APPENDIX 9-1

FLOOD RISK ASSESSMENT

HYDRO ENVIRONMENTAL SERVICES

22 Lower Main St
Dungarvan
Co.Waterford
Ireland

tel: +353 (0)58 44122
fax: +353 (0)58 44244
email: info@hydroenvironmental.ie
web: www.hydroenvironmental.ie

PROPOSED CUNLAGHFADDA GREEN ENERGY PROJECT, CO. MAYO

SITE-SPECIFIC FLOOD RISK ASSESSMENT

FINAL REPORT

Prepared for:

CUNLAGHFADDA GREEN ENERGY LTD

Prepared by:

HYDRO-ENVIRONMENTAL SERVICES

DOCUMENT INFORMATION

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Author(s):	**MICHAEL GILL CONOR MCGETTIGAN NITESH DALAL**
Signed:	Michael Gill ______________________________ **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) was engaged by MKO Ireland to undertake a Site-Specific Flood Risk Assessment (SSFRA), on behalf of Cunlaghfadda Green Energy Ltd, for the Proposed Project.

This FRA is written to accompany Chapter 9 of the Environmental Impact Assessment Report (EIAR) for the Proposed Project. The Proposed Project is described in full in Chapter 4 of the EIAR. For the purposes of this FRA, and consistent with the EIAR, the various components are described and assessed using the following references: 'Proposed Project', 'Proposed Wind Farm', 'Proposed Grid Connection', the 'Site' (as delineated by the EIAR Site Boundary).

The following assessment is carried out in accordance with '*The Planning System and Flood Risk Management Guidelines for Planning Authorities*' (DoEHLG, 2009) (hereafter referred to as the Guidelines). This SSFRA is also completed in accordance with the Flood Risk Management policies (INP 14 to MP 16) and objectives (INO 19 to INO 28) detailed in the Mayo County Development Plan (2022-2028).

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 (BA, BAI, Dip Geol., MSc, MIEI) is an Environmental Engineer and Hydrogeologist with over 23 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments of wind farms and renewable projects in Ireland, as well as accompanying Flood Risk Assessments. He has substantial experience in surface water drainage design and SUDs design and surface water/groundwater interactions. For example, Michael has worked on the Flood Risk Assessment Reports for Oweninny WF, Cloncreen WF, and Yellow River WF, and over 100 other wind farm-related projects.

Conor McGettigan (BSc, MSc) is an Environmental Scientist with over 5 years' experience in environmental consultancy in Ireland. Conor holds an M.Sc. in Applied Environmental Science (2020) and a B.Sc. in Geology (2016) from University College Dublin. Conor has prepared the Land, Soils and Geology and Hydrology and Hydrogeology Chapters for numerous wind farm EIAR projects. Conor routinely completes Flood Risk Assessments for a wide variety of projects including wind farms, quarries and proposed residential developments.

Nitesh Dalal (B.Tech, PG Dip., MSc) is an Environmental Scientist with over 7 years' experience in environmental consultancy and environmental management in India. Nitesh holds a M.Sc. in Environmental Science from University College Dublin (2024), a PG Diploma in Health, Safety and Environment from Annamalai University, India (2021) and B.Tech. in Environmental Engineering (2016) from Guru Gobind Singh Indraprastha University, India (2016).

1.3 REPORT LAYOUT

This SSFRA report has the following format:

- Section 2 describes the setting of the Site and details of the Proposed Project;
- Section 3 outlines the hydrological and geological characteristics of the local area;
- Section 4 presents a site-specific flood risk assessment (SSFRA) undertaken for the Proposed Project which was carried out in accordance with the above-mentioned guidelines. This section includes a detailed assessment of the flood risk at the Site and also determines whether a Justification Test is required for the Proposed Project;
- Section 5 presents the proposed drainage system which will be implemented on-site as part of the Proposed Project. This section also discusses the potential impact that the Proposed Project may have on the downstream flood risk; and,
- Section 6 presents the SSFRA report conclusions.

2. BACKGROUND INFORMATION

2.1 INTRODUCTION

This section provides details on the topographical setting and describes the Site.

2.2 SITE LOCATION AND TOPOGRAPHY

The Site is located within a rural setting in south Co. Mayo, approximately 5.3 kilometres (km) to the northwest of the town of Claremorris. The town of Castlebar is located approximately 16 km north-west of the Site.

The Site comprises a mix of agricultural land, peat bogs and private forestry. The Site predominantly consists of cut peat bogs separated by elevated ridges comprising agricultural pastures. An area of inland marsh land is located to the east of the Site surrounding Drumady Lough that defines the south-eastern boundary of the Site. Agricultural pastures dominate the wider environment/area with some smaller areas of coniferous forestry in the east and more pockets of peat land areas mapped to the south. Isolated dwellings and farm buildings reside along the numerous local roads in the vicinity of the Site.

The N60 National Road runs north-south approximately 2 km to the east. The R331 Regional Road runs northeast-southwest, approximately 5 km from the southern boundary of the Site. Existing access is via the local L15053 road to the south and the local L5536 road to the north. There are several existing forestry/ agricultural tracks within the Site.

Ground elevations within the Site are relatively flat and low-lying, ranging from approximately 60 mOD (metres above Ordnance Datum) to 70 mOD. The topography slopes very gently in an easterly direction towards Drumady Lough. In places topography has been modified through previous peat extraction activities and associated drainage.

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

2.3 PROPOSED PROJECT DETAILS

The Proposed Project consists of a 7 no. turbine wind farm and associated infrastructure including internal access tracks, hard standings, an onsite borrow pit, peat and spoil management areas, temporary construction compound, met mast, biodiversity management and enhancement areas and the Proposed Grid Connection infrastructure.

The Proposed Project is described in full in Chapter 4 of the EIAR.

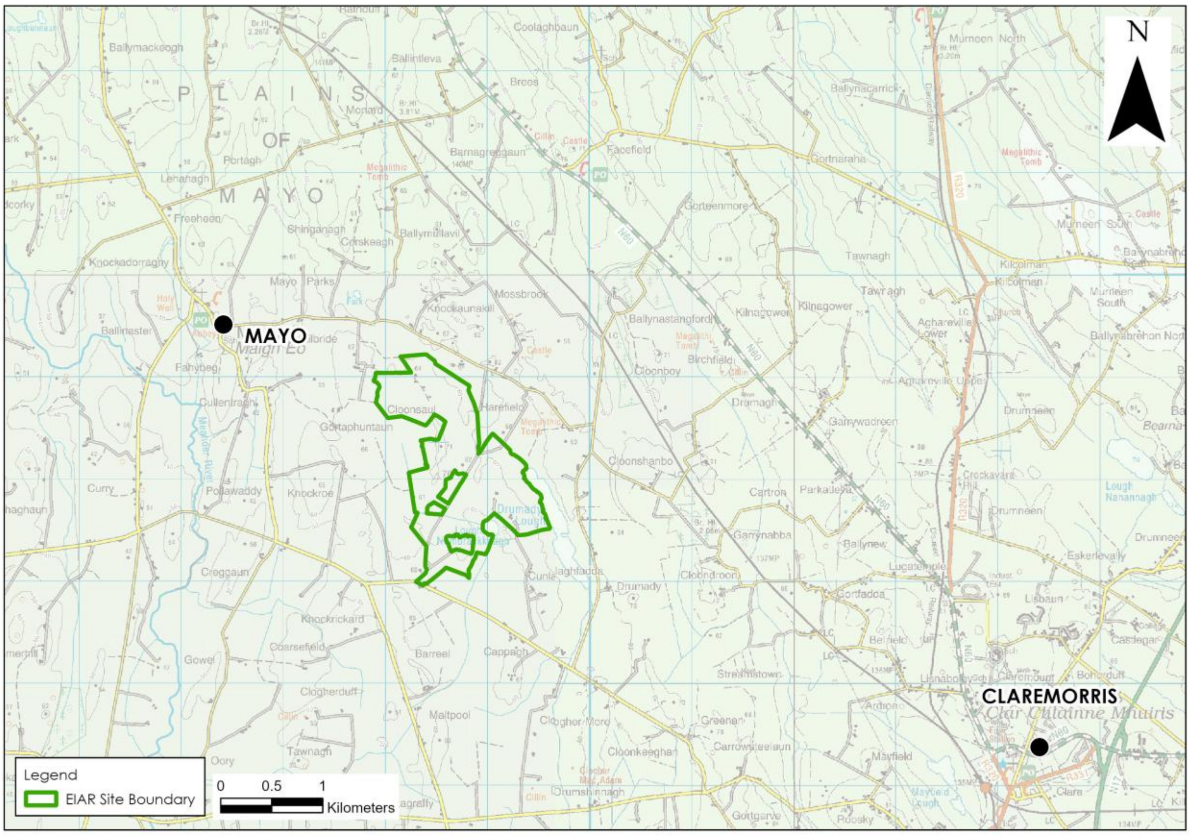

Figure A: Site Location Map

3. EXISTING ENVIRONMENT AND CATCHMENT CHARACTERISTICS

3.1 INTRODUCTION

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

3.2 HYDROLOGY

3.2.1 Regional and Local Hydrology

Regionally, the Site lies at the boundary between 2 no. WFD surface water catchments. The north and south of the Site are mapped in the Moy and Killala Bay Catchment within Hydrometric Area 34. The centre of the Site is located in the Corrib Catchment within Hydrometric Area 30. Both of these surface water catchments are located in the Western River Basin District.

Within the Corrib Catchment, the Site is mapped in the Robe River sub-catchment (Robe_SC_010) and the Robe_030 WFD river sub-basin. The nearest EPA mapped watercourse to this area of the Site is a small 1st order stream which outfalls from the south of Drumady Lough. Drumady Lough itself is located outside of the Site boundary, immediately to the east and 240m from the closest turbine (T4). Local 6" base maps identify 2 no. small streams to discharge into the northern section of Drumady Lough, one of which drains the area of the Site. The stream which outfalls from the lake, flows to the south and discharges into the River Robe (EPA Code: 30R01) ~5.6 km to the south of the Site. The River Robe flows to the southwest past Hollymount and Ballinrobe before it discharges into Lough Mask ~18.5 km to the southwest of the Site.

Within the Moy and Killala Bay Catchment, the Site is mapped in the Castlebar River sub-catchment (Castlebar_SC_020) and 2 no. WFD river sub-basins. The south of the Site is mapped in the Meander_010 WFD river sub-basin whilst the north is mapped in the Tullymore (Mayo)_010 WFD river sub-basin. Within the Meander_010 WFD river sub-basin Lough Nambrackkeagh is situated directly to the south of the Site. The Meander River (EPA Code: 34M05) outflows from Lough Nambrackkeagh, initially flowing to the south before veering to the northwest and discharging into the Manulla River (EPA Code: 34M01) ~5.5 km to the northwest of the Site. The Manulla River continues north and drains into the Castlebar River (EPA Code: 34C01) ~16.6 km northwest of the Site. From this point the Castlebar River feeds into the Toormore and Clydagh Rivers respectively, meandering further north (~10 km) to discharge into Lough Cullin.

The northern portion of the Site resides within the Tullymore (Mayo)_010 WFD river sub basin. The Meander River flows within the southeast of the Site, approximately 372m southwest of T5. The Tullymore Stream is located ~5 km northwest of the Site and flows to the north into the Little Strade River. Inspection of local base maps reveal the presence of some hydrological features which drain this section of the Site and flow to the north and discharge into Lough Fark, located ~700m to the north of the Site.

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

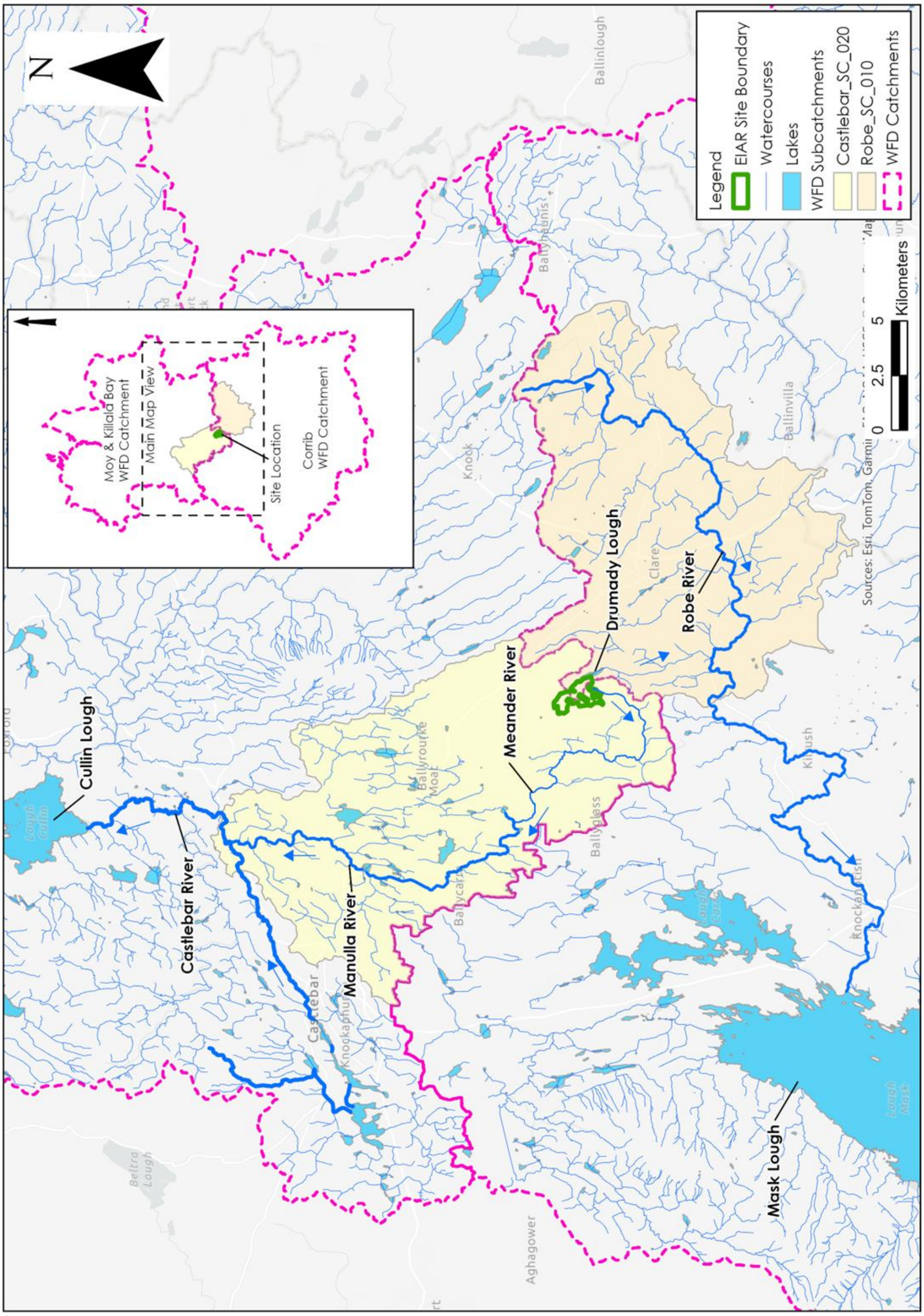

Figure B: Local Hydrology Map

3.2.2 Rainfall and Evaporation

The SAAR (Standard Average Annual Rainfall) recorded at Claremorris, the closest rainfall station to the Site with long term SAAR data, is 1,143mm (www.met.ie). Claremorris rainfall station is located ~6.5 km southeast of the Site.

Met Éireann also provide a grid of Average Annual Rainfall (AAR) for the entire country for the period of 1991 to 2020. Based on this more site-specific modelled rainfall values, the AAR at the Site is 1,298 mm/yr. This is considered to be the most accurate estimate of average annual rainfall from the available sources.

The average Potential Evapotranspiration (PE) at Claremorris is taken to be 407.5 nmm/yr (www.met.ie). The Actual Evapotranspiration (AE) is calculated to be 387mm (95% PE). Using the above figures, the Effective Rainfall (ER)[1] for the area is calculated to be (ER = AAR – AE) 911 mm/yr.

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, 5-year, 30-year, 100-year).

Table A. Return Period Rainfall Depths (mm)

	Return Period (Years)			
Duration	**1**	**5**	**30**	**100**
5 mins	3.7	6.1	10.2	14.1
15 mins	6.0	10.0	16.8	23.2
30 mins	7.8	12.7	21.0	28.6
1 hours	10.2	16.3	26.3	35.4
6 hours	20.2	30.7	47	61.3
12 hours	26.4	39.2	58.9	75.8
24 hours	34.4	50.1	73.8	93.7
2 days	43.7	60.6	84.9	104.5

3.3 EXISTING SITE DRAINAGE

As stated above, the central section of the Site drains towards Drumady Lough situated immediately to the southeast. A mixture of peat and agricultural drainage systems direct drainage towards this lake. A stream outfalls from this lake and flows to the south into the River Robe. The southern section of the Site drains towards the Meander River. This area is predominantly comprised of a peat drainage network that directs surface run off towards Lough Nambrackkeagh which is source of the EPA mapped Meander River. The north of the Site is also drained by a network of manmade drainage features which direct water to the north towards Lough Fark.

In places the natural drainage is further facilitated by a network of manmade drains. The nature of these manmade drains depends on the local land use and comprise of agricultural field drains or forestry drains. Drains are also present in the peat areas where turbary cutting has been taking place.

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

3.4 GEOLOGY

The published Teagasc/EPA soils map (**www.epa.ie**) for the area shows that the Site is mostly overlain by cutover/cutaway peat. Basic, deep well drained mineral soils (BminDW) are also mapped to cover a significant area of the Site, with these soils mapped in the northwest and the southeast. On the perimeter of these basic deep well drained mineral soils, Teagasc also map small pockets of basic poorly drained mineral soils (BminPD).

The GSI subsoil mapping (www.gsi.ie) shows that cut over raised peat is the dominant subsoil type across the Site. Till derived from limestones (TLs) are also mapped in the northwest and the southeast of the Site. Other subsoils mapped in the surrounding lands include gravels derived from limestones (GLs) which are mapped to the north/northeast of the Site. No areas of bedrock outcrop or subcrop are mapped within the Site or in the surrounding lands. A subsoil geology map for the Site is shown as **Figure C.**

Based on the GSI bedrock mapping (www.gsi.ie) the Site is underlain by a total of 4 no. bedrock geological formations. The majority of the Site is underlain by the Ardnasillagh Formation which comprises of dark cherty limestone and thin shales. The south of the Site is underlain by the Cong Canal Formation consisting of medium to thick-bedded pure limestone. A very small area in the east of the Site is mapped to be underlain by the Visean Limestones (undifferentiated). The very northern section of the Site is mapped to be underlain by the Illaunagappul Formation, which consists of limestone and thin shale partings.

The soils, subsoils and bedrock geology at the Site have been verified during site walkover surveys and intrusive site investigations (peat probing, trial pit excavations and borehole drilling). The results of these site investigations are detailed in Chapter 8 of the EIAR.

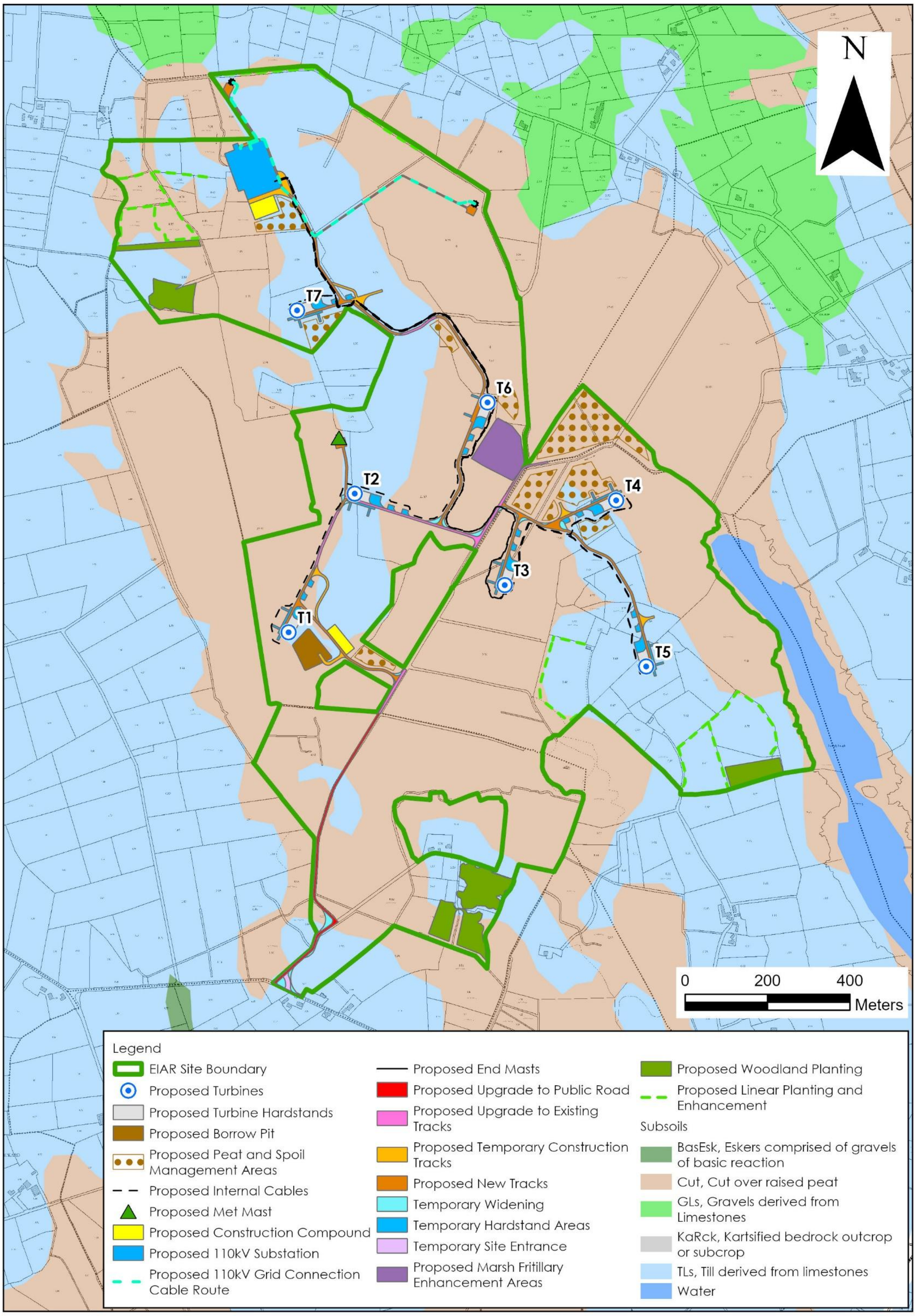

Figure C: Local Subsoil Map (www.gsi.ie)

3.5 HYDROGEOLOGY

The GSI map the Site to be underlain by the Dinantian Pure Bedded Limestones (www.gsi.ie). These rocks are classified by the GSI as a Regionally Important Aquifer - Karstified (conduit). The GSI do not map the presence of any karst features within the Site. The Site is mapped to be underlain by 2 no. Groundwater Bodies (GWBs). The north and south of the Site are underlain by the Swinford GWB whilst the central section of the Site is underlain by the Cong Robe GWB.

The hydrogeological regime at the Site has been characterised by detailed walkover surveys, drainage mapping, peat probing, trial pit excavations and the borehole drilling. The site investigations in terms of hydrogeology are detailed in Chapter 9 of the EIAR.

The site investigations indicate that the Site is underlain predominantly by peat and low permeability till deposits. These deposits protect the underlying regional bedrock groundwater system, preventing significant rates of groundwater recharge within the Site. No karst features were recorded during walkover surveys, and no significant karst was encountered during the drilling of the borehole.

Therefore, the hydrogeological regime at the Site is characterised by high rates of surface water runoff and low rates of groundwater recharge.

3.6 DESIGNATED SITES & HABITATS

Within the Republic of Ireland designated sites include National Heritage Areas (NHAs), Proposed National Heritage Areas (pNHAs), Special Areas of Conservation (SACs) and candidate Special Areas of Conservation (cSAC) and Special Protection Areas (SPAs).

The Site is not located within any designated site. The nearest designated site to the Site is the River Moy SAC (Site Code: 002298) located ~1.95 km straight-line to the west of the Site. This SAC is downstream of the Site via the Meander River. The River Moy SAC follows the course of the Meander, Manulla and Castlebar rivers and further encompasses Lough Cullin downstream of the Site. Lough Cullin itself is also mapped as part of the Lough Conn and Lough Cullin SPA (004228).

2 no. pNHA turlough sites are located west of the River Moy SAC; the Mountpleasant School Turlough (Site Code: 001472) and the Slishmeen Turlough (Site Code: 001559) ~5 km west from the Site.

The Balla Turlough SAC and pNHA (Site Code: 000463) is situated ~5 km north/northwest of the Site. Meanwhile, ~8 km south of the Site is the Carrowkeel Turlough SAC and pNHA (Site Code: 000475). The Towerhill House SAC (Site Code: 002179) is situated ~8 km west of the Site.

Downstream of the Site via the Robe River is the Lough Carra/Mask Complex SAC (Site Code: 001774) and Lough Mask SPA (Site Code: 004062).

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 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 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.

- Estuarine 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 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% 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 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 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 (*i.e.* 6" and 25" base maps) were consulted. There was no identifiable map text on local available historical 6" or 25" mapping for the study area that would identify lands that are "liable to flood" within or in the vicinity of the Site.

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 flood prone areas.

Based on the EPA/GSI soil map for the local area, no fluvial or lacustrine deposits are mapped within the Site. There are no soils present that indicate areas where flooding may have occurred in the past.

The nearest mapped alluvium deposits are located on the Meander River downstream of Drumady Lough.

4.3.3 OPW Past Flood Events Mapping

To identify those areas as being at risk of flooding, the OPW's Past Flood Events Map was consulted (www.floodinfo.ie).

No recurring or historic flood incidents are recorded within the Site or immediately downstream. The closest recurring flood is situated ~2 km northeast of the Site at Barnagreggaun (ID: 4751). The flooding at this location has occurred in a low-lying area on a county road, south of the N60 in the Barnagreggaun area. However, the local area engineer notes, available on www.floodinfo.ie, state that the road levels had been raised and no flooding problems have occurred since (2006).

Further north, the OPW map 2 no. recurring flood events, 1 no. located along the N60 at Brees (ID:4781) and 1 no. at Monard (ID: 4751). Both these recurring events happen in low- lying areas ~2.6 km north of the Site.

A single undated flood event was recorded ~2 km southwest of the Site along a tributary stream of the Meander River. This tributary stream has no direct hydrological connection with the Site.

Historic and recurring flood events in the vicinity and downstream of the Site are shown on **Figure D** below.

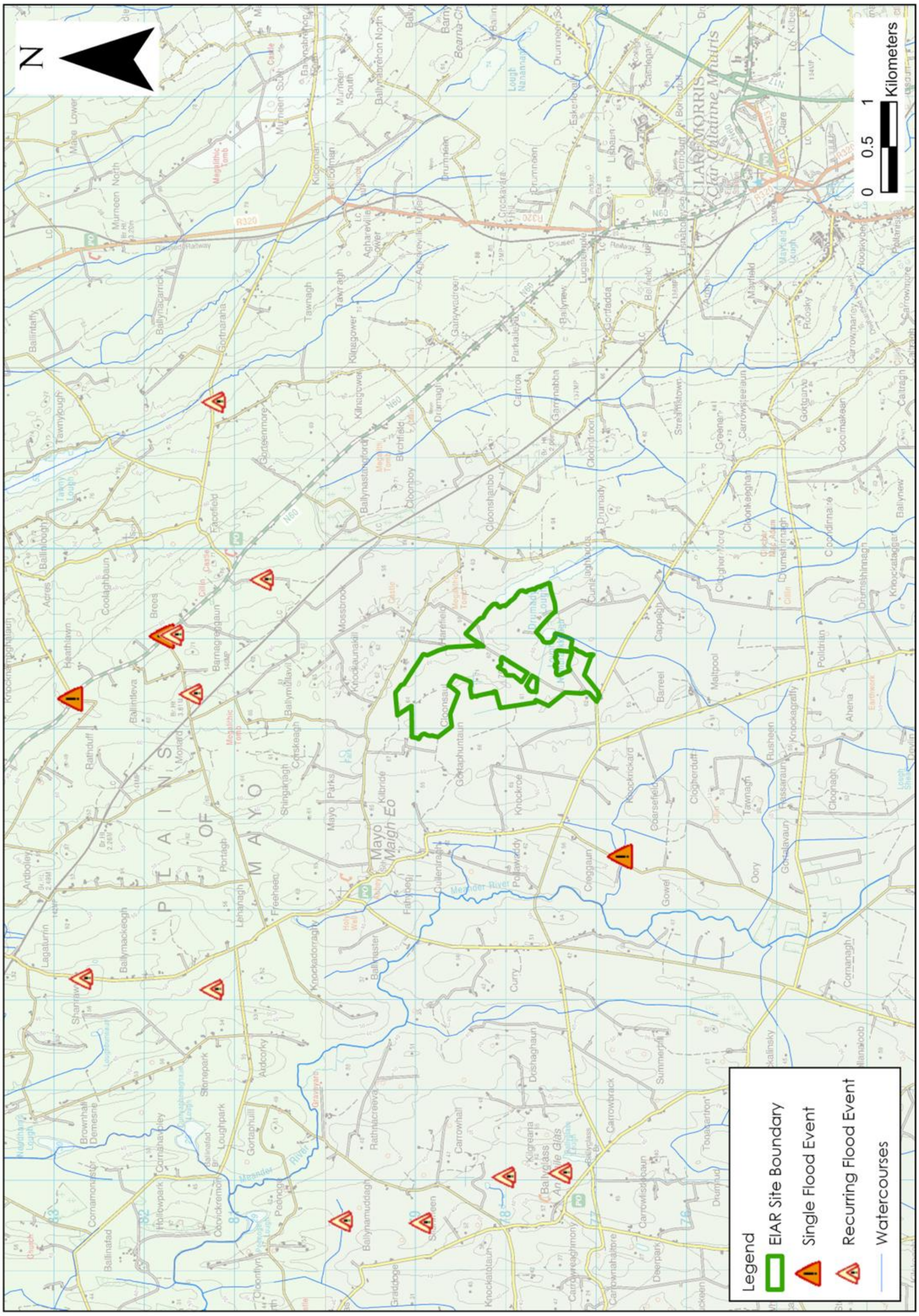

Figure D: OPW Past Flood Events Map

4.3.4 Drainage Schemes

The lands immediately surrounding Drumady and Nambrackkeagh Loughs and the lands around the streams which outflow from these lakes, are mapped as Benefited land layer identifies land that was drained as part of an Arterial Drainage Scheme. Arterial Drainage Schemes were carried out under the Arterial Drainage Act, 1945 to improve land for agriculture and to mitigate flooding. Rivers, lakes weirs and bridges were modified to enhance conveyance, embankments were built to control the movement of flood water and various other work was carried out under Part II of the Arterial Drainage Act, 1945.

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

Furthermore, the GSI Winter (2015/2016) Surface Water Flooding Map[2] shows areas of fluvial and pluvial flood extents during the Winter 2015/2016 flood event, which was the largest recorded flood event in many areas. This surface water flood map is available to view at www.floodinfo.ie.

The GSI record historic flood zones at Drumady Lough to the east of the Site. However, no flooding was recorded to encroach upon the Site with the flooding restricted to the immediate vicinity of the lough.

A small area of surface water flooding was recorded ~0.8 km west of the Site, to the south of Gortaphuntaun. Furthermore, an extensive area of flooding was recorded around the Fark Lough, situated ~1 km northwest of the Site.

The historic flood zones associated with the 2015/2016 flood event are shown on **Figure E** below.

[2] 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)*

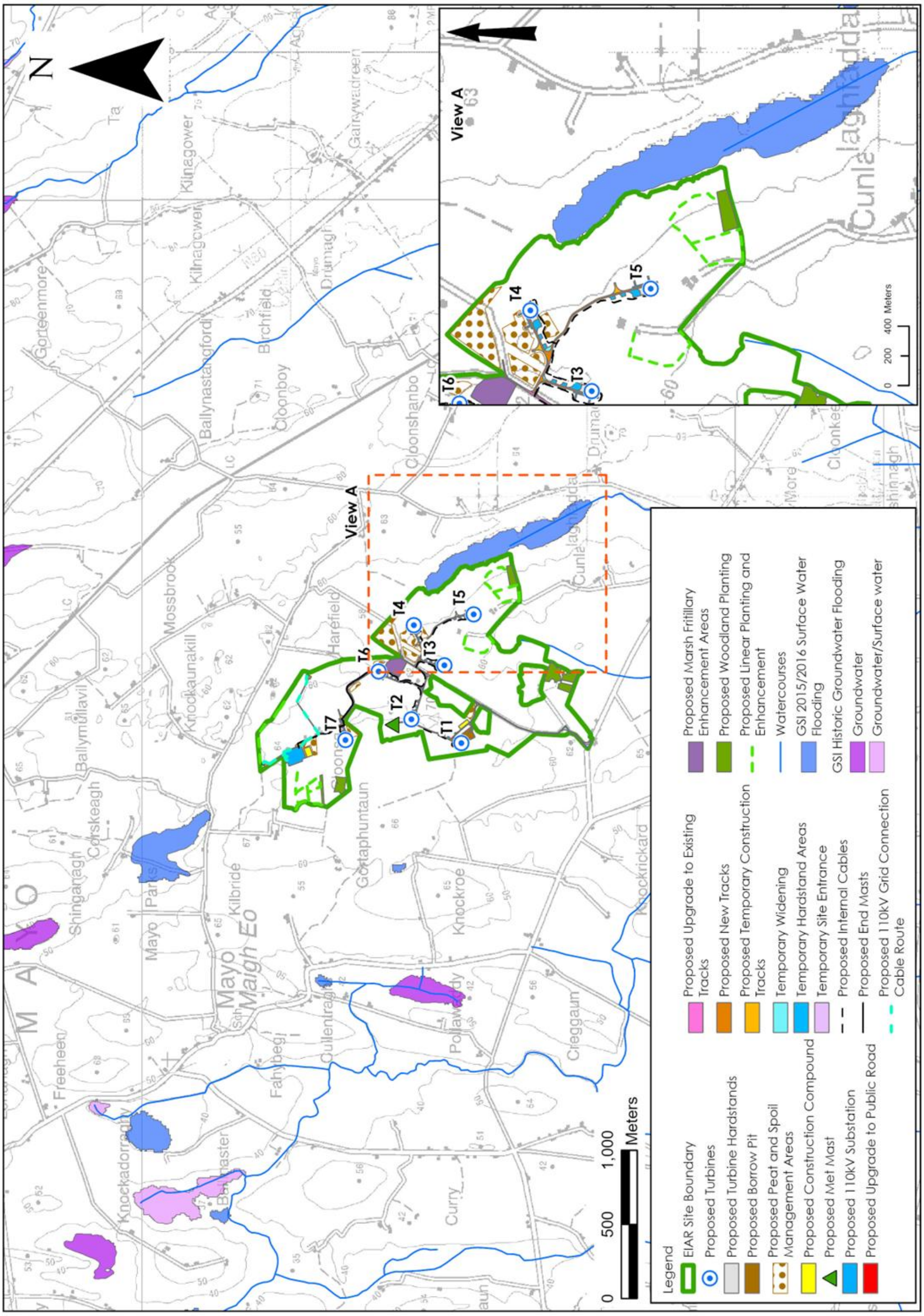

Figure E: GSI Historic (2015/2016) Surface Water Flooding

4.3.6 CFRAM Mapping – Fluvial and Pluvial Flooding

Catchment Flood Risk Assessment and Management (CFRAM)[3] OPW Flood Risk Assessment Maps are now the primary reference for flood risk planning in Ireland and supersede the previous PFRA maps.

CFRAM mapping has not been completed for the area of the Site.

The closest CFRAM fluvial flood zones downstream of the Site are mapped along the Castlebar River, ~16.5 km to the northwest (as the crow flies) and extend from Castlebar to Lough Cullin.

4.3.7 National Indicative Fluvial Flood Mapping

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

The Present-Day Scenario has been generated using 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 4.3.10** below.)

For the Present-Day Scenario, no fluvial flood zones are mapped in the vicinity of the Site. The nearest NIFM fluvial flood zones are mapped along the Meander River ~1.6 km west of the Site.

As such, the entire Site, including all proposed infrastructure is located in Fluvial Flood Zone C, where the probability of fluvial flooding is low (less than 0.1%). The National Indicative Fluvial Flood Mapping for the present-day scenario is included as **Figure F** below.

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

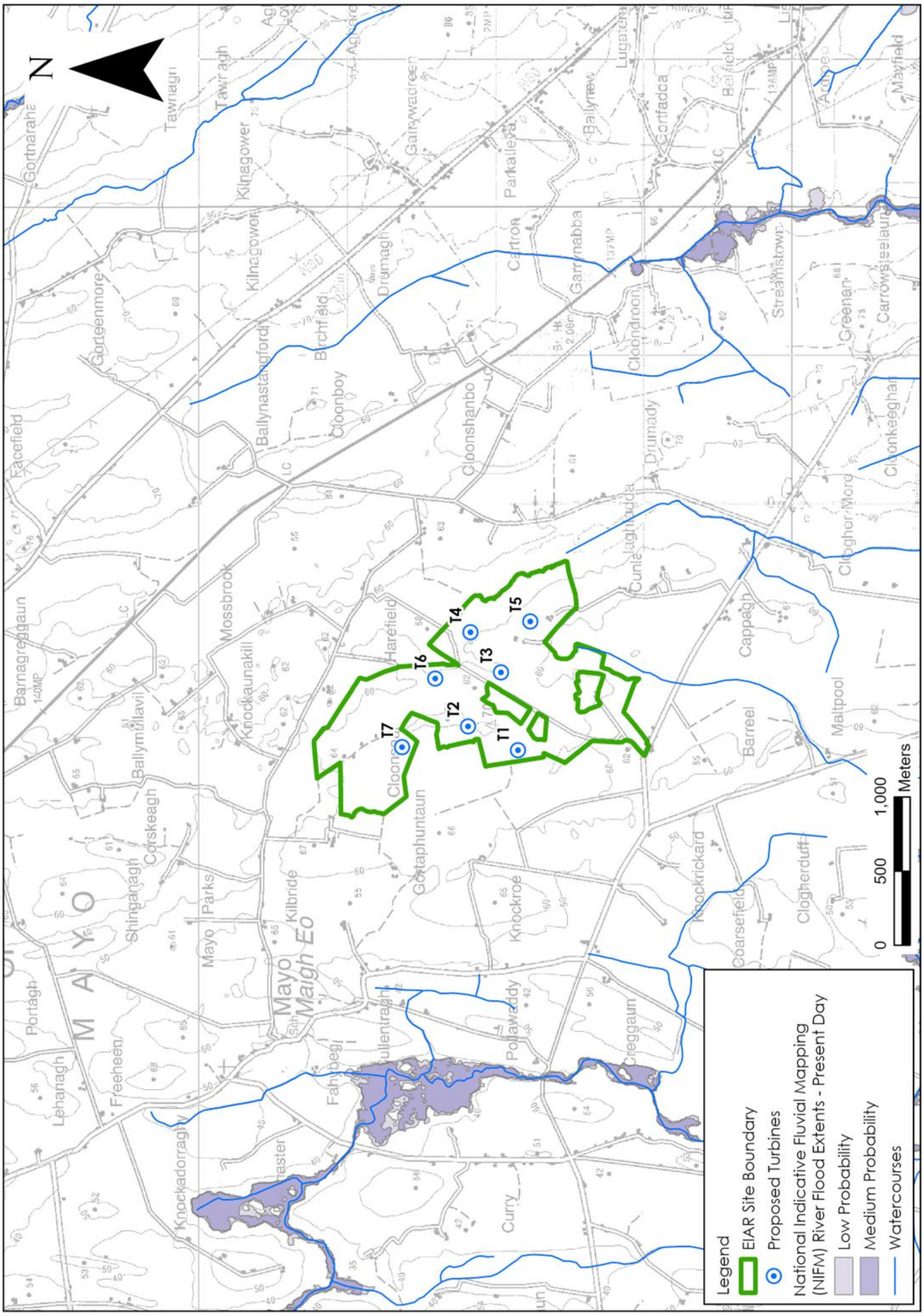

Figure F: OPW National Indicative Flood Mapping

4.3.8 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 Site.

The closest historic and modelled groundwater flood extents are located ~1.4km to the west of the Site. This area has a high probability of groundwater flooding. The historic groundwater flood zones are shown on **Figure E** above.

4.3.9 Coastal Flooding

The Site is located ~38 km inland from the sea and sits at an elevation of 60 mOD.

Therefore, the Site is not at risk of coastal (tidal) flooding.

4.3.10 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 Flood Mapping High-End Future Scenario models flood extents 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** Error! Reference source not found.. Therefore, flood zones at the Site are unlikely to be significantly impacted by future climate change.

4.3.11 Summary – Flood Risk Identification

Based on the information gained through the flood identification process it is apparent that no part of the Site is located in Fluvial Flood Zone A or B. The Site is located in Fluvial Flood Zone C and is at low risk of flooding.

4.4 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. The potential 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 Site.

Source	Pathway	Receptor	Comment
Fluvial	Overbank flooding of the rivers and streams that drain the Site.	Land & infrastructure	The Site is located in Fluvial Flood Zone C where there is a low risk of fluvial flooding.
Pluvial	Ponding of rainwater on the Site	Land & infrastructure	The Site is generally low-lying and flat in places, therefore, localised pluvial flood may occur after heavy or prolonged rainfall.
Surface water	Surface ponding/ Overflow	Land & infrastructure	Same as above (pluvial).
Groundwater	Rising groundwater levels	Land & infrastructure	Based on local hydrogeological regime and GSI mapping, there is negligible risk of groundwater flooding at the Site.
Coastal/tidal	Overbank flooding	Land, People, property	The Site is ~ 38 km inland from the sea and sits at an elevation of ~60 mOD so no coastal flooding will be possible.

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[4] is shown in **Table C** below.

It may be considered that certain elements of the Proposed Project can be categorised as "Highly Vulnerable Development" as they are electricity generating infrastructure (i.e. the proposed onsite substation). Other elements can be considered to be "Less Vulnerable Development".

However, as stated above, the Site is located in Fluvial Flood Zone C (Low Risk) and therefore the Proposed Project is appropriate from a flood risk perspective.

Table C: 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] *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).*

5. FLOOD IMPACT PREVENTION AND DRAINAGE MANAGEMENT

5.1 PROPOSED DRAINAGE

The site drainage system was designed integrally with the Proposed Project design 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.

The hydrogeological regime at the Site is dominated by high rates of surface water runoff with low rates of groundwater recharge.

A fundamental principle in the drainage design is that clean water flowing in the upstream catchment, including overland flow and flow in existing 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 roads. These will be constructed on the upgradient side of the works and piped to the downgradient 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.

5.2 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 and hard-standing footprint only. The aim of the stormwater 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. 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;
  - No instances of recurring or historic flooding were identified on OPW Past Flood Events maps within the Site;
  - The GSI Winter 2015/2016 Surface Water Flood Map records some flooding at Drumady Lough to the east of the Site. These historic flood zones do not encroach upon the Site or extend any significant distance from the lough;
  - No CFRAM fluvial flood mapping has been completed for the area of the Site;
  - The Site is not located within any National Indicative Fluvial Flood Zones; and,
  - No historic or modelled groundwater flood zones are located within the Site.
- The Site is mapped as being located in Fluvial Flood Zone C and is at low risk of flooding;
- During the walkover surveys and flow monitoring at the Proposed Wind Farm site there was no evidence of out of bank flow from within the various stream/river channels. No widespread or even localized flooding was observed during these site visits;
- It may be considered that certain components of the Proposed Project can be categorised as "Highly Vulnerable Development". However, the Proposed Project is entirely located in Flood Zone C and is considered to be at low risk of flooding. The Proposed Project is considered to be appropriate from a flood risk perspective; and,
- The risk of the Proposed Project contributing to downstream flooding is also very low, as the long-term plan for the site is to retain and slow down drainage water rates prior to release. Robust drainage measures on the site will include swales, silt traps, check dams, settlement ponds and buffered outfalls. Please refer to the Chapter 9 of the EIAR for further details.

* *

7. REFERENCES

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