Round 2 of Sampling (Grid Connection)

Total suspended solids at all sampling locations were generally at or below the limit of detection (5mg/l), considerably below the threshold value of 25 mg/l. SW16 was above the limit of detection at 7 mg/l. Nitrite and nitrate values were below or equal to the laboratory detection limit of 0.05 and 5.0 mg/L respectively within all samples.

Ortho-phosphate was below the laboratory detection limit of 0.02mg/L in all 6 locations.

In comparison to the Environmental Objectives Surface Water Regulations (S.I. 272 of 2009), 5 of 6 results for ammonia N were below the "Good Status" threshold, and below the "High Status" threshold. One sample from SW18 exceeded the Good status threshold with a result of 0.05 mg/l.

In relation to ortho-phosphate, all 6 samples were within the "Good Status" and "High status range.

BOD was below the detection limit of 5 mg/l for 5 of 6 samples, however it exceeded both the "Good status" and "High status" threshold at SW16.

Construction Access Road

An additional three sampling location were selected downstream of the construction access road and the results for these are discussed below.

Total suspended solids at all sampling locations (taken 19/03/2020) were <5mg/L. Nitrite, nitrate, orthophosphate, nitrogen and phosphorus values were below or equal to the laboratory detection limits.

Ammonia values ranged between <0.02 and 0.02mg/L.

In comparison to the Environmental Objectives Surface Water Regulations (S.I. 272 of 2009), all ammonia and orthophosphate samples were below the "High Status" threshold. BOD was reported at 2mg/L in all samples which exceeds the "Good Status" threshold.

The results of sampling are presented in Table 9-16.

Table 9-16: Analytical results for Access Road (19/03/2020)

Parameter	EQS	Sample ID		
		SW20	SW21	SW22
Total Suspended Solids (mg/L)	25(+)	<5	<5	<5
Ammonia (mg/L)	≤0.065 to ≤ 0.04(*)	0.02	<0.02	<0.02
Nitrite NO_2 (mg/L)	-	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	≤ 0.035 to ≤0.025(*)	<0.02	<0.02	<0.02
Nitrate - NO_3 (mg/L)	-	<5	<5	<5
Nitrogen (mg/L)	-	<1	<1	<1
Phosphorus (mg/L)	-	<0.1	<0.1	<0.1
Chloride (mg/L)	-	14.9	13.2	15.4
BOD	≤ 1.3 to ≤ 1.5(*)	2	2	2

(+) S.I. No. 293 of 1988: European Communities (Quality of Salmonid Waters) Regulations
(*) S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 (as amended by S.I. No. 296/2009; S.I. No. 386/2015; S.I. No. 327/2012; and S.I. No. 77/2019 and giving effect to Directive 2008/105/EC on environmental quality standards in the field of water policy and Directive 2000/60/EC establishing a framework for Community action in the field of water policy).

9.3.8 Hydrogeology

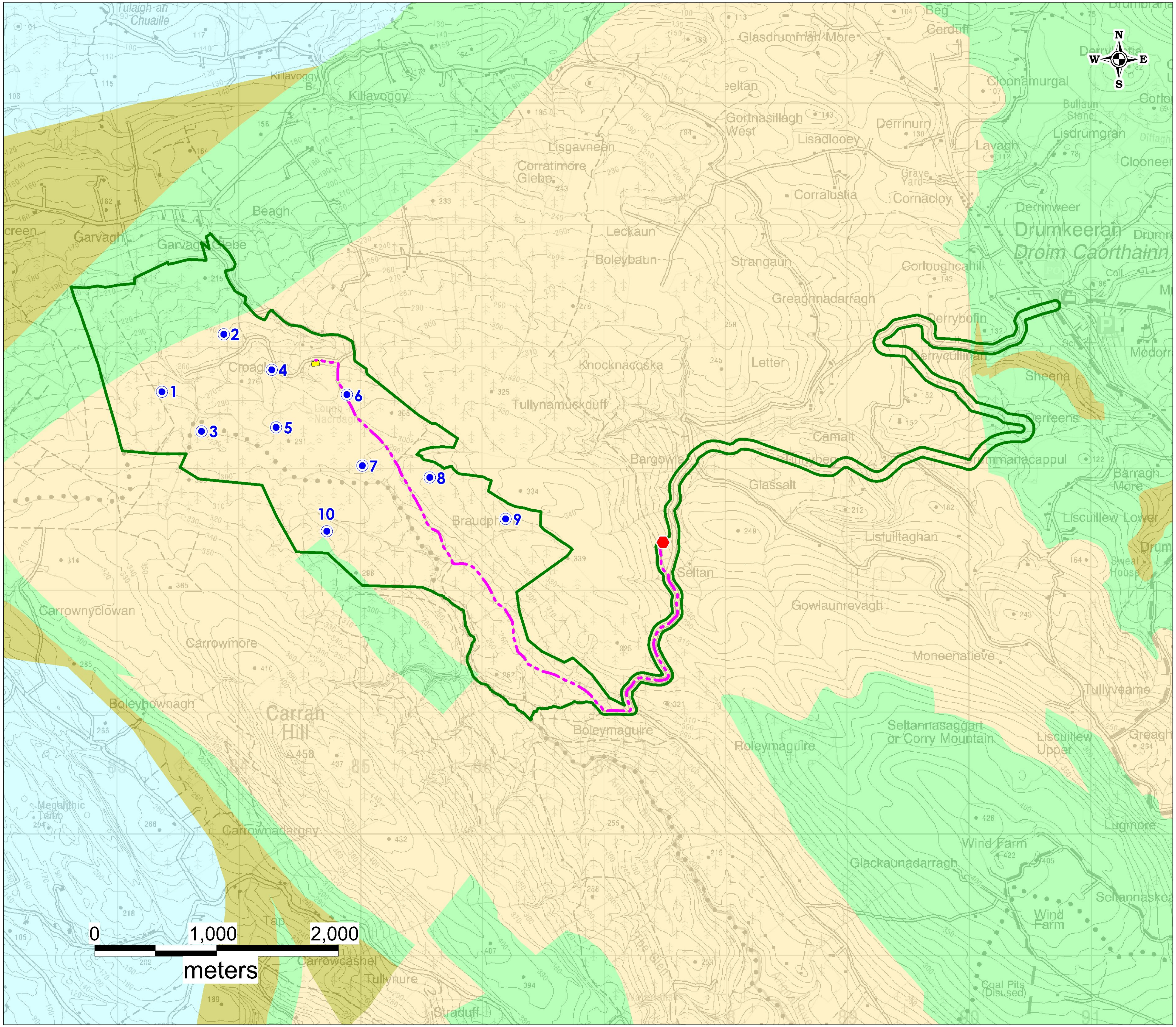
The underlying bedrock within the EIAR site boundary is mapped as being predominantly Namurian Shales, with the north-western tip of the site being mapped as Dinantian Shales and Limestones following a conformable contact (refer to Chapter 8 – Soils & Geology).

The actual bedrock encountered during drilling at the proposed borrow pit locations comprised LIMESTONE (BH1 and BH2) and SILSTONE (BH3 and BH4) which was relatively competent/strong but being locally weak along tight discontinuities. No significant water bearing faults or fractures were encountered. The measured bedrock permeability at each of the boreholes (see Table 9.13) are very low which is characteristic of this bedrock aquifer type (refer to Figure 8.2 and Figure 8.3 of the Land, Soils and Geology Chapter for the borehole locations).

The GSI has classified the Namurian Shales as a Poor Aquifers (Pu -bedrock which is generally unproductive), and the northern Dinantian Shales and Limestones as a Poor Aquifer (Pl–bedrock which is generally unproductive except in local zones). These rocks are described as being devoid of intergranular permeability, with groundwater flow occurring in fault fractures and joints where present. Groundwater paths are suggested to be short, generally 30-300m with groundwater discharging to local streams and to Lough Allen. A bedrock aquifer map is shown as Figure 9-4.

The generally low permeability of these dominantly Namurian Shales and Dinantian Shales and Limestones will likely act as a barrier to groundwater flow from adjoining karstic groundwater bodies. Typically, groundwater flux is likely to occur in the uppermost part of the aquifer, comprising a broken and weathered zone typically less than 3m thick, a zone of interconnected fissuring 10-15m thick, and a zone of isolated poorly connected fissuring typically less than 150m. (GSI, 2004). However, no significant fault or fissure zones were encountered in any of the boreholes which were drilled to a total depth of approximately 30m.

The GSI have mapped two groundwater bodies within the site, the Lough Allen GWB and the Belhavel Lough GWB. These GWB's are delineated along a similar line to that separating the Arigna and Bonet



Legend

- EIAR Site boundary
- Proposed Turbine
- Proposed Substation
- Proposed Underground Grid Connection Route
- Garvagh Substation
- Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones
- Poor Aquifer - Bedrock which is Generally Unproductive except for Local Zones
- Poor Aquifer - Bedrock which is Generally Unproductive
- Regionally Important Aquifer - Karstified (conduit)

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

Client: MKO	
Job: Croagh WF, Co. Leitrim	
Title: Local Bedrock Aquifer Map	
Figure No: 9.4	
Drawing No: P1459-0-0620-A3-904-0A	
Sheet Size: A3	Project No: P1459-0
Scale: 1:30,000	Drawn By: GD
Date: 25/06/2020	Checked By: MG

river subcatchments described earlier. The Lough Allen GWB encompasses most of the southern half of the proposed development site, while the northern half of the site is within the Belhavel Lough GWB.

Baseflow contribution to streams tends to be low, particularly in summer as the groundwater regime cannot sustain summer base flows due to low storativity within the aquifer. In winter, low permeabilities will lead to a high water table and potential water logging of soils which is consistent with the poorly draining nature of the site. Local groundwater flow directions are assumed to mimic topography whereby flow paths will be from topographic high points to lower elevated discharge areas at local streams, this will typically translate to groundwater flux trending north in the northern section of the Aquifer (Belhavel Lough GWB) and trending south in the southern section (Lough Allen GWB).

Groundwater level data for boreholes are shown Table 9.13 below. The groundwater levels, which were measured in summer, are likely to be higher and closer to ground level during winter. Based on experience from similar aquifer types, a high groundwater table at the topographic setting of the site would suggest low permeability bedrock as demonstrated by the permeability tests .

Table 9-17: Results of Groundwater Level Monitoring and Bedrock Permeability Tests

Water Level	BH1		BH2		BH3		BH4	
	mbgl	mOD	mbgl	mOD	mbgl	mOD	mbgl	mOD
24/06/2019	5.42	291.6	12.65	292	-	-	-	-
25/06/2019	-	-	-	-	9.66	274.6	1.76	277.5
Permeability (m/sec)	2.3×10^{-7}		2.81×10^{-8}		7.3×10^{-7}		5.2×10^{-7}	

9.3.9 Groundwater Vulnerability

The vulnerability rating of the aquifer within the EIAR site ranges between “Low to Moderate vulnerability” to “High to Extreme vulnerability” and this reflects the varying depth of local subsoils and peat (the higher the vulnerability rating is a reflection of how close bedrock is to the ground surface). In areas where subsoil is shallow or absent and where bedrock is outcropping an Extreme vulnerability rating is given. The more elevated areas on the south and southeast of the site are rated “High to Extreme” while the remaining central and northern lower lying section of the site is rated as “Low to Moderate”.

However, due to the low permeability nature of the shale bedrock aquifer underlying the site, groundwater flow paths are likely to be short, with recharge emerging close by at seeps and surface streams. This means there is a low potential for groundwater dispersion and movement within the aquifer, making surface water bodies such as drains and streams more vulnerable than groundwater at this site.

9.3.10 Groundwater Hydrochemistry

There is no groundwater quality data for the proposed wind farm site and groundwater sampling would generally not be undertaken for this type of development in terms of EIAR reporting as groundwater quality impacts would not be anticipated.

Based on data from GSI publication Calcareous/Non-calcareous classification of bedrock in the Republic of Ireland (WFD,2004), alkalinity for the Namurian Sedimentary bedrock aquifers generally ranges from 4 – 436 mg/L, with a mean value of 167 mg/l, while electrical conductivity and hardness were reported to have mean values of 418 S/cm and 173 mg/L respectively.

9.3.11 Water Framework Directive Water Body Status & Objectives

The River Basin Management Plan was adopted in 2018 and has amalgamated all previous river basin districts into one national river basin management district. The River Basin Management Plan (2018 - 2021) objectives, which have been integrated into the design of the proposed wind farm development, include the following:

- Ensure full compliance with relevant EU legislation;
- Prevent deterioration and maintain a 'high' status where it already exists;
- Protect, enhance and restore all waters with aim to achieve at least good status by 2021;
- Ensure waters in protected areas meet requirements; and,
- Implement targeted actions and pilot schemes in focused sub-catchments aimed at (1) targeting water bodies close to meeting their objectives and (2) addressing more complex issues that will build knowledge for the third cycle.

Our understanding of these objectives is that surface waters, regardless of whether they have 'Poor' or 'High' status, should be treated the same in terms of the level of protection and mitigation measures employed, i.e. there should be no negative change in status at all.

Strict mitigation measures (refer to Section 9.5.3 and 9.5.4) in relation to maintaining a high quality of surface water runoff from the development and groundwater protection will ensure that the status of both surface water and groundwater bodies in the vicinity of the site will be maintained (see below for WFD water body status and objectives) regardless of their existing status.

9.3.12 Groundwater Body Status

Local Groundwater Body (GWB) status information are available (www.catchments.ie).

The Lough Allen GWB (GWB: IEGBNI_SH_G_002) underlies the south of the site. It is assigned 'Good Status', which is defined based on the quantitative status and chemical status of the GWB.

The Belhavel Lough GWB (IE_WE_G_0045) underlies much of the southern, and part of the eastern section of the proposed development site. It is assigned 'Good Status', which is defined based on the quantitative status and chemical status of the GWB.

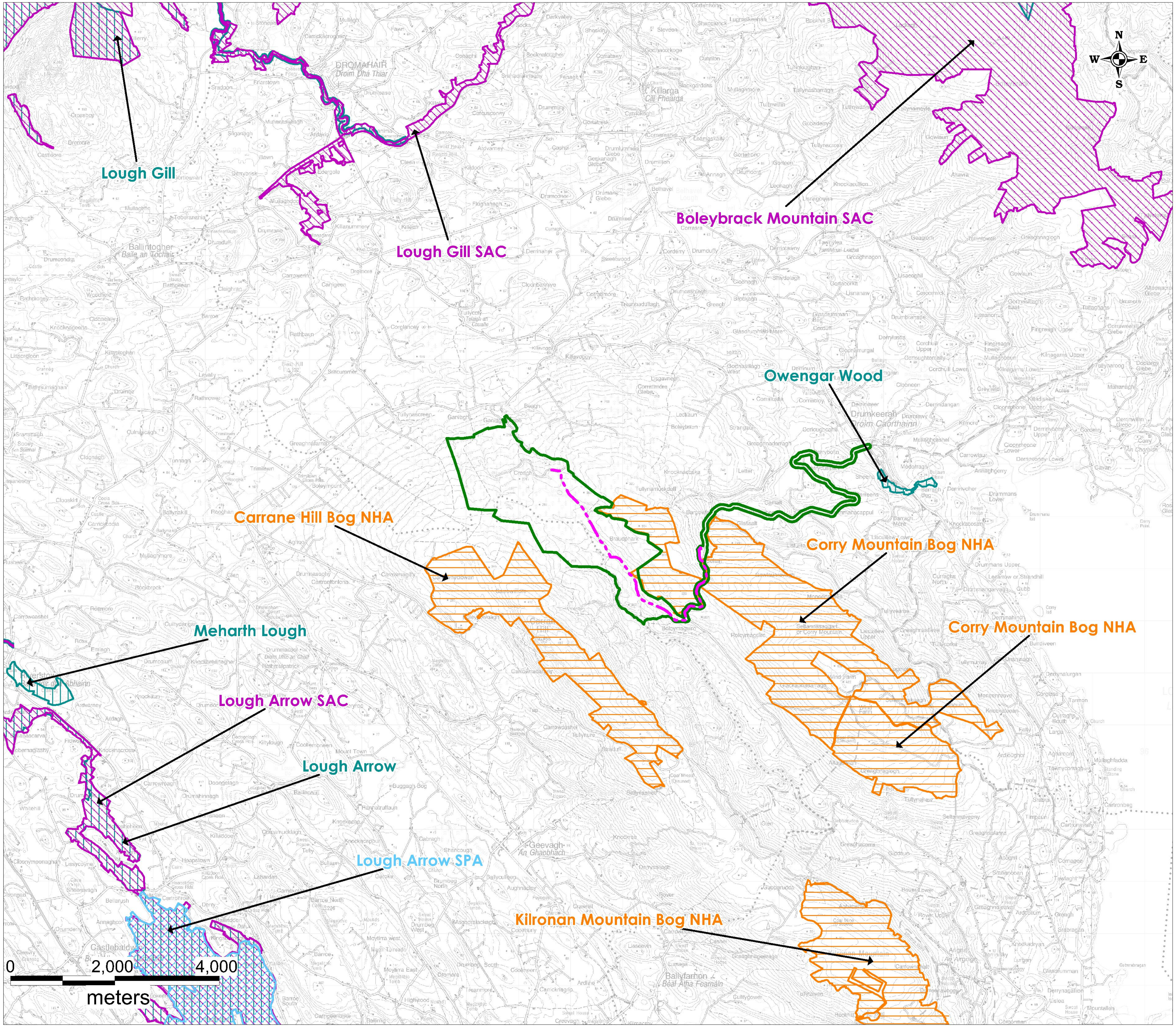
9.3.13 Surface Water Body Status

Local Surface water Body status and risk result are available from (www.catchments.ie).

The Proposed Development site is located within the Arigna 26A_4 and Bonet 35_6 subcatchments. Each subcatchment and associated watercourse achieved good status under the WFD 2010-2015, with the exception of the Killanummery river which achieved high status.

9.3.14 Designated Sites & Habitats

Designated sites include National Heritage Areas (NHAs), Proposed National Heritage Areas (pNHAs) Special Areas of Conservation (SACs), candidate Special Areas of Conservation (cSAC) and Special Protection Areas (SPAs). The Proposed Development is not located within any designated conservation-site. Designated sites in proximity to the proposed development site are shown in Figure 9-5.



Legend

- EIAR Site boundary
- Proposed Underground Grid Connection Route
- SPA
- SAC
- pNHA
- NHA

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

Client: MKO	
Job: Croagh WF, Leitrim	
Title: Designated Sites Map	
Figure No: 9.5	
Drawing No: P1459-0-0620-A3-905-0A	
Sheet Size: A3	Project No: P1459-0
Scale: 1:70,000	Drawn By: GD
Date: 25/06/2020	Checked By: MG

The south-eastern boundary of the site is bounded by the Corry Mountain Bog NHA. As the NHA is entirely above (in elevation) the proposed development area, no part of the proposed development areas drains towards this designated site. The topographical difference between the site and the NHA is shown graphically in Appendix 9-3 Summary data is presented in Table 9-18.

The natural slope in south-eastern area of the wind farm site is from the NHA area down towards the forestry site and the proposed wind farm site. The natural elevation changes along this boundary are moderate, e.g. between the NHA and proposed T9 location the elevation change is ~10m, i.e. the ground elevation at the turbine location is 10m lower than at the NHA boundary over a separation distance of ~160m.

In addition, there is a firebreak along this boundary between the NHA and the adjoining forested areas. This firebreak is approximately 3-5m wide, and bare peat is exposed within the fire break excavation.

In addition to these prevailing conditions, downhill of the firebreak the forestry site has an altered drainage regime with mound drains installed in the peat that do not extend as far as the NHA. There is also ongoing tree felling and replanting in this area of the forestry plantation.

Based on separation distances, the elevation differences between the NHA boundary and proposed development, the presence of dividing fire break, and the existing altered drainage regime we are satisfied that this physical scientific evidence is more than sufficient to conclude that the potential for alteration of the natural peatland hydrology within the NHA by the proposed wind farm development is negligible.

The proposed grid connection route and construction access road have no potential to impact on this NHA as they use an existing track in the area of the NHA.

Table 9-18: Relative distances and elevation changes to Corry Mountain NHA

Transect ID	Development Element	Horizontal Distance from Infrastructure to NHA (m) (⊥ to contours)	Min. Ground Elevation Difference (m)	Gradient to NHA
X-T8	T8	175	~5	Up-gradient
X-T9	T9	160	~10	Up-gradient
X-BP4	BP4	200	~20	Up-gradient

The closest SAC to the site is Boleybrack Mountain SAC located approximately 5.4 km northeast of the proposed development site. No areas of the site drains in this direction. Similarly, Lough Arrow, a SAC, SPA and NHA is located approximately 9.2km southwest of the site. Again, no areas of the site drain in this direction, therefore there will likely be no impact.

The majority of the northern section of the Proposed Development site ultimately drains into the Bonet River which then flows through the Lough Gill SAC, located approximately 10km north of the site. Lough Gill is a large lake, approximately 8km long and over 20m deep in places. Several species of Lamprey as well as Atlantic Salmon and White Clawed Crayfish are found within the lake. The only priority habitat/species listed is the Orchid-rich Calcareous Grassland.

9.3.15 Within the River Shannon catchment, the closest downstream SAC is Lough Forbes Complex which is located 43.1km (approx. 61km surface water

distance) downstream of the Proposed Development. Water Resources

There are no mapped public groundwater supplies or group schemes within 6km of the proposed Croagh Wind Farm and 3 km of the associated grid route.

A total of 7 no. groundwater wells, were identified within a 5km radius from the EIAR site boundary in the GSI well database (www.gsi.ie). These wells, as shown on Figure 9-6, are all located south of the proposed site within the Lough Allen GWB and all were described as being domestic wells. Some information on lithology was available from one well in the townland of Tents/Srabra which was described as black shale/limestone. None of these GSI mapped wells are located downgradient of the proposed wind farm development.

GSI mapped wells with accuracy greater than 50m were not assessed due to the poor information/accuracy regarding their location. To overcome the poor accuracy problem of other GSI mapped wells (>50m accuracy) it is conservatively assumed (for the purpose of assessment only) that every private dwelling in the area (shown also on Figure 9-6) has a well supply and this impact assessment approach is described further below. (Please note wells may or may not exist at each property and our discussions with near neighbours together with the presence of a public water supply in the area support this, but our conservative worst case rationale here is that it is better to assume a well may exist at each downgradient property and assess the potential impacts from the proposed development on such assumed wells, rather than make no assessment and find out later that groundwater wells do actually exist).

The private well assessment undertaken below also assumes the groundwater flow direction underlying the site mimics topography, whereby flow paths will be from topographic high points (i.e. top of hill) to lower elevated discharge areas at local streams/rivers.

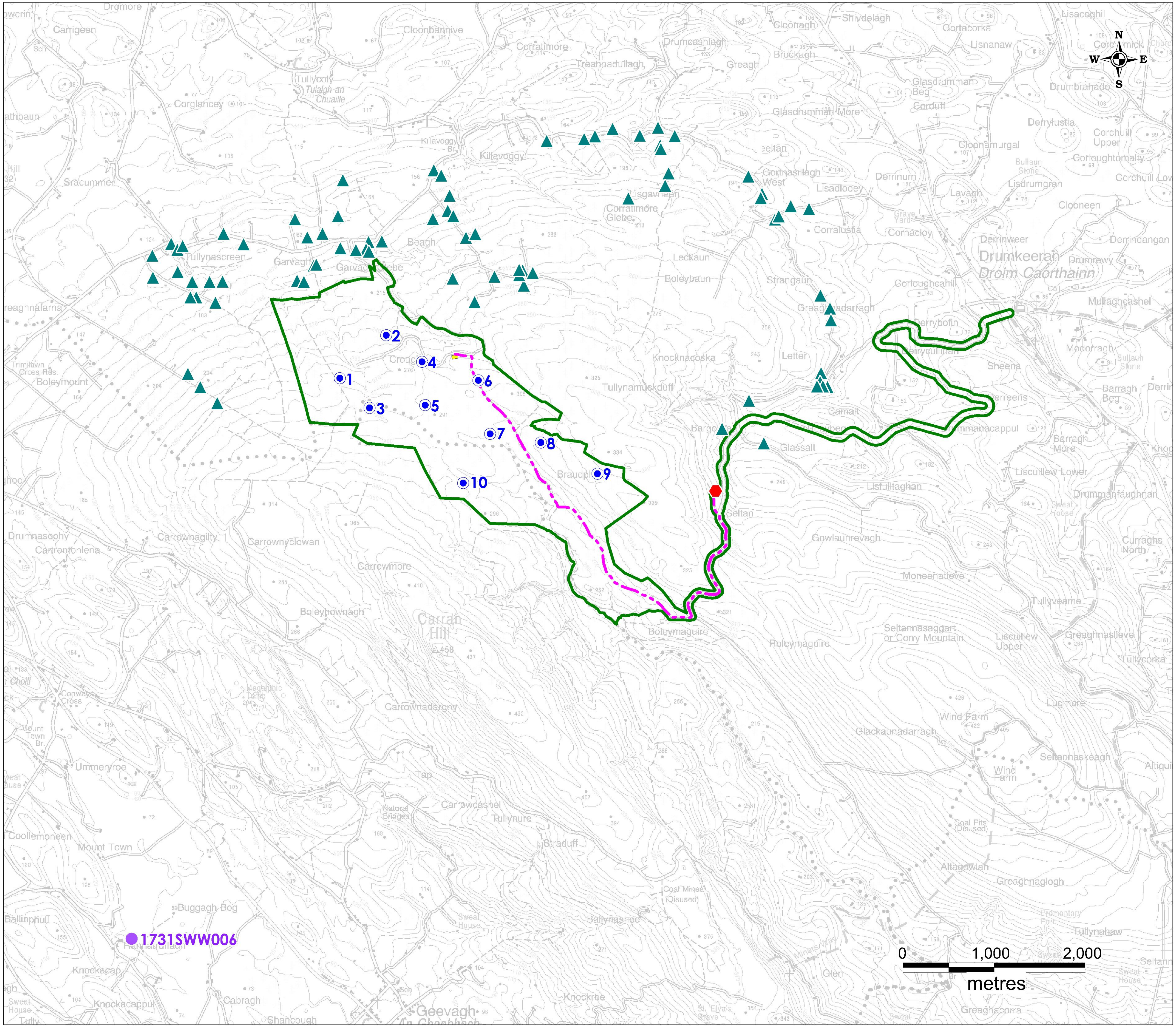
Using this conceptual model of groundwater flow, dwellings that are potentially located down-gradient of the footprint of the proposed development footprint are identified and a worst-case impact assessment for these actual and potential well locations is undertaken.

Based on the above approach no private dwelling houses were identified to be located down-gradient (i.e. downslope) of the proposed wind farm infrastructure development (and in particular turbine and borrow pit locations) and therefore there is no potential to impact on groundwater supplies. This assessment was focused on the turbine locations and borrow pit as this is where the deepest excavations will be required. All excavations required for roads, compounds, met mast, amenity walkways and substations will be relatively shallow and therefore no significant potential to impact on groundwater supplies will occur.

According to the EPA Abstraction Register (http://watermaps.wfdireland.ie/HydroTool/Viewer) Lough Nacroagh was utilised as a private drinking water abstraction point (IE_WE_35_188). However, based on discussion with the local residents this source is no longer in use as the premises in question is now connected to the public supply.

9.3.16 Receptor Sensitivity

Due to the nature of wind farm developments, being near surface construction activities, impacts on groundwater are negligible and surface water is generally the main sensitive receptor assessed during impact assessments. The primary risk to groundwater at the site would be from cementitious materials, hydrocarbon spillage and leakages (These are assessed below at Sections 9.5.3.5 and 9.5.3.7). These are common potential impacts on all construction sites (such as road works and industrial sites). All potential contamination sources will be carefully managed at the site during the construction and operational phases of the development and mitigation measures are proposed below to deal with these potential minor impacts.



Legend

- EIAR Site boundary
- Proposed Turbine
- Proposed Substation
- Proposed Underground Grid Connection Route
- Garvagh Substation
- Houses Location
- GSI Mapped Well (<50m accuracy)

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

Client: MKO

Job: Croagh WF, Leitrim

Title: Public and Private Water Supply Map

Figure No: 9.6

Drawing No: P1459-0-0620-A3-906-0A

Sheet Size: A3	Project No: P1459-0
Scale: 1:40,000	Drawn By: GD
Date: 25/06/2020	Checked By: MG

Based on criteria set out in Table 9.1, groundwater at the site can be classed as Not Sensitive to pollution because the bedrock is generally relatively impermeable and classified as a poor aquifer. In addition, the majority of the site is covered in blanket peat which acts as a protective cover to the underlying aquifer. Any contaminants which may be accidently released on-site are more likely to travel to nearby streams within surface runoff.

Surface waters such as the Rivers Bonet and Arigna are very sensitive to potential contamination. These rivers and associated lakes are known to be of trout potential and are important locally for fishing (see Biodiversity, Chapter 6).

The designated sites that are hydraulically connected (surface water flow paths only) to the proposed wind farm development site is the Lough Gill SAC. This designated site can be considered very sensitive in terms of potential impacts (see Chapter 6 of the EIAR).

Comprehensive surface water mitigation and controls are outlined below to ensure protection of all downstream receiving waters. Mitigation measures will ensure that surface runoff from the developed areas of the site will be of a high quality and will therefore not impact on the quality of downstream surface water bodies. Any introduced drainage works at the site will mimic the existing hydrological regime thereby avoiding changes to flow volumes leaving the site.

A hydrological constraints map for the site is shown as Figure 9-7. 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 upgrade of existing roads and stream crossings, most of the proposed development areas are generally away from areas on the site that have been determined to be hydrologically sensitive. The large setback distance from sensitive hydrological features means they will not be impacted on by excavations/drains etc. It also allows adequate room for the proposed drainage mitigation measures (discussed below) to be properly installed up-gradient of primary drainage features within sub-catchments. This will allow attenuation of surface runoff to be more effective.

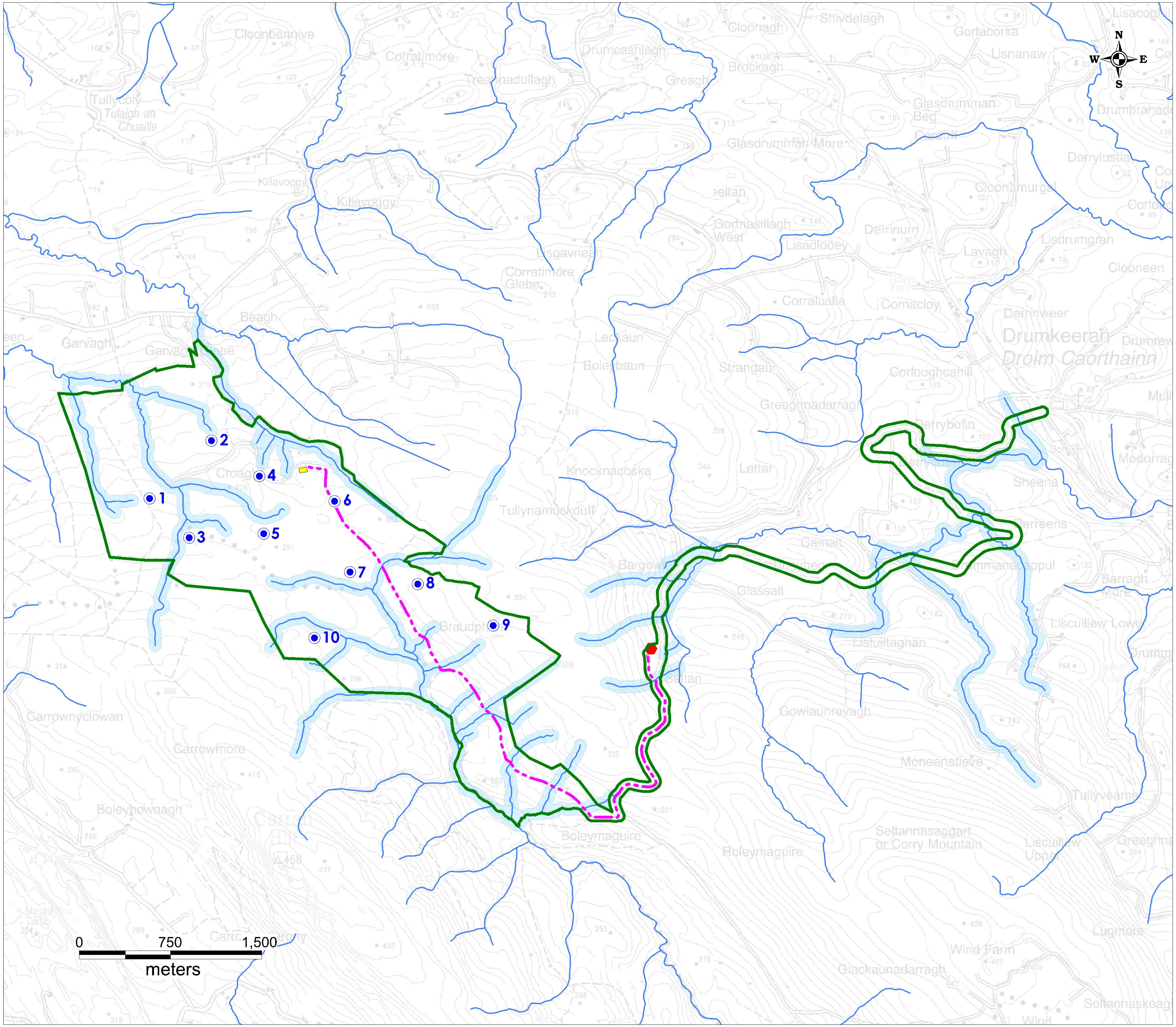
9.4 Characteristics of the Proposed Development

The development comprises of the following:

- 10 no. wind turbines with an overall blade tip height of up to 170 metres and all associated hard-standing areas;
- 1 no. permanent meteorological mast up to a height of 100 metres;
- Provision of new site access roads and upgrade of existing roads and associated drainage;
- 1 no. 38 kV electrical substation;
- 2 no. temporary construction compound;
- All associated underground electrical and communications cabling connecting the turbines to the proposed electrical substation;
- 1 no. borrow pit and 2 no. repository areas;
- Forestry felling;
- All works associated with the connection of the proposed wind farm to the national electricity grid at the existing Garvagh Glebe 110kV substation; and,
- All associated site development works.

9.4.1 Development Interaction with the Existing Forestry Drainage Network

In relation to hydrological constraints, a self-imposed buffer zone of 50m has been put in place for on-site streams and lakes. Manmade forestry drains at the site are not considered a hydrological constraint and therefore no buffering of forestry drains has been undertaken.



Legend

- EIAR Site boundary
- Proposed Turbine
- Proposed Substation
- Proposed Underground Grid Connection Route
- Garvagh Substation
- Rivers
- 50m River Buffer

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

Client: MKO	
Job: Croagh WF, Leitrim	
Title: Hydro-Constraints Map	
Figure No: 9.7	
Drawing No: P1459-0-0620-A3-907-0A	
Sheet Size: A3	Project No: P1459-0
Scale: 1:30,000	Drawn By: GD
Date: 25/06/2020	Checked By: MG

The general design approach to wind farm layouts in existing forestry is to utilise and integrate with the existing forestry infrastructure where possible whether it be existing access roads or the existing forestry drainage network. Utilising the existing infrastructure means that there will be less of a requirement for new construction/excavations which have the potential to impact on downstream watercourses in terms of suspended solid input in runoff (unless managed appropriately). The existing forestry drains have no major ecological or hydrological value and can be readily integrated into the proposed wind farm drainage scheme using the methods outlined below (Sections 9.3.18 and 9.4.3.2).

9.4.2 Proposed Drainage Management

Runoff control and drainage management are key elements in terms of mitigation against impacts on surface water bodies. Two distinct methods will be employed to manage drainage water within the Proposed Development. The first method involves 'keeping clean water clean' by avoiding disturbance to natural drainage features, minimising any works in or around artificial drainage features, and diverting clean surface water flow around excavations, construction areas and temporary storage areas. The second method involves collecting any drainage waters from works areas within the site that might carry silt or sediment, and nutrients, to route them towards stilling ponds prior to controlled diffuse release over vegetated surfaces. There will be no direct discharges to surface waters. During the construction phase all runoff from works areas (i.e. dirty water) will be attenuated and treated to a high quality prior to being released. A schematic of the proposed site drainage management is shown as Plate 9-2 below. A detailed drainage plan showing the layout of the proposed drainage design elements during construction and operation as shown in Plate 9-2 is shown in Appendix 4-5.

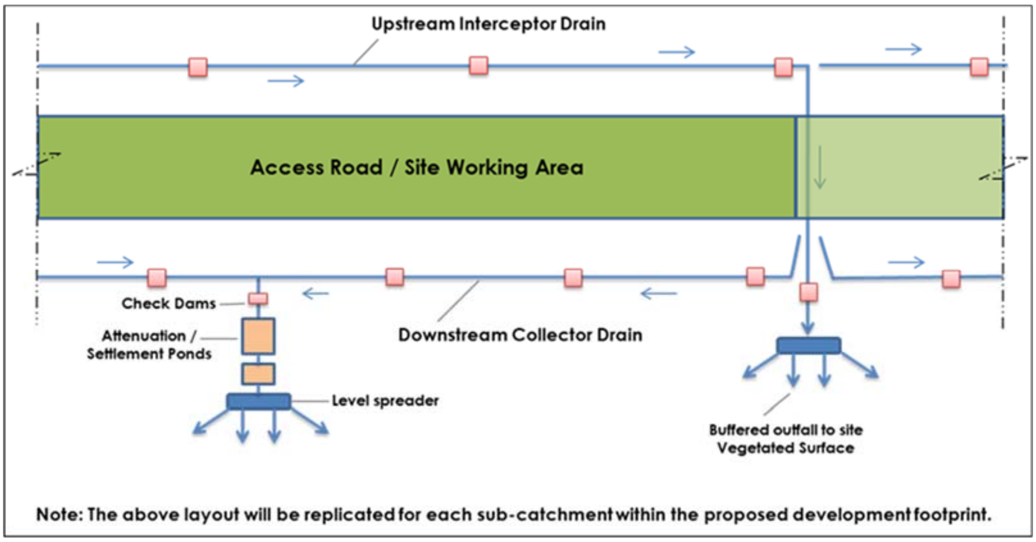


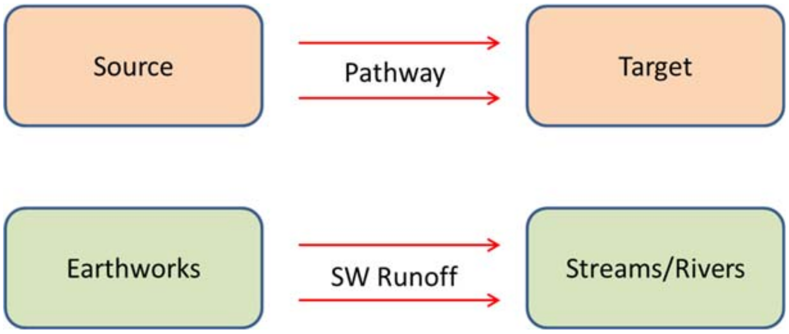
Plate 9-2 Schematic of Proposed Site Drainage Management

9.5 Likely Significant Effects and Associated Mitigation Measures

The potential impacts of the Proposed Development and mitigation measures that will be put in place to eliminate or reduce them are set out below.

9.5.1 Overview of Impact Assessment Process

The conventional source-pathway-target model (see below, top) was applied to assess potential impacts on downstream environmental receptors (see below, bottom as an example) as a result of the proposed wind farm development.



As outlined previously, where potential impacts are identified, the classification of impacts in the assessment follows the descriptors set out in the Glossary of effects (EPA, 2017) as outlined in Chapter 1 of this EIAR.

The descriptors used in this environmental impact assessment are those set out in the EPA (2017) Glossary of effects as shown in Chapter 1 of this EIAR.

The description process clearly and consistently identifies the key aspects of any potential impact source, namely its character, magnitude, duration, likelihood and whether it is of a direct or indirect nature.

In order to provide an understanding of the stepwise impact assessment process applied below (Section 9.5.3 and 9.5.4), we have presented below a summary guide that defines the steps (1 to 7) taken in each element of the impact assessment process (

Table 9-19). The guide also provides definitions and descriptions of the assessment process and shows how the source-pathway-target model and the EPA impact descriptors are combined.

Using this defined approach, this impact assessment process is then applied to all wind farm construction and operation and decommissioning activities.

Table 9-19: Impact Assessment Process Steps

Step 1	Identification and Description of Potential Impact Source: This section presents and describes the activity that brings about the potential impact or the potential source of pollution. The significance of effects is briefly described.	
Step 2	Pathway / Mechanism:	The route by which a potential source of impact can transfer or migrate to an identified receptor. In terms of this type of development, surface water and groundwater flows are the primary pathways, or for example, excavation or soil erosion are physical mechanisms by which a potential impact is generated.
Step 3	Receptor:	A receptor is a part of the natural environment which could potentially be impacted upon, e.g. human health, plant / animal species, aquatic habitats, soils/geology, water resources, water sources. The potential impact can only arise as a result of a source and pathway being present.
Step 4	Pre-mitigation Impact:	Impact descriptors which describe the magnitude, likelihood, duration and direct or indirect nature of the potential impact before mitigation is put in place.
Step 5	Proposed Mitigation Measures:	Control measures that will be put in place to prevent or reduce all identified significant negative impacts. In relation to this type of development, these measures are

Step 1	Identification and Description of Potential Impact Source: This section presents and describes the activity that brings about the potential impact or the potential source of pollution. The significance of effects is briefly described.	
Step 2	Pathway / Mechanism:	The route by which a potential source of impact can transfer or migrate to an identified receptor. In terms of this type of development, surface water and groundwater flows are the primary pathways, or for example, excavation or soil erosion are physical mechanisms by which a potential impact is generated.
		generally provided in two types: (1) mitigation by avoidance, and (2) mitigation by engineering design.
Step 6	Post-Mitigation Residual Impact:	Impact descriptors which describe the magnitude, likelihood, duration and direct or indirect nature of the potential impacts after mitigation is put in place.
Step 7	Significance of Effects:	Describes the likely significant post mitigation effects of the identified potential impact source on the receiving environment.

9.5.2 Do Nothing Scenario

An alternative land-use option to the development of a renewable energy project at the proposed development site would be to leave the site as it is, with no changes made to existing land-use practices. Commercial forestry operations (including the associated drainage measures) would continue at the site.

The existing commercial forestry operations can and will continue in conjunction with this proposed use of the site. Surface water drainage operating in areas of forestry will continue and may be extended in some areas.

9.5.3 Construction Phase - Likely Significant Effects and Mitigation Measures

9.5.3.1 Clear Felling of Coniferous Plantation

It is estimated that 55.1 (hectares) in total of existing plantation forestry will be felled to allow for development of the proposed infrastructure.

Potential impacts during tree felling occur mainly from:

- Exposure of soil and subsoils due to vehicle tracking or forwarding extraction methods resulting in a source of suspended sediment which can become entrained in surface water runoff and enter surface watercourses;
- Entrainment of suspended sediment in watercourses due to vehicle tracking through watercourses;
- Damage to roads resulting in a source of suspended sediment which can become entrained in surface water runoff and enter surface watercourses;
- Release of sediment attached to timber in stacking areas; and,
- Nutrient release.

Pathways: Drainage and surface water discharge routes.

Receptors: Surface water quality and associated dependant ecosystems.

Pre-Mitigation Potential Impact: Negative, moderate, indirect, temporary, likely impact on surface water quality and dependant ecosystems.

Proposed Mitigation Measures:

Best practice methods, relating to water protection, incorporated into the forestry management and mitigation measures (listed below) have been derived from:

- Forestry Commission (2004): Forests and Water Guidelines, Fourth Edition. Publ. Forestry Commission, Edinburgh;
- Coillte (2009): Forest Operations and Water Protection Guidelines;
- Coillte (2009): Methodology for Clear Felling Harvesting Operations;
- Forest Service (Draft): Forestry and Freshwater Pearl Mussel Requirements – Site Assessment and Mitigation Measures; and,
- Forest Service (2000): Forestry and Water Quality Guidelines. Forest Service, DAF, Johnstown Castle Estate, Co. Wexford.

Mitigation by Avoidance:

There is a requirement in the Forest Service Code of Practice and in the FSC Certification Standard for the installation of buffer zones adjacent to aquatic zones at planting stage. Minimum buffer zone widths recommended in the Forest Service (2000) guidance document "Forestry and Water Quality Guidelines" are shown in Table 9.17.

Table 9-17 Minimum Buffer Zone Widths (Forest Service, 2000)

Average slope leading to the aquatic zone		Buffer zone width on either side of the aquatic zone	Buffer zone width for highly erodible soils
Moderate	(0 – 15%)	10 m	15 m
Steep	(15 – 30%)	15 m	20 m
Very steep	(>30%)	20 m	25 m

During the wind turbine construction phase a self-imposed buffer zone of 50 metres will be maintained for all streams These buffer zones are shown on Figure 9-7. With the exception of existing road upgrades and proposed stream crossings all proposed tree felling areas are generally located outside of imposed buffer zones. Additional mitigation (detailed below) will be carried out where tree felling is required inside the buffer zones.

The large distance between most of the proposed felling areas (which are outside the 50m buffer) and sensitive aquatic zones means that potential poor-quality runoff from felling areas will be adequately managed and attenuated prior to even reaching the aquatic buffer zone and primary drainage routes.

The following mitigation measures will be employed during tree felling. Additional measures are indicated for felling inside the 50m buffer zone.

Mitigation by Design:

Mitigation measures which will reduce the risk of entrainment of suspended solids and nutrient release in surface watercourses comprise best practice methods (from the guidance listed above) which are set out as follows:

- Machine combinations (i.e. hand-held or mechanical) will be chosen which are most suitable for ground conditions at the time of felling, and which will minimise soils disturbance;
- Trees will be cut manually inside the 50m buffer and using machinery to extract whole trees only;
- Checking and maintenance of roads and culverts will be on-going through any felling operation. No tracking of vehicle through watercourses will occur, as vehicles will use road infrastructure and existing watercourse crossing points. Where possible, existing drains will not be disturbed during felling works;
- Ditches which drain from the proposed area to be felled towards existing surface watercourses will be blocked, and temporary silt traps will be constructed. No direct discharge of such ditches to watercourses will occur. Drains and sediment traps will be installed during ground preparation. Collector drains will be excavated at an acute angle to the contour (~0.3%-3% gradient), to minimise flow velocities. Main drains to take the discharge from collector drains will include water drops and rock armour, as required, where there are steep gradients, and should avoid being placed at right angles to the contour;
- Sediment traps will be sited in drains downstream of felling areas. Machine access will be maintained to enable the accumulated sediment to be excavated. Sediment will be carefully disposed of in the peat disposal areas. Where possible, all new silt traps will be constructed on even ground and not on sloping ground;
- In areas particularly sensitive to erosion or where felling inside the 50 metre buffer is required, it will be necessary to install double or triple sediment traps.
- Double silt fencing will also be put down slope of felling areas which are located inside the 50 metre buffer zone;
- All drainage channels will taper out before entering the aquatic buffer zone. This ensures that discharged water gently fans out over the buffer zone before entering the aquatic zone, with sediment filtered out from the flow by ground vegetation within the zone. On erodible soils, silt traps will be installed at the end of the drainage channels, to the outside of the buffer zone;
- Drains and silt traps will be maintained throughout all felling works, ensuring that they are clear of sediment build-up and are not severely eroded. Correct drain alignment, spacing and depth will ensure that erosion and sediment build-up are minimized and controlled;
- Brash mats will be used to support vehicles on soft ground, reducing peat and mineral soils erosion and avoiding the formation of rutted areas, in which surface water ponding can occur. Brash mat renewal should take place when they become heavily used and worn. Provision should be made for brash mats along all off-road routes, to protect the soil from compaction and rutting. Where there is risk of severe erosion occurring, extraction should be suspended during periods of high rainfall;
- Timber will be stacked in dry areas, and outside a local 50 metre watercourse buffer. Straw bales and check dams to be emplaced on the down gradient side of timber storage/processing sites;
- Works will be carried out during periods of no, or low rainfall, in order to minimise entrainment of exposed sediment in surface water run-off;
- Checking and maintenance of roads and culverts will be on-going through the felling operation;
- No crossing of streams by machinery will be permitted and only travel perpendicular to and away from stream will be allowed;
- Refuelling or maintenance of machinery will not occur within 100m of a watercourse. Mobile bowser, drip kits, qualified personnel will be used where refuelling is required;
- A permit to refuel system will be adopted at the site; and,
- Branches, logs or debris will not be allowed to build up in aquatic zones. All such material will be removed when harvesting operations have been completed, but care will be taken to avoid removing natural debris deflectors.

Silt Traps:

Silt traps will be strategically placed down-gradient within forestry drains near streams. The main purpose of the silt traps and drain blocking is to slow water flow, increase residence time, and allow settling of silt in a controlled manner.

Drain Inspection and Maintenance:

The following items shall be carried out during pre-felling inspections and after:

- Communication with tree felling operatives in advance to determine whether any areas have been reported where there is unusual water logging or bogging of machines;
- Inspection of all areas reported as having unusual ground conditions;
- Inspection of main drainage ditches and outfalls. During pre-felling inspections, the main drainage ditches shall be identified. Ideally the pre-felling inspection shall be carried out during rainfall;
- Following tree felling all main drains shall be inspected to ensure that they are functioning;
- Extraction tracks nears drains need to be broken up and diversion channels created to ensure that water in the tracks spreads out over the adjoining ground;
- Culverts on drains exiting the site will be unblocked; and,
- All accumulated silt will be removed from drains and culverts, and silt traps, and this removed material will be deposited away from watercourses to ensure that it will not be carried back into the trap or stream during subsequent rainfall.

Surface Water Quality Monitoring:

Sampling will be completed before, during (if the operation is conducted over a protracted time) and after the felling activity. The 'before' sampling should be conducted within 4 weeks of the felling activity, preferably in medium to high water flow conditions. The "during" sampling will be undertaken once a week or after rainfall events. The 'after' sampling will comprise as many samplings as necessary to demonstrate that water quality has returned to pre-activity status (i.e. where an impact has been shown). The felling surface water monitoring data will also be compared with the EIAR baseline water quality sampling data.

Criteria for the selection of water sampling points include the following:

- Avoid man-made ditches and drains, or watercourses that do not have year-round flows, i.e. avoid ephemeral ditches, drains or watercourses;
- Select sampling points upstream and downstream of the forestry activities;
- It is advantageous if the upstream location is outside/above the forest in order to evaluate the impact of land-uses other than forestry;
- Where possible, downstream locations should be selected: one immediately below the forestry activity, the second at exit from the forest, and the third some distance from the second (this allows demonstration of no impact through dilution effect or contamination by other land-uses where impact increases at third downstream location relative to second downstream location); and,
- The above sampling strategy will be undertaken for all on-site sub-catchments streams where tree felling is proposed.

Also, daily surface water monitoring forms will be utilised at every works site near watercourses. These will be taken daily and kept on site for record and inspection.

Residual Impact: Negative, slight, indirect, temporary, unlikely impact on surface water quality, and dependant ecosystems.

Significance of Effects: For the reasons outlined above, no significant effects on the surface water quality will occur.

9.5.3.2 Earthworks (Removal of Vegetation Cover, Excavations and Stock Piling) Resulting in Suspended Solids Entrainment in Surface Waters

Construction phase activities that will require earthworks resulting in removal of vegetation cover and excavation of peat and mineral subsoil (where present) are detailed in Chapter 4: Description of the Proposed Development. Potential sources of sediment laden water include:

- Drainage and seepage water resulting from infrastructure excavation;
- Stockpiled excavated material providing a point source of exposed sediment;
- Construction of the grid connection cable trench resulting in entrainment of sediment from the excavations during construction; and,
- Erosion of sediment from emplaced site drainage channels.

These activities can result in the release of suspended solids to surface watercourses and could result in an increase in the suspended sediment load, resulting in increased turbidity which in turn could affect the water quality and fish stocks of downstream water bodies. Potential impacts are significant if not mitigated against.

Pathways: Drainage and surface water discharge routes.

Receptors: Down-gradient rivers and dependant ecosystems.

Pre-Mitigation Potential Impact: Negative, significant, indirect, short term, unlikely impact on down gradient rivers, water quality, and dependant ecosystems.

Mitigation by Avoidance:

The key mitigation measure during the construction phase is the avoidance of sensitive aquatic areas where possible. From Figure 9-7 it can be seen that all of the key areas of the Proposed Development and the temporary construction access road are actually significantly away from the delineated buffer zones with the exception of existing road upgrades, proposed stream crossings and existing stream crossings requiring upgrading. Additional control measures, which are outlined further on in this section, will be undertaken at these locations.

The large setback distance from sensitive hydrological features means that adequate room is maintained for the proposed drainage mitigation measures (discussed below) to be properly installed and operate effectively. The proposed buffer zone will:

- Avoid physical damage to watercourses, and associated release of sediment;
- Avoid excavations within close proximity to surface water courses;
- Avoid the entry of suspended sediment from earthworks into watercourses; and,
- Avoid the entry of suspended sediment from the construction phase drainage system into watercourses, achieved in part by ending drain discharge outside the buffer zone and allowing percolation across the vegetation of the buffer zone.

Mitigation by Design:

- Source controls:
  - Interceptor drains, vee-drains, diversion drains, flume pipes, erosion and velocity control measures such as use of sand bags, oyster bags filled with gravel, filter fabrics, and other similar/equivalent or appropriate systems.
  - Small working areas, covering stockpiles, weathering off stockpiles andcessation of works.
- In-Line controls:

- Interceptor drains, vee-drains, oversized swales, erosion and velocity control measures such as check dams, sand bags, oyster bags, straw bales, flow limiters, weirs, baffles, silt bags, silt fences, sedimats, filter fabrics, and collection sumps, temporary sumps/attenuation lagoons, sediment traps, pumping systems, settlement ponds, temporary pumping chambers, or other similar/equivalent or appropriate systems.

- Treatment systems:
  - Temporary sumps and attenuation ponds, temporary storage lagoons, sediment traps, and settlement ponds, and proprietary settlement systems such as Siltbuster, and/or other similar/equivalent or appropriate systems.

It should be noted for this site that an extensive network of forestry and roadside drains already exists, and these will be integrated and enhanced as required and used within the wind farm development drainage system. The integration of the existing forestry drainage network and the proposed wind farm network is relatively simple. The key elements being the upgrading and improvements to water treatment elements, such as in line controls and treatment systems, including silt traps, stilling ponds and buffered outfalls.

The main elements of interaction with existing drains will be as follows:

- Apart from interceptor drains, which will convey clean runoff water to the downstream drainage system, there will be no direct discharge (without treatment for sediment reduction, and attenuation for flow management) of runoff from the proposed wind farm drainage into the existing site drainage network. This will reduce the potential for any increased risk of downstream flooding or sediment transport/erosion;
- Silt traps will be placed in the existing drains upstream of any streams where construction works / tree felling is taking place, and these will be diverted into proposed interceptor drains, or culverted under/across the works area;
- During the construction phase of the wind farm, runoff from individual turbine hardstanding areas will be not discharged into the existing drain network but discharged locally at each turbine location through stilling ponds and buffered outfalls onto vegetated surfaces;
- Buffered outfalls which will be numerous over the site will promote percolation of drainage waters across vegetation and close to the point at which the additional runoff is generated, rather than direct discharge to the existing drains of the site; and,
- Drains running parallel to the existing roads that requiring widening will be upgraded, widening will be targeted to the opposite side of the road. Velocity and silt control measures such as check dams, sand bags, oyster bags, straw bales, flow limiters, weirs, baffles, silt fences will be used during the upgrade construction works. Regular buffered outfalls will also be added to these drains to protect downstream surface waters.

Water Treatment Train

A final line of defence will be provided by a water treatment train such as a "Siltbuster" if required. If the discharge water from construction areas fails to be of a high quality during the daily inspections then a filtration treatment system (such as a 'Siltbuster' or similar equivalent treatment train (sequence of water treatment processes) will be used to filter and treat all surface discharge water collected in the dirty water drainage system. This will apply for all of the construction phase.

Silt Fences

Silt fences will be emplaced within drains down-gradient of all construction areas. Silt fences are effective at removing heavy settleable solids. This will act to prevent entry to water courses of sand and gravel sized sediment, released from excavation of mineral sub-soils of glacial and glacio-fluvial origin, and entrained in surface water runoff. Inspection and maintenance of these of these structures during construction phase is critical to their functioning to stated purpose. They will remain in place throughout the entire construction phase. Double silt fences will be placed within drains down-gradient of all construction areas inside the hydrological buffer zones.

Silt Bags

Silt bags will be used where small to medium volumes of water need to be pumped from excavations. As water is pumped through the bag, the majority of the sediment is retained by the geotextile fabric allowing filtered water to pass through. Silt bags will be used with natural vegetation filters or sedimats Sediment entrapment mats, consisting of coir or jute matting, will be placed at the silt bag location to provide further treatment of the water outfall from the silt bag. Sedimats will be secured to the ground surface using stakes/pegs. The sedimat will extend to the full width of the outfall to ensure all water passes through this additional treatment measure.

Pre-emptive Site Drainage Management

The works programme for the initial construction stage of the development will also take account of weather forecasts and predicted rainfall in particular. Large excavations and movements of peat/subsoil or vegetation stripping will be suspended or scaled back if heavy rain is forecast. The extent to which works will be scaled back or suspended will relate directly to the amount of rainfall forecast.

The following forecasting systems are available and will be used on a daily basis at the site to direct proposed construction activities:

- General Forecasts: Available on a national, regional and county level from the Met Eireann website (www.met.ie/forecasts). These provide general information on weather patterns including rainfall, wind speed and direction but do not provide any quantitative rainfall estimates;
- MeteoAlarm: Alerts to the possible occurrence of severe weather for the next 2 days. Less useful than general forecasts as only available on a provincial scale;
- 3-hour Rainfall Maps: Forecast quantitative rainfall amounts for the next 3 hours but does not account for possible heavy localised events;
- Rainfall Radar Images: Images covering the entire country are freely available from the Met Eireann website (www.met.ie/latest/rainfall_radar.asp). The images are a composite of radar data from Shannon and Dublin airports and give a picture of current rainfall extent and intensity. Images show a quantitative measure of recent rainfall. A 3-hour record is given and is updated every 15 minutes. Radar images are not predictive; and,
- Consultancy Service: Met Eireann provide a 24-hour telephone consultancy service. The forecaster will provide interpretation of weather data and give the best available forecast for the area of interest.

Using the safe threshold rainfall values will allow work to be safely controlled (from a water quality perspective) in the event of forecasting of an impending high rainfall intensity event.

Works will be suspended if forecasting suggests either of the following is likely to occur:

- >10 mm/hr (i.e. high intensity local rainfall events);
- >25 mm in a 24-hour period (heavy frontal rainfall lasting most of the day); or,
- >half monthly average rainfall in any 7 days.

Prior to works being suspended the following control measures should be completed:

- Secure all open excavations;
- Provide temporary or emergency drainage to prevent back-up of surface runoff; and,
- Avoid working during heavy rainfall and for up to 24 hours after heavy events to ensure drainage systems are not overloaded.

Management of Runoff from Peat and Subsoil Reinstatement Areas

It is proposed that excavated peat will be used for landscaping throughout the site and any excess peat will be used to reinstate the 1 no. proposed borrow pit and placed within 2 no. possible peat repositories. The proposed borrow pit and peat and spoil repositories arelocated outside the 50m stream and lake buffer zone (refer to Figure 9-7).

During the initial placement of peat and subsoil at repository areas, silt fences, straw bales and biodegradable matting will be used to control surface water runoff from the repository areas. 'Siltbuster' treatment trains will be employed if previous treatment is not to a high quality.

Drainage from peat reinstatement areas will ultimately be routed to an oversized swale and a number of stilling ponds pond and a 'Siltbuster' with appropriate storage and settlement designed for a 1 in 100 year 6 hour return period before being discharged to the on-site drains.

Peat/subsoil reinstatement areas will be sealed with a digger bucket and vegetated as soon possible to reduce sediment entrainment in runoff. Once re-vegetated and stabilised peat/subsoil reinstatement areas will no longer be a potential source of silt laden runoff

Timing of Site Construction Works

Construction of the site drainage system will only be carried out during periods of low rainfall, and therefore minimum runoff rates. This will minimise the risk of entrainment of suspended sediment in surface water runoff, and transport via this pathway to surface watercourses. Construction of the drainage system during this period will also ensure that attenuation features associated with the drainage system will be in place and operational for all subsequent construction works.

Monitoring

An inspection and maintenance plan for the on-site drainage system will be prepared in advance of commencement of any works. Regular inspections of all installed drainage systems will be undertaken, especially after heavy rainfall, to check for blockages, and ensure there is no build-up of standing water in parts of the systems where it is not intended. Inspections will also be undertaken after tree felling.

Any excess build-up of silt levels at dams, the settlement pond, or any other drainage features that may decrease the effectiveness of the drainage feature, will be inspected daily and removed.

During the construction phase field testing and laboratory analysis of a range of parameters with relevant regulatory limits and EQSs will be undertaken for each primary watercourse, and specifically following heavy rainfall events (as per the CEMP).

Residual Impact: The potential for the release of suspended solids to watercourse receptors is a risk to water quality and the aquatic quality of the receptor. Proven and effective measures to mitigate the risk of releases of sediment have been proposed above and will break the pathway between the potential sources and the receptor. The residual effect is considered to be - Negative, imperceptible, indirect, short term, unlikely impact on down gradient rivers, water quality, and dependant ecosystems.

Significance of Effects: For the reasons outlined above, no significant effects on the surface water quality will occur.

9.5.3.3 Potential Impacts on Groundwater Levels and Local Well Supplies During Excavation works & from proposed Borrow Pit

Dewatering of borrow pit (if required) and other deep excavations (i.e. turbine bases) have the potential to impact on local groundwater levels. However, groundwater level impacts will not be significant due the local hydrogeological regime and the proposed borrow pit excavation method as outlined below. No groundwater level impacts will occur from the construction of the grid connection underground cabling trench or any other element of the project (i.e. access roads, substation, carpark, compound, boardwalk, met mast etc) due to the shallow nature of the excavations.

Pathway: Groundwater flowpaths.

Receptor: Groundwater levels.

Pre-Mitigation Potential Impact: Negative, imperceptible, direct, slight, short term, unlikely impact on groundwater levels/flowpaths and groundwater quality.

Impact Assessment

The proposed borrow pit is located in bedrock that has been classified as a Poor bedrock aquifer by the GSI. No groundwater dewatering will be required as rock excavation will progress in a horizontal manner into the side of outcropping bedrock.

The topographical and hydrogeological setting of the proposed borrow pit locations means no significant groundwater dewatering is anticipated to be required during the operation of the borrow pit. Moreover, direct rainfall and surface water runoff will be the main inflows that will require water volume and water quality management. For the avoidance of doubt, we would generally define dewatering as a requirement to permanently drawdown the local groundwater table by means of over pumping, e.g. as would be required for the operation of a bedrock quarry in a valley floor. We consider that this example is very different in scale and operation from the proposed operation of a temporary shallow borrow pit on the side of a hill. In order to explain this thoroughly we will outline our reasoning in a series of bullet points as follows:

- Firstly, the borrow pit areas are located on the side of a local hill where the ground elevations are between 280 and 300m OD;
- These elevations are above the elevations of the local valleys and streams;
- The proposed borrow pit will be between approximately 8 – 10m below ground level which is notable. However, in the context of the topographical/elevated setting of the borrow pit, this depth range is relatively shallow;
- The local bedrock comprises generally siltstone limestone and is known to be generally unproductive. This means that groundwater flows will be relatively minor;
- The investigation drilling encountered competent and relatively unfractured bedrock with tight joint spacing. The measured permeability (refer to Section 9.3.7) at each borehole confirmed the bedrock competency and very low permeability;

- The flow paths (i.e. the distance from the point of recharge to the point of discharge) in this type of geology is short, localised, and will also be relatively shallow;
- No regional groundwater flow regime, i.e. large volumes of groundwater flow, will be encountered at these elevations;
- Therefore, shallow groundwater inflows will largely be fed by recent rainfall, and possibly by limited groundwater seepage form localised shallow bedrock;
- The sloping nature of the ground on the hills where the borrow pit is proposed along with the coverage of soil means groundwater recharge is going to be very low;
- As such the shallow groundwater flow system will be small in comparison to the expected surface water flows from the bog surface;
- This means that there will be a preference for high surface water runoff as opposed to groundwater recharge and flow; and,
- Hence, we consider that the management of surface water will form the largest proportion of water to be managed and treated.

In terms of local well supplies, the assessment undertaken in Section 9.3.15 above identified no potential wells within the same sub-catchments as the proposed development. Therefore, there is no well supplies down-gradient of any proposed development area that can be impacted on.

Residual Impact: Due to large separation distances between proposed development works and water wells and local stream and rivers, and the relatively shallow nature of the proposed borrow pit works, and also the prevailing geology of the proposed development site the potential for water level drawdown impacts at receptor locations is considered negligible. The residual effect is considered to be – Negative, imperceptible, direct, short term, unlikely impact on groundwater levels, and Negative, imperceptible, short term, unlikely impact on groundwater quality.

Significance of Effects: For the reasons outlined above, no significant effects on groundwater levels and groundwater quality will occur.

9.5.3.4 Excavation Dewatering and Potential Impacts on Surface Water Quality

Some minor groundwater/surface water seepages will likely occur in turbine base excavations and the borrow pit and this will create additional volumes of water to be treated by the runoff management system. Inflows will likely require management and treatment to reduce suspended sediments. No contaminated land was noted at the site and therefore pollution issues are not anticipated.

Pathway: Overland flow and site drainage network.

Receptor: Down-gradient surface water bodies.

Pre-Mitigation Potential Impact: Negative, significant, indirect, short term, unlikely impact to surface water quality.

Mitigation by Design:

Management of groundwater seepages and subsequent treatment prior to discharge into the drainage network will be undertaken as follows:

- Appropriate interceptor drainage, to prevent upslope surface runoff from entering excavations will be put in place;
- If required, pumping of excavation inflows will prevent build up of water in the excavation;
- The interceptor drainage will be discharged to the site constructed drainage system or onto natural vegetated surfaces and not directly to surface waters;

- The pumped water volumes will be discharged via volume and sediment attenuation ponds adjacent to excavation areas, or via specialist treatment systems such as a Siltbuster unit;
- There will be no direct discharge to surface watercourses, and therefore no risk of hydraulic loading or contamination will occur;
- Daily monitoring of excavations by a suitably qualified person will occur during the construction phase. If high levels of seepage inflow occur, excavation work should immediately be stopped and a geotechnical assessment undertaken; and,
- A mobile 'Siltbuster' or similar equivalent specialist treatment system will be available on-site for emergencies in order to treat sediment polluted waters from settlement ponds or excavations should they occur. Siltbusters are mobile silt traps that can remove fine particles from water using a proven technology and hydraulic design in a rugged unit. The mobile units are specifically designed for use on construction-sites. They will be used as final line of defence if needed.

Residual Impact: The potential for the release of suspended solids to watercourse receptors is a risk to water quality and the aquatic quality of the receptor. Proven and effective measures to mitigate the risk of releases of sediment have been proposed above and will break the pathway between the potential sources and the receptor. The residual effect is considered to be – Negative, imperceptible, indirect, short term, unlikely impact on local surface water quality.

Significance of the Effects: For the reasons outlined above, no significant effects on the surface water quality will occur.

9.5.3.5 Potential Release of Hydrocarbons during Construction and Storage

Accidental spillage during refuelling of construction plant with petroleum hydrocarbons is a significant pollution risk to groundwater, surface water and associated ecosystems, and to terrestrial ecology. The accumulation of small spills of fuels and lubricants during routine plant use can also be a pollution risk. Hydrocarbon has a high toxicity to humans, and all flora and fauna, including fish, and is persistent in the environment. It is also a nutrient supply for adapted micro-organisms, which can rapidly deplete dissolved oxygen in waters, resulting in death of aquatic organisms.

Pathway: Groundwater flowpaths and site drainage network.

Receptor: Groundwater and surface water.

Pre-Mitigation Potential Impact: Negative, slight, indirect, short term, unlikely impact to local groundwater quality. Negative, significant, indirect, short term, unlikely impact to surface water quality.

Proposed Mitigation Measures:

Mitigation measures proposed to avoid release of hydrocarbons at the site are as follows:

- Minimal refuelling or maintenance of construction vehicles or plant will take place on site. Off-site refuelling will occur at a controlled fuelling station where possible;
- On site re-fuelling of machinery will be carried out using a mobile double skinned fuel bowser. The fuel bowser, a double-axel custom-built refuelling trailer will be re-filled off site, and will be towed around the site by a 4x4 jeep to where machinery is located. The 4x4 jeep will also carry fuel absorbent material and pads in the event of any accidental spillages. The fuel bowser will be parked on a level area in the construction compound when not in use and only designated trained and competent operatives will be authorised to refuel plant on site. Mobile measures such as drip trays and fuel absorbent mats will be used during all refuelling operations;
- Onsite refuelling will be carried out by trained personnel who will require a permit to refuel

- Fuels stored on site will be minimised. Fuel storage areas if required will be bunded appropriately for the fuel storage volume for the time period of the construction and fitted with a storm drainage system and an appropriate oil interceptor;
- The plant used during construction will be regularly inspected for leaks and fitness for purpose; and,
- An emergency plan for the construction phase to deal with accidental spillages will be contained within Construction and Environmental Management Plan (Appendix 4.4). Spill kits will be available to deal with and accidental spillage in and outside the re-fuelling area.

Residual Impact: The potential for the release of hydrocarbons to groundwater and watercourse receptors is a risk to surface water and groundwater quality, and also the aquatic quality of the surface water receptors. Proven and effective measures to mitigate the risk of releases of hydrocarbons have been proposed above and will break the pathway between the potential source and each receptor. The residual effect is considered to be - Negative, imperceptible, indirect, short term, unlikely impact to local groundwater quality. Negative, imperceptible, indirect, short term, unlikely impact to surface water quality.

Significance of Effects: For the reasons outlined above, no significant effects on surface water or groundwater quality will occur.

9.5.3.6 Groundwater and Surface Water Contamination from Wastewater Disposal

Release of effluent from domestic wastewater treatment systems has the potential to impact on groundwater and surface waters if site conditions are not suitable for an on-site percolation unit.

Pathway: Groundwater flowpaths and site drainage network.

Receptor: Down-gradient well supplies, groundwater quality and surface water quality.

Pre-Mitigation Potential Impact: Negative, significant, indirect, short term, unlikely impact to surface water quality. Negative, slight, indirect, temporary, unlikely impact to local groundwater.

Proposed Mitigation by Avoidance:

- A self-contained port-a-loo with an integrated waste holding tank will be used at the site compound, maintained by the providing contractor, and removed from site on completion of the construction works;
- Water supply for the site office and other sanitation will be brought to site and removed after use from the site to be discharged at a suitable off-site treatment location; and,
- No water will be sourced on the site or discharged to the site.

Residual Impact: No residual impact.

Significance of Effects: For the reasons outlined above, no significant effects on surface water or groundwater quality will occur.

9.5.3.7 Release of Cement-Based Products

Concrete and other cement-based products are highly alkaline and corrosive and can have significant negative impacts on water quality. They generate very fine, highly alkaline silt (pH 11.5) that can physically damage fish by burning their skin and blocking their gills. A pH range of ≥ 6 ≤ 9 is set in S.I. No. 293 of 1988 Quality of Salmonid Water Regulations, with artificial variations not in excess of ± 0.5 of a pH unit. Entry of cement based products into the site drainage system, into surface water runoff, and hence to surface watercourses or directly into watercourses represents a risk to the aquatic environment.

Peat ecosystems are dependent on low pH hydrochemistry. They are extremely sensitive to introduction of high pH alkaline waters into the system. Batching of wet concrete on site and washing out of transport and placement machinery are the activities most likely to generate a risk of cement based pollution.

Pathway: Site drainage network.

Receptor: Surface water quality.

Pre-Mitigation Potential Impact: Negative, moderate, indirect, short term, medium probability effect to surface water quality.

Proposed Mitigation by Avoidance:

The following mitigation measures are proposed:

- No batching of wet-cement products will occur on site. Ready-mixed supply of wet concrete products and where possible, emplacement of pre-cast elements, will take place.
- Where possible pre-cast elements for culverts and concrete works will be used.
- Where concrete is delivered on site, only the chute will be cleaned, using the smallest volume of water practicable. No discharge of cement contaminated waters to the construction phase drainage system or directly to any artificial drain or watercourse will be allowed. Chute cleaning water will be undertaken at lined cement washout ponds.
- Weather forecasting will be used to plan dry days for pouring concrete.
- The pour site will be kept free of standing water and plastic covers will be ready in case of sudden rainfall event.

Residual Impact: The potential for the release of cement-based products or cement truck wash water to groundwater and watercourse receptors is a risk to surface water and groundwater quality, and also the aquatic quality of the surface water receptors. Proven and effective measures to mitigate the risk of releases of cement-based products or cement truck wash water have been proposed above and will break the pathway between the potential source and each receptor. The residual effect is considered to be - Negative, imperceptible, indirect, short term, unlikely impact to surface water quality.

Significance of the Effect: For the reasons outlined above, no significant effects on surface water quality will occur.

9.5.3.8 Morphological Changes to Surface Water Courses & Drainage Patterns

Diversion, culverting and bridge crossing of surface watercourses can result in morphological changes, changes to drainage patterns and alteration of aquatic habitats. Construction of structures over water courses has the potential to significantly interfere with water quality and flows during the construction phase.

It is proposed that 9 no. new stream crossings and potentially up to 16 no. existing stream crossing upgrades will be required to facilitate the wind farm development.

Pathway: Site drainage network.

Receptor: Surface water flows, stream morphology and water quality.

Pre-Mitigation Potential Impact: Negative, slight, direct, long term, unlikely impact on stream flows, stream morphology and surface water quality.

Proposed Mitigation by Design:

The following mitigation measures are proposed:

- All proposed new stream crossings will be bottomless culverts or clear span structures and the existing banks will remain undisturbed. No in-stream excavation works are proposed and therefore there will be no direct impact on the stream at the proposed crossing location;
- Where the proposed underground cabling route follows an existing road or road proposed for upgrade, the cable will pass over or below the culvert within the access road;
- Any guidance / mitigation measures required by the OPW or the Inland Fisheries Ireland during consultation/consenting process (such as Section 50 Applications as defined below) will be incorporated into the design of the proposed crossings;
- As a further precaution, near stream construction work, will only be carried out during the period permitted by Inland Fisheries Ireland for in-stream works according to the Eastern Regional Fisheries Board (2004) guidance document "Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites", i.e., May to September inclusive. This time period coincides with the period of lowest expected rainfall, and therefore minimum runoff rates. This will minimise the risk of entrainment of suspended sediment in surface water runoff, and transport via this pathway to surface watercourses (any deviation from this will be done in discussion with the IFI);
- During the near stream construction work double row silt fences will be emplaced immediately down-gradient of the construction area for the duration of the construction phase. There will be no batching or storage of cement allowed in the vicinity of the crossing construction areas; and,
- All new river/stream crossings will require a Section 50 application (Arterial Drainage Act, 1945). The river/stream crossings will be designed in accordance with OPW guidelines/requirements on applying for a Section 50 consent.

Residual Impact: With the application of the best practice mitigation outlined above, we consider the residual effect to be - Negative, imperceptible, direct, long term, unlikely impact on stream flows, stream morphology and surface water quality.

Significance of Effects: For the reasons outlined above, no significant effects on stream morphology or stream water quality will occur at crossing locations.

9.5.3.9 Potential Hydrological Impacts on Designated Sites

The northern section of the site drains towards Lough Gill SAC via the River Bonet. The closest section of the Lough Gill SAC is located ~4.7 km north of the site, while the lake itself is situated 10 km north of the site.

There are 6 no. proposed turbines within the Bonet subcatchment which drain towards this SAC.

The Corry Mountain Bog and Carrane Hill Bog NHA are both located nearby within the Arigna sub-catchment.

Pathway: Surface water and groundwater flowpaths.

Receptor: Down-gradient water quality and designated sites.

Pre-Mitigation Potential Impact: Indirect, negative, imperceptible, short term, likely impact.

Impact Assessment & Proposed Mitigation Measures:

The north-eastern boundary of the site is bounded by the Corry Mountain Bog NHA. Carrane Hill Bog NHA is located further to the west across the Arigna River valley.

As both NHAs are topographically higher (in elevation) than the proposed development area, there is no groundwater flow or surface water drainage towards these designated sites. Also, Carrane Hill Bog NHA is separated from the proposed development by the upper reaches of the Arigna River which acts as a hydrological boundary between the NHA and the proposed development.

Corry Mountain Bog NHA is located upslope (between 100 – 150m) of proposed turbine locations T8 and T9 and also the proposed borrow pit. However, no groundwater level impacts will occur within Corry Mountain Bog NHA due to proposed excavation works at these locations and this is due to the low permeability of the peat, the SILT/CLAY subsoils and the underlying bedrock (as confirmed by the permeability tests). Any groundwater level impacts will be very localised (10 – 15) to the excavation works.

As a result, there will be no impact on the hydrology of either of the NHAs.

The Proposed Development site ultimately drains into the Killanummery river and Cashel stream, which discharge to the River Bonet. The Bonet river then flows into the Lough Gill SAC (mitigation measures for protection of water quality are reviewed below). Mitigation measures for surface water quality protection are summarised again below:

The proposed mitigation measures which will include buffer zones and drainage control measures (i.e. interceptor drains, swales, stilling ponds) will ensure that the quality of runoff from proposed development areas will be very high. As stated in Impact Section 9.4.1.2 above, there could potentially be an “imperceptible, short term, likely impact” on local streams and rivers but this would be very localised and over a very short time period (i.e. hours). Therefore, significant direct, or indirect impacts on the Lough Gill SAC will not occur.

Due to the large downstream distance to Lough Forbes Complex SAC (approx. 61km surface water distance) and the fact that there are several lakes between the Proposed Development and the SAC (Lough Allen, Lough Corry, Lough Nanoge, Lough Tap, Lough Boderg and Lough Bofin), no effects on Lough Forbes are anticipated (even in the absence of mitigation) due to the large natural attenuation capacity of the watercourses and lakes.

Residual Impact: No significant impacts.

Significance of Effects: For the reasons outlined above, no significant impacts on designated sites will occur.

9.5.3.10 Surface Water Quality Impacts on Lough Nacroagh Water Supply

Lough Nacroagh is currently not used as a private drinking water supply, however an impact assessment is undertaken below in case the source is used as a future supply. (IE_WE_35_188).

Pathway: Site drainage network.

Receptor: Lough Nacroagh WS

Pre-Mitigation potential Impact: Negative, imperceptible, indirect, long term, unlikely impact on Lough Nacroagh WS.

Impact Assessment & Proposed Mitigation Measures:

As stated previously in the chapter, a comprehensive surface water management plan and drainage plan has been prepared for the Proposed Development and this will ensure that surface water runoff from the developed areas of the site will be of a high quality and will therefore not impact on the quality of downstream rivers and lakes. During the layout process, all surface waters at the site were classified as very sensitive (the criteria for this are presented in Table 9.1 of the EIAR). Very sensitive surface waters are receptors of high environmental importance such as designated sites (i.e. NHA or SAC) or a public drinking water supply. The surface waters at the proposed development were applied the highest possible sensitivity rating and appropriate mitigation measures which include avoidance and best practice engineering design measures are proposed to avoid significant impacts.

Three turbines, T4, T5 and T6 are situated 250-350m from Lough Nacroagh and are all downstream of the lake and therefore cannot result in impact. The closest turbine to the lake and associated catchment area is T5, which is 200m from the edge of the catchment area. This turbine is still significantly outside the 50m buffer zone and therefore drainage can be adequately managed.

Residual Impact: No impacts on Lough Nacroagh WS will occur.

Significance of Effects: For the reasons outlined above, no significant effects on Lough Nacroagh WS will occur.

9.5.4 Operational Phase - Likely Significant Effects and Mitigation Measures

9.5.4.1 Progressive Replacement of Natural Surface with Lower Permeability Surfaces

Progressive replacement of the peat or vegetated surface with impermeable surfaces could potentially result in an increase in the proportion of surface water runoff reaching the surface water drainage network. This could potentially increase runoff from the site and increase flood risk downstream of the development. In reality, the access roads will have a higher permeability than the underlying peat. However, it is conservatively assumed in this assessment that the proposed access roads and hardstands are impermeable. The assessed footprint comprises turbine bases and hardstandings, access roads, amenity walkways, site entrances, substation, visitor car park and temporary construction compounds. During storm rainfall events, additional runoff coupled with increased velocity of flow could increase hydraulic loading, resulting in erosion of watercourses and impact on aquatic ecosystems.

The emplacement of the proposed permanent development footprint, as described in Chapter 4 of the EIAR, (assuming emplacement of impermeable materials as a worst-case scenario) could result in an average total site increase in surface water runoff of approximately 2,256 m^3/month (73m^3/day).

Table 9-20). This represents a potential increase of approximately 0.28% in the average daily/monthly volume of runoff from the site area in comparison to the baseline pre-development site runoff conditions (Error! Reference source not found.). This is a very small increase in average runoff and results from the naturally high surface water runoff rates and the relatively small area of the site being developed, the proposed total permanent development footprint being approximately 35.2 ha, representing 5.4% of the total study area of approximately 670 ha.

Table 9-20: Baseline Site Runoff V Development Runoff

Study Area (ha)	Site Baseline Runoff/month (m^3)	Baseline Runoff/day (m^3)	Permanent Hardstanding Area (m^2)	Hardstanding Area 100% Runoff (m^3)	Hardstanding Area 95% Runoff (m^3)	Net Increase/month (m^3)	Net Increase/day (m3)	% Increase from Baseline Conditions (m^3)
670	814,720	26,281	352,450	45,114	42,858	2,256	73	0.28

The additional volume is low due to the fact that the runoff potential from the site is naturally high (95%). Also, the calculation assumes that all hardstanding areas will be impermeable which will not be the case as access tracks will be constructed of permeable stone aggregate. The increase in runoff from the proposed development will, therefore, be negligible. This is even before mitigation measures will be put in place.

Pathway: Site drainage network.

Receptor: Surface waters and dependant ecosystems.

Pre-Mitigation Potential Impact: Negative, slight, indirect, permanent, moderate probability effect on all downstream surface water bodies.

Proposed Mitigation by Design:

The operational phase drainage system of the Proposed Development will be installed and constructed in conjunction with the road and hardstanding construction work as described below:

- Interceptor drains will be installed up-gradient of all proposed infrastructure to collect clean surface runoff, in order to minimise the amount of runoff reaching areas where suspended sediment could become entrained. It will then be directed to areas where it can be re-distributed over the ground by means of a level spreader;
- Swales/road side drains will be used to collect runoff from access roads and turbine hardstanding areas of the site, likely to have entrained suspended sediment, and channel it to settlement ponds for sediment settling;
- On steep sections of access road transverse drains ('grips') will be constructed in the surface layer of the road to divert any runoff off the road into swales/road side drains;
- Check dams will be used along sections of access road drains to intercept silts at source. Check dams will be constructed from a 4/40mm non-friable crushed rock;
- Settlement ponds, emplaced downstream of road swale sections and at turbine locations, will buffer volumes of runoff discharging from the drainage system during periods of high rainfall, by retaining water until the storm hydrograph has receded, thus reducing the hydraulic loading to watercourses; and,
- Settlement ponds will be designed in consideration of the greenfield runoff rate.

Residual Effect: With the implementation of the proposed wind farm drainage measures as outlined above, we consider that residual effect is - Negative, imperceptible, indirect, long-term, moderate probability effect on all downstream surface water bodies.

Significance of Effects: For the reasons outlined above, no significant effects on downstream flood risk will occur.

9.5.5 Decommissioning Phase - Likely Significant Effects and Mitigation Measures

The potential impacts associated with decommissioning of the proposed development will be similar to those associated with construction but of a reduced magnitude, due to the reduced scale of the proposed decommissioning works in comparison to construction phase works.

During decommissioning, it may be possible to reverse or at least reduce some of the potential impacts caused during construction by rehabilitating construction areas such as turbine bases, hard standing areas.

This will be done by covering with peatland vegetation/scraw or poorly humified peat to encourage vegetation growth and reduce run-off and sedimentation. Other impacts such as possible soil compaction and contamination by fuel leaks will remain but will be of reduced magnitude. However, as noted in the Scottish Natural Heritage report (SNH) Research and Guidance on Restoration and Decommissioning of Onshore Wind Farms (SNH, 2013) reinstatement proposals for a wind farm are made approximately 30 years in advance, so within the lifespan of the wind farm, technological advances and preferred approaches to reinstatement are likely to change. According to the SNH guidance, it is, therefore:

> *"best practice not to limit options too far in advance of actual decommissioning but to maintain informed flexibility until close to the end-of-life of the wind farm".*

Some of the impacts will be avoided by leaving elements of the proposed development in place where appropriate. The substation will be retained by EirGrid. The turbine bases will be rehabilitated by covering with local topsoil/peat in order to regenerate vegetation which will reduce runoff and sedimentation effects. Internal roads will remain to facilitate forest management and as amenity pathways. Mitigation measures to avoid contamination by accidental fuel leakage and compaction of soil by on-site plant will be implemented as per the construction phase mitigation measures.

No significant effects on the hydrological and hydrogeological environment will occur during the decommissioning stage of the proposed development.

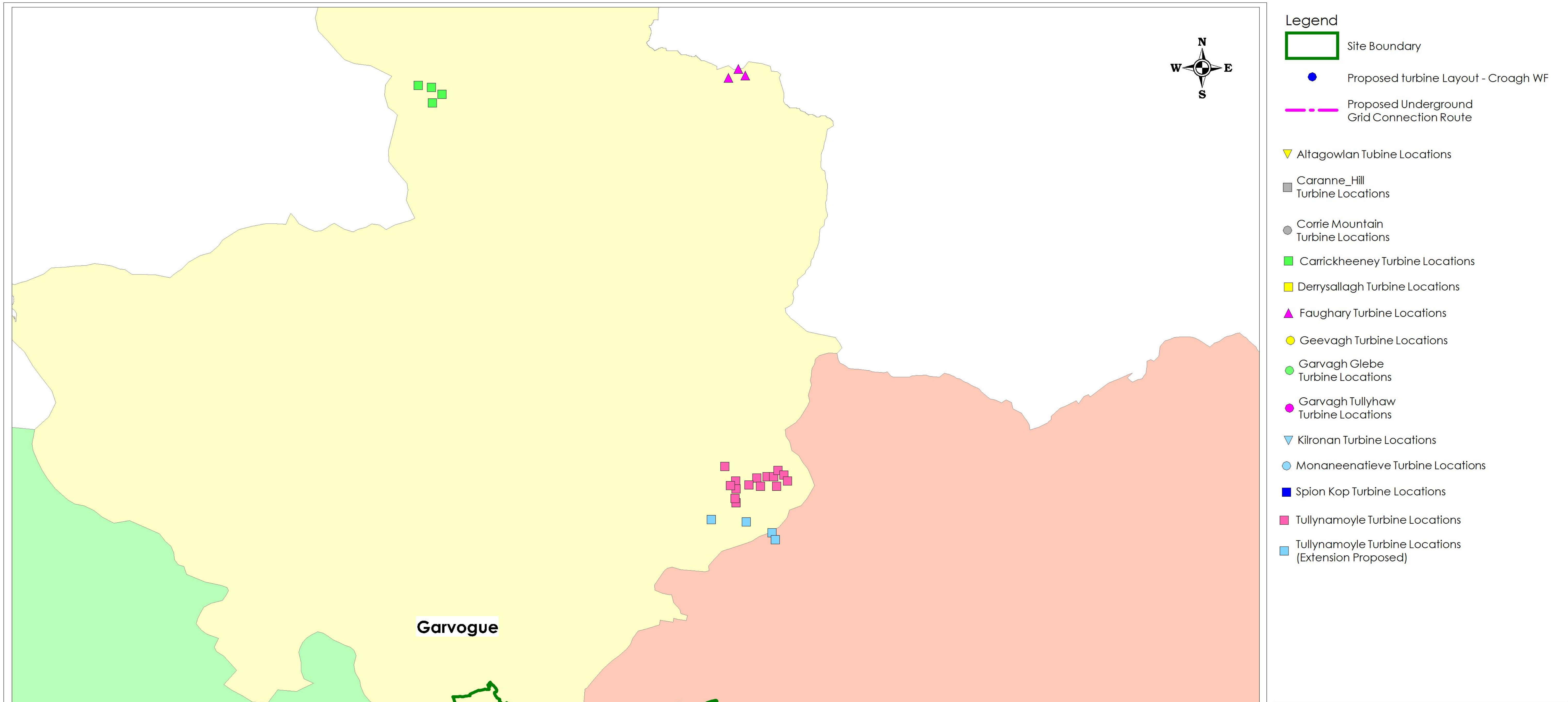
9.5.6 Assessment of Cumulative Effects

In terms of cumulative hydrological effects arising from all elements of the Proposed Development and work design, no significant effects are expected and this is largely due to the proposed works being located in 3 no. separate regional surface water catchments.

The wind farm site itself sits inside two separate regional catchments (River Shannon and Garvogue River regional catchments). The grid connection passes through three separate regional surface water catchments (refer to Table 9.5 above) and also due to the fact that the proposed route is along existing roads (with no requirement for in-stream works) no significant cumulative effects with respect to the grid connection and wind farm are expected.

A hydrological cumulative impact assessment was undertaken with regard other wind farm developments within a 20km radius in the River Shannon and Garvogue River regional catchments (there are no other wind farms located within 20km in the Ballysadare River catchment). The wind farm developments assessed are listed in Table 9.14 below and are shown on Figure 9-8.

The total number of turbines that could potentially be operating inside a 20km radius within the River Shannon catchment is 82 (4 no. from the proposed Croagh wind farm and 78 from other wind farms as shown in Table 9.14 below).



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

Client: MKO	
Job: Croagh WF, Leitrim	
Title: Cumulative Evaluation Impact Map	
Figure No: 9.8	
Drawing No: P1459-0-0620-A3-908-0A	
Sheet Size: A3	Project No: P1459-0
Scale: 1:120,000	Drawn By: GD
Date: 25/06/2020	Checked By: MG

In terms of the Garvogue River catchment, the total number of turbines that could potentially be operating inside a 20km radius is 34 (6 no. from the proposed Croagh wind farm and 28 from other wind farms as shown in Table 9.14 below).

The total catchment area of the River Shannon (inside a 20km radius) is ~614km2 and therefore this equates to one turbine for approximately every ~7.5km2 which is considered imperceptible in terms of potential cumulative hydrological impacts. For the Garvogue River catchment within a 20km radius, which has an area of 351km2 inside a 20km radius, this equates to one turbine for approximately every ~10km^2 which is also considered imperceptible.

Also, implementation of the proposed drainage mitigation will ensure there will be no cumulative significant negative impacts on the water environment from the proposed Croagh Windfarm, and other wind farm developments and non-wind farm developments as described in Chapter 2 of the EIAR within a 20km radius in the Shannon River and Garvogue River catchments.

To account for the tree felling required as part of the Proposed Development, 3 no. sites across Co. Cavan, Co. Roscommon and Co. Wicklow are proposed for the replacement of forestry. There is no potential for cumulative effects as the forestry replacement sites are remote from the Proposed Development with no hydrological connection.

With regard non-wind farm related forestry activities and the potential for cumulative impacts, all Coillte scheduled tree felling or replanting will be planned around the Proposed Development construction phase in order to prevent hydrological cumulative impacts. No scheduled tree felling will occur in the same local catchment where wind farm construction is taking place.

Table 9-14 Other Wind Farm Developments Within 20km of the Proposed Development

Regional Catchment	Wind Energy Developments	Total Turbine No.	Turbine No. in Same Catchment as Proposed Development
Garvogue	Carrickheeney WF	4	4
	Faughary WF	3	3
	Tullynamoyle Existing WF	15	15
	Tullynamoyle Ext WF	4	2
	Garvagh Glebe WF	13	4
Garvogue Total			**28**
	Garvagh Glebe WF	13	9
	Corrie Mountain	8	8
	Monaneenatieve WF	5	5
	Spion Kop WF [3]	2	2

[3] Permission has been granted for the removal of the existing 2 no. turbines and the replacement with 1 no. turbine. The overall cumulative impact with respect other wind farms remains as imperceptible.

Regional Catchment	Wind Energy Developments	Total Turbine No.	Turbine No. in Same Catchment as Proposed Development
Shannon	Altogowlan WF	9	9
	Garvagh Tullyhaw WF	11	11
	Kilronan WF	10	10
	Derrysallagh WF	12	12
	Carrane Hill WF	4	4
	Tullynamoyle EXT WF	4	2
	Geevagh WF	6	6
Shannon Total			78

9.5.7 Post Consent Monitoring

None required.

10. AIR AND CLIMATE

10.1 Air Quality

10.1.1 Introduction

This chapter identifies, describes and assesses the potential significant direct and indirect effects on air quality and climate arising from the construction, operation and decommissioning of the proposed Croagh Wind Farm.

The site of the Croagh Wind Farm development is located on the boundary of Counties Leitrim and Sligo, approximately 5km west of the village of Drumkeeran and 7km southeast of Dromahair. The townlands within which the proposed development site, ancillary works and grid connection cabling route are located can be found in Chapter 1 Table 1-1 of this EIAR.

The primary land-uses within and in the vicinity of the site comprises commercial forestry. Due to the non-industrial nature of the proposed development and the general character of the surrounding environment, air quality sampling was deemed to be unnecessary for this EIAR. It is expected that air quality in the existing environment is good, since there are no major sources of air pollution (e.g. heavy industry) in the vicinity of the site.

The production of energy from wind turbines has no direct emissions as is expected from fossil fuel-based power stations. Harnessing more energy by means of renewable sources will reduce dependency on fossil fuels, thereby resulting in a reduction in harmful emissions that can be damaging to human health and the environment. Some minor short term or temporary indirect emissions associated with the construction of the Proposed Development include vehicular and dust emissions.

10.1.1.1 Relevant Guidance

The air quality and climate section of this EIAR is carried out in accordance with the EIA Directive 2011/92/EU as amended by Directive 2014/52/EU and having regard, where relevant, to guidance contained in the Section 1.8.1 of this EIAR.

10.1.1.2 Statement of Authority

This chapter of the EIAR was completed by Eoin McCarthy and Michael Watson. Eoin is a Senior Environmental Scientist with McCarthy O'Sullivan Ltd. with over 8 years of experience in private consultancy. Eoin holds B.Sc. (Hons) in Environmental Science from NUI, Galway. Michael Watson is Project Director and head of the Environment Team in MKO. Michael has over 18 years' experience in the environmental sector. Following the completion of his Master's Degree in Environmental Resource Management, Geography, from National University of Ireland, Maynooth he worked for the Geological Survey of Ireland. Between them, they have completed Air and Climate EIAR chapters for over twenty wind energy projects.

10.1.2 Air Quality Standards

In 1996, the Air Quality Framework Directive (96/62/EC) was published. This Directive was transposed into Irish law by the Environmental Protection Agency Act 1992 (Ambient Air Quality Assessment and Management) Regulations 1999. The Directive was followed by four Daughter Directives, which set out limit values for specific pollutants:

- The first Daughter Directive (1999/30/EC) addresses sulphur dioxide, oxides of nitrogen, particulate matter and lead.
- The second Daughter Directive (2000/69/EC) addresses carbon monoxide and benzene. The first two Daughter Directives were transposed into Irish law by the Air Quality Standards Regulations 2002 (SI No. 271 of 2002).
- The third Daughter Directive, Council Directive (2002/3/EC) relating to ozone was published in 2002 and was transposed into Irish law by the Ozone in Ambient Air Regulations 2004 (SI No. 53 of 2004).
- The fourth Daughter Directive, published in 2007, relates to polyaromatic hydrocarbons (PAHs), arsenic, nickel, cadmium and mercury in ambient air and was transposed into Irish law by the Arsenic, Cadmium, Mercury, Nickel and Polycyclic Aromatic Hydrocarbons in Ambient Air Regulations, 2009 (S.I. No. 58 of 2009).

The Air Quality Framework Directive and the first three Daughter Directives have been replaced by the Clean Air for Europe (CAFE) Directive (Directive 2008/50/EC on ambient air quality) (as amended by Directive EU 2015/1480) which encompasses the following elements:

- The merging of most of the existing legislation into a single Directive (except for the Fourth Daughter Directive) with no change to existing air quality objectives.
- New air quality objectives for PM2.5 (fine particles) including the limit value and exposure concentration reduction target.
- The possibility to discount natural sources of pollution when assessing compliance against limit values.
- The possibility for time extensions of three years (for particulate matter PM10) or up to five years (nitrogen dioxide, benzene) for complying with limit values, based on conditions and the assessment by the European Commission.

Table 10-1 below sets out the limit values of the CAFE Directive, as derived from the Air Quality Framework Daughter Directives. Limit values are presented in micrograms per cubic metre (μg/m^3) and parts per billion (ppb). The notation PM10 is used to describe particulate matter or particles of ten micrometres or less in aerodynamic diameter. PM2.5 represents particles measuring less than 2.5 micrometres in aerodynamic diameter.

The CAFE Directive was transposed into Irish legislation by the Air Quality Standards Regulations 2011 (S.I. No. 180 of 2011) as amended by the Air Quality Standards (Amendments) and Arsenic, Cadmium, Mercury, Nickel and Polycyclic Aromatic Hydrocarbons in Ambient Air Regulations, 2016 (S.I. 659 2016). These Regulations supersede the Air Quality Standards Regulations 2002 (S.I. No. 271 of 2002), the Ozone in Ambient Air Regulations 2004 (S.I. No. 53 of 2004) and the Ambient Air Quality Assessment and Management Regulations 1999 (S.I. No. 33 of 1999).

Table 10-1 Limit values of Directive 2008/50.EC, 1999/30/EC and 200/69/EC (Source: https://www.epa.ie/air/quality/standards/)

Pollutant	Limit Value Objective	Averaging Period	Limit Value (ug/m^3)	Limit Value (ppb)	Basis of Application of Limit Value	Attainment Date
Sulphur dioxide (SO2)	Protection of Human Health	1 hour	350	132	Not to be exceeded more than 24 times in a calendar year	1st Jan 2005

Pollutant	Limit Value Objective	Averaging Period	Limit Value (ug/m^3)	Limit Value (ppb)	Basis of Application of Limit Value	Attainment Date
Sulphur dioxide (SO2)	Protection of human health	24 hours	125	47	Not to be exceeded more than 3 times in a calendar year	1st Jan 2005
Sulphur dioxide (SO_2)	Upper assessment threshold for the protection of Human Health	24 hours	75	28	Not to be exceeded more than 3 times in a calendar year	1st Jan 2005
Sulphur dioxide (SO_2)	Lower assessment threshold for the protection of human health	24 hours	50	19	Not to be exceeded more than 3 times in a calendar year	1st Jan 2005
Sulphur dioxide (SO2)	Protection of vegetation	Calendar year	20	7.5	Annual mean	19th Jul 2001
Sulphur dioxide (SO2)	Protection of vegetation	1st Oct to 31st Mar	20	7.5	Winter mean	19th Jul 2001
Nitrogen dioxide (NO2)	Protection of human health	1 hour	200	105	Not to be exceeded more than 18 times in a calendar year	1st Jan 2010
Nitrogen dioxide (NO2)	Protection of human health	Calendar year	40	21	Annual mean	1st Jan 2010
Nitrogen dioxide (NO_2)	Upper assessment threshold for the protection of human health	1 hour	140	73	Not to be exceeded more than 18 times in a calendar year	1st Jan 2010

Pollutant	Limit Value Objective	Averaging Period	Limit Value (ug/m^3)	Limit Value (ppb)	Basis of Application of Limit Value	Attainment Date
Nitrogen dioxide (NO_2)	Lower assessment threshold for the protection of human health	1 hour	100	52	Not to be exceeded more than 18 times in a calendar year	1st Jan 2010
Nitrogen monoxide (NO) and nitrogen dioxide (NO2)	Protection of ecosystems	Calendar year	30	16	Annual mean	19th Jul 2001
Particulate matter 10 (PM10)	Protection of human health	24 hours	50	-	Not to be exceeded more than 35 times in a calendar year	1st Jan 2005
Particulate matter 2.5 (PM2.5)	Protection of human health	Calendar year	40	-	Annual mean	1st Jan 2005
Particulate matter 2.5 (PM2.5) Stage 1	Protection of human health	Calendar year	25	-	Annual mean	1st Jan 2015
Particulate matter 10 (PM_{10})	Upper assessment threshold for the protection of human health	24 hours	30	-	Not to be exceeded more than 7 times in a calendar year	Based on the indicative limit values for 1 January 2010
Particulate matter 10 (PM_{10})	Lower assessment threshold for the protection of human health	24 hours	20	-	Not to be exceeded more than 7 times in a calendar year	Based on the indicative limit values for 1 January 2010
Particulate matter 2.5	Protection of human health	Calendar year	20	-	Annual mean	1st Jan 2020

Pollutant	Limit Value Objective	Averaging Period	Limit Value (ug/m^3)	Limit Value (ppb)	Basis of Application of Limit Value	Attainment Date
(PM2.5) Stage 2						

The Ozone Daughter Directive 2002/3/EC is different from the other Daughter Directives in that it sets target values and long-term objectives for ozone rather than limit values. Table 10-2 presents the limit and target values for ozone.

Table 10-2 Target values for Ozone Defined in Directive 2008/50/EC

Objective	Parameter	Target Value for 2010	Target Value for 2020
Protection of human health	Maximum daily 8-hour mean	120 mg/m^3 not to be exceeded more than 25 days per calendar year averaged over 3 years	120 mg/m^3
Protection of vegetation	AOT40* calculated from 1-hour values from May to July	18,000 mg/m^3.h averaged over 5 years	6,000 mg/m^3.h
Information Threshold	1-hour average	180 mg/m^3	-
Alert Threshold	1-hour average	240 mg/m^3	-

*The sum of the differences between hourly ozone concentration and 40 ppb for each hour when the concentration exceeds 40 ppb during a relevant growing season, e.g. for forest and crops.

10.1.2.1 Air Quality and Health

The Environmental Protection Agency (EPA) report '*Air Quality in Ireland 2018'* noted that in Ireland, the premature deaths attributable to poor air quality are estimated at 1,180 people per annum. A more recent European Environmental Agency (EEA) Report, '*Air Quality in Europe – 2019 Report'* highlights the negative effects of air pollution on human health. The report assessed that poor air quality accounted for premature deaths of approximately 412,000 people in Europe in 2016, with regards to deaths relating to $PM_{2.5}$. The estimated impacts on the population in Europe of exposure to NO_2 and O_3 concentrations in 2016 were around 71,000 and 15,100 premature deaths per year, respectively. From this, 1,100 Irish deaths were attributable to fine particulate matter ($PM_{2.5}$), 50 Irish deaths were attributable to nitrogen oxides (NO_2) and 30 Irish deaths were attributable to Ozone (O_3) (Source: *Air Quality in Europe – 2019 Report',* EEA, 2019. These emissions, along with others including sulphur oxides (SO_x) are produced during fossil fuel-based electricity generation in various amounts, depending on the fuel and technology used.

Whilst there is the potential of such emissions and also dust emissions to be generated from the site operations, a number of mitigation measures will be implemented at this site to reduce the impact from dust and vehicle emissions, which are discussed in Sections 10.2.4 below.

10.1.3 Air Quality Zones

The EPA has designated four Air Quality Zones for Ireland:

- Zone A: Dublin City and environs
- Zone B: Cork City and environs
- Zone C: 16 urban areas with population greater than 15,000
- Zone D: Remainder of the country.

These zones were defined to meet the criteria for air quality monitoring, assessment and management described in the Framework Directive and Daughter Directives. The site of the Proposed Development lies within Zone D, which represents rural areas located away from large population centres.

10.1.4 Existing Air Quality

The EPA publishes Air Monitoring Station Reports for monitoring locations in all four Air Quality Zones. The ambient air quality monitoring carried out closest to the proposed development site is at Sligo town, Co, Sligo, located approximately 17.8 km northwest of the site of the Proposed Development. EPA air quality data is available for in the report 'Ambient Air Monitoring in Sligo 20th January 2003 – 2nd October 2003', as detailed below in Tables 10-3 to 10-6. This monitoring location lies within Zone C. Lower measurement values for all air quality parameters would be expected for the proposed development site as it lies in a rural location, within Zone D.

Ozone data for 2019 was obtained from the closest active atmospheric monitoring station at Lough Navar, Glenasheevar Road, Co. Fermanagh, located approximately 37.5 km northeast of the site. (https://www.airqualityni.co.uk/site/LN#statistics). This can be found in Table 10-7 below.

10.1.5 Sulphur Dioxide (SO_2)

Sulphur dioxide data for the period January 2003- October 2003 recorded at the Sligo town air monitoring station is presented in Table 10-3. Neither the hourly limit value nor lower assessment threshold set out in the CAFE Directive were exceeded during the monitoring period.

Table 10-3 Sulphur Dioxide Data for Sligo town in 2003.

Parameter	Measurement
No. of hours	6101
No. of measured values	5926
Percentage Coverage	97.1
Maximum hourly value	52.1 ug/m^3
98 percentile for hourly values	38 ug/m^3
Mean hourly value	11 ug/m^3
Maximum 24-hour mean	37.4 ug/m^3
98 percentile for 24-hour mean	28.5 ug/m^3

10.1.5.1 Particulate Matter (PM_{10})

Particulate matter (PM10) data for the 2003 monitoring period in Sligo town is presented in Table 10-4. The 24-hour limit value for the protection of human health (50 µg/m^3) was not exceeded during the measurement period. The upper assessment threshold was exceeded on 26 days and the lower assessment threshold was exceeded on 55 days. The CAFE Directive stipulates that these assessment thresholds should not be exceeded more than 35 times in a calendar year. The mean of the daily values during the measurement period is below the annual limit value for the protection of human health (40 µg/m^3).

Table 10-4 Particulate Matter (PM10) Data Sligo Town January 2003 to October 2003

Parameter	Measurement
No. of days	254
No. of measured values	184
Percentage Coverage	72.4
Maximum daily value	63.2
Mean daily value	17.7

10.1.5.2 Nitrogen Dioxide (NO_2)

Nitrogen dioxide and oxides of nitrogen data for the 2003 monitoring period in Sligo town is presented in Table 10-5. No hourly mean NO_2 value was above the lower assessment threshold. The CAFE Directive stipulates that this threshold should not be exceeded more than 18 times in a calendar year. The mean hourly NO_2 value during the measurement period was below the annual lower assessment threshold for the protection of human health, which is 26 µg/m^3.

Table 10-5 Nitrogen Dioxide and Oxides of Nitrogen Sligo Town January 2003 to October 2003

Parameter	Measurement
No. of hours	6101
No. of measured values	4850
Percentage Coverage	79.5
Maximum hourly value (NO_2)	245 ug/m^3
98 percentile for hourly values (NO_2)	39.5 ug/m^3
Mean hourly value (NO_2)	11.7 ug/m^3
Mean hourly value (NOx)	18.7 ug/m^3

10.1.5.3 Carbon Monoxide (CO)

Carbon monoxide data for the 2003 monitoring period in Sligo town, is presented in Table 10-6. The mean hourly concentration of carbon monoxide recorded was 0.3 mg/m^3. The carbon monoxide limit value for the protection of human health is 10 mg/m^3. On no occasions were values in excess of the 10 mg limit value set out in the CAFE Directive/ Air Quality Standards Regulations 2011 (as amended) recorded.

Table 10-6 Carbon Monoxide Data for 2003 in Sligo Town

Parameter	Measurement
No. of hours	6101
No. of measured values	4784
Percentage Coverage	78.4
Maximum hourly value	7.4 mg/m^3
98 percentile for hourly values	1.0 mg/m^3
Mean hourly value	0.3 mg/m^3
Maximum 8 hour mean	1.6 mg/m^3
98 percentile for 8-hour mean	0.9 mg/m^3

10.1.5.4 Ozone (O_3)

Ozone data for the Lough Navar Atmospheric Monitoring Station, for 2019, is presented in Table 10-7. The mean hourly concentration of ozone recorded was 50 µg/m^3.There were no exceedances of the daily maximum 8-hour running mean of 120 µgm^3 and no exceedances of the 180 µg/m^3 information threshold value set for the protection of the general population.

Table 10-7 Summary statistics for O_3 concentrations for year to date 2019: Lough Navar

Parameter	Measurement
Percentage Coverage	98
Annual hourly Mean	50 µg/m^3
Annual Mean Daily Max 8 Hour	66 µg/m^3
Max Daily Mean	124 µg/m^3
Max Hourly Mean	153 µg/m^3
Max 8-hour running mean > 120µg/m^3 on more than 25 days	0

10.1.5.5 Dust

There are no statutory limits for dust deposition in Ireland. However, EPA guidance suggests that a deposition of 10 mg/m^2/hour can generally be considered as posing a soiling nuisance. This equates to 240 mg/m^2/day. The EPA recommends a maximum daily deposition level of 350 mg/m^2/day when measured according to the TA Luft Standard 2002.

Construction dust has the potential to be generated from on-site activities such as excavation and backfilling. The extent of dust generation at any site depends on the type of activity undertaken, the location, the nature of the dust, i.e. soil, sand, peat, etc., and the weather. In addition, dust dispersion is influenced by external factors such as wind speed and direction and/or, periods of dry weather. Construction traffic movements also have the potential to generate dust as they travel along the haul route.

The potential dust-related effects on local air quality and the relevant associated mitigation measures are presented in Sections 10.1.6.3 below.

10.1.6 Likely and Significant Impacts and Associated Mitigation Measures

10.1.6.1 'Do-Nothing' Effect

If the Proposed Development were not to proceed, the opportunity to reduce emissions of carbon dioxide, oxides of nitrogen (NOx), and sulphur dioxide (SO_2) to the atmosphere would be lost due to the continued dependence on electricity derived from coal, oil and gas-fired power stations, rather than renewable energy sources such as the proposed renewable energy development. This would result in an indirect negative impact on air quality nationally..

10.1.6.2 Construction Phase

10.1.6.2.1 *Exhaust Emissions*

Turbines and Other Infrastructure

The construction of turbines, the anemometry mast, site roads and other onsite infrastructure will require the operation of construction vehicles and plant on site. Exhaust emissions associated with vehicles and plant will arise as a result of construction activities. This potential effect will not be significant and will be restricted to the duration of the construction phase and localised to works locations. Therefore, this is considered a short-term, slight, negative impact. Mitigation measures to reduce this impact are presented below.

Borrow Pit

The proposed borrow pit will also require the use of construction machinery and plant, thereby giving rise to exhaust emissions. This is also a short-term slight negative impact, which will be reduced through use of the best practice mitigation measures as presented below.

Substation, and Grid Connection Cable

The construction of the proposed substation and the grid connection cabling route to the Garvagh 110kV substation will require the use of construction machinery, thereby giving rise to exhaust emissions. This is a short-term slight negative impact, which will be reduced through use of the best practice mitigation measures as presented below.

Transport to Site

The transport of turbines and construction materials to the site, which will occur on specified routes only (see Section 14.1 of this EIAR), will also give rise to exhaust emissions associated with the transport vehicles. This constitutes a slight negative impact in terms of air quality. Mitigation measures in relation to exhaust emissions are presented below.

Mitigation

- All construction vehicles and plant will be maintained in good operational order while onsite, thereby minimising any emissions that arise.
- All machinery will be switched off when not in use.
- The majority of aggregate materials for the construction of the proposed development will be obtained from the borrow pit on site. This will significantly reduce the number of delivery vehicles accessing the site, thereby reducing the amount of emissions associated with vehicle movements.

Residual Impact

Short-term Imperceptible Negative impact.

Significance of Effects

Based on the assessment above there will be no significant direct or indirect effects on air quality due to the construction of the proposed development.

10.1.6.3 Dust Emissions

Turbines and Other Infrastructure

The construction of turbine bases and hardstands, anemometry mast, site roads and other onsite infrastructure (as outlined in Chapter 4 of this EIAR) will give rise to dust emissions during the construction phase. The potential for impacts on off-site receptors is limited due to the isolated nature of the site and the vegetative screening that exists surrounding the site. This potential effect will not be significant and will be restricted to the duration of the construction phase. Therefore, this is a short-term, slight, negative impact. Dust suppression mitigation measures to reduce this impact are presented below.

Borrow Pit

The extraction of material from the borrow pit will give rise to localised dust emissions. This is a short-term, moderate, negative impact. Mitigation measures to reduce this impact are presented below.

Substation and Grid Connection Cable

The construction of the proposed substation, and the excavation of the grid connection cabling route will give rise to localised dust emission during their construction. This is a short-term slight negative impact. Mitigation measures to reduce this impact are presented below.

Transport to Site

The transport of turbines and construction materials to the wind farm site will give rise to some localised dust emissions during periods of dry weather. This is a short-term slight negative impact. Mitigation measures to reduce the significance of this effect are presented below.

Mitigation

- In periods of extended dry weather, dust suppression may be necessary along haul roads, site roads, substation and construction compounds and around the borrow pit area to ensure dust does not cause a nuisance. If necessary, de-silted water will be taken from stilling ponds in the site's drainage system and will be pumped into a bowser or water spreader to dampen down haul roads, borrow pit and site compounds to prevent the generation of dust where required. Water bowser movements will be carefully monitored to avoid, insofar as reasonably possible, increased runoff.

- All plant and materials vehicles shall be stored in dedicated areas (on site).
- Areas of excavation will be kept to a minimum, and stockpiling will be minimised by coordinating excavation, spreading and compaction.
- Turbines and construction materials will be transported to the site on specified haul routes only.
- The agreed haul route roads adjacent to the site will be regularly inspected for cleanliness and cleaned as necessary.
- The transport of construction materials which may have the potential to generate dust will be undertaken with tarpaulin cover or similar, where necessary.
- The transport of dry excavated material from the on-site borrow pit which may have potential to generate dust will be minimised. If necessary, excavated material will be dampened prior to transport from the borrow pits.
- A Construction and Environmental Management Plan (CEMP) will be in place throughout the construction phase (see Appendix 4-4). The CEMP includes dust suppression measures.

Residual Impact

Short-term Imperceptible Negative Impact

Significance of Effects

Based on the assessment above there will be no significant direct or indirect effects on air quality due to dust emissions during the construction phase of the Proposed Development.

10.1.7 Operational Phase

10.1.7.1.1 *Exhaust Emissions*

Exhaust emissions associated with the operational phase of the Proposed Development will arise from occasional machinery and Light Goods Vehicles (LGV) that are intermittently required onsite for maintenance. This will give rise to a long-term, imperceptible, negative impact.

Mitigation

Any vehicles or plant brought onsite during the operational phase will be maintained in good operational order, thereby minimising any emissions that arise.

Residual Impact

Long-term Imperceptible Negative Impact

Significance of Effects

Based on the assessment above there will be no significant direct or indirect effects on air quality from exhaust emissions during the operation of the Proposed Development.

10.1.7.1.2 *Air Quality*

By providing an alternative to electricity derived from coal, oil or gas-fired power stations, the proposed development will result in emission savings of carbon dioxide (CO_2), oxides of nitrogen (NO_x), and sulphur dioxide SO_2. The production of renewable energy from the Proposed Development will have a long-term, significant, positive impact on air quality. Further details on the carbon dioxide savings associated with the Proposed Development are presented in Section 10.2.3.

Residual Impact

Long-term Significant Positive Impact

Significance of Effects

Based on the assessment above there will be a significant positive effect on air quality due to the operation of the Proposed Development.

10.1.7.1.3 *Human Health*

Exposure to chemicals such as SO_2 and NO_x are known to be harmful to human health. The production of clean renewable energy from the Proposed Development will offset the emission of these harmful chemicals by fossil fuel powered sources of electricity and, therefore, will have a long term slight positive impact on human health. Further information on the impact of the proposed development on Human Health is contained in Chapter 5: Population and Human Health.

Residual Impact

Long-term Slight Positive Impact

Significance of Effects

Based on the assessment above there will be a significant positive effect on human health due to the operation of the Proposed Development.

10.1.7.2 Decommissioning Phase

Any impact and consequential effect that occurs during the decommissioning phase are similar to that which occurs during the construction phase, albeit of less impact. The mitigation measures prescribed for the construction phase of the proposed development will be implemented during the decommissioning phase thereby minimising any potential impacts.

10.2 Climate

All relevant legislation and policy in relation to climate is outlined in detail in Chapter 2 of this EIAR. A summary of the same is provided in the following sections.

10.2.1 Climate Change and Greenhouse Gases

Although variation in climate is thought to be a natural process, the rate at which the climate is changing has been accelerated rapidly by human activities. Climate change is one of the most challenging global issues facing us today and is primarily the result of increased levels of greenhouse gases in the atmosphere. These greenhouse gases come primarily from the combustion of fossil fuels in energy use. Changing climate patterns are thought to increase the frequency of extreme weather conditions such as storms, floods and droughts. In addition, warmer weather trends can place pressure on animals and plants that cannot adapt to a rapidly changing environment. Moving away from our reliance on coal, oil and other fossil fuel driven power plants is essential to reduce emissions of greenhouse gases and combat climate change.

10.2.1.1 Greenhouse Gas Emission Targets

Ireland is a Party to the Kyoto Protocol, which is an international agreement that sets limitations and reduction targets for greenhouse gases for developed countries. It is a protocol to the United Nations Framework for the Convention on Climate Change. The Kyoto Protocol came into effect in 2005, as a result of which, emission reduction targets agreed by developed countries, including Ireland, are now binding.

Under the Kyoto Protocol, the EU agreed to achieve a significant reduction in total greenhouse gas emissions in the period 2008 to 2012. These EU emission targets are legally binding on Ireland. Ireland's contribution to the EU commitment for the period 2008-2012 was to limit its greenhouse gas emissions to no more than 13% above 1990 levels.

10.2.1.1.1 *Doha Amendment to the Kyoto Protocol*

In Doha, Qatar, on 8th December 2012, the "Doha Amendment to the Kyoto Protocol" was adopted. The amendment includes:

- New commitments for Annex I Parties to the Kyoto Protocol who agreed to take on commitments in a second commitment period from 1 January 2013 to 31 December 2020;
- A revised list of greenhouse gases (GHG) to be reported on by Parties in the second commitment period; and
- Amendments to several articles of the Kyoto Protocol which specifically referenced issues pertaining to the first commitment period and which needed to be updated for the second commitment period.

During the first commitment period, 37 industrialised countries and the European Community committed to reduce GHG emissions to an average of 5% below 1990 levels. During the second commitment period, Parties committed to reduce GHG emissions by at least 18% below 1990 levels in the eight-year period from 2013 to 2020. The composition of Parties in the second commitment period is different from the first; however, Ireland and the EU signed up to both the first and second commitment periods.

Under the protocol, countries must meet their targets primarily through national measures, although market-based mechanisms (such as international emissions trading) can also be utilised.

10.2.1.1.2 *COP21 Paris Agreement*

COP21 was the 21st session of the Conference of the Parties (COP) to the United Nations Convention. Every year since 1995, the COP has gathered the 196 Parties (195 countries and the European Union) that have ratified the Convention in a different country, to evaluate its implementation and negotiate new commitments. COP21 was organised by the United Nations in Paris and held from 30th November to 12th December 2015.

COP21 closed on 12th December 2015 with the adoption of the first international climate agreement (concluded by 195 countries and applicable to all). The twelve-page text, made up of a preamble and 29 articles, provides for a limitation of the temperature rise to below 2°C above pre-industrial levels and even to tend towards 1.5°C. It is flexible and takes into account the needs and capacities of each country. It is balanced as regards adaptation and mitigation, and durable, with a periodical ratcheting-up of ambitions.

10.2.1.1.3 COP25 Climate Change Conference

The 25th United Nations Climate Change conference COP25 was held in Madrid and ran from December 2nd to December 13th, 2019. While largely regarded as an unsuccessful conference, the European Union launched its most ambitious plan, 'The European Green New Deal' which aims to lower CO_2 emissions to zero by 2050. The deal includes proposals to reduce emissions from the transport, agriculture and energy sectors and will affect the technology chemicals, textiles, cement and steel industries. Measures such as fines and pay-outs by member states who rely on coal power will be in place to encourage the switch to renewable clean energies such as wind. On the 4th of March 2020, the European Commission put forward the proposal for a European climate law. This aims to establish the framework for achieving EU climate neutrality. It aims to provide a direction by setting a pathway to climate neutrality and to this end, aims to set in legislation the EU's 2050 climate-neutrality objective. If accepted, this climate law will likely be implemented in 2021. Decisions regarding the global carbon market were postponed until the next Climate Conference (COP26) which will be held in Glasgow in November 2020.

10.2.1.1.4 Emissions Projections

Ireland's target is to achieve a 20% reduction of non-Emissions Trading Scheme (non-ETS) sector emissions, i.e. agriculture, transport, residential, commercial, non-energy intensive industry and waste, on 2005 levels, with annual binding limits set for each year over the period 2013 – 2020. The Environmental Protection Agency (EPA) publish Ireland's Greenhouse Gas Emission Projection and at the time of writing, the most recent report, 'Ireland's Greenhouse Gas Emissions Projections 2018– 2040 was published in June 2019. The report includes an assessment of Ireland's progress towards achieving its emission reduction targets out to 2020 and 2030 set under the EU Effort Sharing Decision (Decision No 406/2009/EU) and Effort Sharing Regulation (Regulation (EU) 2018/842).

The 2019 emission projections report include the impact of new climate mitigation policies and measures which were outlined in the National Development Plan 2018. These projections see a greater impact from policies and measures and a greater reduction in emissions over the longer term, particularly in the "With Additional Measures" scenario. The 2019 emissions projections do not take into account policies and measures set out in the Climate Action Plan 2019. Such measures will be taken into consideration in an updated future projections report in 2020.

Greenhouse gas emissions are projected to 2040 using two scenarios; 'With Existing Measures' and 'With Additional Measures'. The 'With Existing Measures' scenario assumes that no additional policies and measures, beyond those already in place by the end of 2017 (latest national greenhouse gas emission inventory) are implemented. The 'With Additional Measures' scenario assumes the implementation of the "With Existing Measures" scenario and further implementation of the governments renewable and energy efficiency policies including those set out in the National Renewable Energy Action Plan (NREA), the National Energy Efficiency Action Plan (NEEAP) and the National Development Plan 2018-2027.

The EPA Emission Projections Update notes the following key trends:

- Total emissions are projected to increase from current levels by 1% and 6% by 2020 and 2030, respectively, under the "With Existing Measures" scenario.
- Under the "With Additional Measures" scenario, emissions are estimated to decrease by 0.4% and 10% by 2020 and 2030, respectively.
- Ireland's non-Emissions Trading Scheme (ETS) emissions are projected to be 5% and 6% below 2005 levels in 2020 under the 'With Existing Measures' and 'With Additional Measures' scenarios, respectively. The target for Ireland is a 20% reduction.

- Ireland has exceeded its annual binding limits in 2016 and 2017 under both scenarios, 'With Existing Measures' and 'With Additional Measures'.
- Over the period 2013 – 2020, Ireland is projected to cumulatively exceed its compliance obligations by 10 Mt CO_2 (metric tonnes of Carbon Dioxide) equivalent under the 'With Existing Measures' scenario and 9 Mt CO_2 equivalent under the 'With Additional Measures' scenario.

The report concludes:

- *"Projections indicate that Ireland will exceed the carbon budget over the period 2021-2030 by 52-67Mt CO_2 equivalent with the gap potentially narrowing to 7-22 Mt CO_2 equivalent if both the ETS and LULUCF flexibilities described in the Regulation are fully utilised."*
- *"To determine compliance under the Effort Sharing Decision, any overachievement of the binding emission limit in a particular year (between 2013 and 2020) can be banked and used towards compliance in a future year. However, even using this mechanism Ireland will still be in non-compliance according to the latest projections."*
- "*A significant reduction in emissions over the longer term is projected as a result of the expansion of renewables (e.g. wind), assumed to reach 41-54% by 2030, with a move away from coal and peat... [...] ... However, Ireland still faces significant challenged in meeting EU 2030 targets in the non-ETS sector and national 2050 reduction targets in the electricity generation, built environment and transport sectors. Progress in achieving targets is dependent on the level of implementation of current and future plans."*

10.2.1.1.5 *Climate Action Plan*

The Climate Action Plan 2019 (CAP) was published on the 1st of August 2019 by the Department of Communications, Climate Action and Environment. The CAP sets out an ambitious course of action over the coming years to address the impacts which climate may have on Ireland's environment, society, economic and natural resources. This Plan clearly recognises that Ireland must significantly step up its commitments to tackle climate disruption.

Chapter 1 of the CAP sets out the nature of the challenge which Ireland faces over the coming years. The CAP notes that the evidence for warming of our climate system is beyond dispute with observations showing that global average temperatures have increased by more than 1°C since pre-industrial times. These changes will cause extensive direct and indirect harm to Ireland and its people, as well as to other countries more exposed and less able than we are to withstand the associated impacts environmental impacts such as extremes in weather, flooding, displacement of population by the creation of climate refugees, poorer water quality and poorer air quality. In order to help reduce CO_2 emissions and reach our 2030 and 2050 emissions targets, CAP has set out a list of renewable energy goals which includes implementing up to 8.2 GW total of increased onshore wind capacity on the island.

The Proposed Development can assist in reaching this target not only by fulfilling the implementation of renewable energy and much needed grid infrastructure, it has the capacity to offset 1,655,640 tonnes of CO_2 thereby reducing the Greenhouse Gas effect and improving air quality as we transition to cleaner energy industries. Please see Section 10.2.3 for details on Carbon offset calculations.

10.2.1.1.6 Progress to Date

The 'Europe 2020 Strategy' is the EU's agenda for growth and jobs for the current decade. The Europe 2020 Strategy targets on climate change and energy include:

- Reducing greenhouse gas (GHG) emissions by at least 20% compared with 1990 levels;
- Increasing the share of renewable energy in final energy consumption to 20%; and
- Moving towards a 20% increase in energy efficiency.

Further details on the Europe 2020 Strategy are included in Chapter 2: Background to the Proposed Development of this EIAR. Regarding progress on targets, the 'Europe 2020 indicators – climate change and energy' report provides a summary of recent statistics on climate change and energy in the EU.

In 2015, EU greenhouse gas emissions, including emissions from international aviation and indirect carbon dioxide (CO2) emissions, were down by 22.1% when compared with 1990 levels. However, regarding the progress of individual Member States, and Ireland in particular, the Europe 2020 indicators include the following statements:

- 24 countries are on track to meet their GHG targets, except Austria, Belgium, Ireland and Luxembourg.
- Luxembourg emitted the most GHG per capita in the EU in 2014 followed by Estonia, Ireland, the Czech Republic and the Netherlands.
- In 2015, Malta was the farthest from reaching their national target, followed by Ireland, Belgium and Luxembourg.

While the EU as a whole is projected to exceed it's 2020 target of reducing GHG emissions by 20%, Ireland is currently one of the countries projected to miss its national targets.

Further details on the Europe 2020 Strategy are included in Section 2.2.3.3 of this EIAR in Chapter 2: Background to the Proposed Development. Regarding progress on targets, the 'Europe 2020 indicators – climate change and energy' report provides a summary of recent statistics on climate change and energy in the EU.

10.2.1.1.7 United Nations Sustainable Development Summit 2015

Transforming our World: the 2030 Agenda for Sustainable Development which includes 17 Sustainable Development Goals (SDGs) and 169 targets was adopted by all UN Member States at a UN summit held in New York in 2015. The Agenda is universally applicable with all countries having a shared responsibility to achieve the goals and targets. Coming into effect on January 1st, 2016, the goals and targets are to be actions over the 15-year period, are integrated and indivisible i.e. all must be implemented together by each Member State.

The Sustainable Development Goals National Implementation Plan 2018-2020 was published by the Department of Communications, Climate Action & Environment in partnerships with OSI, Esri Ireland and the Central Statistics Office. The Plan sets out how Ireland will work to achieve the goals and targets of the Agenda for Sustainable Development both domestically and internationally. Relevant SDGs and how they are implemented into Irish National plans and policies can be found in Table 10-8.

Table 10-8 United Nations Sustainable Development Goals adopted in 2015. https://sustainabledevelopment.un.org/sdgs

SDG	Targets	International Progress to Date (2019)	National Relevant Policy
SDG 7 Affordable and Clean Energy: *Ensure access to affordable, reliable, sustainable and modern energy for all*	• By 2030, ensure universal access to affordable, reliable and modern energy services • By 2030, increase substantially the share of renewable energy in the global energy mix • By 2030, double the global rate of improvement in energy efficiency • By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with	The renewable energy share of total final energy consumption gradually increased from 16.6 per cent in 2010 to 17.5 per cent in 2016, though much faster change is required to meet climate goals. Global primary energy intensity (ratio of energy used per unit of GDP) improved from 5.9 in 2010 to 5.1 in 2016, a rate of improvement of 2.3 per cent, which is still short of the 2.7 per cent annual rate needed to reach target 3 of Sustainable Development Goal 7.	*Ireland's Transition to a Low Carbon Energy Future 2015-2030* *Strategy to Combat Energy Poverty in Ireland* *Ireland's Transition to a Low Carbon Energy Future 2015- 2030* *National Mitigation Plan* *National Energy Efficiency Action Plan for Ireland # 4 2017-2020* *Better Energy Programme* *One World, One Future* *The Global Island*

	their respective programmes of support		
SDG 13 Climate Action: *Take urgent action to combat climate change and its impacts** **Acknowledging that the United Nations Framework Convention on Climate Change is the primary international, intergovernmental forum for negotiating the global response to climate change.*	Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries Integrate climate change measures into national policies, strategies and planning Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible	In 2017, greenhouse gas concentrations reached new highs, with globally averaged mole fractions of CO_2 at 405.5 parts per million (ppm), up from 400.1 ppm in 2015, and at 146 per cent of pre-industrial levels. Moving towards 2030 emission objectives compatible with the 2°C and 1.5°C pathways requires a peak to be achieved as soon as possible, followed by rapid reductions. During the period 1998–2017, direct economic losses from disasters were estimated at almost $3 trillion. Climate-related and geophysical disasters claimed an estimated 1.3 million lives. As of April 2019, 185 parties had ratified the Paris Agreement. Parties to the Paris Agreement are expected to prepare, communicate and maintain successive nationally determined contributions, and 183 parties had communicated their first nationally determined contributions to the secretariat of the United Nations Framework Convention on Climate Change, while 1 party had	*National Adaptation Framework* *Building on Recovery: Infrastructure and Capital Investment 2016-2021* *National Mitigation Plan* *National Biodiversity Action Plan 2017-2021* *National Policy Position on Climate Action and Low Carbon Development*

		communicated its second. Under the Agreement, all parties are required to submit new nationally determined contributions, containing revised and much more ambitious targets, by 2020. Global climate finance flows increased by 17 per cent in the period 2015–2016 compared with the period 2013–2014. As at 20 May 2019, 75 countries are seeking support from the Green Climate Fund for national adaptation plans and other adaptation planning processes, with a combined value of $191 million.	

10.2.1.1.8 Climate Action Network Europe Off Target Report 2018

The June 2018 '*Off Target Report'* published by the Climate Action Network (CAN) Europe which ranks EU countries ambition and progress in fighting climate change listed Ireland as the second worst performing EU member state in tackling climate change. It also stated that Ireland is set to miss its 2020 climate (20% reduction in greenhouse gases) and renewable (40% increase in overall energy from renewable electricity sources) energy targets. Additionally, it was noted that Ireland is also off course for its 2030 emissions target.

In March 2019, the Minister for Communications, Climate Action, and the Environment, Richard Bruton, announced a renewable electricity target of 70% by 2030 for Ireland. Furthermore, the release of the Climate Action Plan in June 2019 has noted a 30% reduction in greenhouse gases by 2030. Considering only renewable energy from electricity as part of this plan and to meet the required level of emissions reduction by 2030, Ireland will:

- Reduce CO_2 eq. emissions from the sector by 50–55% relative to 2030 NDP projections.
- Deliver an early and complete phase-out of coal- and peat-fired electricity generation.
- Increase electricity generated from renewable sources to 70%, indicatively comprised of:
  - at least 3.5 GW of offshore renewable energy;
  - up to 1.5 GW of grid-scale solar energy; and
  - up to 8.2 GW total of increased onshore wind capacity.
- Meet 15% of electricity demand by renewable sources contracted under Corporate PPAs.

Achieving 70% renewable electricity by 2030 will involve phasing out coal and peat-fired electricity generation plants, increasing our renewable electricity, reinforcing our grid (including greater interconnection to allow electricity to flow between Ireland and other countries), and putting systems in place to manage intermittent sources of power, especially from wind.

As noted previously, Ireland is not on track for meeting its 2020 renewable energy targets. It is now more critical than ever that we continue to progress renewable energy development in Ireland so as we are successful in meeting our 2030 target.

The Climate Action Plan noted specific sectors which are required to step-up in order to help Ireland achieve its EU targets. The renewable energy sector was cited alongside the country's commitment to increase onshore wind capacity by up to 8.2 GW. The proposed development will help contribute towards this target.

The proposed wind farm development is compatible with the relevant provisions as set out in the Climate Action Plan 2019, relating to the harnessing of renewable energy. In summary, the proposed development will contribute the following:

- Production of 147,168 MWh of electricity which would be sufficient to supply 35,040 Irish households with electricity per year. This calculation is presented in Chapter 4 of this EIAR.
- Helping to meet the target that 70% of our electricity needs will come from renewable sources by 2030.
- Helping to reduce carbon emissions and improving Ireland's security of energy supply.
- Provision of grid connection infrastructure to support the renewable energy output from the proposed development.

Further detail on the EU 2030 targets are noted in Chapter 2, Section 2.3 of this EIAR.

10.2.1.1.9 *Climate Change Performance Index*

Established in 2005, the Climate Change Performance Index (CCPI) is an independent monitoring tool which tracks countries climate protection performance. It assesses individual countries based on climate policies, energy usage per capita, renewable energy implementation and Greenhouse Gas Emissions (GHG) and ranks their performance in each category and overall. The 2020 CCPI was published in December 2019 and presented at the COP25. While the CCPI 2020 indicated signs of potential reductions in global emissions, no country achieved its Paris Climate targets and therefore the first three places of the ranking system remain unoccupied.

Ireland, ranked the worst EU performer in the CCPI 2019, climbed 7 places from 48th out of 60 globally ranked countries to 41st place and has moved from a "very low" to "low" in international performance. However, it remains at "very low" at a national performance level. The CCPI report states that while some improvements have been made, GHG per capita emissions are at a high level and "significant challenges lie ahead in closing Ireland's emission gap, meeting the current (2030) target and aligning Ireland's emission trajectory with a net zero goal for 2050. Therefore, the country still ranks among the bottom ten performers in this indicator." Recognising Ireland's Climate Action Plan 2019, the CCPI states:

"*the government must go much further in implementing policies across all sectors that drive sustained emissions reductions over the next decade. Near-term ambition needs to be ratcheted up quickly by specifying deep cuts in fossil fuel and reactive nitrogen usage to put Ireland on a net zero emissions pathway aligned with the Paris temperature goals".*

10.2.2 Climate and Weather in the Existing Environment

Ireland has a temperate, oceanic climate, resulting in mild winters and cool summers. The nearest meteorological monitoring station, with data over a 30-year period (1971-2000), is the Claremorris monitoring station which is located 69km southwest of the development site. Meteorological data for this period at this location can be found in Table 10-9. The wettest months are October and December, and April is usually the driest. July is the warmest month with an average temperature of 18.9° Celsius. The mean annual temperature recorded at Claremorris was 12.9° Celsius.

Table 10-9 Data from Met Eireann Weather Station at Claremorris 1979-2000

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
TEMPERATURE (degrees Celsius)													
mean daily max	7.5	8.1	9.8	12.1	14.9	17.0	18.9	18.7	16.4	13.1	9.9	8.1	12.9
mean daily min	1.7	1.8	2.9	3.9	6.1	8.8	11.0	10.6	8.6	6.4	3.5	2.5	5.7
mean temperature	4.6	4.9	6.3	8.0	10.5	12.9	15.0	14.7	12.5	9.8	6.7	5.3	9.3
absolute max.	13.3	13.6	16.2	22.3	25.4	29.8	30.5	28.0	25.1	19.9	15.9	14.3	30.5
min. maximum	-2.9	0.1	0.0	5.0	6.1	11.2	11.7	12.2	10.5	6.8	1.3	-1.5	-2.9
max. minimum	11.3	10.9	10.4	11.3	14.2	15.3	17.0	16.7	16.7	15.6	12.5	12.1	17.0
absolute min.	-11.7	-9.1	-8.0	-5.5	-3.1	0.7	0.6	2.6	-1.2	-4.3	-5.3	-12.9	-12.9
mean num. of days with air frost	8.7	7.3	5.2	3.3	0.8	0.0	0.0	0.0	0.1	1.2	5.3	7.6	39.5
mean num. of days with ground frost	15	14	12	10	5	0	0	0	2	5	12	14	89
mean 5cm soil	3.2	3.1	4.5	7.3	10.9	14.1	15.5	14.6	12.0	8.9	5.3	4.2	8.6
mean 10cm soil	3.5	3.4	4.7	7.0	10.3	13.5	15.0	14.3	12.0	9.3	5.8	4.5	8.6
mean 20cm soil	4.2	4.2	5.5	7.7	10.7	13.8	15.3	15.0	13.0	10.3	6.9	5.3	9.3
RELATIVE HUMIDITY (%)													
mean at 0900UTC	90.7	90.3	88.7	82.5	79.3	80.4	83.6	86.2	88.1	91.6	91.2	91.0	87.0

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
mean at 1500UTC	85.6	79.8	75.7	67.9	68.0	71.1	73.2	73.4	74.7	80.2	84.4	88.1	76.8
SUNSHINE (hours)													
mean daily duration	1.3	1.9	2.6	4.3	5.0	4.4	3.7	3.8	3.2	2.4	1.7	0.9	2.9
greatest daily duration	7.9	9.3	10.8	13.4	15.1	15.8	14.8	13.7	11.4	9.3	8.6	6.7	15.8
mean num. of days with no sun	9.5	7.3	5.7	2.8	2.0	2.2	2.2	2.1	3.4	5.0	8.1	10.8	61.1
RAINFALL (mm)													
mean monthly total	127.9	102.1	101.6	63.7	68.1	64.5	70.1	95.7	94.3	128.2	127.7	129.6	1173.6
greatest daily total	31.5	107.0	26.8	34.0	51.3	38.0	42.2	49.7	41.0	46.7	54.9	41.2	107.0
mean num. of days with >= 0.2mm	21	18	21	16	16	15	17	18	18	21	21	22	224
mean num. of days with >= 1.0mm	18	15	17	12	12	11	12	13	14	17	18	17	176
mean num. of days with >= 5.0mm	9	7	7	4	4	4	4	6	5	8	8	9	75
WIND (knots)													
mean monthly speed	10.2	10.3	10.2	8.7	8.1	7.7	7.2	6.8	7.7	8.7	8.9	9.7	8.7
max. gust	96	85	74	74	62	51	66	78	58	70	67	81	96
max. mean 10-minute speed	59	48	45	41	41	34	39	32	37	46	40	52	59

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
mean num. of days with gales	1.4	0.9	0.7	0.1	0.1	0.0	0.0	0.0	0.1	0.3	0.4	0.8	4.8
WEATHER (mean no. of days with..)													
snow or sleet	5.7	4.4	3.8	1.6	0.2	0.0	0.0	0.0	0.0	0.1	1.2	3.1	20.0
snow lying at 0900UTC	2.3	0.7	0.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.7	4.6
Hail	4.4	3.2	5.4	3.2	1.6	0.4	0.1	0.0	0.7	0.8	2.6	2.7	25.2
Thunder	0.3	0.1	0.2	0.2	0.4	0.7	0.7	0.2	0.2	0.2	0.3	0.5	4.0
Fog	3.4	2.3	1.6	1.8	1.2	1.4	2.0	3.2	3.3	3.2	2.6	3.4	29.5

10.2.3 Calculating Carbon Losses and Savings from the Proposed Development

10.2.3.1 Background

In addition to the combustion of fossil fuels, greenhouse gases are also released through natural processes such as the decomposition of organic material (which is composed of carbon). Bogs and peatlands are known to store large amounts of carbon. Due to the waterlogged nature of these habitats, stored carbon is not broken down and released into the atmosphere. The construction of wind farms on bog and peat habitats may affect the natural hydrological regime, thus exposing and drying out the peat and allowing the decomposition of carbon. It is necessary therefore to demonstrate that any wind farm constructed on such sites saves more carbon than is released. The site of the proposed development is partially situated on peat habitats. For this reason, the carbon balance between the use of renewable energy and the loss of carbon stored in the peat is assessed in this section of the EIAR.

CO_2 emissions occur naturally in addition to being released with the burning of fossil fuels. All organic material is composed of carbon, which is released as CO_2 when the material decomposes. Organic material acts as a store of carbon. Peatland habitats are significant stores of organic carbon. The vegetation on a peat bog slowly absorbs CO_2 from the atmosphere when it is alive and converts it to organic carbon. When the vegetation dies, in the acidic waterlogged conditions of bogs and peatlands, the organic material does not decompose fully and the organic carbon is retained in the ground.

The carbon balance of proposed wind farm developments in peatland habitats has attracted significant attention in recent years. When development such as wind farms are proposed for peatland areas, there will be direct impacts and loss of peat in the area of the development footprint. There may also be indirect impacts where it is necessary to install drainage in certain areas to facilitate construction. The works can either directly or indirectly allow the peat to dry out, locally, which permits the full decomposition of the stored organic material with the associated release of the stored carbon as CO_2. It is essential therefore that any wind farm development in a peatland area saves more CO_2 than is released.

10.2.3.2 Methodology for Calculating Losses

A methodology was published in June 2008 by scientists at the University of Aberdeen and the Macauley Institute with support from the Rural and Environment Research and Analysis Directorate of the Scottish Government, Science Policy and Co-ordination Division. The document, '*Calculating Carbon Savings from Wind Farms on Scottish Peat Lands*', was developed to calculate the impact of wind farm developments on the soil carbon stocks held in peat. This methodology was refined and updated in 2011 based on feedback from users of the initial methodology and further research in the area. The web-based version of the carbon calculator, which supersedes the excel based versions of the tool, was released in 2016. The tool provides a transparent and easy to follow method for estimating the impacts of wind farms on the carbon dynamics of peatlands. Previously guidance produced by Scottish Natural Heritage in 2003 had been widely employed to determine carbon payback in the absence of any more detailed methods.

Although the loss of carbon fixing potential from plants on peat land is not substantial, it is nonetheless calculated for areas from which peat is removed and the areas affected by drainage. This calculation can take account of the annual gains due to the carbon fixing potential of the peat land and the time required for any habitat restoration. The carbon sequestered in the peat itself represents a much more substantial potential source of carbon loss. During wind farm construction, carbon is lost as a result of peat excavation and peat drainage. The amount of carbon lost is estimated using default values from the Intergovernmental Panel on Climate Change (IPCC, 1997) as well as by more site-specific equations derived from the scientific literature. Carbon gains due to habitat improvement and site restoration are calculated in a similar fashion.

Peatlands are essentially unbalanced systems. When flooded, peat soils emit less carbon dioxide but more methane than when drained. In waterlogged soils, carbon dioxide emissions are usually exceeded by plant fixation, so the net exchange of carbon with the atmosphere is negative and soil carbon stocks increase. When soils are aerated, carbon emissions usually exceed plant fixation, so the net exchange of carbon with the atmosphere is positive. In order to calculate the carbon emissions resulting from the removal or drainage of the peat, the Macauley Institute method accounts for emissions occurring if the peat had been left in-situ and subtracts these from the emissions occurring after removal and drainage.

The Macauley Institute methodology states that the total volume of peat impacted by the construction of the wind farm is strongly correlated to the extent of the peatland affected by drainage at the site.

The drainage of peat soils leads to continual loss of soil carbon until a new steady state is reached, when inputs are approximately equal to losses. For peats, this steady state approximates 0% carbon, so 100% carbon loss from drained peats is assumed if the site is not restored after decommissioning of the wind farm. The amount of carbon lost is calculated on the basis of the annual emissions of methane and carbon dioxide, the area of drained peat, and the time until the site is restored. In the case of the proposed wind farm site, the model has been prepared on the basis of two scenarios, one where restoration of the wind farm areas will occur on decommissioning, and another where restoration will not occur.

The effects of drainage may also reduce dissolved and particulate organic carbon retention within the peat. Losses of carbon dioxide due to leaching of dissolved and particulate organic carbon are calculated as a proportion of the gaseous losses of carbon from the peat. The Macauley Institute method assumes that published good practice is employed in relation to avoiding the risk of peat landslides. This is certainly the case in respect of the proposed development, which has been the subject of a peat stability risk assessment, as described in the *Geotechnical Peat Stability Assessment Report* in Appendix 8-1 of this EIAR. Therefore, this potentially large carbon loss pathway is omitted from the calculations.

Clearfelling of existing forestry surrounding turbine locations may often be necessary to allow for the construction of the proposed development footprint and the erection of the wind turbines, to avoid reductions in the wind energy yield of the wind farm proposal and to protect local bat populations. Forestry may be felled earlier than originally planned due to the wind farm development, so limiting the nature and longevity of the resulting timber produced. If a forestry plantation was due to be felled with no plan to replant, the effect of the land use change is not attributable to the wind farm development and is omitted from the calculation. If, however, the forestry is felled for the development, the effects are judged to be attributable to the wind farm development. Carbon losses as a result of felling are calculated from the area to be felled, the average carbon sequestered annually, and the lifetime of the wind farm. Alterations in soil carbon levels following felling are calculated using the equations for drainage and site restoration already described.

10.2.3.3 Calculating Carbon Losses and Savings

10.2.3.3.1 *Carbon Losses*

The Scottish Government on-line carbon calculator as outlined in the sections above, was used to assess the impacts of the proposed wind farm in terms of potential carbon losses and savings taking into account peat removal, drainage, habitat improvement, forestry felling and site restoration.

A copy of the outputs is provided as Appendix 10-1 of this EIAR. Where available and relevant, site-specific information was inserted into the worksheet. Otherwise, default values were used.

The worksheet was pre-loaded with information specific to the CO_2 emissions from the United Kingdom's electricity generation plant, which is used to calculate emissions savings from proposed wind farm projects in the UK. Similar data to that used in the worksheet to calculate the CO_2 emissions from the UK electricity generation plant, was not available for the Irish electricity generation plant, and so the CO_2 emissions savings from the proposed wind farm development were calculated separately from the worksheet.

The main CO_2 losses due to the proposed wind farm development are summarised in Table 10-10.

Table 10-10 CO_2 losses from the Proposed Development

Origin of Losses	CO_2 Losses (tonnes CO_2 equivalent)	
	Expected	Maximum
Losses due to turbine life (e.g. due to production, transportation, erection, operation and dismantling of the wind farm)	41,945	41,945
Losses due to backup (i.e. electricity obtained from fossil fuel source to stabilise electricity supply to the national grid)	28,382	28,382
Losses due to reduced carbon fixing potential	1,401	2,624
Losses due to leaching of dissolved and particulate organic carbon	0	0
Losses from soil organic matter (CO2 loss from removed and drained peat)	29,232	74,910
Losses due to felling forestry	21,463	24,095
Total	122,074	171,606

The worksheet model calculates that the proposed development is expected to give rise to 122,074 tonnes of CO_2 equivalent losses over its 30-year life. Of this total figure, the proposed wind turbines directly account for 41,495 tonnes, or 34%. Losses due to backup account for 28,382 tonnes, or 23%. Losses from soil organic matter, reduced carbon fixing potential and the felling of forestry accounting for the remaining 43% or 52,096 tonnes. The figure of 29,232 tonnes of CO_2 arising from ground activities associated with the proposed development is calculated based on the entire development footprint being "Acid Bog", as this is one of only two choices the model allows (the other being Fen). The habitat that will be impacted by the development footprint comprises predominantly commercial forestry rather than the acid bog assumed by the model that gives rise to the 21,463 tonnes and therefore the actual CO_2 losses are expected to be lower than this value.

The figures discussed above are based on the assumption that the hydrology of the site and habitats within the site are restored on decommissioning of the proposed wind farm after its expected 30-year useful life. As a worst-case scenario, the model was also used to calculate the CO_2 losses from the wind farm if the hydrology and habitats of the site were not to be restored, as may be the case if the turbines were replaced with newer models, rather than decommissioned entirely and taking account of the future peat extraction activities. This worst-case scenario would increase the expected carbon losses by an additional 49,535 tonnes, or by 41% to 171,606 tonnes. Any failure to restore the site habitats or hydrology for the reasons outlined above would be further offset by the carbon-neutral renewable energy that the new turbines would generate.

10.2.3.3.2 Carbon Savings

According to the model described above, the proposed wind farm development will give rise to total losses of 122,074tonnes of carbon dioxide.

A simple formula can be used to calculate carbon dioxide emissions reductions resulting from the generation of electricity from wind power rather than from carbon-based fuels such as peat, coal, gas and oil. The formula is:

$$CO_2 \text{ (in tonnes)} = \frac{(A \times B \times C \times D)}{1000}$$

where: A = ... The rated capacity of the wind energy development in MW

B = ... The capacity or load factor, which takes into account the intermittent nature of the wind, the availability of wind turbines and array losses etc.

C = ... The number of hours in a year

D = ... Carbon load in grams per kWh (kilowatt hour) of electricity generated and distributed via the national grid.

For the purposes of this calculation, the rated capacity of the proposed wind farm is assumed to be approximately 48 MW.

A load factor of 0.35 (or 35%) has been used for the proposed development.

The number of hours in a year is 8,760.

The most recent data for the carbon load of electricity generated in Ireland is for 2018 and was published in Sustainable Energy Authority Ireland's (SEAI) December 2019 report, '*Energy in Ireland, 2019 Report.*' The emission factor for electricity in Ireland in 2018 was 375 g CO_2/kWh.

The calculation for carbon savings is therefore as follows:

$$CO2 \text{ (in tonnes)} = \frac{(48 \times 0.35 \times 8{,}760 \times 375)}{1000}$$

$$= 55{,}188 \text{ tonnes per annum}$$

Based on this calculation, approximately 55,188 tonnes of carbon dioxide will be displaced per annum from the largely carbon-based traditional energy mix by the proposed wind farm. Over the proposed thirty-year lifetime of the wind farm, therefore, 1,655,640 tonnes of carbon dioxide will be displaced from traditional carbon-based electricity generation.

As noted previously areas cleared of forestry for the proposed development at Croagh will be replaced by replanting at alternatives sites. A total of 54.2 hectares of new forestry will be replanted at alternative sites to compensate the loss of forestry at the development site. Given that losses due to felling forestry account for 21,463 tonnes of CO_2, it has been assumed for the purposes of this calculation that the same quantity of CO_2 can be saved by replanting forestry at alternative sites.

In total, it is estimated that 1,655,640 tonnes of carbon dioxide will be displaced over the proposed thirty-year lifetime of the wind farm.

Based on the Scottish Government carbon calculator as presented above 122,074 tonnes of CO_2 will be lost to the atmosphere due to changes in the peat environment and due to the construction and operation of the proposed development. This represents 7.4% of the total amount of carbon dioxide emissions that will be offset by the proposed wind farm project. The 122,074 tonnes of CO_2 that will be lost to the atmosphere due to changes in the peat environment and due to the construction and operation of the proposed development will be offset by the proposed development in approximately 26.5 months of operation.

10.2.4 Likely Significant Effects and Associated Mitigation Measures

10.2.4.1 'Do-Nothing' Effect

If the proposed development were not to proceed, greenhouse gas emissions, e.g. carbon dioxide (CO2), carbon monoxide and nitrogen oxides associated with construction vehicles and plant would not arise. However, the opportunity to further significantly reduce emissions of greenhouse gas emissions, including carbon dioxide (CO_2), oxides of nitrogen (NO_x), and sulphur dioxide (SO_2), to the atmosphere would be lost. The opportunity to contribute to Ireland's commitments under the Kyoto Protocol and EU law would also be lost. This would be a long-term, moderate, negative impact.

10.2.4.2 Construction Phase

10.2.4.2.1 *Greenhouse Gas Emissions*

Turbines and Other Infrastructure

The construction of turbine bases and hardstands, site roads, site entrances, anemometry mast bases and all associated infrastructure will require the operation of construction vehicles and plant on site. Greenhouse gas emissions, e.g. carbon dioxide (CO_2), carbon monoxide and nitrogen oxides associated with vehicles and plant will arise as a result of the construction and demolition activities. This potential impact will be slight, given the insignificant quantity of greenhouse gases that will be emitted, and will be restricted to the duration of the construction phase. Therefore, this is a short-term slight negative impact. Mitigation measures to reduce this impact are presented below.

Grid Connection

The construction of 1 No. 38 kV substation and excavation of associated cable trenches will require the use of construction machinery giving rise to greenhouse emissions. This is a short-term slight negative impact, which will be reduced through use of the best practice mitigation measures as presented below.

Transport to Site

The transport of turbines and construction materials to the site, which will occur on specified routes only (see Section 14.1 of this EIAR), will give rise to greenhouse gas emissions associated with the transport vehicles. This constitutes a slight negative impact in terms of air quality. Mitigation measures in relation to greenhouse gas emissions are presented below.

Mitigation

- All construction vehicles and plant will be maintained in good operational order while onsite, thereby minimising any emissions that arise.
- Turbine components and construction materials will be transported to the site on specified routes, assessed in Section 14.1 of this EIAR and agreed with the Planning Authority prior to the construction phase.
- The majority of aggregate materials for the construction of site access tracks and all associated infrastructure will be won from the borrow pit onsite, which will further reduce potential emissions.

Residual Impact

Short-term Imperceptible Negative Impact on Climate as a result of greenhouse gas emissions.

Significance of Effects

Based on the assessment above there will be no significant direct or indirect effects.

10.2.4.3 Operational Phase

10.2.4.3.1 *Greenhouse Gas Emissions*

The proposed development will generate energy from a renewable source. This energy generated will offset energy and the associated emission of greenhouse gases from electricity-generating stations dependent on fossil fuels, thereby having a positive effect on climate. The proposed development will displace carbon dioxide from fossil fuel-based electricity generation, over the proposed 30-year lifespan of the proposed wind farm. The proposed project will assist in reducing carbon dioxide (CO_2) emissions that would otherwise arise if the same energy that the proposed wind farm will generate were otherwise to be generated by conventional fossil fuel plants. This is a long-term significant positive effect.

Residual Impact

Long-term Moderate Positive Impact on Climate as a result of reduced greenhouse gas emissions.

Significance of Effects

Based on the assessment above there will long-term positive effects.

10.2.4.4 Decommissioning Phase

Any impact and consequential effect that occurs during the decommissioning phase are similar to that which occur during the construction phase, be it of less impact. The mitigation measures prescribed for the construction phase of the proposed development will be implemented during the decommissioning phase thereby minimising any potential impacts.

10.3 Cumulative Assessment

Potential cumulative effects on air quality and climate between the Proposed Development and other developments in the vicinity were also considered as part of this assessment. The developments considered as part of the cumulative effect assessment are described in Section 2.5 of this EIAR.

The nature of the proposed development is such that, once operational, it will have a long-term, moderate, positive impact on the air quality and climate.

During the construction phase of the Proposed Development and other developments within 20 kilometres of the wind farm site that are yet to be constructed, there will be minor emissions from construction plant and machinery and potential dust emissions associated with the construction activities. However, once the mitigation proposals, as outlined in Section 10.2.4.2 and Section 10.3.4.2 are implemented during the construction phase of the Proposed Development, there will be no cumulative negative effect on air and climate.

There will be no net carbon dioxide (CO_2) emissions from operation of the proposed wind farm. Emissions of carbon dioxide (CO_2), oxides of nitrogen (NO_x), sulphur dioxide (SO_2) or dust emissions during the operational phase of the Proposed Development will be minimal, relating to the use of operation and maintenance vehicles onsite, and therefore there will be no measurable negative cumulative effect with other developments on air quality and climate.

The nature of the Proposed Development and other wind energy developments within 20 kilometres are such that, once operational, they will have a cumulative long-term, significant, positive effect on the air quality and climate.

11. NOISE & VIBRATION

11.1 Introduction

11.1.1 Background & Objectives

This chapter of the EIAR describes the assessment undertaken of the potential noise and vibration impact from the proposed Croagh Wind Farm Development (the 'Proposed Development') on local residential amenity. The Proposed Development comprises up to 10 no. wind turbines with a maximum overall ground level to blade tip height of up to 170 metres, an electricity substation, construction compound and all ancillary infrastructure. A full description of the proposed development is provided in Chapter 4 of this EIAR. There are 78 no. noise sensitive locations within 2.2 km of the proposed turbine locations. The nearest noise sensitive location (NSL) is located approximately 850m to the nearest proposed turbine location (i.e. Location H037 from proposed turbine T6).

Noise impact assessments have been prepared for the operational phase and the construction phase of the Proposed Development to the nearest noise sensitive locations (NSLs). To inform this assessment background noise levels have been measured at locations representative of the nearest NSLs to assess the potential impacts associated with the operation of the Proposed Development. The current *Wind Energy Development Guidelines for Planning Authorities,* published by the Department of the Environment, Heritage and Local Government in 2006, defines a noise sensitive location as any occupied dwelling house, hostel, health building or place of worship and may include areas of particular scenic quality or special recreational amenity importance. In this instance all of the NSLs are dwellings.

Existing, under construction, permitted and proposed wind farm developments have been identified in the wider study area and the cumulative impact of these developments has been considered in this assessment. Further details on each of these developments is provided in Chapter 2 of this EIAR.

11.1.2 Statement of Authority

This chapter of the EIAR has been prepared by the following staff of AWN Consulting Ltd:

Dermot Blunnie

Dermot Blunnie (Senior Acoustic Consultant) holds a BEng. from the University of South Wales, a M.Sc. from the University of Derby and IOA Diploma in Acoustics and Noise Control from the Institute of Acoustics. He has over 10 years' experience as an acoustic consultant and is a member of the Institute of Acoustics. He has extensive knowledge and experience in relation to commissioning noise monitoring and impact assessment of wind farms as well as a detailed knowledge of acoustic standards and proprietary noise modelling software packages. He has commissioned noise surveys and completed noise impact assessments for numerous wind farm projects within Ireland.

Leo Williams

Leo Williams holds a BA, BAI (Mechanical and Manufacturing Engineering) and a MAI (Mechanical and Manufacturing Engineering). He is an Associate Member of the Institute of Acoustics (IOA) and has completed the IOA Diploma in Acoustics and Noise Control. He has over five years' experience working in the field of acoustics and has prepared numerous environmental impact assessment chapters for various developments such as infrastructural developments, mixed use developments and specialises in wind energy development projects.

Mike Simms

Mike Simms BE MEngSc MIOA MIET, Senior Acoustic Consultant at AWN, who has worked in the field of acoustics for over 19 years and has been a consultant since 1998. He has extensive experience in all aspects of environmental surveying, noise modelling and impact assessment for various sectors including, energy, industrial, commercial and residential.

11.2 Fundamentals of Acoustics

A sound wave travelling through the air is a regular disturbance of the atmospheric pressure. These pressure fluctuations are detected by the human ear, producing the sensation of hearing. To take account of the vast range of pressure levels that can be detected by the ear, it is convenient to measure sound in terms of a logarithmic ratio of sound pressures. These values are expressed as Sound Pressure Levels (SPL) in decibels (dB).

The audible range of sounds expressed in terms of Sound Pressure Levels is 0dB (for the threshold of hearing) to 120dB (for the threshold of pain). In general, a subjective impression of doubling of loudness corresponds to a tenfold increase in sound energy which conveniently equates to a 10dB increase in SPL. It should be noted that a doubling in sound energy (such as may be caused by a doubling of traffic flows) increases the SPL by 3 dB.

The frequency of sound, the rate at which a sound wave oscillates, is expressed in Hertz (Hz). The sensitivity of the human ear to different frequencies in the audible range is not uniform. For example, hearing sensitivity decreases markedly as frequency falls below 250Hz. In order to rank the SPL of various noise sources, the measured level has to be adjusted to give comparatively more weight to the frequencies that are readily detected by the human ear. The 'A-weighting' system defined in the international standard, BS ISO 226:2003 Acoustics Normal Equal-loudness Level Contours has been found to provide the best correlations with human response to perceived loudness. SPL's measured using 'A-weighting' are expressed in terms of dB(A).

An indication of the level of some common sounds on the dB(A) scale is presented in Figure 11-1.

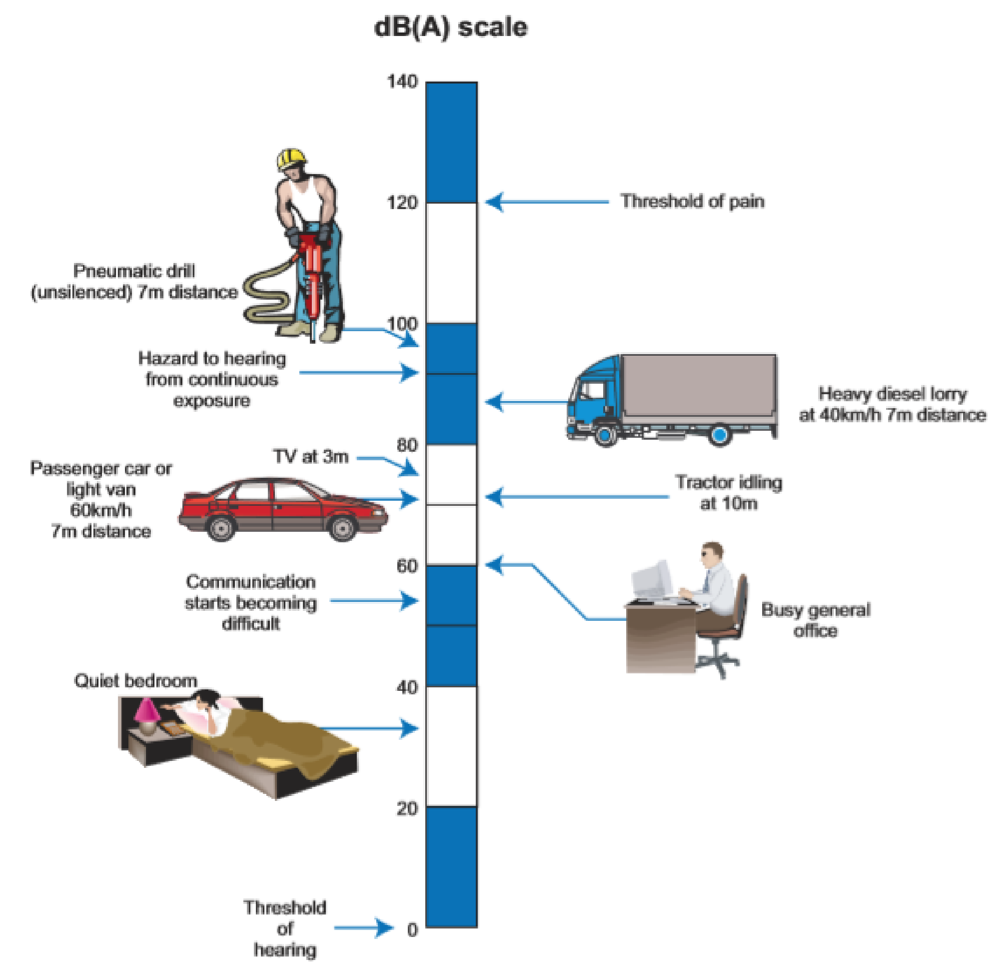


Figure 11-1 The level of typical common sounds on the dB(A) scale (NRA Guidelines for the Treatment of Noise and Vibration in National Road Schemes, 2004)

For a glossary of terms used in this chapter please refer to Appendix 11-1.

11.3 Assessment Methodology

The assessment of impacts for the Proposed Development have been undertaken with reference to the most appropriate guidance documents relating to environmental noise and vibration which are set out in Section 11.3.2.

In addition to the specific guidance documents outlined in this chapter, the Environmental Impact Assessment (EIA) guidelines listed in Chapter 1 were considered and consulted for the purposes of preparing this EIAR chapter.

The methodology adopted for this noise impact assessment is summarised as follows:

- Review of appropriate guidance to identify appropriate noise and vibration criteria for both the construction and operational phases;
- Characterise the receiving environment through baseline noise surveys at various NSLs surrounding the proposed development;
- Undertake predictive calculations to assess the potential impacts associated with the construction phase of the proposed development at NSLs;

- Undertake predictive calculations to assess the potential impacts associated with the operational of the proposed development at NSLs; evaluate the potential noise and vibration impacts and effects;
- Specify mitigation measures to reduce, where necessary, the identified potential outward impacts relating to noise and vibration from the proposed development; and
- Describe the significance of the residual noise and vibration effects associated with the proposed development.

11.3.1 EPA Description of Effects

The significance of effects of the proposed development shall be described in accordance with the EPA guidance document Draft *Guidelines on the information to be contained in Environmental Impact Assessment Reports (EIAR), (EPA, 2017).*

The effects associated with the proposed development are described with respect to the EPA guidance in the relevant sections of this chapter.

11.3.2 Guidance Documents and Assessment Criteria

The following sections review best practice guidance that is commonly adopted in relation to developments such as the one under consideration here.

11.3.2.1 Construction Phase

11.3.2.1.1 *Construction Noise*

There is no published statutory Irish guidance relating to the maximum permissible noise level that may be generated during the construction phase of a project. Local authorities normally control construction activities by imposing limits on the hours of operation and may consider noise limits at their discretion.

In the absence of specific noise limits, appropriate criteria relating to permissible construction noise levels for a development of this scale may be found in the British Standard 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise.*

The approach adopted here calls for the designation of a noise sensitive location into a specific category (A, B or C) based on existing ambient noise levels in the absence of construction noise. This then sets a threshold noise value that, if exceeded at the façade of residential noise sensitive receivers, (construction noise only), indicates a potential significant noise impact is associated with the construction activities.

Table 11-1 sets out the values which, if exceeded, potentially signify a significant effect as recommended by BS 5228 – 1. These levels relate to construction noise only.

Table 11-1 Example Threshold of Potential Significant Effect at Dwellings

Assessment category and threshold value period (T)	Threshold values, $L_{Aeq,T}$ dB		
	Category A Note A	Category B Note B	Category C Note C
Night-time (23:00 to 07:00hrs)	45	50	55
Evenings and weekends Note D	55	60	65
Daytime (07:00 – 19:00hrs) and Saturdays (07:00 – 13:00hrs)	65	70	75

Note A Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are less than these values.
Note B Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are the same as category A values.
Note C Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are higher than category A values.
Note D 19:00 – 23:00 weekdays, 13:00 – 23:00 Saturdays and 07:00 – 23:00 Sundays.

This assessment method is only valid for residential properties. For the appropriate period (e.g. daytime) the ambient noise level is determined and rounded to the nearest 5 dB. In this instance, with the rural nature of the site, properties near the development have daytime ambient noise levels that typically range from 40 to 50 dB $L_{Aeq,1hr}$. Therefore, all properties will be afforded a Category A designation.

See Section 11.5.2 for the detailed assessment in relation to the proposed development. If the specific construction noise level exceeds the appropriate category value (e.g. 65 dB $L_{Aeq,T}$ during daytime periods) then a significant effect is deemed to have occurred.

11.3.2.1.2 *Additional Vehicular Activity*

For the assessment of potential noise impacts from construction related traffic along public roads and haul routes it is proposed to adopt guidance from Design Manual for Roads and Bridges (DMRB), Highways England, Transport Scotland, The Welsh Government and The Department of Infrastructure 2019.

Table 11-2, taken from Section 13.7 of DMRB presents guidance as to the likely impact associated with any change in the background noise level ($L_{Aeq,T}$) at a noise sensitive receiver as a result of construction traffic.

Section 3.19 of DMRB states that construction noise and construction traffic noise shall constitute a significant effect where it is determined that a major or moderate magnitude of impact will occur for a duration exceeding:

- 10 or more days or nights in any 15 consecutive days or nights;
- A total number of days exceeding 40 in any 6 consecutive months.

Table 11-2 Likely Impacts Associated with Change in Traffic Noise Level (Source DMRB, 2019)

Change in Sound Level	Magnitude of Impact
0	No Change
0.1 – 0.9	Negligible
1.0 – 2.9	Minor
3.0 – 4.9	Moderate
>5	Major

The DMRB guidance outlined will be used to assess the predicted increases in traffic levels on public roads associated with the proposed development and comment on the likely impacts during the construction phase.

11.3.2.1.3 *Construction Vibration*

Vibration standards come in two varieties: those dealing with human comfort and those dealing with cosmetic or structural damage to buildings. With respect to this development, the range of relevant criteria used for building protection is expressed in terms of Peak Particle Velocity (PPV) in mm/s.

Guidance relevant to acceptable vibration within buildings is contained in the following documents:

- BS 7385 – *Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from groundborne vibration* (BSI, 1993); and
- BS 5228 – *Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration* (BSI, 2009+A1:2014).

BS 7385 states that there should typically be no cosmetic damage if transient vibration does not exceed 15 mm/s at low frequencies rising to 20 mm/s at 15 Hz and 50 mm/s at 40 Hz and above.

BS 5228 recommends that, for soundly constructed residential property and similar structures that are generally in good repair, a threshold for minor or cosmetic (i.e. non-structural) damage should be taken as a peak particle velocity of 15 mm/s for transient vibration at frequencies below 15 Hz and 20 mm/s at frequencies above than 15 Hz. Below these vibration magnitudes minor damage is unlikely, although where there is existing damage these limits may be reduced by up to 50%. In addition, where continuous vibration is generated the limits discussed above may need to be reduced by 50%.

The Transport Infrastructure Ireland (TII) (formerly National Roads Authority (NRA)) document *Guidelines for the Treatment of Noise and Vibration in National Road Schemes* (NRA, 2004) also contains information on the permissible construction vibration levels during the construction phase as shown in
Table 11-3.

Table 11-3 Allowable Transient Vibration at Properties

Allowable vibration (in terms of peak particle velocity) at the closest part of sensitive property to the source of vibration, at a frequency of		
Less than 10Hz	10 to 50Hz	50 to 100Hz (and above)
8 mm/s	12.5 mm/s	20 mm/s

11.3.2.2 Operational Phase

11.3.2.2.1 *Noise*

The noise assessment in this chapter has been based on guidance in relation to acceptable levels of noise from wind farms as contained in the document *Wind Energy Development Guidelines for Planning Authorities* published by the Department of the Environment, Heritage and Local Government in 2006. These guidelines are in turn based on detailed recommendations set out in the Department of Trade and Industry (UK) Energy Technology Support Unit (ETSU) publication *The Assessment and Rating of Noise from Wind Farms* (1996). The ETSU document has been used to supplement the guidance contained within the *Wind Energy Development Guidelines* publication where necessary.

11.3.2.2.2 *Wind Energy Development Guidelines*

Section 5.6 of the Wind Energy Development Guidelines published by the Department of the Environment, Heritage and Local Government (2006) addresses noise and outlines the appropriate noise criteria in relation to wind farm developments.

The following extracts from this document should be considered:

> "*An appropriate balance must be achieved between power generation and noise impact.*"

While this comment is noted it should be stated that the Guidelines give no specific advice in relation to what constitutes an 'appropriate balance'. In the absence of this, guidance will be taken from alternative and appropriate publications.

> "*In the case of wind energy development, a noise sensitive location includes any occupied house, hostel, health building or place of worship and may include areas of particular scenic quality or special recreational importance. Noise limits should apply only to those areas frequently used for relaxation of activities for which a quiet environment is highly desirable. Noise limits should be applied to external locations and should reflect the variation in both turbine source noise and background noise with wind speed.*"

As will be seen from the calculations presented later in this chapter, the various issues identified in this extract have been incorporated into our assessment.

"In general, a lower fixed limit of 45dB(A) or a maximum increase of 5dB(A) above background noise at nearby noise sensitive locations is considered appropriate to provide protection to wind energy development neighbours."

This represents the commonly adopted daytime noise criterion curve in relation to wind farm developments. However, an important caveat should be noted as detailed in the following extract.

"However, in very quiet areas, the use of a margin of 5dB(A) above background noise at nearby noise sensitive properties is not necessary to offer a reasonable degree of protection and may unduly restrict wind energy developments which should be recognised as having wider national and global benefits. Instead, in low noise environments where background noise is less than 30dB(A), it is recommended that the daytime level of the $L_{A90,\ 10min}$ of the wind energy development be limited to an absolute level within the range of 35 – 40dB(A)."

In relation to night time periods the following guidance is given:

"A fixed limit of 43dB(A) will protect sleep inside properties during the night."

This limit is defined in terms of the $L_{A90,10min}$ parameter. This represents the commonly adopted night time lower limit noise criterion curve in relation to wind farm developments.

In summary, the Wind Energy Development Guidelines outlines the following guidance to identify appropriate wind turbine noise criteria curves at noise sensitive locations:

- an appropriate absolute limit level for quiet daytime environments of less than 30 dB $L_{A90,10min}$;
- 45 dB $L_{A90,10min}$ for daytime environments greater than 30 dB $L_{A90,10min}$ or a maximum increase of 5 dB above background noise (whichever is higher), and;
- 43 dB $L_{A90,10min}$ or a maximum increase of 5 dB above background noise (whichever is higher) for night time periods.

While the caveat of an increase of 5dB(A) above background for night-time operation is not explicit within the current guidance it is commonly applied in noise assessments prepared and is detailed in numerous examples of planning conditions issued by local authorities and An Bord Pleanála. Therefore, a night time 5dB(A) above background allowance has also been adopted in the criteria for this assessment.

This set of criteria has been chosen as it is in line with the relevant Irish guidance. The proposed operational noise criteria curves for wind turbine noise at various noise sensitive locations are presented in Section 11.4.1.

11.3.2.2.3 *The Assessment and Rating of Noise from Wind Farms – ETSU-R-97*

As stated previously the core of the noise guidance contained within the *Wind Energy Development Guidelines* is based on the 1996 ETSU publication *The Assessment and Rating of Noise from Wind Farms* (ETSU-R-97).

ETSU-R-97 calls for the control of wind turbine noise by the application of noise limits at the nearest noise sensitive locations. ETSU-R-97 considers that absolute noise limits applied at all wind speeds are not suited to wind turbine developments and recommends that noise limits should be set relative to the existing background noise levels at noise sensitive locations. A critical aspect of the noise assessment of wind energy proposals relates to the identification of baseline noise levels through on-site noise surveys.

ETSU-R-97 states on page 58, "*...absolute noise limits and margins above background should relate to the cumulative effect of all wind turbines in the area which contribute to the noise received at the properties in question...*". Therefore, the noise contribution from all wind turbine development in the area should be included in the assessment.

11.3.2.2.4 *Institute of Acoustics Good Practice Guide*

The guidance contained within the institute of Acoustics (IoA) document A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (2013) (IOA GPG) and Supplementary Guidance Notes are considered to represent best practice and have been adopted for this assessment. The IOA GPG states, that at a minimum continuous baseline noise monitoring should be carried out at the nearest noise sensitive locations for typically a two-week period and should capture a representative sample of wind speeds in the area (i.e. cut in speeds to wind speed of rated sound power of the proposed turbine). Background noise measurements (i.e. $L_{A90,10min}$) should be related to wind speed measurements that are collated at the site of the wind turbine development. Regression analysis is then conducted on the data sets to derive background noise levels at various wind speeds to establish the appropriate day and night time noise criterion curves.

Noise emissions associated with the wind turbine can be predicted in accordance with ISO 9613: Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation (1996). This is a noise prediction standard that considers noise attenuation offered, amongst others, by distance, ground absorption, directivity and atmospheric absorption. Noise predictions and contours are typically prepared for various wind speeds and the predicted levels are compared against the relevant noise criterion curve to demonstrate compliance with the appropriate noise criteria.

Where noise predictions indicate that reductions in noise emissions are required in order to satisfy any adopted criteria, consideration can be given to detailed downwind analysis and operating turbines in low noise mode, which is typically offered by modern wind turbine units.

For guidance on the methodology for the background noise survey and operation impact assessment for wind turbine noise the IoA GPG has been taken into account.

Assessment of Cumulative Turbine Noise Impacts

The IOA GPG states that cumulative noise exceedances should be avoided and where existing or permitted development is at the noise limit any new turbine noise sources should be designed to be 10 dB below the limit value.

Section 5.1 of the relevant IoA GPG states the following:

> *"5.1.1 ETSU-R-97 states at page 58, "...absolute noise limits and margins above background should relate to the cumulative effect of all wind turbines in the area which contribute to the noise received at the properties in question..."*
>
> *5.1.2 The HMP[1] Report states that "If an existing wind farm has permission to generate noise levels up to ETSU-R-97 limits, planning permission noise limits set at any future neighbouring wind farm would have to be at least 10 dB lower than the limits set for the existing wind farm to ensure there is no potential for cumulative noise impacts to breach ETSU-R-97 limits (except in such cases where a higher fixed limit could be justified)". Such an approach could prevent any further wind farm development in the locality, and a more detailed analysis can be undertaken on a case by case basis.*
>
> *5.1.3 As with the assessment of noise for all wind farm developments, sequential steps need to be taken, but such steps require more detailed attention due to the added complexity of cumulative noise impacts. The advice of the EHO[2] could be invaluable to this part of the assessment."*
>
> *Cumulative impact assessment necessary*
>
> *5.1.4 During scoping of a new wind farm development consideration should be given to cumulative noise impacts from any other wind farms in the locality. If the proposed wind farm produces noise levels within 10 dB of any existing wind farm/s at the same receptor location, then a cumulative noise impact assessment is necessary.*
>
> *5.1.5 Equally, in such cases where noise from the proposed wind farm is predicted to be 10 dB greater than that from the existing wind farm (but compliant with ETSU-R-97 in its own right), then a cumulative noise impact assessment would not be necessary."*

11.3.2.2.5 *Future Potential Guidance Change*

Proposed changes to the assessment of noise impacts associated with on-shore wind energy developments are outlined in the *Draft Revised Wind Energy Development Guidelines* December 2019 prepared by the Department of Housing, Planning and Local Government. These Guidelines are currently in draft format and subject to public and stakeholder consultation. In line with best practice, the assessment presented in the EIAR is based on the current guidance outlined in Section 5.6 of the Wind Energy Development Guidelines for Planning Authorities, 2006.

11.3.2.2.6 *World Health Organisation (WHO) Noise Guidelines for the European Region*

The World Health Organisation (WHO) *Environmental Noise Guidelines for the European Region* (2018) provide guidance on protecting human health from exposure to environmental noise. They set

1 HMP: Hayes McKenzie Partnership Ltd. Report on "Analysis of How Noise Impacts are considered in the Determination of Wind Farm Planning Applications" Ref HM: 2293/R1 dated 6th April 2011.
2 Environmental Health Officer