APPENDIX 9-1

FLOOD RISK ASSESSMENT

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PROPOSED CRUMHACH WIND FARM, CO. SLIGO

SITE SPECIFIC FLOOD RISK ASSESSMENT

FINAL REPORT

Prepared for:

MKO

Prepared by:

HYDRO-ENVIRONMENTAL SERVICES

HES Report No.: P1694-0_FINAL F0 **Report Date: 15th July 2026**

DOCUMENT INFORMATION

Document Title:	**CRUMHACH WIND FARM, CO. SLIGO - SITE SPECIFIC FLOOD RISK ASSESSMENT**
Issue Date:	**15th July 2026**
Project Number:	**P1694-0**
Project Reporting History:	**-**
Current Revision No:	**P1694-0_ FINAL_F0**
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1. INTRODUCTION

1.1 BACKGROUND

Hydro-Environmental Services (HES) were requested by MKO to complete a site-specific Flood Risk Assessment (FRA) for the Proposed Crumhach Wind Farm, Co. Sligo. A site location map is shown as **Figure A** below.

The Proposed Project (Proposed Wind Farm and Proposed Grid Connection Route) is described in full in Chapter 4 of the EIAR. Refer to Section 2.2 below for a summary of the Proposed Project.

Where the 'Site' is referred to, this relates to the primary study area for the Proposed Project EIAR, as delineated by the EIAR Site Boundary and includes the Proposed Wind Farm and Proposed Grid Connection Route.

The following assessment is carried out in accordance with '*The Planning System and Flood Risk Management Guidelines for Planning Authorities*' (DoEHLG, 2009) and is submitted in supported of the Proposed Project EIAR.

1.2 STATEMENT OF QUALIFICATIONS

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 (P. Geo., B.A.I., MSc, Dip. Geol., MIEI) is an Environmental Engineer/Hydrologist with over 24 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments for wind farms in Ireland. He has also managed EIAR assessments for infrastructure projects and private residential and commercial developments. In addition, he has substantial experience in wastewater engineering and site suitability assessments, contaminated land investigation and assessment, wetland hydrology/hydrogeology, water resource assessments, surface water drainage design and SUDs design, and surface water/groundwater interactions. For example, Michael has worked on the EIS/EIARs for Lemanaghan Wind Farm, Seven Hills Wind Farm, Carrownagowan Wind Farm, and over 100 other wind farm related projects across the country. Michael worked on his first wind energy project in 2003, and he has continued to work on similar projects since then.

David Broderick (P. Geo., BSc, H. Dip Env Eng, MSc) is a Hydrogeologist with over 19 years' experience in both the public and private sectors. Having spent two years working in the Geological Survey of Ireland working mainly on groundwater and source/resource protection studies David moved into the private sector. David has a strong background in groundwater resource assessment and hydrogeological/hydrological investigations in relation to developments such as quarries and wind farms. David has completed numerous geology and water sections and flood risk assessments for input into EIARs for a range of commercial developments. David has worked on the EIS/EIARs for Lyre Wind Farm, Glenard Wind Farm, Ballyouskill Wind Farm, and over 60 other wind farm related projects across the country. David worked on his first wind energy project in 2010, and he has continued to work on similar projects since then.

1.3 REPORT LAYOUT

This FRA report has the following format:

- Section 2 describes the Site setting and details of the Proposed Project;
- Section 3 outlines the hydrological and geological characteristics of the Site;
- Section 4 presents a site-specific flood risk assessment (FRA) undertaken for the Site which was carried out in accordance with DoEHLG, 2009 Guidelines and determines if a Justification Test is required;
- Section 5 presents responses to local authority planning policy; 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, along with site surveys:

- OPW Flood Studies Update (FSU) Web Portal;
- Geological Survey of Ireland (GSI) maps on superficial deposits;
- EPA/WFD hydrology maps;
- OPW CFRAM & National Indicative Fluvial Mapping (NIFM);
- Sligo County Development Plan 2024 – 2030;
- Site investigation and geotechnical data; and,
- Site walkovers and drainage surveys conducted by HES 3rd and 4th of October and13th November 2024, 22nd and 23rd May 2025, 3rd February, 4th March and 2nd April 2026.

2. BACKGROUND INFORMATION

2.1 INTRODUCTION

This section provides details on the topographical setting of the Site along with a description of the Proposed Project.

2.2 PROPOSED PROJECT DETAILS

Where the 'Site' is referred to, this relates to the primary study area for the Proposed Project EIAR, as delineated by the EIAR Site Boundary and includes the Proposed Wind Farm and Proposed Grid Connection Route.

The 'Proposed Wind Farm' includes 17 no. Proposed Turbines and associated foundations and hard-standing areas, access tracks, temporary construction compounds, on-site 110kV substation, internal underground cabling, onsite LiDAR compounds, peat and spoil management areas, site drainage, biodiversity enhancement, borrow pits, turbine delivery route (TDR) accommodation works and all ancillary works and apparatus. The 'Proposed Turbines' refers to the 17 no. turbines associated with the Proposed Wind Farm as outlined above.

Where the 'Proposed Grid Connection Route' is referred to this encompasses the proposed 41.6km 110kV underground cabling connecting the Proposed Wind Farm on-site 110kV substation to the existing Srananagh 220kV substation, and all ancillary works and apparatus.

Where the 'Existing Wind Farm' is referred to, this relates to all components of the existing Dunneill Wind Farm and Kingsmountain Wind Farm developments which are located within the Site.

In addition, where the construction phase is detailed and assessed within the EIAR, this includes for the removal of the existing 23 no. turbines at the Existing Wind Farm and the construction of the 17 no. Proposed Turbines and associated infrastructure at the Site. The existing turbines will be removed prior to constructing the 17 no. Proposed Turbines.

2.3 SITE LOCATION AND TOPOGRAPHY

The Proposed Wind Farm is situated on the northwestern slopes of the Ox Mountains, located approximately 4.5km south of the village of Dromore West and 3km southwest of the village of Templeboy in Co. Sligo, at their nearest points.

The Proposed Wind Farm is in an upland setting which is dominated by blanket bog and coniferous forestry. There are two wind farms within the Site (Existing Wind Farm), namely Dunneill Wind Farm which is located on the north of the Site and Kingsmountain Wind Farm which is located on the east of the Site. The Site has existing access tracks (Existing Wind Farm, forestry and bog tracks), with up to 8.2km to be upgraded and utilised by the Proposed Project. The total Existing Wind Farm footprint is 9ha and approximately 3.7ha is to be used as part of Proposed Project.

The Proposed Wind Farm is accessed via the L6309 and L2702 Local Roads off the N59 National Road, travelling in an east-west direction north of the Site and the N17 National Road, which runs in a north-south direction to the southeast of the Site. The current entrance to the Existing Wind Farm is proposed as the main site entrance, utilising the existing access tracks and infrastructure. 1 no. additional existing access location on the L2702, 2 no. new access locations on the L2702 and 1 no. new access location on the L6309 are also proposed for the Proposed Wind Farm.

Proposed Turbines T8 to T17 are located within the Existing Wind Farm, while Proposed Turbines T1 to T7 as well as the proposed 110kV substation are located in coniferous forestry and peatlands on the west of the Site that were not previously developed for wind energy.

The topography of the Proposed Wind Farm is mountainous with a ground elevation of between 110 and 390m OD. The highest elevations are on the southeast of the Proposed Wind Farm where the ground slopes steeply up towards the summit of the Ox Mountains. The upper reaches of the Dunneill River (referred to as the Owenduff River within the Site) flows through the Proposed Wind Farm. Ground slopes in the central and western part of the Proposed Wind Farm are more moderate.

Land-cover on the Proposed Wind Farm primarily comprises peat bog, with coniferous forest to the north-west, east and south of the Proposed Wind Farm. South of the Proposed Wind Farm comprises largely of transitional wood scrub, while land-use in the northern end of the Site comprises largely of pastoral agriculture and low-density residential.

Current land-use along the Proposed Grid Connection Route and TDR accommodation works areas comprise public road corridor, pastures, low density residential, industry, commercial forestry and land principally used for agriculture with significant areas of natural vegetation.

The proposed Biodiversity Management and Enhancement Plan (BMEP) lands, situated centrally within the Proposed Wind Farm, are located on open peatland and also at areas proposed for peat and spoil management.

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

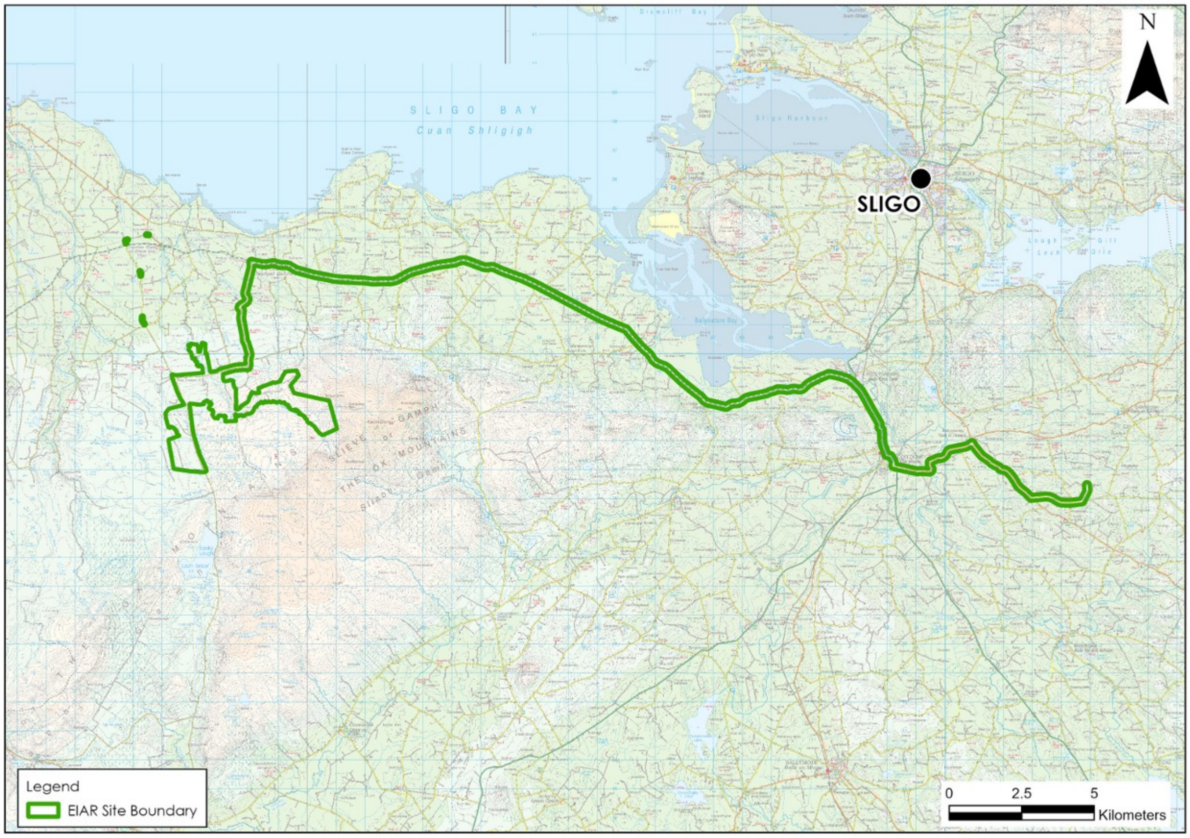

Figure A: Site Location Map

3. EXISTING ENVIRONMENT AND CATCHMENT CHARACTERISTICS

3.1 INTRODUCTION

This section gives an overview of the hydrological and geological characteristics in the area of the Site.

3.2 HYDROLOGY

3.2.1 Regional and Local Hydrology

Regionally, the Site is located in the WFD Sligo Bay surface water catchment within Hydrometric Area No. 35 of the North Western River Basin District.

On a more local scale the Proposed Wind Farm is located in 2 no. sub catchments; namely the Easky_SC_010 and the Dunmoran_SC_010. Within the Easky_SC_010 the Proposed Wind Farm drains to the Easky River (Easky_010) and the Buncrowey River (Buncrowey_010). The Buncrowey River is a tributary of the Easky River. A regional hydrology map is shown as **Figure B** below.

With the Dunmoran_SC_010, the Proposed Wind Farm drains to the Dunneill River (Dunneill_010), Doonbeakin River (Doonbeakin_010) and Lugdoon Stream (Lugdoon_010).

All the above-mentioned river waterbodies drain into Sligo Bay to the north which is approximately 6km downstream of the Proposed Wind Farm at its closest point.

On leaving the proposed 110kV substation on the west of the Proposed Wind Farm, the Proposed Grid Connection Route passes through the Easky_SC_010 (1.6km), Dunmoran_SC_010 (26.1km), Owenmore[Sligo]_SC_040 (5.5km) and Owenmore[Sligo]_SC_030 (7.8km).

The TDR overrun area works located along local road L2702 and L6309 to the west and north of the Proposed Wind Farm, are located in the Easky_SC_010 and Dunmoran_SC_010 sub-catchments respectively. A TDR overrun area on the N59 near Ballysadare is located in the Owenmore(Sligo)_SC_040 sub-catchment.

The proposed BMEP lands, situated centrally within the Proposed Wind Farm, are located within the Easky_SC_010 and Dunmoran_SC_010 where they drain to the Buncrowey River (Buncrowey_010) and Dunneill River (Dunneill_010) respectively.

The 23 no. turbines from the Existing Wind Farm are located in the Dunmoran_SC_010 and drain to the Dunneill River (Dunneill_010 and Doonbeakin_010 sub-basins).

A regional hydrology map is attached as **Figure B.**

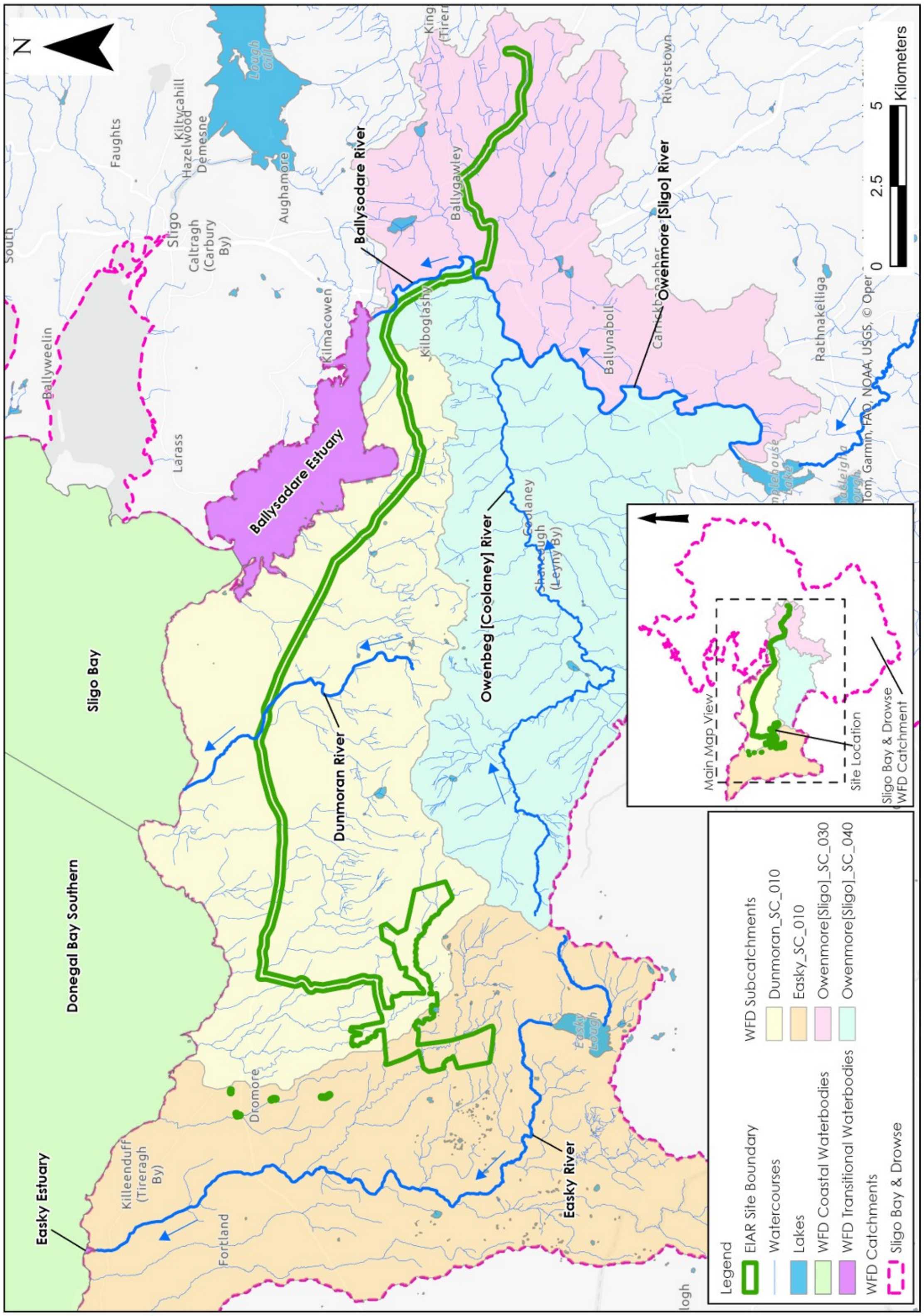

Figure B: Regional Hydrology Map

3.2.2 Rainfall and Evaporation

Long term Average Annual Rainfall (AAR) and evaporation data was sourced from Met Éireann. The 30-year annual average rainfall (AAR) (1981-2010) recorded at Cloonacool (Lough Easky) rainfall station, ~3.7km southwest of the Proposed Wind Farm is 1,602mm/year.

Met Éireann also provide a grid of average annual rainfall for the entire country for the period of 1991 to 2020. Based on this more site-specific modelled rainfall values, the average annual rainfall at the Proposed Wind Farm ranges from 1,360 to 1,900mm/year. The higher value is used in the water balance presented below. This data is the most accurate estimate of average annual rainfall from the available sources).

The closest synoptic[1] station where the average potential evapotranspiration (PE) is recorded is at Bellmullet, ~75km west of the Proposed Wind Farm. The long-term average PE for this station is 510mm/year. This value is used as a best estimate of the site PE. Actual Evaporation (AE) at the Site is estimated as 485mm/year (which is 0.95 × PE).

The effective rainfall (ER)[2] represents the water available for runoff and groundwater recharge. The ER for the Project Wind Farm is calculated as follows:

$$\text{Effective rainfall (ER)} = \text{AAR} - \text{AE}$$

$$= 1{,}900\text{mm/year} - 485\text{mm/year}$$

$$\text{ER} = 1{,}415\text{mm/year}$$

Based on groundwater recharge coefficient estimates from the GSI (www.gsi.ie), recharge is capped at 50 - 200mm/year due to the poorly productive nature of the underlying bedrock aquifer at the Proposed Wind Farm (refer to EIAR Section 9.3.8 which deals with Site hydrogeology). 100mm/year is taken as an average for the Proposed Wind Farm (recharge coefficient of ~7%).

This means that the hydrology of the Proposed Wind Farm is characterised by high surface water runoff rates (93%) and low groundwater recharge rates (7%). Therefore, conservative annual recharge and runoff rates for the Proposed Wind Farm are estimated to be 100mm/yr and 1,315mm/yr respectively.

A recharge coefficient is not applicable to the Proposed Grid Connection Route due to the cabling being placed within the carriageway of public roads (i.e. existing impermeable manmade surface).

[1] *Meteorological station at which observations are made for synoptic meteorology and at the standard synoptic hours of 00:00, 06:00, 12:00, and 18:00.*
[2] *ER – Effective Rainfall is the excess rainfall after evaporation which produces overland flow and recharge to groundwater.*

In addition to average rainfall data, extreme value rainfall depths are available from Met Eireann. **Table A** below presents return period rainfall depths for the area of the 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, 10-year, 30-year and 100-year).

Table A. Project Site – Return Period Rainfall Depths (mm)

Return Period (Years)				
Storm Duration	**1**	**10**	**30**	**100**
5 mins	3.6	7.6	10.6	14.9
15 mins	5.8	12.5	17.4	24.5
30 mins	7.6	15.9	21.8	30.3
1 hour	9.9	20.1	27.2	37.4
6 hours	19.7	37.2	48.7	64.7
12 hours	25.7	47.1	61	80
24 hours	33.5	59.7	76.4	98.9
2 days	42.2	70.6	88	110.8

3.3 GEOLOGY

A detailed description of the geology of the Site is presented in Chapter 8: Land, Soils and Geology of the EIAR.

Regional baseline geological data is available from the GSI through their online map viewer (www.gsi.ie). The bedrock across the Site is variable and is mapped by the GSI as mainly SCHIST and PSAMMITIC at the eastern and southern portions, including the Existing Wind Farm (Kingsmountain).

LIMESTONE and SHALES are mapped below the northern and western portions of the Proposed Wind Farm, including the Existing Wind Farm (Dunneill). Subsoils are predominantly mapped as blanket peat with some metamorphic tills and alluvium mapped along river valleys.

The Proposed Project investigations and geotechnical assessments were extensive and consisted of 850 no. peat depth probes and 19 no. trial pits and extensive ground truthing.

In addition, there are historical trial pit logs (27 no.), shell and auger borehole logs (11 no.), dynamic probing (6 no.) and geophysical surveys (electrical resistivity) available for Existing Wind Farm.

The baseline geological setting of the Proposed Project has been thoroughly examined is fully understood.

Site investigations are summarised as follows:

- Peat depths recorded across the Proposed Wind Farm ranged from 0 to 7.2m with an average depth of 1.15m;
- Approximately 55% of recorded peat depth were less than 1m, 76% less and 2m and 90% less than 3m;

- The average peat depths recorded at the Proposed Turbines varied from 0.2 to 3m with an average of 1.3m;
- With respect to the new proposed access tracks, peat depths are typically less than 2m (average 1.8m) and therefore proposed access track construction will be a combination of floating and founded (i.e. excavate and replace methods);
- At the 3 no. proposed borrow pit locations, peat depths are shallow (<0.5m);
- Mineral subsoils (glacial tills) typically consisted of brown silty SAND and GRAVEL with cobbles and boulders and/or brown slightly gravelly sandy SILT with cobbles and boulders;
- Bedrock was encountered at 4 no. of the IDL trial pit locations which are all located along the Existing Wind Farm (Kingsmountain) access roads. Depth to bedrock ranged from 0m to 3.2m;
- Historical borehole logs for the Existing Wind Farm (Kingsmountain) encountered strong SCHIST bedrock at depths ranging from 2.3 to 6.6mbgl with an average of 4.9m; and,
- Historical trial pit logs for the Existing Wind Farm (Dunneill) encountered SHALE bedrock at depths ranging from 2.2 to 3.6mbgl with an average of 3.1m.

3.4 SITE DRAINAGE

3.4.1 Existing Site Drainage

Refer to **Figure C** below for existing drainage at the Proposed Wind Farm.

The portion of the Proposed Wind Farm within the Easky River sub-catchment (Easky_SC_010) is drained by several unnamed headwater streams of the Easky River itself along with the upper reaches of Buncrowey River (upper reaches are referred to as the Crowagh River and Owenminna River).

Easky River emerges from Easky Lough which is located 1.9km to the south of the Proposed Wind Farm. The Proposed Wind Farm is not located in the Easky Lough surface water catchment. Easky Lough is located 5km further up-stream in the Easky River catchment relative to the Proposed Wind Farm.

The southwestern portion of the Proposed Wind Farm is drained by headwater streams that drain directly into the Easky River which is located 4km to the west of the Site. There is 1 no. existing watercourse crossing along an existing bog track between Proposed Turbines T3 and T5 that will be upgraded as part of the Proposed Wind Farm.

The Buncrowey River, which is a tributary of the Easky River, forms from several headwater streams that flow through the western portion of Proposed Wind Farm after emerging from the slopes of the Ox Mountain to the south of the Proposed Wind Farm. The existing public road (L2702) on the west of the Proposed Wind Farm that will be upgraded by the Proposed Wind Farm crosses 3 no. headwater streams of the Buncrowey River. There is also 1 no. existing crossing of a Buncrowey headwater stream on the L6309 on the north of the Site which is also proposed for upgrade.

The central and eastern portion of the Proposed Wind Farm drain directly to the upper reaches of the Dunneill River (referred to as the Owenduff River on its upper reaches) which flows along the southeastern boundary of the Proposed Wind Farm prior to flowing through the central portion of the Proposed Wind Farm for approximately 3km. The Existing Wind Farm (including its 23 no. turbines) also drains directly to the Dunneill River.

3 no. EPA mapped headwater streams of the Dunneill River are crossed by the Existing Wind Farm access track infrastructure that will be upgraded for the Proposed Wind Farm.

The Dunneill River (Owenduff River) then flows northerly through the central and northern portion of the Proposed Wind Farm prior to flowing off-site at the Existing Wind Farm (Dunneill). Also, there is also 1 no. existing crossing of the Dunneill River on the L6309 public road on the north of the Proposed Wind Farm.

The northeastern portion of the Proposed Wind Farm is drained by headwater streams of the Doonbeakin River and Lugdoon Stream, with the former being a tributary of the Dunneill River.

Runoff from Existing Wind Farm hardstand and access tracks is typically 'over the edge' with roadside drains present along some sections of access tracks. On steeper sections of the Existing Wind Farm access tracks at Kingsmountain, ACO drains ('drainage grips') are present on the road surface for control of surface water runoff. Refer to the Proposed Wind Farm drainage drawings (EIAR Appendix 4-3) for the locations of existing access track ACO drains and drain culverts.

Along the Proposed Grid Connection Route there are 15 no. bridge crossings and 19 no. culvert crossings (34 no. watercourse crossings in total), which includes natural stream/rivers and drains. 31 no. of these watercourses are EPA mapped watercourse crossing locations.

All 34 no. watercourse crossings (both drains and natural) are existing culverts and bridges where works are required to accommodate the underground Proposed Grid Connection Route cable. No in-stream works are proposed at any of the Proposed Grid Connection Route crossing locations. Refer to the TLI Construction Methodology for the Proposed Grid Connection Route (EIAR Appendix 4-7).

3.5 DESIGNATED SITES & HABITATS

The Proposed Wind Farm is located adjacent to the Ox Mountain Bogs SAC and pNHA. An area of the Ox Mountain Bog SAC is located within the Site, adjacent to the Existing Wind Farm, however, no new infrastructure is proposed in this area.

Additionally, only the western portion of the Proposed Wind Farm (i.e. Proposed Turbines T1 to T6) is potentially located upgradient of the SAC with regard surface water runoff and groundwater flow. However, the Proposed Wind Farm infrastructure such as Proposed Turbines, hardstands and access tracks are setback more than 200m from the SAC boundary.

On the eastern portion of the Proposed Wind Farm the upper reaches of the Dunneill River (Owenduff River) form a hydrological boundary between the Proposed Wind Farm and the SAC downslope to the south. Even though the Proposed Wind Farm infrastructure is located upslope of the SAC topographically, there is no potential for surface water or groundwater flows towards the SAC due to the presence of the hydrological boundary offered by the Owenduff River.

Designated sites further downstream of the Proposed Project include Dunneill River pNHA (Site Code: 001664) which is located approximately 4.5km downstream of the Site.

In addition, Easky River pNHA (Site Code: 001665) is located approximately 8.5km downstream of the Site.

Designated sites downstream of the Proposed Grid Connection Route only include Unshin River SAC and Ballysadarre SAC. The Proposed Grid Connection Route intercepts the Unshin River SAC at 2 no. locations along the underground cable route, which includes 1 no. existing bridge crossing on the Owenmore River and 1 no. existing bridge crossing on the Unshin River.

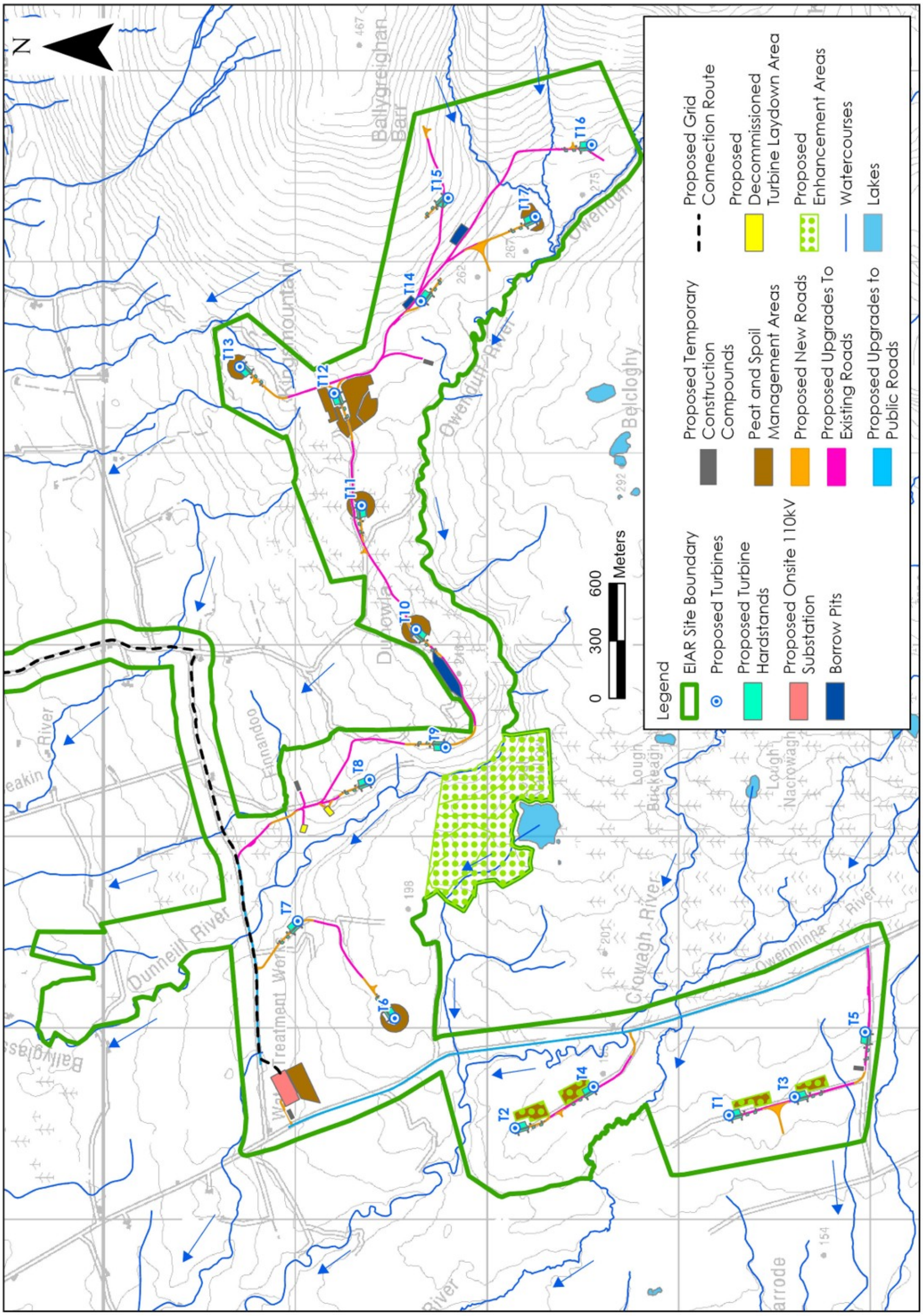

Figure C: Site Drainage Map

4. SITE SPECIFIC FLOOD RISK ASSESSMENT

4.1 INTRODUCTION

The following flood risk 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 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 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.

Due to its inland location, coastal flooding is not applicable to the 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 storm water 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 level may rise slowly, it may be in place for extended periods of time. 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. 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 river banks.

The Flood Risk Management Guidelines (DOEHLG, 2009) provide direction on flood risk and development. The DOEHLG, 2009 Guidelines recommend a precautionary approach when considering flood risk management and the core principle of the DOEHLG, 2009 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 DOEHLG, 2009 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.

Once a flood zone has been identified for a site, the DOEHLG, 2009 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 through the application of a Justification Test, where the planning need and the sustainable management of flood risk to an acceptable level must be demonstrated by the applicant.

The Justification Test 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 DoEHLG, 2009 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 DoEHLG, 2009 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 potentially at risk of flooding, historical mapping (*i.e.* 6" and 25" base maps) were consulted. There was no identifiable map text on local available historical mapping for the Site that identify lands that are "liable to flood".

4.3.2 Soils Maps - Fluvial Maps

A review of the soil types in the vicinity of the 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 flood plain and hence the presence of these soils is a good indicator of potentially fluvial flood prone areas.

Based on the EPA/GSI soil map for the area of the Proposed Wind Farm, alluvium soils are mapped along the Dunneill River and Buncrowey River that flow through the Site. There is no Proposed Wind Farm infrastructure located on mapped alluvium soils.

Alluvium soils are also frequently mapped along the Proposed Grid Connection Route at the larger watercourse crossing locations. However, due to the Proposed Grid Connection Route being located primarily within the carriageway of public roads, the proposed infrastructure does not interact with lands where alluvial soils are mapped.

4.3.3 OPW Past Flood Event Mapping

To identify those areas as being potentially at risk of recurring flooding, OPW's Past Flood Event mapping (www.floodinfo.ie) were consulted.

No recurring flood incidents within the Proposed Wind Farm were identified from OPW's Past Flood Event Mapping.

The closest mapped downstream flood event (flood ID: 4446) to the Proposed Wind Farm is a recurring event along the Easky River at Bellafarney Gleneasky townland, approximately 4.1km to the northwest of the Proposed Wind Farm, where "*flooding occurs in the flood plain here and lands badly affected*". The flooding is caused by increased river water levels rising over the winter period.

The are no past flood events mapped along the Dunneill River catchment in which all the Existing Wind Farm is located and most of the Proposed Wind Farm infrastructure (including Proposed Turbines T7 to T17).

There are several recurring flood events mapped along the N59 which overlaps with the Proposed Grid Connection Route, but due to the temporary nature of the constructions works and the fact that the insulated electrical cable will be placed underground, flood events will not pose a risk to the Proposed Grid Connection Route.

Past flood events mapped in the vicinity of the Site are shown on **Figure D** below.

No areas within the Proposed Wind Farm are mapped as an OPW Drainage District (i.e. an area where drainage schemes to improve land for agricultural purpose) or as Benefiting Lands (i.e. land identified by the OPW as potentially benefitting from the implementation of Arterial (Major) Drainage Schemes and an indicator of land subject to flooding and poor drainage).

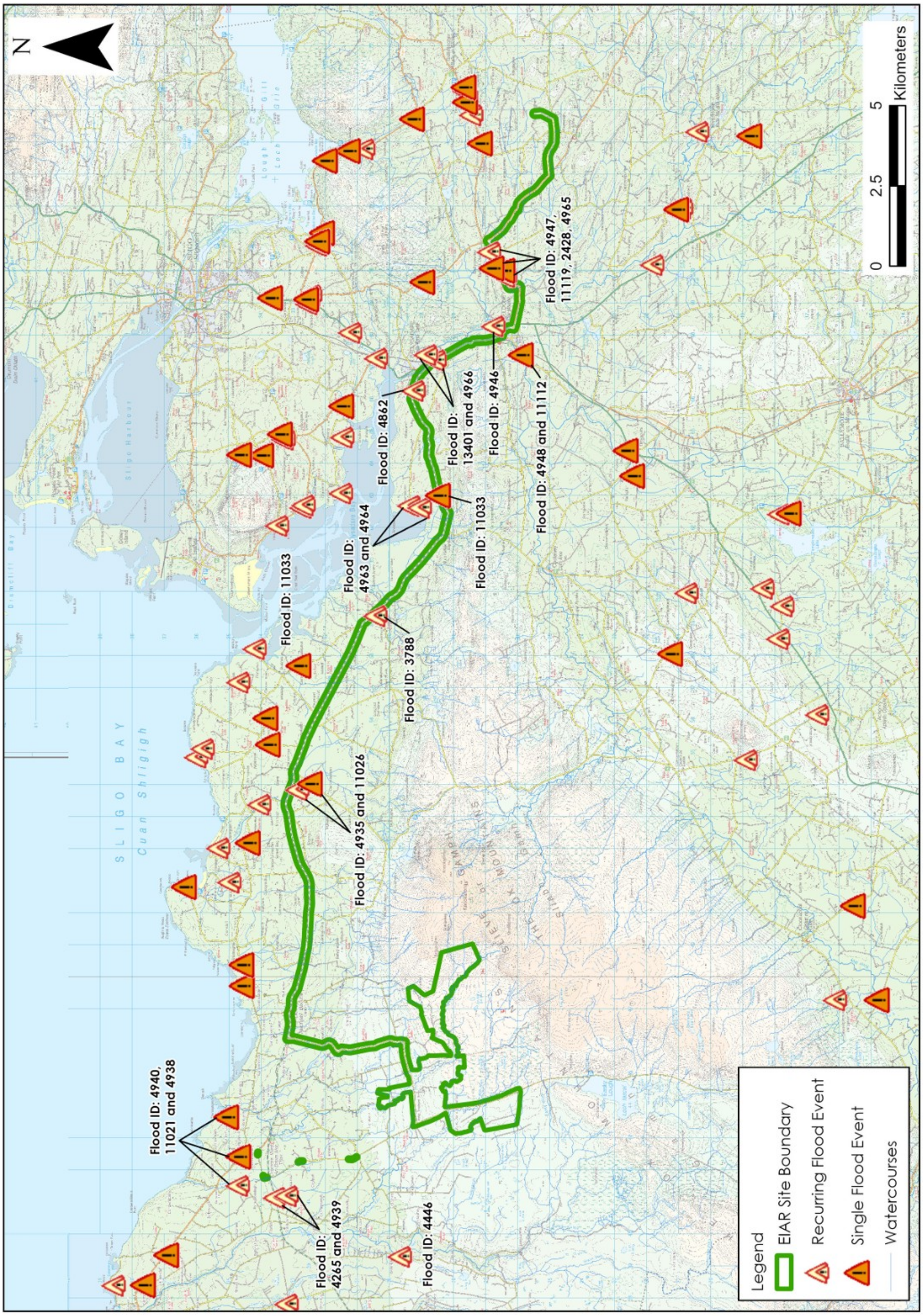

Figure D: OPW Past Flood Event Map

4.3.4 GSI Winter (2015/2016) Surface Water Flood Mapping

The GSI Winter (2015/2016) Surface Water Flooding Map[3] shows surface water flood extents for this particular winter flood event. This flood event is recognised as being the largest flood event on record in many areas. The flood map for this event does not record any fluvial flood zones along watercourses within the Site.

The nearest GSI Winter 2015/2016 Surface Water Flood Map flood zones are located close to lake waterbodies to the south of the Proposed Wind Farm including Lough Nafullow and Belcloghy Lough which are the larger of the lakes in close proximity to the Proposed Wind Farm. Lough Nafullow is 0.49km from the closest Proposed Wind Farm infrastructure (Proposed Turbine T9), while Belcloghy Lough is 1km from the closest Proposed Wind Farm infrastructure (Proposed Turbine T17).

Additionally, GSI Winter (2015/2016) Surface Water Flooding Maps have recorded flood zones along the N59 which contains the Proposed Grid Connection Route.

However, due to the Proposed Grid Connection Route cable being underground within the carriageway of public roads, the proposed infrastructure will not interact with these mapped flood zones.

4.3.5 CFRAM River Flood Extents Mapping

Catchment Flood Risk Assessment and Management (CFRAM)[4] River Flood Extent Maps are now the primary reference for flood risk planning in Ireland and are more accurate than the National Indicative Fluvial Mapping (NIFM).

CFRAM mapping has only been completed for Owenmore River and Unshin River at the eastern end of the Proposed Grid Connection Route. The Proposed Grid Connection Route passes over both these rivers within the carriageway of the R290 regional road and its bridge crossing.

A map showing the CFRAM Mapping for the present-day scenario is included as **Figure E** below.

4.3.6 National Indicative Fluvial Mapping (NIFM)

National Indicative Fluvial Mapping (www.floodinfo.ie) shows probabilistic fluvial flood zones for catchments only greater than 5km^2 for which flood maps were not produced under the CFRAM Programme.

The Present-Day Scenario has been generated using modelling methodologies based on historic flood data and does not consider the potential changes due to climate change. The potential effects of climate change on flooding have been separately modelled (see Section 4.3.9 below.)

The NIFM mapping shows localised fluvial flood zones close to the channels of the Dunneill River and Buncrowey River (upper Easky River) where they flow through the Proposed Wind Farm. However, mapped flood zones are very localised to the river channel and do not

[3] 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)*

[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.*

encroach any Proposed Wind Farm infrastructure. Therefore, all Proposed Wind Farm infrastructure is located in Flood Zone C (Low risk).

NIFM flood zones are mapped along the Proposed Grid Connection Route at the larger watercourse crossing locations. However, due to the underground nature of the Proposed Grid Connection Route, the cabling has no potential to affect fluvial flooding.

A map showing the National Indicative Fluvial Mapping for the present-day scenario is also included on **Figure E** below along with the CFRAM mapping.

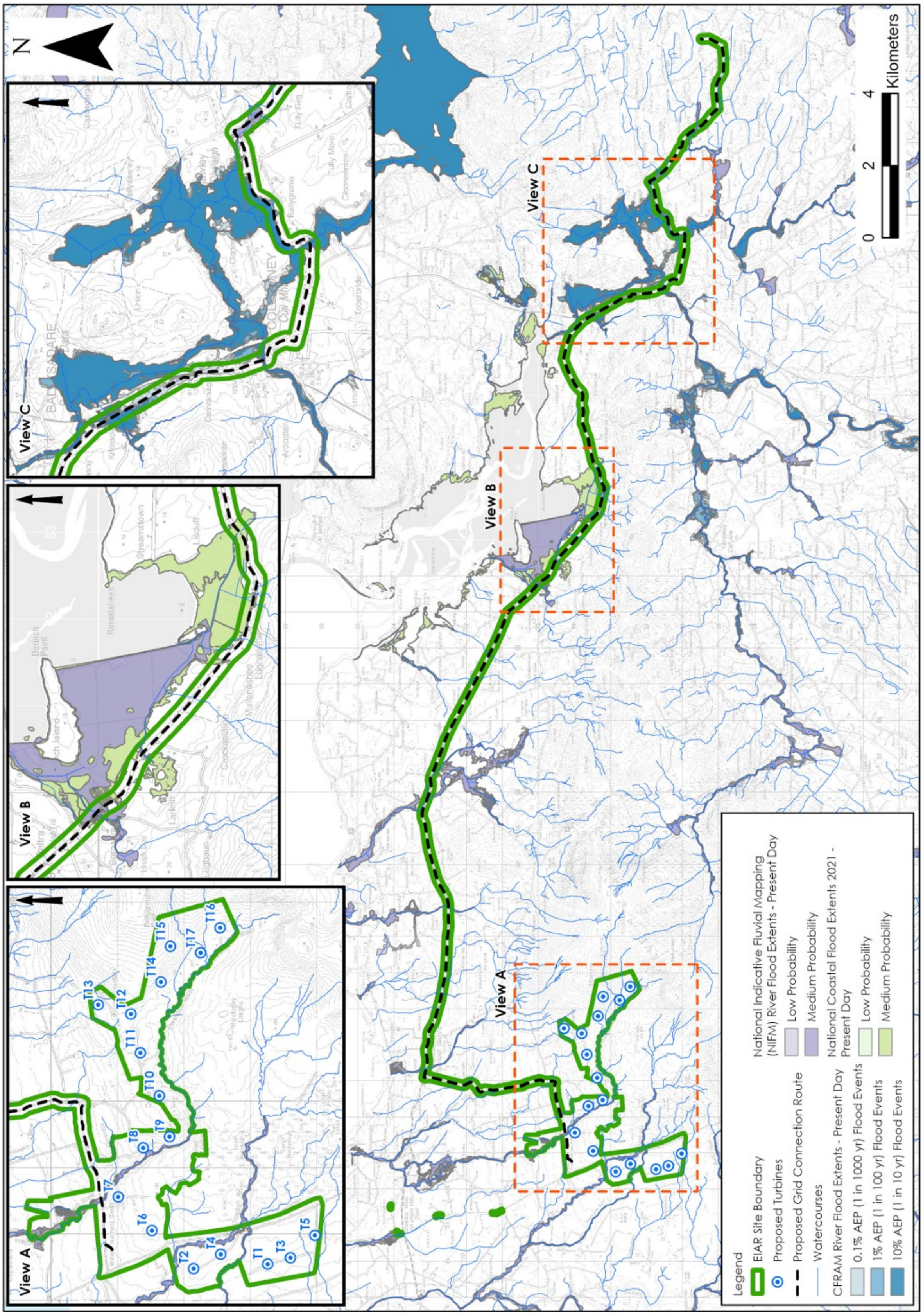

Figure E: CFRAM and NIFM Flood Zones

4.3.7 Groundwater Flooding

The GSI Historical Groundwater flood map and the modelled groundwater flood extents map (www.floodinfo.ie) do not show the occurrence of any groundwater flooding within the Proposed Wind Farm or its vicinity.

Due to the Proposed Wind Farm's elevation and bedrock aquifer (poorly productive), groundwater flooding would not be anticipated.

4.3.8 Coastal Flooding

The Proposed Wind Farm is located at elevations of between 110 to 390m OD and is approximately 6km from the coastline. Therefore, the Proposed Wind Farm is not at risk of coastal (tidal) flooding.

No CFRAM coastal flood mapping has been prepared for Sligo Bay.

4.3.9 Climate Change

Fluvial flood modelling has also been completed to consider future climate scenarios where the potential effects of climate change can increase rainfall.

The National Indicative Fluvial Flood Mapping Mid-Range Future Scenario models flood extents based on a 20% increase in rainfall. Similarly, the National Indicative Fluvial Mapping High-End Future Scenario models flood extends based on a 30% increase in rainfall.

Both of these modelled flood extents show similar flood zones to the Present Day Scenario discussed above in Section 4.3.6**.** Therefore, flood zones at the Site are unlikely to be significantly impacted by future climate change.

The CFRAM flood mapping has also been completed for the Mid-Range and High-End Future Scenarios. Both of these modelled flood extents show similar flood zones to the Present Day Scenario discussed above in Section 4.3.5.

Therefore, flood zones at the Site are unlikely to be significantly impacted by future climate change.

4.3.10 Summary – Flood Risk Identification

Based on the information gained through the flood identification process it is apparent that all Proposed Wind Farm infrastructure is located in Fluvial Flood Zone C, where the probability of flooding is low.

NIFM and CFRAM flood zones are mapped along the Proposed Grid Connection Route at the larger watercourse crossing locations. However, due to the underground nature of the Proposed Grid Connection Route, the cabling or joint bays have no potential to affect fluvial flooding or be affected by flooding.

4.4 INITIAL FLOOD RISK ASSESSMENT

Based on the information gained through the flood identification process and Initial Flood Risk Assessment process it has been determined that flooding is likely to pose a low risk within the Site.

The sources of flood risk for the site are outlined and assessed in **Table B**.

Table B. S-P-R Assessment of Flood Sources for the Proposed Project

Source	Pathway	Receptor	Comment
Fluvial	Overbank flooding of the rivers and streams that are close to some of the wind farm infrastructures.	Land & infrastructure	Proposed Wind Farm infrastructure is located in Fluvial Flood Zone C where there is a low risk of fluvial flooding. The 110kV substation element is also located in Flood Zone C. Some areas of the Proposed Grid Connection Route are located within Flood Zone A or B, but due to the underground nature of the infrastructure, are not risk.
Pluvial	Ponding of rainwater on site	Land & infrastructure	There is a low risk of significant pluvial flooding due to the extensive manmade drainage networks and sloping topography
Surface water	Surface ponding/ Overflow	Land & infrastructure	Same as above (pluvial).
Groundwater	Rising groundwater levels	Land & infrastructure	Based on local hydrogeological regime and topography, there is no apparent risk of groundwater flooding at the Site.
Coastal/tidal	Overbank flooding	Land, People, property	No coastal flooding will be possible at the Site due to distance to coast (>6km) and ground elevation.

4.5 JUSTIFICATION TEST

A matrix of vulnerability versus flood zone to illustrate appropriate development and that required to meet the Justification Test is shown in **Table C**. This table is adapted from Table 3.2 of the PSFRM Guidelines (DoEHLG, 2009).

It may be considered that the Proposed Wind Farm including the proposed 110kV onsite substation can be categorised as “Highly Vulnerable Development”, while the Proposed Grid Connection Route is a “Water Compatible Development” due to the subsurface nature of the sealed/insulated electrical cable.

Therefore, the Proposed Project is appropriate from a flood risk perspective, and a Justification Test is not required.

Table C: Matrix of Vulnerability versus Flood Zone

	Flood Zone A	**Flood Zone B**	**Flood Zone C**
Highly vulnerable development (including essential infrastructure) **Proposed Wind Farm**	Justification test	Justification test	**<u>Appropriate</u>**
Less vulnerable development	Justification test	Appropriate	Appropriate
Water Compatible development **Proposed Grid Connection Route**	**<u>Appropriate</u>**	**<u>Appropriate</u>**	**<u>Appropriate</u>**

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

5. FLOOD RISK PLANNING POLICY

5.1 PLANNING POLICY AND COUNTY DEVELOPMENT PLAN

The following policies (**Table D**) are defined in Sligo County CDP 2024-2030 in respect of flooding, and we have outlined in the column to the right how these policies are provided for within the proposed project design:

Table D: Sligo County Council Flood Risk Management Policy and Responses

No.	Policy	Development Design Response
P-FRM-3	Contribute towards the general maintenance of a 20-metre-wide flood protection zone around lakes and along both sides of all rivers, and a 100- metre-wide flood protection zone from soft shorelines. Development proposals will be required to maintain these flood protection zones generally free from development.	A hydrological constraints map for the Proposed Wind Farm is shown as EIAR Figure 9-9. A self-imposed 50m buffer from streams and lakes was applied during the constraints mapping and will be maintained during the construction phase. Apart from the total 9 no. existing EPA mapped water crossing locations (Existing Wind Farm access tracks, public roads (for upgrade) and existing bog tracks) and TDR overrun areas, the Proposed Wind Farm infrastructure is located outside the delineated buffer zones within the Proposed Wind Farm.
P-FRM-4	Ensure that new developments proposed in Arterial Drainage Schemes and Drainage Districts preserve access for maintenance and do not result in a significant negative impact on the integrity, function and management of these areas. Where developments are proposed in the vicinity of Flood Relief Schemes, drainage channels and rivers for which the OPW is responsible, the Planning Authority will consult with the OPW and, where appropriate, will require the retention of a strip on either side of such channels, to facilitate maintenance access thereto.	Not applicable to this Site (refer to Section 4.3.3 above).
P-FRM-6	Require development proposals, where appropriate, to be accompanied by a detailed flood risk assessment in accordance with the provisions of the DoEHLG and OPW's Planning System and Flood Risk Management Guidelines for Planning Authorities and to address flood risk management in the detailed design of development, as set out in Appendix B of the Guidelines.	As Outlined in this FRA
P-FRM-6B	Site-specific flood risk assessments shall consider climate change impacts and adaptation measures, shall apply the precautionary approach recommended in the Guidelines, and shall be informed by the advice on the expected impacts of climate change and the allowances to be provided for future flood risk management (refer to the OPW's 2019 Flood Risk Management Climate Change Sectoral Adaptation Plan and the guidance on potential future scenarios contained therein).	As Outlined in this FRA
P-FRM-6D	In Flood Zone C, where the probability of	As Outlined in this FRA

	flooding is low (less than 0.1%), site-specific flood risk assessment may be required, and the developers should satisfy themselves that the probability of flooding is appropriate to the development being proposed. Prospective applicants shall consult the SFRA datasets accompanying this Development Plan and the most up-to-date Catchment Flood Risk Assessment and Management (CFRAM) Programme climate scenario mapping. Applications for development on sites identified as "'benefitting lands' may be prone to flooding, and site-specific flood risk assessments may be required in these areas	
P-FRM-6E	Groundwater and pluvial flood risks shall be considered by any site-specific flood risk assessment undertaken at project level, in compliance with the Planning Systems and Flood Risk Management Guidelines	As Outlined in this FRA

5.2 PROPOSED DRAINAGE

The wind farm drainage system was designed integrally with the Proposed Project 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 dominant, 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 and drains, 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 tracks. 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 tracks. 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.

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

5.3 PROPOSED ON-SITE RUNOFF ATTENUATION

The creation of impermeable areas within a 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 Project 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 Proposed Project, 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, access tracks 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 check 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 fences 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. Therefore, the Proposed Project 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.

6. REPORT CONCLUSIONS

- A flood risk identification study was undertaken to identify existing potential flood risks associated with the Proposed Project. From this study:
  - No instances of historical flooding were identified in historic OS maps within the Proposed Wind Farm;
  - No instances of recurring flooding were identified on OPW maps within the Proposed Wind Farm;
  - The GSI Winter 2015/2016 Surface Water Flooding and Groundwater flood Mapping provides no evidence of historical flooding at the Proposed Wind Farm;
  - No CFRAM or NIFM fluvial flood zones are encroached by the Proposed Wind Farm infrastructure;
  - Sections of the Proposed Grid Connection Route pass through NIFM and CFRAM flood zones but this has no consequence or risk for the Proposed Project due to the underground and insulated nature of the infrastructure;
  - The proposed on-site 110kV substation element of the Proposed Wind Farm is located in Flood Zone C at the Proposed Wind Farm.
- Therefore, the Proposed Project is appropriate from a flood risk perspective, and no Justification Test is required; and,
- This FRA fulfils the requirements for a site-specific flood risk assessment and is consistent with the recommendations made in the Sligo County Development Plan (2024-2030).

* *

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.
Sligo County Council	2024	County Sligo Development Plan 2024-2030