APPENDIX 3

CHAPTER 9 'WATER'

9. WATER

9.1 Introduction

9.1.1 Background and Objectives

Hydro-Environmental Services (HES) was engaged by MKO to undertake an assessment of the potential direct, indirect and cumulative effects of the proposed 10 no. turbine, Croagh Wind Farm development (the 'proposed development') on water aspects (hydrology and hydrogeology) of the receiving environment.

The objectives of the assessment are to:

- Produce a baseline study of the existing water environment (surface water and groundwater) in the area of the proposed wind farm development and associated works;
- Identify likely significant effects of the proposed development on surface water and groundwater during construction, operational and decommissioning phases of the development;
- Identify mitigation measures to avoid, reduce or offset significant negative effects;
- Assess significant residual effects; and
- Assess cumulative effects of the proposed development and other local developments.

9.1.2 Statement of Authority

Hydro-Environmental Services (HES) are a specialist hydrological, hydrogeological and environmental practice which delivers a range of water and environmental management consultancy services to the private and public sectors across Ireland and Northern Ireland. HES was established in 2005, and our office is located in Dungarvan, County Waterford.

Our core areas of expertise and experience include upland hydrology and windfarm drainage design. We routinely complete impact assessments for hydrology and hydrogeology for a large variety of project types.

This chapter of the EIAR was prepared by Michael Gill, David Broderick and Adam Keegan.

Michael Gill (BA, BAI, Dip Geol., MSc, MIEI) is an Environmental Engineer and Hydrogeologist with over 18 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments of wind farms and renewable projects in Ireland. He has substantial experience in surface water drainage design and SUDs design and surface water/groundwater interactions. For example, Michael has worked on the EIS/EIAR for Oweninny WF, Cloncreen WF, Derrinlough WF and Yellow River WF, and over 100 other wind farm-related projects.

David Broderick is a hydrogeologist with over 13 years' experience in both the public and private sectors. Having spent two years working in the Geological Survey of Ireland working mainly on groundwater and source protection studies David moved into the private sector. David has a strong background in groundwater resource assessment and hydrogeological/hydrological investigations in relation to developments such as quarries and wind farms. David has worked on the EIS for Oweninny WF, Meenbog WF, Glenmore WF, Yellow River WF, and over 80 other wind farm-related projects.

Adam Keegan is a hydrogeologist with two years of experience in the environmental sector in Ireland. Adam has been involved in Environmental Impact Assessment Reports (EIARs) for numerous projects including wind farms, grid connections, quarries and small housing developments. Adam holds an MSc in Hydrogeology and Water Resource Management. Adam has worked on several wind farm EIAR projects, including Croagh WF, Lyrenacarriga WF (SID), Cleanrath WF, Carrownagowan WF (SID), and Fossy WF.

9.1.3 Scoping and Consultation

The scope for this chapter of the EIAR has also been informed by consultation with statutory consultees, bodies with environmental responsibility and other interested parties. This consultation process is outlined in Section 2.6 of this EIAR. Issues and concerns highlighted with respect to the water environment are summarised in

Table 9-1 below.

Table 9-1:Summary of Water Environment Related Scoping Responses

Degree/Nature	Description	Addressed in Section
Inland Fisheries Ireland (IFI)	• IFI is seriously concerned over the potential for landslides in this area, based on the occurrence of two landslides in close proximity to this site which resulted in significant damage to the fisheries resource and water quality in the Owengar River.	Refer to Land, Soils and Geology Chapter (Chapter 8) for a peat stability risk assessment
Geological Survey of Ireland (GSI)	• The Geological Survey of Ireland have also identified numerous landslides in this area, indicating significant risks from activities involving large scale earth works such as windfarms.	
Irish Peatland Conservation Council (IPCC)	• There is a risk landslide events may occur within the locality of the proposed wind farm. Landsides are disastrous for wildlife (aquatic and terrestrial). • Most of the footprint of the proposed windfarm is situated on peat soils. Peat is very sensitive to development and will require extra stringent planning procedures	Refer to Land, Soils and Geology Chapter (Chapter 8) for a peat stability risk assessment and a peat management plan
Department of Culture Heritage and Gaeltacht	• In order to assess impacts it may be necessary to obtain hydrological and/or geological data. Any impact on water table levels or groundwater flows may impact on wetland sites some distance away. The EIAR should assess cumulative impacts with other plans or projects if applicable. Where negative impacts are identified suitable mitigation measures should be detailed as appropriate	Sections: 9.3.4, 9.3.7, 9.3.12 and 9.4.3.9

Degree/Nature	Description	Addressed in Section
Health Services Executive (HSE)	• HSE have particular interest in environmental impact studies, methodologies and proposed mitigation measures in the areas of ground and surface water quality and protection, at construction, operational and decommissioning phases. • Recommendation made that all surface waters and private wells affected be identified and that qualitative analysis of both surface and groundwaters be as current as possible.	Sections: 9.3.17 and 9.4.3
Department of Agriculture, Food and the Marine	• The interaction of these proposed works with the environment locally and more widely, in addition to potential direct and indirect impacts on designated sites and water, is assessed	Sections: 9.3.4, 9.3.7, 9.3.12 and 9.4.3.9
OPW	• The OPW has no records of flooding in this area. • It will be a requirement of the applicant to apply for Section 50 consent for all new and upgraded culverts and bridges	Sections: 9.4.3.8

9.1.4 Relevant Legislation

This chapter of the EIAR is prepared in accordance with the requirements of the Environmental Impact Assessment legislation outlined in Chapter 1: Introduction.

The requirements of the following legislation are complied with:

- S.I. No. 349 of 1989: European Communities (Environmental Impact Assessment) Regulations, and subsequent Amendments (S.I. No. 84 of 1994, S.I. No. 101 of 1996, S.I. No. 351 of 1998, S.I. No. 93 of 1999, S.I. No. 450 of 2000 and S.I. No. 538 of 2001, S.I. 134 of 2013 and the Minerals Development Act 2017), the Planning and Development Act 2000 (as amended), and S.I. 600 of 2001 Planning and Development Regulations and subsequent Amendments. These instruments implement EU Directive 2011/92/EU and subsequent amendments, on the assessment of the effects of certain public and private projects on the environment;
- 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) and S.I. No. 722 of 2003 European Communities (Water Policy) Regulations which implement EU Water Framework Directive (2000/60/EC) establishing a framework for the Community action in the field of

water policy and provide for implementation of 'daughter' Groundwater Directive (2006/118/EC) on the protection of groundwater against pollution and deterioration. Since 2000 water management in the EU has been directed by the Water Framework Directive (2000/60/EC) (as amended by Decision No. 2455/2011/EC; Directive 2008/32/EC; Directive 2008/105/EC; Directive 2009/31/EC; Directive 2013/39/EU; Council Directive 2013/64/EU; and Commission Directive 2014/101/EU ("WFD"). The WFD was given legal effect in Ireland by the European Communities (Water Policy) Regulations 2003 (S.I. No. 722 of 2003);

- S.I. No. 684 of 2007: Waste Water Discharge (Authorisation) Regulations 2017, resulting from EU Directive 2000/60/EC on the protection of water; S.I. No. 106 of 2007: European Communities (Drinking Water) Regulations 2007and S.I. No. 122 of 2014: European Communities (Drinking Water) Regulations 2014, arising from EU Directive 98/83/EC on the quality of water intended for human consumption (the "Drinking Water Directive") and EU Directive 2000/60/EC;
- S.I. No. 9 of 2010: European Communities Environmental Objectives (Groundwater) Regulations 2010 (as amended by S.I. No. 389/2011; S.I. No. 149/2012; S.I. No. 366/2016; the Radiological Protection (Miscellaneous Provisions) Act 2014; and S.I. No. 366/2016); and,
- S.I. No. 296 of 2009: The European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009 (as amended by S.I. No. 355 of 2018).

9.1.5 Relevant Guidance

The Hydrology and Hydrogeology chapter of the EIAR has been completed in accordance with guidance outlined in Chapter 1: Introduction and the guidance contained in the following:

The water section of the EIAR is also carried out in accordance with guidance contained in the following:

- Environmental Protection Agency (2006): Environmental Management in the Extractive Industry;
- Environmental Protection Agency (2003): Advice Notes on Current Practice (in the preparation of Environmental Impact Statements) where relevant;
- Institute of Geologists Ireland (2013): Guidelines for Preparation of Soils, Geology & Hydrogeology Chapters in Environmental Impact Statements;
- National Roads Authority (2005): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;
- Forestry Commission (2004): Forests and Water Guidelines, Fourth Edition. Publ. Forestry Commission, Edinburgh;
- Coillte (2009): Forest Operations & Water Protection Guidelines;
- Coillte (2009): Methodology for Clear Felling Harvesting Operations;
- Forest Services (Draft) Forestry and Freshwater Pearl Mussel Requirements – Site Assessment and Mitigation Measures;
- Forest Service (2000): Forestry and Water Quality Guidelines. Forest Service, DAF, Johnstown Castle Estate, Co. Wexford;
- COFORD (2004): Forest Road Manual – Guidelines for the Design, Construction and Management of Forest Roads;
- Inland Fisheries Ireland (2016): Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters;
- Good Practice During Wind Farm Construction (Scottish Natural Heritage, 2010);
- PPG1 - General Guide to Prevention of Pollution (UK Guidance Note);
- PPG5 – Works or Maintenance in or Near Watercourses (UK Guidance Note);
- CIRIA (Construction Industry Research and Information Association) 2006: Guidance on 'Control of Water Pollution from Linear Construction Projects' (CIRIA Report No. C648, 2006);

- CIRIA 2006: Control of Water Pollution from Construction Sites - Guidance for Consultants and Contractors. CIRIA C532. London, 2006;
- Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment (DoHPLG, 2018); and,

9.2 Methodology

9.2.1 Desk Study & Preliminary Hydrological Assessment

A desk study and preliminary hydrological assessment of the EIAR Site Boundary and the surrounding area was completed in advance of the site investigations. This involved collection of all relevant geological, hydrological, hydrogeological and meteorological data for the study area. This included consultation and review of the following data sources:

- Coillte databases on forestry and drainage;
- Environmental Protection Agency database (www.epa.ie);
- Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Met Eireann Meteorological Databases (www.met.ie);
- National Parks & Wildlife Services Public Map Viewer (www.npws.ie);
- EPA/Water Framework Directive Map Viewer (www.catchments.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 7 (Geology of Sligo-Leitrim). Geological Survey of Ireland (GSI, 1996);
- Geological Survey of Ireland (2004) – Lough Allen Groundwater Body Initial Characterization Report;
- OPW Flood Hazard Mapping (www.floodinfo.ie);
- Environmental Protection Agency – “Hydrotool” Map Viewer (www.epa.ie);
- CFRAM flood risk mapping (www.cfram.ie); and,
- Department of Environment, Community and Local Government on-line mapping viewer (www.myplan.ie).

9.2.2 Site Investigations

Detailed walkover surveys, geological mapping and peat/soil augering was undertaken by HES on 3rd and 4th April 2018 with follow up visits carried out on 14th and 20th November 2018, 6th September 2019 and 19th March 2020. Water sampling within local streams was carried out on the 14th and 20th of November 2018, as well as the 6th September 2019 and19th March 2020. Trial pit investigations (3 phases – 2017, 2019 and 2020) and bedrock investigation drilling in 2019 was completed by Fehily Timoney & Company (FT, formally AGEC Ltd).

In summary, site investigations to address the Water Section of the EIAR included the following:

- A total of over 850 no. peat probe depths were carried out by HES, MKO and FT, between 2013 and 2020, to determine the depth and geomorphology of the blanket peat at the site;
- Walkover surveys and drainage mapping of the site and the surrounding area were undertaken whereby water flow directions and drainage patterns were recorded;
- Field hydrochemistry measurements (electrical conductivity, pH, dissolved oxygen and temperature) were taken to determine the origin and nature of surface water flows;
- Surface water sampling (4 rounds) were undertaken to determine the baseline water quality of the primary surface waters originating from the site and along the grid connection route;
- Surface water flow monitoring of the primary streams passing through the site and along the grid connection route;
- Drilling of 4 no. bedrock boreholes to assess hydrogeological conditions at the proposed borrow pit locations;
- Assessment of bedrock permeability at the proposed borrow pit locations; and,

- Excavation of 40 no. trial pits across the site (2017, 2019 and 2020 investigations) to assess subsoil lithology and depth.

9.2.3 Impact Assessment Methodology

The guideline criteria (EPA, August 2017) for the assessment of likely significant effects require that likely effects are described with respect to their extent, magnitude, type (i.e. negative, positive or neutral) probability, duration, frequency, reversibility, and transfrontier nature (if applicable). The descriptors used in this environmental assessment are those set out in the EPA (2017) Glossary of effects as shown in Chapter 1 of this EIAR.

In addition to the above methodology, the sensitivity of the water environment receptors was assessed on completion of the desk study and baseline study. Levels of sensitivity which are defined in Table 9-2 are then used to assess the potential effect that the Proposed Development may have on them.

Table 9-2: Receptor Sensitivity Criteria (Adapted from www.sepa.org.uk)

Sensitivity of Receptor	
Not sensitive	Receptor is of low environmental importance (e.g. surface water quality classified by EPA as A3 waters or seriously polluted), fish sporadically present or restricted). Heavily engineered or artificially modified and may dry up during summer months. Environmental equilibrium is stable and is resilient to changes which are considerably greater than natural fluctuations, without detriment to its present character. No abstractions for public or private water supplies. GSI groundwater vulnerability “Low” – “Medium” classification and “Poor” aquifer importance.
Sensitive	Receptor is of medium environmental importance or of regional value. Surface water quality classified by EPA as A2. Salmonid species may be present and may be locally important for fisheries. Abstractions for private water supplies. Environmental equilibrium copes well with all natural fluctuations but cannot absorb some changes greater than this without altering part of its present character. GSI groundwater vulnerability “High” classification and “Locally” important aquifer.
Very sensitive	Receptor is of high environmental importance or of national or international value i.e. NHA or SAC. Surface water quality classified by EPA as A1 and salmonid spawning grounds present. Abstractions for public drinking water supply. GSI groundwater vulnerability “Extreme” classification and “Regionally” important aquifer

9.3 Receiving Environment

9.3.1 General Site Description

The Proposed Development site (EIAR Site Boundary) is located approximately 1.3 kilometres northeast of Drumkeeran, Co. Leitrim, at its closest point. The total study area is approximately 670 ha (~6.7km^2). The site setting is forested upland blanket bog which is owned by Coillte. The site is accessible from public roads via a network of existing forestry tracks.

The proposed construction access road for the wind farm commences from the R280 at Drumkeeran village, approximately 6km to the east of the main site area and traverses private land, a public road and Coillte property before emerging onto the local road that approaches the core wind farm site.

The overall elevation of the site ranges between approximately 90m to 330m OD (Ordnance Datum) with the northern section of the site sloping in a northerly direction and the southern section of the site sloping to the southwest.

There is 1 no. proposed grid route, along with 1 no. proposed substation. The proposed substation is located approximately 330 metres east of Turbine No. 4 along an existing access road. From here, the proposed underground grid connection cabling route runs southeast along existing forestry roads for ~ 4.1 km before turning north and following the public road for ~ 1.9km and connecting with the existing Garvagh Glebe 110kV substation.

9.3.2 Water Balance

Long term rainfall and evaporation data was sourced from Met Éireann. The 30-year annual average rainfall (1981 - 2010) recorded at Dromahair (Market St), approximately 4 kilometres east of the site, are presented in

Table 9-3. The is the nearest and most appropriate station with respect to topography and elevation.

Table 9-3: Local Average long-term Rainfall Data (mm)

Station		X-Coord		Y-Coord		Ht (MAOD)		Opened		Closed		
Dromahair		180600		331500		27		1960		N/A		
Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
125	87	99	66	79	86	89	108	113	129	125	127	1231

The closest synoptic[1] station where the average potential evapotranspiration (PE) is recorded is at Mullingar, approximately 80 kilometres southeast of the site. The long-term average PE for this station is 446mm/yr. This value is used as a best estimate of the site PE. Actual Evaporation (AE) at the site is estimated as 423mm/yr (which is 0.95 × PE).

The effective rainfall (ER) represents the water available for runoff and groundwater recharge. The ER for the site is calculated as follows:

Effective rainfall (ER) = AAR – AE

= 1,231mm/yr – 423mm/yr

ER = 808mm/yr

Based on recharge coefficient estimates from the GSI (www.gsi.ie), an estimate of 5% recharge is taken for the site as an overall average. This value is for "Peat" with a "High" vulnerability rating. Areas where peat is absent may have slightly higher recharge rates, but on this site, these areas are generally on sloping ground. The high stream density in the area would also suggest that recharge rates are very low.

[1] Meteorological station at which observations are made for synoptic meteorology and at the standard synoptic hours of 00:00, 06:00, 12:00, and 18:00.

The lowest value in the available range was chosen to reflect the large coverage of blanket peat and high drainage density. Therefore, annual recharge and runoff rates for the site are estimated to be 40mm/yr and 768mm/yr respectively.

Table 9-4 presents return period rainfall depths for the centre of the Croagh wind farm site. This data is taken from https://www.met.ie/climate/services/rainfall-return-periods and they provide rainfall depths for various storm durations and sample return periods (1-year, 50-year, 100-year). These extreme rainfall data will be used for wind farm drainage design and not the long-term averages.

Table 9-4: Return Period Rainfall Depths for Croagh site

Duration	10-year Return Period	50-Year Return Period	100-Year Return Period
15-min	14.2	22.0	26.4
1-hour	22.7	32.6	38.3
6-hour	39.7	54.4	62
12-hour	49.7	66.3	74.8
24-hour	62.3	80.9	90.1
48-hour	77.2	97.7	107.7

9.3.3 Regional and Local Hydrology

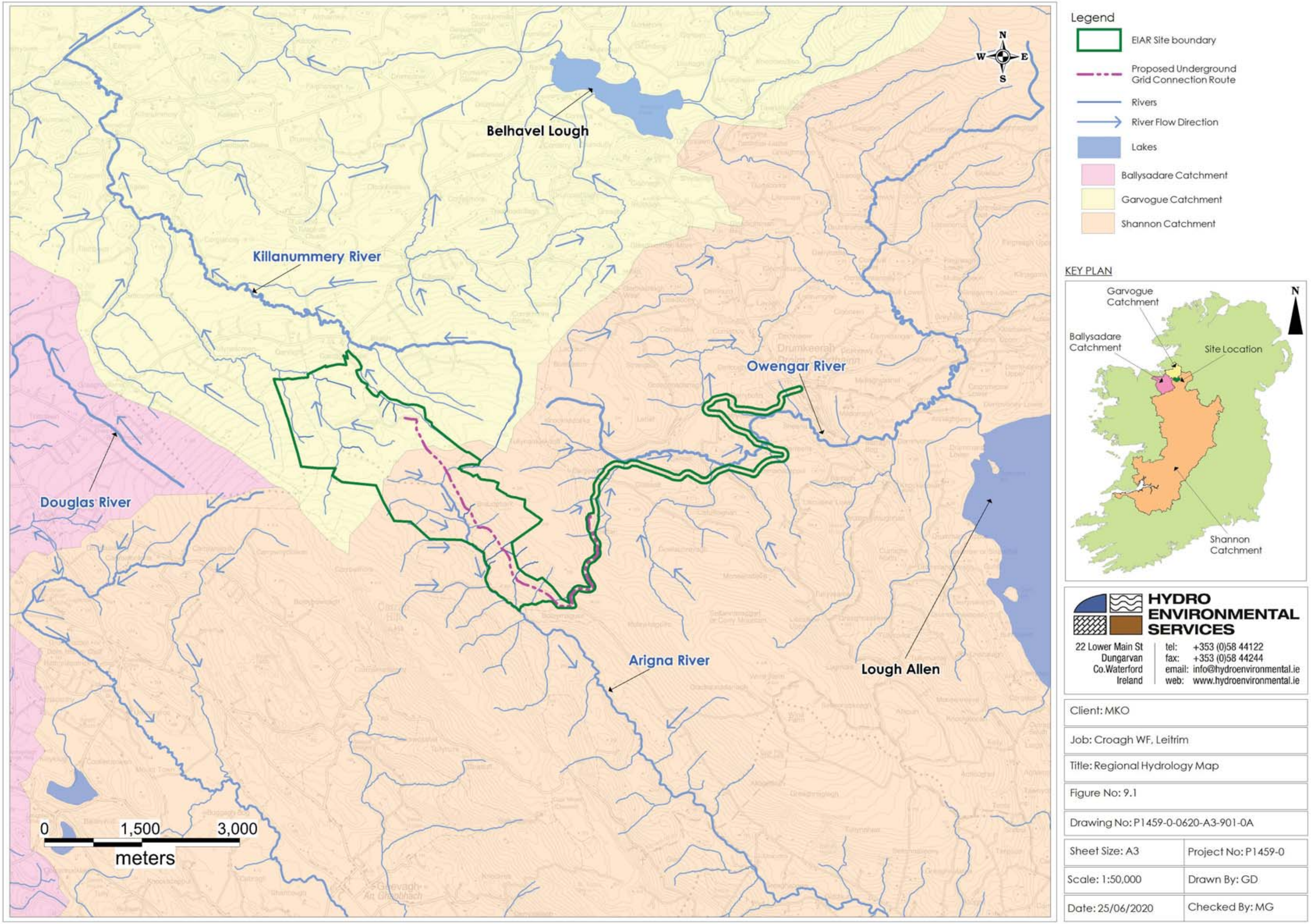
With respect to regional hydrology, the Proposed Development is located in 2 no. river basins and 3 no. regional surface water catchments. The southern half of the wind farm site is located in the Shannon River surface water catchment within the Shannon International River Basin District (SHIRBD). The northern half of the wind farm site is located in the Garvogue River surface water catchment. Both the Garvogue River and the Ballysadare River are located within the North Western International River Basin District (NWIRBD).

In terms of turbine distribution, 4 no. are located in the Shannon River surface water catchment and 6 no. are located in the Garvogue River surface water catchment.

The Garvagh grid connection route, which runs to the southeast of the site, passes through the Shannon River surface water catchment (for 6.4km) and the Garvogue River surface water catchment (for 0.7km). Approximately 8.5km of the construction access road is in the Shannon River catchment.

In terms of local hydrology, the southern half of the windfarm site is located in the Arigna River surface water catchment. The Arigna River flows into Lough Allen approximately 16km downstream of the site. The north half of the windfarm site is located in the Bonet River surface water catchment. The Bonet River flows into Lough Gill approximately 15km downstream of the site. Approximately 6km of the construction access road drains directly to Lough Allen via the Owengar River.

A regional hydrology map is attached as Figure 9-1.



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Client: MKO	
Job: Croagh WF, Leitrim	
Title: Regional Hydrology Map	
Figure No: 9.1	
Drawing No: P1459-0-0620-A3-901-0A	
Sheet Size: A3	Project No: P1459-0
Scale: 1:50,000	Drawn By: GD
Date: 25/06/2020	Checked By: MG

9.3.4 Local & Site Drainage

There are four main rivers which drain the Proposed Development site, namely the upper reaches of the Killanummery River (IE_WE_35K030600) which drains the north-western section of the site. The Killanummery River continues to flow northwest, before meeting the River Bonet just south of Dromahair, approximately 7.5 km north of the site. The smaller Tullynascreen Stream (IE_WE_35K030600) runs parallel to this river, and flows northwest, meeting the Killanummery River approximately 2 km north of the site. The Tullynascreen Stream emanates from Lough Nacroagh, a small lake with an area of ~0.01 km^2.

The Cashel Stream drains the north-eastern section of the proposed site. The Cashel Stream is fed from several smaller streams which converge near Kilavoggy Bridge ~1.5km north of the site. The stream then flows north/northeast, meeting the River Bonet approximately 1 km southeast of Dromahair.

The southern section of the proposed site is drained by the Arigna River. The Arigna River runs south through the site and delineates much of the southwestern boundary of the site. It flows through a steep valley between Carrane Hill and Corry Mountain, and the drainage network suggest it is fed primarily from surface waters draining from the peaked ridge of Carrane Hill, which runs parallel to the river, approximately 1 km southwest of the river. The Arigna River continues to flow south before discharging into the southern tip of Lough Allen, some 3km northwest of Drumshanbo.

The site access road is drained by several headwater streams that flow easterly to form the Owengar River which flows into Lough Allen which is located 2km east of the site entrance.

A local hydrology map is shown as Figure 9-2 and a site drainage map is shown as Figure 9-3.

A summary of the sub-catchments along with relevant Proposed Development infrastructure and significant existing drainage features/routes are shown in

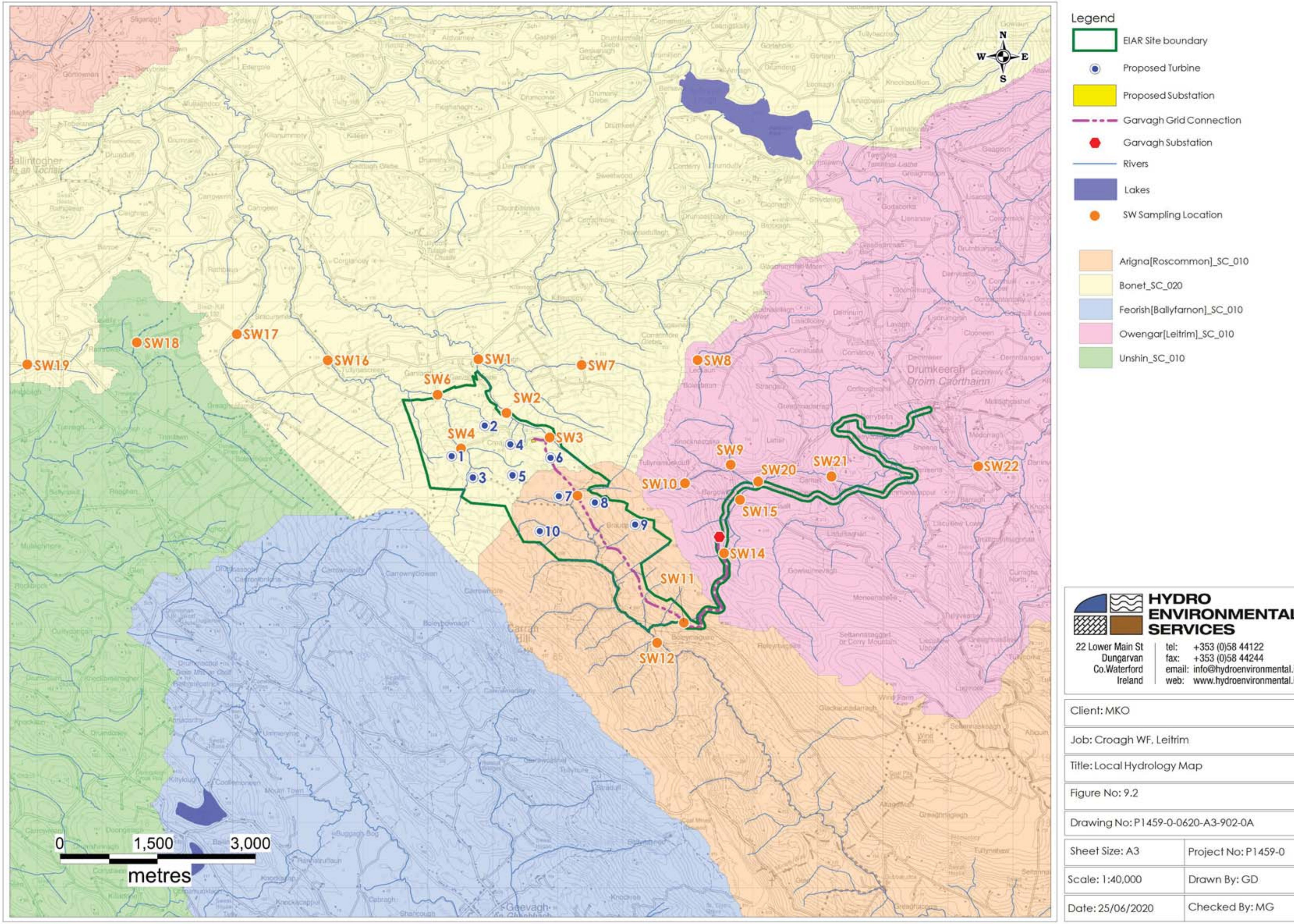
Table 9-5.

Within the Proposed Development site there are numerous manmade drains that are in place predominately to drain the forestry plantations. The current internal forestry drainage pattern is influenced by the topography, peat subsoils, layout of the forest plantation and by the existing road network. The forest plantations, which cover the majority of the site (where clearfelling has occurred forest drains still exist as before, and replanting has generally taken place) are generally drained by a network of mound drains or ploughed ribbons, which typically run perpendicular to the topographic contours of the site and feed into collector drains, which discharge to interceptor drains down-gradient of the plantation.

Mound drains and ploughed ribbon drains are generally spaced approximately every 15m and 2m respectively. As illustrated in Plate 9-1, interceptor drains are generally located up-gradient (cut-off drains) and down-gradient of forestry plantations. Interceptor drains are also located up-gradient of forestry access roads. Culverts are generally located at stream crossings and at low points under access roads which drain runoff onto down-gradient forest plantations. A schematic of a typical standard forestry drainage network and one which is representative of the site drainage network is shown as Plate 9-1.

The forestry drains are the primary drainage routes towards the natural streams on the development site, but the flows in these drains are generally very low. The integration of the existing main drains with the proposed wind farm drainage is a key component of the drainage design which is discussed further in Sections 9.4.1 and 9.4.2 below.

Monitoring of stream discharge in the main streams passing through the site, along the grid connection and the construction access road was undertaken in April and November 2018, as well as low flow monitoring in September 2019 and this data is presented in Table 9-6 below. The flows are typical for upland high energy watercourses.



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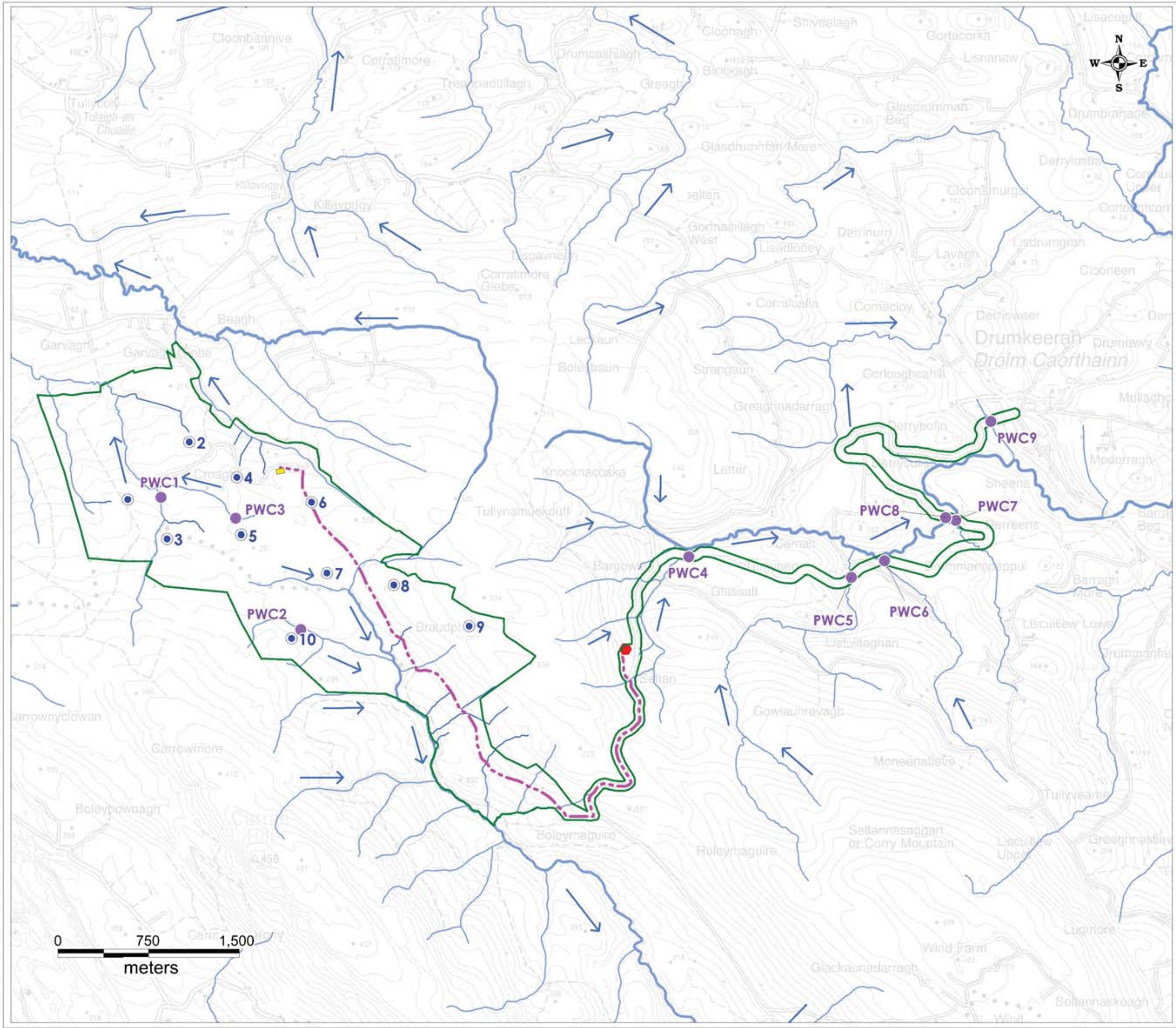
Client: MKO	
Job: Croagh WF, Leitrim	
Title: Local Hydrology Map	
Figure No: 9.2	
Drawing No: P1459-0-0620-A3-902-0A	
Sheet Size: A3	Project No: P1459-0
Scale: 1:40,000	Drawn By: GD
Date: 25/06/2020	Checked By: MG



Legend

- EIAR Site boundary
- Proposed Turbine
- Proposed Substation
- Proposed Underground Grid Connection Route
- Garvagh Substation
- Rivers
- River Flow Direction
- Proposed WC Crossing (PWC)

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Job: Croagh WF, Leitrim	
Title: Site Drainage Map	
Figure No: 9.3	
Drawing No: P1459-0-0620-A3-903-0A	
Sheet Size: A3	Project No: P1459-0
Scale: 1:30,000	Drawn By: GD
Date: 25/06/2020	Checked By: MG

Flow duration curves, generated by the EPA HydroTool website, are presented in Plate 9-2 below, and these represent likely volumetric flow variations between dry and wet weather.

The locations of the monitoring points are shown in Figure 9-2.

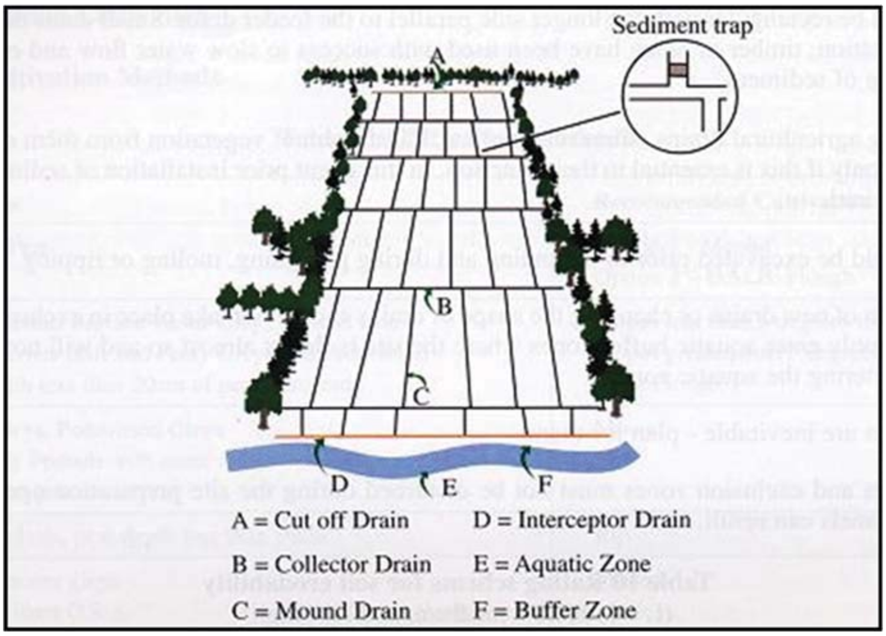

Plate 9-1: Standard forestry drainage network

Table 9-5: Summary of Regional/Local hydrology & Proposed Windfarm Infrastructure

Regional Catchments	Sub-catchment	Main Development Infrastructure	Primary Drainage Features
Shannon	Arigna	4 no. turbines, 1 no. borrow pit, 1 no. peat and spoil repository area,1 no. construction compound and 1.4km of the grid connection route and boardwalk	Arigna River
	Owengar	3.95km of the grid connection route and 8.5km of the construction access road	Owengar River
Garvogue	Bonet	6 no. turbines, substation, 1 no. peat and spoil repository area, 1 no. construction compound, 0.6km of the Garvagh grid connection route and met mast	Killanummery River

Table 9-6: Surface Water Flow Monitoring Data

Location	04/04/2018	14/11/2018	20/11/2018	06/09/2019
	Flow (litres/sec)	Flow (litres/sec)	Flow (litres/sec)	Flow (litres/sec)

Location	04/04/2018	14/11/2018	20/11/2018	06/09/2019
SW1	15	200	20	15
SW2	10	40	10	6
SW3	12	200	15	10
SW4	<10	30	<10	5
SW5	<10	30	<10	5
SW6	22	250	30	15
SW7	<10	100	<10	5
SW8	15	120	20	10
SW9	12	50	15	10
SW10	<10	30	<10	5
SW11	<10	30	<10	5
SW12	90	800	100	80

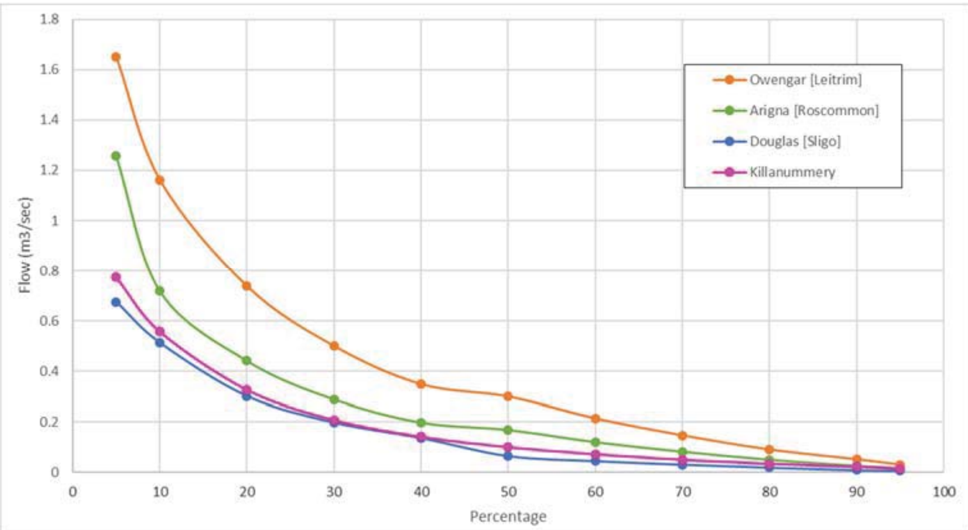

Plate 9-2: Flow Duration Curves for Local Rivers downstream of proposed development [2]

9.3.5 Baseline assessment of site runoff

This section undertakes a long-term water balance assessment and surface water runoff assessment for the baseline conditions at the proposed development site.

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2 http://watermaps.wfdireland.ie/HydroTool/Authentication/Login.aspx?ReturnUrl=%2fHydroTool%2fDefault.aspx

The rainfall depths used in this water balance, long term averages, are not used in the design of the sustainable drainage system for the wind farm. The 100-year rainfall depth will be used for the purpose of drainage design.

The water balance calculations are carried out for the month with the highest average recorded rainfall minus evapotranspiration, for the current baseline site conditions (Table 9-7). It represents, therefore, the long-term, average, wettest monthly scenario in terms of volumes of surface water runoff from the site pre-wind farm development. The worst case surface water runoff co-efficient for the site is estimated to be 96% based on the predominant peat coverage (refer to Section 9.3.2).

The highest long-term average monthly rainfall recorded at Dromahair over the period 1987 – present occurred in December, at 128mm. The average monthly evapotranspiration for the synoptic station at Mullingar over the period 1961-1990, for the month of December, was 0mm. The calculation is carried out for the entire study area. The balance indicates that a conservative estimate of surface water runoff for the study area during the highest rainfall month is 814,720m^3/month, which equates to an average of 26,281m^3/day, as outlined in Table 9-8.

Table 9-7: Water Balance and Baseline Runoff Estimates for Wettest Month (December)

Water Balance Component	Depth (m)
Average December Rainfall (R)	0.128
Average December Potential Evapotranspiration (PE)	0
Average December Actual Evapotranspiration (AE = PE x 0.95)	0
Effective Rainfall December (ER = R - AE)	0.128
Recharge co-efficient (5% of ER)	0.0064
Runoff (95% of ER)	0.1216

Table 9-8: Baseline Runoff for the Study Area

Approx. Area (ha)	Baseline Runoff per month (m^3)	Baseline Runoff per day (m^3)
670	814,720	26,281

9.3.6 Flood Risk Identification

OPW's indicative river and coastal flood map (www.floodmaps.ie), CFRAM Preliminary Flood Risk Assessment (PFRA) maps (www.cfram.ie), Department of Environment, Community and Local Government on-line planning mapping (www.myplan.ie) and historical mapping (i.e. 6" & 25" base maps) were consulted to identify those areas as being at risk of flooding.

A site specific Flood Risk Assessment was completed for the Proposed Development and this is attached as Appendix 9-1 of the EIAR. A summary of the FRA is provided in this section.

No recurring flood incidents within the EIAR site boundary were identified from OPW's indicative river and coastal flood map. A recurring flooding incident is mapped downstream of the site at the southern tip of Lough Allen, where the Arigna and Owengar Rivers discharge.

The PFRA mapping shows the extents of the indicative 100-year flood zone which relates to fluvial (i.e. river) and pluvial (i.e. rainfall) flood events. The 100-year fluvial flood zones mapped within the site boundary generally occur in close proximity to the stream channel itself. All proposed turbine locations, substation, construction compounds, met mast, borrow pit, peat repository areas and access roads (with the exception of stream crossings and road upgrades) are located at least 50m away from streams and are therefore outside of the fluvial indicative 100-year flood zone.

The Department of Environment, Community and Local Government on-line mapping viewer (www.myplan.ie.) has areas indicated as "fluvial flooding" in the close proximity of streams which pass through the site.

There is no text on local available historical 6" or 25" mapping for the proposed site that identify areas that are "prone to flooding" within the study area or benefitting lands (lands benefitting from the OPW arterial drainage scheme).

It is a key mitigation of the proposed wind farm development to ensure all surface water runoff is treated (water quality control) and attenuated (water quantity control) prior to diffuse discharge at pre-existing Greenfield rates. As such the mechanism by which downstream flooding is prevented and controlled is through avoidance by design. These proposed drainage attenuation measures are outlined in the impact assessment section below.

9.3.7 Surface Water Hydrochemistry

9.3.7.1 Proposed Wind Farm Site

Q-rating data for EPA monitoring points on Arigna River are available from a location approximately 3.5km south of the southern site boundary, referred to as Altagowlan School. Most recent data (2004 to present) show that the river has a Q-4 rating (Good Status). A Q-rating point is also located approximately 2.5 km southeast of the Altagowlan school monitoring point. This monitoring point also has a Q-4 rating.

Q ratings are also available along the Owengar river. The river achieved a Q-4 rating at a monitoring point approximately 2 km east of the eastern boundary of the site.

Q ratings for the River Bonet are also available from a monitoring point approximately 3 km north of the site at a bridge along the L4275. The last Q rating at this point was a Q4-5. Q ratings for the Killanummery River are available from a monitoring location at a bridge north of Garvagh Glebe. A Q-4 rating is assigned to the river at this point. A Q rating was also available from the small Cashel Stream which originates at Lough Nacroagh. The monitoring point is located approximately 1km west of the Killanummery River monitoring point. A Q4 rating is reported at this point. These are latest values available from the EPA, please refer to the aquatic section (Chapter 6 of the EIAR) for more contemporary values for the area of the Proposed Development.

Field hydrochemistry measurements of unstable parameters, electrical conductivity (µS/cm), pH (pH units) and temperature (C°) were taken at locations across the site within surface water courses on 14th and 20th November 2018 and 6th September 2019. The results are listed in Table 9-9 below.

Electrical conductivity (EC) values for surface waters at the site area ranged between 38 and 116µS/cm. This indicates that surface water is derived mainly from rainfall input. Measurement in lower-flow conditions (lower water levels in late summertime) may indicate a higher groundwater flow component (i.e. baseflow - typically signified by 'higher' EC values) contributing to discharge in the Bonet, Owengar and Arigna Rivers.

The pH values, which ranged between 4.7 and 7.2, had an overall average value of 6.32. Slightly acidic values were observed, especially at SW4 and SW6 where values <5 were recorded. This is most likely due to discharge from the small lake Lough Nacroagh, where waters may become relatively acidic due to the residence time within the bog lake.

Slightly acidic pH values of surface waters would be typical of peatland environments due to the decomposition of peat. In addition, the shale bedrock (and related till subsoils) which underlie the area would have slightly acidic groundwater characteristics which would have some effect on surface water chemistry specifically during dryer periods when baseflow is likely to be more prevalent.

Table 9-9: Summary of Surface Water Chemistry Measurements

Location	EC (µS/cm)			pH			Dissolved Oxygen (mg/L)		
	R1	R2	R3	R1	R2	R3	R1	R2	R3
SW1	58.1	57	57.9	5.93	6.16	6.9	10.82	11.06	10.51
SW2	76.3	67	-	6.33	6.5	-	10.74	10.78	-
SW3	82.7	106	-	6.92	6.81	-	10.72	11.01	-
SW4	37.7	54	-	4.95	6.14	-	10.04	10.38	-
SW5	40.9	39	34.3	5.02	7.11	6.6	10.42	10.84	10.3
SW6	65.6	51	-	4.71	5.85	-	10.71	11.1	-
SW7	54.9	48	54.1	5.88	6.36	6.79	10.48	11.17	10.43
SW8	47.3	54	46.3	5.82	6.85	6.55	10.7	11.09	10.62
SW9	58.1	116	94.9	6.82	7.22	7.39	10.79	10.97	10.48
SW10	51.3	42	-	6.09	6.83	-	10.8	11.34	-
SW11	59.6	72	-	6.84	7.13	-	10.69	11.37	-
SW12	57.4	60	-	6.22	7.21	-	10.62	11.42	-

R1 (Round 1) – 14/11/2018, R1 (Round 2) – 20/11/2018, R3 (Round 3) – 06/09/2019

Two rounds of surface water sampling were completed on 6 no. of the wind farm downstream monitoring locations (See Table 9-10 and (+) *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).

Table 9-11 below for the locations sampled) on the 14th November and 20th November 2018. These 6 no. sampling locations are situated downstream of the key proposed infrastructure locations.

Sampling was carried out along the grid connection option on 3rd and 4th April 2019 (refer to

Table 9-14 and (+) *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).

Table 9-15). Further sampling was carried out at points within the proposed wind farm site boundary and along the grid route (Table 9-12) on the 6th September 2019. The sampling results for the wind farm and grid route are discussed separately below.

Results of analysis are shown alongside relevant water quality regulations. In addition, relevant Environmental Objectives Surface Water Regulations (S.I. 272 of 2009) threshold values are shown in Table 9-13 below. Laboratory reports are shown as Appendix 9-2.

Table 9-10: Analytical Results of Surface Water Samples (Wind farm Round 1)

Parameter	EQS	Sample ID					
		SW1	SW3	SW6	SW8	SW10	SW12
Total Suspended Solids (mg/L)	25(+)	17	17	27	<5	<5	<5
Ammonia (mg/L)	≤0.065 to ≤ 0.04(*)	0.04	0.04	0.05	0.02	0.02	<0.02
Nitrite NO_2 (mg/L)	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	≤ 0.035 to ≤0.025(*)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrate - NO_3 (mg/L)	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Nitrogen (mg/L)	-	<1.0	<1.0	1.0	<1.0	<1.0	<1.0
Phosphorus (mg/L)	-	0.14	0.1	0.1	<0.1	<0.1	<0.1
Chloride (mg/L)	-	11	12.6	12.6	9	9.6	10.4
BOD	≤ 1.3 to ≤ 1.5(*)	<2	5	<2	<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).

Table 9-11: Analytical Results of Surface Water Samples (Wind farm Round 2)

Parameter	EQS	Sample ID					
		SW1	SW3	SW6	SW8	SW10	SW12
Total Suspended Solids (mg/L)	25(+)	<5	<5	<5	<5	<5	<5
Ammonia (mg/L)	≤0.065 to ≤ 0.04(*)	0.03	0.03	0.08	0.02	0.03	<0.02
Nitrite NO_2 (mg/L)	-	<0.05	0.05	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	≤ 0.035 to ≤0.025(*)	0.03	0.02	0.04	0.02	0.03	0.03
Nitrate - NO_3 (mg/L)	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Nitrogen (mg/L)	-	5.7	7.6	5.5	7.2	2.2	4.1
Phosphorus (mg/L)	-	<0.1	<0.1	0.11	<0.1	<0.1	0.11
Chloride (mg/L)	-	9.8	12.1	12.9	9.9	9.7	9.8
BOD	≤ 1.3 to ≤ 1.5(*)	2	<2	2	<2	3	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).

Table 9-12: Analytical Results of Surface Water Samples (Wind Farm/Grid Route(s) Round 3)

Parameter	EQS	Sample ID									
		SW1	SW5	SW6	SW7	SW8	SW9	SW11	SW12	SW16	SW17
Total Suspended Solids (mg/L)	25(+)	8	8	<5	<5	<5	<5	<5	6	<5	6
Ammonia (mg/L)	≤0.065 to ≤ 0.04(*)	0.02	<0.02	0.03	<0.02	<0.02	0.04	<0.02	<0.02	<0.02	<0.02
Nitrite NO_2 (mg/L)	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	≤ 0.035 to ≤0.025(*)	0.02	<0.02	0.04	0.02	<0.02	0.02	0.02	0.03	0.02	0.03
Nitrate - NO_3 (mg/L)	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Nitrogen (mg/L)	-	1.3	1.1	1.7	1.4	2.7	1.0	1.0	1.5	1.5	2.0
Phosphorus (mg/L)	-	0.11	<0.1	0.1	<0.1	0.1	<0.1	<0.1	0.1	0.1	0.1
Chloride (mg/L)	-	8.8	5.1	10.0	8.8	8.5	8.2	5.8	7.9	9.3	12.3
BOD	≤ 1.3 to ≤ 1.5(*)	2	<2	2	2	2	<2	2	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).

*Table 9-13: Chemical Conditions Supporting Biological Elements**

Parameter	Threshold Values (mg/L)
BOD	High status ≤ 1.3 (mean)
	Good status ≤ 1.5 mean
Ammonia-N	High status ≤ 0.04 (mean)
	Good status ≤0.065 (mean)
Ortho-phosphate	High status ≤0.025 (mean)
	Good status ≤0.035 (mean)

* European Communities Environmental Objectives Surface Water Regulations (S.I. 272 of 2009)

Round 1 of Sampling (Windfarm)

Total suspended solids at all sampling locations were generally less than 25mg/l, the threshold value contained within the European Communities (Quality of Salmonid Waters) Regulations (S.I. No. 293 of 1988). 1 no. sample at SW6 exceeded this value at 27 mg/l. This is likely due to the very high rainfall in the days prior to sampling, leading to excess runoff and the associated increase in suspended solids. This high TSS is also likely linked to the low pH value observed at this sampling location, with peaty solids leading to a temporary increase in acidity of the surface waters. Nitrite and nitrate values were below or equal to the laboratory detection limit of 0.05 and 5.0 mg/L respectively.

Ortho-phosphate was below the laboratory detection limit of 0.02mg/L in 5 of 6 locations, with the sample at SW6 returning a value of 0.04mg/l.

In comparison to the European Communities 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 SW6 exceeded the Good status threshold with a result of 0.05 mg/l.

In relation to ortho-phosphate, again, 5 of 6 were within the "Good Status" and "High status range while SW6 exceeded the "High Status" threshold values.

BOD was below the detection limit of 2 mg/l for 4 of 6 samples, however it exceeded both the "Good status" and "High status" threshold in the remaining two samples.

The results of round 1 sampling are presented in Table 9-10.

Round 2 of Sampling (Windfarm)

Total suspended solids at all sampling locations during round 2 (20/11/2018) were <5mg/L and nitrite and nitrate values were below or equal to the laboratory detection limits.

Ortho-phosphate ranged between <0.03 and 0.04mg/L, while phosphorus was generally below detection limit of 0.1 mg/l, but rose to 0.11 mg/l on two occasions at SW6 and SW12. Ammonia values ranged between <0.02 and 0.08mg/L.

In comparison to the European Communities Environmental Objectives Surface Water Regulations (S.I. 272 of 2009), 5 of 6 sample results for ammonia N were below the "good" and "High Status" threshold while all results 2 of 6 no. samples were below the detection limit for BOD, with the remaining 4 exceeding both the "Good" and "High" status.

The results of round 2 sampling are presented in Table 9-11.

Round 3 of Sampling (Windfarm/ Grid route(s))

Total suspended solids at all sampling locations during round 3 (06/09/2018) ranged from <5mg/L to 6 mg/L. Nitrite and Nitrate values were below or equal to the laboratory detection limits.

Ortho-phosphate ranged between <0.02 and 0.04mg/L, while phosphorus was generally at or below the detection limit of 0.1 mg/. Ammonia values ranged between <0.02 and 0.04mg/L which is within the "High Status threshold" as outlined in Table 9-13.

BOD ranged from <2 to 2 mg/l in all samples.

The results of round 2 sampling are presented in Table 9-12.

Round 1 of Sampling (Grid Connection)

6 no. additional sampling locations were used for the grid connection baseline monitoring. These locations are downstream on the main watercourses intercepted by the proposed route.

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

Table 9-14: Analytical results of Grid route samples (Round 1)

Parameter	EQS	Sample ID					
		SW14	SW15	SW16	SW17	SW18	SW19
Total Suspended Solids (mg/L)	25(+)	<5	<5	9	5	<5	<5
Ammonia (mg/L)	≤0.065 to ≤ 0.04(*)	<0.02	<0.02	0.03	0.02	0.03	0.03
Nitrite NO_2 (mg/L)	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	≤ 0.035 to ≤0.025(*)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrate - NO_3 (mg/L)	-	<5.0	<5.0	8	8.8	5.1	<5.0
Nitrogen (mg/L)	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Phosphorus (mg/L)	-	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chloride (mg/L)	-	13.4	12.9	17.1	17.9	17.5	16.6
BOD	≤ 1.3 to ≤ 1.5(*)	<5	<5	<5	<5	<5	<5

(+) 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).

Table 9-15: Analytical results of Grid route samples (Round 2)

Parameter	EQS	Sample ID					
		SW14	SW15	SW16	SW17	SW18	SW19
Total Suspended Solids (mg/L)	25(+)	<5	<5	7	<5	<5	<5
Ammonia (mg/L)	≤0.065 to ≤ 0.04(*)	0.02	0.02	0.03	0.02	0.05	0.03
Nitrite NO_2 (mg/L)	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	≤ 0.035 to ≤0.025(*)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrate - NO_3 (mg/L)	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Nitrogen (mg/L)	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Phosphorus (mg/L)	-	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chloride (mg/L)	-	13.4	12.7	16.7	18	17.9	16.8
BOD	≤ 1.3 to ≤ 1.5(*)	<5	<5	8	<5	<5	<5

(+) 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).

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

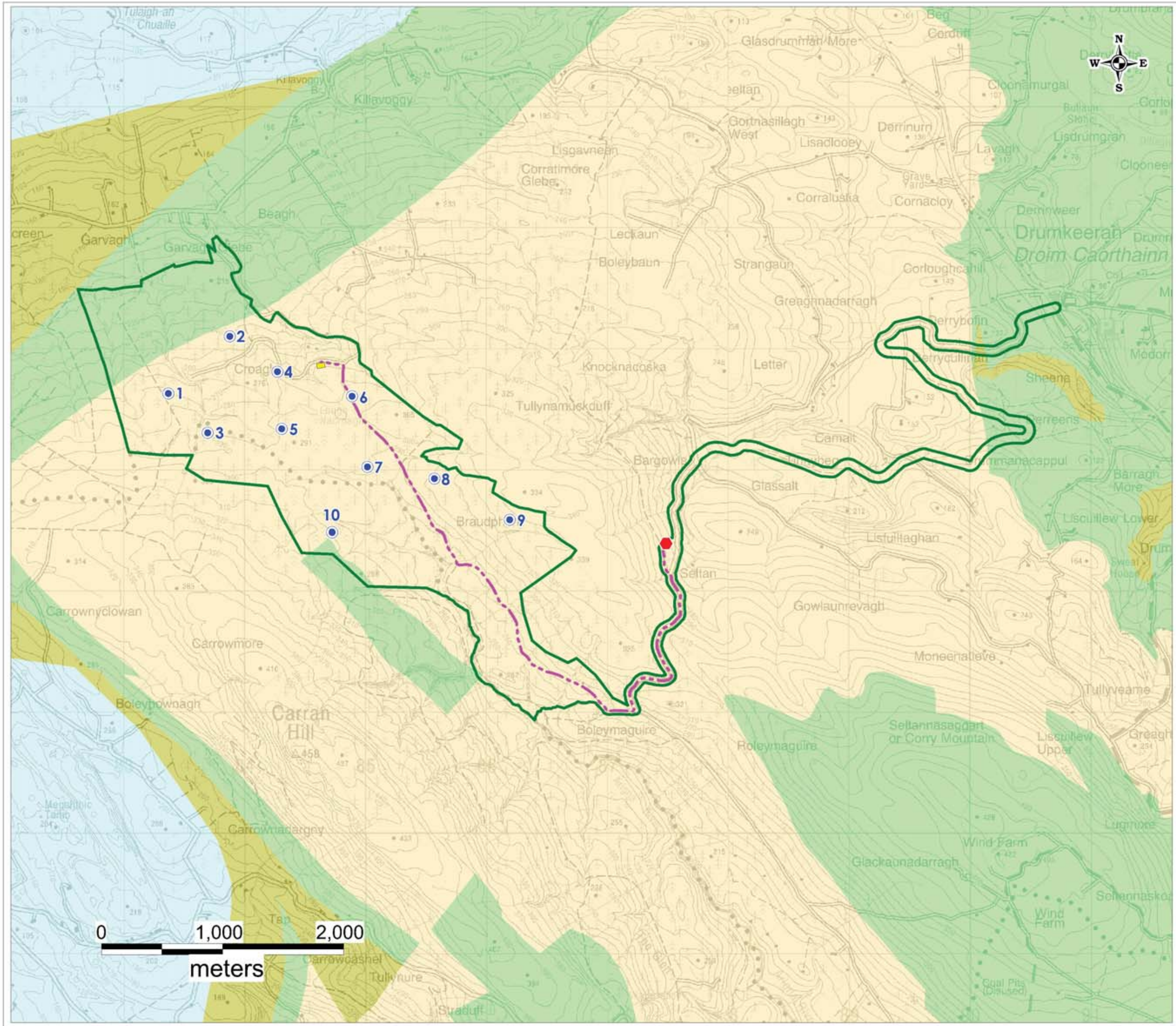
The underlying bedrock within the EIAR site boundary is mapped as being predominantly Namurian Shales, with the north-western tip of the site being mapped as Dinantian Shales and Limestones following a conformable contact (refer to Chapter 8 – Soils & Geology).

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)

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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.

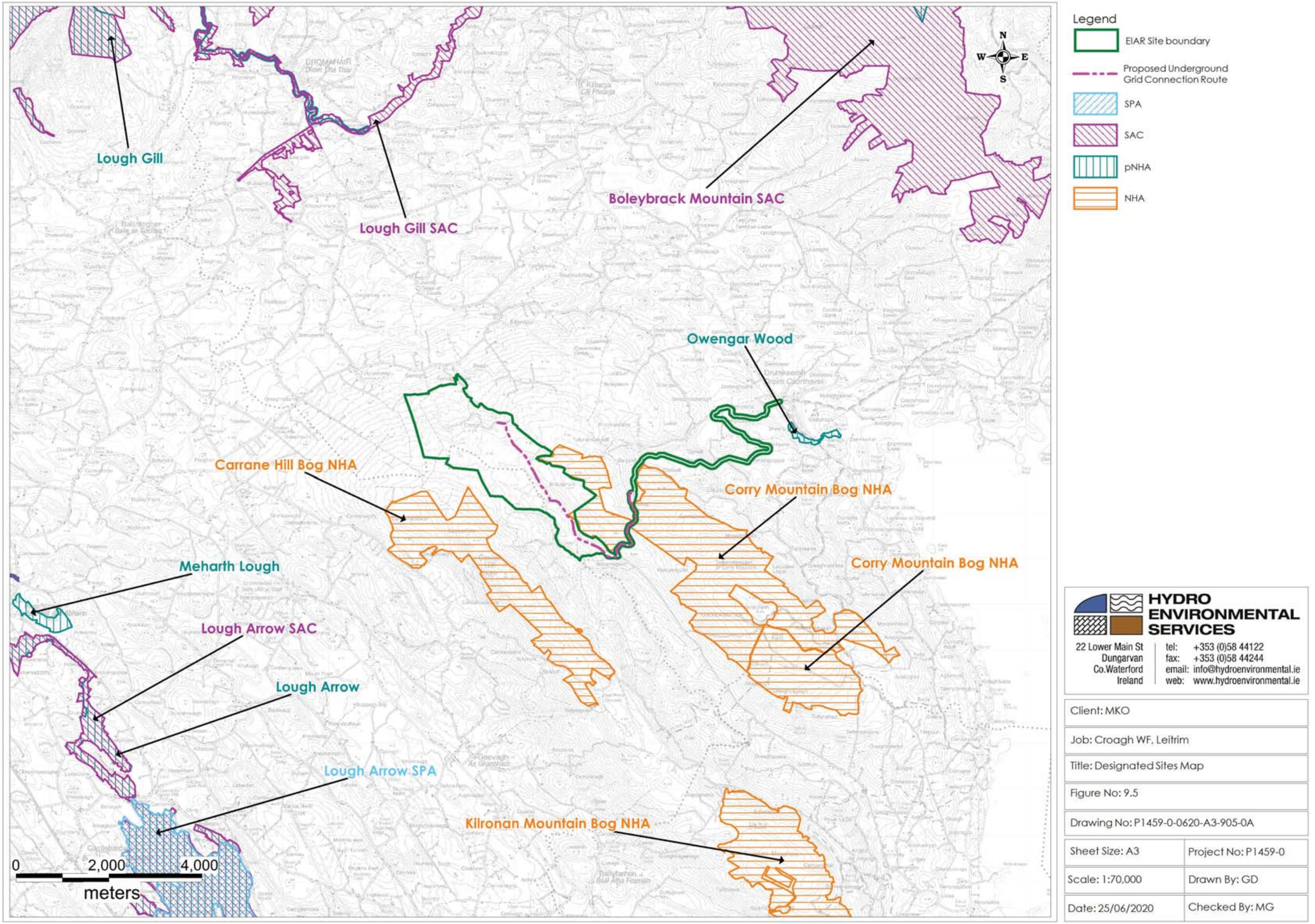
9.3.13 Surface Water Body Status

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.



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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.

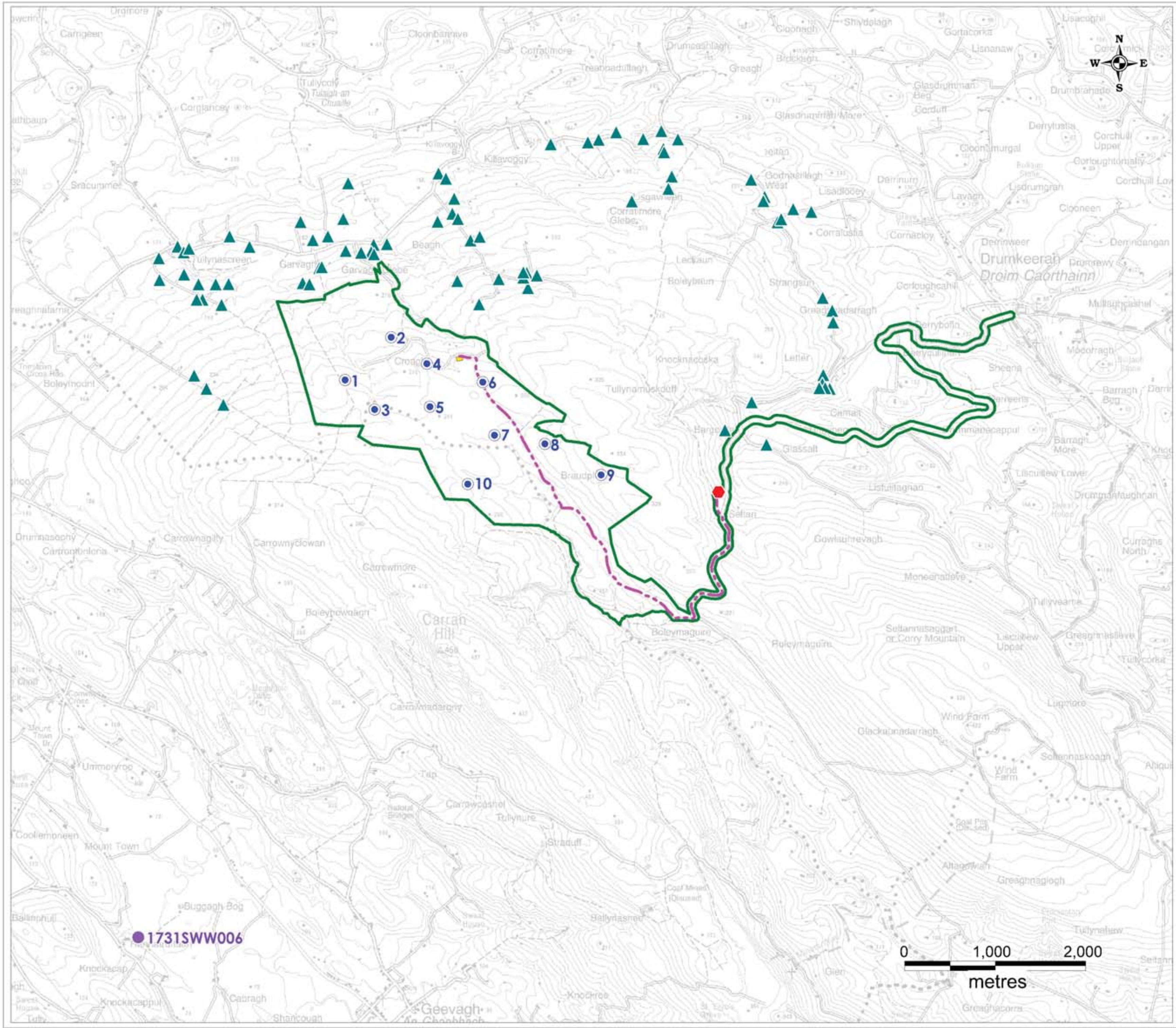
Using this conceptual model of groundwater flow, dwellings that are potentially located down-gradient of the footprint of the proposed development footprint are identified and a worst-case impact assessment for these actual and potential well locations is undertaken.

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)

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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.

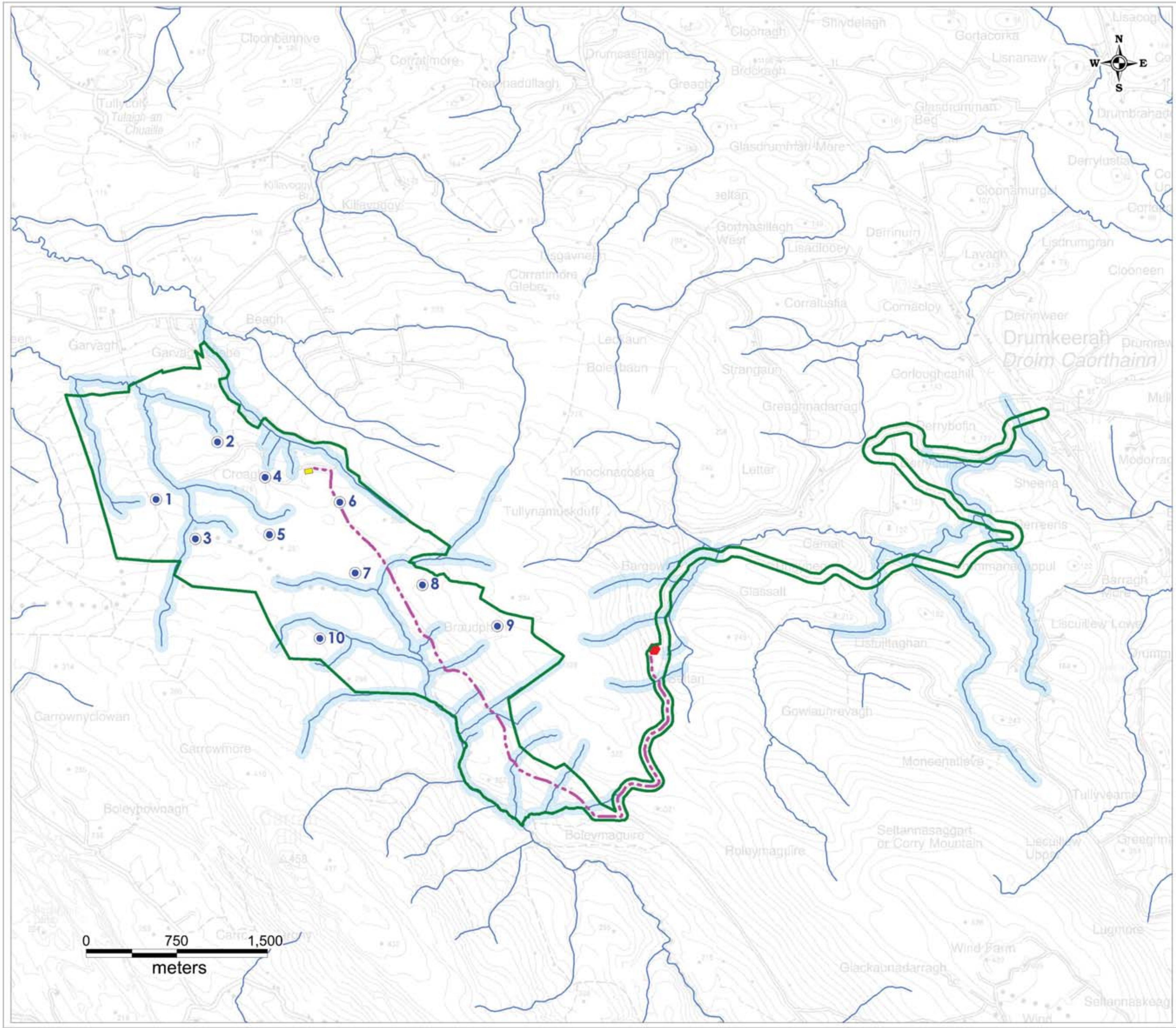
9.4 Characteristics of the Proposed Development

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

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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
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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.

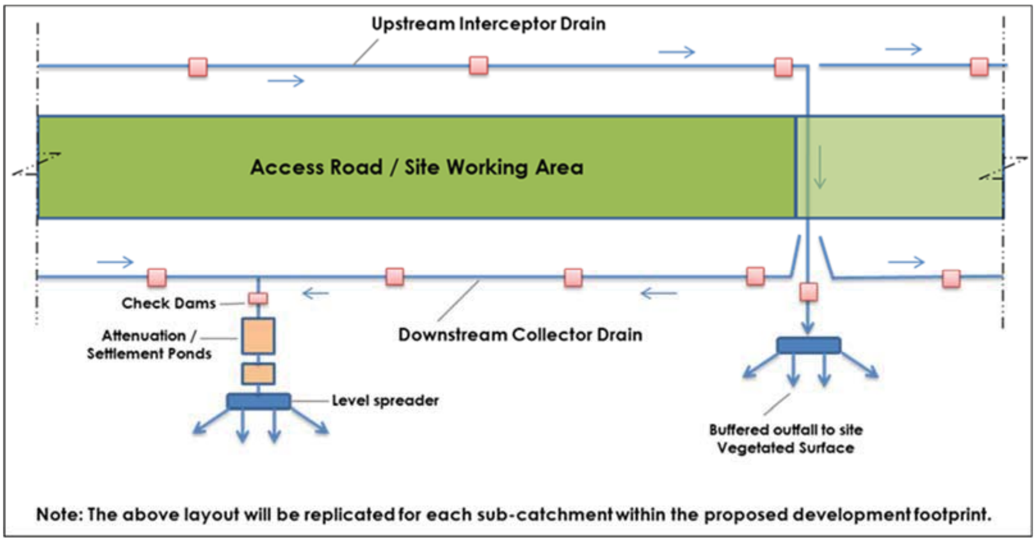


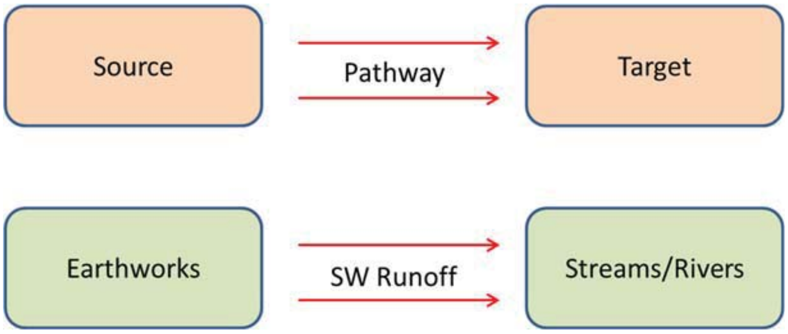
Plate 9-2 Schematic of Proposed Site Drainage Management

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 $\geq 6 \leq 9$ is set in S.I. No. 293 of 1988 Quality of Salmonid Water Regulations, with artificial variations not in excess of $\pm$ 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.

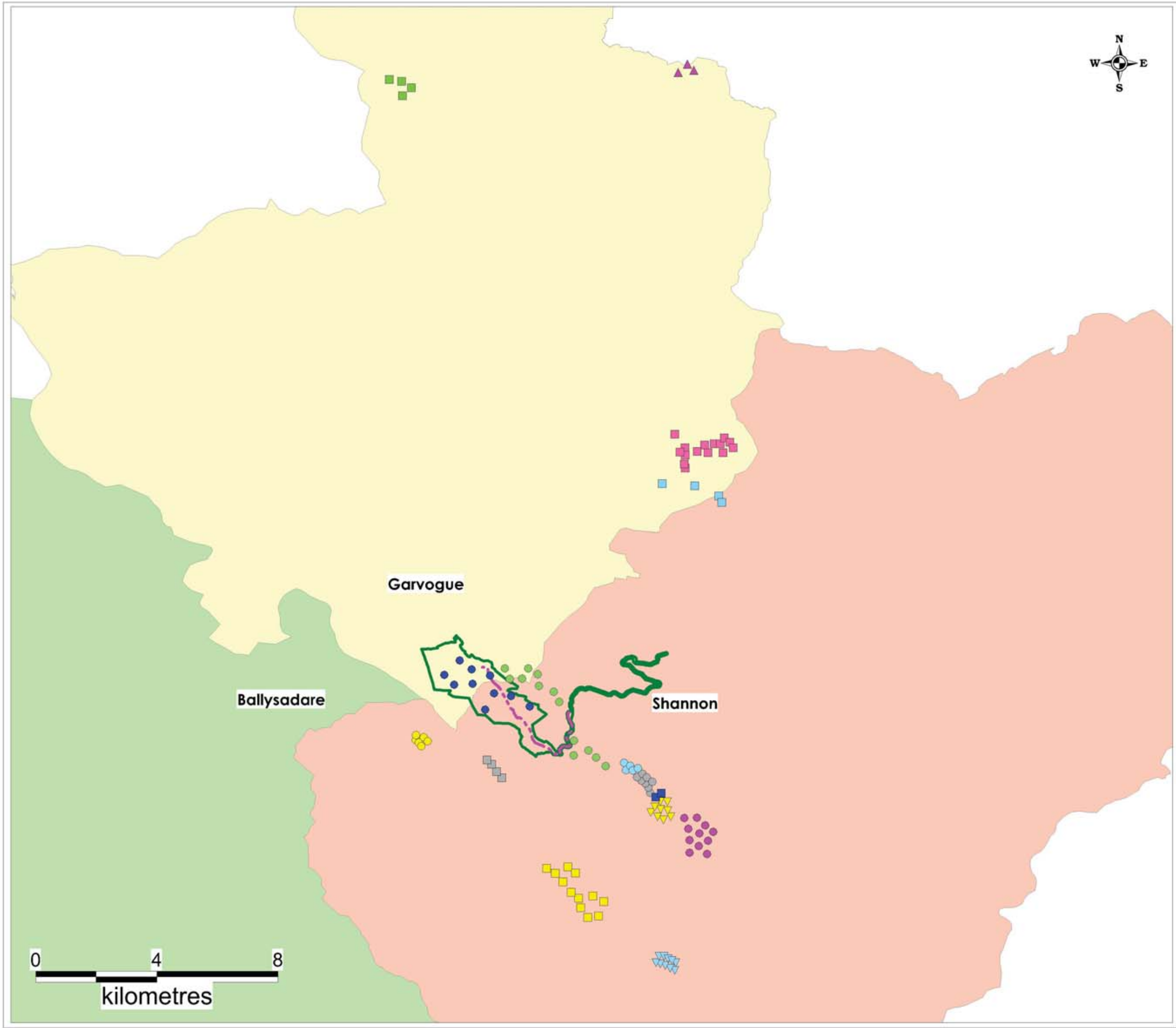
9.5.6 Assessment of Cumulative Effects

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).



Legend

- Site Boundary
- Proposed turbine Layout - Croagh WF
- Proposed Underground Grid Connection Route
- Altagowlan Tubine Locations
- Caranne_Hill Turbine Locations
- Corrie Mountain Turbine Locations
- Carrickheeney Turbine Locations
- Derrysallagh Turbine Locations
- Faughary Turbine Locations
- Geevagh Turbine Locations
- Garvagh Glebe Turbine Locations
- Garvagh Tullyhaw Turbine Locations
- Kilronan Turbine Locations
- Monaneenatieve Turbine Locations
- Spion Kop Turbine Locations
- Tullynamoyle Turbine Locations
- Tullynamoyle Turbine Locations (Extension Proposed)

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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.