forestry plantations. Mound drains and ploughed ribbon drains are generally spaced approximately every 15m and 2m respectively. As illustrated in **Figure H**, interceptor drains are generally located up-gradient (cut-off drains) and down-gradient of forestry plantations. Interceptor drains are also located up-gradient of forestry access roads. Culverts are generally located at stream crossings and at low points under access roads which drain runoff onto down-gradient forest plantations. A schematic of a typical standard forestry drainage network and one which is representative of the site drainage network is shown as **Figure H**.

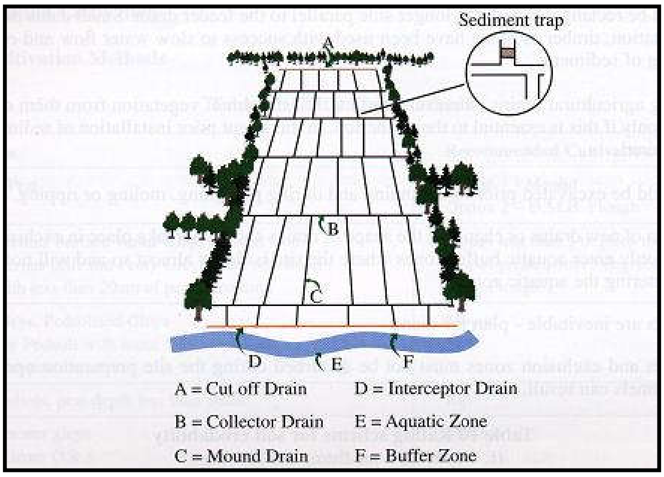

Figure H: Schematic of typical forestry drainage layout.

4.4.3 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 most consequence for the proposed site, is fluvial. The primary potential pathways, in the most likely order of significance, would be overbank flooding of the Carrownagowan, Coumnagun, Inchaluchoge, Killuran, Ballymacdonnell and Anamullaghaun Rivers during significant rainfall events. The potential receptors in the area are infrastructure and land as outlined below.

4.4.4 Summary – Initial Flood Risk Assessment

Based on the information gained through the flood identification process and Initial Flood Risk Assessment process it would appear that flooding is unlikely to be problematic at the site or downstream of the site. The potential sources of flood risk for the proposed site are outlined and assessed in **Table D**.

Table D: S-P-R Assessment of Flood Sources for the proposed site

Source	Pathway	Receptor	Comment
Tidal	Not applicable	Land and infrastructure.	The proposed site is ~20km from the coast, and at an elevation >120mOD, and there is no risk of coastal flooding.
Fluvial	Overbank flooding of the Carrownagowan, Coumnagun, Ballymacdonnell and Killuran Rivers.	Land and infrastructure.	There are several turbines close to the 100-year fluvial flood zone, including T9 (~200m) and T18 (~160m); however all proposed turbines and infrastructure are outside the 50m buffer zone.
Pluvial	Ponding of rainwater on site	Land and infrastructure.	There is very little risk of pluvial flooding within the proposed site as drainage moves relatively freely off sloping ground. Small localised areas of pluvial flooding are mapped.
Surface water	Surface ponding/ Overflow	Land and infrastructure	Same as above (pluvial).
Groundwater	Rising groundwater levels	Land and infrastructure.	Based on local hydrogeological regime and PFRA mapping, there is no apparent risk from groundwater flooding.

4.5 REQUIREMENT FOR A JUSTIFICATION TEST

The matrix of vulnerability versus flood zone to illustrate appropriate development and that required to meet the Justification Test[2] is shown in **Table E** below.

It may be considered that the proposed wind farm can be categorised as "Highly Vulnerable Development" However, as stated above, with the exception of watercourse crossings (many already existing), all proposed infrastructure, including the proposed substation, is located in Flood Zone C (Low Risk) and therefore the proposed development is appropriate from a flood risk perspective (refer to **Table E** below).

[2] *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 E: 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*

5. FLOOD IMPACT PREVENTION AND DRAINAGE MANAGEMENT

5.1 RELEVANT LOCAL AUTHORITY SUDS GUIDANCE

Guidance in relation to surface water management and sustainable urban drainage is provided in the Clare County Development Plan 2017-2023. Section 18.6.2 of the development plan requires that:

> *"No additional surface water shall be allowed to discharge to foul sewers or combined sewers. Surface water drainage systems for new developments will be designed in accordance with the principles of attenuation and controlled discharges, SuDS and with any storm water policy documents which may be produced by the Council. The full suite of SuDS measures should be considered, as appropriate, in any drainage scheme."*

Further objectives are defined as;

> *"To ensure that adequate storm water infrastructure is in place to accommodate the planned level of growth in the Plan area."*

> *"To ensure the implementation of Sustainable Urban Drainage Systems (SuDS) and in particular, to ensure that all storm water generated in a new development is disposed of on-site or is attenuated and treated prior to discharge to an approved storm water system."*

5.2 PROPOSED DRAINAGE

The site drainage system was designed integrally with the wind farm layout as a measure to ensure that the proposal will not change the existing flow regime across the site, will not deteriorate water quality and will safeguard existing water quality status of the catchments from wind farm related sediment runoff.

Overland flow rates are likely to be very significant and the drainage system must be designed and managed properly if it is to work effectively. A fundamental principle in the drainage design is that clean water flowing in the upstream catchment, including overland flow and flow in existing streams, is allowed to bypass the works areas without being contaminated by silt from the works. The dirty water from the works areas is collected in a separate drainage system and treated by removing the suspended solids before discharging it to the downstream watercourse. This minimises the volume of dirty water requiring treatment.

Existing streams crossing the works area will be piped to isolate them from the works. New drains will be constructed to collect overland flow that is intercepted by the works areas or by new access roads. These will be constructed on the uphill side of the works and piped to the downhill side, bypassing the works areas. However, this will cause the normally dispersed flow to be concentrated at specific discharge points downstream of the works. In order to disperse this flow each clean water drain will be terminated in a discharge channel running parallel to the ground contours that will function as a weir to disperse the flow over a wider area of vegetation. This will prevent erosion of the ground surface and will attenuate the flow rate to the downstream receiving waters.

The resultant diversion of clean water runoff will ensure that the treatment system will only need to deal with construction related runoff. The treatment system consists of a series of settlement ponds that are located at each works site and at intervals along the access roads. The outflow from the settlement ponds will be allowed to disperse across vegetation and will become diluted through contact with the clean water runoff in the buffer areas before entering the downstream watercourses.

5.3 PROPOSED ON-SITE RUNOFF ATTENUATION

The creation of impermeable areas within a development site has the effect of increasing rates of runoff into the downstream drainage system and this may increase flood risk and flood severity downstream. This applies particularly to urban areas that drain to closed pipe systems which do not have the capacity to cater for increased hydraulic loads. The proposed Carrownagowan wind farm development is located within a large rural catchment with an open drainage system. The footprint of the impermeable areas and the associated increase in runoff rate is very small in the context of the catchment size and therefore represents a negligible increase in downstream flood risk. Notwithstanding the low increase in flood risk due to the development, the drainage system has been designed to prevent any increase in discharge rates above that which already exist in the undeveloped site.

The volume of water requiring attenuation relates to direct precipitation on the roads and hard-standing footprint only. The aim of the storm water attenuation measures is to limit the flow rate from the developed area to that which prevails on the undeveloped site. This is achieved by limiting the flow rate to the downstream receiving waters and temporarily storing the excess water that accumulates as a result. The developed surfaces have some permeability and this reduces the attenuation requirement. Conventional attenuation systems use proprietary flow control units but these can become blocked with debris and vegetation and require regular maintenance. They are therefore not appropriate for use within a forestry environment or where routine maintenance would not be practical.

It is proposed to provide the temporary storage within the drainage channels by creating stone dams within them at regular intervals. The spacing of the dams is typically 100m but depends on the channel slope, with steeper channels requiring shorter intervals. The dams, which are constructed with small sized aggregate, also reduce the flow rate through the drainage system and are an effective means of providing flow control. Silt fence also provide storage and flow control.

All runoff from the developed areas will be routed through settlement ponds downstream. The outflow from the settlement ponds will be released in a controlled and diffuse manner onto the vegetation or forestry floor where selected forestry rills may be blocked to further promote diffusion of runoff. Therefore, the proposal will not increase the magnitude of the hydrograph peak. The control measures are passive as opposed to mechanical and do not require maintenance to ensure their ongoing effectiveness.

5.4 FLOOD IMPACT SCREENING FOR DESIGNATED SITES

Table F provides a flood impact screening for local designated sites.

Table F: Flood Impact Screening for Local Designated Sites

Name	Site Code	Flood Risk Screening
Slieve Bearnagh SAC	002312	No increased flood risk, attenuation proposals outlined above.
Lough Derg SPA	004058	No increased flood risk, no hydrological connection.

6. REPORT CONCLUSIONS

6.1 CONCLUSIONS

- A flood risk identification study was undertaken to identify existing potential flood risks associated with the proposed wind farm development at Carrownagowan, Co. Clare. 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; and,
  - Areas of the proposed site were identified with the PFRA Flood Zones as described below.
- The Preliminary Flood Risk Assessment (PFRA) mapping indicates that there are areas of the proposed site located in the fluvial Flood Zone A; however these areas do not coincide with proposed turbine locations, access roads or other infrastructure;
- The remainder of the proposed site is not mapped as susceptible to flooding, aside from isolated small areas where pluvial flooding may occur; however as before, these areas do not coincide with any areas of proposed development;
- The Justification Test concluded that the proposed wind farm and associated infrastructure is located within a low risk area (Flood Zone C), and as such is appropriate from a flood risk perspective;
- Residual flood risks associated with potential fluvial flooding at the affected sections of the proposed route can be managed by way of avoidance during flooding, standard road drainage measures and scour protection measures; and,
- The overall risk of flooding within the proposed site boundary is estimated to be low.

* *

7. REFERENCES

AGMET	1996	Agroclimatic Atlas of Ireland.
DOEHLG	2009	The Planning System and Flood Risk Management.
Met Eireann	1996	Monthly and Annual Averages of Rainfall for Ireland 1961-1990.