Planning and Environmental Consultants

Environmental Impact Assessment Report

Carrig Renewable Energy Wind Farm

Chapter 9 – Hydrology and Hydrogeology

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9. HYDROLOGY AND HYDROGEOLOGY

9.1 Introduction

9.1.1 Background and Objectives

Hydro-Environmental Services (HES) was engaged by MKO to carry out an assessment of the potential likely and significant effects of the proposed Carrig Renewable Energy Wind Farm including grid connection (Proposed Development) in Co. Tipperary on water aspects (hydrology and hydrogeology) of the receiving environment.

The Proposed Development, which includes 7 no. turbines, substation and underground grid connection is located at Carrig (and surrounding townlands), situated approximately 9km to the northeast of Borrisokane, Co. Tipperary. A full description of the Proposed Development is provided in Chapter 4 of this EIAR.

The proposed underground grid connection is to the Dallow substation, situated 2.5km north of Birr (Co. Offaly) and measures a total distance of 13.7km.

The Proposed Development site (as defined by the EIAR Study Area boundary) includes the wind farm site and grid connection route.

The objectives of the assessment are:

- Produce a baseline study of the existing water environment (surface water and groundwater, i.e. natural resources) in the area of the Proposed Development;
- Identify likely significant effects of the Proposed Development on surface water and groundwater natural resources during construction, operational and decommissioning phases of the Proposed Development;
- Identify mitigation measures to avoid, reduce or offset significant negative effects;
- Assess significant residual effects; and
- Assess cumulative hydrological effects of the Proposed Development and other local developments (as described in Chapter 2; Section 2.8 of this EIAR).

Please note that in this chapter, for descriptive purposes, we refer to the wind farm site, the grid connection cable route and the overall Proposed Development site (EIAR Site Boundary).

The potential Zone of Impact of the Proposed Development on the Water Environment is limited within the Water Study Area as defined on Figure 9-1, as these are the catchments within which the Proposed Development is located. The Proposed Development Water Study Area is defined by the Little Brosna River catchment as shown in Figure 9-1 below.

9.1.2 Statement of Authority

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

Our core areas of expertise and experience include peatland hydrology and windfarm drainage design. We routinely complete impact assessment reports for hydrological and hydrogeological aspects for a variety of project types.

This chapter of the EIAR was prepared by Michael Gill, David Broderick and Conor McGettigan.

Michael Gill (P. Geo., B.A.I., MSc, Dip. Geol., MIEI) is an Environmental Engineer with over 22 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments of wind farms in Ireland. He has also managed EIAR assessments for infrastructure projects and private residential and commercial developments. In addition, he has substantial experience in wastewater engineering and site suitability assessments, contaminated land investigation and assessment, wetland hydrology/hydrogeology, water resource assessments, surface water drainage design and SUDs design, and surface water/groundwater interactions. For example, Michael has worked on the EIS/EIARs for Derrinlough WF, Cahermurphy (Phase I & II) WF, Carrownagowan WF and Croagh WF and over 100 other wind farm related projects across the country.

David Broderick (P. Geo, BSc, H. Dip Env Eng, MSc) is a hydrogeologist with over 17 years' experience in both the public and private sectors. Having spent two years working in the Geological Survey of Ireland working mainly on groundwater and source protection studies David moved into the private sector. David has a strong background in groundwater resource assessment and hydrogeological/hydrological investigations in relation to developments such as quarries and wind farms. David has completed numerous geology and water sections for input into EIARs for a range of commercial developments. David has worked on the EIS/EIARs for Derrykillew WF, Croagh WF, and Oweninny WF, and over 60 other wind farm related projects across the country.

Conor McGettigan (BSc, MSc) is a Junior Environmental Scientist with 3 years' experience in the environmental sector in Ireland. Conor has completed a Bachelor of Science (Geology) (2016) and a Masters in Applied Environmental Science (2020) from University College Dublin. In recent times Conor has assisted in the preparation of the Hydrology and Hydrogeology Chapters for several developments including wind farms and quarries.

9.1.3 Scoping and Consultation

The scope for this chapter of the EIAR has also been informed, in part, by consultation with statutory consultees, bodies with environmental responsibility and other interested parties. This consultation process and the List of Consultees is outlined in Section 2.6 of this EIAR. Matters raised by Consultees in their responses with respect to the Water Environment are summarised in Table 9-1 below.

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

Consultee	Description	Addressed in Section
Inland Fisheries Ireland (IFI)	*"In particular the protection of streams such as the Faddan Beg that crosses the proposed site and which feeds into the Little Brosna River which flows directly to the River Shannon at Victoria Lock, part of the River Shannon Callows SAC"* *"We are concerned about soils, their structure and types around all the turbines, turbine pads, associated access roads and site development. In particular we have concerns about the stability of the soils and the impact that works on both the turbines and access roads may have either directly or by vibration on the stability of the soils. IFI are particularly concerned where it is proposed to construct wind turbines on peat soils especially if these peat soils are located on upland areas. Extra caution will be required to prevent deleterious discharges to waters".*	Mitigation measures for the protection of surface water quality are detailed in Sections 9.4.1, 9.4.2, 9.5.2.1, 9.5.2.2 & 9.5.2.3.

Consultee	Description	Addressed in Section
Geological Survey of Ireland (GSI)	*""Arragh More Bog, Co. Tipperary (GR 197387, 201288), under IGH themes: IGH7 Quaternary, IGH16 Hydrogeology. An active raised-bog in a low-lying hollow 6 km east of Carrigahorig. The entire Arragh More Bog comprises several interconnecting bogs, with till ridges running between deeper areas of bog. Peat has developed on some of the ridges. A large flush occurs in the northern area of the bog partially forested by conifers. Large areas of the southern part of the bog are characterised by cutover".* *"With the current plan, there may be potential impacts on the integrity of current CGSs envisaged by the proposed development, should these sites not be assessed as constraints. Ideally, the sites should not be damaged or integrity impacted or reduced in any manner due to the proposed development. However, this is not always possible, and in this situation appropriate mitigation measures should be put in place to minimize or mitigate potential impacts".*	An assessment of potential hydrological effects on Arragh More Bog are detailed in Sections 9.3.14 & 9.5.2.13
	"There is a groundwater drinking water abstraction within the proposed wind farm study area for which there is a source protection area: Abbeyville Group Water Scheme (GWS). Key to groundwater protection in general, and protection of specific drinking water supplies, is preventing ingress of road runoff to the aquifer. Design of access road drainage will need to be cognisant of this supply scheme and the interactions between surface water and groundwater as well as run-off. Appropriate design should be undertaken by qualified and competent persons to include mitigation measures as necessary, such as SUDs or other drainage mitigation measures. Given the nearby drinking water source, the effects of any potential contamination/dewatering as a result of the wind farm development would need to be assessed".	The potential effects on groundwater supplies are assessed in Section 9.3.15.

9.1.4 Relevant Legislation

The EIAR is prepared in accordance with the requirements of European Union Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment (the 'EIA Directive') as amended by Directive 2014/52/EU.

Regard has also been taken of the requirements of the following legislation:

- Planning and Development Acts, 2000 (as amended);
- Planning and Development Regulations, 2001 (as amended);

- S.I. No 296/2018: European Union (Planning and Development) (Environmental Impact Assessment) Regulations 2018 which transposes the provisions of the EIA Directive as amended by Directive 2014/52/EU into Irish Law;
- S.I. No. 477/2011 – European Communities (Birds and Natural Habitats) Regulations 2011 which give effect to EU Directives 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (the Habitats Directive) and 79/409/EEC on the conservation of wild birds (the Birds Directive);
- S.I. No. 293/1988: Quality of Salmon Water Regulations;
- S.I. No. 272/2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009, as amended, and S.I. No. 722 of 2003 European Communities (Water Policy) Regulations, as amended, which implement EU Water Framework Directive (2000/60/EC) and provide for implementation of 'daughter' Groundwater Directive (2006/118/EC). Since 2000 water management in the EU has been directed by the Water Framework Directive (WFD). The key objectives of the WFD are that all water bodies in member states achieve (or retain) at least 'good' status by 2015. Water bodies comprise both surface and groundwater bodies, and the achievement of 'Good' status for these depends also on the achievement of 'good' status by dependent ecosystems. Phases of characterisation, risk assessment, monitoring and the design of programmes of measures to achieve the objectives of the WFD have either been completed or are ongoing. In 2015 it was fully replaced a number of existing water related directives, which are successively being repealed, while implementation of other Directives (such as the Habitats Directive 92/43/EEC) will form part of the achievement of implementation of the objectives of the WFD;
- S.I. No. 684/2007: Waste Water Discharge (Authorisation) Regulations, 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. 294/1989 of 1989: Quality of Surface Water Intended for Abstraction (Drinking Water), resulting from EU Directive 75/440/EEC concerning the quality required of surface water intended for the abstraction of drinking water in the Member States (as amended by 2000/60/EC in 2007);
- S.I. No.106/2007: European Communities (Drinking Water) Regulations and S.I. No. 122/2014: European Union (Drinking Water) Regulations, arising from EU Directive 98/83/EC on the quality of water intended for human consumption (the Drinking Water Directive) and WFD 2000/60/EC (the Water Framework Directive);
- S.I. No. 9/2010: European Communities Environmental Objectives (Groundwater) Regulations 2010, as amended; and,
- S.I. No. 296/2009: European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009, as amended.

9.1.5 Relevant Guidance

The Hydrology and Hydrogeology chapter of the EIAR is carried out in accordance with guidance listed below:

- Environmental Protection Agency (2022): Guidelines on the Information to be contained in Environmental Impact Assessment Reports;
- Institute of Geologists Ireland (2013): Guidelines for Preparation of Soils, Geology & Hydrogeology Chapters in Environmental Impact Statements;
- National Roads Authority (2008): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;
- Department of Environment, Heritage and Local Government (2006): Wind Energy Development Guidelines for Planning Authorities;

- Inland Fisheries Ireland (2016): Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters;
- Scottish Natural Heritage (2010): Good Practice During Wind Farm Construction;
- PPG1 - General Guide to Prevention of Pollution (UK Guidance Note);
- PPG5 – Works or Maintenance in or Near Watercourses (UK Guidance Note);
- CIRIA (Construction Industry Research and Information Association) (2006): Guidance on 'Control of Water Pollution from Linear Construction Projects' (CIRIA Report No. C648, 2006);
- CIRIA 2006: Control of Water Pollution from Construction Sites - Guidance for Consultants and Contractors (CIRIA C532, 2006);
- Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment (DoHPLG, 2018);
- DOE/NIEA (2015): Wind Farms and Groundwater Impacts – A guide to EIA and Planning Considerations; and,
- Guidance on the preparation of the EIA Report (Directive 2011/92/EU as amended by 2014/52/EU), (European Union, 2017).

9.2 Methodology

9.2.1 Desk Study

A desk study of the Proposed Development site and Water Study Area was completed prior to the undertaking of field mapping, walkover assessments and investigations. The desk study involved collecting all relevant geological, hydrological, hydrogeological and meteorological data for the Proposed Development site and Water Study Area. This included consultation of the following:

- Environmental Protection Agency databases (www.epa.ie);
- Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Met Eireann Meteorological Databases (www.met.ie);
- National Parks and Wildlife Services Public Map Viewer (www.npws.ie);
- EPA/Water Framework Directive Map Viewer (www.catchments.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 15 (Geology of Galway - Offaly). Geological Survey of Ireland (GSI, 1999); and,
- Geological Survey of Ireland (2003) – Groundwater Body Initial Characterization Reports;
- OPW Flood Maps (www.floodinfo.ie).

9.2.2 Baseline Monitoring and Site Investigations

Hydrological walkover surveys, including detailed drainage mapping and baseline monitoring/sampling, was undertaken by David Broderick of HES (refer to Section 9.1.2 above for qualifications and experience) on 24th August 2022, 17th, 24th January, 25th March and 14th April 2023.

Geotechnical ground investigations and a peat stability assessment were undertaken by Gavin and Doherty Geosolutions (GDG). The combined geological and hydrogeological site investigation dataset collated by HES, MKO and GDG has been used in the preparation of this EIAR Chapter.

Hydrological and hydrogeological factors were also assessed in the Peat Stability Risk Assessment Report, and interaction between GDG, HES and MKO was undertaken throughout the iterative design process.

In summary, all site investigations to address the Hydrology and Hydrogeology chapter of the EIAR are as follows:

- Walkover surveys and hydrological mapping of the Proposed Development site were undertaken whereby water flow directions and drainage patterns were recorded;
- A total of 163 no. peat probes were undertaken by GDG, MKO & HES to determine the thickness and geomorphology of the cutover raised peat overlying the Proposed Development site;
- A Peat Stability Risk Assessment was undertaken by GDG (June 2023);
- A total of 10 no. gouge core sample points were undertaken by HES across the Proposed Development site to investigate peat and mineral subsoil lithology;
- Trial pitting (15 no.) was completed by GDG at the wind farm site to investigate underlying mineral subsoil lithology and the subsoil-bedrock interface;
- Field hydrochemistry measurements (electrical conductivity, pH, dissolved oxygen, turbidity and temperature) and surface water flow measurements were taken to determine the origin and nature of surface water flows within and surrounding the Proposed Development site; and
- A total of 2 no. rounds of surface water samples were taken to determine the baseline water quality of the primary surface waters originating from and intercepted by the Proposed Development site.

9.2.3 Impact Assessment Methodology

The guideline criteria (EPA, 2022) for the assessment of likely significant effects require that likely effects are described with respect to their extent, magnitude, type (i.e. negative, positive or neutral) probability, duration, frequency, reversibility, and transfrontier nature (if applicable). The descriptors used in this environmental impact assessment are those set out in the EPA (2022) Glossary of effects as shown in Chapter 1, Section 1.6 of this EIAR.

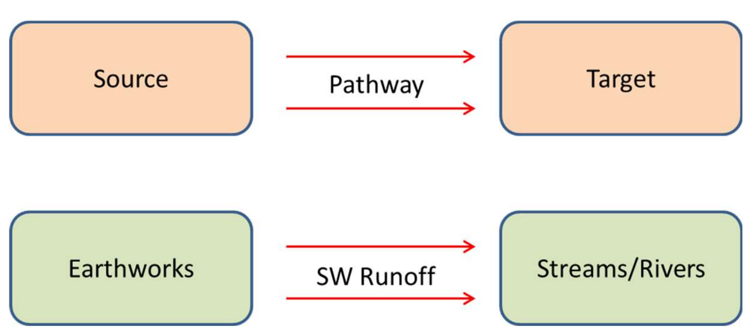
In addition to the above methodology, the sensitivity of the water environment receptors was assessed on completion of the desk study and baseline study. Levels of sensitivity which are defined in Table 9-2 are used to assess the potential effect that the Proposed Development may have on them.

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

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

9.2.4 Overview of Impact Assessment Process

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



Where potential impacts are identified, the classification of impacts in the assessment follows the descriptors provided in the Glossary of Impacts contained in the following guidance documents produced by the Environmental Protection Agency (EPA):

- Guidelines on the Information to be Contained in Environmental Impact Assessment Reports (EPA, 2022)

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

In order to provide an understanding of the stepwise impact assessment process applied below (Section 9.5), we have firstly presented below a summary guide that defines the steps (1 to 7) taken in each element of the impact assessment process. The guide also provides definitions and descriptions of the assessment process and shows how the source-pathway-target model and the EPA impact descriptors are combined.

Using this defined approach, this impact assessment process is then applied to all wind farm and grid connection construction and operation and decommissioning activities which have the potential to generate a source of significant adverse impact on the geological and hydrological/ hydrogeological (including water quality) environments.

Table 9-1: Stepwise Impact Assessment Approach

Step 1	Identification and Description of Potential Impact Source This section presents and describes the activity that brings about the potential impact or the potential source of pollution. The significance of effects is briefly described.	
Step 2	Pathway / Mechanism:	The route by which a potential source of impact can transfer or migrate to an identified receptor. In terms of this type of development, surface water and groundwater flows are the primary pathways, or for example, excavation or soil erosion are physical mechanisms by which a potential impact is generated.
Step 3	Receptor:	A receptor is a part of the natural environment which could potentially be impacted upon, e.g. human health, plant / animal species, aquatic habitats, soils/geology, water resources, water sources. The potential impact can only arise as a result of a source and pathway being present.
Step 4	Pre-mitigation Impact:	Impact descriptors which describe the magnitude, likelihood, duration and direct or indirect nature of the potential impact before mitigation is put in place.
Step 5	Proposed Mitigation Measures:	Control measures that will be put in place to prevent or reduce all identified significant adverse impacts. In relation to this type of development, these measures are generally provided in two types: (1) mitigation by avoidance, and (2) mitigation by engineering design.
Step 6	Post Mitigation Residual Impact:	Impact descriptors which describe the magnitude, likelihood, duration and direct or indirect nature of the potential impacts after mitigation is put in place.
Step 7	Significance of Effects:	Describes the likely significant post mitigation effects of the identified potential impact source on the receiving environment.

9.2.5 Limitations and Difficulties Encountered

No limitations or difficulties were encountered during the preparation of the Water Chapter of the EIAR.

9.3 Receiving Environment

9.3.1 Site Description and Topography

The wind farm site is a low-lying cutaway raised bog setting (basin peat) located 9km to the northeast of Borrisokane, Co. Tipperary. The town of Birr in County Offaly is located 6.5km to the northeast. Access to the wind farm site is from the N52 which is located approximately 1.5km to the east of the Proposed Development site.

The wind farm site, which has a total area of approximately 314ha, is predominantly cutaway raised bog with areas of agricultural grassland and forestry. The surrounding area is largely agricultural including a piggery development which is located immediately to the northwest of the wind farm site. The wind farm site is accessible via network of public roads which run through the site along with some bog tracks that give access to various turbary plots on the periphery of the bog.

The wind farm site is located in a low-lying area (surrounded by small hills) where the ground is largely flat and sits at approximately 60m OD. The ground level rises to 70m OD on the east and west of the wind farm site where small hills are present. This forms a subdued topographic divide running through the centre of the wind farm site which creates gentle falls to the north and south.

Most of the wind farm site is exposed cutaway raised bog (with pockets of intact bog towards the centre), however there is tree coverage on the bog particularly on the northeast, northwest and west. There is agricultural land on the southwest.

The proposed grid connection is to the Dallow substation, situated 2.5km north of Birr (Co. Offaly) and measures a total distance of approximately 13.7km. The proposed route is located entirely along public roads.

9.3.2 Water Balance

Long term Annual Average Rainfall (AAR) and evaporation data was sourced from Met Éireann. The 30-year annual (1980 – 2010) average rainfall recorded at the Birr rainfall station, located approximately 6.5km northeast of the Proposed Development site are presented in Table 9-4.

Table 9-4 Local Average long-term Rainfall Data (Birr) (mm)

Station		X-Coord		Y-Coord		Ht (MAOD)		Opened		Closed		
Birr		207,400		204,400		73		1954		N/A		
Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
80	57	67	56	59	67	63	80	67	94	79	80	849

The closest synoptic[1] station where the average potential evapotranspiration (PE) is recorded is also at Birr. The long-term average PE for this station is 445mm/year. This value is used as a best estimate of the wind farm site PE. Actual Evaporation (AE) at the site is estimated as 423mm/year (which is 0.95 × PE).

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

Effective rainfall (ER) = AAR – AE

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

= 849mm/year – 423mm/year

ER = 426mm/year

GSI groundwater recharge coefficient estimates at the wind farm site range from 4% to 10% which is for cutover raised bog with a groundwater vulnerability rating of between low and high respectively (www.gsi.ie). An average of 7% is taken for the overall wind farm site area.

The hydrology of the wind farm site is characterised by very high surface water runoff rates and very low groundwater recharge rates. Therefore, conservative annual recharge and runoff rates for the wind farm site are estimated to be 30m/year and 396mm/year respectively.

Table 9-5 below presents return period rainfall depths for the area of the wind farm site. These data are taken from https://www.met.ie/climate/services/rainfall-return-periods and they provide rainfall depths for various storm durations and sample return periods (1-year, 50-year, 100-year). These extreme rainfall depths will be the basis of the proposed wind farm drainage hydraulic design as described further below at Section 0.

Table 9-5 Return Period Rainfall depths (mm) for the Carrig Renewable Wind Farm Development

	Return Period (Years)			
Storm Duration	1	5	30	100
5 mins	3.9	6.8	12.1	17.3
15 mins	6.4	11.2	19.8	28.3
30 mins	8.1	13.7	23.3	32.3
1 hour	10.3	16.7	27.3	36.9
6 hours	19.2	28.0	41.1	52.1
12 hours	24.5	34.2	48.1	59.5
24 hours	31.1	41.7	56.4	68.0
2 days	38.5	50,5	66.5	79.0

9.3.3 Regional and Local Hydrology

Regionally the Proposed Development site is located in the Lower River Shannon surface water catchment within Hydrometric Areas 25A and 25B of the Shannon International River Basin District. A regional hydrology map is shown as Figure 9-1.

On a more local scale, the Proposed Development site is located entirely within the LittleBrosna_SC_020 sub-catchment (Little Brosna River catchment). The Little Brosna River flows to the east of the wind farm site at a downstream distance of approximately 5.5km. The Little Brosna River flows into the Shannon River approximately 22km downstream of the wind farm site. The grid connection crosses over the Little Brosna River northwest of Birr Town.

The Proposed Development site drains directly into the Little Brosna River via several local river waterbodies as described below in Section 9.3.4.

A local hydrology map is shown as Figure 9-2.

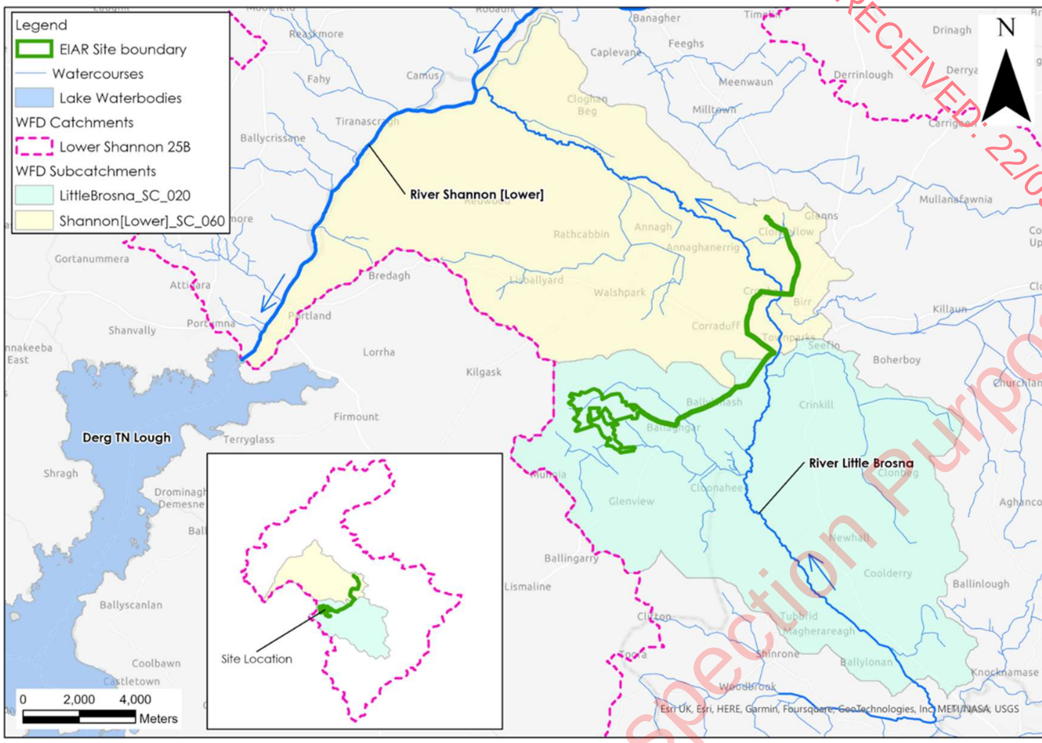


Figure 9-1: Regional Hydrology Map

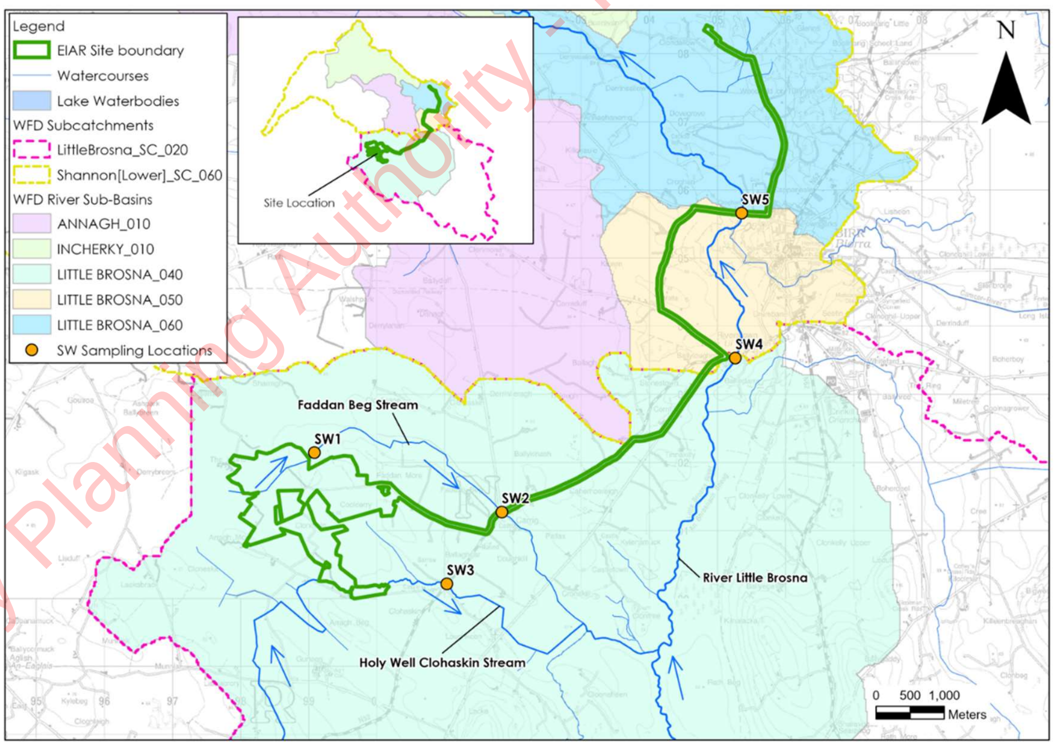


Figure 9-2: Local Hydrology Map

9.3.4 Wind Farm Site Drainage

The wind farm site drains to the Little Brosna River via 3 main river waterbodies. The Fadden Beg Stream on the north of the proposed site, the Holy Well Clohaskin Stream and Fadden More Stream on the south of the proposed site.

The northern portion of the wind farm site (including 6 no. of the 7 no. proposed turbine locations) is drained by the Faddan Beg Stream (EPA Code: 25F29) which flows through the northwestern section of the wind farm site.

The Faddan Beg Stream is a first order stream that rises to the west of the wind farm site and then flows along the northern edge of the cutaway raised bog on which many of the proposed turbines are located. The bog is significantly cutaway and has turbary plots that extend into the central portion of the bog. There are several drainage outfalls from the cutaway raised bog that flow northerly towards the Faddan Beg Stream as it passes through the wind farm site. The portion of the wind farm site to the north of the Faddan Beg Stream is largely covered by a coniferous forest which has a network of large land drains that flow to the southeast towards the Faddan Beg Stream.

The Faddan Beg Stream is joined by a second (unnamed) first order stream that emerges from the southwestern portion of the wind farm site and then flows along the south-eastern edge of the cutover raised bog before merging with the Faddan Beg Stream close to the northern boundary. The unnamed stream also drains some agricultural land located to the south of the cutaway raised bog.

The southern portion of the wind farm site drains to the Holy Well Clohaskin Stream (EPA Code: 25F29), which is a second order stream, that intercepts the southern section of the wind farm site. The Holy Well Clohaskin Stream is fed by a smaller first order stream (Fadden More Stream) that flows along the south-eastern boundary of the wind farm site.

Proposed wind farm infrastructure in the southern portion of the wind farm site that drains to the Holy Well Clohaskin Stream include 1 no. turbine (T1) along with the site entrance and main access road. There is an area of commercial bog cutting in the south of the wind farm site that also drains to the Holy Well Clohaskin Stream and Fadden More Stream.

An existing drainage map for the wind farm site is shown within Figure 9-3. The drainage map was created using OSI mapped watercourses, aerial photography,field mapping. Lidar data allows detailed mapping on the topographic contours of the wind farm site, thereby identifying all the linear drainage features at the site that are greater than 150m in length. Based on this assessment the main drainage pathways at the wind farm site are shown and the connectivity (i.e. pathways and outlet points) of these drains with the downstream EPA mapped streams/rivers can be clearly illustrated.

Surface water flow monitoring of the main streams emerging from the wind farm site was undertaken at 3 no. locations (SW1 – SW3) (Table 9-6) and also downstream of the grid connection route on Little Brosna River (SW4 & SW5).

The flows are typical of small streams (watercourses draining the wind farm site) and larger waterbodies (Little Brosna River).

Table 9-6 Surface Water Flow Monitoring

Location	17/01/2023	13/04/2023
	Flow (l/sec)	Flow (l/sec)
SW1	15	10
SW2	45	30
SW3	70	50
SW4	+500	+300
SW5	+1000	+800

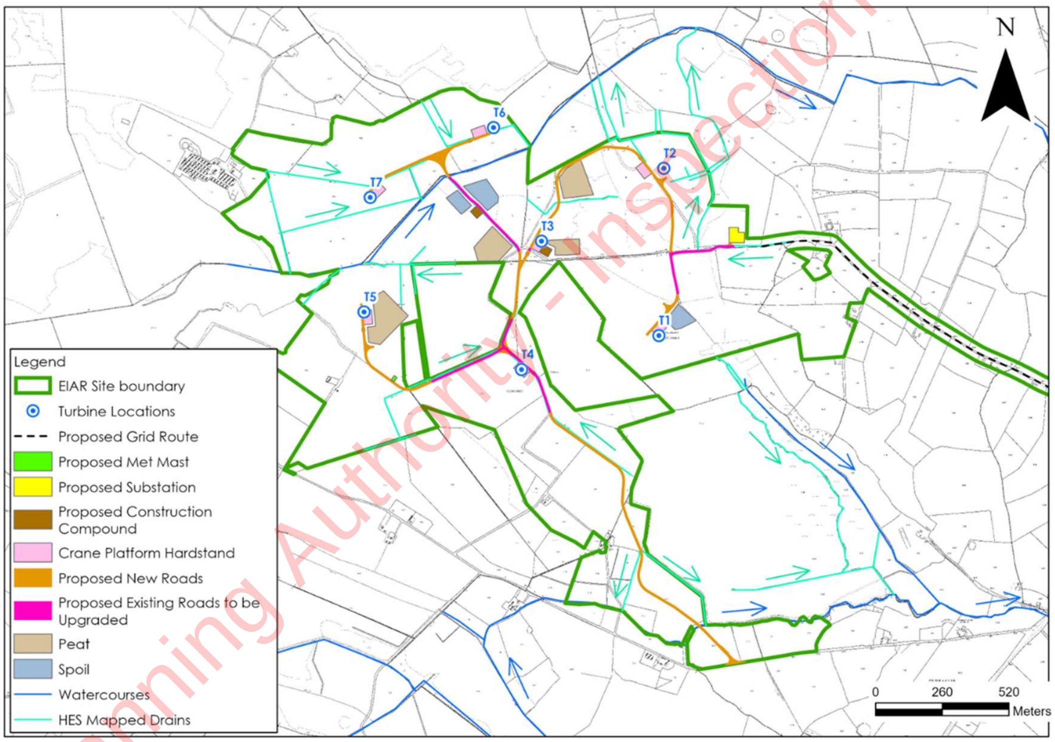


Figure 9-3: Wind Farm Site Drainage Map

9.3.5 Baseline Assessment of Wind Farm Site Runoff

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

The following water balance assessment gives a preliminary indication of the highest monthly average volume of surface water runoff expected. The calculations are carried out for the month with the highest average recorded rainfall versus evapotranspiration (October), in terms of subsoil and recharge.

The rainfall depths used in this water balance, are long term averages. Please note the long term averages are not used in the design of the sustainable drainage system for the wind farm.

The water balance calculations are carried out for the month with the highest average recorded rainfall minus evapotranspiration, for the current baseline site conditions (Table 9-7). It represents, therefore, the long-term average wettest monthly scenario in terms of volumes of surface water runoff from the site pre-wind farm development.

An average of 7% groundwater recharge is taken for the overall wind farm site area. Therefore the surface water runoff co-efficient for the wind farm site is estimated to be 93%. Surface water runoff rates at the wind farm site are high due to the coverage of low permeability basin peat. This high rate of surface water runoff is reflected in the high density of drains and surface water features within the wind farm site also.

The highest long-term average monthly rainfall recorded at Birr rainfall station over 30 years occurred in the month of October, at 94mm. The average monthly evapotranspiration for the synoptic station at Malin Head over the same period in October was ~18mm. The water balance volumes presented in Table 9-8 indicates that a conservative estimate of surface water runoff for the wind farm site during the highest rainfall month is 224,855m^3/month or 7,253m^3/day.

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

Water Balance Component	Depth (m)
Estimated Average October Rainfall (R)	0.094
Average October Potential Evapotranspiration (PE)	-0.018
(AE = PE x 0.95)	-0.017
Effective Rainfall October (ER = R - AE)	0.077
Recharge (7% of ER)	0.0054
Runoff (93% of ER)	0.0716

Table 9-8: Baseline Runoff for the Wind Farm Site

Proposed Development Site Area (ha)	Baseline Runoff per Wettest month (m^3)	Baseline Runoff per day (m^3) in wettest month
314	224,855	7,253

9.3.6 Summary Flood Risk Assessment

A Flood Risk Assessment (FRA) for the Proposed Development has been completed, the findings of which are presented in full in Appendix 9-1 and are summarised below in this section.

To identify those areas as being at risk of flooding, the OPW's Past Flood Events Maps, the National Indicative Fluvial Mapping, CFRAM River Flood Extents, historical mapping (i.e. 6" and 25" base maps) and the GSI Groundwater Flood Maps were consulted. These flood maps are available to view at Flood Maps - Floodinfo.ie.

Identifiable map text on local available historical 6" or 25" mapping for the wind farm site area do not identify any lands that are "liable to flood".

The OPW Past Flood Events Maps have no records of recurring or historic flood instances within the Wind Farm Site or in the surrounding lands (refer to Figure 9-4). The closest mapped recurring flood event (Flood ID: 790) to the wind farm site is located along the N52, northeast of Ballingarry and ~2km from the site. This recurring flood event is associated with a turlough (*i.e.* groundwater flooding). Recurring groundwater flood events associated with turloughs are also mapped to the northwest of the wind farm site at Kilgask (Flood ID: 782) and to the southwest at Lismacroy (Flood ID: 782). Downstream of the wind farm site, recurring flood events (Flood ID: 2820 and 2828) are mapped on a small stream in the vicinity of Birr Town.

The GSI Winter 2015/2016 Surface Water Flood Map shows surface water flood extents for this winter flood event. This flood event is recognised as being the largest flood event on record in many areas. The flood map for this event does not record any surface water flood zones within the wind farm site. Some flooding was recorded in the bog ~300m north of the site and likely resulted from pluvial flooding (*i.e.* surface water ponding after rainfall). Some surface water flooding was also recorded in the agriculture lands to the south but these are very localised and do not encroach upon the wind farm site.

No CFRAM mapping has been completed for the area of the wind farm site. The closest mapped CFRAM fluvial flood zones are located on the Little Brosna River downstream of the wind farm site. The closest mapped flood zones are ~900m southeast of the wind farm site.

The National Indicative Fluvial Flood Map for the Present Day Scenario shows flooding along the Fadden Beg and the Holy Well Clohaskin Streams which drain the wind farm site (Figure 9-5). The medium (1% AEP, 1 in 100yr) and low (0.1% AEP, 1 in 1,000yr) probability flood zones encroach upon only very small areas of the wind farm site.

The Mid-Range and High-End scenarios model potential flood zones associated with climate change and an increase in rainfall of 20% and 30% respectively. These modelled flood zones do not differ significantly from the Present Day Scenario.

The National Indicative Fluvial Flood Map show that a short section of proposed access road (~50m), close to the wind farm site entrance, is mapped inside a 100-year and 1000-year flood zone.

Based on the GSI Groundwater Flood Maps the wind farm site is not mapped within any historic or modelled groundwater flood zones. Groundwater flood zones are mapped in the lands surrounding the wind farm site, predominantly to the west and are generally associated with mapped turloughs.

The main risk of flooding at the wind farm site is via pluvial flooding. This is due to the low permeability of the peat soils and subsoils overlying the wind farm site. The surface of the bog contains a network of peat and forestry drains with surface water outflows from the bogs. This existing drainage network has reduced the risk of pluvial flooding across much of the wind farm site. However, following periods of intense and prolonged rainfall events localised surface water ponding is still likely to occur in localised depressions.

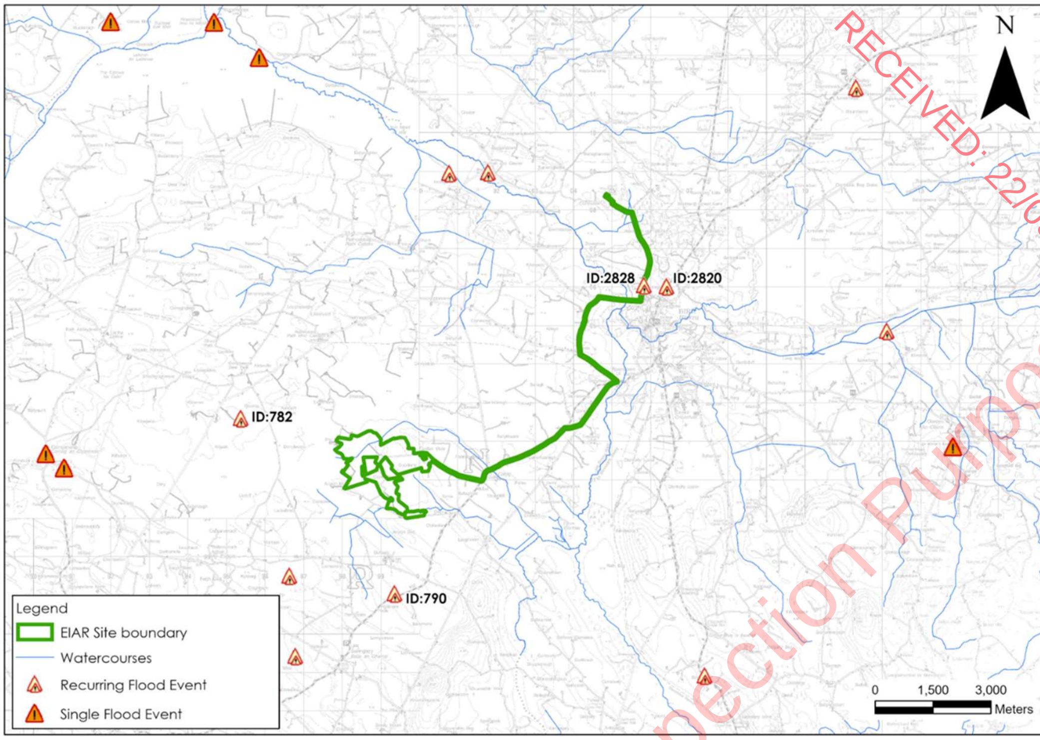


Figure 9-4: OPW's Past Flood Event Mapping

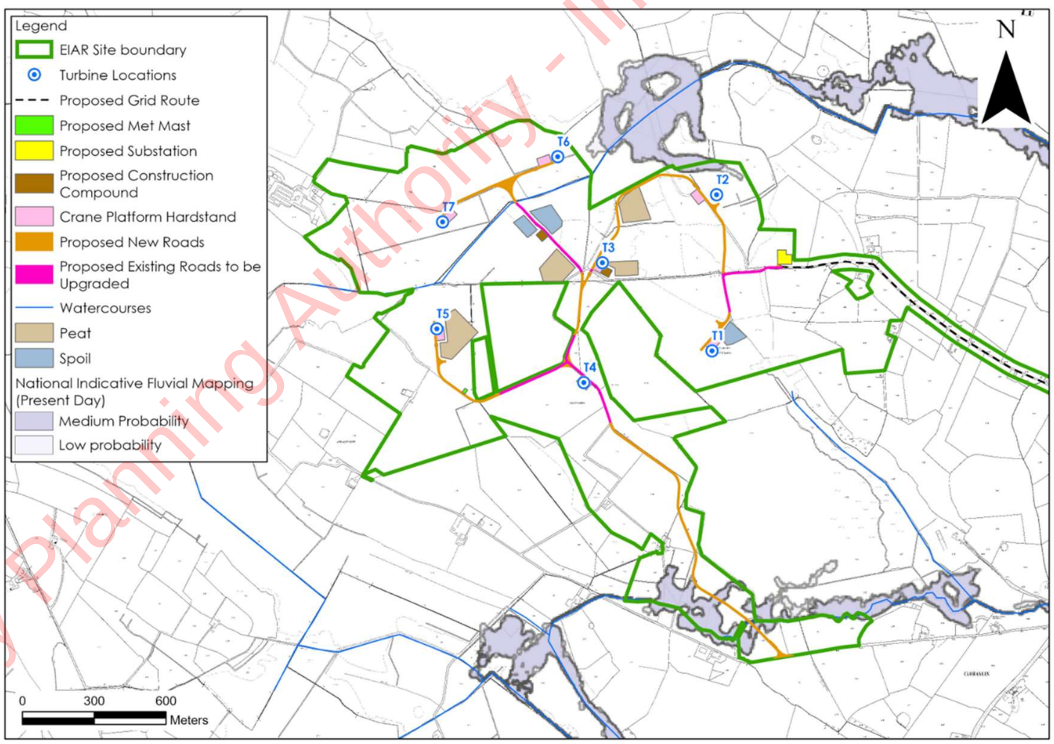


Figure 9-5: National Indicative Fluvial Flood Map (Present-Day Scenario)

9.3.7 Surface Water Quality

9.3.7.1 Wind Farm Site

The Biological Q-Rating is a water quality rating system based on both the habitat and the invertebrate community assessment and is divided into status categories ranging from Q1 (Bad) to 4-5 (High).

Q-ratings are not available for any of the streams draining the wind farm site. Biological Q-rating[2] data for EPA monitoring points in the local catchments downstream of the wind farm site are shown in Table 9-9 below. Downstream of the wind farm site, the Little Brosna achieved a Q-rating of Q3-4 (*i.e.* Moderate status) at Riverstown Bridge (Station ID: RS25L020700) where the N52 crosses the Little Brosna River to the southwest of Birr town. Downstream of Birr Town, the Little Brosna also a achieved a Q-rating of Q3-4 downstream of Croghan Bridge on the L1077 (Station ID: RS25L020810).

Table 9-9:EPA Water Quality Monitoring Q-Rating Values downstream of Wind Farm Site

Waterbody	Station ID	Easting	Northing	EPA Q-Rating Status	Year
Little Brosna	RS25L020700	205281	203542	(3-4) Moderate	2021
Little Brosna	RS25L020810	205367	205670	(3-4) Moderate	2021

Field hydrochemistry measurements of unstable parameters, electrical conductivity (µS/cm), pH (pH units) and turbidity (NTU) were taken at 3 no. surface water sampling locations downstream of the windfarm site over 2 no. monitoring rounds completed on 17th January 2023 and 14th April 2023.

The monitoring locations are shown in Figure 9-2 above. SW1 is located on the Fadden Beg Stream within the wind farm site and SW2 is located downstream of the wind farm site at the N52. Meanwhile SW3 is located on the Holy Well Clohaskin Streams downstream of the wind farm site also at the N52.

Electrical conductivity values at the monitoring locations ranged between 452 and 685µS/cm, with an average conductivity value of 584µS/cm. Dissolved Oxygen (% saturation) ranged from 83 to 94%. The pH values were generally neutral or slightly basic, ranging between 7.1 and 7.5, with an average pH of 7.4.

Table 9-10: Field Hydrochemistry for Wind Farm Site (17/01/2023 – 14/04/2023)

Location ID	DO (% Sat)	SPC (µS/cm)	pH
SW1	83 - 92	452 - 460	7.5 - 73
SW2	93 - 94	685 - 682	7.1 - 72
SW3	88 - 88	507 - 515	7.5 – 7.3

Surface water grab samples were also taken at these locations for laboratory analysis. Results of the laboratory analysis are shown alongside relevant water quality regulations in Table 9-11 below. Original laboratory reports are attached as Appendix 9.2.

Suspended solid concentrations ranged were below the level of detection of the laboratory (i.e. <5mg/l) in all samples. All suspended solid concentrations were therefore below the S.I 293/1988 threshold limit of 25 mg/l.

2 The Q-Rating scheme method is used whereby a Quality-index is assigned to a river or stream based on macroinvertebrate data.

Ammonia ranged between 0.03 and 0.24mg/l during both monitoring rounds. The highest ammonia concentrations were recorded at SW1 within the wind farm site, with ammonia exceeding the Good status threshold of ≤0.065mg/l as set out in S.I. 272/2009 at this location on both monitoring rounds. Elsewhere SW3 achieved High status with respect to ammonia during both rounds. SW2 achieved High status and then exceeded the Good status in the consecutive rounds.

BOD ranged between <1 and 2 mg/l. All results for SW1 were above the Good status threshold while all results for SW2 and SW3 were below the High status threshold.

Orthophosphate concentrations ranged from <0.02 to 0.23mg/l. In comparison to S.I. No. 272 of 2009, a total of 4 no. samples were of High status (i.e. ≤0.025mg/l). Orthophosphate concentrations exceeded the Good status threshold (≤0.035mg/l) at SW1 and SW2 during 1 no. sampling round only.

Table 9-11: Surface water quality data for wind farm site (17/01/2023 – 14/04/2023)

Location ID	Suspended Solids (mg/l)	BOD_5 (mg/l)	Orthophosphate (mg/l)	Nitrate (mg/l NO_3)	Ammonia (mg/l)	Chloride (mg/l)
EQS	≤25([3])	≤ 1.3 to ≤ 1.5([4])	-≤ 0.035 to ≤0.025([2])	-	-≤0.065 to ≤ 0.04([2])	-
SW1	<5	2 - 2	<0.02 – 0.04	7.6 – 20.3	0.14 – 0.24	16.5 – 20.3
SW2	<5	<1 - 1	<0.02 – 0.23	24.9 - 29.0	0.04 – 0.07	26.0 – 30.7
SW3	<5	1 - 1	<0.02 - <0.02	14.2 - 20.6	0.03 - 0.04	21.6 - 23.5

9.3.7.2 Grid Connection Route

Most recent data available (2021) show that the Little Brosna River downstream of the grid connection route achieved a Q-rating of Q3-4 (*i.e.* Moderate status).

Upstream of its confluence with the Little Brosna River the Lower Shannon achieved a Q-rating of Q3-4 (Station ID: RS25S012060). There are no recent Q-rating data available downstream of where the Little Brosna discharges into the Shannon and Lough Derg.

Field hydrochemistry measurements of unstable parameters were taken at 3 no. surface water sampling locations (SW2, SW4 and SW5) along the grid connection over 2 no. monitoring rounds completed on 17th January 2023 and 14th April 2023.

Electrical conductivity values at the monitoring locations ranged between 600 and 692µS/cm, with an average conductivity value of 645µS/cm. Dissolved Oxygen (% saturation) ranged from 87 to 98% (refer to Table 9-12). The pH values were generally neutral or slightly basic, ranging between 7.1 and 7.4, with an average pH of 7.2.

[3] *S.I. No. 293 of 1988: European Communities (Quality of Salmonid Waters) Regulations*

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

Table 9-12: Field Hydrochemistry along Grid Route (17/01/2023 – 14/04/2023)

Location ID	DO (% Sat)	SPC (µS/cm)	pH
SW2	93 - 94	685 - 682	7.1 - 72
SW4	87 - 92	692 - 690	7.4 – 7.3
SW5	92 - 98	600 - 610	7.3 – 7.2

Surface water grab samples were also taken at these locations for laboratory analysis. Results of the laboratory analysis are shown alongside relevant water quality regulations in Table 9-13 below. Original laboratory reports are attached as Appendix 9.2.

Suspended solid concentrations ranged were below the level of detection of the laboratory (i.e. <5mg/l) in all samples. All suspended solid concentrations were below the S.I 293/1988 threshold limit of 25 mg/l.

Ammonia ranged between 0.03 and 0.07mg/l during both monitoring rounds. In comparison to S.I. No. 272/2009, a total of 4 of the 6 no. samples were below or equal to the High status threshold value of ≤0.04mg/l. Only 1 no. sample exceed the Good status threshold of ≤0.065mg/l which was SW2.

BOD ranged between <1 and 2 mg/l. 5 of the 6 no. samples achieved High status with regard to S.I. No. 272/2009. Only 1 no. sample at SW4 exceeded the Good status threshold.

Orthophosphate concentrations ranged from <0.02 to 0.23mg/l. In comparison to S.I. No. 272/2009, a total of 5 no. samples were of High status (i.e. ≤0.025mg/l). Orthophosphate concentrations exceeded the Good status threshold (≤0.035mg/l) at SW2 on 1 no. sampling occasion.

Table 9-13: Surface water quality data for grid route (17/01/2023 – 14/04/2023)

Location ID	Suspended Solids (mg/l)	BOD_5 (mg/l)	Orthophosphate (mg/l)	Nitrate (mg/l NO_3)	Ammonia (mg/l)	Chloride (mg/l)
EQS	≤25([5])	≤ 1.3 to ≤ 1.5([6])	-≤ 0.035 to ≤0.025([2])	-	-≤0.065 to ≤ 0.04([2])	-
SW2	<5	<1 - 1	<0.02 – 0.23	24.9 - 29.0	0.04 – 0.07	26.0 – 30.7
SW4	<5	1 - 2	<0.02	14.1 – 23.2	0.03 – 0.04	19.6 – 25.8
SW5	<5	<1 - 1	<0.02	16.8 - 19.9	0.03 – 0.05	21.3 - 24.0

[5] *S.I. No. 293 of 1988: European Communities (Quality of Salmonid Waters) Regulations*

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

9.3.8 Hydrogeology

According to GSI mapping (www.gsi.ie) the majority of the wind farm site is underlain by Dinantian Pure Bedded Limestones. This bedrock unit is classified by the GSI as a Regionally Important Aquifer – Karstified (diffuse). Dinantian Pure Bedded Limestones and underlie a small section of the wind farm site and these rocks are classified as a Locally Important Aquifer – Bedrock which is Generally Moderately Productive. Meanwhile, the north of the wind farm site is underlain by Dinantian Pure Unbedded Limestones of the Waulsortian Limestone Formation. These rocks are classified by the GSI as being a Locally Important Aquifer – Bedrock which is Moderately Productive only in Local Zones (Ll). A bedrock aquifer map is attached as Figure 9-6.

In terms of proposed development infrastructure, a total of 3 no. turbines on the north of the wind farm site are underlain by a Locally Important Aquifer. All other key proposed development infrastructure are mapped over the Regionally Important Aquifer – Karstified (diffuse).

However, due to the presence of the basin peat at the wind farm site and the bulk low permeability of the underlying mineral subsoil deposits (clays and silts), local groundwater recharge will be minimal. Recharge is likely to be limited to the perimeter of the bog where the peat is thin or absent (the presence of peat will prevent rapid recharge to underlying regional groundwater systems described above). Groundwater movement through the underlying subsoil glacial deposits will be relatively slow unless higher permeability sands and gravels are present. During the trial pitting minor groundwater seepages from the mineral subsoils were noted in some of the trial pits

Groundwater flows direction is in as southeasterly direction towards the Little Brosna River. This is consistent with the local surface water drainage regime. As stated above more localised groundwater flow directions are also likely to occur, with groundwater discharging to nearby drains and streams.

A shallow perched ground water table exists in the peat and is largely isolated from the underlying regional groundwater system (which occurs in the underlying till and bedrock).

Karst features are mapped by the GSI and are available to view through the GSI online viewer (www.GSI.ie). The GSI do not map the occurrence of any karst features within the wind farm site. No karst features were identified during the walkover surveys of the wind farm site or during the intrusive site investigations.

The closest mapped karst feature to the wind farm site is an enclosed depression, located ~800m to the north in the townland of Sharragh. The GSI also map several turloughs in the surrounding lands. Ballingarry turlough is mapped ~2km to the south of the wind farm site. Meanwhile, Liskeenan turlough is mapped ~2.7km to the southwest of the wind farm site. The GSI also map a turlough and a swallow hole ~2.5km to the northwest.

The wind farm site is underlain by 2 no. Ground Waterbodies (GWBs). The north of the wind farm site including 3 no. turbines are underlain by the Banagher GWB (IE_SH_G_040). Meanwhile, the majority of the wind farm site and all other key proposed development infrastructure are underlain by the Birr GWB (IE_SH_G_041). The Banagher GWB is described as poorly productive while the Birr GWB is described as karstic.

With regard the grid connection route, the proposed route overlies the Birr GWB (IE_SH_G_041) and the Birr Gravels GWB (IE_SH_G_244). This latter extends to the northwest and northeast from Birr town. The permeable gravel subsoils in this aquifer store groundwater and contribute to the storage of the underlying bedrock aquifers.

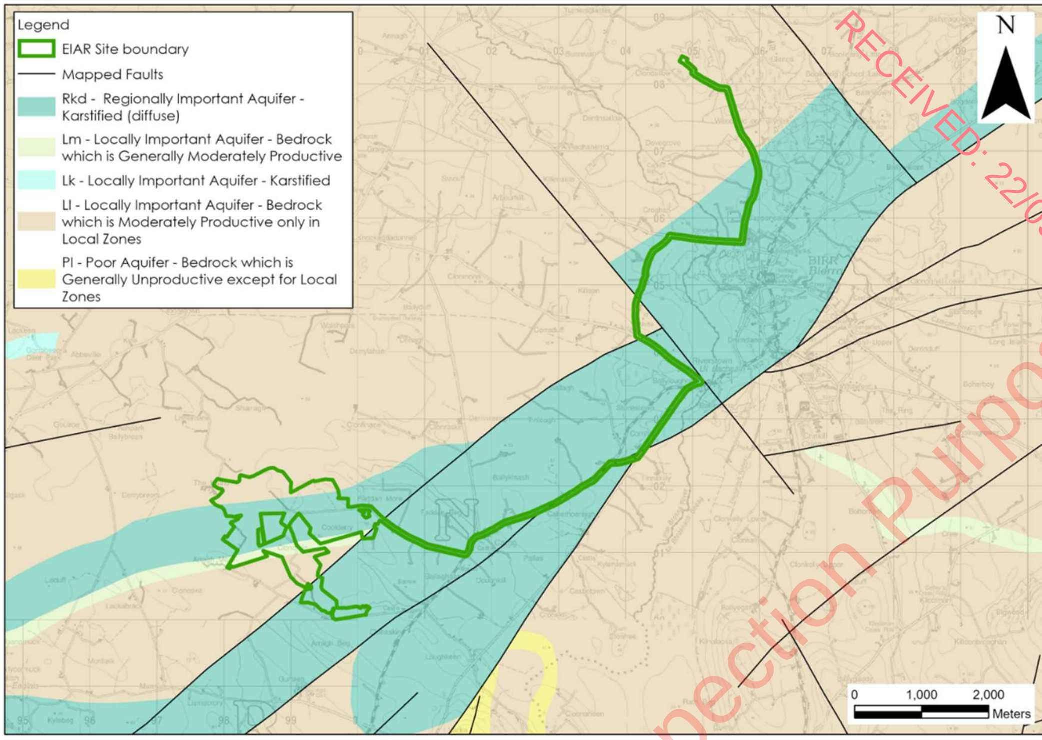


Figure 9-6: Bedrock Aquifer Map (www.gsi.ie)

9.3.9 Groundwater Vulnerability

9.3.9.1 Wind Farm Site

The GSI describe groundwater vulnerability as a term used to represent the natural ground characteristics that determine the ease with which groundwater may be contaminated by human activities. Groundwater vulnerability embodies the characteristics of the intrinsic geological and hydrogeological features at a site that determine the ease of groundwater contamination. Groundwater vulnerability is related to recharge acceptance, whereby in areas where recharge occurs more readily, a higher quantity of contaminants will have access to groundwater. Refer to Table 9-14 below for GSI criteria.

The GSI mapped (www.gsi.ie) vulnerability rating of the bedrock aquifers underlying the wind farm site ranges from "Moderate" to "High" and this reflects the varying depth of peat and underlying mineral subsoil over the bedrock.

The total thickness of mineral subsoils over bedrock (i.e. depth to bedrock) was only confirmed in 2 no. of the 15 no. trial pits (refer to Appendix 8-1 for trial pit logs). These trials pits were located at proposed turbine T3 (TP03) and at the construction compound (TP04). Limestone bedrock was confirmed at 1.8mbgl at turbine T3 and 2.8mbgl at the construction compound which suggests "Extreme" groundwater vulnerability ratings at these locations. The remaining trial pits did not encounter any bedrock and comprised of topsoil or peat over mineral subsoils to a maximum depth of >4mbg. Based on the site investigation data groundwater vulnerability across most of the wind farm site is likely to be "Moderate" to High".

Table 9-2: Groundwater Vulnerability and Subsoil Permeability and Thickness (Source: www.gsi.ie)

Vulnerability Rating	Hydrogeological Conditions				
	Subsoil Permeability (Type) and Thickness			Unsaturated Zone	Karst Features
	High permeability (sand/gravel)	Moderate permeability (e.g. Sandy subsoil)	Low permeability (e.g. Clayey subsoil, clay, peat)	(Sand/gravel aquifers only)	(<30 m radius)
Extreme (E)	0 - 3.0m	0 - 3.0m	0 - 3.0m	0 - 3.0m	-
High (H)	>3.0m	3.0 - 10.0m	3.0 - 5.0m	>3.0m	N/A
Moderate (M)	N/A	>10.0m	5.0 - 10.0m	N/A	N/A
Low (L)	N/A	N/A	>10.0m	N/A	N/A

Notes: (1) N/A = not applicable.
(2) Precise permeability values cannot be given at present.
(3) Release point of contaminants is assumed to be 1-2 m below ground surface.

9.3.9.2 Grid Connection Route

Groundwater vulnerability along the grid connection route ranges from "Moderate" to "Extreme X" with much of the grid route mapped in areas of "Moderate" and "High" vulnerability. The GSI map Extreme groundwater vulnerabilities along the N52 at Carrig and in the townland of Killeen to the west of Birr.

9.3.10 Groundwater Hydrochemistry

There are no groundwater quality data for the wind farm site and groundwater sampling would not be undertaken for this type of development in terms of EIAR reporting, as groundwater quality impacts are extremely unlikely. There are also no proposed discharges to ground.

The WFD status for the local groundwater bodies underlying the wind farm site in terms of water quality is Good and therefore this is assumed to be the baseline condition for groundwater underlying the wind farm site.

The GSI's Birr Groundwater Body Characterisation Report (GSI, 2004) states that the groundwater in this body has a calcium bicarbonate signature reflecting the predominance of limestone bedrock. The waters in the GWB are generally hard (251 – 350mg/l) to very hard (>350mg/l).

The GSI's Banagher Groundwater Body Characterisation Report (GSI, 2004) states that the groundwater in this GWB also has a calcium bicarbonate signature. Groundwaters are very hard (380 – 450mg/l) and have high electrical conductivities (650 - 800µS/cm). These values are typical of limestone rocks and the pH is generally neutral.

Details on the available hydrochemistry data for the Banagher and Birr GWBs which underlie the majority of the grid connection route are detailed above.

9.3.11 Water Framework Directive Water Body Status & Objectives

The River Basin Management Plan was adopted in 2018 and has amalgamated all previous river basin districts into one national river basin management district. The River Basin Management Plan (2022 - 2027) objectives, which have been integrated into the design of the Proposed Development, include the following:

- Ensure full compliance with relevant EU legislation;
- Build on the achievements of the 2nd Cycle;
- Prevent deterioration and maintain a 'high' status where it already exists;
- Protect, enhance and restore all waters with aim to achieve at least good status by 2027;
- Ensure waters in protected areas meet requirements; and,
- Implement targeted actions and pilot schemes in focused sub-catchments aimed at restoring impacted waters and protecting waters from deterioration.

Our understanding of these objectives is that surface waters, regardless of whether they have 'Poor' or 'High' status, should be treated the same in terms of the level of protection and mitigation measures employed, i.e. there should be no negative change in status at all. Furthermore any development must not in any way prevent a waterbody from achieving at least good status by 2027.

Strict mitigation measures (refer to Section 9.5 below) in relation to maintaining a high quality of surface water runoff from the development and groundwater protection will ensure that the status of both surface water and groundwater bodies in the vicinity of the Proposed Development Site will be at least maintained (see below for WFD water body status and objectives) regardless of their existing status and the Proposed Development will not prevent waterbodies from achieving Good Status.

A full WFD Compliance Assessment is included as Appendix 9-3.

9.3.12 Groundwater Body Status

Local Groundwater Body (GWB) and Surface water Body (SWB) status information is available from (www.catchments.ie).

Summary WFD information for the GWBs underlying the Proposed Development site (wind farm site and grid route options) are shown below in Table 9-15.

The Banagher GWB and Birr GWB underlying the Proposed Development site achieved "Good" status in all 3 no. WFD cycles.

All GWBs underlying the Proposed Development site have been deemed to be "not at risk" of failing to meet their respective WFD objectives. No significant pressures have been identified to be impacting on any of these GWBs.

Table 9-15: Summary of Ground Waterbody Status

GWB	Overall Status 2010-2015	Overall Status 2013-2018	Overall Status 2016-2021	3rd Cycle Risk Status	WFD Pressures
Banagher	Good	Good	Good	Not at risk	-
Birr	Good	Good	Good	Not at risk	-

9.3.13 Surface Water Body Status

9.3.13.1 Wind Farm Site

A summary of the WFD status and risk result of Surface Waterbodies (SWBs) in the vicinity and downstream of the wind farm site are shown in Table 9-16. WFD information for these SWBs is available at www.catchments.ie.

As stated above the wind farm site is located in the Little Brosna_040 river sub-basin. This SWB achieved "Moderate" status in all 3 no. WFD cycles. Further downstream, the Little Brosna_050 and _060 SWBs achieved "Moderate" status in the latest WFD cycle which was a deterioration on the "Good" status achieved previously. Further downstream the Incherky_010 SWB and the Lower Shannon_030 SWBs achieved "Good" and "Moderate" status respectively in the latest cycle.

The Little Brosan_040 and _050 SWBs in the vicinity and downstream of the wind farm site have been deemed to be "at risk" of failing to meet their respective WFD objectives. Meanwhile the Little Brosna_060 SWB is "not at risk". The risk status of the Incherky_010 and Lower Shannon_030 SWBs are currently under review.

The 3rd Cycle Draft Catchment Report (EPA, 2021) states that excess nutrients and morphological issues remain the most prevalent issues in the Lower Shannon (HA 25B) catchment. The Little Brosna_040 SWB has been identified as being under significant pressure from agriculture, hydromorphology and peat extraction activities. In relation to agriculture, the 3rd cycle draft catchment report states that the issues relating to farming in this catchment are predominantly due to phosphorus loss to surface waters from direct discharges or runoff from roads or poorly draining soils. Sediment is also a problem from land drainage works and bank erosion at animal crossings. In relation to hydromorphology, the 3rd cycle draft report states the extensive modification has occurs in the Little Brosna catchment due to drainage schemes. Meanwhile, in relation to peat extraction the 3rd cycle draft report states that in the Little Brosna_040 there has been some peat extraction, however, there is an extensive drainage network which has resulted in increased sediment loads, which alters habitats, morphology and hydrology.

Table 9-16: Summary of WFD Surface Waterbody Information (WF Site)

River Waterbody	Status 2010-2015	Status 2013-2018	Status 2016-2021	3rd Cycle Risk Status	WFD Pressures
Little Brosna_040	Moderate	Moderate	Moderate	At risk	Agriculture, peat and hydromorphology
Little Brosna_050	Good	Good	Moderate	At risk	-
Little Brosna_060	Good	Good	Moderate	Not at risk	-
Incherky_010	Unassigned	Moderate	Good	Under review	-
Lower Shannon_030	Unassigned	Moderate	Moderate	Under review	-

9.3.13.2 Grid Connection Route

A summary of the WFD status and risk result of Surface Waterbodies (SWBs) in the vicinity and downstream of the grid route are shown in Table 9-17.

The proposed grid connection route is located in the catchment of the Little Brosna River. The available WFD information for the SWBs (Little Brosna_040, _050, _060, Incherky_010 and Shannon (Lower)_030) in these areas are detailed in Section 9.3.13.1 above as these are the same waterbodies which drain the wind farm site.

Table 9-17: Summary of WFD Surface Waterbody Information (Grid Route)

River Waterbody	Status 2010-2015	Status 2013-2018	Status 2016-2021	3rd Cycle Risk Status	WFD Pressures
Grid Route Options A & B					
Little Brosna_040	Moderate	Moderate	Moderate	At risk	Agriculture, peat and hydromorphology
Little Brosna_050	Good	Good	Moderate	At risk	-
Little Brosna_060	Good	Good	Moderate	Not at risk	-
Incherky_010	Unassigned	Moderate	Good	Under review	-
Lower Shannon_030	Unassigned	Moderate	Moderate	Under review	-

9.3.14 Designated Sites and Habitats

9.3.14.1 Nature Conservation Designations

9.3.14.1.1 *Wind Farm Site*

Within the Republic of Ireland designated sites include Natural Heritage Areas (NHAs), Proposed Natural Heritage Areas (pNHAs), Special Areas of Conservation (SACs), candidate Special Areas of Conservation (cSAC) and Special Protection Areas (SPAs). A designated site map for the area is shown as Figure 9-7.

Arragh More Bog NHA (Site Code: 000640) is located immediately to the west of the wind farm site. This NHA is descried as a remnant of a large bog which are not separated by roads and areas of cutover bog. The site is noted to support a good diversity of raised bog microhabitats, including hummocks, pools and a flush. Arragh More Bog NHA is located ~200m from the closest works area which is turbine T5.

An area in the northwest of Arragh More Bog has also been designated as an SAC (Arragh More (Derrybreen) Bog SAC (Site Code: 002207)). The SAC is located ~450m west of the wind farm site. This SAC contains a large area of degraded raised bog which is of conservation value as it is considered to be progressing to active raised bog. This site is actively managed for conservation as part of the Coillte EU Life Project. Arragh More Bog NHA/SAC is located up-gradient of the Proposed Development site with regard surface water and groundwater flows. Arragh More Bog SAC is located ~1km from T5, which is the closest proposed infrastructure. Ballyduff/Clonfinane Bog SAC/pNHA is located ~340m from turbine T6.

Ballyduff/Clonfinane Bog SAC and pNHA (Site Code: 000641) is located ~110m northeast of the wind farm site. This designated site is comprised of 2 no. bogs, Clonfinane in the west and Ballyduff in the east, separated by a small area of cutover bog. The designated section of Clonfinane Bog is described as a large, flat lowland raised bog which is bordered by drains. The northern section of the bog does not form part of the SAC due to previous degradation of the bog due to peat production. Ballyduff/Clonfinane Bog SAC and pNHA is located up-gradient of the Proposed Development site with regard surface water and groundwater flows. Ballyduff/Clonfinane Bog SAC/pNHA is located ~340m from turbine T6. Piezometers installed between proposed turbine T6 and Ballyduff/Clonfinane Bog SAC, show that the groundwater flow direction is to the southeast and not northeast towards the SAC.

Kilcarren-Firville Bog SAC and pNHA (Site Code: 000647) is located ~1.5km west of the wind farm site. This site is designated due to the presence of active raised bog and degraded raised bog. Kilcarren-Firville Bog SAC and pNHA is also located up-gradient of the Proposed Development site.

Other designated sites located in the vicinity and/or downstream of the wind farm site are outlined below:

- Killeen Bog NHA (Site Code: 000648) exists ~790 east of the wind farm site. No direct surface water pathways exist between the wind farm site and Killeen Bog NHA.
- Sharavogue Bog SAC (Site Code: 000585) exists ~2.5km southeast of the wind farm site. The Little Brosna River, located along the western margin of the SAC acts as a hydrological barrier between the wind farm site and this designated site.
- Liskeenan Fen SAC and pNHA (Site Code: 001683) exists ~2.6km southwest of the wind farm site. The Holy Well Clohaskin Stream acts as a hydrological barrier between the wind farm site and this designated site.
- Lorrha Bog NHA (Site Code: 001684) is located ~4.9km northwest of the wind farm site. This designated site is located in the Lorrha stream river sub-basin and no direct surface water pathways are mapped between the wind farm site and Lorrha Bog SAC.

- Dovegrove Callows SPA (Site Code: 004137) and pNHA (Site Code: 000010) is located ~6.7km northeast of the wind farm. Direct hydrological connections exist between the wind farm site and the SPA via the Fadden Beb and Holy Well Clohaskin streams which discharge into the Little Brosna River.
- The Little Brosna Callow SPA (Site Code:004086) and NHA (Site Code: 000564) is situated ~3.3km north of the wind farm site. This designated site is located downstream of the wind farm site via the Little Brosna River.
- The River Shannon Callows SAC (Site Code: 000216) is located ~8.5km west of the wind farm site. This designated site hydrologically connected with the wind farm site via the Little Brosna River and its associated tributaries.
- Lough Derg, North-East Shore SAC (Site Code: 002241) is located ~6km west of the wind farm site. This SAC is located downstream of the wind farm site with the River Shannon discharging into Lough Derg.

9.3.14.1.2 Grid Connection Route

The proposed grid connection route is located immediately to the west of the Woodville Woods pNHA (Site Code: 000927) along the R439 to the north of Birr town. The Dallow substation is situated immediately to the south of Ross and Glenns Eskers pNHA (Site Code: 000920). The proposed works along the grid route are also located upstream of Dovegrove Callows SPA (Site Code: 004137) and pNHA (Site Code: 000010) on the Little Brosna River and the associated Little Brosna Callows SPA (Site Code: 004086) and NHA (Site Code: 000564).

All watercourses draining grid route flow in a westerly direction before discharging into the River Shannon. In this area the Shannon has the following designations; River Shannon Callows SAC and pNHA (Site Code: 000216) and Middle Shannon Callows SPA (Site Code: 004096).

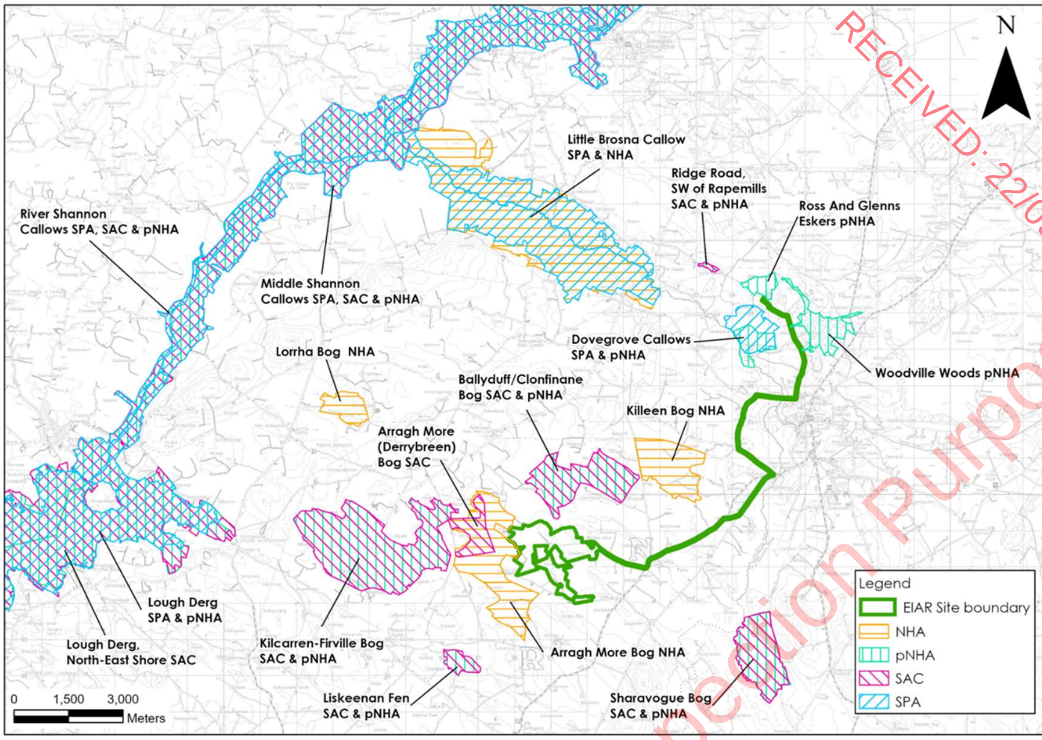


Figure 9-7: Designated Site Map

9.3.14.2 Nutrient Sensitive Waters

Nutrient Sensitive Areas (NSA) comprise Nitrate Vulnerable Zones and polluted waters designated under the Nitrates Directive (91/676/EEC) and areas designated as sensitive areas under the Urban Wastewater Treatment Directive (UWWTD)(91/271/EEC). Sensitive areas under the UWWTD are water bodies affected by eutrophication associated with elevated nitrate concentrations and act as an indication that action is required to prevent further pollution caused by nutrients.

According to EPA online mapping (www.catchments.ie) there are no NSAs located in the vicinity or downstream of the wind farm site or grid connection.

9.3.14.3 Salmonid Waters

There are no waters in the vicinity or immediately downstream of the Proposed Development site which are listed in the Salmonid Regulations (S.I. no. 293/1988).

9.3.15 Water Resources

9.3.15.1 Groundwater Resources

The GSI do not map the presence of any National Federation registered Group Water Schemes (GWS) or Public Water Schemes (PWS) or an associated groundwater Source Protection Area (SPA) within the Proposed Development site or in the surrounding lands (www.gsi.ie).

The closest mapped GWS is Lacka GWS located ~1.5km south of the wind farm site. The Abbeyville GWS source is mapped ~1.9km to the northwest of the wind farm site. None of the associated SPAs (Source Protection Areas) intercept the Proposed Development site.

A search of private well locations (accuracy of 1 – 50m only) was undertaken using the GSI well database (www.gsi.ie). There are no wells with an accuracy of 1 – 50m mapped in the wind farm site or in the surrounding lands. The GSI map several wells with a location accuracy of ≥1km in the surrounding lands. The yields associated with these wells are generally reported as being poor.

We have completed an assessment below of private wells in the lands surrounding the wind farm site (Section 9.5.2.11 below). In order to be conservative and following the worst case assumption, we have assumed that all dwellings in the surrounding lands have a private groundwater well. A number of private dwelling houses were identified along the local roads to the southeast and down-gradient (i.e., downslope) of the wind farm site.

GSI mapped wells and private dwelling houses are shown on Figure 9-8 below.

9.3.15.2 Surface Water Resources

There are no SWBs in the vicinity of the Proposed Development site which are identified as Drinking Water Protected Areas (DWPAs). Downstream of the Proposed Development site, Lough Derg is listed as a DWPA.

Also, the Shannon (Lower)_010 SWB is listed as a DWPA in Article 7 – Abstraction for Drinking Water.

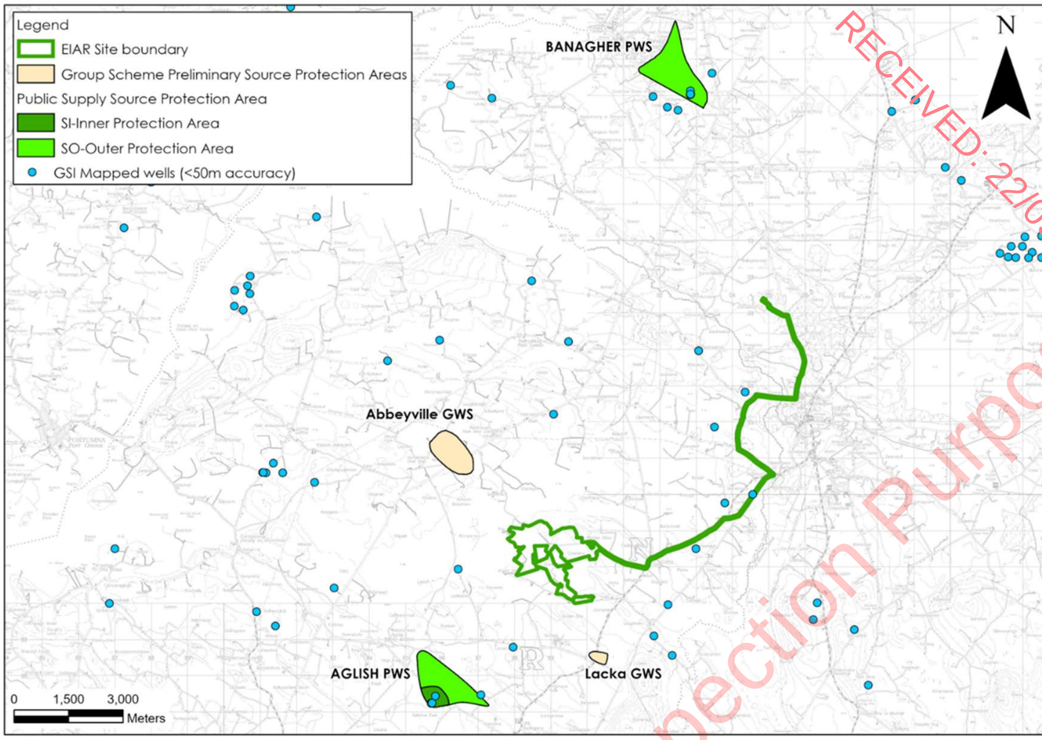


Figure 9-8: Map of Groundwater Wells and Groundwater Resources (www.gsi.ie)

9.3.16 Receptor Sensitivity

Due to the nature of wind farm developments (and associated grid connections), being near surface construction activities, impacts on groundwater are generally negligible and surface water is generally the main sensitive receptor assessed during impact assessments.

The primary risks to groundwater at the Proposed Development site would be from cementitious materials, hydrocarbon spillage and leakages during the construction phase and potential piling/earthworks works. These are common potential risks on all construction sites (such as road works and industrial sites), which can be addressed by way of mitigation. All potential contamination sources are to be carefully managed at the wind farm site and along the grid route during the construction, operational and decommissioning phases of the Proposed Development and mitigation measures are proposed below to deal with these potential risks.

Based on criteria set out in Table 9-2 above, the Regionally Important Aquifer – Karstified (diffuse) which underlies the majority of the Proposed Development site can be classed as Very Sensitive to pollution. Meanwhile, the Locally Important Aquifers which underlie the remainder of the Proposed Development site can be classed as being Sensitive to pollution. However due to the presence of peat and low permeability subsoils across the wind farm site, the area has low rates of groundwater recharge. The peat and subsoil clay layers act as a protective cover over the underlying bedrock. Local private groundwater sources are not likely to be sensitive to impact due to local hydrological/hydrogeological regime.

Due to the hydrological and hydrogeological regime, particularly at the wind farm site, any contaminants which may be accidently released on-site are more likely to travel to nearby streams within surface water runoff.

The surface waters in the vicinity and downstream of the Proposed Development site are Sensitive to pollution due to the presence of downstream designated sites such as River Shannon Callows SAC and pNHA (Site Code: 000216) and Middle Shannon Callows SPA (Site Code: 004096).

Comprehensive surface water mitigation and control measures are outlined below to avoid this occurring and to ensure protection of all downstream receiving waters. These mitigation and control measures will also be utilised during works for the grid route where applicable, also noting that the grid connection works are shallow and transient in nature and the works will mainly be completed within an existing road carriageway.

Mitigation measures will ensure that surface runoff from the developed areas of the wind farm site and grid route will be of a high quality and will therefore not impact on the quality of downstream surface water bodies. Any introduced drainage works at the wind farm site will mimic the existing drainage regime thereby avoiding changes to flow volumes leaving the wind farm site.

9.4 Characteristics of the Proposed Development

Please refer to Section 4.1 of the EIAR for the Development Description.

The main characteristics of the Proposed Development that could impact on hydrology and hydrogeology are:

- Establishment of the temporary construction compounds, which will involve minor regrading of soil/subsoil and the emplacement of the construction compound. Welfare facilities will be provided at the primary temporary construction compound. Wastewater effluent will be collected in a wastewater holding tank and periodically emptied by a licenced contractor.
- Construction of the site access tracks will use the floating technique as well as the excavate and replace technique. This will involve the use of aggregate, imported from local quarries where required. Construction of these access tracks has the potential to impact on surface water quality.
- Construction of the crane hardstand areas and turbine assemblage areas will utilise ground bearing foundations. Construction of these areas has the potential to impact on surface water quality.
- Settlement ponds where constructed will be volume neutral, i.e. all material excavated will be used to form side bunds and landscaping around the ponds. There will be no excess material from settlement pond construction. The material will also be reinstated during decommissioning.
- Construction of the onsite substation will be completed with a ground bearing foundation. Welfare facilities will be provided at the substation. Construction of the onsite substation and associated parking area has the potential to impact on surface water quality.
- Grey water will be supplied by rainwater harvesting and water tankered to site where required. Bottled water will be used for potable supply.
- Construction of the turbine foundations, which will either be piled or gravity foundation (both options are assessed). Worst case excavations volumes arising from gravity foundations are assessed.
- Cabling between turbine locations and the onsite substation will involve the excavation of a shallow trench (approximately 1.2m deep), placement of ducting and backfilling with aggregate, lean-mix concrete, and excavated material, as appropriate (depending on the location of the cable trench). These works have the potential to impact on surface water quality.
- Tree felling for the purposes of wind farm construction. While this work will be done with Forestry Service licences and approvals, the works could result in soil/subsoils erosion.

The Proposed Development will also include works along the grid connection route. The underground cabling route between the proposed on-site substation and the Dallow 110 kV Substation will involve the excavation of a trench predominantly within the public road, placement of ducting and backfilling with lean-mix concrete and compacted engineered fill. These works have the potential to impact on surface water quality, in particular where works are completed in close proximity to surface watercourses.

There are 4 no. crossings over EPA mapped watercourses as follows:

- Along the N52 over a small stream referred to by the EPA as the Faddan Beg Stream.
- Along the L1077 (i.e. Croghan Rd.) over the Little Brosna River at Croghan Bridge.
- Along the R439 over a small stream referred to by the EPA as the Ross Stream.
- Along an unnamed local road over a small stream referred to by the EPA as the Woodfield Stream.

9.4.1 Proposed Drainage Management

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

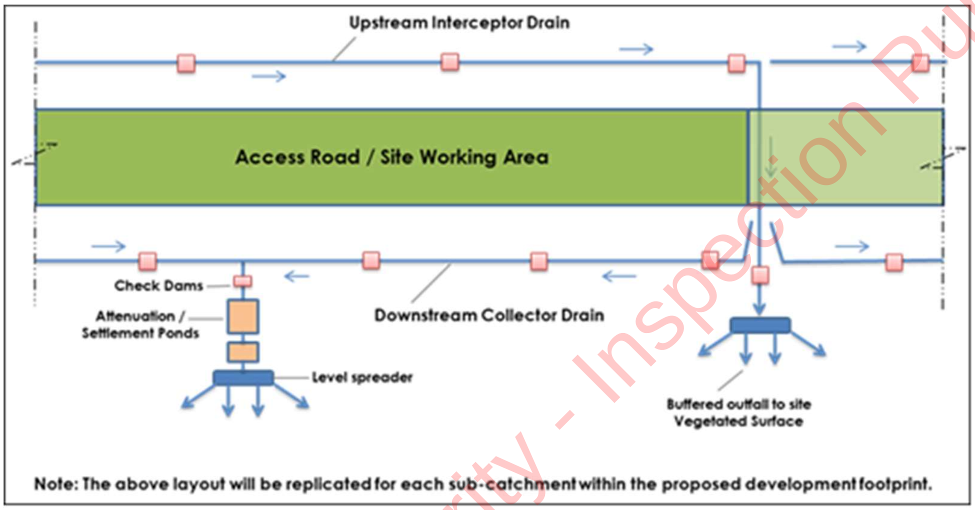


Figure 9-9: Schematic of Proposed Site Drainage Management

9.4.2 Development Interaction with the Existing Drainage Network

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

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

9.5 Likely Significant Effects and Associated Mitigation Measures

9.5.1 Do -Nothing Scenario

If the Proposed Development were not to proceed, the existing land use practices including forestry, peat cutting and agricultural activities will continue at the wind farm site. Forestry will be felled as forestry compartments reach maturity. Re-planting of these areas with coniferous plantation is likely to occur. Surface water drainage carried out in areas of forestry will continue to function and may be extended in some areas.

If the Proposed Development were not to proceed, the opportunity to generate renewable energy and electrical supply to the national grid would be lost, as would the opportunity to further contribute to meeting Government and EU targets for the production and consumption of electricity from renewable resources and the reduction of greenhouse gas emissions.

9.5.2 Construction Phase - Likely Significant Effects and Mitigation Measures

This section identifies the likely significant effects of the construction phase of the Proposed Development and lists the proposed mitigation measures that will be put in place to eliminate or reduce any potential effects. It should be noted that the main potential effects on the hydrological and hydrogeological environment will occur during the construction phase.

9.5.2.1 Earthworks Resulting in Suspended Solids Entrainment in Surface Waters

Construction phase activities including access road construction, construction compound, turbine base/hardstanding construction, cabling trenching within the wind farm site, and along the underground grid route connection will require earthworks resulting in removal of vegetation cover and excavation/landscaping of small volumes of soil and mineral subsoil where present. The soil and subsoil removed will be accommodated within dedicated peat and spoil storage areas within the wind farm site or transported to a local licenced facility. The peat and spoil storage areas will be situated outside of all mapped watercourse buffer zones. Potential sources of sediment laden water include:

- Drainage and seepage water resulting from site infrastructure excavation;
- Stockpiled excavated material providing a point source of exposed sediment;
- Construction of the underground electrical cabling 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.

Pathways: Drainage and surface water discharge routes.

Receptors: Down-gradient streams and rivers (Fadden Beg and Holy Well Clohaskin Streams and the Little Brosna River) and dependent ecosystems.

Pre-Mitigation Potential Effects: Indirect, negative, significant, temporary, likely effect on surface water quality in downstream surface water receptors.

Proposed Mitigation Measures:

Wind Farm Site

The key mitigation measure during the construction phase is the avoidance of sensitive aquatic areas where possible, by application of suitable buffer zones (i.e. 50m to main watercourses). All of the key development components within the wind farm site are located significantly away from the delineated 50m watercourse buffer zones with the exception of 3 no. new watercourse crossing locations.

Spoil and peat management areas for removed soil/subsoil will be localised to spoil and peat repository areas outside of these buffer zones and will be designed and constructed with the minimal amount of surface area exposed. In these spoil and peat management areas, the vegetative top-soil layer will be removed and re-instated or reseeded directly after construction, allowing for re-vegetation which will mitigate against erosion. Additional control measures, which are outlined further on in this section, will be undertaken at the proposed watercourse crossing locations.

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

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

- Apart from interceptor drains, which will convey clean runoff water to the downstream drainage system there will be no direct discharge (without treatment for sediment reduction, and attenuation for flow management) of runoff from the wind farm site drainage into the existing site drainage network where possible. This will reduce the potential for any increased risk of downstream flooding or sediment transport/erosion;
- Silt traps will be placed in the existing drains upstream of any streams where construction works / tree felling is taking place, and these will be diverted into proposed interceptor drains, or culverted under/across the works area;
- Buffered outfalls which will be numerous over the wind farm site which will promote percolation of drainage waters across vegetation and close to the point at which the additional runoff is generated, rather than direct discharge to the existing drains; and,
- Drains running parallel to the existing roads requiring widening will be upgraded. Velocity and silt control measures such as check dams, sand bags, oyster bags, straw bales, flow limiters, weirs, baffles, silt fences will be used during the upgrade construction works. Regular buffered outfalls will also be added to these drains to protect downstream surface waters.

Grid Route

The vast majority of the underground electrical cabling connection route options are >50m from any nearby watercourse. Sections of the grid route which are within 50m of a watercourse are confined to existing watercourse crossings at bridges. It is proposed to limit works in any areas located within 50m of any watercourse/waterbody including the stockpiling of excavated soils and subsoils.

There are a total of 4 no. watercourse crossings and 3 no. drain crossings along the grid connection and all the crossings are existing bridges and culverts along the public road.

No in-stream works are required at any of these crossings, however due to the proximity of the streams to the construction work at the crossing locations, there is a potential for surface water quality impacts during trench excavation work. Mitigation measures are outlined below.

A constraint/buffer zone will be maintained for all crossing locations where possible, whereby all watercourses will be fenced off. In addition, measures which are outlined below will be implemented to ensure that silt laden or contaminated surface water runoff from the excavation work does not discharge directly to the watercourse.

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

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

Pre-commencement Temporary Drainage Works at Windfarm Site

Prior to the commencement of the construction works the following key temporary drainage measures will be installed:

- All existing dry drains that intercept the proposed works area will be temporarily blocked down-gradient of the works using check dams/silt traps;
- Clean water interceptor drains will be installed upgradient of the works areas;
- Check dams/silt fence arrangements (silt traps) will be placed in all existing drains that have surface water flows and also along existing roadside drains; and,
- A double silt fence perimeter will be placed down-slope of works areas that are located inside the watercourse 50m buffer zone.

These details are included in the drainage plans attached as Appendix 4-4.

Water Treatment Train:
If the discharge water from construction areas fails to be of a high quality, then a filtration treatment system (such as a 'siltbuster' or similar equivalent treatment train (sequence of water treatment processes)) will be used to filter and treat all surface discharge water collected in the dirty water drainage system. This will apply for all of the construction phase.

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

Silt Bags:
Silt bags will be used where small to medium volumes of water need to be pumped from excavations. As water is pumped through the bag, most of the sediment is retained by the geotextile fabric allowing filtered water to pass through. Silt bags will be used with natural vegetation filters.

Pre-emptive Site Drainage Management:
The works programme for the initial construction stage of the Proposed Development will also take account of weather forecasts, and predicted rainfall in particular. Large excavations and movements of soil/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 (threshold limits listed below) will allow work to be safely controlled (from a water quality perspective) in the event of forecasting of an impending high rainfall intensity event.

Works will be suspended if forecasting suggests any of the following is likely to occur, or if on-site monitoring indicates any of the following has occurred:

- >10 mm/hr (i.e. high intensity local rainfall events);
- >25 mm in a 24 hour period (heavy frontal rainfall lasting most of the day); or,
- >half monthly average rainfall in any 7 days.
- Prior to, and after, works being suspended the following control measures will be undertaken:
    - All open excavations will be secured and sealed off;
    - Provide temporary or emergency drainage to prevent back-up of surface runoff; and,
    - Avoid working during heavy rainfall and for up to 24 hours after heavy events to ensure drainage systems are not overloaded.

Management of Runoff from Spoil and Peat Repository Areas:
It is proposed that excavated soil will be used for landscaping where required. The excess material will then be placed in 5 no. dedicated Peat Repository Areas (PSA) and 3 no. Spoil Repository Areas (SPA).

During the initial construction of roads, silt fences, straw bales and biodegradable geogrids will be used to control surface water runoff from works areas.

Where applicable, the vegetative top-soil layer of the spoil management areas will be rolled back to facilitate placement of excavated spoil up to a maximum height of 1.0 metres, following which the vegetative-top soils layer will be reinstated. Where reinstatement is not possible, spoil and peat management areas will be sealed with a digger bucket and seeded as soon possible to reduce sediment entrainment in runoff.

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

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

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

During the construction phase field testing and laboratory analysis of a range of parameters with relevant regulatory limits and EQSs should be undertaken for each primary watercourse, and specifically following heavy rainfall events (i.e. weekly, monthly and event based).

Post-Mitigation Residual Effects: The potential for the release of suspended solids to watercourse receptors is a risk to water quality and the aquatic quality of the receptor. Proven and effective measures to mitigate the risk of releases of sediment have been proposed above and will break the pathway between the potential sources and the receptor. The residual effect will be a negative, indirect, imperceptible, temporary, unlikely effect on the water environment within and downstream of the Proposed Development site (Fadden Beg and Holy Well Clohaskin Streams and the Little Brosna River).

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

9.5.2.2 Excavation Dewatering and Potential Effects on Surface Water Quality

Groundwater seepages may occur in turbine base excavations and this will create additional volumes of water to be treated by the drainage management system.

Inflows will likely require management and treatment to reduce suspended sediments. No contaminated land was noted at the site and therefore pollution issues are not anticipated in this respect.

Some minor groundwater/surface water seepages will likely occur in trench excavations and this will create additional volumes of water to be treated by the runoff management system. Inflows will likely require management and treatment to reduce suspended sediments. No contaminated land was noted along the underground electrical cabling route therefore pollution issues are not anticipated.

Pathways: Overland flow and site drainage network.

Receptors: Surface water bodies (Fadden Beg and Holy Well Clohaskin Streams and the Little Brosna River).

Pre-Mitigation Potential Effects: Indirect, negative, significant, temporary, unlikely effect on surface water quality.

Proposed Mitigation Measures (By Design)
Management of excavation seepage and subsequent treatment prior to discharge into the drainage network will be undertaken as follows:

- Appropriate interceptor drainage, to prevent upslope surface runoff from entering excavations will be put in place;
- If required, pumping of excavation inflows will prevent build-up of water in the excavation;
- The interceptor drainage will be discharged to the wind farm site constructed drainage system or onto natural vegetated surfaces and not directly to surface waters;
- The pumped water volumes will be discharged via volume and sediment attenuation ponds adjacent to excavation areas, or via specialist treatment systems such as a Siltbuster unit;
- There will be no direct discharge to surface watercourses, and therefore no risk of hydraulic loading or contamination will occur; and,
- Daily monitoring of excavations by a suitably qualified person will occur during the construction phase. If high levels of seepage inflow occur, excavation work should immediately be stopped and a geotechnical assessment undertaken.

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

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

9.5.2.3 Clear Felling of Coniferous Plantation at Wind Farm Site

Tree felling is a minor component of the proposed works at the wind farm site with ~9.7ha felling proposed.

The tree felling activities required as part of the Proposed Development will be the subject of a Felling Licence application to the Forest Service, in accordance with the Forestry Act 2014 and the Forestry Regulations 2017 (SI 191/2017) and as per the Forest Service's policy on granting felling licenses for wind farm developments.

Potential effects during tree felling occurs mainly from:

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

These effects have the potential to affect the water quality and fish stocks of downstream water bodies. Potential effects on all watercourses downstream of the proposed felling areas could be significant if not mitigated.

Pathways: Drainage and surface water discharge routes.

Receptors: Surface waters within and downstream of the wind farm site (Fadden Beg and Holy Well Clohaskin Streams and the Little Brosna River) and associated water-dependant ecosystems.

Pre-Mitigation Potential Effects: Indirect, negative, moderate, temporary, likely effect on surface water quality.

Proposed Mitigation Measures:

All felling operations will conform to current best practice Forest Service regulations, policies and strategic guidance documents as well as Coillte and DAFM guidance documents, including the specific guidelines listed below, to ensure that felling, planting and other forestry operations result in minimal potential negative effects to the receiving environment.

- Forestry Standards Manual (Forest Service, 2015)
- Environmental Requirements for Afforestation (Forest Service, 2016a)
- Land Types for Afforestation (Forest Service, 2016b)
- Forest Protection Guidelines (Forest Service, 2002)
- Forest Operations and Water Protection Guidelines (Coillte, 2013)
- Forestry and Water Quality Guidelines (Forest Service, 2000b)
- Forestry and the Landscape Guidelines (Forest Service, 2000c)
- Forestry and Archaeology Guidelines (Forest Service, 2000d)
- Forest Biodiversity Guidelines (Forest Service, 2000e)
- Forests and Water, Achieving Objectives under Ireland's River Basin Management Plan 2018-2021 (DAFM, 2018)
- Coillte Planting Guideline SOP
- A Guide to Forest Tree Species Selection and Silviculture in Ireland (Horgan et al., 2003)
- Management Guidelines for Ireland's Native Woodlands. Jointly published by the National Parks & Wildlife Service (Cross and Collins, 2017)
- Native Woodland Scheme Framework (Forest Service, 2018)
- Code of Best Forest Practice (Forest Service, 2000)

<u>Mitigation by Avoidance:</u>

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

Table 9-3.

All felling operations are located outside the 50m watercourse buffer zone.

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

- Avoid physical damage (river/stream banks and river/stream beds) to watercourses and the associated release of sediment;
- Avoid peat/soil disturbance and compaction within close proximity to surface watercourses;
- Avoid the entry of suspended sediment from works into watercourses; and,
- Avoid the entry of suspended sediment from the drainage system into watercourses, achieved in part by ending drain discharge outside the buffer zone and allowing percolation across the vegetation of the buffer zone.

Table 9-3: Recommended minimum buffer zone widths

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

In addition to the application of buffer/setback zones, the following supplementary mitigation measures will be employed during felling works:

<u>Mitigation by Design:</u>

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

- Machine combinations will be chosen which are most suitable for ground conditions at the time of felling, and which will minimise soils disturbance. The harvester and the forwarder are designed specifically for the forest environment and are low ground pressure machines;
- All machinery will be operated by suitably qualified personnel;
- Checking and maintenance of roads and culverts will be on-going through any felling operations. No tracking of vehicle through watercourses will occur, as vehicles will use road infrastructure and existing watercourse crossing points. Where possible, existing drains will not be disturbed during felling works;
- These machines will traverse the site along specified off-road routes (referred to as racks);
- The location of racks will be chosen to avoid wet and potentially sensitive areas;
- Brash mats will be placed on the racks to support the vehicles on soft ground, reducing peat and mineral soil disturbance and erosion and avoiding the formation of rutted areas, in which surface water ponding can occur. Brash mat renewal will take place when they become heavily used and worn. Provision will be made for brash mats along all off-road routes, to protect the soil from compaction and rutting. Where there is risk of severe erosion occurring, extraction will be suspended during periods of high rainfall;
- Silt fences will be installed at the outfalls of existing drains downstream of felling areas. No direct discharge of such drains to watercourses will occur. Sediment traps and silt fences will be installed in advance of any felling works and will provide surface water settlement for runoff from work areas and will prevent sediment from entering downstream watercourses. Accumulated sediment will be carefully disposed of at pre-selected peat and spoil disposal areas. Where possible, all new silt traps will be constructed on even ground and not on sloping ground;
- In areas particularly sensitive to erosion it will be necessary to install double or triple sediment traps and increase buffer zone width. These measures will be reviewed on site during construction;
- Double silt fencing will also be put down slope of felling areas which are located in close proximity to streams and/or relevant watercourses;
- Drains and silt traps will be maintained throughout all felling works, ensuring that they are clear of sediment build-up and are not severely eroded;
- Timber will be stacked in dry areas, and outside watercourse buffer zones. Straw bales and check dams to be emplaced on the down gradient side of timber storage/processing sites;

- Works will be carried out during periods of no, or low rainfall, in order to minimise entrainment of exposed sediment in surface water runoff;
- Refuelling or maintenance of machinery will not occur within 50m of an aquatic zone or within 20m of any other hydrological feature. Mobile bowser, drip kits, qualified personnel will be used where refuelling is required; and,
- Branches, logs or debris will not be allowed to build up in aquatic zones. All such material will be removed when harvesting operations have been completed, but care will be taken to avoid removing natural debris deflectors.

Silt Traps:

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

Pre-emptive Site Drainage Management :

The works programme for the felling operations will also take account of weather forecasts and predicted rainfall in particular. Operations 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.

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

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

Drain Inspection and Maintenance:

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

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

Post-Mitigation Residual Effects: The potential for the release of suspended solids to watercourse receptors during tree felling is a risk to water quality and the aquatic quality of the receptor. Proven forestry best practice measures to mitigate the risk of releases of sediment have been proposed above and will break the pathway between the potential sources and the receptor. The residual effect will be a negative, imperceptible, indirect, temporary, likely effect on downstream water quality and aquatic habitats.

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

9.5.2.4 Potential Effects on Groundwater Levels during Excavation Works

Dewatering of deeper excavations (i.e. turbine bases) as well as turbine base piling have the potential to impact on local groundwater levels and flows.

However, the effects are likely to be localised due to the relatively shallow excavation depths and the local hydrogeological regime with low to moderate permeability peat and glacial tills overlying the limestone bedrock. Effects on groundwater levels will only be for a temporary basis during the construction work. Water level impacts will be temporary and are unlikely to be significant beyond 50m from any excavation.

Regarding works along the grid route, no groundwater level effects will occur. This is due to the shallow nature of the excavation trench (i.e. ~1.2m), the location of the trench in the existing road carriageway and the unsaturated nature of the soil/subsoil to be excavated.

Pathways: Groundwater flowpaths.

Receptors: Groundwater levels within the GWBs underlying the wind farm site (Banagher and Birr GWBs).

Pre-Mitigation Potential Effects: Direct, negative, slight, temporary, unlikely effect on local groundwater levels within the wind farm site.

Impact Assessment:

- There are large separation distances between proposed works and local houses, and associated water wells. The GSI does not map any groundwater wells with a locational accuracy <100m in the area of the wind farm site;
- Similarly, main streams and rivers are at least 100 – 300mm away from any turbine bases, and at these distances potential effects will be imperceptible;
- The proposed underground cable trench is designed to be shallow and will only be approximately 1.3m in depth. At this depth, it will only potentially interact with shallow perched water within the peat profile. No interaction with deeper regional groundwater will occur. Therefore, no effects on the local groundwater table or flows will occur from this element of the development;
- The construction of the proposed electrical substation, the temporary construction compounds and roads will be relatively shallow and will only have the potential to interact with the shallow perched water table within the peat bog. No interaction with the deeper regional groundwater regime will occur. Therefore, no effects on the local groundwater table or flows will occur; and,
- The potential effect of potential piling works on groundwater is assessed separately in Section 9.5.2.8.

Post-Mitigation Residual Effects: Due to large separation distances between proposed works and water wells, local streams and rivers, and the relatively shallow nature of the proposed works, and also the prevailing geology of the proposed site the potential for water level drawdown impacts at receptor locations are considered negligible. The residual effect will be imperceptible, direct, temporary, unlikely effects on local groundwater levels.

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

9.5.2.5 Potential Release of Hydrocarbons

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

Hydrocarbon storage will not occur during the grid route construction as the works are transient. Vehicles will be refuelled before reaching the grid route.

Pathways: Groundwater flowpaths and site drainage network.

Receptors: Groundwater (Banagher and Birr GWBs) and surface waters (Fadden Beg and Holy Well Clohaskin Streams and the Little Brosna River) and associated dependant ecosystems.

Pre-Mitigation Potential Effects:

Indirect, negative, slight, long term, unlikely effect on local groundwater quality.

Indirect, negative, moderate, short term, unlikely effect on surface water quality.

Proposed Mitigation Measures:

- All plant will be inspected and certified to ensure they are leak free and in good working order prior to use on site;
- On-site re-fuelling of machinery will be carried out using a mobile double skinned fuel bowser. The fuel bowser, a double axel custom-built refuelling trailer or truck will be re-filled off site and will be towed/driven around the site to where machinery is located. The 4x4 jeep/fuel truck will also carry fuel absorbent material and pads in the event of any accidental spillages. The fuel bowser will be parked on a level area in the construction compound when not in use and only designated trained and competent operatives will be authorised to refuel plant on site. Mobile measures such as drip trays and fuel absorbent mats will be used during all refuelling operations;
- Fuels stored on site will be minimised. Any storage areas will be bunded appropriately for the fuel storage volume for the period of the construction;
- The substation building will be bunded appropriately to the volume of oils likely to be stored and to prevent leakage of any associated chemicals and to groundwater or surface water. The bunded area will be fitted with a storm drainage system and an appropriate oil interceptor;
- The plant used will be regularly inspected for leaks and fitness for purpose;
- An emergency plan for the construction phase to deal with accidental spillages will be contained within the Construction Environmental Management Plan (refer to Appendix 4-3 of this EIAR). Spill kits will be available to deal with accidental spillages.

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

Significance of Effects: For the reasons outlined above, and with the implementation of the listed mitigation measures, no significant effects on surface water or groundwater quality will occur.

9.5.2.6 Groundwater and Surface Water Contamination from Wastewater Disposal

Release of effluent from on-site temporary wastewater treatment systems has the potential to impact on groundwater and surface water quality if site conditions are not suitable for an on-site percolation unit. Impacts on surface water quality could affect fish stocks and aquatic habitats.

Pathways: Groundwater flowpaths

Receptors: Groundwater quality (Banagher and Birr GWBs) and surface water quality (Fadden Beg and Holy Well Clohaskin Streams and the Little Brosna River) and associated dependant ecosystems.

Pre-mitigation Effects:

Indirect, negative, slight, temporary, unlikely effect on surface water quality.

Indirect, negative, significant, temporary, unlikely effect on local groundwater.

Proposed Mitigation Measures:

- During the construction phase, a self-contained port-a-loo with an integrated waste holding tank will be used at the primary construction compound, maintained by the providing contractor, and removed from the site on completion of the construction works;
- Water supply for the site office and other sanitation will be brought to site and removed after use by a licensed contractor to be discharged at a suitable off-site treatment location; and,
- No water or wastewater will be sourced on the site, nor discharged to the site.

Post-Mitigation Residual Effects: The potential for contamination resulting from wastewater disposal is a risk to surface and groundwater quality. This is a risk common to all construction sites containing welfare facilities. Proven and effective measures to mitigate the release of wastewater on site have been proposed above and will break the pathway between the potential source and each receptor. The residual effect will be a negative, imperceptible, indirect, short-term, unlikely effect on surface water or groundwater quality.

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

9.5.2.7 Release of Cement-Based Products

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 11.5) that can physically damage fish by burning their skin and blocking their gills. A pH range of $\geq 6 \leq 9$ is set in S.I. No. 293 of 1988: European Communities (Quality of Salmonid Waters) Regulations, with artificial variations not in excess of $\pm$ 0.5 of a pH unit. Entry of cement-based products into the site drainage system, into surface water runoff, and hence to surface watercourses or directly into watercourses represents a risk to aquatic species and habitats.

Peat ecosystems are dependent on low pH hydrochemistry. They are extremely sensitive to the introduction of high pH alkaline waters into the system. Batching of wet concrete on site and washing out of transport and placement machinery are the activities most likely to generate a risk of cement-based pollution. Placed concrete in turbine bases and foundations can also have minor local effects on groundwater quality over time. However, due to the limited surface area of exposed concrete, the anoxic conditions below ground, and the high rate of dilution from the wider groundwater system relative to the small volumes of groundwater that would come in contact with the concrete, the potential for impacts are low.

Pathways: Site drainage network and groundwater flow

Receptors: Groundwater quality (Banagher and Birr GWBs) and surface water quality (Fadden Beg and Holy Well Clohaskin Streams and the Little Brosna River) and associated dependant ecosystems.

Pre-Mitigation Effects:

Indirect, negative, moderate, short term, unlikely effect on surface waters such as the Faddan Beg and Holy Well Clohaskin Streams and the Little Brosna River.

Indirect, negative, imperceptible, long term, unlikely effect on local groundwater quality.

Proposed Mitigation Measures:

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

No mitigation required for potential groundwater impacts as these are imperceptible at the outset.

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

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

9.5.2.8 Potential Effects Associated with Piled Foundations

Due to the possibility of deep peat and glacial tills at some of the proposed turbine's locations, a range of foundation scenarios are proposed, including:

- Gravity foundations;
- Piled foundation with a configuration of up to 50 no. 300mm square concrete driven piles. These piles could extend to a depth of between 5 to ~18metres below ground level; and,
- Piled foundation with a configuration of up to 20 no. 900 to 1200mm cylindrical bored piles. These piles could extend to a depth of between 5 to ~18metres below ground level.

The following potential scenarios arise in respect of proposed piling works:

- Creation of preferential pathways, through a low permeability subsurface layer (an aquitard such as lacustrine clay), to allow downward flow into the underlying aquifer;
- Creation of preferential pathways, through a low permeability subsurface layer (an aquitard such as lacustrine clay), to allow upward migration alkaline groundwater to the acidic bog surface, thus potentially altering local hydrochemistry and therefore vegetation at the bog surface; and,
- Creation of a blockage to regional groundwater flow within the underlying aquifer due to placement of pile clusters.

These pathways are analogous to pathways described for piling works associated with contaminated land sites, as detailed in Environment Agency (2001).

Pathways: Groundwater flowpaths (upward and/or downward pathways, and regional groundwater flows).

Receptors: Groundwater quality in the underlying Banagher and Birr GWBs and groundwater hydrochemistry at the surface and within the peat bog.

Pre-Mitigation Potential Effects: Negative, moderate, direct, short term, likely effect on groundwater quality/hydrochemistry.

Proposed Mitigation Measures:

The proposed mitigation measures designed for the protection of downstream surface water quality and groundwater quality within the peat bog will be implemented at all construction work areas.

- Mitigation measures for sediment control are detailed in Section 9.5.2.2.
- Mitigation measures for the control of hydrocarbons during construction works are detailed in Section 9.5.2.5.
- Mitigation measures for the control of cement-based products during construction works are detailed in Section 9.5.2.7.

Proposed mitigation measures relative to piling works will comprise:

- Strict QA/QC procedures for piling works will be followed;
- Piles will be kept vertical during piling works;
- Good workmanship will be employed during all piling works; and,
- Where required use bentonite seal to prevent upward/downward movement of surface water/groundwater.

Impact Assessment:
The ground conditions at the proposed site can be typically categorised into the following deposits (based on data presented in Chapter 8):

- **Peat** – Typically described as spongy, dark brown, pseudo fibrous peat. Peat thicknesses from ranged from 0.6 – 3.7m at turbine locations;
- **Lacustrine Clay** – Located at turbine T5 only (2m);
- **Glacial Tills** – Mainly CLAYs and SILTs (glacial tills derived from limestone). The thickness of the layer is variable across the proposed site ranging between 0 and >2.4m in the trial pits;
- **Limestone Bedrock** – Limestone bedrock was encountered in only 2 no. trial pits at depths of 1.8 and 2.8m.
- **Groundwater** – Groundwater ingress was recorded in 5 of the 15 no. trial pits completed at the wind farm site. The depth of groundwater ingress ranges between 0.9 and 3.6mbgl.

Proposed piles will penetrate through peat deposits, lacustrine clay deposits (where they occur), and then into underlying glacial tills or bedrock. Where present the clay layer is likely to act as an aquitard/low permeability layer, through which only very small amounts of water can flow.

Peat water is perched above the regional groundwater table. Peat water occurs in the bog basins, while regional groundwater flow will occur in the underlying bedrock aquifer. Glacial tills that occur between the base of the peat/lacustrine clays may be permeable in local zones, but in general will have a moderate to low permeability. Therefore, the two main groundwater systems are the upper acidic peat water, and the lower regional bedrock groundwater water. As the underlying bedrock is mainly limestone, the groundwater occurring within this aquifer will be alkaline.

For the driven piles the clay and also the glacial tills are likely to 'self-seal' around the piles, meaning that a long term pathway between the upper peat/bog water and the lower bedrock aquifer will not be sustained.

Research indicates that provided the aquitard layer is of a reasonable thickness and the piles driven through have a cross section without re-entrant angles, the likelihood of creating preferential flow paths for downward migration of leachate (i.e. peat water) is very low. This hypothesis is consistent with the results obtained by Hayman et al (1993) and Boutwell et al (2000).

For bored piles, as the temporary steel casing is removed, a steel reinforcement cage is added to the pile column and then concrete is added to the toe of the pile using a tremie pipe. Vermiculite is used to create a plug between the concrete and the displaced water, therefore the concrete seals the entire pile column and pushes the vermiculite plug to the surface as concrete is added. The temporary steel casing is removed carefully as the concreting works are being completed. This concreting process is similar to that used when grouting a water supply production well (IGI (2007), and EPA (2013)). This means that a long term pathway between the upper peat/bog water and the lower bedrock aquifer will not be sustained.

Scenario 1: Creating a Pathway for Downward Flow

To ensure downward flow of peat water and/or pollutants from the piling works does not occur, a bentonite seal will be used in a starter pit for each driven pile, and the mitigation measures outlined above will be implemented. The concrete added to the bored pile will seal the pile annulus. As a result, the potential for either piling work option to create pathways for downward flow of peat water or pollutants that could affect groundwater quality in the underlying aquifer is imperceptible.

Scenario 2: Creating a Pathway for Upward Flow

No upwelling of groundwater to the peat surface water recorded in any of the site investigation locations recorded across the proposed site.

Notwithstanding this, to ensure upward flow of underlying groundwater via potential pathways created by piling works does not occur, a bentonite seal will be used in a starter pit for each driven pile, and the mitigation measures outlined above will be implemented. The concrete added to the bored pile will seal the pile annulus. As a result, the potential for piling works to create pathways for upward flow of alkaline groundwater to the bog surface is imperceptible.

Scenario 3: Blocking Regional Groundwater Flow

For example, if a piling array of 50 no. 300mm piles is applied at each turbine base (as piling Option 1), this combined area of piling footprint amounts to ~24.7m^2, or 3.53m^2 per turbine base. Each turbine base is 500m – 800m apart. The area of the piles driven into the ground is distributed over a very large area, and that area only amounts to <0.02% of the development footprint, or <0.0005% of the proposed site area. Also, none of the proposed piles would penetrate any great distance into the underlying bedrock aquifer, as they will find sufficient resistance, either in the over lying glacial tills/mineral subsoils or upon reaching the top of bedrock. At such wide separation distance, the ability of clusters of piles, with a plan area of ~3.53m^2 per turbine, to alter or affect regional groundwater flow is imperceptible.

Post-Mitigation Residual Effects: Should piling works be required at any of the proposed turbine locations, they potentially pose a threat to groundwater quality in the underlying regional groundwater system, and also could potentially create a pathway for upward migration of alkaline groundwater to the peat surface. These potential effects will not arise at the proposed site due to a combination of the prevailing ground conditions, groundwater conditions, and proposed mitigation measures, outlined above, that will ensure the potential pathways for interaction of shallow (acidic peat water) and deeper (alkaline) groundwater are prevented from occurring. In addition, due to the small footprint of proposed pile clusters, and the significant spacing between turbine bases where pile clusters are proposed, the potential for such pile clusters to block regional groundwater flow is imperceptible at that scale. The proposed piled foundations therefore have no potential to change the WFD status or impact the WFD objectives of the underlying Banagher and Birr GWBs. The residual effect will be a negative, imperceptible, indirect, short term, unlikely effect on groundwater flow, and ground quality/peat water hydrochemistry.

Significance of Effects: For the reasons given above, no significant effects on regional groundwater and the Banagher and Birr GWBs will occur, and no significant effects on peat water hydrochemistry will occur from proposed piling works.

9.5.2.9 Morphological Changes to Surface Water Courses & Drainage Patterns within Wind Farm Site

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

There are 2 no. proposed watercourse crossing locations within the wind farm site.

Pathways: Site drainage network.

Receptors: Surface water flows within the Wind Farm Site (Faddan Beg and Holy Well Clohaskin streams).

Pre-Mitigation Potential Effects: Negative, direct, slight, long term, likely effect on local steam morphology and water quality.

Proposed Mitigation Measures:

The proposed mitigation measures include:

- All proposed new stream crossings will be bottomless or clear span culverts and the existing banks will remain undisturbed. No in-stream excavation works are proposed and therefore there will be no direct impact on the stream at the proposed crossing location;
- Where the proposed underground cabling route follows an existing road or road proposed for upgrade, the cable will pass over or below the culvert within the access road;
- All guidance / mitigation measures proposed by the OPW or the Inland Fisheries Ireland[7] is incorporated into the design of the proposed crossings;
- As a further precaution, near stream construction work, will only be carried out during the period permitted by Inland Fisheries Ireland for in-stream works according to the Eastern Regional Fisheries Board (2004) guidance document "Requirements for the Protection of Fisheries Habitat during Construction and

[7] *Inland Fisheries Ireland (2016): Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters*

Development Works at River Sites", i.e., May to September inclusive. This time period coincides with the period of lowest expected rainfall, and therefore minimum runoff rates. This will minimise the risk of entrainment of suspended sediment in surface water runoff, and transport via this pathway to surface watercourses (any deviation from this will be done in discussion with the IFI);
- Where works are necessary inside the 50m buffer double row silt fences will be emplaced immediately down-gradient of the construction area for the duration of the construction phase. There will be no batching or storage of concrete allowed in the vicinity of the crossing construction areas; and,
- All new river/stream crossings will require a Section 50 application (Arterial Drainage Act, 1945). The river/stream crossings will be designed in accordance with OPW guidelines/requirements on applying for a Section 50 consent.

Post-Mitigation Residual Effects: With the application of the best practice mitigation outlined above, the residual effect will be a negative, imperceptible, direct, long term, unlikely effect on stream flows, stream morphology and surface water quality.

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

9.5.2.10 Morphological Changes and Surface Water Quality Effects Along Grid Connection Route

The grid connection route is located in the catchment of the Little Brosna River. There are a total of 4 no. crossings proposed over EPA mapped watercourses and 3 no. drain crossings along the grid route which are existing bridge and culvert crossing. The proposed crossing methods are as follows:

<u>**Crossing Over Existing Culverts**</u>

Option A –

Where adequate cover exists above a culvert, the standard trench arrangement will be used where the cable ducts pass over a culvert without any contact with the existing culvert or water course. The cable trench will pass over the culvert in a standard trench.

Option B –

Where the culvert consists of a socketed concrete or sealed plastic pipe and sufficient depth is not available over the crossing, a trench will be excavated beneath the culvert, and cable ducts will be installed in the standard formation 300mm below the existing pipe.

Option C –

Where cable ducts are to be installed over an existing culvert and sufficient cover cannot be achieved, the ducts will be laid in a much shallower trench, the depth of which will be determined by the cover available at the culvert crossing location. The ducts within the shallow formation trench will be encased in 6mm thick steel galvanized plates and backfilled with 35N concrete.

Option D –

Directional Drilling is a method of drilling under obstacles such as bridges, culverts, railways, water courses, etc. in order to install cable ducts under the obstacle. This method is employed where installing the ducts using standard installation methods is not possible.

Pathways: Runoff and surface water flowpaths.

Receptors: Down-gradient water flows and quality (Faddan Beg Stream and Little Brosna River).

Pre-Mitigation Potential Effect: Negative, moderate, indirect, temporary, likely effect on downstream surface water flows and surface water quality.

Proposed Mitigation Measures:

Prior to the commencement of cable trenching or crossing works the following key temporary drainage measures will be installed:

- All existing roadside drains that intercept the proposed works area will be temporarily blocked down-gradient of the works using check dams/silt traps;
- Culverts, manholes and other drainage inlets will also be temporarily blocked;
- A double silt fence perimeter will be placed along the road verge on the down-slope side of works areas that are located inside the watercourse 50m buffer zone.

The following mitigation measures are proposed for the grid connection watercourse crossing works:

- No stockpiling of construction materials, inside 50m buffer zones, will take place along the grid connection route
- No refuelling of machinery or overnight parking of machinery is permitted in this area;
- No concrete truck chute cleaning is permitted in this area;
- Works will not take place at periods of high rainfall, and will be scaled back or suspended if heavy rain is forecast;
- Local road drainage, culverts and manholes will be temporarily blocked during the works;
- Machinery deliveries will be arranged using existing structures along the public road;
- All machinery operations will take place away from the stream and ditch banks, apart from where crossings occur. Although no instream works are proposed or will occur;
- Any excess construction material will be immediately removed from the area and sent to a licenced waste facility;
- No stockpiling of materials will be permitted in the constraint zones;
- Spill kits will be available in each item of plant required to complete the stream crossing; and,
- Silt fencing will be erected on ground sloping towards watercourses at the stream crossings if required.

Mitigation Measures relating to the use of a mixture of a natural, inert and fully biodegradable drilling fluid such as Clear Bore™ and water for directional drilling:

- The area around the Clear Bore™ batching, pumping and recycling plants will be bunded using terram and sandbags in order to contain any spillages;
- One or more lines of silt fences will be placed between the works area and adjacent rivers and streams on both banks;
- Accidental spillage of fluids will be cleaned up immediately and transported off site for disposal at a licensed facility; and,
- Adequately sized skips will be used for temporary storage of drilling arisings during directional drilling works. This will ensure containment of drilling arisings and drilling flush.

Post-Mitigation Residual Effect: The potential for the release of suspended solids and other contaminants to watercourse receptors is a risk to water quality and the aquatic quality of the receptor. Proven and effective measures to mitigate the risk of releases of sediment have been proposed above and will break the pathway between the potential sources and the receptor. The residual effect will be a negative, imperceptible, direct, long term, likely effect on surface water flows and surface water quality.

Significance of Effects: For the reasons outlined above, no significant effects on surface water flows and surface water quality will occur due to construction of the grid connection route.

9.5.2.11 Potential Effects on Local Groundwater Well Supplies

The groundwater flow in the mineral soil deposits beneath the peat at the wind farm site will discharge into the local surface water drainage network, i.e. the existing bog drainage network which discharges to tributaries of the Little Brosna River. Groundwater flow is expected to be to the southeast and discharge into the Little Brosna River and its tributaries.

Using this conceptual model of groundwater flow an impact assessment for local wells is undertaken below. This assessment is completed in accordance with "Wind farms and groundwater impacts - A guide to EIA and Planning considerations" (DoE/NIEA, 2015).

The biggest risk to groundwater wells will be from where deep excavations are required such as the turbine bases. Construction of the Proposed Development site access road, underground cable route trench between the turbines and the substation and the construction of substation and the grid connection will not have the potential to affect local wells due to the shallow nature of the works.

There are no public or group scheme or EPA registered abstraction groundwater supplies down-gradient of the wind farm site that can be impacted by the Proposed Development. Furthermore the GSI do not map any wells with a locational accuracy of ≤100m in the vicinity of the wind farm site.

We have completed an assessment of private wells in the lands surrounding the wind farm site. In order to be conservative and following a precautionary approach, we have assumed that all dwellings in the surrounding lands have a private groundwater well. A number of private dwelling houses were identified along the local roads to the southeast and down-gradient (i.e., downslope) of the wind farm site.

The majority of proposed key infrastructure elements (i.e. Proposed Development elements which have deep excavations and a potential to effect the regional groundwater system below the peat basin) are located a significant distance (>500m) from dwellings. Due to the high drainage density of the peat bog and the surrounding lands, it is expected that the majority of groundwater flow will discharge to local watercourses, as well as to the larger drainage ditches around the bog. These drainage systems and water bodies will act as hydraulic barriers between the development locations and the location of potential groundwater wells.

However, there are a number of dwellings situated along local roads to the southeast which are potentially down-gradient of turbine locations. The closest houses are detailed below:

- A dwelling is located ~1.2m southeast of T1; and
- A dwelling is located ~>740m southeast of T2.

Due to the shallow nature of the excavation works at the proposed substation location, no effects on groundwater levels or local wells will occur.

All turbines are located >740m from third party dwellings. This is a sufficient distance to ensure that there will be no effects on these local wells.

Pathways: Groundwater flowpaths.

Receptors: Local Groundwater Supplies.

Pre-Mitigation Effect: Negative, imperceptible, indirect, short-term, unlikely effect on local groundwater supplies.

Mitigation Measures:

The implementation of the mitigation measures described above will ensure the protection of groundwater quality and quantity:

- An impact assessment for potential effects on groundwater levels is detailed in Section 9.5.2.4.
- Mitigation measures for the control of hydrocarbons during construction works are detailed in Section 9.5.2.5.
- Mitigation measures to prevent contamination from wastewater disposal during the construction phase are detailed in Section 9.5.2.6
- Mitigation measures for the control of cement-based products during construction works are detailed in Section 9.5.2.7.
- Mitigation measures for the use of piled foundation are detailed in Section 9.5.2.8.

No additional specific mitigation measures are required with respect to local groundwater supplies.

Post-Mitigation Residual Effects: For the reasons given in the impact assessment above (separation distances, and prevailing geology, topography and groundwater flow directions), we consider the residual effects to be a negative, imperceptible, indirect, short-term, unlikely effect in terms of quality or quantity on local groundwater well supplies.

Significant of Effects: For the reasons outlined above, and with the implementation of the detailed mitigation measures, no significant effects on existing groundwater supplies will occur.

9.5.2.12 Use of Siltbuster and Impacts on Downstream Surface Water Quality

Siltbusters are regularly used to remove suspended sediments on construction sites by means of chemical dosing and sedimentation (i.e. use of coagulants and flocculants to accelerate the settlement process). The benefits of using enhanced settlement systems on downstream surface water quality are widely known, and are a positive effect. However, potential overdosing with chemical agents means there is a perceived risk of chemical carryover in post treatment water which could result in negative effects on downstream water quality.

Wind farm construction water (i.e. surface water runoff or pumped groundwater) has sometimes very fine particles, particularly clays and peat, with slow settling velocities which do not settle out efficiently, even in a lamella clarifier at normal flow rates. In these cases, chemical dosing can be used to aggregate the particles (i.e. force them to combine and become heavier), increasing the particle settling rate and cleaning the water via gravity separation techniques. Agents commonly used include poly aluminium chloride (PAC), aluminium sulphate, ferric iron and ferrous iron. These agents are commonly used in drinking water treatment plants. So their use is widespread, and there is significant scientific knowledge around their use and control.

The benefits of using a Siltbuster system in emergency scenarios where all other water treatment systems have proven ineffective are considerable. An example of treatment capability of siltbuster systems from northwest Mayo is provided in Figure 9-10. This is a duration curve of downstream water quality data post siltbuster treatment. The system was setup so that any water not meeting discharge criteria was recycled back to the settlement ponds. The graph shows all data, and only 24 data points out of 1194 records were above 20 mg/L (i.e. recycling, and repeat treatment occurred at these times to ensure compliance at the discharge location).

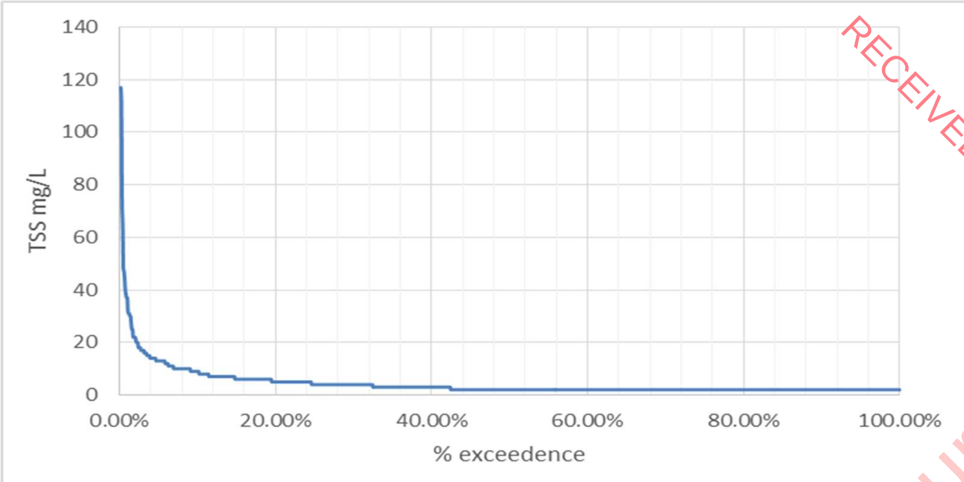


Figure 9-10: TSS treatment data using Siltbuster systems (with chemical dosing)

Pathways: Drainage and surface water discharge routes.

Receptors: Surface water quality in downstream rivers (Faddan Beg Stream, Holy Well Clohaskin Stream and Little Brosna River) and designated sites and associated water-dependent ecosystems.

Pre-Mitigation Potential Effects: Negative, slight, indirect, temporary, likely effect on downstream surface water quality.

Mitigation Measures:

Measures employed to prevent overdosing and potential chemical carryover:

- The siltbuster system comprises an electronic in-line dosing system which provides an accurate means of adding reagents, so overdosing cannot occur;
- Continued monitoring and water analysis of pre and post treated water by means of an inhouse lab and dedicated staff, means the correct amount of chemical is added by the dosing system;
- Dosing rates of chemical to initiate settlement is small, being in the order of 2-10 mg/L and the vast majority of the chemical is removed in the deposited sediment;
- Final effluent not meeting the discharge criteria is recycled and retreated, which has a secondary positive effect of reducing carryover; and,
- Use of biodegradable chemical agents can be used at very sensitive sites (i.e. adjacent to SACs).

Post-Mitigation Residual Effects: With the implementation of the dosing technology and the continual monitoring of pre and post treatment water, the appropriate volume of chemical agent can be added to ensure that chemical carryover concentrations are present only in tiny trace amounts which will not cause any effects to receiving waters or associated aquatic ecology. The residual effect will be negative, imperceptible, indirect, temporary, unlikely effect on downstream water quality.

Significance of Effects: For the reasons outlined above, no significant effects on the surface water quality will occur. In fact, we consider that the use of siltbuster systems has a significant positive effect in respect of protected surface water quality.

9.5.2.13 Potential Effects on Designated Sites

The wind farm site is not located within any designated conservation site. However, as stated in Section 9.3.14.1 above, several designated sites occur in the lands surrounding the wind farm site. These designated sites include Arragh More Bog NHA, Arragh More (Derrybreen) Bog SAC and Ballyduff/Clonfinane Bog SAC and pNHA. The setbacks distances and up-gradient location of these designated sites to the wind farm site means hydrological and hydrogeological effects will not occur.

All these local designated bogs are either located to the north or west of the Proposed Development site and are therefore situated up-gradient of the Proposed Development works.

Other designated sites located downstream of the Proposed Development include:

- Dovegrove Callows SPA and pNHA which is located ~6.7km northeast of the wind farm along the Little Brosna River and downstream of the wind farm site/grid route;
- The Little Brosna Callows SPA and NHA, situated ~3.3km north of the wind farm site on the Little Brosna River. This designated site is also downstream of the grid route;
- The River Shannon Callows SAC, located ~8.5km west and downstream of the wind farm site via the Little Brosna River;
- The Middle Shannon Callows SPA, located ~8.5km west of the wind farm site and is downstream of the Little Brosna River.

The surface water connections from the wind farm site and the grid connection could transfer poor quality surface water that may affect the conservation objectives of these designated sites.

Due to physical and hydrological and hydrogeological separation all other designated sites have no potential to be affected by the Proposed Development.

The potential effects of the Proposed Development on designated sites has also been completed as part of a detailed WFD Compliance Assessment Report and is included in Appendix 9-3.

Pathways: Surface water flowpaths and groundwater levels.

Receptors:

Down-gradient water quality and downstream designated sites (*i.e.* Dovegrove Callows SPA and pNHA, Little Brosna Callows SPA and NHA, River Shannon Callows SAC and Middle Shannon Callows SPA).

Water quality and groundwater levels in the adjacent designated sites (*i.e.* Arragh More Bog NHA, Arragh More (Derrybreen) Bog SAC and Ballyduff/Clonfinane Bog SAC and pNHA.

Pre-Mitigation Potential Effects:

Indirect, negative, moderate, short-term, likely effect on downstream designated sites.

Indirect, negative, imperceptible, short-term, unlikely effect on adjacent designated site.

Impact Assessment & Proposed Mitigation Measures:

<u>Adjacent Designated Sites</u>

The Proposed Development has no potential to affect the status of the Arragh More Bog NHA, Arragh More (Derrybreen) Bog SAC and Ballyduff/Clonfinane Bog SAC and pNHA.

These designated sites are located up-gradient of all proposed wind farm infrastructure and proposed works areas. Surface and groundwater flows within the wind farm site are to the southeast, towards the Little Brosna River. Therefore, there is no potential for water quality (surface and groundwater) effects to occur to the Arragh More Bog NHA, Arragh More (Derrybreen) Bog SAC and Ballyduff/Clonfinane Bog SAC and pNHA.

In terms of groundwater levels effects during earthworks, the designated sites are located a sufficient distance from proposed works areas as detailed below:

- Arragh More Bog NHA is located ~200m from the closest works area which is turbine T5;
- Arragh More Bog SAC is located ~1km from T5.
- Ballyduff/Clonfinane Bog SAC/pNHA is located ~340m from turbine T6.

As stated in Section 9.5.2.4, any potential water level effects associated with temporary dewatering works are unlikely to be significant beyond 50m from any excavation due to the dominance of moderate to low permeability glacial till subsoils and lacustrine deposits below the wind farm site. Therefore, the distances between the proposed works areas and the designated sites are sufficient to ensure that the Proposed Development has no potential to effect groundwater levels within these adjacent designated sites.

Downstream Designated Sites

Implementation of the mitigation measures described above will ensure the protection of surface water quality in receiving and downstream surface waters:

- Mitigation measures for sediment control are detailed in Section 9.5.2.1 and Section 9.5.2.2.
- Mitigation measures for clear felling of coniferous forestry plantations are detailed in Section 9.5.2.3.
- Mitigation measures for the control of hydrocarbons during construction works are detailed in Section 9.5.2.5.
- Mitigation measures to prevent contamination from wastewater disposal during the construction phase are detailed in Section 9.5.2.6
- Mitigation measures for the control of cement-based products during construction works are detailed in Section 9.5.2.7.

Furthermore, groundwater from below the wind farm site may also discharge as baseflow to local watercourse and to the Little Brosna River, thus entering the downstream designated sites. The implementation of the mitigation measures described above will ensure the protection of groundwater quality:

- An impact assessment for potential effects on groundwater levels is detailed in Section 9.5.2.4.
- Mitigation measures for the control of hydrocarbons during construction works are detailed in Section 9.5.2.5.
- Mitigation measures to prevent contamination from wastewater disposal during the construction phase are detailed in Section 9.5.2.6
- Mitigation measures for the control of cement-based products during construction works are detailed in Section 9.5.2.7.
- Mitigation measures for the use of piled foundation are detailed in Section 9.5.2.8.

Post-Mitigation Residual Effects: Construction activities pose a threat to designated sites hydrologically linked with the Proposed Development. Proven and effective measures to mitigate the risk of surface and groundwater contamination have been proposed which will break the pathway between the potential source and the downstream receptors. These mitigation measures will ensure that surface water runoff will be equivalent to baseline conditions and will therefore have no effect on downstream water quality. No significant effects on adjacent or hydrologically connected designated sites will occur. Please see Chapter 6 Biodiversity for details.

Significance of Effects: No significant effects on designated sites will occur.

9.5.2.14 Potential Effects on Surface Water and Groundwater WFD Status

The WFD status for GWBs and SWBs underlying and downstream of the Proposed Development are defined in Section 9.3.12 and Section 9.3.13 respectively. The WFD status for the watercourses downstream of the Proposed Development are of "Moderate" and "Good" status. Meanwhile the underlying GWBs achieved "Good" status.

Changes in surface water of groundwater flow regimes and water quality has the potential to impact on the objectives and status of the associated GWB and SWBs.

A detailed WFD Compliance Assessment Report has been completed in combination with this EIAR Chapter and is included in Appendix 9-3.

Pathways: Surface water flowpaths and groundwater flowpaths.

Receptors: WFD Groundwater Bodies and Surface Water Bodies.

Pre-Mitigation Potential Effect:

Indirect, negative, moderate, temporary, unlikely effect on downstream SWBs.

Indirect, negative, slight, temporary, unlikely effect on the underlying GWBs.

Impact Assessment & Proposed Mitigation Measures:

Mitigation measures to ensure the protection of receiving surface waters are described in the following sections:

- Mitigation measures for sediment control are detailed in Section 9.5.2.1 and Section 9.5.2.2.
- Mitigation measures for clear felling of coniferous forestry plantations are detailed in Section 9.5.2.3.
- Mitigation measures for the control of hydrocarbons during construction works are detailed in Section 9.5.2.5.
- Mitigation measures to prevent contamination from wastewater disposal during the construction phase are detailed in Section 9.5.2.6
- Mitigation measures for the control of cement-based products during construction works are detailed in Section 9.5.2.7.

Mitigation measures to ensure the protection of the receiving groundwaters are described in the following sections:

- An impact assessment for potential effects on groundwater levels is detailed in Section 9.5.2.4.
- Mitigation measures for the control of hydrocarbons during construction works are detailed in Section 9.5.2.5.
- Mitigation measures to prevent contamination from wastewater disposal during the construction phase are detailed in Section 9.5.2.6
- Mitigation measures for the control of cement-based products during construction works are detailed in Section 9.5.2.7.
- Mitigation measures for the use of piled foundation are detailed in Section 9.5.2.8.

Post-Mitigation Residual Effects: There is no direct discharge from the Proposed Development site to downstream receiving surface waters or the underlying GWB. Mitigation for the protection of surface and groundwater during the construction phase of the Proposed Development will ensure the qualitative and quantitative status of the receiving waters will not be altered by the Proposed Development.

There will be no change in GWB or SWB status in the underlying GWB or downstream SWBs resulting from the Proposed Development. There will be no change in quantitative (volume) or qualitative (chemical) status, and the underlying GWB and downstream SWBs are protected from any potential deterioration.

There will be no residual effect on Groundwater Bodies.

There will be no residual effect on Surface Water Bodies.

Significance of Effects: No significant effects on WFD status of surface water or groundwater bodies will occur.

9.5.3 Operational Phase – Likely Impacts and Mitigation Measures

9.5.3.1 Progressive Replacement of Natural Surface with Lower Permeability Surfaces

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

Pathway: Site drainage network.

Receptors: Surface waters (Faddan Beg Stream, Holy Well Clohaskin Stream and Little Brosna River) and associated dependent ecosystems.

Pre-Mitigation Potential Effect: Negative, slight, indirect, long term, likely effect on all downstream surface water bodies.

Impact Assessment:

The emplacement of the proposed permanent development footprint, as described in Chapter 4 of the EIAR, (assuming emplacement of impermeable materials as a worst-case scenario) could result in an average total site increase in surface water runoff of approximately 351m^3/month or 11.3 m^3/day (Table 9-19). This represents a potential increase of approximately 0.16% in the average daily/monthly volume of runoff from the site area in comparison to the baseline pre-development site runoff conditions. This is a very small increase in average runoff and results from the naturally high surface water runoff rates and the relatively small area of the site being developed, the proposed total permanent development footprint being approximately 6.5ha, representing ~2% of the EIAR Site Boundary area of 314ha.

Table 9-19: Baseline Site Runoff V Development Runoff

Site Baseline Runoff/month (m^3)	Baseline Runoff/day (m^3)	Permanent Hardstanding Area (m^2)	Hardstanding Area 100% Runoff (m^3)	Hardstanding Area 93% Runoff (m^3)	Net Increase/month (m^3)	Net Increase/day (m3)	% Increase from Baseline Conditions (m^3)
224,855	7,253	65,100	5,013	4,662	351	11.3	0.16

The additional volume is low due to the fact that the runoff potential from the site is naturally high (93%). Also, the calculation assumes that all hardstanding areas will be impermeable which will not be the case as access tracks and turbine hardstands will be constructed of permeable stone aggregate. The increase in runoff from the Proposed Development will, therefore, be negligible. This is even before mitigation measures will be put in place.

Proposed Mitigation by Design:

The drainage system of the Proposed Development will be installed and constructed in conjunction with the road and hardstanding construction work as described below and as shown on the Drainage drawings submitted with this planning application (Appendix 4-4):

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

As described above the proposed integration of the wind farm drainage with the existing forestry and bog drainage is a key component of the proposed drainage management within the development. By integration we mean maintaining surface water flowpaths where they already exist, avoid creation of new or altered surface water flowpaths, and maintaining the drainage regime (i.e. normal flow) within each forestry compartment. Critically, there will be no alteration of the catchment size contributing to each of the main downstream watercourses. All wind farm drainage water captured within individual site sub-catchments will be attenuated and released within the same sub-catchments that it was captured.

Post-Mitigation Residual Effect: Proven and effective measures to attenuate runoff and mitigate the risk of flooding will be employed. The residual effect will be a neutral, indirect, long term, likely effect on down gradient streams/rivers.

Significance of Effects: No significant effects on downstream flood risk will occur during the operational phase of the Proposed Development.

9.5.3.2 Runoff Resulting in Contamination of Surface Waters

During the operational phase, the potential for silt-laden runoff is much reduced compared to the construction phase. In addition, all permanent drainage controls will be in place and the disturbance of ground and excavation works will be complete. Some minor maintenance works may be completed, such as maintenance of site entrances, internal roads and hardstand areas. These works would be of a very minor scale and would be very infrequent. Potential sources of sediment laden water would only arise from surface water runoff from small areas where new material is added during maintenance works.

These minor activities could, however, result in the release of suspended solids to surface water 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 could be significant if not mitigated.

During such maintenance works there is a small risk associated with the release of hydrocarbons from site vehicles, although it is not envisaged that any significant refuelling works will be undertaken on site during the operational phase.

Maintenance works will likely be contained within the wind farm site boundary and no maintenance works are likely to be required along the grid route.

Pathways: Drainage and surface water discharge routes.

Receptors: Down-gradient rivers (Faddan Beg Stream, Holy Well Clohaskin Stream and Little Brosna River) and associated dependent ecosystems.

Pre-Mitigation Potential Effect: Negative, slight, indirect, temporary, likely effect on down-gradient rivers.

Proposed Mitigation Measures:

Mitigation measures for sediment control are the same as those outlined in Section 9.5.2.1.

Mitigation measures for the control of hydrocarbons during maintenance works are similar to those outlined in Section 9.5.2.5.

Post-Mitigation Residual Effects: With the implementation of the proposed wind farm drainage measures as outlined above, and based on the post-mitigation assessment of runoff, the residual effects will be Negative, imperceptible, indirect, temporary, unlikely effect on downstream water quality in the Little Brosna River (and associated tributaries) and dependent aquatic ecosystems.

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

9.5.3.3 Assessment of Effects on WFD Objectives

There is no direct discharge from the Proposed Development to downstream receiving waters. Mitigation for the protection of surface water during the operational phase of the Proposed Development will ensure the qualitative status of the receiving SWBs will not be altered by the Proposed Development.

Similarly there is no direct discharge to groundwaters associated with the Proposed Development. Mitigation for the protection of groundwater during the operational phase of the Proposed

Development will ensure that the qualitative status of the receiving GWB will not be altered by the Proposed Development.

A full assessment of the potential effects of the operational phase of the Proposed Development on the status of the receiving waterbodies is included in WFD Compliance Assessment Report attached as Appendix 9-3.

9.5.4 Decommissioning Phase - Likely Significant Effects and Mitigation Measures

The Proposed Development is expected to have a lifespan of ~30 years. Upon decommissioning, the wind turbines the wind turbines and meteorological masts will be dismantled and all above ground components would be removed off-site for recycling.

The potential effects associated with decommissioning of the Proposed Development will be similar to those associated with construction but of a reduced magnitude, due to the reduced scale of the proposed decommissioning works in comparison to construction phase works. Turbine and mast foundations will remain and will be covered with earth and allowed to revegetate. Site roads will continue to be used as amenity pathways and will therefore not be removed. The underground cables will be cut and tied and the ducting will be left in place. Excavation and removal of this infrastructure would result in considerable disturbance to the local environment in terms of disturbance to underlying soils and an increased sedimentation (if turbine foundations and hardstands are being reinstated there is a risk of silt-laden run-off entering receiving waters) and an increased possibility of contamination of local groundwater.

A decommissioning plan will be agreed with the local authority prior to decommissioning of the Proposed Development. A decommissioning plan is included as Appendix 4-5.

However, as noted in the Scottish Natural Heritage report (SNH) Research and Guidance on Restoration and Decommissioning of Onshore Wind Farms (SNH, 2013) reinstatement proposals for a wind farm are made approximately 30 years in advance, so within the lifespan of the wind farm, technological advances and preferred approaches to reinstatement are likely to change. According to the SNH guidance, it is, therefore:

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

Mitigation measures to avoid contamination by accidental fuel leakage and compaction of soil by on-site plant will be implemented as per the construction phase mitigation measures.

No significant effects on the hydrological and hydrogeological environment are envisaged during the decommissioning stage of the Proposed Development.

9.5.5 Risk of Major Accidents and Disasters

The main risk of MADs at peatland sites is related to peat stability. A peat stability risk assessment (Appendix 8-1) has been completed for the Proposed Development Site and it concludes that due to the flat topography of the wind farm site, and with the implementation of the proposed mitigation measures, that the risk of a peat failure at the Proposed Development Site is negligible/none.

Flooding can also result in downstream MADs. However, due to the small scale of the Proposed Development footprint, the naturally high runoff rates and with the implementation of the proposed mitigation measures, the increased flood risk associated with the Proposed Development is negligible/none (refer to Section 9.5.3.1).

9.5.6 Assessment of Potential Health Effects

Potential health effects arise mainly through the potential for surface and groundwater contamination which may have negative effects on public and private water supplies. There are no mapped public or group water scheme groundwater protection zones in the area of the wind farm site or grid route options. Notwithstanding this, the Proposed Development design and mitigation measures ensures that the potential for effects on the water environment will not be significant.

Flooding of property can cause inundation with contaminated flood water. Flood waters can carry waterborne disease and contamination/effluent. Exposure to such flood waters can cause temporary health issues.

A detailed Flood Risk Assessment has been caried out for the Proposed Development, summarised in Section 9.3.6. This Flood Risk Assessment, combined with the assessment of changes in permeable surfaces (Section 9.5.3.1) demonstrates that the risk of the Proposed Development contributing to downstream flooding is insignificant. On-site (construction and operation phase) drainage control measures will ensure no downstream increase in local flood risk.

9.5.7 Cumulative Effects

This section presents an assessment of the potential cumulative effects associated with the Proposed Development and other developments (existing and/or proposed) on the hydrological and hydrogeological environment.

The main likelihood of cumulative effects is assessed to be hydrological (surface water quality) rather than hydrogeological (groundwater). Due to the local hydrogeological setting (i.e. low permeability peat and glacial tills) and the near surface nature of construction activities, cumulative effects with regard groundwater quality or quantity arising from the Proposed Development are assessed as not likely.

The primary potential for cumulative effects will occur during the construction phase of the Proposed Development as this is when earthworks and excavations will be undertaken at the Proposed Development Site. The potential for cumulative effects during the operational phase of the Proposed Development will be significantly reduced as there will be no exposed excavations, there will be no sources of sediment to reach watercourses, there will be no use of cementitious materials and fuels/oil will be kept to a minimum at the site. During the decommissioning phase, the potential cumulative effects are similar to the construction phase, but to a lesser degree with less ground disturbance.

A cumulative hydrological and hydrogeological study area has been delineated as shown below in Figure 9-11. The cumulative study area is delineated by the catchment of the Little Brosna River. Downstream of the Little Brosna River catchment (i.e. the River Shannon itself) no cumulative hydrological effects are likely due to large upstream catchment area of the River Shannon (i.e. ~8,124km^2) and the very high dilution effects afforded by such a large regional catchment and subsequent large surface water flows.

In comparison, the Little Brosna River catchment (~588km^2) only accounts for 7% of the River Shannon catchment upstream of the Little Brosna River confluence. The potential for dilution effects is very high.

9.5.7.1 Cumulative Effects with Agriculture

The wind farm site is situated in the catchment of the Little Brosna River. According to Corine land cover mapping (www.epa.ie) (2018) the Little Brosna River catchment is a largely agricultural catchment.

Agriculture is the largest pressure on water quality in Ireland and has been listed as a significant pressure on the Little Brosna_040 SWB in the vicinity of the wind farm site. Agricultural practices such as the movement of soil and the addition of fertilizers and pesticides can lead to nutrient losses and the entrainment of suspended solids in local surface watercourses. This can have a negative effect on local and downstream surface water quality.

In an unmitigated scenario the Proposed Development would have the potential to interact with these agricultural activities and contribute to a deterioration of downstream surface water quality through the emissions of elevated concentrations of suspended solids and ammonia.

However the mitigation measures detailed in Section 9.5 for the construction, operation and decommissioning phases of the Proposed Development will ensure the protection of downstream surface water quality.

For these reasons we consider that there will not be a significant cumulative effect associated with agricultural activities.

9.5.7.2 Cumulative Effects with Commercial Forestry

The wind farm site is situated in the catchment of the Little Brosna River. According to Corine land cover mapping (www.epa.ie) (2018) coniferous forestry plantations are not extensive within the cumulative study area, with most of the plantations located on the western slopes of the Slieve Blooms Mountains. The Slieve Blooms drain to the Little Brosna River to the southwest and the Camcor River to the northwest. The Camcor River confluences with the Little Brosna at Birr Town, downstream of the wind farm site.

The most common water quality problems arising from forestry relate to the release of sediment and nutrients to the aquatic environment, and impacts from acidification. Forestry may also give rise to modified stream flow regimes caused by associated land drainage.

Given that most of the main forestry plantations are located a significant distance from the wind farm site, the likelihood of significant potential effects occurring is very small. Nevertheless, given that the wind farm site and these forested areas drain to the Little Brosna River, the potential cumulative effects on downstream water quality and quantity need to be assessed.

However the mitigation measures detailed for the construction, operation and decommissioning phases of the Proposed Development will ensure the protection of downstream surface water quality.

For these reasons we consider that there will not be a significant cumulative effect associated with commercial forestry activities.

9.5.7.3 Cumulative Effects with Turbary Peat Cutting Activities

The Little Brosna_040 SWB is under significant pressure from peat extraction activities. The draft 3rd Cycle Catchment Report (EPA, 2021) states there is an extensive drainage network which has resulted in increased sediment loads, which alters habitats, morphology and hydrology.

Private peat cutting on turbary plots will likely continue in the vicinity of the wind farm site and in the wider cumulative area. The construction phase of the Proposed Development may interact with these turbary activities and result in a deterioration of downstream surface water quality through the emissions of elevated concentrations of suspended solids and ammonia.

However, the areas of private peat cutting will be small, significantly limiting the potential for cumulative effects to arise with the Proposed Development. Nevertheless, the mitigation measures detailed for the construction, operation and decommissioning phases of the Proposed Development will ensure the protection of downstream surface water quality.

For these reasons outlined above we consider that there will not be a significant cumulative effect associated with turbary activities.

9.5.7.4 Cumulative Effects with One Off Housing Developments

A detailed cumulative assessment has been carried out for all planning applications (granted and awaiting decisions) within the cumulative assessment area described above.

There are applications are for new dwellings or renovations of existing dwellings, as well as for the erection of farm buildings. Based on the scale of the works, their proximity to the Proposed Development Site and the temporal period of likely works, no cumulative effects will occur as a result of the Proposed Development (construction, operation and decommissioning phases).

9.5.7.5 Cumulative Effects with Other Wind Farms

In addition to the proposed Carrig Renewable Energy Wind Farm, 2 no. other wind farms have been identified within the cumulative study area (refer to Table 9-20). Within these existing wind farms there are a total of 8 no. turbines situated within the cumulative study area.

The other wind farms identified within the cumulative study area have already been constructed and are currently in the operational phase of development and are generating electricity. Given that the construction phase of the Proposed Development cannot overlap with the construction phase of these operational wind farms, the potential for cumulative hydrological effects to occur is significantly reduced.

The total number of wind turbines that could potentially be operating in the cumulative study area is 15 no. (7 no. from the Carrig Renewable Energy Wind Farm site and 8 no. turbines from the other wind farms (i.e. Carrig WF – 3 no. and Skehanagh WF – 5 no.)

The total area of the Little Brosna River catchment is c. 588km^2 which equates to 1 no. turbine per 39km^2 which is considered not significant in terms of likely cumulative hydrological effects on the Little Brosna River.

The EIARs for the above wind farm developments detail potential hydrological and hydrogeological issues relating to the operation and decommissioning phases of these developments and propose a suite of best practice mitigation measures designed to ensure that the developments do not in any way have a negative effect on downstream surface water quality and quantity. Similarly, the mitigation and best practice measures proposed in this EIAR chapter will ensure that the Proposed Development does not have the potential to result in significant effects on the hydrological/hydrogeological environment.

Therefore, with the implementation of the proposed mitigation measures (both for the Proposed Development and for the other wind farms listed in Table 9-20) there will be no cumulative effects associated with the construction, operational or decommissioning phases of the Proposed Development and other wind farms within the cumulative study area.

Table 9-20: List of Other Wind Farm Developments Assessed for Hydrological Cumulative Effects

Catchment	Wind Energy Developments (Status)	Total Turbine No.	Turbine No. in Catchment
Little Brosna River	Carrig WF (Existing)	3	3
	Skehanagh WF (Existing)	5	5
Totals		8	8

9.5.8 Non-Technical Summary

This chapter assesses the likely significant effects that the Proposed Development may have on hydrology and hydrogeology and sets out the mitigation measures proposed to avoid, reduce or offset any potential significant effects that are identified.

Regionally, the proposed Carrig wind farm site is located in the Little Brosna River surface water catchment. The proposed site drains to the south towards the Little Brosna River via 2 no. streams: the Feddan Beg stream in the east and the Holy Well Clohaskin stream in the west. All surface water drainage pathways from the proposed Carrig wind farm site eventually discharge to the Little Brosna River.

Due to the nature of wind farm developments, being near surface construction activities, effects on groundwater are generally negligible and surface water is generally the main sensitive receptor assessed during impact assessments. The primary risk to groundwater would be from oil spillage and leakages at turbine foundations or during construction plant refuelling. These are common potential impacts to all construction sites (such as road works and industrial sites). These potential contamination sources are to be carefully managed at the proposed site during the construction and operational phases of the development and measures are proposed within the EIAR to deal with these potential minor local impacts.

During each phase of the Proposed Development (construction, operation, and decommissioning) a number of activities will take place at the proposed site, some of which will have the potential to significantly affect the hydrological regime or water quality at the proposed site or downstream of the proposed site. These significant potential effects generally arise from sediment input from runoff and other pollutants such as hydrocarbons and cement-based compounds.

Surface water drainage measures, pollution control and other preventative measures have been incorporated into the project design to minimise significant impacts on water quality and downstream designated sites. A self-imposed 50m stream and lake buffer was used during the design of the Proposed Development, thereby avoiding sensitive hydrological features. 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 watercourses or into the existing bog drainage network. This will be achieved by avoidance methods (i.e. stream buffers) and design methods (i.e. surface water drainage plan). Preventative measures also include fuel and concrete management and a waste management plan which will be incorporated into the Construction and Environmental Management Plan.

No significant impacts to surface water (quality and flows) and groundwater (quality and quantity, and any local groundwater wells) will occur as a result of the Proposed Development provided the proposed mitigation measures are implemented. This EIAR presents proven and effective mitigation measures to mitigate the release of sediment which will reduce the concentration of suspended solids to acceptable levels. The storage and handling of hydrocarbons/chemicals will be carried out using best practice methods which will ensure the protection of surface and groundwater quality. The Proposed Development drainage system will be designed to slow surface water runoff from the proposed site by providing greater attenuation. This will ensure that the Proposed Development does not alter downstream surface water flows and will not contribute to downstream flooding.

A hydrological assessment of potential impacts on local designated sites was undertaken. The Dovegrove Callows SPA and pNHA, the Little Brosna Callow SPA and NHA and the River Shannon Callows SAC are considered to be hydrologically connected to the wind farm site via the Little Brosna River and its tributaries. Following implementation of the appropriate mitigation measures as outlined in the EIAR no significant impacts on this designated site will occur as a result of the Proposed Development.

A Water Framework Directive (WFD) Compliance Assessment has been completed for all waterbodies (surface water and groundwater bodies) with the potential to be impacted by the Proposed Development. With the implementation of the mitigation measures detailed in this EIAR there will be no change in the WFD status of the underlying groundwater body or downstream surface waterbodies as a result of the Proposed Development. The Proposed Development has been found to be fully compliant with the WFD and will not prevent any waterbody from achieving its WFD objectives.

An assessment of potential cumulative effects associated with the Proposed Development and other developments on the hydrological and hydrogeological environment has been completed. With the implementation of the mitigation measures detailed in this EIAR, the cumulative assessment found that there will be no significant effects on the hydrological and hydrogeological environments.

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