9.0 HYDROLOGY AND HYDROGEOLOGY

9.1 INTRODUCTION

This chapter of the EIAR assesses the effects of the proposed Cloghercor Wind Farm project as described in Chapter 2 (Description of the Proposed Project) on the Hydrology, Hydrogeology and Water Quality environment. Information on the existing hydrological (surface water) and hydrogeological (groundwater) environment is presented as a baseline for the site. The potential effects of the development of the proposed wind farm and associated infrastructure are discussed along with prescribed mitigation measures for each potential effect. Any residual and cumulative effects are also assessed.

9.1.1 Statement of Authority

TOBIN Consulting Engineers (TOBIN) have completed this chapter. TOBIN Hydrologists and Hydrogeologists are intimately familiar with the site characteristics for the Cloghercor Wind Farm, having worked on other wind farms including Castlebanny, Lisheen, Bruckana and Derryadd set in various ground conditions and water environments. This chapter has been completed by John Dillon, Mistaya Langridge and Laura McGrath of TOBIN Consulting Engineers.

John Dillon (BSc., MSc., DIC, MCIWM, PGeo) is a hydrogeologist with 18 years' geological/hydrogeological experience in groundwater development, windfarm and major infrastructure developments. John has authored numerous Hydrology, Hydrogeology and Water Quality chapters for EIARs for a range of projects.

Laura McGrath (BSc., MSc., PGeo) is a hydrogeologist with six years hydrogeological experience in groundwater resources, contaminated land, ground investigation and various infrastructure developments including wind farms. Laura has authored a number of Hydrology, Hydrogeology and Water Quality chapters for EIARs for various projects.

Mistaya Langridge is a hydrologist/engineer with eight years' experience in Flood Risk Assessment (FRA). Mistaya has authored a number of FRAs for EIARs for various renewable projects.

9.2 ASSESSMENT METHODOLOGY

The methodology used to produce this chapter included a review of relevant legislation and guidance, a desktop study, a site walkover, an intrusive investigation, an evaluation of potential effects, an evaluation of the significance of the effects, and an identification of measures to prevent and mitigate the effects.

9.2.1 Guidance and Legislative Review

The EU Water Framework Directive (2000/60/EC) (WFD) established a framework for the protection of both surface water and groundwater. Transposing legislation (S.I. No. 272 of 2009, European Communities Environmental Objective (Surface Water) Regulations 2009 as amended) outlines the water protection and water management measures required in Ireland to maintain high or good status of waters.

The first cycle of the River Basin management Plan (RBMP) ran from 2009-2015, where eight separate plans were devised for all of the River Basin Districts (RBDs) with the objective of achieving at least 'good' status for all waters by 2015 (noting that later dates were set for certain waterbodies noted to be under significant pressures). The second cycle of the River Basin Management Plan: 2018-2021, was published by the Department of Housing, Planning and Local Government in April 2018. The third cycle of the River Basin Management Plan: 2022 – 2027 was published in 2022.

The WFD establishes common principles and an overall framework for action in relation to water protection and developed the overall principles and the structure for protection and sustainable use of water in the European union.

There are three separate objectives that are of particular relevance to the characterisation of water quality, hydrology and hydrogeology (Article 4.1):

- To prevent deterioration of status of all waterbodies;
- To protect, enhance and restore all waterbodies with the aim of achieving 'Good' status by 2015, with some limited exceptions, or by the dates set out in the River Basin Management Plans; and
- To reverse any significant and sustained upward trend in the concentration of any pollutant resulting from the impact of human activity on groundwater.

The European Communities Environmental Objectives (Surface Waters) Regulations, 2009 give effect to the criteria and standards to be used for classifying surface waters in accordance with the ecological objectives approach of the WFD. In accordance with the regulations, waters classified as 'High' or 'Good' must not be allowed to deteriorate. Waters classified as less than good must be restored to at least good status within a prescribed timeframe. In addition, the regulations address certain shortcomings identified by the European Court of Justice in relation to Ireland's implementation of the Dangerous Substances Directive (76/464/EEC), as amended. The regulations set standards for biological quality elements and physico-chemical conditions, supporting biological elements (e.g., temperature, oxygen balance, pH, salinity, nutrient concentrations and specific pollutants), which must be complied with. These parameters establish the 'ecological status' of a water body.

This chapter has been prepared having regard to the legislation quoted below in accordance with policy documents:

- Circular Letter PL 1/2017: Implementation of Directive 2014/52/EU on the effects of certain public and private projects on the environment (EIA Directive);
- Planning and Development Act 2000, as amended;
- Planning and Development Regulations 2001, as amended;
- 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 80/68/EEC on the protection of groundwater against pollution caused by certain dangerous substances (the Groundwater Directive);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).

The assessment was carried out in accordance with the following guidance and tailored accordingly based on professional judgement and experience:

- Environmental Protection Agency (EPA) (May 2022): Guidelines on the Information to be contained in Environmental Impact Assessment Reports;
- Construction Industry Research and Information Association (CIRIA) (2001): Control of Water Pollution from Construction Sites - Guidance for Consultants and Contractors. CIRIA C532. London, 2001; and,
- Environmental Protection Agency (EPA) (2006): Environmental Management in the Extractive Industry (Non-Scheduled Minerals);
- Institute of Geologists Ireland (IGI) (2013): Guidelines for Preparation of Soils, Geology & Hydrogeology Chapters in Environmental Impact Statements; and
- (National Roads Authority (NRA) 2008a): Environmental Impact Assessment of National Road Schemes – A Practical Guide
- National Roads Authority (NRA) (2008b): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;
- Guidelines for Planning Authorities on 'The Planning System and Flood Risk; Management' published in November 2009, jointly by the Office of Public Works (OPW) and the Department of Environment, Heritage and Local Government (DEHLG) (now the Department of Housing, Local Government and Heritage (DHLGH)).

9.2.2 Desk Review

A desk study was undertaken in order to collate and review background information of the receiving environment during the assessment. The sources of information obtained is listed below:

- National Peatland Strategy (NPWS, 2015);
- Hydrological features (drains, silt ponds, outfalls) provided by Bord na Móna;
- Geological Survey of Ireland (GSI) online mapping;
- Environmental Protection Agency database (www.epa.ie);
- Teagasc SIS Map Viewer (www.gis.teagasc.ie/soils/map.php);
- Met Éireann Meteorological Databases (www.met.ie);
- National Parks and Wildlife Services Public Map Viewer (www.npws.ie);
- Water Framework Directives Catchments Map Viewer (www.catchments.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet No. 7; Geological Survey of Ireland;
- Geological Survey of Ireland – Groundwater Body Characterisation Reports;

- OPW Indicative Flood Maps (www.floodmaps.ie);
- Environmental protection Agency - HydroTool Map Viewer (www.watermaps.wfdireland.ie/HydroTool);
- CFRAM Preliminary Flood Risk Assessment (PFRA) maps (www.floodinfo.ie); and
- Department of Environment, Community and Local Government on-line mapping viewer (www.myplan.ie).

9.2.3 Field Survey

A total of six site walkovers were undertaken to review the ground conditions and assess the topography, geomorphology and requirements for further investigations were carried out in November 2021, June 2022, October 2022 and November 2022.

The objectives of the intrusive site investigations conducted in June and July 2022 included mapping the distribution and depth of blanket peat at the site along with assessing the mineral subsoil / bedrock interface beneath the peat at key development locations (i.e., proposed turbine, substation, compound and borrow pit locations. The surveying of several bedrock exposures at the site (not forming part of the project) confirmed the findings of the investigations and allowed the development of an accurate hydrogeological conceptual model of the site.

The hydrological walkover survey involved the following:

- Walkover surveys and hydrological mapping of the proposed project, grid connection route, the Turbine Delivery Route and the surrounding area (including the Biodiversity Enhancement Lands) were undertaken whereby water flow directions and drainage patterns were recorded;
- An assessment of the hydraulic capacity/adequacy of existing stream culverts (those being altered by construction) and design specifications for proposed stream culverts; and
- A flood risk assessment for the proposed project footprint area.

Site surveys relating to the water environment and ground investigations were undertaken from June to August 2022. These included:

- Flow Measurements;
- Water Sampling;
- Logging of the soil layers and sampling of each stratum encountered; and
- Laboratory analyses of the samples collected during the above investigations.

9.2.4 Consultation

The EIAR Scoping and consultation activities were carried out in accordance with all relevant guidance documents as set out in Section 1.8 of this EIAR. The purpose of scoping for the EIAR is to provide a framework for the approach to be taken by the individual specialists in carrying out their evaluations, identifying environmental aspects for which potential significant environmental impacts may arise. It also provides a framework for the consultation process and sets out the intended structure of the EIAR.

Responses were received from GSI, DAU, IFI and Irish Water and included in Appendix 1- 4. The most relevant consultation was with GSI and identified the requirement for the assessment of peat, geohazards and geological heritage sites.

IFI requested the following be addressed:

- Fuel storage,
- Site drainage,
- Erosion control,
- Site management to minimise sedimentation,
- Potential impacts to runoff rates should be considered,
- Construction phase monitoring and ensuring a suitably qualified person is on site during construction to ensure mitigation is used correctly,
- Continual assessment is carried out,
- Works stop should any issue arise,
- Peat reinstatement is carried out correctly and arrangements are in place to contact statutory bodies on works progression.

The considerations have been addressed within this chapter. The content of the scoping is further summarised in Chapter 1.

9.2.5 Impact Assessment Methodology

The importance of the hydrogeological and hydrological receptors was assessed on completion of the desk study and baseline assessment. Using the NRA Guidance presented in Appendix C of the IGI guidelines (2013), an estimation of the importance of the hydrological and hydrogeological environments is set out in Table 9-1 and Table 9-2.

Table 9-1: Estimation of Importance of Hydrology Attributes

Importance	Criteria	Typical Example
Extremely High	Attribute has a high quality or value on an international scale.	• River, wetland or surface water body ecosystem protected by EU legislation, e.g., 'European sites' designated under the Habitats Regulations or 'Salmonid waters' designated pursuant to the European Communities (Quality of Salmonid Waters) Regulations, 1988.
Very High	Attribute has a high quality or value on a regional or national scale.	• River, wetland or surface water body ecosystem protected by national legislation – NHA status. • Regionally important potable water source supplying >2500 homes. • Quality Class A (Biotic Index Q4, Q5). • Flood plain protecting more than 50 residential or commercial properties from flooding. • Nationally important amenity site for wide range of leisure activities.
High	Attribute has a high quality or value on a local scale.	• Salmon fishery locally important potable water source supplying >1000 homes. • Quality Class B (Biotic Index Q3-4). • Flood plain protecting between 5 and 50 residential or commercial properties from flooding.
Medium	Attribute has a medium quality or value on a local scale.	• Coarse fishery. • Local potable water source supplying >50 homes Quality Class C (Biotic Index Q3, Q2-3). • Flood plain protecting between 1 and 5 residential or commercial properties from flooding.
Low	Attribute has a low quality or value on a local scale.	• Locally important amenity site for small range of leisure activities. • Local potable water source supplying <50 homes.

Importance	Criteria	Typical Example
		• Quality Class D (Biotic Index Q2, Q1) Flood plain protecting 1 residential or commercial property from flooding. • Amenity site used by small numbers of local people.

Table 9-2: Estimation of Importance of Hydrogeology Attribute

Importance	Criteria	Typical Example
Extremely High	Attribute has a high quality or value on an international scale.	• Groundwater supports river, wetland or surface water body ecosystem protected by EU legislation, e.g., SAC or SPA status.
Very High	Attribute has a high quality or value on a regional or national scale.	• Regionally Important Aquifer with multiple wellfields. • Groundwater supports river, wetland or surface water body ecosystem protected by national legislation - NHA status. • Regionally important potable water source supplying >2500 homes Inner source protection area for regionally important water source.
High	Attribute has a high quality or value on a local scale.	• Regionally Important Aquifer Groundwater provides large proportion of baseflow to local rivers. • Locally important potable water source supplying >1000 homes. • Outer source protection area for regionally important water source. • Inner source protection area for locally important water source.
Medium	Attribute has a medium quality or value on a local scale.	• Locally Important Aquifer. • Potable water source supplying >50 homes. • Outer source protection area for locally important water source.
Low	Attribute has a low quality or value on a local scale.	• Poor Bedrock Aquifer Potable water source supplying <50 homes.

9.2.5.1 Overview of Impact Assessment Process

The conventional source-pathway-receptor model (Figure 9-1) for groundwater and surface water protection was applied to assess potential effects on groundwater and surface water specifically on downstream sensitive ecological receptors and local groundwater supplies.

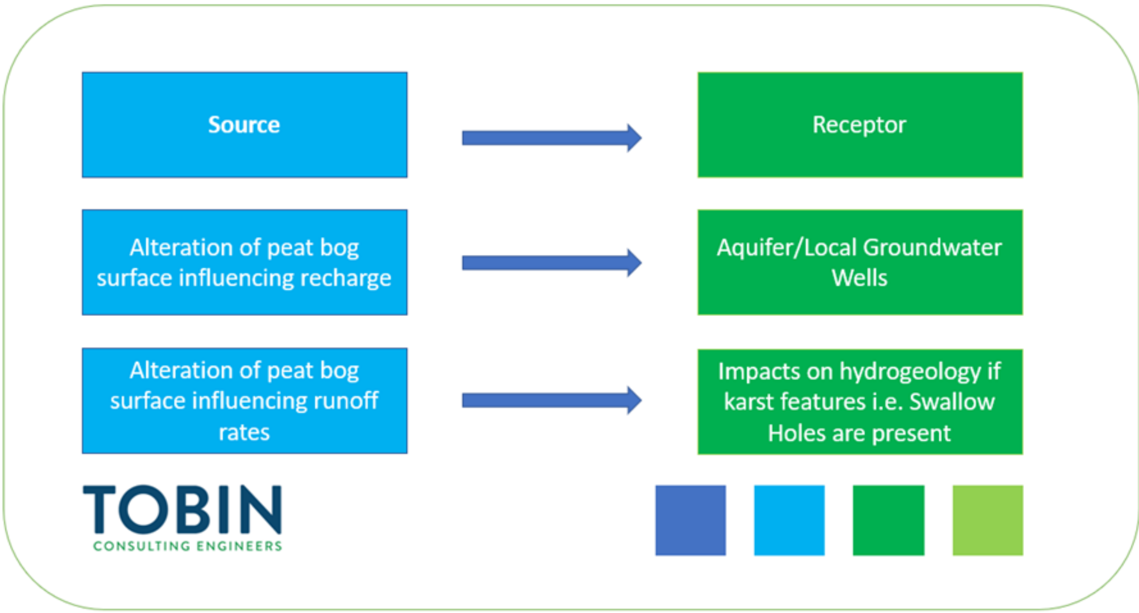


Figure 9-1: Example of a Source Pathway Receptor Model

In this chapter, the potential effects on the water environment resulting from the proposed project are evaluated and mitigation measures are proposed to reduce any significant effects. Based on the mitigation measures proposed, the significance of the residual effects on the water environment is determined.

The significance of effects of the proposed project has been assessed in accordance with the EPA guidance document Guidelines on the Information to be contained in Environmental Impact Assessment Reports (May 2022). The magnitude of any effects takes into account the likely scale of the predicted change to the baseline conditions, resulting from the predicted effect and considers the duration of the effect i.e., temporary or permanent. Definitions of the magnitude of any effects are provided in Table 9-3.

Table 9-3: Definitions of the Magnitude of Effects (Source: Boxes 5.2 and 5.3 from the NRAs Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes)

Magnitude	Criteria	Typical Example
Large Adverse	Results in loss of attribute and/or quality and integrity of attribute	Loss or extensive change to a waterbody or water dependent habitat. Increase in predicted peak flood level >100mm. Extensive loss of fishery. Extensive reduction in amenity value. Removal of large proportion of aquifer. Changes to aquifer or unsaturated zone resulting in extensive change to existing water supply springs and wells, river baseflow or ecosystems. Potential high risk of pollution to groundwater from routine run-off. Calculated risk of serious pollution incident >2% annually.
Moderate Adverse	Results in impact on integrity of attribute or loss of part of attribute	Increase in predicted peak flood level >50mm. Partial loss of fishery. Partial reduction in amenity value. Removal of moderate proportion of aquifer.

Magnitude	Criteria	Typical Example
		Changes to aquifer or unsaturated zone resulting in moderate change to existing water supply springs and wells, river baseflow or ecosystems. Potential medium risk of pollution to groundwater from routine run-off. Calculated risk of serious pollution incident >1% annually.
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute	Increase in predicted peak flood level >10mm. Minor loss or fishery. Slight reduction in amenity value. Removal of small proportion of aquifer. Changes to aquifer or unsaturated zone resulting in minor change to water supply springs and wells, river baseflow or ecosystems. Potential low risk of pollution to groundwater from routine run-off. Calculated risk of serious pollution incident >0.5% annually.
Negligible	Results in an impact on attribute but of insufficient magnitude to affect either use or integrity.	Negligible change in predicted peak flood level Calculated risk of serious pollution incident < 0.5% annually
Minor Beneficial	Results in minor improvement of attribute quality	Reduction in predicted peak flood level >10mm Calculated reduction in pollution risk of 50% or more where existing risk is <1% annually
Moderate Beneficial	Results in moderate improvement of attribute quality	Reduction in predicted peak flood level >50mm Calculated reduction in pollution risk of 50% or more where existing risk is >1% annually
Major Beneficial	Results in major improvement of attribute quality	Reduction in predicted peak flood level >100mm

Potential effects may have a negative, neutral or positive effects on the water environment. Terms relating to the duration of impacts are described in accordance with the EPA's guidelines on the information to be included in Environmental Impact Assessment Reports (2022) as:

- Momentary Effects – Effects lasting from seconds to minutes;
- Brief Effects – Effects lasting less than a day;
- Temporary Effects – Effects lasting one year or less;
- Short term Effects – Effects lasting one to seven years;
- Medium term Effects – Effects lasting seven to fifteen years;
- Long term Effects – Effects lasting fifteen to sixty years;
- Permanent Effects – Effects lasting over sixty years; and
- Reversible Effects – Effects than can be undone, for example through remediation or restoration.

The likelihood of effects is necessary to know in order to identify a list of effects which are considered likely or unlikely. According to the EPA's guidelines (2022), likely effects are those *"that can reasonably be expected to occur because of the planned project if all mitigation measures are properly implemented"*. Conversely, unlikely effects are those *"that can reasonably be expected not to occur because of the planned project if all mitigation measures are properly implemented"*

Figure 9-2 below shows how comparison of the character of the predicted effect to the sensitivity of the receiving environment can determine the significance of the effect.

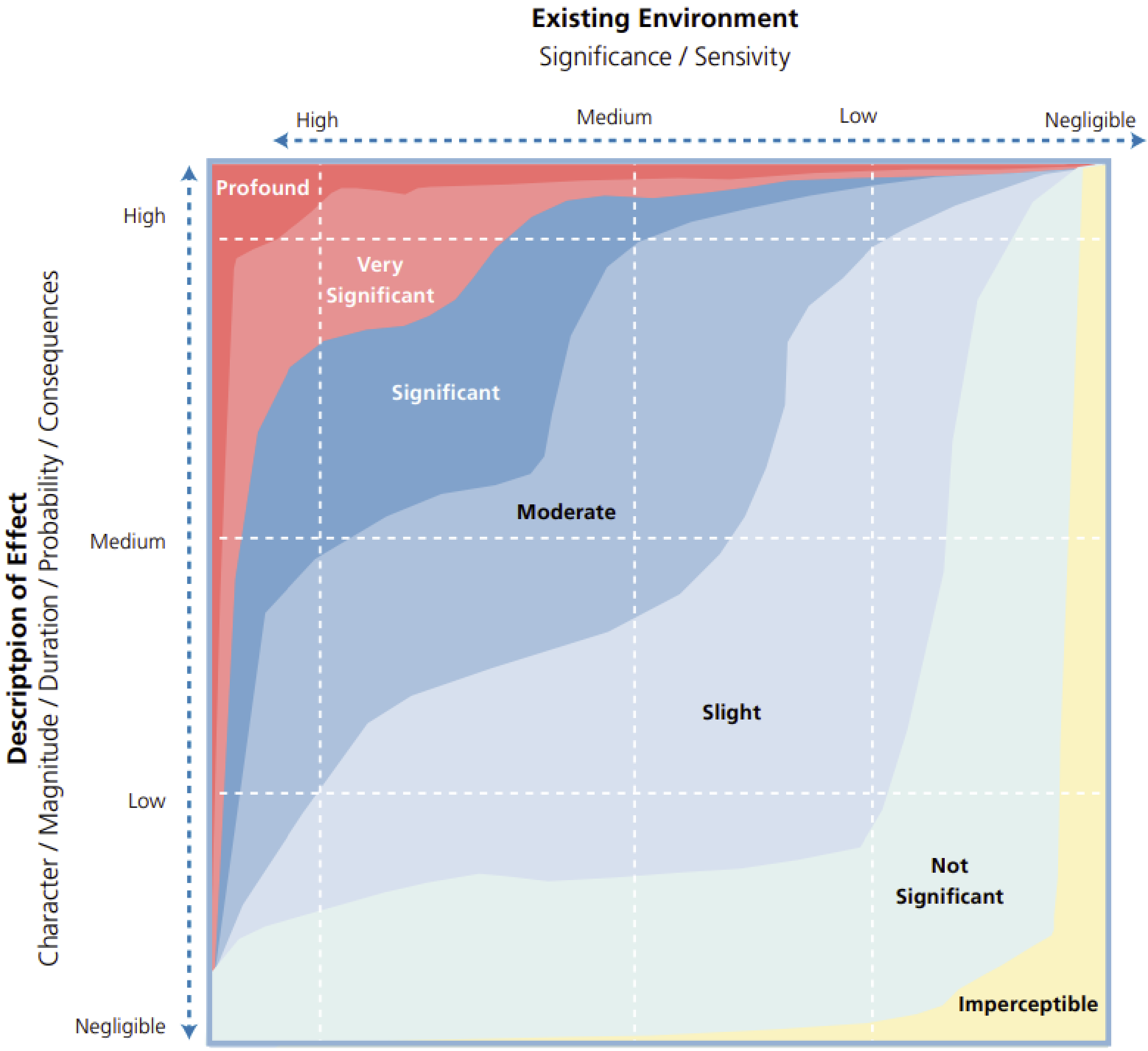


Figure 9-2: Significance of Impacts Matric for EIARs (EPA, 2022)

In order for a potential effect to be realised, three factors must be present. There must be a source of a potential effect, a receptor which can be affected and a pathway or connection which allows the source to affect the receptor (Figure 9-1). Only when all three factors are present can an effect be realised.

9.3 RECEIVING ENVIRONMENT

The existing water environment is discussed in terms of hydrology and hydrogeological conditions.

The regional review of geological conditions covers a zone of minimum 2km from the site boundary as suggested in the Institute of Geologists of Ireland (IGI) guidelines. This recommended minimum distance of 2km has been reviewed in the context of the geological/hydrogeological environment as well as the scale of activities and increased to reflect the sensitivity of the subsurface, for example where karst systems are present, to a maximum distance of 2km from the proposed wind farm site boundary.

9.3.1 Desk Review and Field Surveys

The hydrology, hydrogeology and water quality of the proposed project and the surrounding area was investigated through comprehensive desk studies and field inspections. A walkover survey of the site as described in Section 9.2.3 was carried out in order to identify hydrological features e.g., wet ground, drainage patterns and distribution, exposures and drains etc. Following the field surveys, the results were reviewed using GIS software in conjunction with publicly available hydrological and hydrogeological data from the Geological Survey of Ireland (GSI), Environmental Protection Agency (EPA) and Office of Public Works (OPW).

9.3.2 Site Description

The proposed wind farm site is located in Cloghercor, which is a townland approximately 3.5km south of Glenties, Co. Donegal. The EIAR study area is shown in Figure 1-1 of this EIAR (see Chapter 1 – Introduction), which includes the Biodiversity Enhancement Lands and the Turbine Delivery Route.

9.3.3 Site Topography and Geomorphology

The proposed wind farm site stretches from the Gweebarra River which runs along the northwestern ownership boundary toward the mountainous area in the north, east and south of the site. The area is moderately steep with areas of increase slope associated with granitic rock outcrops.

Cloghercor is located to the north-northeast of Glenties and the landscape is dominated by Croghleheen Mountain along the northwestern proposed wind farm site; Garfarretmoyle (also known as Cloghercor South) and Gaffaretcor Mountains and Derkbeg Hill to the south-eastern; Cleengort Hill along the southwestern of the proposed wind farm site.

The height and slope details for the mountains are as follows:

- Croghleheen Mountain has a peak of 385m AOD (above ordinance datum) which is located approximately 135m east of the site border and an approximate slope of 0.25m/m;
- Garfarretmoyle Mountain (Cloghercor South) has a peak of 301m AOD and an approximate slope of 0.25m/m;
- Gaffaretcor Mountain has a peak of 292m AOD which is located approximately 55m south of the site border and an approximate slope of 0.5m/m;
- Derkbeg Hill has a peak of 332m AOD which is located approximately 50m southeast of the site border and an approximate slope of 0.25m/m; and
- Cleengort Hill has a peak of 236m AOD which is located approximately 235m northwest of the site border and an approximate slope of 0.15m/m.

The site ranges from 0m at the Gweebarra river to a maximum topographic high of approximately 365m in the northeast of the site.

9.3.4 Surface Water Hydrology

The purpose of this section is to describe the surface water environment including the following:

- Catchment Overview;
- Site Surface Water Features and Drainage;
- Surface Water Quality;

- Assessment of Hydrometric Data;
- Surface Water Abstractions; and
- Flood Risk Assessment (FRA).

Catchment Overview

The site is located within the Gweebarra-Sheephaven Water Framework Directive (WFD) catchments (hydrometric area) which covers an area of 1451km^2 in west Donegal. These catchments are further subdivided into sub-catchments with the site located within the Gweebarra_SC_010 WFD sub-catchment and the Mulnamin_Beg_010 WFD river sub-basin which covers an area of 32.4km^2. All of these waters are of moderate to steep gradient and higher flow rate, representing natural watercourses typical eroding/upland rivers (FW1), that are actively eroding, unstable, where there is little or no deposition of fine sediment. Streams are largely unaltered and do not suffer from urban encroachment and associated point sources of pollution.

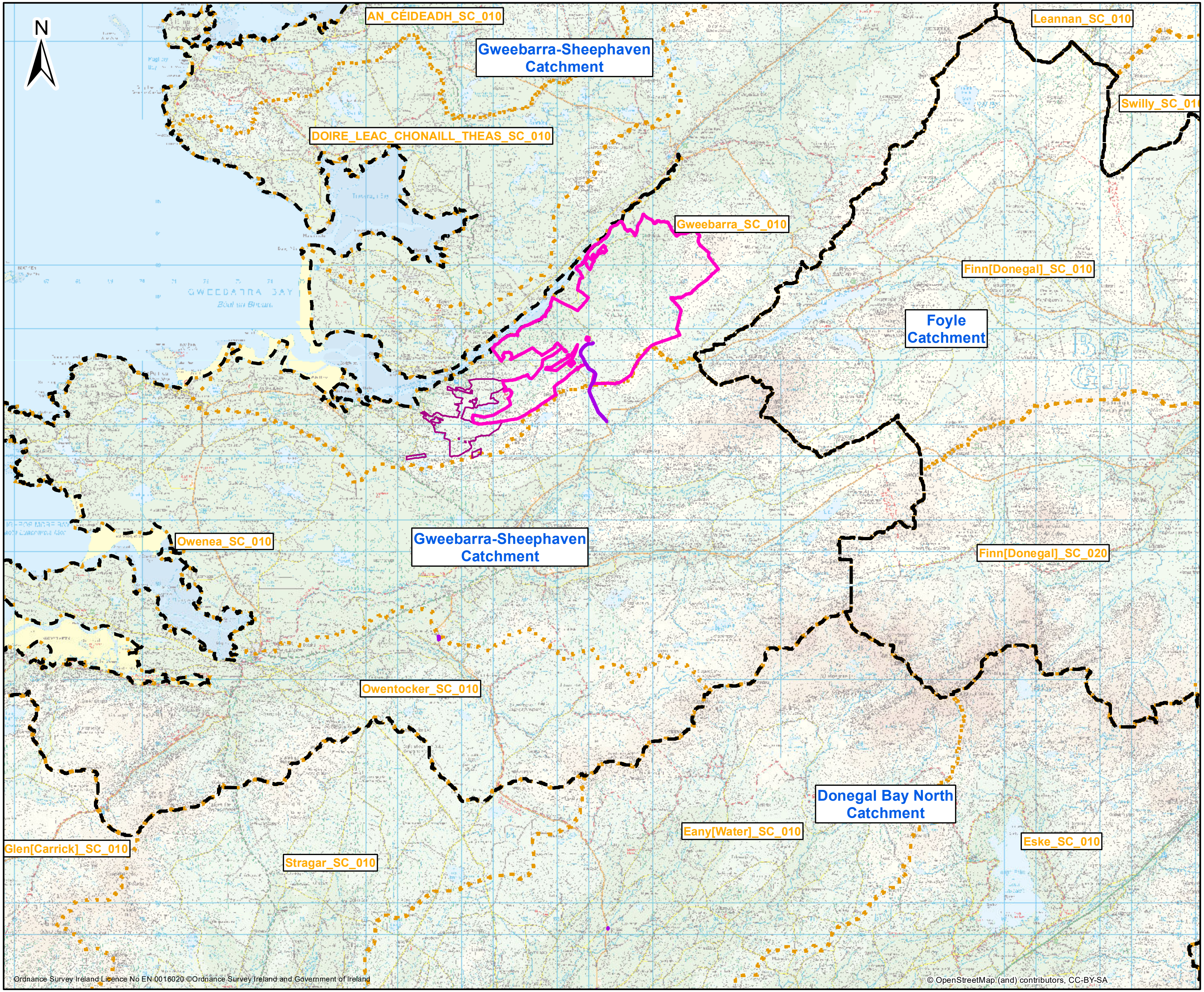
A catchment, also referred to as a drainage basin and watershed, is a topographic area that collects and discharges surface streamflow through one outlet or mouth. The catchment boundary is the dividing land where surface drainage flows toward a given stream from land where it drains into a separate stream. The regional natural surface water drainage pattern, in the environs of the proposed project is shown on Figure 9-3 'Regional Catchment Delineation Overview'.

Minor roadworks are proposed for the TDR route. It is proposed that the turbine components will be delivered to the site via Killybegs Port in southwest County Donegal as shown in Figure 2-3. The route heads north from the port in Killybegs on the R263 to the N56 where it turns eastwards. The route then continues generally eastwards on the N56 to the junction with the R262, where it makes a northerly turn in the direction of Glenties. The current application includes the proposed temporary works along the public road corridor of the turbine delivery route. At the end of the construction phase, all areas which were given temporary hardcore surfaces will be reinstated by being covered in topsoil and reseeded. TDR works are located in the catchments of the Owentocker River (Turbine Changeover), Coastal streams (near Killybegs) and Eany Water (Inver to Glenties road).

Site Surface Water Features and Drainage

During the desk review and site surveys, a number of surface water features were noted on the site. The drainage hierarchy with respect to these features is displayed in

Figure 9-4. These features, and monitoring points in the area of the proposed wind farm are illustrated in Figure 9-5.



Legend *

- Proposed Wind Farm Site Boundary
- Turbine Delivery Route works
- Biodiversity Enhancement lands
- WFD - Catchments
- WFD - Subcatchments

* all land identified is within Boundary of the Proposed Project

0 1 2 3 4
Kilometres

NOTES

1. FIGURED DIMENSIONS ONLY TO BE TAKEN FROM THIS DRAWING
2. ALL DRAWINGS TO BE CHECKED BY THE CONTRACTOR ON SITE
3. ENGINEER TO BE INFORMED OF ANY DISCREPANCIES BEFORE ANY WORK COMMENCES
4. ALL LEVELS RELATE TO ORDNANCE SURVEY DATUM AT MALIN HEAD

A	03/03/2023	Final issue	S.P	J.D
Issue	Date	Description	By	Chkd.

Client:
Cloghercor Wind Farm ltd.

Project:
Cloghercor Wind Farm

Title:
Figure 9-3:
Regional Catchment Delineation Overview

Scale @ A4: 1:150,000

Prepared by: S.Pezzetta
Checked: J.Dillon
Date: March 2023

Project Director: O.Fitzpatrick

TOBIN
CONSULTING ENGINEERS
Consulting, Civil and Structural Engineers,
Block 10-4, Blanchardstown Corporate Park,
Dublin 15, Ireland.
tel: +353-(0)1-8030406
fax:+353-(0)1-8030409
e-mail: info@tobin.ie
www.tobin.ie

10798 - 013 - CAs - S.Cas - TOB - A

Draft: A

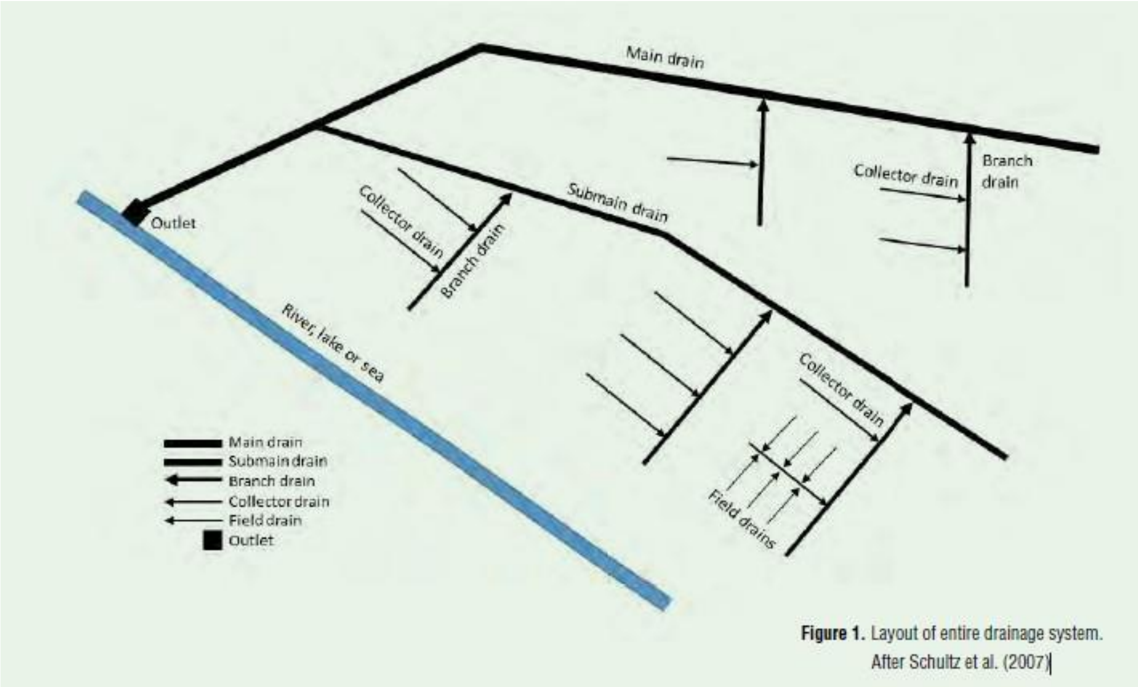


Figure 9-4:Site Drainage Hierarchy

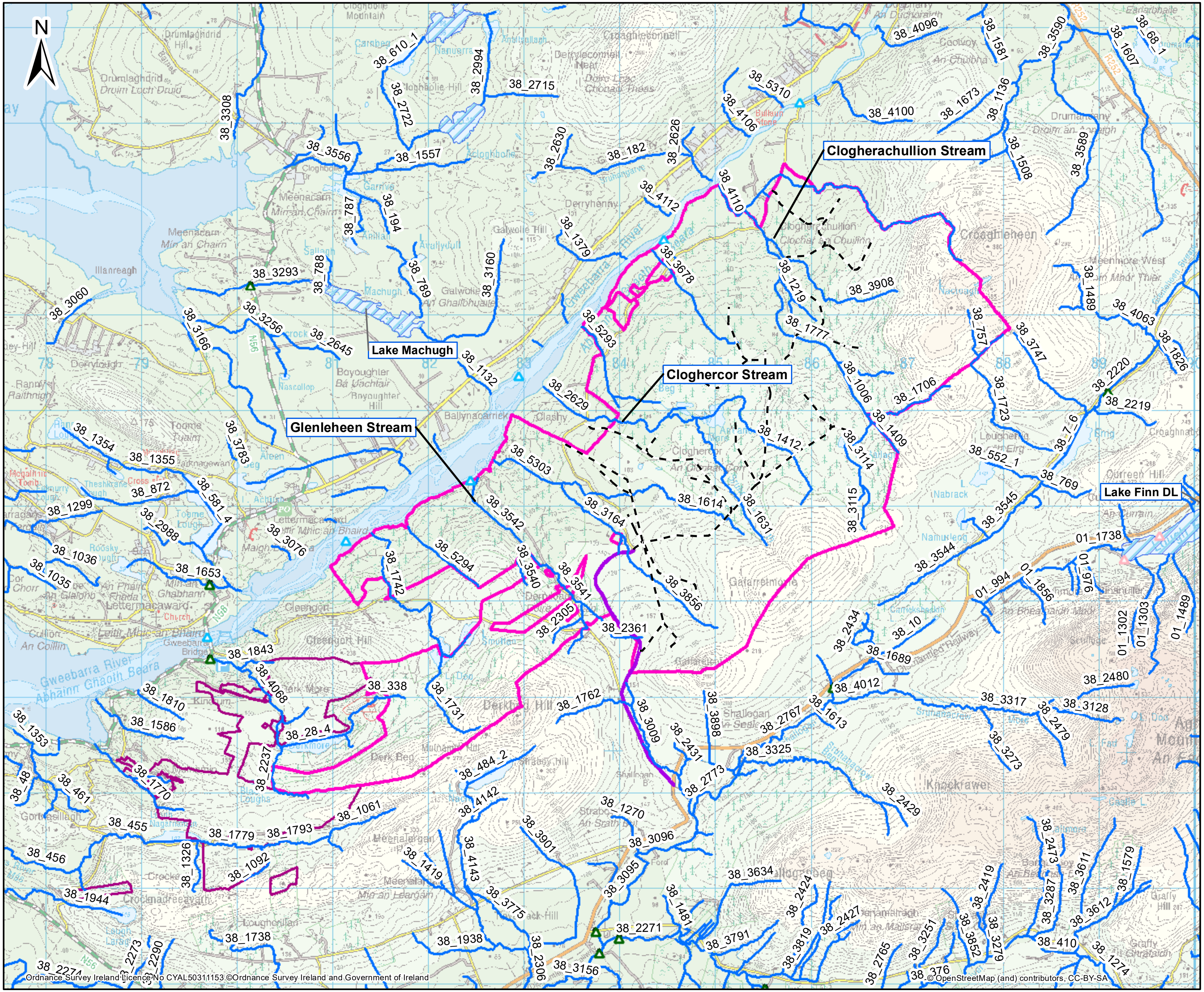
The surface waterbodies present within and alongside the proposed project consist of one transitional waterbody, eight lakes waterbodies and 12 rivers waterbodies with multiple tributaries. These are presented in Figure 9-5 below.

All river waterbodies, except one, flow in a general southeast to northwest direction into the Gweebarra Estuary. An unnamed stream and it's tributary in the north-eastern corner of the site flow in a northwest to south east direction into the Glenleheen (Stream), which flows northwards and meets the Gweebarra river and eventually flows into the Gweebarra Estuary to the north of the site. Although these waterbodies are not within the site boundaries, all rivers and streams downgradient of these unnamed streams are hydraulically connected to the site. It is noted that all the river waterbodies within the site are collectively identified as the Mulnamin Beg 10 subcatchment and the two river waterbodies in the north part of the site are part of the Glenleheen Stream_10 river system.

Derkmore Lough and a smaller unnamed lake are located to the west of the site boundary but are not hydrologically connected to the proposed wind farm site. Golden Eagle habitat enhancement is proposed in the Derkmore Catchment – See Chapter 6 Biodiversity. Aneane More (Lough) and Aneane Beg (Lough) are located downgradient of T6 and T11 towards the centre of the site. A small lake, Lough Sallagh, is located to the south of T9.

Table 9-4: Waterbodies present within and alongside the wind farm site boundary

Transitional waterbodies	Lakes	Rivers
Gweebarra Estuary	Lake Doo Lake Smuttan Nacroagh (Lough) Sallagh (Lough) Aneane More (Lough) Aneane Beg (Lough) 3 unnamed lakes/ponds	River waterbodies which flow northwest from the site into the Gweebarra Estuary – collectively identified as Mulnamin Beg 10: 1 unnamed river with 2 named tributaries (Clochar An Chuilinn and Loch Eirg) and 7 unnamed tributaries 3 unnamed streams 1 unnamed stream with 1 unnamed tributary An Clochar Corr with 3 unnamed tributaries 1 unnamed stream with 2 unnamed tributaries Doire Luacháin with 3 unnamed tributaries Cleengort with 1 unnamed tributary Derk More Mulnamin Beg River waterbodies which flow southeast from the site into the Glenleheen (Stream) – collectively identified as Glenleheen Stream 10: 1 unnamed stream with 1 unnamed tributary



Legend*

- Proposed Wind Farm Site Boundary
- Turbine Delivery Route works
- Biodiversity Enhancement lands
- Site Roads
- EPA - Rivers
- WFD - Lake Water Bodies

Surface Water Monitoring Locations

- River Station
- Lake Station
- Transitional Station

*all land identified is within Boundary of the Proposed Project

0 0.5 1 1.5 2
Kilometres

NOTES
1. FIGURED DIMENSIONS ONLY TO BE TAKEN FROM THIS DRAWING
2. ALL DRAWINGS TO BE CHECKED BY THE CONTRACTOR ON SITE
3. ENGINEER TO BE INFORMED OF ANY DISCREPANCIES BEFORE ANY WORK COMMENCES
4. ALL LEVELS RELATE TO ORDNANCE SURVEY DATUM AT MALIN HEAD

Issue	Date	Description	By	Chkd.
A	08/03/2023	Final issue	S.P	J.D

Client: Cloghercor Wind Farm ltd.

Project: Cloghercor Wind Farm

Title: Figure 9-5: Existing Surface Water Features and EPA Surface Water Monitoring Locations

Scale @ A4: 1:50,000

Prepared by: S.Pezzetta | Checked: J.Dillon | Date: March 2023

Project Director: O.Fitzpatrick

TOBIN CONSULTING ENGINEERS
Consulting, Civil and Structural Engineers,
Block 10-4, Blanchardstown Corporate Park,
Dublin 15, Ireland.
tel: +353-(0)1-8030406
fax:+353-(0)1-8030409
e-mail: info@tobin.ie
www.tobin.ie

Draft: A

10798 - 014 - RI - W.ML - TOB - A

The upper reaches of the small streams, particularly in the south east of the site are ephemeral. This means that they are dry during periods of low rainfall i.e., the summer months. Generally, the streams on site are eroding upland streams in their youthful stages as they are proximal to their sources (Croaghleheen and Garfarretmoyle). Where small streams meet existing road crossings, they are managed using culverts typically between 0.4m and 0.6m in width. The streams on site vary in size but are usually less than 1m in width, and normally c. 0.2 to 0.6m deep.

The afforested proposed wind farm site and adjacent lands also include man-made drains which flow into the watercourses mentioned above. These drains are primarily used to assist in the drainage of agricultural land-use and forestry. A number of streams and drainage ditches will be crossed by the proposed access tracks.

9.3.5 Flow data

According to the online EPA Maps, there are no long-term recording surface water flow gauging stations in or near the site, other than those monitoring the Gweebarra Estuary. Gauging stations that measure the flow of surface water features give an excellent indication of surface water response at the time of monitoring. Given the substantial variation of soils across the site, runoff rates vary.

Flow data for the rivers emerging from the proposed wind farm site were calculated based on the EPA HydroTool data, and these data are presented on Figure 9-6.

Historical hydrometrics data in the wind farm site is limited. There are no active hydrometric stations within the site. A baseline survey and a hydrometric monitoring program were undertaken as part of the EIAR. Equations to estimate low flows based on catchment areas (Martin and Cunnane, 1977, MacCarthaigh, 2002) are available and are calculated as part of the project. These equations are largely guided by the values plotted for the larger catchments, (Brogan and Cunnane, 2005).

The Site monitoring data corresponds to low flow and rainfall data suggests that the 95%ile and Dry Weather Flow (DWF) will be lower for the wind farm site. Applying the methodology as outlined in Mundal and Cunnane (2009) the Standard Annual Average Rainfall depth model (SAAR) and (Mean flow model) MF calculations are included in Table 9-5 below.

Table 9-5: Mean and 95%ile flow estimates

Location	Data source	DTM Area	95 %ile	50%ile	10%ile
Clogherachullion		*[Km2]*	*(m3/s)*	*(m3/s)*	*(m3/s)*
	Area	2.5			
	SAAR		0.005	0.044	0.19
	MF		0.007	0.061	0.14
	Flow Measurements		0.004	0.051	0.015

Flow monitoring was undertaken on the streams in June and July 2022. Variances in mean flow are accounted for by different flow monitoring periods and lower soil moisture deficits in the summer of 2022.

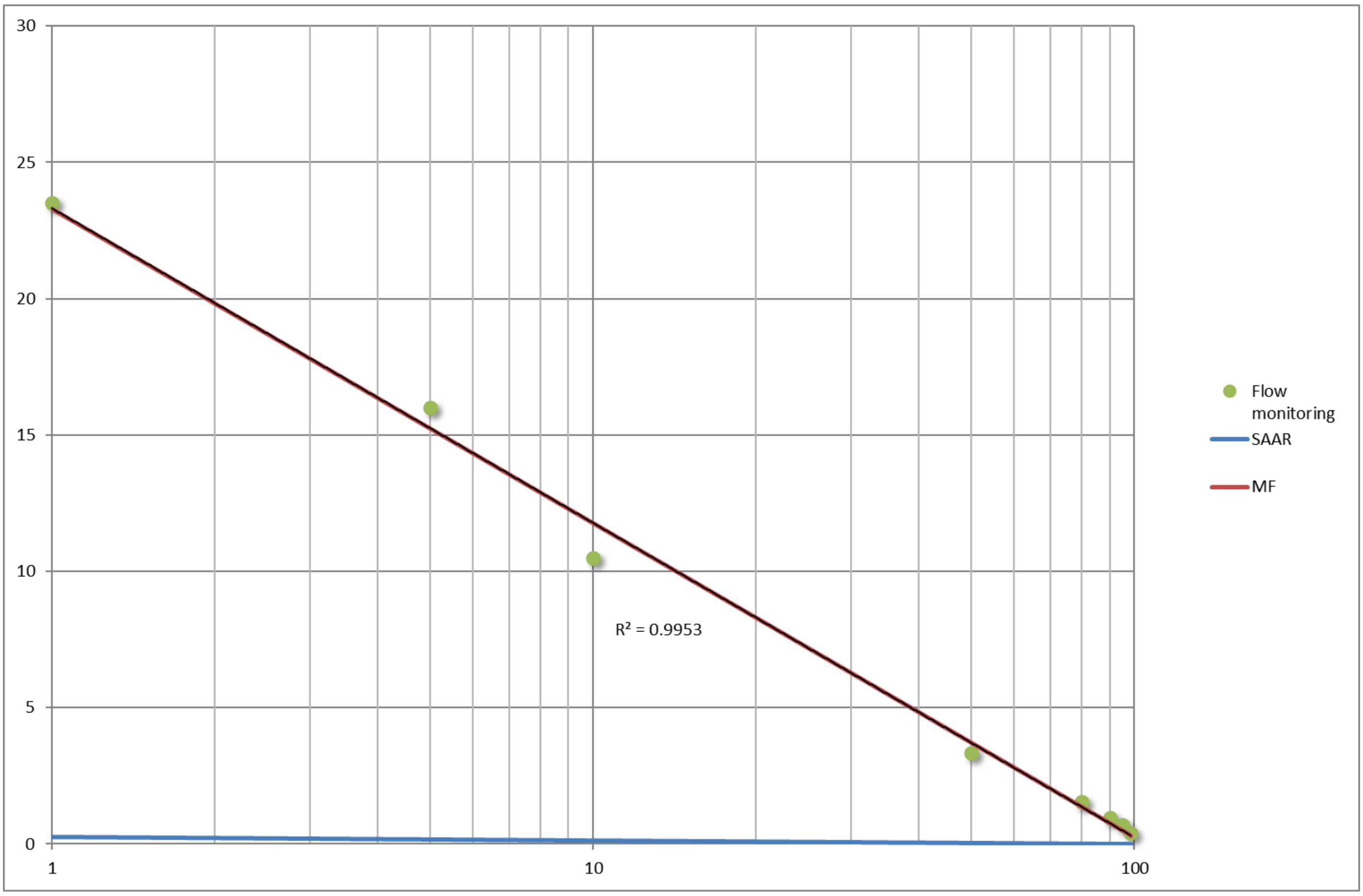


Figure 9-6: Flow monitoring - Downstream of proposed T5-T7 Road

Surface runoff results from rainfall, resulting in an increase in river flow with rainfall and a reduction when rainfall ceases. The baseflow recession is that part of the river flow which comes from groundwater storage. In general, there is a gradual decrease in groundwater discharge during dry periods. The groundwater storage of the bedrock and shallow subsoils (10-7 to 10-8 m/sec) is low. As a consequence, run off from the proposed wind farm site is primarily surface water runoff with a minor component of baseflow. Baseflow increases on the Clogherachullion stream due to the presence of small lakes on site. The main parameters involved in the estimation of recharge/groundwater infiltration are:

- annual rainfall;
- annual evapotranspiration;
- a recharge coefficient.

The recharge coefficient is estimated using Guidance Document GW5, Groundwater Working Group 2005. The recharge over the extreme and high vulnerability areas and moderately permeable till, peat and rock close to or at surface is in the order of 90% surface water runoff.

9.3.5.1 Surface Water Quality

The Environmental Protection Agency (EPA) has carried out biological water quality monitoring on selected watercourses all over Ireland since the early 1970's. In order to gain an understanding of historical water quality in the watercourses hydrologically connected to the proposed Cloghercor Wind Farm a review of the EPA's historical biological water quality monitoring was carried out.

The Environmental Protection Agency (EPA) regularly monitors water bodies in Ireland as part of their remit under the Water Framework Directive (WFD) (2000/60/EC). The WFD requires that the quality of all waterbodies is assessed in terms of five statuses; bad, poor, moderate, good and high, and that every waterbody is maintained at good status level or restored to at least good status level. These water quality statuses are based on:

- The biology of the waterbody i.e., the plants and animals living in the waterbody and within in the area of the waterbody;
- The chemical water quality i.e., the concentration levels of specific nutrients and harmful chemicals;
- The water quantity i.e., the water flow and water level; and
- The hydromorphology i.e., the physical habitat conditions of the waterbody

The water quality monitoring programmes are described in the 2021 EPA publication 'Water Quality in Ireland, 2020' and in the 2022 EPA fact sheet 'How We Assess Water Quality'.

In order to determine the biological quality of the river, the Q-scheme index is used whereby the analyst assigns a Biotic Index value (Q-Value) based on macro invertebrate results. The Biotic Index is a quality measurement for freshwater surface waterbodies that range from Q1 - Q5 with Q1 being of poorest quality and Q5 being pristine or unpolluted quality. The criteria used in the assessment of ecological water quality and their relationship to the water quality classes defined above are set out in Table 9-6 below. Subsequently, the Q-values for the rivers relevant to the proposed project based on this criteria are listed in Table 9-7 below.

There are no monitoring points within the proposed wind farm site boundary, however there are three monitoring stations down hydraulic gradient of the site. The first monitoring station is located on the Glenleheen Stream approximately 1.2km east-southeast from the north-eastern corner of the site. The second monitoring station is located on the confluence of the Glenleheen Stream and the Gweebarra River approximately 1km east-northeast from the north-eastern corner of the site. The third monitoring station is located at the confluence of the Gweebarra River and the Gweebarra Estuary approximately 2.15km north of the northern site boundary. All three monitoring stations are on waterbodies hydraulically connected to the proposed project site via two unnamed streams in the north-eastern corner of the site.

Table 9-6: Biotic Index of Water Quality

Biotic Index (Q-Value)	WFD Status	Pollution Status	Condition
Q5, Q4-5	High	Unpolluted	Satisfactory
Q4	Good	Unpolluted	Satisfactory
Q3-4	Moderate	Slightly polluted	Unsatisfactory
Q3, Q2-3	Poor	Moderately polluted	Unsatisfactory
Q2, Q1-2, Q1	Bad	Seriously polluted	Unsatisfactory

Table 9-7: Q-Values at various EPA monitoring stations in the study area

Monitoring Station Details			
WFD SubCatchments	Gweebarra_SC_010		
WFD River Sub Basin	Glenleheen Stream_010		Gweebarra_020/ Mulnamin_Beg_010
River	Glenleheen Stream		Gweebarra
Station Name	Glenleheen Stream - Bridge d/s Lough Errig	Glenleheen Bridge	Gweebarra - Bridge in Doocharry
Station Code	RS38G070200	RS38G070300	RS38G020300

Date	Q-Value		
1973			Q5
1980			Q5
1985			Q5
1990	Q4	Q5	Q4-5
1994		Q4-5	Q4-5
1997		Q4-5	Q5
2000		Q4-5	Q4-5
2003		Q4	Q5
2006		Q4	Q4-5
2009		Q4	Q4
2012		Q4	Q4
2015		Q4	Q4
2018		Q4	Q4
2021		Q4	Q3-4

Based on the data presented in the above tables, the overall water quality in the area surrounding Cloghercor Wind Farm has been of good to high status over the past 50 years, since regular monitoring commenced, with Q-values being consistently between Q4 and Q5.

The rivers, lakes and estuary associated with the proposed project have been assessed in terms of their respective WFD Status 2013-2018. All waterbodies are classified as having 'Good' status.

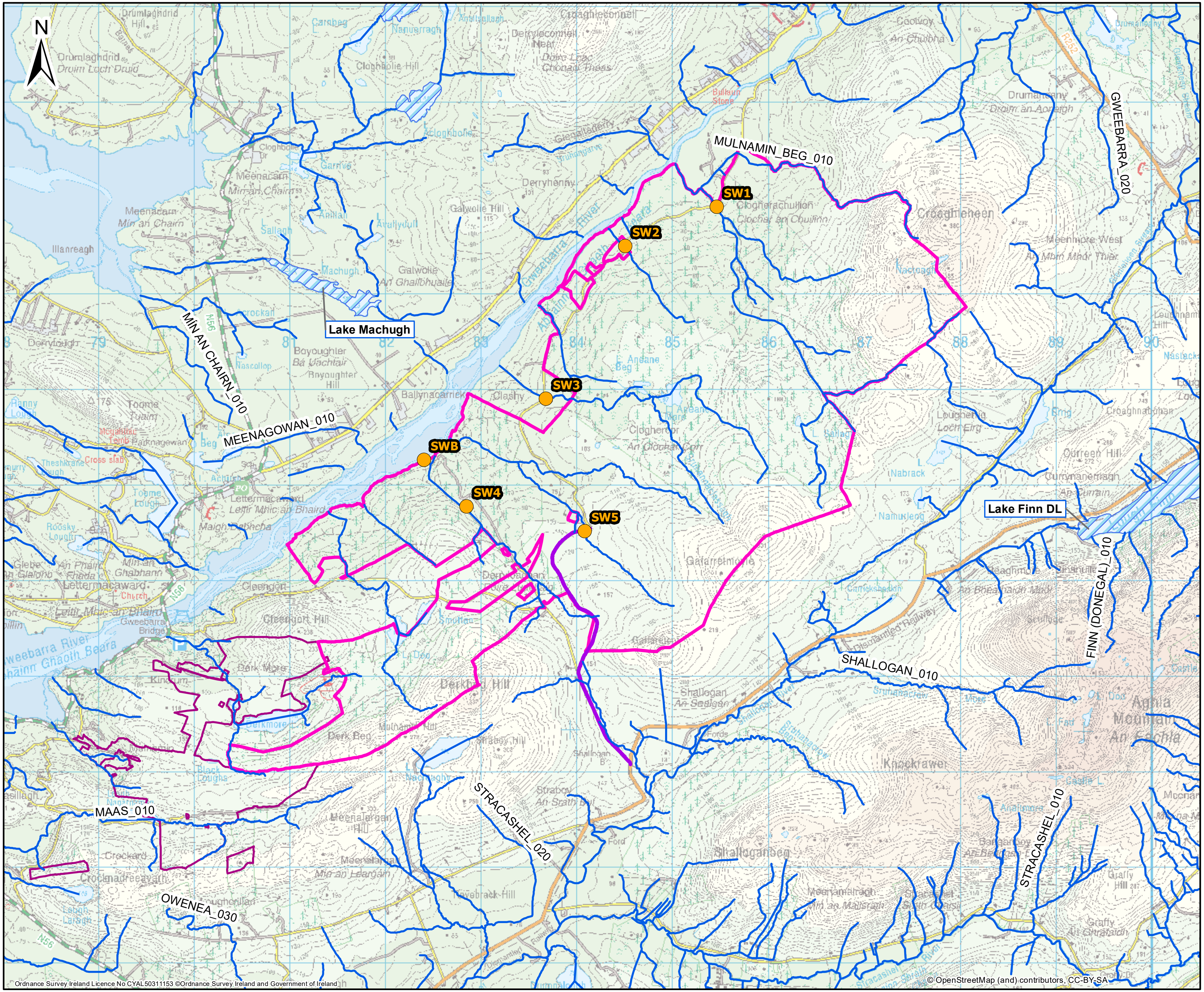
The EPA has also mapped waterbodies based on their risk of meeting WFD objectives by 2027. The risk of WFD objectives was determined by assessment of monitoring data, data on the pressures and data on the measures that have been implemented. Waterbodies that are at risk are prioritised for implementation of measures. This assessment was completed in 2020 by the EPA Catchments Unit in conjunction with other public bodies and was primarily based on monitoring data up to the end of 2018. In relation to the proposed project, all waterbodies within the wind farm site boundaries as well as the Gweebarra Estuary are under 'review' to verify if they will meet the WFD objectives. The Glenleheen Stream, including its unnamed tributaries in the north-eastern corner of the site, and the Gweebarra River are 'not at risk' of meeting the WFD objectives.

Surface Water Quality – Field Studies

Surface water sampling was carried out on the proposed project t on three occasions in 2022. This involved five to six different surface water sampling points (SW1 to SW5, SWA, SWB and SWC) tested on each occasion. The location of each sampling point is shown in Figure 9-7 below. SW1, SW2, SW3, SW4 and SW5 were taken from streams located within the site boundary, while SWA, SWB and SWC were taken at various locations along the Gweebarra Estuary. SWA was taken approximately 0.7km north of the northern r proposed wind farm boundary.

Following collection of the samples on site, they were sent to Eurofins Chemtest Laboratories and ALS Environmental Ltd for testing against a suite of parameters. The results of these sampling programmes are summarised in Table 9-8.

Field hydrochemistry measurements of pH, electrical conductivity (µS/cm), Turbidity, and Dissolved Oxygen (DO, mg/L) were taken at locations across the proposed project site (in November 2021, February 2022, July 2022 and October 2022. The results are listed in Table 9-9 below. Electrical conductivity values for the samples taken range from 69 – 121 µS/cm. This is indicative of surface water, which is mainly derived from precipitation, with limited groundwater input. The pH values at the proposed project site ranged from 6.2-7.3, with most pH values below 7, indicating surface waters which are generally slightly acidic. The pH of the surface waters is typical for an afforested area with peaty soils and underlying granite bedrock, along with limited granitic subsoils. Dissolved oxygen at the proposed project site ranges from 82 to 101% DO saturation typical of unpolluted, well oxygenated surface waters. Turbidity values range from <10 to 21 FNU. Higher values of turbidity are associated with precipitation events.



Legend*

- Proposed Wind Farm Site Boundary
- Turbine Delivery Route works
- Biodiversity Enhancement lands
- WFD - River Water Bodies
- WFD - Lake Water Bodies
- Surface Water Sampling Point Locations

*all land identified is within Boundary of the Proposed Project

0 0.5 1 1.5 2
Kilometres

NOTES
1. FIGURED DIMENSIONS ONLY TO BE TAKEN FROM THIS DRAWING
2. ALL DRAWINGS TO BE CHECKED BY THE CONTRACTOR ON SITE
3. ENGINEER TO BE INFORMED OF ANY DISCREPANCIES BEFORE ANY WORK COMMENCES
4. ALL LEVELS RELATE TO ORDNANCE SURVEY DATUM AT MALIN HEAD

Issue	Date	Description	By	Chkd.
A	08/03/2023	Final issue	S.P	J.D

Client: Cloghercor Wind Farm ltd.

Project: Cloghercor Wind Farm

Title: Figure 9-7: Location of Surface Water Sampling Points

Scale @ A4: 1:50,000

Prepared by: S.Pezzetta | Checked: J.Dillon | Date: March 2023

Project Director: O.Fitzpatrick

TOBIN CONSULTING ENGINEERS
Consulting, Civil and Structural Engineers, Block 10-4, Blanchardstown Corporate Park, Dublin 15, Ireland.
tel: +353-(0)1-8030406
fax:+353-(0)1-8030409
e-mail: info@tobin.ie
www.tobin.ie

Draft: A

10798 - 015 - RI - W.S.Pt - TOB - A

Table 9-8:Surface Water Field Monitoring Results (2022)

Parameter	Units	EU Directives for Salmonid Streams	Surface Water Regs	SW1			SW2			SW3			SW4		
			(as amended)	01-Feb	01-Jul	01-Oct	01-Feb	01-Jul	01-Oct	01-Feb	01-Jul	01-Oct	01-Feb	01-Jul	01-Oct
pH	**pH**	≥6, ≤9		6.4	6.5	6.5	7.1	6.8	6.7	6.1	6.3	6.3	6.3	6.2	6.2
Electrical Conductivity	**µS/cm**			112	121	101	72	80	76	74	69	80	90	82	95
Turbidity	**FNU**	NA		22	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
DO	**% saturation**	80- 120		92	88	93	86	96	94	91	90	87	101	93	90

Table 9-9: Surface Water Sampling Results (2022)

Parameter	Units	EU Directives for Salmonid Streams	Surface Water Regs 2007 (as amended)	SW1		SW2		SW3			SW4	SW5	SWA	SWB
				18/02	29/07	18/02	29/07	18/02	03/05	29/07	18/02	18/02	29/07	29/07
pH	**pH**	≥6, ≤9	Soft(3)Water 4.5< pH < 9.0	6.4		7.3		6.1			6.3	6.5		
Electrical Conductivity	**µS/cm**			110	129	70	82	70		97	90	110	83	586
Suspended Solids @105°C	**mg/l**	≤ 25		18	<5	<5.0	<5	13		<5	<0.5	<5.0	<5	<5
Chemical Oxygen Demand	**mgO_2/l**			28		17		21			17	22		
Chloride	**mg/l**			17		11		9			19	12		
Ammonium	**mg/l**	≤ 1	Good status ≤ 0.065 (mean) and ≤ 0.140 (95%ile)	0.12	0.03	<0.05	0.03	<0.05		<0.03	<0.05	<0.05	0.06	0.06
Nitrate	**mg/l**			2.2	<5.0	1.5	<5.0	<0.50		<5.0	<0.50	3	<5.0	<5.0
Nitrite	**mg/l**	≤0.05			<0.01		<0.01			<0.01			<0.01	<0.01
Total Oxidised Nitrogen	**mg/l**		≤2.6		<0.25		<0.25			<0.25			<0.25	0.68
Phosphorus (Total)	**mg/l**		≤0.025	<0.02		<0.02		<0.02			<0.02	<0.02		
Phosphate	**mg/l**		Lakes -Good status ≤ 0.025 (mean)	<0.20		<0.20		<0.20			<0.20	<0.20		
Orthophosphate as PO_4	**mg/l**		Good status ≤ 0.065 (mean) and ≤ 0.140 (95%ile)	<0.05	0.02	<0.05	0.02	<0.05		<0.02	<0.05	<0.05	0.02	0.04
EH >C10 - C20	**µg/l**								<10					
EH >C20 - C40	**µg/l**								<10					
EH >C6 - C10	**µg/l**								<10					
EH >C6 - C40	**µg/l**								<10					

The above results indicate that pH was mainly acidic across each of the different sampling points. The highest value recorded 7.3 at SW2 and the lowest pH was 6.44 recorded at SW1. Most samples were slightly acidic.

Electrical conductivity is a measure of the ability of water to pass an electrical current. Conductivity in water is affected by the presence of dissolved substances, chemicals and minerals such as chloride, nitrate, magnesium and calcium. Organic compounds like oil do not conduct electrical current very well and therefore have a low conductivity when in water. Conductivity is also affected by temperature: i.e., the warmer the water, the higher the conductivity. For this reason, conductivity is reported as conductivity at 25°C. Conductivity in streams and rivers is affected primarily by the geology of the area through which the water flows. Streams that run through areas with granite bedrock tend to have lower conductivity because granite is composed of more inert materials that do not ionize (dissolve into ionic components) when washed into the water. On the other hand, streams that run through areas with clay soils tend to have higher conductivity because of the presence of materials that ionize when washed into the water. Ground water inflows can have the same effects depending on the bedrock they flow through.

The lowest conductivity was recorded at SW4. SW4 had an electrical conductivity of 82µS/cm. The underlying bedrock at this location is granite which corresponds to the low conductivity values. The highest value was recorded in the Gweebarra where electrical conductivity was 550µS/cm and influenced by the brackish waters.

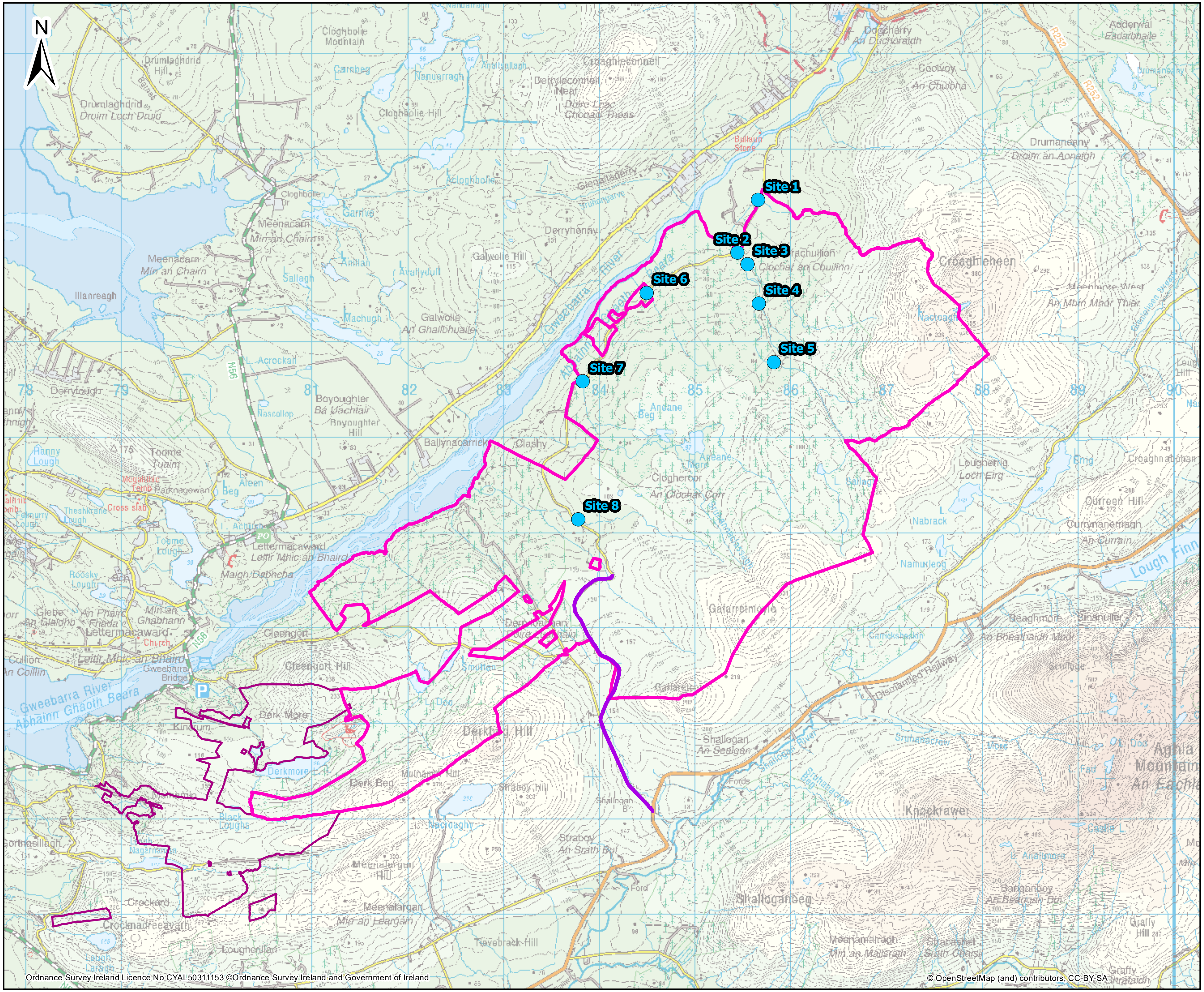
Each sampling location recorded relatively low suspended solid values. They were all within the below 25 mg/l. SW3 and SW4 were below the limit of detection (5mg/l). The highest number of suspended solids were noted in SW1 in the where the value was 18mg/l.

In SW1 Ammonia was 0.14mg/l. Nitrite was also below detection limits in all of the samples. There are no EU Directives listed for the other parameters, but the values recorded indicate no major concern with respect to surface water quality.

Phosphorus was below the detection limits in all samples. Chloride samples were within natural background concentrations.

Surface Water Quality – Aquatic Q value Field Studies

In September 2021, a macroinvertebrate baseline survey was undertaken in the study area – See Figure 9-8 and Appendix 6-2 of the EIAR. The aquatic survey involved the collection of kick samples at eight sampling locations. The collection of these kick samples allowed for the accurate collection of Q-Values as well as classifying the streams with a Small Streams Risk Score (SSRS). The SSRS is a biological risk assessment system for identifying rivers that are definitely 'at risk' of failing to achieve the 'good' water quality status goals of the Water Framework Directive (WFD). It was developed by the EPA in association with the Western River Basin District (WRBD) in 2006.



Legend *

- Proposed Wind Farm Site Boundary
- Turbine Delivery Route works
- Biodiversity Enhancement lands
- Kick Sample locations

*all land identified is within Boundary of the Proposed Project

0 0.5 1 1.5 2
Kilometres

NOTES
1. FIGURED DIMENSIONS ONLY TO BE TAKEN FROM THIS DRAWING
2. ALL DRAWINGS TO BE CHECKED BY THE CONTRACTOR ON SITE
3. ENGINEER TO BE INFORMED OF ANY DISCREPANCIES BEFORE ANY WORK COMMENCES
4. ALL LEVELS RELATE TO ORDNANCE SURVEY DATUM AT MALIN HEAD

A	08/03/2023	Final issue	S.P	J.D
Issue	Date	Description	By	Chkd.

Client:
Cloghercor Wind Farm ltd.

Project:
Cloghercor Wind Farm

Title:
Figure 9-8:
Kick Sample Locations

Scale @ A4: 1:50,000

Prepared by: S.Pezzetta | Checked: J.Dillon | Date: March 2023

Project Director: O.Fitzpatrick

TOBIN
CONSULTING ENGINEERS

Consulting, Civil and Structural Engineers,
Block 10-4, Blanchardstown Corporate Park,
Dublin 15, Ireland.
tel: +353-(0)1-8030406
fax:+353-(0)1-8030409
e-mail: info@tobin.ie
www.tobin.ie

Draft: A

10798 - 016 - K.S.Loc - S.BO - TOB - A

The SSRS method is a rapid field methodology for risk assessment that is based solely on macroinvertebrate indicators of water quality and their well understood response to pollution. Importantly the SSRS score indicates whether or not the stream is at risk from pollution and not the ecological health of the stream. The score is less than 6 at all locations. If the score is less than 6.5 the stream is considered to be at risk. The results of the sampling programme are shown in below.

Nine survey sites were, selected relevant to the proposed works areas including installation sites for turbines and road crossings. Sites were selected based on their location within and outside the proposed wind farm site boundary, available access, previous Q-Value Status from Environmental Protection Agency (EPA) surveys, and stream order, giving a good representation of the overall aquatic ecology throughout the study area.

These aquatic survey locations were not directly within the footprint of any proposed turbine. No surveys were conducted in the Gweebarra estuary which is located directly outside the site boundary. Rare / protected / conservation interest aquatic species such as Otter were also searched for at each survey site. The site locations are provided in the Table 9-10 below.

Table 9-10: Location of Sampling Sites within the proposed wind farm site

Sampling Site	Q-value	SSRS score	Water Framework Directive Ecological Status
1	4-5	3.2	High
2	5	3.2	High
3	4-5	2.4	High
4	4	4	Good
5	4-5	3.2	High
6	4-5	4	High
7	3	0	Moderate
8	4	1.6	Good
9	4-5	2.4	High

The macroinvertebrate communities of the site are indicative of good water quality however there is generally limited productivity in the streams due to the lack of suitable ecological niches.
The steep vegetated banks (many undercut) reduced the capacity of the stream to support macrophytes, and very high energy of the stream have limited the diversity and abundance of species present across all sites.

Many of the watercourses surveyed were small, shallow, high-energy, upland eroding streams draining afforested and or blanket bog areas. These featured cobble/boulder-dominated substrata which were often bedded in peat and had a lack (not absence) of finer gravels for spawning.

Assessment of Hydrometric Data
Hydrometric data is information on levels and flow of surface water (e.g., rivers) and groundwater (e.g., springs). Discharge refers to the volumetric flow rate of water that is transported through a given cross-sectional area. Hydrometric data is collected as part of the EPA's Hydrometric Programme at over 1,000 active hydrometric stations around the country.

It is noted that there were no active hydrometric stations located in the immediate environs of the proposed wind farm site. Although hydrometric stations do exist on watercourses down hydraulic gradient of the development, they include flows coming from a number of different tributaries. As such, they are not representative of the actual flows occurring at the site.

Runoff on the site is expected to be higher in the peaty areas. Surface water runoff or overland flow is the flow of water occurring on the ground surface when excess rainwater, stormwater, meltwater, or other sources, can no longer sufficiently infiltrate into the soil. HR Wallingford developed a number of UK Sustainable Drainage System tools (available at www.uksuds.com) including the Greenfield Runoff Rate Estimation Tool which was used to provide an estimation of runoff for the proposed wind farm site. When accessing runoff characteristics of the proposed wind farm site, it can be best described as an area with low infiltration, steep slopes and high rainfall. The Doocharry rainfall monitoring station operated by Met Éireann since 1981 collects daily rainfall levels and is located approximately 0.46km west of the northern section of the site. Data from this station indicates there is an average annual rainfall of approximately 1,600mm/yr.

However, the groundwater recharge dataset from the Geological Survey Ireland (GSI) indicates an effective rainfall (i.e., rainfall minus the amount of water which goes back into the atmosphere through evaporation and transpiration) is approximately 1,120mm/yr and <100mm/yr can infiltrate into the underlying soils and bedrock aquifer.

Surface Water Abstractions

The EPA Map Viewer provides information on the locations of surface water protection areas. These are in the form of:

- Drinking Water – Rivers;
- Drinking Water – Lakes;
- Geological Survey Ireland (GSI) Public Supply Source Protection Areas; and
- National Federation Group Water Schemes (NFGWS) Group Scheme Source Protection Areas.

There is no GSI public supply source protection areas, NFGWS group scheme source protection areas or protected lakes used for drinking water supplied. All the river waterbodies within the Mulnamin Beg 10 river system are protected under an Article 7 abstraction for drinking water license. There are no public supplies located within the river system.

Flood Risk Assessment

The Office of Public Works (OPW) provides information on flood risk throughout Ireland. This includes historical events as well as modelled flood extents for:

- Low probability events i.e., 1-in-1000 chance of occurring or being exceeded in any given year, also known as an Annual Exceedance Probability (AEP) of 0.1%;
- Medium probability events i.e., 1-in-a-100 chance of occurring or being exceeded in any given year, or an AEP of 1%; and
- High probability events i.e., 1-in-a-10 chance of occurring or being exceeded in any given year, or an AEP of 10%.

Based on the information provided by the OPW’s publicly available online tool Flood Maps, there are no past flood events within the proposed wind farm site boundary. The nearest historical flood event is a recurring flood from estuarine waters at Doocharry approximately 2.1km north of the northern section of the site.

The GSI winter 2015/2016 surface water flooding maps show areas of fluvial (rivers) and pluvial (rain) floods during the winter 2015/2016 flood event. The flood areas extents within the proposed wind farm site boundary presented in the dataset correspond with the extent of the various lake waterbodies. This indicates that the lakes are in localised topographically low areas and act as a drainage catchment for the surrounding area. The GSI also produced a model which calculated areas at risk of low, medium and high probability flood event. There are no such areas within the site boundary.

Flood extents for the various flood events were modelled under the Catchment Flood Risk Assessment and Management (CFRAM) Programme. Based on the model output, there is no risk of a flood event within the proposed wind farm site boundary, however it is possible that a model was not created for this area. The nearest possible CFRAM modelled flood is located along the Owenea River between Glenties and Ardara approximately 3.7km south of the southern section of the site.

The National Indicative Fluvial Mapping includes data for catchments greater than $5km^2$ for which flood maps were not produced under the CFRAM programme. This model does not show any areas at risk of a medium probability and a low probability flood event in the area of the proposed wind farm site. The closest is a small area along the north-western boundary of the site along the route of the Gweebarra river. There are no works proposed in this area and hence the flood extents will not impact on the proposed project.

Based on these modelled flood maps, it is estimated that the proposed wind farm site is not at risk of fluvial, pluvial or groundwater flooding. The natural topography of the site is such that flood waters would flow away from the site towards lands further downstream that are at lower elevations.

The Planning System and Flood Risk Management Guidelines (OPW/DoEHLG, 2009) classify electricity generating stations as "essential infrastructure" considered appropriate in Flood Zone C. The proposed wind farm has therefore been assessed against a 0.1% AEP MRFS flood (i.e., a 1000-year flood in a likely climate change scenario). The Flood Risk Assessment is provided in the Appendix 2-8.

9.3.6 Groundwater Hydrogeology

The information provided herein relates to the hydrogeology (groundwater) environment. It is provided to give context to the groundwater characteristics and flow patterns within and adjacent to the proposed project site. Groundwater is water that has infiltrated into the ground to fill the spaces between sediments and cracks in rock. An aquifer is an underground layer of groundwater-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand or silt), that can yield a usable quantity of water.

Aquifer Potential and Characteristics

The aquifer potential of a bedrock unit is determined by the groundwater productivity, which in turn is determined based on hydraulic characteristics compiled from borehole data throughout the country. The GSI categorises the aquifer bodies into Regionally Important Aquifers, Locally Important Aquifers and Poor Aquifers. These are then subcategorised to create a total of seven bedrock aquifer categories and two sand and gravel aquifer categories.

Reference to the GSI National Aquifer Map for the study area indicates that the proposed wind farm site is predominantly underlain by a Poor Aquifer - Bedrock which is Generally Unproductive except for Local Zones (Pl). The southern area of the site is underlain by a Poor

Aquifer - Bedrock which is Generally Unproductive (Pu) and a Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones (LI). The underlying bedrock aquifer map for the wind farm site is shown in Figure 9-9. The subsoil deposits overlying the bedrock are not considered to be of sufficient lateral extent or depth to represent an aquifer body. The aquifer characteristics of the underlying aquifers are summarised in Table 9-11 below. Refer to Chapter 8 Land, Soils and Geology of this EIAR for detailed information on the associated bedrock.

Table 9-11: Bedrock Aquifer Classification and Characteristics

Aquifer Classification	Productivity	Bedrock	Hydrostratigraphic Rock Unit Group	Karst Features
Locally Important Aquifer (LI)	Bedrock which is moderately productive only in local zones	Falcarragh Limestone Formation	Precambrian Marbles	yes
Poor Aquifer (Pl)	Bedrock which is generally unproductive except for local zones	Metadolerite	Precambrian Quartzites, Gneisses and Schists	No
		Sessiagh-Clonmass Formation		
		Thorr Granite Migmatitic Facies		
		Main Donegal Granite	Granites and other Igneous Intrusive rocks	
Poor Aquifer (Pu)	Bedrock which is generally unproductive	Upper Falcarragh Pelite Formation	Precambrian Quartzites, Gneisses and Schists	No

The Falcarragh Limestone Formation is the most productive bedrock aquifer within the proposed wind farm site boundaries and underlies approximately 0.134km^2 of the site ownership boundary. There is no proposed development in the limestone formation. The remaining bedrock types are classified as poor which is typical for granites and other igneous intrusive rocks.

Groundwater bodies are the groundwater management unit under the Water Framework Directive (WFD). Groundwater bodies are subdivisions of large geographical areas of aquifers so that they can be effectively managed in order to protect the groundwater and linked surface waters. A groundwater body is defined as a distinct volume of groundwater, including recharge and discharge areas with little flow across the boundaries.

The proposed wind farm site is located within the Northwest Donegal groundwater body (GWB). The GSI GWB description (2004) characterises the Donegal Granites and the Precambrian Quartzites, Gneisses and Schists in the GWB as having low yields. These rocks are likely to have low specific capacity, low storativity and low transmissivity in the range of 20 – 30m^2/d, although higher values may be achieved in faulted zones. The Precambrian Marbles are expected to be slightly more productive than the surrounding rocks, but there is no aquifer characteristic data available for these particular marbles.

The Precambrian Marbles elsewhere in Donegal have recorded yields of 2 – 1090m^3/d with an average yield of 202m^3/d from 15 wells, a transmissivity value of approximately 11 to 12 m^2/d and a specific capacity ranging between 0.1 – 165m^3/d/m. The Precambrian Marbles in the Culdaff area in north Donegal have excellent yields and provide 523m^3/d to the Culdaff Water Supply Scheme. Karstification is known to occur in these rocks e.g., a fractured cavity recorded in the Culdaff WSS borehole log and the Pollnapaste Cave which is a Geological Heritage Site located approximately 1.0km west of the south-western site boundary and is not hydraulically connected to proposed project.

Groundwater Quality

The GSI GWB description (2004) for the Northwest Donegal GWB states that there is no hydrochemical data available within this particular GWB. However, hydrochemical data is provided under the national classification for the various hydrostratigraphical rock units within the GWB. This information is summarised in Table 9-12 below. The GSI notes that minerals present in granite are generally acidic and hence corrosion and leaching of metals such as iron and manganese may be problematic. Radon and Uranium are also associated with granitic bodies.

Table 9-12: Rock unit hydrochemical signature data

Rock Unit	Alkalinity (mg/l $CaCO_3$)	Total Hardness (mg/l)	Electrical Conductivity (uS/cm)
Granites and Other Igneous Intrusive Rocks	14 – 400, mean 168	46 – 412, mean 200	160 – 752, mean 446
Precambrian Quartzites, Gneisses and Schists	43 – 298, mean 179	103 – 304, mean 183	317 – 1017, mean 495

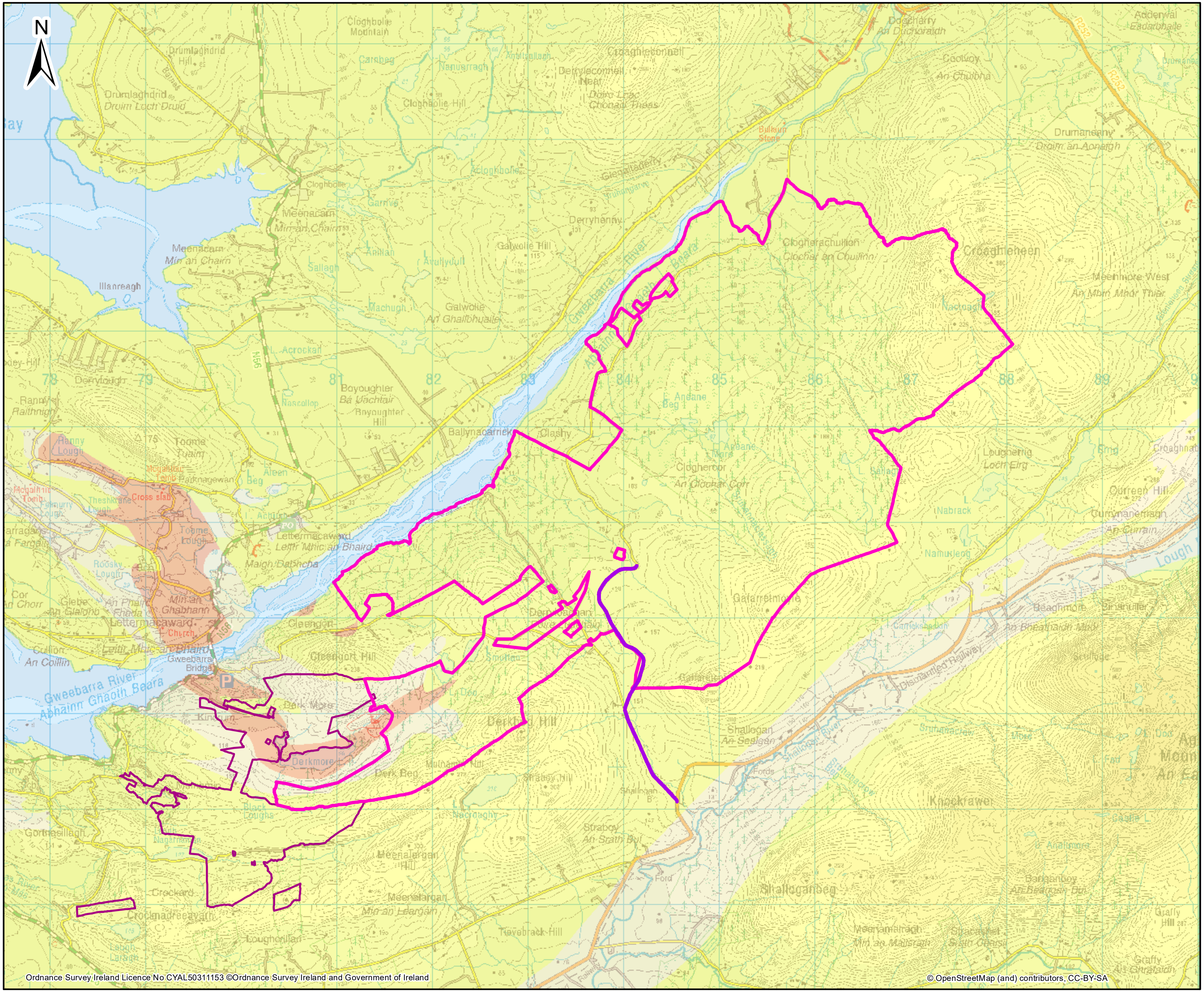
The WFD groundwater quality status classifications are based on an assessment of the point and diffuse sources in the area that may affect groundwater quality. The WFD requires Member States to designate these waterbodies so that each one achieves good chemical and good quantitative status. The Ground Waterbody WFD Status 2013-2018 for the Northwest Donegal groundwater body is described as 'good'.

The WFD also classifies each groundwater body in terms of its risk of failing to meet the WFD objectives by 2027. The risk of not meeting WFD objectives was determined by assessment of monitoring data, data on the pressures and data on the measures that have been implemented. Waterbodies that are At Risk are prioritised for implementation of measures. This assessment was completed in 2020 by the EPA Catchments Unit in conjunction with other public bodies and was primarily based on monitoring data up the end of 2018. The Northwest Donegal GWB is classified as 'Not at risk'.

Given that the GWB at the proposed project has 'Good' status and is 'Not at Risk', overall, based upon the EPA and WFD data the groundwater quality is good. Due to the hydraulic connectivity of the Pollnapaste Cave karst feature and direct access which surface water has to groundwater through this feature, there is a potential for discharge into and subsequent contamination of groundwater outside of the proposed project site boundary.

Groundwater Levels and Groundwater Flow

Water levels in the Northwest Donegal GWB are expected to be shallow (0 – 8m below ground level) and groundwater gradients are expected to be steep. Groundwater flows are expected to occur primarily within the broken and weathered zone in the upper 3m of the bedrock aquifer, in a zone of interconnected fissuring approximately 10m thick and in a zone of isolated poorly connected fissuring typically less than 150m. Groundwater flow paths are considered to be short i.e. 30 – 300m in length and the main discharges from the bedrock aquifers are to rivers and streams crossing the GWB, however baseflow to rivers and streams is relatively low (GSI, 2004). On a regional scale, the groundwater flow direction is generally a subdued reflection of surface water drainage. It is assumed that groundwater flow would mirror topography, and local flows are likely to be varied reflecting the local drainage patterns.



Legend ✱

- Proposed Wind Farm Site Boundary
- Turbine Delivery Route works
- Biodiversity Enhancement lands

Aquifer Bedrock

- LI - Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones
- PI - Poor Aquifer - Bedrock which is Generally Unproductive except for Local Zones
- Pu - Poor Aquifer - Bedrock which is Generally Unproductive

✱ all land identified is within Boundary of the Proposed Project

0 0.5 1 1.5 2
Kilometres

NOTES

1. FIGURED DIMENSIONS ONLY TO BE TAKEN FROM THIS DRAWING
2. ALL DRAWINGS TO BE CHECKED BY THE CONTRACTOR ON SITE
3. ENGINEER TO BE INFORMED OF ANY DISCREPANCIES BEFORE ANY WORK COMMENCES
4. ALL LEVELS RELATE TO ORDNANCE SURVEY DATUM AT MALIN HEAD

A	08/03/2023	Final issue	S.P	J.D
Issue	Date	Description	By	Chkd.

Client:
Cloghercor Wind Farm ltd.

Project:
Cloghercor Wind Farm

Title:
Figure 9-9:
Aquifer Bedrock

Scale @ A4: 1:50,000

Prepared by: S.Pezzetta
Checked: J.Dillon
Date: March 2023

Project Director: O.Fitzpatrick

TOBIN
CONSULTING ENGINEERS
Consulting, Civil and Structural Engineers,
Block 10-4, Blanchardstown Corporate Park,
Dublin 15, Ireland.
tel: +353-(0)1-8030406
fax:+353-(0)1-8030409
e-mail: info@tobin.ie
www.tobin.ie

Draft: A

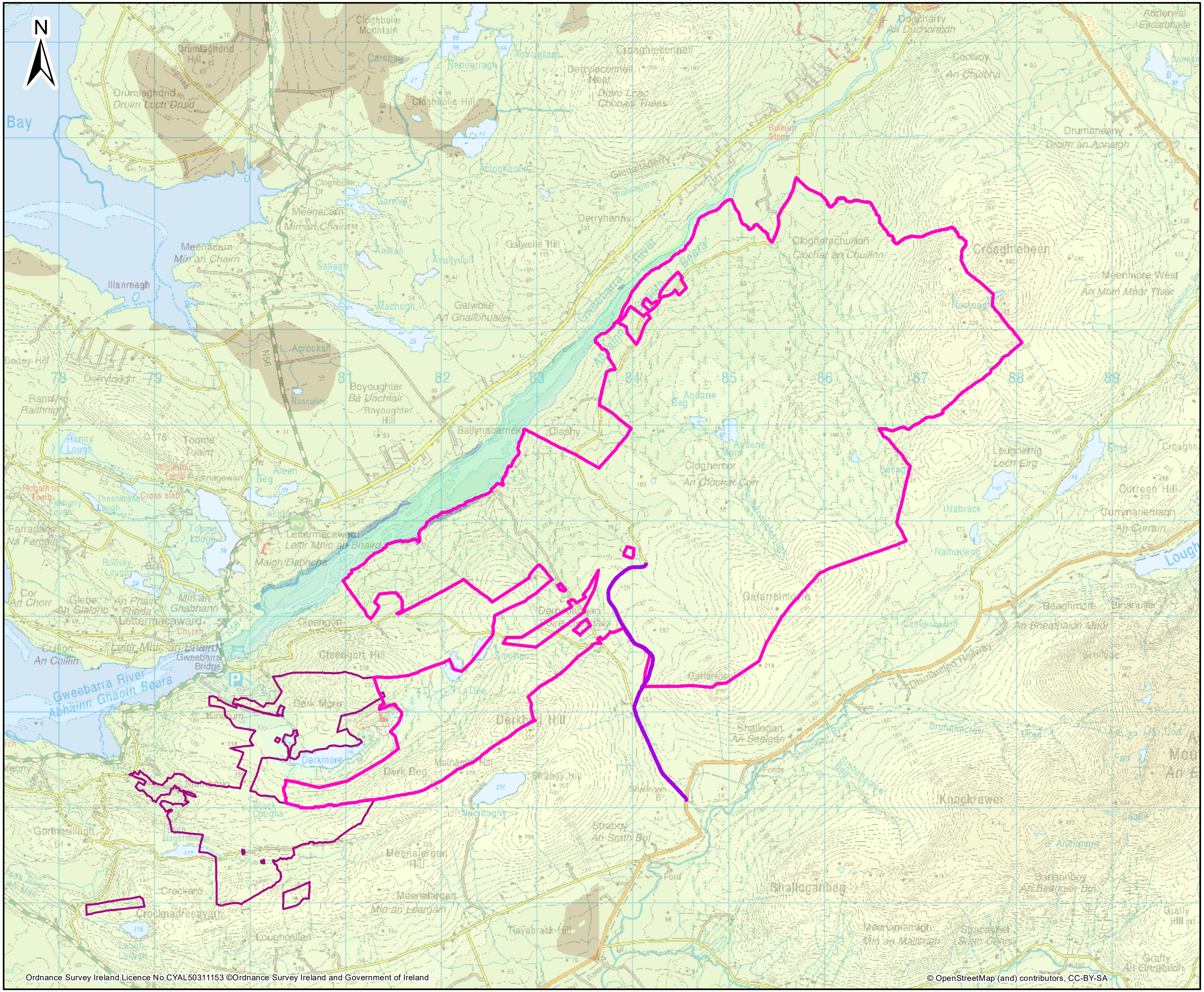
10798 - 017 - Aq.B - S.BO - TOB - A

On a local site scale, it is assumed that groundwater flow is towards local drains and streams, reflecting the general flow direction of the various river waterbody catchments.

Groundwater Recharge

The GSI estimates groundwater recharge rates throughout the country which are displayed on the online map viewer. Analysis of these maps provides a good representation of the groundwater recharge for the proposed project. The recharge values vary greatly across the site. The highest recharge rates are found where bedrock is close to the surface or where karst features are present and the lowest recharge rates are found in the peaty areas of the site or where there is low permeability subsoil. Groundwater recharge across the proposed wind farm site is shown in Figure 9-10.

A recharge cap i.e., the maximum amount which the underlying bedrock aquifer can accept, is applied to the full extent of the proposed wind farm site. This is 100mm/yr over the Donegal Granites and the Precambrian Quartzites, Gneisses and Schists and 200mm/yr over the Precambrian Marbles. Consequently, any rainfall greater than this amount will flow overland into the surface waterbodies.



Legend *

- Proposed Wind Farm Site Boundary
- Turbine Delivery Route works
- Biodiversity Enhancement lands

Groundwater Recharge - Annual Recharge (mm)

- 1001-1400 mm
- 901-1000 mm
- 801-900 mm
- 701-800 mm
- 601-700 mm
- 551-600 mm
- 301-350 mm
- 251-300 mm
- 201-250 mm
- 151-200 mm
- 101-150 mm
- 51-100 mm
- 1-50 mm

* all land identified is within Boundary of the Proposed Project

0 0.5 1 1.5 2
Kilometres

NOTES

1. FIGURED DIMENSIONS ONLY TO BE TAKEN FROM THIS DRAWING
2. ALL DRAWINGS TO BE CHECKED BY THE CONTRACTOR ON SITE
3. ENGINEER TO BE INFORMED OF ANY DISCREPANCIES BEFORE ANY WORK COMMENCES
4. ALL LEVELS RELATE TO ORDNANCE SURVEY DATUM AT MALIN HEAD

A	08/03/2023	Final issue	S.P	J.D
Issue	Date	Description	By	Chkd.

Client:
Cloghercor Wind Farm ltd.

Project:
Cloghercor Wind Farm

Title:
Figure 9-10:
Groundwater Recharge

Scale @ A4: 1:50,000

Prepared by: S.Pezzetta
Checked: J.Dillon
Date: March 2023

Project Director: O.Fitzpatrick

TOBIN
CONSULTING ENGINEERS
Consulting, Civil and Structural Engineers,
Block 10-4, Blanchardstown Corporate Park,
Dublin 15, Ireland.
tel: +353-(0)1-8030406
fax:+353-(0)1-8030409
e-mail: info@tobin.ie
www.tobin.ie

10798 - 019 - GRD.R - S.BO - TOB - A

Draft: A

Groundwater Vulnerability

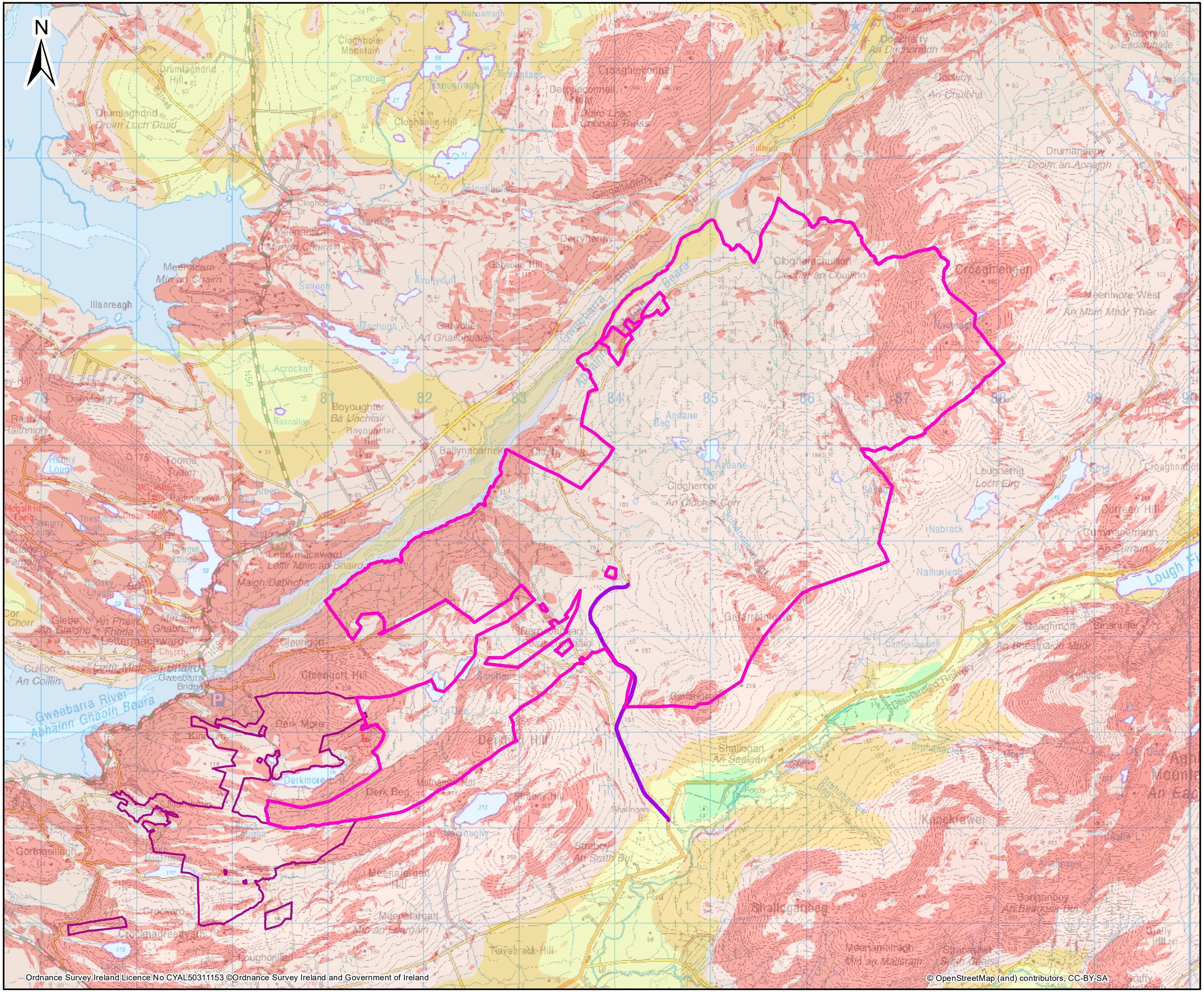
Groundwater vulnerability represents the intrinsic geological and hydrogeological characteristics that determine how easily groundwater may be contaminated by activities at the surface. Vulnerability depends on the quantity of contaminants that can reach the groundwater, the time taken by water to infiltrate to the water table and the attenuating capacity of the geological deposits through which the water travels. These factors are controlled by the type of subsoils that overlie the groundwater, the way in which the contaminants recharge the geological deposits (whether point or diffuse) and the unsaturated thickness of geological deposits from the point of contaminant discharge.

Groundwater is most at risk where the subsoils are absent or thin and in areas of karstic limestone. The Groundwater Vulnerability Map (Figure 9-11) is based on the type and thicknesses of subsoils (sands, gravels, glacial tills (or boulder clays), peat, lake and alluvial silts and clays) and the presence of karst features. Groundwater that readily and quickly receives water (and contaminants) from the land surface is considered to be more vulnerable than groundwater that receives water (and contaminants) more slowly and consequently in lower quantities. Groundwater vulnerability is classified as follows:

- Rock at or near surface or karst (X);
- Extreme (E);
- High (H);
- Moderate (M); and
- Low (L).

A detailed description of the vulnerability categories can be found in the Groundwater Protection Schemes document (DELG/EPA/GSI, 1997) and in the draft GSI Guidelines for Assessment and Mapping of Groundwater Vulnerability to Contamination.

The proposed wind farm site and the majority of the surrounding area is predominantly categorised as having rock at or near surface, extreme groundwater vulnerability. This reflects the thin soil layer and numerous bedrock outcrops throughout the site and is typical for mountainous areas.



Legend ✱

- Proposed Wind Farm Site Boundary
- Turbine Delivery Route works
- Biodiversity Enhancement lands

Groundwater Vulnerability

- Rock at or near Surface or Karst
- Extreme
- High
- Moderate
- Low
- Water

✱ all land identified is within Boundary of the Proposed Project

0 0.5 1 1.5 2

Kilometres

NOTES

1. FIGURED DIMENSIONS ONLY TO BE TAKEN FROM THIS DRAWING
2. ALL DRAWINGS TO BE CHECKED BY THE CONTRACTOR ON SITE
3. ENGINEER TO BE INFORMED OF ANY DISCREPANCIES BEFORE ANY WORK COMMENCES
4. ALL LEVELS RELATE TO ORDNANCE SURVEY DATUM AT MALIN HEAD

Issue	Date	Description	By	Chkd.
A	08/03/2023	Final issue	S.P	J.D

Client: Cloghercor Wind Farm ltd.

Project: Cloghercor Wind Farm

Title: Figure 9-11: Groundwater Vulnerability

Scale @ A4: 1:50,000

Prepared by: S.Pezzetta | Checked: J.Dillon | Date: March 2023

Project Director: O.Fitzpatrick

TOBIN
CONSULTING ENGINEERS
Consulting, Civil and Structural Engineers,
Block 10-4, Blanchardstown Corporate Park,
Dublin 15, Ireland.
tel: +353-(0)1-8030406
fax:+353-(0)1-8030409
e-mail: info@tobin.ie
www.tobin.ie

Draft: A

10798 - 020 - GRD.V - S.BO - TOB - A

Groundwater Depth

Trial pits carried out by Ground Investigations Ireland Ltd (GII) in June 2022 to October 2022 encountered water within the subsoils at various depths between 0.2m –4 m below ground level. However, the trial pits remained stable and were only terminated due to obstructions, generally presumed to be boulders or bedrock. Hence, these occurrences are of perched water that has infiltrated into the relatively impermeable peaty subsoils but it is not an indication of groundwater depths. Rotary core boreholes carried out by GII in July 2022 encountered limited groundwater in the underlying bedrock (1.1mbgl).

Groundwater levels would be expected to vary with the time of year, rainfall, nearby construction and a variety of other factors.

Groundwater Usage and Wells

There are a number of small GSI group water schemes and public supplies in County Donegal, all of which are described in the Donegal Groundwater Protection Scheme Report (2004). The nearest scheme to the site is located approximately 40km east-northeast of the northern boundary of the proposed wind farm site. There are also a small number of NFGWS in County Donegal with the nearest one located approximately 18.5km north of the northern boundary of the site. Hence, there are no groundwater dependent drinking water schemes close to the proposed wind farm site which need to be considered.

There are no records of groundwater wells and springs within the extent of the proposed wind farm site included in the GSI database. However, as part of the consultation process a number of domestic use wells/surface water abstractions were identified and are located >800m to the north of the proposed wind farm See Figure 5-3 of the 2004 Report.

9.3.7 Designated Sites

There are a number of Special Areas of Conservation (SACs), Special Protection Areas (SPAs), National Heritage Areas (NHAs) and proposed National Heritage Areas (pNHAs) located within close proximity to the proposed wind farm site. One NHA and one pNHA overlap with the site boundaries. These are Meenmore West Bog NHA (site code: 002453) located in the north-eastern corner of the site on the eastern slopes of Croaghleheen Mountain and Derkmore Wood Nature Reserve pNHA (site code: 000131) located in the south-western area of the site on the southern slopes of Cleengort Hill.

Meenmore West Bog is considered a site of considerable conservation significance for containing a large upland blanket bog, which is a globally scarce resource. However, there are numerous channels and small streams throughout the site as well as an oligotrophic lake, Lough Nacroagh, located at the north-west corner of the site. Derkmore Wood is of interest due to it being one of the few remaining areas of semi-natural woodland in west Donegal.

There are several SACs, SPAs and NHAs which are outside of the proposed wind farm site but are hydraulically connected to the site. These are summarised in Table 9-13 below and include Cloghernagore Bog and Glenveagh National Park SAC and pNHA; Derryveagh and Glendowan Mountains SPA and the West of Ardara/Maas Road SAC and pNHA. Locations of the designated sites are shown on Figure 6-4.

Table 9-13: Natural 2000 sites

Site ID	Site Classification	Site Code	Proximity to site	Connection to site
Cloghernagore Bog and Glenveagh National Park	SAC pNHA	002047	c. 3.4km northeast of northern site boundary	Via Glenleheen Stream
Derryveagh And Glendowan Mountains SPA	SPA	004039	c. 3.4km northeast of northern site boundary	Via Glenleheen Stream
West Of Ardara/Maas Road SAC	SAC pNHA	000197	Adjacent to western site boundary	Via all river waterbodies and Gweebarra Estuary

The Cloghernagore Bog and Glenveagh National Park SAC and pNHA is located to the north of the proposed wind farm site and is connected to the site via the unnamed streams in the north-eastern corner of the site flowing into the Glenleheen Stream which flows into the Gweebarra River and which in turn flows along the southern boundary and through the southern section of the Natura 2000 site. The site is designated an SAC based on a number of habitats and species listed on Annex I/ II of the E.U. Habitats Directive, several of which are water dependent and include oligotrophic waters containing very few minerals, floating river vegetation, wet heath, freshwater pearl mussel, Atlantic salmon and otters.

The Derryveagh and Glendowan Mountains SPA under the E.U. Birds Directive is a habitat for a number of rare species, some of which use the lakes within the site for feeding.

West Of Ardara/Maas Road SAC is located along the western boundary of the proposed wind farm site and incorporates the Gweebarra Estuary, hence it is hydraulically connected to the site via the numerous river waterbodies flowing into the estuary. The site is designated an SAC based on a number of habitats and species listed on Annex I/ II of the E.U. Habitats Directive, several of which are water dependent and include estuaries, tidal mudflats and sandflats, large shallow inlets and bays, oligotrophic waters containing very few minerals, oligotrophic to mesotrophic standing waters, alkaline fens, wet heath, freshwater pearl mussel, Atlantic salmon, otters and seals.

Additional designated sites which are in the area of the proposed wind farm site, but which are not hydraulically connected to it include:

- Coolvoy Bog SAC and pNHA, site code: 001107, located approximately 0.3km north of the northern section of the site on the north-western slopes of Croaghleheen Mountain;
- Gannivegil Bog SAC and pNHA, site code: 000142, located approximately 0.5km west of the western site boundary on the western side of the Gweebarra Estuary;
- Galwolie Bog pNHA, site code: 001132, located approximately 1.4km northwest of the western site boundary on the western side of the Gweebarra Estuary.

Detailed information on these sites is provided in Chapter 6 – Biodiversity Flora and Fauna of this EIAR.

9.4 POTENTIAL EFFECTS

This section provides an assessment of the environmental effects of the proposed project on the Hydrology, Hydrogeology and Water Quality environment within the study area that extends to all of the hydrological links waterbodies.

The potential impacts may comprise direct and indirect effects on the quality of surface waters and groundwater. Thus, the hydrological and hydrogeological assessment identified water sensitive receptors located within the proposed wind farm site area and downstream from the proposed infrastructure works.

The current proposals for all construction activities and operational infrastructure were reviewed to identify activities likely to effect upon identified water bodies including relevant water courses within and remote from the site. Following the identification of sensitive water receptors and potential effects to the water environment at the development stage, the extent and severity of potential construction, operational, decommissioning, and cumulative effects were evaluated, taking into account all proposed control measures included in the project design.

9.4.1 Sensitivity of Receptors

The sensitivity of an environmental receptor is based on its ability to absorb an effect without perceptible change. The hydrological environment is considered to be of moderate to very high sensitivity for receptors draining to the Gweebarra River via hydrological links. Further information on the sensitivity rating for aquatic macroinvertebrates species can be found in Section 6.2 of the Biodiversity Chapter. The onsite lakes are considered sensitive receptors however the rivers appear to limit potential for fisheries due to the low biological production, fish barriers and lack of suitable aquatic habitats. A number of natural fish barriers exist on the Cloghercor and Clogherachullion streams. Where barriers impede or block access of migratory fish to large portions of catchments a direct reduction in the production potential of these systems results. Biodiversity and associated economic value suffer as a result.

As detailed in Section 9.3, a number of lakes are present within the Landownership boundary. The proposed layout has avoided all of these lakes, namely Lake Doo, Lake Smuttan, Nacroagh (Lough) and Sallagh (Lough). As there are no developments located in the lake catchment areas, there is no potential effects. Three small unnamed lakes are located to the south of T13 however there is no proposed development in the catchment areas to the unnamed lakes/ponds. Turbines T10 to T12 are located in the catchment area of Lough Aneane More and Lough Aneane Beg. Mitigation measures are proposed in Section 9.5 of this EIAR.

9.4.2 Do-Nothing Scenario

As outlined in the Guidelines on the Information to be Contained in Environmental Impact Assessment Reports (EPA, 2022), the description of Do-Nothing effects relates to the environment as it would be in the future should the subject project not be carried out. If the wind farm development does not take place, the site will most likely continue to look like it does today. There would be no major changes in land-use. Sheep farming, forestry, localised peat cutting/peat harvesting would characterise the region. In a ‘do-nothing’ scenario there would be no significant effect to the hydrology, hydrogeology and water quality environment.

9.4.3 Potential Effects – Construction Phase

9.4.3.1 Construction Activities

Forestry Felling

The total area of forestry to be felled is estimated to be between approximately 69.8ha and 90.9ha, of which approximately 12.6 ha will be replanted on site at the end of the construction phase (at the temporary construction compounds and reinstated borrow pits). As a commercial crop, this forestry is scheduled to be felled in the future regardless of the proposed wind farm being constructed or not.

The construction phase of the project will involve the following key activities that could have potential effects on surface water and groundwater conditions:

- Earthworks related to:
  - Construction of temporary and permanent infrastructure on site, including turbine foundations, hardstands, site access tracks, substation, construction compounds, and all associated onsite infrastructure;
  - Laying of all underground electrical cabling, both within the proposed wind farm site, and as part of the grid connection;
  - Minor works at a number of locations along the Turbine Delivery Route (TDR);
  - Borrow Pit excavations; and
  - Stockpiling material.
- Handling and storage of hydrocarbons, concrete and other potential pollutants.

The construction of the temporary site compounds, site access tracks, turbine foundations, turbine hardstands, borrow pits, laying of underground electrical cabling and drainage channels will involve the removal of vegetation and forestry, the excavation of mineral subsoil and rock primarily from proposed borrow pits. Exposed and disturbed ground may increase the risk of erosion and subsequent sediment laden surface water runoff. The release of suspended solids is primarily a consequence of the physical disturbance of the ground during the construction phase, if not correctly compacted.

Incorrect site management of earthworks and excavations could, therefore, lead to loss of suspended solids to surface waters as a consequence of the following activities:

- Run-off and erosion from soil stockpiles (prior to reinstatement/profiling/side casting);
- Dewatering of excavations for turbine foundations and met mast foundations. The result of increased sediment loading to watercourses is to degrade water quality of the receiving waters and change the substrate character.

9.4.3.2 Hydrological and Hydrogeological Effects

Based on the construction phase activities outlined above, the potential hydrological and hydrogeological effects can be summarised as follows:

- Surface water quality effects;
- Surface water flow alterations; and
- Groundwater flow and quality effects

The permanent footprint of the wind farm will be 1.4% of the overall proposed project area. There is potential for an increase in runoff due to 27.32ha of permanent additional hardstanding surfaces (e.g., turbine foundations, access tracks and substation buildings).

Hardstand areas and additional access tracks could potentially reduce infiltration capacity of the soils in areas where earthworks are undertaken and increase the rate and volume of direct surface runoff. However, the underlying geology has a low infiltration capacity and therefore limited capacity exists to alter infiltration rates. Surface water control measures are incorporated into the design of the wind farm. The potential for an increase in runoff to streams is limited as surface water runoff will be controlled as part of the project design. Pre-mitigation, this potential construction effect will be a slightly negative short-term effect.

Flood Risk - Pluvial Flooding

There is no record of pluvial flooding at the proposed wind farm site. Surface water arising at developed areas of the site will be managed by a dedicated stormwater drainage system which has been designed in accordance with Sustainable Drainage Systems (SuDS) principles, limiting discharge from the site to greenfield runoff rates.

The natural landscaping and topography of the site will provide safe exceedance flow paths and confine surface water ponding, therefore minimising residual risks associated with an extreme flood event. On this basis, the proposed wind farm is not at risk of significant pluvial flooding and there will be no cumulative effects on flood risk elsewhere based on the Flood Risk Assessment. The proposed wind farm will not significantly alter the drainage regime of the site. Therefore, no cumulative impacts on other projects are anticipated.

Flood Risk – Fluvial Flooding

There are no large streams or rivers located on the site that could lead to significant fluvial flooding. Due to the size of these streams (catchment areas <5km^2), they were not surveyed or modelled as part of the OPW's CFRAM Programme. Based on the indicative flood mapping produced as part of the National PFRA Study, it is considered that the proposed wind farm is not at risk of fluvial flooding from watercourses in the area.

It is calculated that the stormwater management system proposed as part of the project will limit runoff from the site to greenfield runoff rates, therefore mitigating against an increase in flood risk elsewhere. A flood risk assessment is included in Appendix 2-8.

Flood Risk – Groundwater Flooding

There is no evidence from GSI Online Map Viewer to suggest that groundwater is a potential source of flood risk to the proposed wind farm site.

Flood Risk – Coastal Flooding

Given the elevated nature of the proposed wind farm site (10 mOD to 180 mOD), it is considered that there is no risk of coastal flooding.

Overall Flood Risk

Based on the results of the Flood Risk Assessment, it is considered that the risk of flooding to the proposed wind farm will be minimal, and that the project will not increase the risk of flooding elsewhere.

Effects to Water Quality

There is a potential for effect on water quality as a result of the construction of turbine bases and excavation of borrow pits on site. Turbine base areas for example, are 3.5m to bottom of foundation concrete and will be up to 4m deep based on site investigations.

Groundwater inflows may need to be pumped, resulting in short term localised drawdown of the water table and discharges to surface water channels. Due to the low permeability of soils across the majority of the proposed wind farm the potential for groundwater ingress would be low. However, groundwater ingress can occur in the peat and at the interface between soil/peat transition zone. The time that excavations are open will be kept to a minimum to prevent water ingress. Management and treatment of groundwater ingress is detailed in Section 9.5.3.

There are no water supply wells nor any PWS ZOCs within 0.8km of the proposed turbine locations and borrow pits. All works within 50 m of waterbodies kept to minimum, with all significant infrastructure (turbine foundations, site compounds, borrow pits and substation) at a minimum 50 m set-back.

As described in Chapter 2 of this EIAR (Description of the Proposed Project), the wind farm involves the felling of a total of 90.9 ha of onsite forestry in order to facilitate the construction of the wind farm infrastructure. The main potential effects during felling operations are the mobilisation of sediment and nutrient release (See Appendix 2-5 to this EIAR).

During construction of the wind farm, there is a risk of accidental pollution incidences from the following sources:

- Spillage or leakage of oils and fuels stored on site;
- Spillage or leakage of oils and fuels from construction machinery/vehicles;
- Spillage or leakage of wastewater from temporary site facilities;
- Spillage of oil or fuel from refuelling machinery on site; and
- Spillages arising during the use of concrete and cement for turbine foundations and hardstanding areas.

There will be a risk of pollution from site traffic through the accidental release of oils, fuels and other contaminants from vehicles. Concrete and other cement-based products are highly alkaline and corrosive and can have significant negative effects on water quality. They generate very fine, highly alkaline silt (pH of 11.5) that can physically damage fish by burning their skin and blocking their gills. A pH range of ≥ 4 ≤ 9 is set in S.I. No. 293 of 1988 Quality of Salmonid Water Regulations, with artificial variations not in excess of ± 0.5 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 aquatic environment. The washing out of transport and placement machinery are the activities most likely to generate a risk of cement-based pollution. The pre-mitigation effect is considered as indirect, negative, short-term and likely to effect surface water.

River Crossings

A number of watercourse crossings (See Table 9-14 to Table 9-16) will be required, detailed as follows:

- 2 No. of Existing Piped Culvert upgrades; and
- 10 No. of New Clear Span Watercourse Crossings;

Table 9-14: Existing and Proposed Bridges along windfarm access roads

EPA Segment code	EPA Segment code	Turbines/Infrastructure	Catchment area km2	Flow 1:100 yr	Gradient/Dimensions	Culvert
Clochar An Chuilinn	38_3908	Bridge to T1/T2	0.9	3.3	0.08, 1.3m wide, 1.0m deep, U shaped stream	Proposed Clear span
	38_3908	Northern Access road existing Bridge	1.0	3.6	0.06, 2.1m wide, 2m deep , U shaped stream. 1.2m concrete culvert	Existing, no upgrade required
	38_1777	Spine road between T7 and T5, existing bridge	2.5	9	0.02, 1.8 to 2.3m wide, 1m deep, V shaped stream. 1.5m concrete culvert	Existing, upgrade required
Unnamed Stream	38_3678	Bridge to T6	0.05	0.15	0.01, 1m wide, 0.5 m deep, U shaped drain	Proposed Clear span
An Clochar Corr/ Sruhannaclassagh	38_1412	Bridge to T8/T9	0.45	1.6	0.12, 1.8m wide, 1.3m deep, V shaped stream.	Proposed Clear span
	38_1412	Bridge along spine road N of T12	0.5	1.8	0.09, 2m wide, 1.2m deep, V shaped stream.	Proposed Clear span
	38_1631	Bridge along spine road NE of T15	0.35	1.25	0.034, 2m wide, 0.8m deep. V shaped stream.	Proposed Clear span
	38_1614	Bridge along spine road NE of T15	0.2	0.75	0.069, 2m wide, 0.8m deep, V shaped stream.	Proposed Clear span
	38_1614	Bridge along road N of T17	0.7	2.5	0.013, 1.6m wide, 1.2m deep, U shaped stream.	Proposed Clear span

Table 9-15: Proposed Bridges along cable access roads

EPA Segment code	EPA Segment code	Turbines/Infrastructure	Catchment area km2	Flow 1:100 yr	Gradient/Dimensions	Culvert
An Clochar Corr/ Sruhannaclassagh	38_3856	Bridge S of T18	0.5	1.8	0.09, 2m wide, 1.2m deep, V shaped stream.	Proposed Clear span

Table 9-16: Proposed Bridges along amenity tracks

EPA Segment code	EPA Segment code	Turbines/Infrastructure	Catchment area km2	Flow 1:100 yr	Gradient/Dimensions	Culvert
An Clochar Corr/ Sruhannaclassagh	38_1631	Amenity Bridge – West of T11	0.5	1.8	0.06, 2m wide, 1.3m deep	Proposed Clear span
	38_3856	Amenity Bridge - East of T11	0.75	2.5	0.05, 1.7m wide, 1.2m deep	Proposed Clear span

Construction of structures over water courses has the potential to alter water quality and flows during the construction phase. Mitigation measures are proposed in Section 9.5 of this chapter.

Lakes/Ponds

As detailed in Section 9.3 a number of lakes are present within the Landownership boundary. The proposed layout has avoided the catchment areas to Lake Doo, Lake Smuttan, Nacroagh (Lough) and Sallagh (Lough). As there are no developments located in the lake catchment areas, there is no potential effects. Three small unnamed lakes are located to the south of T13 however there is no proposed development in the catchment areas to the unnamed lakes/ponds.

Turbines T10 to T12 are located in the catchment area of Lough Aneane More.

Excavation and disturbance of soils, subsoils and peat could result in changes in the chemistry of surface water runoff including colour, dissolved organic carbon (DOC), Turbidity and nutrients. As with erosion and sedimentation, this can have implications on both the quality of the aquatic habitat and also the resource potential of the lake.

Construction activities in the catchment area to Lough Aneane More has the potential to alter water quality and flows during the construction phase. Mitigation measures are proposed in Section 9.5 of this chapter.

9.4.3.3 Earthworks (Removal of Vegetation Cover, Excavations and Stock Piling)

Construction phase activities of the proposed project will require earthworks resulting in the removal of vegetation cover and excavation of mineral subsoil and are detailed in Chapter 2 (Description of the Proposed Project) and Chapter 8 (Land, Soils and Geology). Peat removal will be required for part for the site for founded roads. 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 effects are significant if not mitigated against. The pathways identified for construction earthworks are drainage and surface water discharge routes. The main receptors are downgradient rivers (Gweebarra River, Cloghercor River and Clogherachullion River) and associated dependent ecosystems. The pre-mitigation effect is indirect, negative, significant, temporary and of a medium probability effect.

All proposed stream crossings will utilise clear span structures. For the clear span structures, the existing banks will remain undisturbed and no in-stream excavation works are proposed. Therefore, there will be no direct effect on the stream at the proposed crossing location. Drainage width, side slopes and substrate will be replicated in the proposed drainage channels. Where existing drains need to be rerouted/reprofiled, the original bed material will be reused. The sizing of any new internal drainage crossings will maintain existing depth of flow and channel characteristics. Where required, culverts will be buried at an appropriate depth below the channel bed.

9.4.3.4 Potential Effects on Groundwater Levels during Excavation Works and from Proposed Borrow Pits

Dewatering of borrow pits and other deep excavations (i.e., turbine bases) have the potential to effect on local groundwater levels. Groundwater level effects are not anticipated to be significant due to the local hydrogeological regime, as described below.

Borrow pit areas, where the granite bedrock depth ranges from near surface to 2m below ground level, will be excavated up to a maximum depth of 7m and deep excavations (i.e., turbine bases) up to 5 m deep, and will not encounter actual groundwater. However limited groundwater inflows and rainwater may need to be pumped, treated and discharged to the surface water channels.

Due to the low permeability of the proposed wind farm site, the potential impacts are short term, not significant, likely and negative.

Aquifer Hydraulic Properties

Slug tests were undertaken in BH2 to provide an estimate of the hydraulic conductivity of the bedrock formation. This method consists of measuring the static water level (head) in the borehole, then introducing a near instantaneous change in water level, and measuring the change in water level over time until the water level returns to the original static water level. The instantaneous change in piezometric head (static water level) can be achieved by adding or removing a volume of water from a well.

Typical specific dry weather flows in the bedrock in Donegal are low (0.41 to 1.1 l/s/km2), indicating that this aquifer does not make a significant baseflow contribution to streamflow.

Storativity is also expected to be low, as would also be expected of the Granites rock group. Most groundwater flow is in the uppermost part of the aquifer comprising a broken and weathered zone typically less than 3 m thick.

A slug test provides a very local estimate of hydraulic conductivity or transmissivity in the near vicinity of a well. As for aquifer tests, several analytical methods have been developed for the analysis of slug tests. Hvorslev (1951) was used to analyse the data.

The hydraulic permeability of the unconsolidated material interpreted from the data recorded from the test and interpreted using the mathematical solution by Hvorslev by matching a straight line to water level displacement collected during an overdamped slug test is presented in the Appendix 9-2. The average permeability, based on a number of different interpretations of the data is 0.04m/day.

Based on the permeability recorded within the site the Transmissivity is at the lower range of 1 to 5 m^2/day.

Dewatering Volume

The volume of water and the radius of influence is first estimated by empirical Sichardt Formula for radial flow:

$$R_o = C\ (H - h_w)\sqrt{K}$$

Where *C* is the empirical calibration factor usually taken as 3000 when units are (m) for drawdown and (m/s) for permeability; Where *H* is the initial aquifer piezometric or phreatic level; Where h_w is the piezometric or phreatic level in the equivalent well; Where $(H - h_w)$ is the drawdown in equivalent well (i.e., target drawdown); and where *K* is permeability.

Estimation of Discharge and Drawdown

- Radial Flow – Unconfined Conditions;

$$Q = \pi . k \frac{(H^2 - h^2)}{\left\{\ln\left(\frac{R_o}{re}\right)\right\}}$$

Where *re* is the equivalent well radius. This *re* can be taken as the radius of the equivalent well.

Based on the above principles and a Transmissivity value of 1m^2/day to 5m^2/day; required groundwater discharge rates of 100m^3/day to 250m^3/day are obtained. Assuming each borrow pit is reaching a maximum depth of 10m below ground level (BGL), the empirical estimate calculates the 0.1m drawdown at <25m. There are no wells within 800m of the borrow pits or turbine bases.

Dewatering of borrow pits and other deep excavations (i.e., turbine bases) have the potential to effect localised groundwater levels. However, groundwater level effects are not anticipated to be significant, due to low permeability bedrock and the relatively small volumes to be abstracted e.g., 10m^3/day to 250m^3/day. Dewatering will locally depress groundwater levels by 0.1m in the immediate vicinity (25 m) of the pumping regime.

The pre-mitigation effect is considered as not significant, short term and unlikely to affect groundwater wells due to potential effects of dewatering being very shallow and limited to 0.025km from the point of abstraction, resulting in a temporary localised shallow depression in the aquifer.

9.4.3.5 Turbine Delivery Route (TDR) and Cable Route

The excavations for cable route trenches and the temporary alterations for the TDR may have a direct permanent effect on the exposed soils and rock in the form of increased erosion and sediment release that, without mitigation, could also have additional effects on water quality (due to sedimentation of water courses).

No in-stream or riparian works are proposed to facilitate the turbine delivery route road/junction accommodation works. Where any works are proposed within 50m of a watercourse, there is an increased potential for sediment release to the watercourse. The small scale and temporary nature of these works will result in ground conditions similar to agricultural cultivation at these locations. Overall, without mitigation, these works have the potential to have slight negative short-term effect on the surface water environment.

Modifications along the TDR involves the temporary removal of signage and clearing of some vegetation in addition to the temporary local widening at bends/junctions/narrow sections and creation of a blade changeover area using hardcore material. Inappropriate management of the carrying out of these modifications could result in blockages of existing roadside drainage.

Any excavations for the cable route will expose bare soil for a temporary period over a short section of the trench. The trench will be backfilled immediately following the installation of each section of cabling. While the trench is open, there will be a potential effect to the adjacent watercourse of an increase in the concentration of suspended solids.

There are 2 no. watercourse crossings on the proposed grid connection route i.e., across 38_1614 and 38_3856. The locations of these crossings are shown on Figure 9-5. Existing forestry and shallow artificial agricultural field drainage channels were also present, though these are thought to remain dry for the vast majority of the time.

The method for cable crossing two watercourses, is a trenchless crossing as set out in Appendix 2-4 - Outline Construction Methodology. It is proposed that horizontal directional drilling (HDD) under the stream bed will be undertaken to prevent direct effects on the watercourse. HDD involves drilling of a pilot hole from a drilling machine positioned at one side of the obstacle to be crossed. The hole is then reamed to make it larger and once the hole is of sufficient size, a pipe or conduit is pulled into the drilled hole. During the horizontal directional drilling, groundwater may be encountered.

The proposed HDD method carries a risk of indirect effects from sediment laden runoff during the drilling launch pit excavation works. There is also the unlikely risk of frac out and contamination of the watercourse with drilling mud (clay). Mitigation measures to manage silt are included in Section 9.5. Guidance and mitigation measures recommended by Inland Fisheries Ireland (IFI) during the consultation process have been incorporated into the design of the proposed crossings.

The pre-mitigation effect of the TDR/Grid Route is considered as slight, short term and unlikely to effect the surface water due to the use of trenchless technology and the proposed design.

9.4.4 Potential Effects - Operational Phase

The proposed project footprint will comprise of 27.3ha within the proposed wind farm site area of 1,945ha (1.4%). The potential for significant changes in runoff is, therefore, low with a slight potential increase in runoff.

In addition, the greenfield runoff rate has been calculated based on the EPA guidance 'Rainfall Runoff Management for Developments' SC030219 (2013), the SuDS Manual C753 (CIRIA, 2015) and the non-statutory standards for SuDS (Defra, 2015). The SuDS Online Greenfield Runoff Rate Estimation Tool was used to assist in calculations.

The hydrometric gauges used by the EPA have gathered data for SAAR in the region, with values typically in the region of 1,620mm being recorded. The proposed wind farm site is characterised by moderately steep slopes and limited infiltration rates. The areas of the site which have peat have low infiltration rates. The UK SuDS Tool estimates a SAAR for the proposed wind farm site of 1,620mm. The Standard Percentage Runoff (SPR) is 0.53. SPR is assumed to be the proportion of rainfall that contributes to surface water runoff. The mean annual maximum flow rate (Q_{bar}) is calculated to be between 13l/s/ha – 16.8 l/s/ha . Based on climate change and an increase in hardstand surfaces, there is potential for an increase in runoff. The potential for infiltration on the site is limited due to the existing topography and low permeability soils and bedrock. Climate change scenarios suggest fluvial floods in the 2080's increasing by up to 10% (low and medium low scenarios) or by up to 20% (medium high and high scenarios). To address climate change, the present recommendations are to include in the design flow a 20% increase in flood peaks as a result of climate change. The potential for increased runoff is addressed in the SuDS design measures described in Section 9.5.3. Mitigation measures are outlined in Section 9.5 and include the use of swales, settlement ponds and other SuDS measures. Overall runoff is included below in Table 9-17.

Table 9-17: Overall Runoff Calculation Table

Item	Values	Notes
Site Area	1,945ha	Ownership boundary
Development Area for Construction	27.3	Permanent development area
Rainfall	1620mm	IrishSuds
Impermeable Area Before Development	90%	Low permeability soils and bedrock
Impermeable Area After Development	90-95%%	Based on the increase in runoff from 90% to 95% in the development footprint
Increase in Runoff	57m^3/day	Increase in runoff from impermeable area
Potential % of Increased Runoff	0.07%	Mitigation included in Section 9.5

With regard to water quality effects, while there will be no significant direct discharges to the surface water environment during the operational phase due to the nature of the development. Occasional access will be required there will be vehicles periodically on the site at any given time. This may lead to occasional accidental emissions, in the form of oil, petrol or diesel leaks, which could cause localised contamination of site drainage channels. However, due to the periodic nature of visits, the risk of surface water pollution during operation is considered to be low.

The presence of occasional maintenance workers at the proposed substation will lead to the generation of foul sewage from toilets and washing facilities. This foul sewage will be collected and tankered off-site for disposal at a licensed wastewater treatment facility.

The pre-mitigation effect is considered as slight, short term and likely to effect on surface waters.

9.4.5 Potential Effects – Decommissioning Phase

Decommissioning of the proposed wind farm will involve the disassembly and removal of the turbines offsite. These effects have been assessed as similar to the Construction Phase and, therefore, the mitigation measures for the Construction Phase will also be implemented during decommissioning. Turbine hardstands will be covered over with soil and allowed to vegetate. It is not proposed to restore the hardstanding areas to commercial forestry after decommissioning.

Potential effects will be minimised by leaving elements of the proposed project in place where appropriate including the site roads, turbine foundations, substation and the grid connection infrastructure. Internal roads and drainage will remain in place for forestry and recreational access and management.

9.4.6 Magnitude and Significance of Effect

The magnitude of an effect includes the timing, scale, size and duration of the potential effect. The magnitude criteria for hydrology/hydrogeology are defined as set out in Table 9-18 to 9-20 below. There will be no direct discharges from the wind farm to any existing lakes or rivers.

Table 9-18:Magnitude and Significance of Hydrological and Hydrogeological Criteria - Construction Phase

Criteria	Description	Duration and Frequency of Effect	Significance of Potential Effect
Runoff Regime	Potential localised increase in surface water runoff may be caused by impermeable areas on site. Impermeable areas may give rise to a slight increase in surface water flow locally but will not have a significant effect on the volumetric flow rate of downstream rivers. Potential increase in runoff is <0.1% from the windfarm area.	Indirect, Short term and rarely	Slight negative
Surface Water Quality	Sedimentation of drainage ditches and streams. Sensitive receptors include the existing streams and Gweebarra transitional waters	Indirect, Temporary and medium probability	Moderate negative
Groundwater Levels	No change in groundwater is expected. No ZOCs or wells within 750m of turbines.	Not applicable	Not significant
Groundwater Quality	Minor leaks or spills during the construction phase.	Indirect, Short term and unlikely	Not significant

Table 9-19: Magnitude and Significance of Hydrological and Hydrogeological Criteria - Operational Phase

Criteria	Description	Duration and Frequency of Effect	Significance of Potential Effect

Runoff Regime	Increased surface runoff caused by impermeable areas on site may increase surface water flow locally but will not have a significant effect on the volumetric flow rate of downstream rivers. Site to be maintained at greenfield runoff rates.	Long term and rarely	Not significant
Surface Water Quality	No significant loss in water quality is expected.	Long term and rarely	Not significant
Groundwater Levels	No significant change in groundwater is expected.	Not applicable	Not significant
Groundwater Quality	No change in groundwater quality is expected.	Not applicable	Not significant

Table 9-20 Magnitude and Significance of Hydrological and Hydrogeological Criteria - Decommissioning Phase

Criteria	Description	Duration and Frequency of Effect	Significance of Potential Effect
Runoff Regime	Potential localised increase in surface water runoff may be caused by impermeable areas on site. Impermeable areas may give rise to a slight increase in surface water flow locally but will not have a significant effect on the volumetric flow rate of downstream rivers. Potential increase in runoff is 1% from the windfarm area.	Short term and rarely	Slight negative
Surface Water Quality	Sedimentation of drainage ditches and streams.	Temporary and unlikely	Slight/moderate negative
Groundwater Levels	No change in groundwater is expected. No ZOCs or wells within 50m of turbines.	Temporary and unlikely	Not significant
Groundwater Quality	Minor leaks or spills during the construction phase.	Temporary and unlikely	Not significant

9.5 MITIGATION MEASURES

As outlined in Chapter 2 of this EIAR (Description of the Proposed Project), the design of the proposed project has considered a range of best practice construction measures which will ensure avoidance and reduction of effects throughout the construction, operational and decommissioning phases. Additional measures have been developed to mitigate the effects identified in the preceding section.

9.5.1 Mitigation by Avoidance

In identifying and avoiding sensitive surface waters, the proposed project has implemented 'avoidance of effect' measures. Mitigation by avoidance is viewed as part of the 'Reasonable Alternatives' outlined in Chapter 3 of this EIAR. Examples include locating fuel storage and construction compounds >50m from surface water streams. No marked streams are crossed by the turbine access tracks. Areas of deeper peat were avoided as part of the site entrance and grid connection.

9.5.2 Mitigation by Prevention and Reduction

A number of mitigation measures are outlined below and are considered as in-built to the design of the project. These mitigation measures are a combination of measures to comply with legislation and best practice construction methods to be implemented in order to prevent water (surface water and groundwater) pollution. Examples of these measures are the storage of potentially polluting materials in fully bunded tanks and controlling / reducing runoff from hardstand areas.

9.5.3 Mitigation Measures – Construction Phase

In order to mitigate potential effects during the construction phase, best practice construction methods will be implemented in order to prevent water (surface water and groundwater) pollution. A CEMP (Appendix 2-2 of the EIAR) was developed for the project to ensure adequate protection of the water environment. All personnel working on the project will be responsible for the environmental control of their work and will perform their duties in accordance with the requirements and procedures of the CEMP.

During the construction phase, all works associated with the construction of the wind farm will be undertaken in accordance with the guidance contained within CIRIA Document C741 'Environmental Good Practice on Site' (CIRIA, 2015). Any groundwater encountered will be managed and treated in accordance with CIRIA C750, 'Groundwater control: design and practice' (CIRIA, 2016). Groundwater from the borrow pits will be treated in the settlement lagoons. Monitoring of groundwater quality and quantity will be undertaken downgradient of the works during the pre-construction and during the construction phase.

All mitigation and management measures outlined hereunder will be incorporated into the Surface Water Management Plan, which forms part of the CEMP (Appendix 2-2 of the EIAR). Mitigation measures are incorporated into the CEMP and will be incorporated into the specification for the Civil Engineering Works contract. The implementation of the Surface Water Management Plan will be overseen by a suitably qualified ecologist/engineer and will be regularly audited throughout the construction phase. The assigned ecologist/engineer will be required to stop works on site if he/she is of the opinion that a mitigation measure or corrective action is not being appropriately or effectively implemented.

9.5.3.1 Forestry felling.

The total area of forestry to be felled is estimated to be between approximately 69.8ha and 90.9ha, of which approximately 12.6 ha will be replanted on site at the end of the construction phase (at the temporary construction compounds and reinstated borrow pits). As a commercial crop, this forestry is scheduled to be felled in the future regardless of the proposed wind farm being constructed or not.

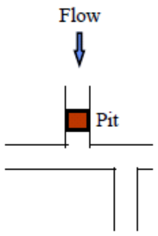
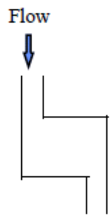
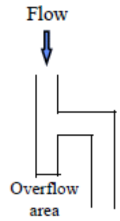
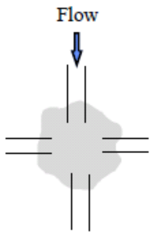
The Felling and Reforestation Standards describe the universal standards that apply to all felling (thinning, clear felling) and reforestation projects on all sites, will be implemented under a felling licence issued by the Department of Agriculture, Food & the Marine.

Buffer zones are also identified and will be marked out on the ground. Correct buffer zone management will help reduce the risk of sedimentation from felling operations. Buffer zone guidelines for planting and felling activities are provided by the *Forestry Service in the Forestry and Water Quality Guidelines (2000).* It is proposed to apply these buffer zone guidelines to construction activities also. Construction activities will be curtailed within buffer zones in order to reduce erosion and sedimentation and, therefore, to protect water quality. Buffer zone widths vary from 10m to 25m, depending on slope and soil erosion classification. Details of buffer zones are included in Table 9-21.

The slopes across the proposed wind farm site are moderate with some steep slopes. As an additional measure, all infrastructure on the proposed wind farm site including for turbines, borrow pits, site compounds, substation and access tracks (excluding grid connection) will maintain a 50m set back from streams and lakes. The construction works will involve some works within 50m of streams (such as site access tracks and clearspan bridges). However, no instream works are proposed, and a suite of measures are in place to avoid any adverse effects on streams. Clear span bridges will be utililsed for stream crossings. Trees will be cut manually inside the 50m buffer. During the near stream construction work, silt traps and a double row silt fences will be placed immediately down-gradient of the construction area for the duration of the construction phase. All associated tree felling will be undertaken using good working practices as outlined by the Forest Service in their *Forestry Harvesting and Environment Guidelines* (2000) and the *Forestry and Water Quality Guidelines* (2000). The latter guidelines deal with sensitive areas, erosion, buffer zone guidelines for aquatic zones, ground preparation and drainage, chemicals, fuel and machine oils. Brash mats will also be used to support harvesting and forwarding machinery. The brash mats reduce erosion of the surface and will be renewed as they become used and worn over time.

As part of felling works, temporary water crossings are required for forest drains, roadside drains, relevant streamss and aquatic watercourses. The following measures will be adhered to as per the 2019 *Standards for Felling and Reforestation:*

Typical sediment trap designs are illustrated below (source *Forestry Schemes Manual, 2017)*:

No. 1 (Pit)	No. 2 (Staggered Type)	No. 3 (Run Off Type)	No 4 (Swamp Type)
			
The end of the mound drain is slightly deepened for c. 0.3 metres before it enters the collector drain.	Forces water to slow down within the trap - more efficient than if the water ran straight through the trap. Minimum 1 metre long.	Caters for runoff events that exceed the design capacity. Useful on slopes. Overflows floods onto vegetation. Do not plant within 4 metres of the lower side in order to conserve dense vegetation.	Many drains may enter a natural depression to create a mini "swamp". Dimensions of the "swamp" depend on the needs of the site. May be c. 20 sq. metres. Do not plant within 4 metres of the "swamp".

Sediment traps will require monitoring and maintenance throughout the construction stage. Sediment traps will be constructed and maintained in line with the requirements of the *Forestry Schemes Manual (2011), the Forest Road Manual and Forest Drainage Engineering – A Design Manual.*

Forest Drains:

- Minimise the crossing of drains during felling and extraction and restrict machine activity to brashed extraction racks and forwarding routes
- Where a drain crossing is needed, based on the size of the forest drain one of the following methods will be selected that prevents the breakdown and erosion of drain sides, namely:
    - For larger drains, deploy a heavy-duty plastic culvert lengthways into the channel and cover with brash material. The culvert must be of a diameter approximating the depth of the drain, to avoid any unnecessary undulation along the extraction route.
    - Where required, a solution for smaller drains is to temporarily lay log sections lengthways into the channel and overlay with brash. Again, logs will be that approximate the depth of the channel to be crossed.

Aquatic Zones and Larger Relevant Watercourses:

- Minimise the crossing of streams during felling and extraction by choosing alternative routes which avoid the watercourses/aquatic zones.
- Direct crossing over the stream bed will not be permitted.
- Water Feature will be crossed at a right angle to the flow of water.
- Any necessary crossing will be via an appropriate structure that spans proud of the flow of water and prevents the breakdown and erosion of the banks.

9.5.3.2 Turbines, Hardstanding, Temporary Construction Compounds, Met Mast and Access Tracks

As stated previously, to maximise the erosion and sediment control benefits of natural vegetation soil cover, stripping of soil is to be kept to a minimum and confined to construction areas only. Where practical, construction works will be staged to minimise the extent and duration of disturbance, e.g., plan for progressive site clearance, only disturbing areas when they are scheduled for current construction work.

To minimise any effect on the underlying subsurface strata from material spillages, all oils and solvents used during construction will be stored within specially constructed dedicated bunded areas, see Photo 1, Section 9.5.3.3 below. Refuelling of construction vehicles and the addition of hydraulic oils or lubricants to vehicles will take place in a designated area of the site, away from surface water gullies or drains. Spill kits and hydrocarbon absorbent packs will be stored in this area and operators will be fully trained in the use of this equipment. For certain vehicles which are less mobile, refuelling may need to occur elsewhere on site. This will be carried out using a double skinned and bunded bowser, towed behind a jeep (or similar). Refuelling using this will take place only by trained personnel, and only at locations greater than 50m from any stream. A spill kit will be stored with the bowser and the person operating the bowser will be trained in their use. When not in use this will be stored in the designated area of the construction compounds.

All construction waste will be sorted and stored in on-site skips, prior to removal by a licensed waste management contractor.

9.5.3.3 Concrete

Concrete is required for the construction of the turbine bases and foundations. After concrete is poured at a construction site, the chutes of ready mixed concrete trucks must be washed out to remove the remaining concrete before it hardens. Wash out of the main concrete bottle will not be permitted on site; wash out is restricted only to chute wash out. Wash down and washout of the concrete transporting vehicles will take place at an appropriate facility offsite.

The best management practice objectives for concrete chute washout are to collect and retain all the concrete washout water and solids in leak proof containers or impermeable lined wash out pits, so that the wash material does not reach the soil surface and then migrate to surface waters or into the ground water. The collected concrete washout water and solids will be emptied on a regular basis. Washout will be undertaken at the construction compounds.

Photo 1 Example of a Concrete Washout Site

9.5.3.4 Fuels and Chemicals

With regards to on-site storage and handling of potentially pollutant materials:

- Fuels and chemicals will be stored within bunded areas as appropriate to guard against potential accidental spills or leakages. The bund area will have a volume of at least 110 % of the volume of such materials stored;

* All on-site refuelling will be carried out by a trained competent operative.
* Mobile measures such as drip trays and fuel absorbent mats kept with all plant and bowsers and will be used as required during all refuelling operations;
* A spill kit will be stored with the bowser and the person operating the bowser will be trained in their use;
* No refuelling will take place within 50 m of any stream;
* All equipment and machinery will have regular checking for leakages and quality of performance and will carry spill kits;
* Any servicing of vehicles will be confined to designated and suitably protected areas such as construction compounds; and
* Additional drip trays and spill kits will be kept available on site, to ensure that any spills from vehicles are contained and removed off site.

9.5.3.5 Erosion and Sediment Control

As outlined above, if not correctly managed, earthworks can lead to loss of suspended solids to surface waters. The main factors influencing the rate of soil loss and subsequent sediment release include:

* Climate;
* Length and steepness of slopes;
* Soil erosion potential;
* Soil Vegetation/cover;
* Duration and extent of works; and
* Erosion and sediment control measures.

Pre-emptive Site Drainage Management
The works programme for the initial construction stage of the proposed project will take account of weather forecasts and predicted rainfall in particular. Large excavations and movements of 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 the following is likely to occur:

- >10mm/hr (i.e., high intensity local rainfall events);
- >25mm 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 will 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; and
- Provide cover to material storage areas i.e., adequate tarpaulin over stockpile areas if material cannot be reinstated prior to suspension.

9.5.3.6 Fisheries

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"* , that is, 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.

Runoff will be maintained at Greenfield (pre-development) runoff rates. The layout of the development has been designed to collect surface water runoff from hardstanding areas within the development and discharge to associated surface water attenuation lagoons adjacent to the proposed infrastructure. It will then be managed by gravity flow at Greenfield runoff rates.

It is proposed, that during the ground clearance of the proposed project, the contractor will implement water control measures to limit the effect on water quality using standards measures as set out in the Forestry Report – Appendix 2-5. Brash will be used along harvesting and extraction routes for soil protection. The forwarder will be loaded to the manufacturer's maximum specification and no more to avoid overloading and unnecessary soil compaction.

Suspended solid (silt) removal features will be implemented in accordance with CIRIA C697 SuDS Manual, and CIRIA C648 *Control of water pollution from linear construction projects*.

All temporary and permanent drainage from the site shall be designed to have as a minimum three stages of treatment, as defined in the SuDS Manual. Management of runoff will include the following:

- Filtration of water through filter media (sand / stone check dam, silt fence);
- Detention / settlement in settlement ponds or behind check dam in swales; and
- Conveyance of shallow depths of water in vegetated swale.

Interceptor Drains

Interceptor drains/diversion ditches will be installed ahead of the main earthworks activities to minimise the effects of collected water on the stripped/exposed soils once earthworks commence. This drainage will integrate into the existing forestry drainage. These drainage ditches will be installed on the upgradient boundary of the areas affected by the access track earthworks operations and installed ahead of the main track construction operations commencing. They will generally follow the natural flow of the ground. The interceptor drains will intercept any storm water surface run-off and collect it to the existing low points in the ground, allowing the clean water flows to be transferred independently through the works without mixing with the construction drainage. It will then be directed to areas where it can be redistributed over the ground by means of a level spreader.

Swales

Track edge drainage/swales are required to control run-off from the running surface to lower water levels in the subgrade, to control surface water and to carry this flow to outlet points. Swales along access tracks are to be installed in advance of the main construction phase. On sections of track where there is significant longitudinal gradient, regular surface water interception channels will be employed – these will typically be at 10-20m intervals to collect any surface water that is discharging as sheet flow along the track and discharge the flow into the trackside swale. Swales will provide additional storage of storm water where located along gradient. Drainage details are included in the CEMP and Drawings 10798-2060 to 10798-2065.

Given the steep longitudinal gradients on some sections of access track, regular check dams will be employed within the trackside swale on these sections to reduce the flow velocity and provide settlement opportunity. Check dams will be constructed from course gravel/ crushed rock. Check dams will have a minimum 0.2m freeboard (from top of check dam) to top of swale level, to prevent overtopping of flows onto the access track. All check dams, etc to be checked at least once weekly via a walkover survey during the full period of construction. All excess silts to be removed and disposed of appropriately. Where check dams have become fully blocked with silt, they will be replaced.

Swales will be re-vegetated by hydro-seeding with indigenous seed mix as soon as is practicable following excavation. This will reduce the flow velocity, treat potential pollutants, increase filtration and silt retention.

Settlement Ponds/Lagoons

Settlement ponds will be located downstream of road swale sections and at turbine/hardstand locations, to manage/buffer volumes of runoff discharging from the drainage system during periods of high rainfall, thereby reducing the hydraulic loading to watercourses. Settlement ponds are designed in consideration of the greenfield runoff rates. The following shall apply to construction of settlement ponds at the site:

- Pond depths generally to be excavated to less than 2m;
- Side slopes to be shallow, nominally at a 1 in 3 side slope (maximum); and
- Material excavated from the settlement pond should be compacted around the edge of the pond.

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. Drainage details are included in the CEMP (Appendix 2-2) and Drawings 10798-2060 to 10798-2065, in Appendix 1-1.

The settlement pond design is based on primary settling out of suspended solids from aqueous suspension. The theory behind the design of the settlement lagoons is the application of Stoke's Law. The settlement lagoons will be designed to provide sufficient retention time and a low velocity environment to allow suspended solids of a very small particle size to fall out of suspension prior to allowing the water to outfall to the receiving environment. Flow rates for storm events will be maintained at or below greenfield runoff rates as detailed above.

Settlement lagoons will be installed concurrently with the formation of the road and will be fenced off for safety. They will be located as close to the source of sediment as possible and as far as possible from the buffer zones of existing streams. The minimum buffer zone width will be 50m as outlined above.

Settlement lagoons will be regularly cleaned/maintained to provide effective and successful operation throughout the works. Outfalls and drainage ditches will be cleaned, when required, starting up stream with the outfalls blocked temporarily prior to cleaning.

The sediments/silt in the settlement lagoons will be cleaned regularly and removed via the contractor and deposited at suitable locations on site, away from watercourses. Machine access is required to excavate the accumulated sediment. Control measures include:

- Regular inspection and maintenance of settlement lagoons and drains;
- Settlement lagoon maintenance and/or cleaning will not take place during periods of extended heavy rain;
- Settlement lagoons will be fenced off for safety;
- Settlement lagoons will where practicable be constructed on even ground and not on sloping ground and discharge into vegetation areas to aid filtration and dispersion; and
- The settlement lagoons will be monitored closely over the construction timeframe to ensure that they are operating effectively.

All stockpiled material will be side cast, battered back and profiled to reduce rainfall erosion potential. The stockpiling of materials will be carefully supervised as per the mitigation measures listed in Chapter 8 of this EIAR (Land, Soils and Geology).

The surface water management system will be visually inspected on a daily basis during construction works to ensure that it is working optimally. The frequency of inspection will be increased at settlement ponds adjacent to areas where earthworks are being carried out and during excavations at T10 to T12. Where issues arise, such as blockages, construction works will be stopped immediately, and the source of the issue will be investigated. Records of all maintenance and monitoring activities associated with the surface water network will be retained by the Contractor on-site, including results of any discharge testing requirements.

Traffic on site will be kept to a minimum. Only the proposed onsite access track will be used for project-related traffic.

Correct buffer zone management will help reduce the risk of sedimentation from felling operations (See Appendix 2-5). Buffer zone guidelines for planting and felling activities are provided by the Forestry Service in the *'Forestry and Water Quality Guidelines'*. It is proposed to apply these buffer zone guidelines to construction activities also. Construction activities will be curtailed within buffer zones in order to reduce erosion and sedimentation and, therefore, to protect water quality. Buffer zone widths vary from 10m to 25m, depending on slope and soil erosion classification. Details of buffer zones are included in Table 9-21.

Table 9-21: Recommended Buffer Zone Widths

Average Slope Leading to Aquatic Zone	Buffer Zone Width on Each Side of the Aquatic Zone	Buffer Zone Width for Highly Erodible Soils
Moderate (even to 1:7 / 0% - 15%)	10m	15m

Steep (1:7 - 1:3 / 15% - 30%)	15m	20m
Very steep (1:3 / >30%)	20m	25m

The slopes across the proposed wind farm site are predominantly moderate (<1:7) with steeper slopes to the southeast and northeast of the proposed project. As the soil type varies across the site, this suggests that a 10m to 20m buffer zone is appropriate. As an additional measure, all infrastructure on the proposed wind farm site including for turbines, borrow pits, site compounds, substation will maintain a 50 m set back from streams.

All associated tree felling will be undertaken using good working practices as outlined in the Forestry Report and CEMP (Appendices 2-5 and 2-2 of this EIAR), the Forest Service in their 'Forestry Harvesting and Environment Guidelines' (2000) and the 'Forestry and Water Quality Guidelines '(2000). The latter guidelines deal with sensitive areas, erosion, buffer zone guidelines for aquatic zones, ground preparation and drainage, chemicals, fuel and machine oils. Brash mats will also be used to support harvesting and forwarding machinery. The brash mats reduce erosion of the surface and will be renewed as they become used and worn over time.

Temporary Site Construction

During the construction phase, two temporary site compounds will be required. Temporary on-site toilet facilities (chemical toilets) will be used. These will be sealed with no discharge to the surface water or groundwater environment adjacent to the site.

Surface Water Flow and Stream Crossings

Potential effects on surface water flow during the construction phase of the wind farm are mitigated by the proposed drainage design which has been designed to minimise disturbance to the current hydrological regime by maintaining diffuse flows. Where stream crossings occur (i.e., access tracks), it is proposed to use a clear-span design bridges. Installation of such features will take place during dry periods to reduce the risk of sediment entering the watercourse. Smaller forestry drains and streams will be crossed using normal culverts.

A number of ephemeral drainage features (drains) are also present on site. Culverting of these will only take place during dry weather periods. Culverts will be designed to be of a size adequate to carry expected peak flows. Culverts will be installed to conform to the natural slope and alignment of the drainage line. Culverts will be buried at an appropriate depth below the channel bed and the original bed material placed at the bottom of the culvert. The sizing of any new internal drainage crossings will maintain existing depth of flow and channel characteristics.

The CEMP and method statement for stream crossings follows the guidelines set out in the following documents:

- CIRIA (2006). Control of Pollution from Linear Construction Project; Technical Guidance (C648). Construction Industry Research and Information Association, London.
- CIRIA (2015b). Environmental Good Practice on Site (4th edition) (C741). Construction Industry Research and Information Association, London.
- CIRIA (2019). Culvert, screen and outfall manual (C786). Construction Industry Research and Information Association, London.
- DHPLG (2019). Draft Revised Wind Energy Development Guidelines. Department of Housing, Planning and Local Government. December 2019

- IFI (2016). Guidelines on Protection of Fisheries during Construction Works in and adjacent to waters. Inland Fisheries Ireland, Dublin.
- NRA (2008). Guidelines for the Crossing of Watercourses during the Construction of National Road Schemes. National Roads Authority.
- SNH (2019). Good Practice during Wind Farm Construction (4^{th} edition). Scottish Natural Heritage.

Embedded culverts will be buried to a depth of 0.3m or 20% of their height (whichever is greatest) below the bed. Crossing construction will be carried out, in so far as is practical, with minimal disturbance to the drain bed and banks. If they have to be disturbed, all practicable measures including location of stockpiles away from drainage ditches will be taken to prevent soils from entering any water – see section 9.5.2. Any culverting works at drains will take place only during dry periods when the drains are dry/stagnant. Silt traps will be placed on the downgradient side of the crossing.

Cement and raw concrete will not be spilled into watercourses. No batching of wet-cement products will occur on site. Ready-mixed supply of wet concrete products and emplacement of pre-cast elements will take place. Pre-cast elements for bridge, culverts and concrete works will be used. During the delivery of concrete on site, only the chute will be cleaned on-site, using the smallest volume of water practicable. Chute cleaning will be undertaken at lined cement washout lagoons. These lagoons will be cleaned out by a licensed waste contractor. No discharge of cement contaminated waters to the construction phase drainage system or directly to any artificial drain or watercourse will be allowed. 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.

A setback distance of 10m to 20m from any stream will be kept clear of brash as far as practicable, to avoid felling of trees into watercourses and removal of them or any other accidental blockages that may occur. Where practicable, crossings should be adequately elevated with low approaches such that water drains away from the crossing point. Earth embankments constructed for bridge approaches will be protected against erosion e.g., by re-vegetation or rock surfacing etc.

9.5.3.7 *Substation*

The mitigation strategies for the substation foundations follow similar procedures to the excavations for turbine and hardstanding foundations, see Section 9.5. All works will be monitored by a suitably qualified and experienced engineer.

Where existing drainage ditches need to be realigned (e.g., around substation), the new swale will match the profile of the existing ditch in relation to side-slope profile and the material at the base of the channel.

9.5.3.8 *Turbine Delivery Route and Grid Connection Route*

Silt fencing will be erected at the location of stream crossings along the grid connection route. Silt curtains and floating booms will also be used where deemed to be appropriate and this will be assessed separately at each individual location.

No refuelling of machinery will take place within 50 m of a stream. Excavated material will not be stockpiled or side-cast within 50 m of a stream. Appropriate steps will be taken to prevent soil/dirt generated during the temporary upgrade works to the TDR from being transported on the public road. Silt fences will be located at the toe of the slope to reduce sediment transport.

Road sweeping vehicles will be used to ensure that the public road network remains free of soil/dirt from the location of the TDR works and grid connection when required. This will reduce the potential for sedimentation of surface watercourses locally.

Further mitigation measures in relation to the grid connection cable route and road/junction accommodation works on the TDR are outlined in the CEMP in Appendix 2-2 of the EIAR.

There will be 2 no. natural watercourse crossings along the grid connection route, and 9 no. stream crossing. Directional drilling is the proposed construction method for 2 no. of identified grid crossings.

Where existing drainage ditches need to be realigned, new drainage ditches will match profile of existing drains in relation to width, with shallower side slope profile and material at base of channel will be reused. The sizing of any new culverts will be designed to maintain existing flow characteristics and depth of flow. Within the site development area, culverts will be assessed to ensure no barriers to fish migration occur. Where barriers occur, such culverts will be improved to increase fisheries potential under advice from the ECOW. Based on the existing data, fisheries potential is low due to natural barriers to migration and low aquatic productivity.

Directional Drilling Mitigation Measures:

Horizontal directional drilling (HDD) is used in the construction industry as a convenient way to install cabling with minimum disruption. In order to limit water quality effects and morphological effects, trenchless technology will be carried out to install the cable below two. streams. While the HDD method limits water quality impacts, the following mitigation apply to ensure the correct operation of this cabling technique and are listed below:

- A minimum 50 m vegetative buffer zone will be maintained between the works area and the stream.
- There will be no storage of material/equipment or overnight parking of machinery inside the 50m buffer zone;
- Before any ground works are undertaken, double silt fencing will be placed upslope of the stream channel along the 50 m buffer zone boundary;
- Additional silt fencing or straw bales (pinned down firmly with stakes) will be placed across any natural surface depressions / channels that slope towards the stream;
- Silt fencing will be embedded into the local soils to ensure all site water is captured and filtered;
- The area around the bentonite (clay) batching, pumping and recycling plant will be bunded using terram and sandbags in order to contain any spillages;
- Drilling fluid returns will be contained within a sealed tank/sump to prevent migration from the works area;
- Spills of drilling fluid will be cleaned up immediately and stored in an adequately sized skip before being taken off-site;
- If rainfall events occur during the works, there will be a requirement to collect and treat small volumes of surface water from areas of disturbed ground (i.e., soil and subsoil exposures created during site preparation works);
- This will be completed using a shallow swale and sump down slope of the disturbed ground; and water will be pumped to a proposed distribution area at least 50 m from the stream;
- The discharge of water onto vegetated ground at the percolation area will be via a silt bag which will filter any remaining sediment from the pumped water;
- Any sediment laden water from the works area will not be discharged directly to a stream or drain;

- Daily monitoring of the compound works area, the water treatment and pumping system and the percolation area will be completed by a suitably qualified person during the construction phase. All necessary preventative measures will be implemented to ensure no entrained sediment, or deleterious matter is discharged to the watercourse;
- If high levels of silt or other contamination is noted in the pumped water or the treatment systems, all construction works will be stopped. No works will recommence until the issue is resolved and the cause of the elevated source is remedied;
- On completion of the works, the ground surface disturbed during the site preparation works and at the entry and exit pits will be carefully reinstated and re-seeded at the earliest opportunity to prevent soil erosion;
- The silt fencing upslope of the river will be left in place and maintained until the disturbed ground has re-vegetated;
- There will be no refuelling allowed within 50 m of the stream crossing; and,
- All plant will be checked for purpose of use prior to mobilisation at the stream crossing.
- The drilling fluid/bentonite will be non-toxic and naturally biodegradable (i.e., Clear Bore Drilling Fluid or similar will be used);
- The area around the drilling fluid batching, pumping and recycling plants will be bunded using terram and/or sandbags to contain any potential spillage;
- Spills of drilling fluid will be cleaned up immediately and transported off-site for disposal at a licensed facility;
- Adequately sized skips will be used where temporary storage of arisings are required;
- The drilling process / pressure will be constantly monitored to detect any possible leaks or breakouts into the surrounding geology or local stream;
- This will be gauged by observation and by monitoring the pumping rates and pressures. If any signs of breakout occur, then drilling will be immediately stopped;
- Any frac-out material will be contained and removed off-site; and
- The drilling location will be reviewed, before re-commencing with a higher viscosity drilling fluid mix.

9.5.3.9 Major Accidents/Disasters

This section describes the expected significant effects on the environment arising from the vulnerability of the proposed project to risks of major accidents and/or natural disasters which are relevant the project.

The assessment must consider the expected effects deriving from the vulnerability of the project to risks of major accidents and/or disasters that are relevant to the project.

As detailed in Section 9.3, there is no significant risk of flooding on the site based on current climatic conditions and predicted climate change. In this regard, the most likely major accidents or disaster that could occur as a result of the proposed project (and its associated works) include peat slippage. Details of Peat Stability are included in Chapter 8 Land, Soils and Geology.

It can be concluded that the risk of major accidents associated with this development and hydrological/hydrogeological factors is low and would not cause unusual, significant or adverse effects on the hydrological or hydrogeological environment during the construction, operational and decommissioning phases.

9.5.4 Mitigation Measures – Operational Phase

The following mitigation measures will be implemented during the operational stage.

9.5.4.1 Turbines, Hardstanding, Temporary Construction Compounds, Met Mast and Access Tracks

The operational team will carry out maintenance works such as servicing of wind turbine and transmission infrastructure, upkeep of access tracks and any hardstand areas, ensuring the drainage system remains functional throughout the operation of the windfarm.

Mitigation for the operational maintenance works include regular scheduled maintenance works, regular inspections of all project elements with any unscheduled repairs or maintenance arising to be undertaken.

The potential effect of hydrocarbon or oil spills during the operational phase of the windfarm are limited by the size of the fuel tank of vehicles used on the site. Mitigation measures for the potential release of hydrocarbons or oil spills include:

- The plant and vehicles to attend site should be regularly inspected or at least prior to the scheduled site visit to be free from leaks and is fit for purpose;
- Fuels stored on site will be minimised, any storage areas will be bunded appropriately for the fuel storage volume for the time period of the operation;
- Operational team to be competent and trained in an emergency plan for the operation phase to deal with accidental spillages; and
- Spill kits will be available to deal with accidental spillages.

9.5.4.2 Substation

All fuel will be stored in bunded areas. The bund capacity will be sufficient to accommodate 110% of the largest tank's maximum capacity or 25% of the total maximum capacities of all tanks, whichever is the greater. The exception to this being double walled tanks equipped with leak detection, which do not require additional retention.

A hydrocarbon interceptor will be installed at the proposed substation site with regular inspection and maintenance, to ensure optimal performance.

Given the requirement for sanitary facilities during occasional operation and maintenance works, wastewater effluent will be directed to an onsite holding tank, from where it will be tankered off site to a suitably licensed wastewater treatment plant. An automatic alert system will be used to monitor the holding tank to alert the operator if the tank is nearing full capacity. A rainwater harvesting facility will be provided at the substation control building. Potable water will be provided by water dispensers.

9.5.5 Mitigation Measures – Decommissioning Phase

Decommissioning of the proposed project would result in the cessation of renewable energy generation, the removal of all above ground turbine components whilst other infrastructural elements such as turbine foundations. The site access tracks, parking area, cabling and substation will remain in place.

The risks associated with leaving tracks and infrastructural components in situ are relatively low. The decommissioning phase will not require any significant works that will effect the drainage network. A fuel management plan to avoid contamination by fuel leakage during decommissioning works will be implemented as per the construction phase mitigation measures.

Mitigation measures applied during decommissioning activities will be similar to those applied during construction where relevant. Some of the effects will be avoided by leaving elements of the proposed project in place. The turbine bases and hardstanding areas will be rehabilitated by covering with locally sourced topsoil in order to regenerate vegetation which will reduce runoff and sedimentation effects.

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 mentioned in Section 9.5.

These effects have therefore been assessed as similar to the construction phase. Mitigation measures for the construction phase will therefore also be implemented during decommissioning.

Monitoring

It is proposed that local surface water features in the immediate vicinity of the site boundary are monitored pre-construction and during construction to take account of any variations in the quality of the local surface water and groundwater environment as a result of activities related to the proposed project.

Inspections of silt control measures are critical after prolonged or intense rainfall while maintenance will ensure maximum effectiveness of the proposed measures. A programme of inspection and maintenance is proposed, and dedicated construction personnel assigned to manage this programme.

During the construction phase, field testing and laboratory analysis of a range of parameters will be undertaken at adjacent streams, specifically following heavy rainfall events (i.e., weekly, monthly and event based as appropriate).

Regular visual inspections of all streams (flow conditions, discolouration, collection of debris, fish in distress or floating), presented in a monthly report on water quality, will be carried out by an independent, suitably qualified Environmental Clerk of Works (ECoW) with particular emphasis placed on:

- Streams downstream of site activities;
- At times when heavy traffic is frequenting the site;
- During and after periods of heavy or prolonged rainfall and during winter months;
- During fish migration and spawning periods; and
- Stream crossings to ensure that the existing mitigation measures are effective in preventing any sediment reaching streams.

9.6 RESIDUAL EFFECTS

The potential residual effects on the surrounding water quality, hydrology and existing drainage regime at the proposed wind farm site are considered to be slight and temporary/short term in nature. The existing on-site drainage system will remain active during construction and operation of the proposed project.

The construction timescale of activities within the site will be phased and short-term in duration and, thereafter, the only activities occurring within the site will be associated with maintenance, such as maintaining the wind turbines and existing drains, ongoing maintenance, replacement of turbines and onsite infrastructure and monitoring during the operational phase. There are no significant long-term effects.

The design of the proposed wind farm has taken account of the potential effects of the development and the risks to the surface water and groundwater environment. Measures have been developed to mitigate the potential effects on the water environment. These measures seek to avoid or minimise potential effects in the main through the implementation of best practice construction methods and adherence to all relevant legislation. Residual effects post mitigation is outlined in Table 9-22, Table 9-23 and Table 9-24.

Table 9-22: Magnitude and Significance of Hydrological and Hydrogeological Criteria - Residual Effects (Construction Phase) post mitigation

Criteria	Duration and Frequency of Effects	Significance of Potential Effects
Runoff Regime	Short term and rarely	Not significant
Surface Water Quality	Temporary and occasional	Not significant
Groundwater Levels	Short term and rarely	Not significant
Groundwater Quality	Short term and occasional	Not significant

Potential residual effects from the construction phase of the proposed project on the hydrological and hydrogeological environment are considered to be negative, short term and not significant.

Table 9-23: Magnitude and Significance of Hydrological and Hydrogeological Criteria - Residual Effects (Operational Phase)

Criteria	Duration and Frequency of Effects	Significance of Potential Effects
Runoff Regime	Long term and rarely	Not significant
Surface Water Quality	Long term and rarely	Not significant
Groundwater Levels	Long term and rarely	Imperceptible
Groundwater Quality	Long term and rarely	Imperceptible

Potential residual effects from the operational phase of the proposed project on the hydrological and hydrogeological environment are considered to be negative, of an unlikely probability, long term and not significant.

Table 9-24: Magnitude and Significance of Hydrological and Hydrogeological Criteria - Residual Effects (Decommissioning Phase)

Criteria	Duration and Frequency of Effects	Significance of Potential Effects
Runoff Regime	Short term and rarely	Not significant
Surface Water Quality	Temporary and occasional	Not significant
Groundwater Levels	Short term and rarely	Imperceptible
Groundwater Quality	Short term and occasional	Imperceptible

In terms of the hydrological effects, there is no potential for effect on a number of the sensitive receptors as a result of keeping most of the below ground infrastructure. No changes to the internal drainage which could lead to localised erosion are anticipated. The decommissioning phase would have an unlikely and imperceptible effect for the high sensitivity streams.

9.7 CUMULATIVE EFFECTS

The cumulative effects of this project with other developments in the region, as discussed in Chapter 4 - Policy, Planning and Development Context, relate to the indirect effects that may arise due to the use of public roads as haul roads to bring materials to site.

In terms of the potential effects of wind farm developments on downstream surface water bodies, the biggest risk is during the construction phase of the project as this is the phase when earthworks and excavations will be undertaken at the sites.

Potential hydrological cumulative effects arising from the proposed wind farm and proposed grid connection are also not expected to be significant because the cables will be placed within the one trench along existing roads thereby reducing overall excavation requirements. Also, no in-stream works are required along the grid connection route.

The proposed forestry replanting sites are remote from the site of the proposed project (i.e., in different counties and groundwater and surface water catchments). There is no hydrological or hydrogeological connectivity between the replanting sites and the site of the proposed project, and therefore there can be no cumulative effects or interactions at any phase of the development. There are no predicted significant effects of forestry replanting with the implementation of the Forestry and Water Quality Guidelines (Forest Service, 2000).

A review of the 'other developments' as described in Chapter 4 (Planning Policy and Development Context) was carried out in Appendix 4-1. There were a number of (hydrologically) relevant planning applications in terms of the 10km zone of influence radius surrounding the proposed project site. A number of windfarms including Loughderryduff Wind Farm and Maas Wind Farm (which was refused by Donegal County Council and is currently being appealed to An Bord Pleanála) are located within 10km however there are located in separate surface water catchments. No other significant developments are proposed within 10km that would result in cumulative/in combination effects.

9.8 CONCLUSIONS

The following conclusions can be drawn in relation to surface water and groundwater:

- The site drains to a number of tributaries surrounding the site boundary. These consist of tributaries of the Gweebarra River;
- The site is underlain predominantly by low permeability soil and peat overlying shallow glacial till on top of granite bedrock;
- Man-made drains are located within the site and will continue to operate as part of the water management system on site;
- The site is generally moderately to steeply sloping and has two topographically higher areas in the south of the site, the moderate slope gradients consequently have a moderate risk due to changes caused by the development on the hydrological regime;
- Water quality in the immediate area of the site is unpolluted and is consistent with the expected natural water quality for a similar environment. The water quality reported by the EPA downstream of the site is of good status; and
- The site overlies a poorly productive aquifer with low groundwater recharge and high groundwater vulnerability.

The residual effects on the surrounding water quality, hydrology, hydrogeology and existing drainage regime at the site are considered to be not significant and mainly short term in nature. The existing on-site drainage system will remain active during the construction and operation of the proposed wind farm and the 110kV cable and will be complemented by the drainage plan that has been designed for this development. Apart from the upgrade of existing roads and stream crossings along the grid connection, most of the proposed project 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 or any general construction works. There are no significant long-term effects.

Detailed mitigation measures have been provided with regard to the design, construction, maintenance and decommissioning of the proposed project. The surface water drainage plan will be the principal means of significantly reducing sediment runoff arising from construction activities and to control runoff rates. The key surface water control measure is that there will be no direct discharge of wind farm runoff into local streams. This will be achieved by avoidance methods (i.e., stream buffers) and design methods (i.e., surface water drainage plan). Water monitoring will be carried out to alert the applicant to any issues.

In summary, the available information indicates that the proposed project presents no significant long-term effect on water quality, hydrology and hydrogeology, provided that the works are designed, constructed, maintained and decommissioned in accordance with the mitigation measures outlined in this chapter.

No significant cumulative effects on any of the regional surface water catchment or groundwater bodies are anticipated from the proposed project and associated grid connection. The proposed project will not impact upon any surface water or groundwater body, it will not cause a deterioration of the status of the body and/or it will not jeopardise the attainment of good status.