Drumlins Park Wind Farm

Chapter 7: Water

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Contents

7.1 Introduction

7.1.1 Background and Objectives

This chapter provides an assessment of the likely impacts of the proposed development (including 3 no. grid connection options and haul route upgrade works) on water aspects (hydrology and hydrogeology) of the receiving environment.

The objectives of the assessment are to:-

- Produce a baseline study of the existing water environment (surface and groundwater) in the area of the proposed development;
- Identify likely positive and negative impacts of the proposed development on surface and groundwater during construction, operational and decommissioning phases of the development;
- Identify mitigation measures to avoid, remediate or reduce likely or significant negative impacts; and,
- Assess likely or significant cumulative impacts of the proposed development as a result of other local wind farms and other infrastructural developments.

7.1.2 Development Description

The proposed development will comprise the installation of 8 no. turbines and all ancillary infrastructure including turbine foundations, hardstanding areas, access tracks, underground cabling, upgrades to haul roads and grid connection (3 no. options assessed). The full project description is provided at **Chapter 3** of this EIAR. The proposed development also includes 2 no. dedicated spoil deposition areas which will accommodate any excess excavated material which cannot be utilised during landscaping or reinstatement works.

7.1.3 Statement of Authority

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

Our core areas of expertise and experience include upland hydrology and wind farm drainage design. We routinely complete impact assessments for hydrology and hydrogeology for a large variety of project types, including wind farms and associated grid connections.

This chapter was prepared by Michael Gill and David Broderick.

Michael Gill (BA, BAI, Dip Geol., MSc, MIEI) is an Environmental Engineer and Hydrogeologist with over 17 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments of wind farms and renewable projects in Ireland. He has substantial experience in surface water drainage design and SUDs design, and surface water/groundwater interactions. For example, Michael was involved in the preparation of Environmental Impact Statements (EIS) for Oweninny WF, Cloncreen WF, and Yellow River WF, and over 100 no. other wind farm related projects.

David Broderick (BSc, H.Dip Env Eng, MSc) is a hydrogeologist with over 13 years' experience in both the public and private sectors. 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 Environmental Impact Assessment Reports/Environmental Impact Statements (EIAR/EIS) for a range of commercial developments. For example, David was also involved in the preparation of Environmental Impact Statements (EIS)for Oweninny WF, Cloncreen WF, and Yellow River WF, and over 100 other wind farm related projects across Ireland.

7.1.4 Relevant Legislation

This chapter has been 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 (where relevant):-

- Planning and Development Act 2000 (as amended);
- Planning and Development Regulations, 2001 (as amended);
- S.I. No 296 of 2018: European Union (Planning and Development) (Environmental Impact Assessment) Regulations 2018 which transposes the provisions of Directive 2014/52/EU into Irish Law;
- S.I. No. 94 of 1997: European Communities (Natural Habitats) Regulations, resulting from 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 of 1988: Quality of Salmon Water Regulations, resulting from EU Directive 78/659/EEC on the Quality of Fresh Waters Needing Protection or Improvement in order to Support Fish Life;
- S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 and S.I. No. 722 of 2003 European Communities (Water Policy) Regulations 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 will fully replace 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. 41 of 1999: Protection of Groundwater 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. 249 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 (repealed by 2000/60/EC in 2007);
- S.I. No. 439 of 2000: Quality of Water intended for Human Consumption Regulations and S.I. No. 278 of 2007 European Communities (Drinking Water No.

2) 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. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009;
- S.I. No. 9 of 2010: European Communities Environmental Objectives (Groundwater) Regulations 2010; and,
- S.I. No. 296 of 2009: European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009.

7.1.5 Relevant Guidance

This chapter has been prepared in accordance with guidance contained in the following:-

- Guidance on the preparation of the EIA Report (Directive 2011/92/EU as amended by 2014/52/EU);
- Environmental Protection Agency (2017): Draft Guidelines on the Information to be Contained in Environmental Impact Assessment Reports;
- Environmental Protection Agency (September 2015): Draft - Advice Notes on Current Practice (in the preparation on Environmental Impact Statements) where relevant;
- Environmental Protection Agency (September 2015): Draft – Revised Guidelines on the Information to be Contained in Environmental Impact Statements where relevant;
- Environmental Protection Agency (2003): Advice Notes on Current Practice (in the preparation on Environmental Impact Statements) where relevant;
- Environmental Protection Agency (2002): Guidelines on the Information to be Contained in Environmental Impact Statements where relevant;
- Institute of Geologists Ireland (2013): Guidelines for Preparation of Soils, Geology & Hydrogeology Chapters in Environmental Impact Statements;
- National Roads Authority (2005): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;
- Wind Energy Development Guidelines for Planning Authorities (2006);
- Forestry Commission (2004): Forests and Water Guidelines, Fourth Edition. Publ. Forestry Commission, Edinburgh;
- Coillte (2009): Forest Operations & Water Protection Guidelines;
- Forest Services (Draft) Forestry and Freshwater Pearl Mussel Requirements – Site Assessment and Mitigation Measures;
- Forest Service (2000): Forestry and Water Quality Guidelines. Forest Service, DAF, Johnstown Castle Estate, Co. Wexford;
- COFORD (2004): Forest Road Manual – Guidelines for the Design, Construction and Management of Forest Roads;
- Inland Fisheries Ireland (2016): Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters;
- Good Practice During Wind Farm Construction (Scottish Natural Heritage, 2010);
- PPG1 - General Guide to Prevention of Pollution (UK Guidance Note);
- PPG5 – Works or Maintenance in or Near Watercourses
- (UK Guidance Note);
- CIRIA (Construction Industry Research and Information Association) 2006: Guidance on 'Control of Water Pollution from Linear Construction Projects' (CIRIA Report No. C648, 2006); and,

- CIRIA 2006: Control of Water Pollution from Construction Sites - Guidance for Consultants and Contractors. CIRIA C532. London, 2006.

7.2 Methodology

7.2.1 Desk Study

A desk study of the proposed development site and surrounding area was completed in advance of undertaking the walkover survey, field mapping and site investigations. This involved collecting all relevant geological, hydrological, hydrogeological and meteorological information for the proposed development and surrounding area. The desk study included consultation of the following data sources:

- Environmental Protection Agency database (www.epa.ie); Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Met Eireann Meteorological Databases (www.met.ie);
- National Parks & Wildlife Services Public Map Viewer (www.npws.ie);
- Water Framework Directive/EPA Catchments Map Viewer (www.catchments.ie);
- Geological Survey of Ireland (GSI, 1996); Bedrock Geology 1:100,000 Scale Map Series, Sheet 15 (Geology of Monaghan-Carlingford);
- Geological Survey of Ireland (2004); Groundwater Body Initial Characterization Reports;
- OPW Flood Hazard Mapping (www.floodinfo.ie);
- Environmental Protection Agency – "Hydrotool" Map Viewer (www.epa.ie);
- CFRAM Flood Risk Assessment (PFRA and CFRAM) maps (www.cfram.ie); and,
- Department of Environment, Community and Local Government on-line mapping viewer (www.myplan.ie);
- Ordnance Survey Ireland (OSI) – 6 inch and 1;5000 scale basemaps; and,
- Aerial photography (www.bing.com/maps, www.google.com/maps)

7.2.2 Site Investigations

Detailed drainage mapping, hydrological constraints mapping, and baseline monitoring was undertaken by HES on 25th and 26th July 2019 and on the 15th August 2019. Intrusive site investigations (described below) were undertaken on 14th and 15th August 2019.

In summary, site investigations to address and inform the preparation of this chapter include the following:

- Walkover surveys and hydrological mapping of the proposed development and the surrounding area were undertaken whereby water flow directions and drainage patterns were recorded;
- A trial pit (3.5 - 4m depth) was undertaken at each of the turbine locations and at the 110kV substation (grid connection Option G3) location (9 no. trial pits in total) to investigate subsoil depth and lithology along with groundwater conditions (i.e. potential inflows);
- Field hydrochemistry measurements (electrical conductivity, pH, dissolved oxygen and temperature) were taken to determine the origin and nature of surface water flows; and,
- Surface water sampling was undertaken to determine the baseline water quality of the primary surface waters originating from the wind farm site.

7.2.3 Receptor Sensitivity / Importance / Impact Criteria

Using the National Roads Authority (NRA 2008) guidance, an estimation of the importance of the water environment within and downstream of the proposed development area are quantified by applying the importance criteria set out in **Table 7.1** and **Table 7.2**; the impact magnitude is assessed using **Table 7.3** and **Table 7.4** and the impact rating using **Table 7.5**.

Importance	Criteria	Typical Example
Extremely High	• Attribute has a high quality or value on an international scale.	• River, wetland or surface water body ecosystem protected by EU legislation, e.g. 'European sites' designated under the Habitats Regulations or 'Salmonid Waters' designated pursuant to the European Communities (Quality of Salmonid Waters) Regulations, 1988.
Very High	• Attribute has a high quality or value on a regional or national scale.	• River, wetland or surface water body ecosystem protected by national legislation – NHA status. • Regionally important potable water source supplying >2500 homes. • Quality Class A (Biotic Index Q4). • Flood plain protecting more than 50 residential or commercial properties from flooding. • Nationally important amenity site for wide range of leisure activities.
High	• Attribute quality or value on a local scale.	• Salmon fishery Locally important potable water source supplying >1000 homes. • Quality Class B (Biotic Index Q3-4). • Flood plain protecting between 5 and 50 residential or commercial properties from flooding. • Locally important amenity site for wide range of leisure activities.
Medium	• Attribute has a medium quality or value on a local scale.	• Coarse fishery. • Local potable water source supplying >50 homes Quality Class C (Biotic Index Q3, Q2-3). • Flood plain protecting between 1 and 5 residential or commercial properties from flooding.
Low	• Attribute has a low quality or value on a local scale.	• Locally important amenity site for small range of leisure activities. • Local potable water source supplying <50 homes. • Quality Class D (Biotic Index Q2, Q1) Flood plain protecting 1residential or commercial property from flooding. • Amenity site used by small numbers of local people.

Table 7.1: Estimation of Importance of Hydrology Criteria (NRA, 2008)

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

Table 7.2: Estimation of Importance of Hydrogeology Criteria (NRA, 2008)

Magnitude	Criteria	Typical Examples
Large Adverse	Results in loss of attribute and /or quality and integrity of attribute	Loss or extensive change to a waterbody or water dependent. Habitat Increase in predicted peak flood level >100mm. Extensive loss of fishery Calculated risk of serious pollution incident >2% annually. Extensive reduction in amenity value

Moderate Adverse	Results in impact on integrity of attribute or loss of part of attribute	Increase in predicted peak flood level >50mm. Partial loss of fishery. Calculated risk of serious pollution incident >1% annually. Partial reduction in amenity value.
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute	Increase in predicted peak flood level >10mm. Minor loss of fishery. Calculated risk of serious pollution incident >0.5% annually. Slight reduction in amenity value.
Negligible	Results in an impact on attribute but of insufficient magnitude to affect either use or integrity	Negligible change in predicted peak flood level. Calculated risk of serious pollution incident <0.5% annually.

Table 7.3: Magnitude of Hydrology Impact (NRA, 2008)

Magnitude	Criteria	Typical Examples
Large Adverse	Results in loss of attribute and /or quality and integrity of attribute	Removal of large proportion of aquifer. Changes to aquifer or unsaturated zone resulting in extensive change to existing water supply springs and wells, river baseflow or ecosystems. Potential high risk of pollution to groundwater from routine run-off. Calculated risk of serious pollution incident >2% annually.
Moderate Adverse	Results in impact on integrity of attribute or loss of part of attribute	Removal of moderate proportion of aquifer Changes to aquifer or unsaturated zone resulting in moderate change to existing water supply springs and wells, river baseflow or ecosystems. Potential medium risk of pollution to groundwater from routine run-off. Calculated risk of serious pollution incident >1% annually.
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute	Removal of small proportion of aquifer Changes to aquifer or unsaturated zone resulting in minor change to water supply springs and wells, river baseflow or ecosystems. Potential low risk of pollution to groundwater from routine run-off. Calculated risk of serious pollution incident >0.5% annually.
Negligible	Results in an impact on attribute but of insufficient magnitude to affect either use or integrity	Calculated risk of serious pollution incident <0.5% annually.

Table 7.4: Magnitude of Hydrogeology Impact (NRA, 2008)

	Magnitude of Impact			
Importance of Tribute	Negligible	Small Adverse	Moderate Adverse	Large Adverse
Extremely High	Imperceptible	Significant	Profound	Profound
Very High	Imperceptible	Significant/Moderate	Profound/Significant	Profound
High	Imperceptible	Moderate/Slight	Significant/Moderate	Profound/Significant
Medium	Imperceptible	Slight	Moderate	Significant
Low	Imperceptible	Imperceptible	Slight	Slight/Moderate

Table 7.5: Estimation of Impact Rating (NRA, 2008)

7.2.4 Consultation

The scope for this assessment has also been informed by consultation with statutory consultees and other bodies with environmental responsibility in both the Republic of Ireland and Northern Ireland.

This consultation process is outlined in **Chapter 1** of this EIAR. Issues, concerns and recommendations highlighted by the responses in relation to the water environment are summarised in **Table 7.6** below. The full responses from each of the below consultees are provided in **Annex 1.4.**

Consultee	Summary of Consultee Response	Issue Addressed in Section
Inland Fisheries Ireland (IFI)	The hydrology of the site must be maintained. It is important that the natural flow paths (under or above ground) are not interrupted or diverted in such a manner that will give rise to erosion or instability. Concern is that the construction of roads will provide preferential flow paths for surface water.	7.3.14 7.3.15 7.3.16
	Attention needs to be given to drainage during both the construction and operational phase. This includes runoff and any pumped water. Adequate water retention times need to be provided to ensure no deleterious material is discharged to any waters.	7.3.15 7.3.16 7.4.3.1 7.4.4.1
	Drainage from disturbed and stockpiled soils will have to be considered well in advance of works. Stock piling operations should be carried out in confined areas only and to vegetate the soils with suitable vegetation to promote stability. Consideration must be given of leachate/drainage from stockpiles.	7.4.3.1
	The use of sedimentary rocks, such as shale, in road construction should be avoided as fine eroded material from these rock types is difficult to precipitate by attenuation and may give rise to water pollution.	
	In relation to watercourse crossings, IFI will require to	

	be consulted well in advance of the works. Clear span bridges are the preferred option for crossings in upland areas. Works that will directly impact on the watercourse should only be undertaken between the 1st May and 30th September.	7.5.16
Department of Agriculture, Environment and Rural Affairs (Northern Ireland)	The Land and Groundwater Team (Regulation Unit) has considered the potential impacts of the proposal on the water environment (especially groundwater) within Northern Ireland. On the basis of the information provided the Land and Groundwater Team, Regulation Unit of the NIEA has no comment to make.	
Health Service Executive (HSE)	Concerns relating to drinking water supplies and impacts from the proposed development. The HSE recommends that any private well data is verified through site visits or communication with the landowner.	7.3.13

Table 7.6: Summary of Scoping Responses

7.3 Description of the Existing Environment

7.3.1 Site Location and Description

The proposed development site is located ~5km southeast of Clones and ~2km southwest of Newbliss, Co. Monaghan.

The topography of the wind farm site area is hilly due to a drumlin type landscape. The proposed development itself is spread out over several drumlin hills with the overall site elevation ranging between approximately 100 and 170m OD (Ordnance Datum). Across the proposed development footprint, ground slopes are moderate to steep.

Current land use within the proposed development site is exclusively agricultural, with small pockets of commercial forestry within the wider landscape. Each of the proposed turbine locations and access roads are situated in grassland. Ground conditions are generally dry and firm with the exception of some wet/boggy ground on the lower-lying lands between drumlins where a number of small to medium sized watercourses are present. Generally, the soils and subsoils at the site are naturally poorly draining and therefore numerous manmade drains are present within the site, typically located along field boundaries and hedges.

The grid connection route option to the existing Clones 38kV substation (Option G1) runs in a north-westerly direction for approximately 5km. The proposed grid connection option comprises approximately 4km of overhead line (OHL) and 1km of underground line (UGL). The route mainly passes through agricultural grassland. The ground elevation along the grid connection decreases from ~100m OD at the substation to ~50m OD at the northern end where the route crosses the Finn River valley just south of Clones.

The grid connection route option to the existing Shankill 110kV substation (Option G2) runs in a south-westerly direction for approximately 16km. The proposed grid connection option is comprised almost exclusively of OHL with only short sections of UGL at either end to facilitate connection to the respective substations. Similar to the Clones option, the route mainly passes through agricultural grassland with some marginal boggy land. The ground elevation along the grid connection decreases to ~60m OD at the central section where the route crosses the Annalee River valley, 7km north of Shankill.

The proposed 110kV substation option (Option G3), which is located in grassland to the southeast of the wind farm, will be connected by ~0.6km of internal wind farm cabling along a local public road. The elevation of the proposed substation location is approximately 100m OD with similar topography to that of the proposed wind farm site.

The proposed haul route works are on national and regional roads and typically comprise road widening and road profile regrading. These works will be undertaken at various locations along the proposed turbine component haul route and are typically surrounded by grassland and/or artificial surfaces.

7.3.2 Water Balance

Long term rainfall and evaporation data was sourced from Met Éireann. The 30-year annual average rainfall (1981-2010) recorded at Newbliss, approximately 5 km northwest of the wind farm site, are presented in **Table 7.7** below.

Newbliss												
Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
103.8	76	89.5	71.3	72.4	78.2	84.4	102.6	82	111.7	102.2	104.4	1078.5

Table 7.7: Local Average Long-Term Rainfall Data (mm)

The closest synoptic station where the average potential evapotranspiration (PE) is recorded is at Clones, approximately 5 km northwest of the site. The long-term average PE for this station is 439mm/yr. This value is used as a best estimate of the proposed development site's PE. Actual Evaporation (AE) at the site is estimated as 417mm/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

= 1,079mm/year – 417mm/year

ER = 662mm/year

Based on recharge coefficient estimates from the GSI (www.gsi.ie), an estimate of 7.5% recharge is taken for the area of the site. This value is for "low permeability subsoil" (*i.e.* boulder clays as described in **Chapter 6**). The high drainage density in the area, found to be present during the site walkover surveys, also suggest that surface drainage is the dominant flow regime at the site.

The recharge coefficient of 7.5% was used to calculate values for key hydrological properties. Therefore, annual recharge and runoff rates for the site are estimated to be 50mm/year and 612mm/year respectively.

Table 7.8 presents return period rainfall depths for the area of the proposed development. 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 design.

Duration	10-year Return Period	50-Year Return Period	100-Year Return

	(mm)	(mm)	Period (mm)
15 min	11	15.3	17.5
1 hour	20	27.7	31.7
6 hour	43.2	59.9	68.6
12 hour	58.1	80.6	92.4
24 hour	78.3	108.6	124.4
48 hour	94.4	127.6	144.6

Table 7.8: Return Period Rainfall Depths for Drumlin Park

7.3.3 Local and Regional Hydrology

On a regional scale, the proposed development site, grid connection route options (3 no.) and haul route works are located in the Lough Erne surface water catchment within the North Western International River Basin District (NWIRBD) in Hydrometric Area 36.

On a more local scale, the majority of the wind farm site (including all of the proposed turbine locations), the Shankill grid connection route option, the proposed 110kV substation grid connection option and 4 no. of the 5 no. permanent haul route works areas are located in the Annalee River surface water catchment. The vast majority of the Clones grid connection route option and 1 no. of the 5 no. haul route works areas are located in the Finn River surface water catchment (approximately 500m of underground cable section of the grid route is located in the Annalee River surface water catchment).

Elements of the proposed development site inside the Finn River surface water catchment include the main site entrance (Site Entrance 1) and approximately 1.3km of proposed wind farm access track.

The Finn River and the Annalee River drain into Upper Lough Erne which is located some 20km northwest of the wind farm site.

The Finn River flows in a south-westerly direction approximately 3km north of the proposed wind farm site. The Clones grid connection route option crosses the Finn River channel by OHL. The Annalee River, which is crossed by the Shankill grid connection route option, flows in a westerly direction approximately 7km south of the site (the wind farm site itself drains into the Annalee River via the local Bunnoe River which flows approximately 1km to the southeast of the proposed wind farm site and c. 0.7km southeast of the 110kV substation (grid connection option)).

Local hydrology maps are shown below as **Figure 7A** and **Figure 7B**.

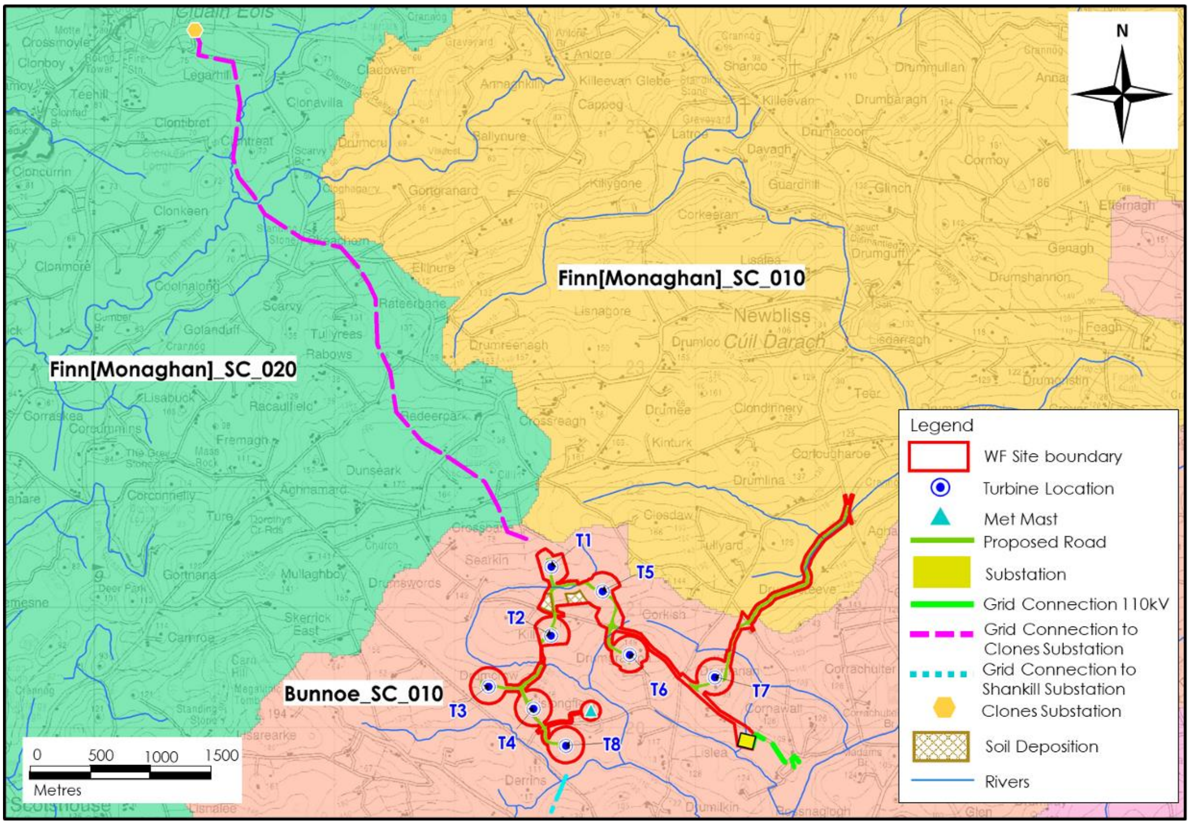


Figure 7A: Local Hydrology Mapping

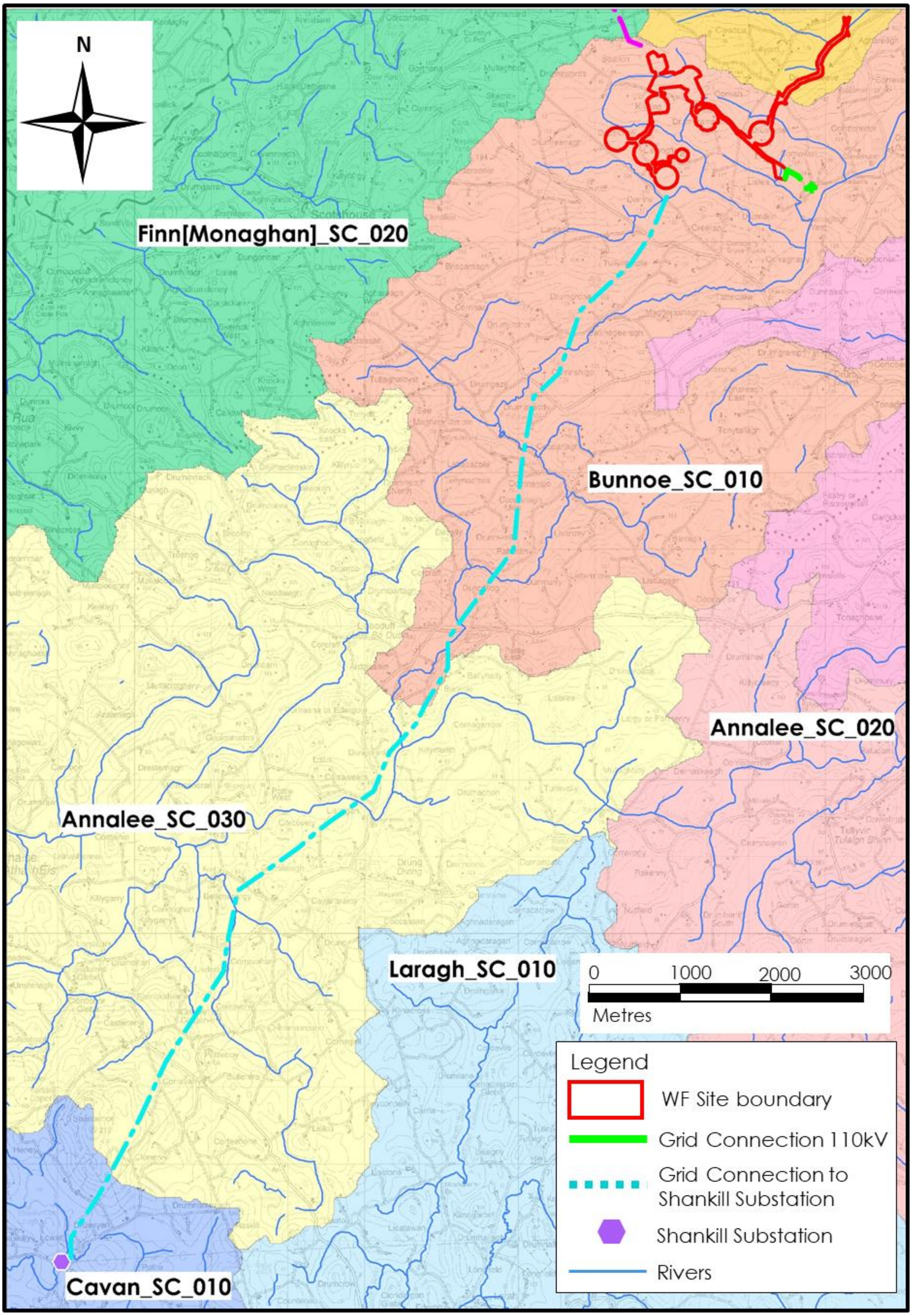


Figure 7B: Local Hydrology Mapping

7.3.4 Wind Farm Site Drainage

The proposed wind farm site is drained by 3 no. main streams within the Annalee River catchment and 1 no. stream within the Finn River catchment. The streams drain a number of localised catchments/valleys within the site which are formed by the local drumlin topography and these streams flow in a general south-easterly direction through site. Streams typically rise at the base of hills in the vicinity of the site.

The streams draining the site are first or second order sized watercourses where they intercept proposed wind farm infrastructure (i.e. proposed access track watercourse crossings) with channel widths and depths of typically 2m and 1m respectively. The 3 no. main streams within the Annalee River catchment, namely the Closdaw, Dunnaluck and Skerrick East streams, drain south-easterly towards the Bunnoe River which is located between 1.5 and 2km downstream (via surface water feature) of the site.

The stream within the Finn River catchment that flows adjacent to the site entrance road, namely the Newbliss stream, emerges from a marsh/wetland area (approximately 8 no. hectares (ha) in area) that is located immediately north of the arterial access track leading from Site Entrance 1. The total catchment area to the marsh/wetland area (which includes the surrounding hills) incorporates approximately 0.65km of the arterial access track (i.e. runoff from this section of the access track will flow initially through the marsh/wetland prior to reaching the stream.

In addition to these streams, there are numerous manmade field/agricultural drains draining the site. These drains have been constructed due to the naturally poorly draining nature of the soils and subsoils. The drains typically run along field boundary hedges and flow towards the streams at the base of hills.

7 no. watercourse crossings are likely to be required within the wind farm site; 5 no. are in the Annalee River catchment and 2 no. is in the Finn River catchment.

All watercourse crossings along the Clones and Shankill grid connection route will be via OHL).

A site drainage map is shown as **Figure 7.1** (**Annex 7.1**).

7.3.5 Flood Risk Identification

To identify those areas of the proposed development as being at risk of flooding, OPW's indicative river flood map (www.floodinfo.ie), Catchment Flood Risk Assessment and Management (CFRAM) Preliminary Flood Risk Assessment (PFRA) maps (www.cfram.ie), and historical mapping (*i.e.* 6" and 25" base maps) were consulted.

No recurring flood incidents were identified within or in the immediate vicinity of the proposed wind farm site from OPW's Flood Hazard Mapping as indicated in **Figure 7C** below. The closest mapped recurring flood event is along the Bunnoe River approximately 2km upstream of the wind farm site to the northeast.

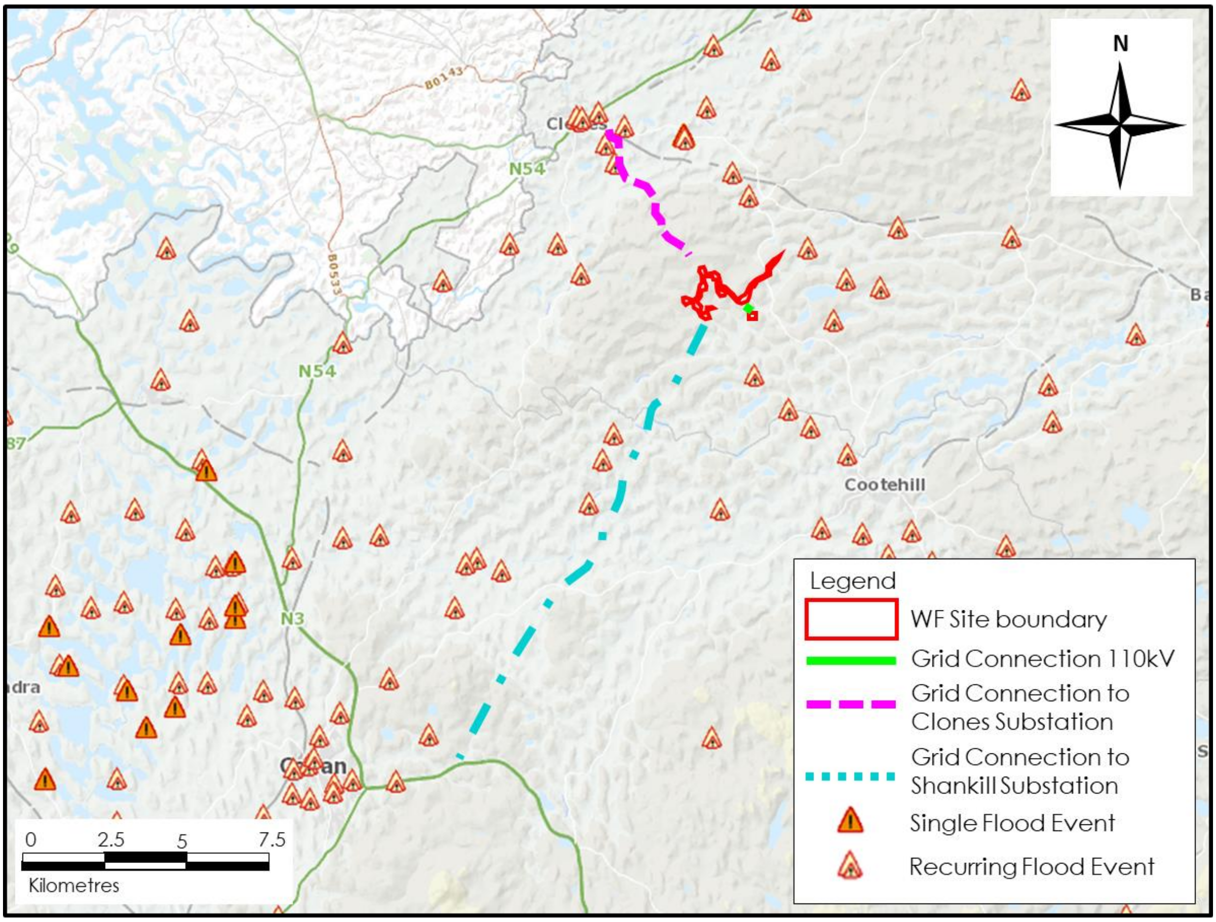


Figure 7C: OPW Flood Hazard Mapping

A review of historical 6" mapping shows that the wetland/bog area which exists immediately north of the arterial access track is "*Liable to Floods*". This is discussed further below.

Where complete the CFRAM Study OPW Flood Risk Assessment Maps are now the primary reference for flood risk planning in Ireland and supersede the PFRAM maps. There is no CFRAM mapping available for the area of the wind farm site and therefore the PFRA mapping has been reviewed. The PFRA mapping is shown as **Figure 7D** below.

The PFRA mapped 100-year fluvial flood zone within the wind farm site is typically constrained by topography and confined to land in close proximity of mapped watercourses.

The proposed turbine locations are not within any PFRA mapped fluvial flood zones. The watercourse crossing locations along the proposed wind farm access roads are within mapped fluvial flood zones along with a section of the arterial access track.

Localised pluvial zones are mapped in low-lying areas between the drumlin hills and some access roads are within mapped pluvial flood zones (*i.e.* access road leading to turbine T6). There is a mapped pluvial flood zone to the southwest of the 110kV substation (grid connection option). The grid connection options pass through mapped fluvial and pluvial flood zones; however, given they comprise OHL, impacts are unlikely to be experienced.

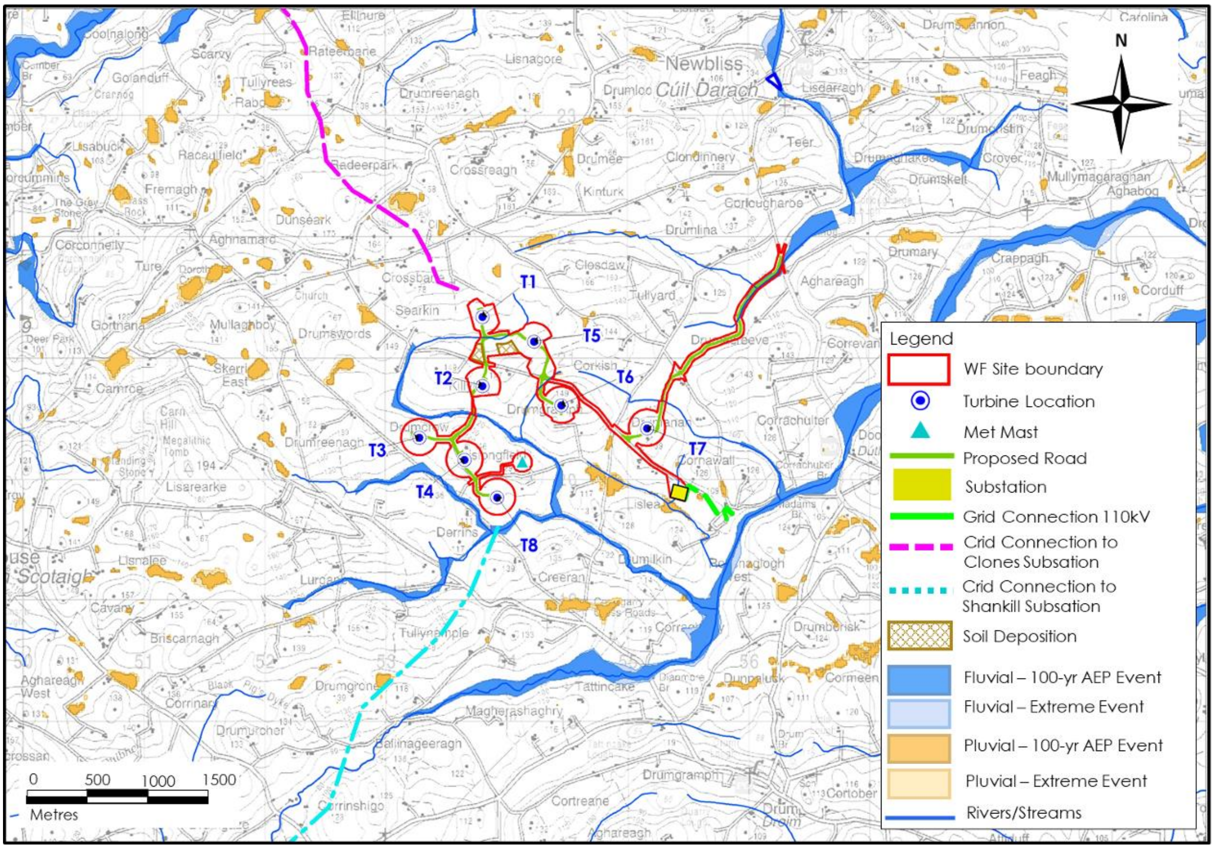


Figure 7D: PFRA Flood Zone Mapping

A detailed walkover of the proposed wind farm site was undertaken on 25th and 26th July and on the 15th August 2019 and the lands, specifically the areas identified from the PFRA and OSI base mapping (discussed above) were surveyed for any signs or anecdotal evidence of flooding. The local landowners were also consulted in relation to historical flooding on their lands.

A walkover along the edge of wetland/bog area north of the proposed arterial access track identified some anecdotal evidence (in the form of flood debris) which suggests that the waterline of wetland/bog area extends approximately 2–3m south of the wetland/marsh area during winter. The proposed access track runs along grassland to the south which is at least 10m from the edge of the wetland/bog area and flooding is not anticipated to encroach onto the alignment of the proposed access track.

Soil cores undertaken along the route of the access track indicate that the proposed route is underlain by glacial tills and not lacustrine/wetland deposits (i.e. silts and clays). The presence of silts and clays on the lands to the south of the wetland/bog area would suggest the lands flood on a regular basis. Having consulted with the relevant landowner, it is confirmed that flooding of this grassland (along the proposed access road route), to the south of the wetland/marsh area, has not been an issue during winters to date.

The wetland/marsh drains to the Newbliss stream which flows adjacent to the arterial access track. The proposed access track follows the stream channel from the wetland/marsh as far as the proposed site entrance (~600m) and the PFRA mapping indicates that this section of the proposed route is within a 100-year fluvial flood zone. A survey of the channel, which was heavily vegetated in most parts, suggests relatively low flows would be continued within the stream channel. The fact that the stream emerges from a wetland (which provides storage) means flash flooding is not anticipated.

Some localised pluvial flooding is mapped at the north-eastern corner of the 110kV substation location and also immediately to the southwest. The site slopes notably to the southwest and therefore pluvial flooding/surface water ponding at the north-eastern corner of the proposed substation location is not likely.

It is a key mitigation measure of the proposed development to ensure that all surface water runoff is treated (water quality control) and attenuated (water quantity control) prior to diffuse discharge at pre-existing Greenfield rates. As such, the mechanism by which downstream flooding is prevented and controlled is through avoidance by design.

7.3.6 Surface Water Hydrochemistry

Q-rating data for EPA monitoring points are available on the Finn River and the Bunnoe River in the area of the proposed development.

Most recent data shows that the Bunnoe River has a Q2-3 rating (Poor Status) both upstream and downstream of the wind farm site which improves to Moderate Status (Q3-4) further downstream towards the Annalee River. The Annalee River is reported to have a Good Status (Q4).

The Finn River both upstream and downstream of the site typically varies between Moderate and Poor Status but becomes predominately Poor Status downstream of the site.

Field hydrochemistry measurements of unstable parameters, electrical conductivity (µS/cm), pH (pH units), temperature (^{0}C) and dissolved oxygen (DO) were taken from surface water features in the vicinity of the site on 15th August 2019 and the results are listed in **Table 7.9** below.

Electrical conductivity (EC) values for surface waters at the site area ranged between 278 and 310µS/cm which would be typical for the local mapped geology (*i.e.* shale and greywacke). The measurements were taken in late summer and therefore the results are more representative of groundwater baseflow to streams.

It is considered that measurement in higher-flow conditions (during winter) is likely to result in an overall lower electrical conductivity range due to higher volumes of surface water runoff within streams.

The pH values, which ranged between 7.1 and 7.3, were generally near neutral, would be typical of catchments with mineral soil coverage. The dissolved oxygen concentrations are within the normal range for a Poor to Moderate status watercourse during the summer months.

Surface water samples were taken from 4 no. sample locations within and downstream of the proposed development site. Sampling was undertaken on 15th August 2019 during a relatively dry spell of weather. Refer to **Figure 7.1** for sample locations.

Location	EC (µS/cm)	pH	Dissolved Oxygen (mg/L)

SW1	290	7.2	9.8
SW2	278	7.3	9.2
SW3	285	7.2	9.3
SW4	310	7.1	9.8

Table 7.9: Summary of Surface Water Chemistry Measurements

Results of analysis are shown alongside relevant water quality regulations in **Table 7.10** below. In addition, Environmental Objectives Surface Water Regulations (S.I. 272 of 2009) are shown in **Table 7.11** below. Laboratory reports are provided at **Annex 7.2**.

Parameter	EC DIRECTIVES			Sample ID			
	2006/44/EC		EC DW Regs 2007	SW1	SW2	SW3	SW4
	Salmonid	Cyprinid					
Total Suspended Solids (mg/L)	≤ 25 (O)	≤ 25 (O)	-	20	<5	6	7
Ammonia N (mg/L)	≤0.04	≤0.02	0.3	0.03	0.05	0.06	0.14
Nitrite NO_2 (mg/L)	≤ 0.01	≤ 0.03	0.5	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	-	-	-	0.27	0.05	0.11	0.22
Nitrate - NO_3 (mg/L)	-	-	50	<5	<5	<5	<5
Nitrogen (mg/L)	-	-	-	6.9	24	4.6	3.2
Phosphorus (mg/L)	-	-	-	0.16	0.22	0.22	0.42
Chloride (mg/L)	-	-	250	12.6	11	13.2	14.4
BOD	≤ 3	≤ 6	-	5	3	3	3

Table 7.10: Analytical Results of Surface Water Sampling

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

Table 7.11: Chemical Conditions Supporting Biological Elements*

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

Total suspended solids, which ranged between <5 and 20mg/L, were all below the Freshwater Fish Directive (2006/44/EC) MAC of 25mg/L. SW1 was notably higher than the rest of the samples and this was due to the presence of algae in the stream at the time of sampling.

Nitrate and nitrite values were below the laboratory detection limit of 5 and 0.05 mg/L respectively in all samples.

Ortho-phosphate ranged between 0.05 to 0.27mg/l which is likely to be reflective of agricultural activities in the local area. In comparison to the Environmental Objectives Surface Water Regulations (S.I. 272 of 2009), all results for ortho-phosphate exceeded the "Good Status" threshold.

In relation to Ammonia N, which ranged between 0.03 and 0.14mg/L, the results exceeded the "High Status" threshold in 3 no. of the samples and the "Good Status" threshold in 1 no. of the samples.

BOD ranged between 3 and 5mg/L, which exceeds both the "Good status" and "High status" threshold limits.

7.3.7 Hydrogeology

The Ordovician Metasediments which underlie the wind farm site, the majority of the grid connection route options and the haul route upgrade locations are classified by the GSI (www.gsi.ie) as a Poor Aquifer - Bedrock which is generally unproductive except for local zones (Pl).

Dinantian sandstones, shales and limestones which underlie the northern end of the Clones grid connection are classified as a Regionally Important Fissured Aquifer (Rf). A bedrock aquifer map is shown below as **Figure 7E and Figure 7F**.

In terms of local Groundwater Bodies (GWBs), the proposed wind farm site and the majority of the grid connection options and haul route upgrades are located in the Cavan GWB (IE_NW_G_061). The northern end of the Clones grid connection route option is located in the Clones GWB (IE_NW_G_063).

The Ordovician Metasediments generally have an absence of inter-granular permeability, and most groundwater flow is expected to be in the uppermost part of the aquifer comprising a broken and weathered zone typically less than 3m thick, a zone of interconnected fissuring 10m thick, and a zone of isolated poorly connected fissuring typically less than 15m.

Groundwater levels in this bedrock type elsewhere have been measured mainly 0-5m below ground level. Groundwater flowpaths are likely to be short (30-300m), with groundwater discharging to nearby streams and small springs. Water strikes deeper than the estimated interconnected fissure zone suggests a component of deep groundwater flow, however shallow groundwater flow is thought to dominant. Groundwater flow directions are expected to follow topography and therefore groundwater directions within the site are expected to be towards the primary streams within the valleys of the site (GSI, 2004).

Baseflow contribution to streams tends to be low, particularly in summer as the groundwater regime cannot sustain significant summer baseflows due to low storativity with the aquifer. Local groundwater flow directions will mimic topography, whereby flowpaths will be from topographic high points to lower elevated discharge areas at local streams (GSI, 2004).

As indicated by the classification of the Dinantian sandstones, shales and limestones, larger regional flows via fissured rock can be expected in this aquifer type.

Based on the trial pit investigation and observations of the local geological setting, the proposed wind farm site (and particularly the turbine locations which are located on drumlins) is underlain by thick deposits (likely to be 15 – 30m) of boulder clay which is largely devoid of groundwater due to its stiff structure and low permeability. No groundwater inflows/flowpaths were encountered in any of the proposed turbine locations trial pits which were carried out in August 2019.

During winter, it is anticipated that there are likely to be some minor shallow groundwater seepages in the top 0.5 – 1m of the soils/subsoils as this upper profile is slightly less CLAY dominant than the deeper, much stiffer subsoils.

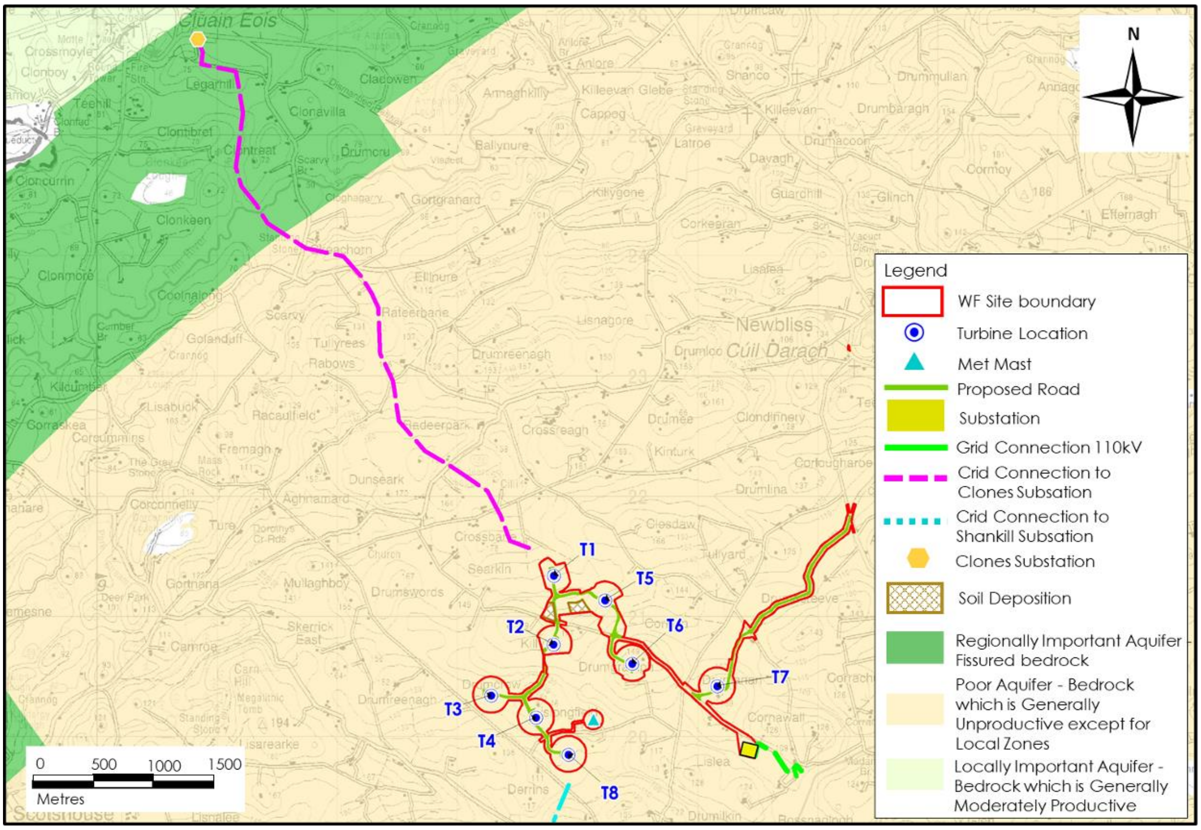


Figure 7E: Bedrock Aquifer Mapping

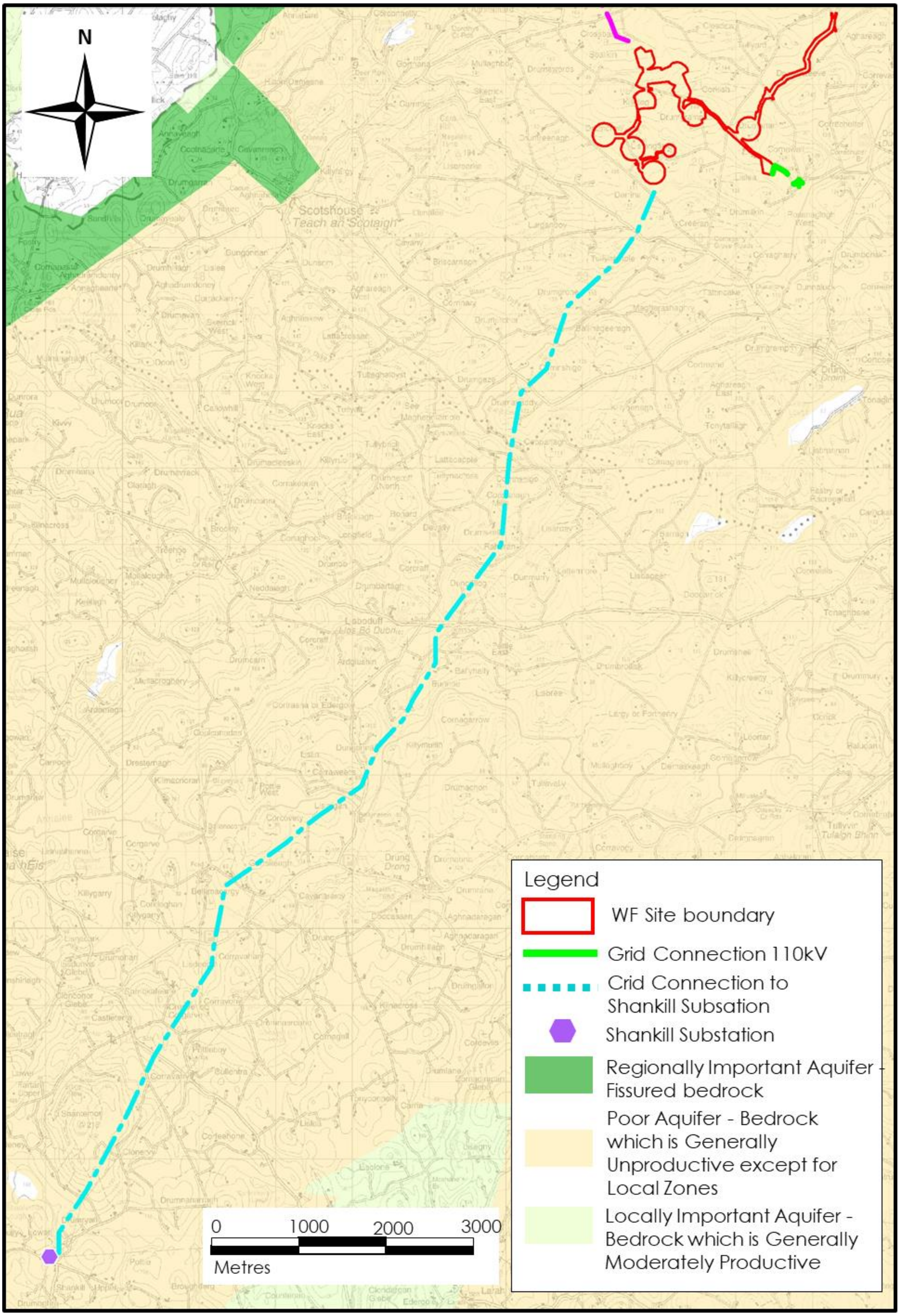


Figure 7F: Bedrock Aquifer Mapping

7.3.8 Groundwater Vulnerability

The vulnerability rating of the aquifer beneath the proposed wind farm site is exclusively "Low vulnerability" which is a reflection of the large depths of low permeability boulder clay associated with local hills/drumlins. The vulnerability rating along the proposed grid connection options is mainly "Low vulnerability" with some section of "Extreme vulnerability" on hill tops where shallower bedrock exists. A "Low vulnerability" rating is also mapped at the haul route upgrade locations.

Due to the large depths and low permeability nature of the boulder clay underlying the proposed development site (specifically the wind farm site), groundwater flow paths, confined within the upper subsoil horizon, will be short (i.e. flow from top of drumlin down to the nearest watercourse), with recharge emerging close by at seeps and surface streams. This means there is a very low potential for vertical downward movement and dispersion in the underlying bedrock aquifer, making surface water bodies such as drains and streams more vulnerable than groundwater at this site.

7.3.9 Groundwater Hydrochemistry

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

Based on data from the GSI publication on the Cavan GWB, alkalinity is expected to be in the range of 10 to 470 mg/l $CaCO_3$. The groundwaters are typically calcium - magnesium - bicarbonate type waters with conductivities ranging from 80 to 470µS/cm.

7.3.10 Groundwater Body Status

Local Groundwater Body (GWB) status information is available from www.catchments.ie. The Cavan GWB (IE_NW_G_061) underlies the proposed wind farm site, the haul route upgrades and the majority of the grid connection options. The northern end of the Clones grid connection route option is also located in the Clones GWB (IE_NW_G_063).

Both GWBs are assigned 'Good Status', which is defined based on the quantitative status and chemical status of the GWB.

7.3.11 Surface Water Body Status

River Water Body status information is also available from www.catchments.ie. River Water Body status information is available for sub-catchments within the Finn River, Annalee River and Bunnoe River in the area of the proposed development.

The wind farm footprint is split between two sub-catchments, the Bunnoe_SC_020 and the Finn(Monaghan)_SC_030 with all 8 no. proposed turbines being located in the former catchment and approximately 1.3km of the arterial access track and Site Entrance 1 being located in the latter sub-catchment.

The Clones grid connection option is largely located in the Finn (Monaghan)_SC_030 while the 110kV substation option is located in the Bunnoe_SC_020.

The Shankill grid option passes through 6 no. sub-catchments, namely; the Bunnoe_SC_020, Bunnoe_SC_030, Bunnoe_SC_040, Annalee_SC_070, Annalee_SC_080 and Cavan_SC_010.

The haul route upgrades are located in the Bunnoe_SC_010 (4 no. of 5 no.) and the

Finn (Monaghan)_SC_030 (1 no. of 5 no.)

A summary of the WFD Riverbody Status and Risk are shown in **Table 7.12** below.

Sub-Catchment	Status	Risk
Bunnoe_SC_010	Poor	At Risk
Bunnoe_SC_020	Poor	At Risk
Bunnoe_SC_030	Good	Under Review
Bunnoe_SC_040	Moderate	At Risk
Finn(Monaghan)_SC_030	Moderate	At Risk
Annalee_SC_070	Good	Not At Risk
Annalee_SC_080	Good	Not At Risk
Cavan_SC_010	Poor	At Risk

Table 7.12: Summary of River Water Body WFD Status and Risk

7.3.12 Designated Sites & Habitats

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

Due to the transboundary nature of the proposed development in terms of hydrology, designated sites in Northern Ireland have also been assessed.

Within Northern Ireland, designated sites include Special Areas of Conservation (SACs), Areas of Special Scientific Interest (ASSIs), Local Nature Reserves (LNRs) and National Natures Reserves (NNRs).

Local designated sites in the area and downstream of the proposed wind farm site, grid connection route options and haul route upgrade locations are shown on **Figure 7G** below. The proposed wind farm site, grid connection options and haul route works are not located within any designated conservation sites.

The only downstream designated site within the Republic of Ireland that is hydrologically connected to the proposed development is Lough Oughter and Associated Loughs (SAC, SPA and pNHA). Of those surface water features located downstream of the proposed development, only the Annalee River drains into Lough Oughter and Associated Loughs SAC (the Finn River does not) and the downstream distance from the proposed development to the SAC is approximately 20km.

Within Northern Ireland, Upper Lough Erne is a designated ASSI and SAC. Both the Annalee River and the Finn River drain into Upper Lough Erne and the downstream distance from the proposed development to the SAC/ASSI is approximately 45km and 15km respectively.

There are a number of pNHA designated lakes locally (*i.e.* Lisabuck Lough, Drumcor Lough etc) but there are no watercourses draining the proposed wind farm site, grid connection options or haul route upgrade locations that flow into any of these lakes (*i.e.* the catchments to these small lakes are confined and localised to the lake waterbody).

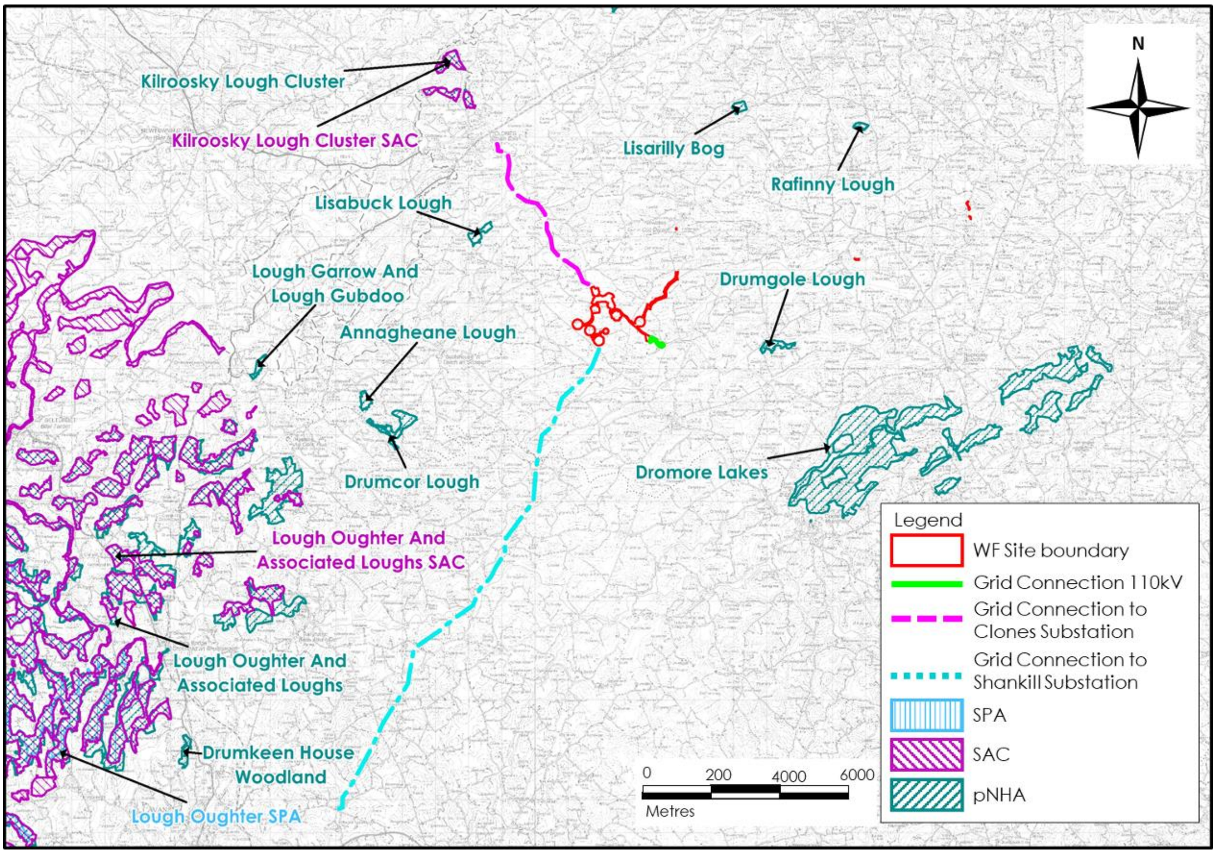


Figure 7G: Designated Sites

7.3.13 Water Resources

There are no mapped groundwater source protection areas for either public water supplies or group water schemes in the area of the proposed development (National Federation Group Water Schemes only).

Consultation with local landowners (proposed development landowners) was also undertaken to identify potential wells in close proximity to the development footprint. 1 no. well was identified to be located near the proposed meteorological mast. Due to the localised and shallow nature of the works at the meteorological mast no effects on this well are likely.

Private well locations (accuracy of <50m only) were then reviewed using GSI well database (www.gsi.ie) and no wells are mapped within 1km of the proposed wind farm site. Wells along the OHL grid connection options and haul route works were not assessed as no impacts on groundwater are expected due to the shallow nature of these proposed works.

GSI mapped wells with accuracy greater than 50m were not assessed due to the poor information/accuracy regarding their location. To overcome the poor accuracy (>50m accuracy) it is conservatively assumed that every private dwelling in the area (shown on **Figure 7H**) has a well supply and this impact assessment approach is described further below.

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

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

Based on the above approach, no private dwelling houses were identified to be located immediately down-gradient (i.e. downslope; nearest dwelling located in excess of 500m from turbine location) of the proposed development (and in particular turbine locations) and therefore there is no likelihood to impact on groundwater supplies. This assessment was focused on the turbine locations as this is where the deepest excavations will be required. All excavations required for roads, compounds and substations will be shallow and therefore there is no likelihood for significant impacts on groundwater supplies.

According to the EPA Abstraction Register (http://watermaps.wfdireland.ie/HydroTool/Viewer) there is a public water supply surface water abstraction from the Annalee River at Ballyhaise town (Source ID 0200PUB1005) which is approximately 20km downstream of the proposed wind farm site. The population served is reported to be 450.

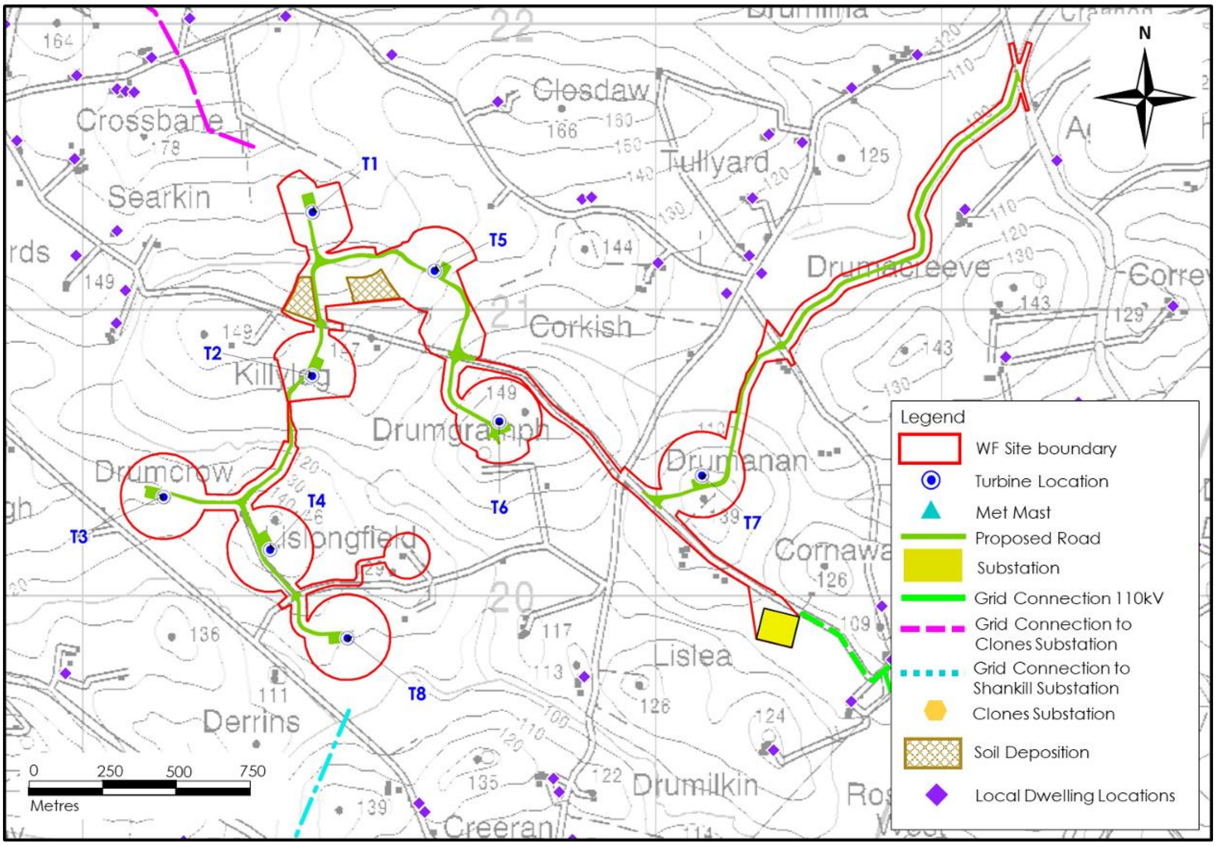


Figure 7H: Private Dwelling Locations

7.3.14 Assessment of Changes in Site Runoff Volumes

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, for the current baseline site conditions, in terms of subsoil type and thickness (**Table 7.13**). It represents, therefore, the average wettest monthly scenario in terms of volumes of surface water runoff from the study area pre-development.

The rainfall depths presented in this section, which are long term averages, are not used in the design of the sustainable drainage system for the proposed development. As outlined in **Section 7.5.1.1** below, a 1 in 100-year 6-hour return period will be used for design purposes.

The surface water runoff co-efficient for the area is estimated to be 92.5%, based on the low permeability soil and subsoil coverage at the site. The highest long-term average monthly rainfall recorded at Newbliss over the period 1981 – 2010 occurred in October, at 111.7mm. The average monthly evapotranspiration for the synoptic station at Clones over the same period in October was 16.8mm. The calculation is carried out for the entire landholding (~375ha). The balance indicates that a conservative estimate of surface water runoff for the study area during the highest rainfall month is 331,959m³/month, which equates to an average of 10,708m³/day, as outlined in **Table 7.14.**

Water Balance Component	Depth (m)
Average October Rainfall (R)	0.1117
Average October Potential Evapotranspiration (PE)	0.0168
Average October Actual Evapotranspiration (AE = PE x 0.95)	0.016
Effective Rainfall October (ER = R - AE)	0.0957
Recharge (7.5% of ER)	0.0072
Runoff (92.5% of ER)	0.0885

Table 7.13: Water Balance and Baseline Runoff Estimates for Wettest Month (October)

Approx. Area (ha)	Baseline Runoff per month (m³)	Baseline Runoff per day (m³)
375	331,959	10,708

Table 7.14: Baseline Runoff for the Landholding

Baseline Runoff/month (m³)	Baseline Runoff/day (m³)	Permanent Footprint Area (m²)	Footprint Area 100% Runoff (m3) (m³)	Footprint Area 92.5% Runoff (m³)	Net Increase/month (m³)	Net Increase/day (m³)	% Increase from Baseline Conditions (m³)

Baseline Runoff/month (m^3)	Baseline Runoff/day (m^3)	Permanent Footprint Area (m^2)	Footprint Area 100% Runoff (m3) (m^3)	Footprint Area 92.5% Runoff (m^3)	Net Increase/month (m^3)	Net Increase/day (m^3)	% Increase from Baseline Conditions (m^3)
331,959	10,708	68,426	6,548	6,057	491	15.8	0.15

Table 7.15: Baseline Runoff for the Landholding

The emplacement of the proposed development footprint, as described in **Chapter 3**, (assuming emplacement of impermeable materials) could result in an average total site increase in surface water runoff of 491m^3/month, for the month of highest average recorded rainfall. This equates to an average increase of 15.8m^3/day (**Table 7.15**). This represents a 0.15% increase in the average daily/monthly volume of runoff from the site in comparison to the baseline pre-development site runoff conditions. This is a very small increase in average runoff and results from a relatively small area of the overall study area being developed. Specifically, the proposed permanent development footprint is approximately 6.8ha, representing 1.8% of the total study area of 375ha.

The additional runoff volume is low due to the fact that the runoff potential from the site is already naturally high (92.5%) due to the prevailing baseline conditions at the site. Also, this calculation assumes that all hardstanding areas will be impermeable which is a conservative approach given that access tracks and crane hardstands will be constructed of aggregates which will facilitate the permeation of rainfall. The increase in runoff from most of the development catchment will therefore be negligible even in the absence of surface water control measures. Therefore, it is assessed that there will be no risk of exacerbated flooding down-gradient of the site.

7.3.15 Development Interaction with the Existing Manmade Drainage Network

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

The general design approach for wind farm developments is to utilise and integrate the project with the existing land infrastructure where possible whether it be existing access roads or the existing land 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 land drains have no notable hydrological value and can be readily integrated into the proposed wind farm drainage scheme using the methods outlined below (**Sections 7.3.16 and 7.4.3.1**).

7.3.16 Proposed Drainage Management

Runoff control and drainage management are key elements in terms of mitigation against impacts on surface water bodies. Two distinct methods will be employed to manage drainage water within the proposed development. The first method involves 'keeping clean water clean' by avoiding disturbance to natural drainage features, minimising any works in or around artificial drainage features, and diverting clean surface water flow around excavations, construction areas and temporary storage areas.

The second method involves collecting any drainage waters from works areas within the site that might carry silt or sediment, and nutrients, to route them towards stilling ponds prior to controlled diffuse release over vegetated surfaces. There will be no direct discharges to surface waters. During the construction phase all runoff from works areas (i.e. dirty water) will be attenuated and treated, through various attenuation methods, to a high quality prior to being released. Examples of attenuation methods include interceptor drains, collector drains, check dams, settlement/stilling/silt ponds and buffered outfalls.

A schematic of the proposed site drainage management is shown as **Figure 7I** below. A detailed drainage plan will be prepared, post consent, as part of the detailed design process (as is the normal course) demonstrating the implementation of the drainage design and attenuation infrastructure.

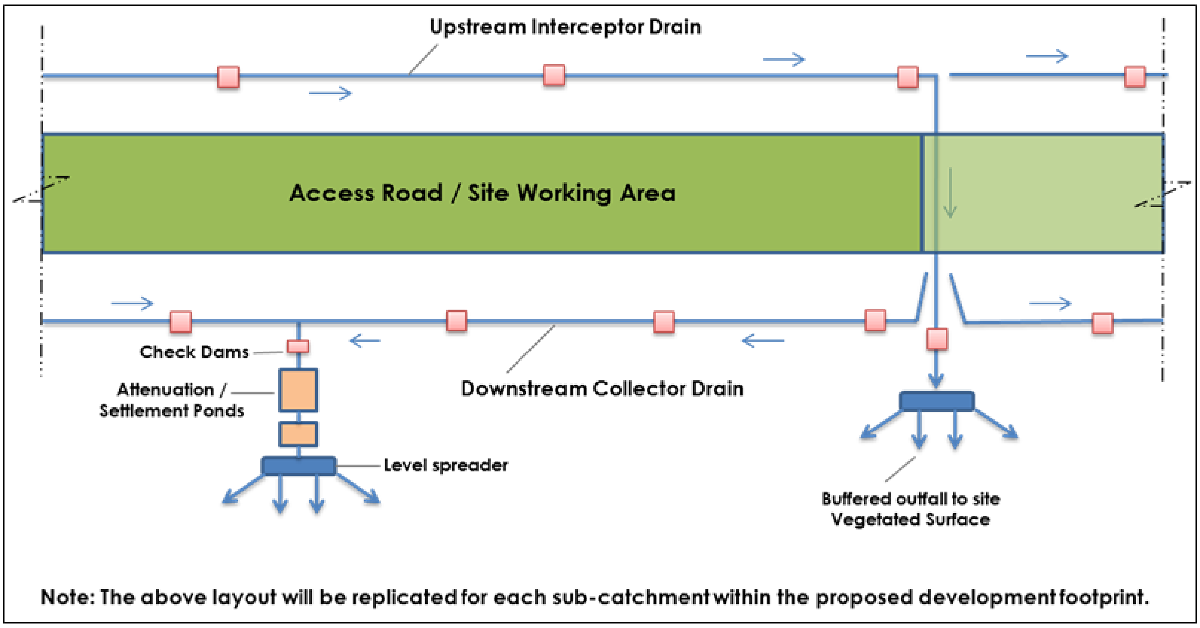


Figure 7I: Schematic of Proposed Site Drainage Management

7.3.17 Receptor Sensitivity

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 environmental impact assessment reporting. The primary risk to groundwater at the site would be from cementitious materials, hydrocarbon spillage and leakages. These are common potential impacts on all construction sites (such as road works and industrial sites). All potential contamination sources are to be carefully managed at the site during the construction, operational and decommissioning phases of the development and mitigation measures are proposed below to deal with these potential minor impacts.

Based on criteria set out in **Table 7.2**, groundwater at the site can be classed as Low Importance in terms sensitivity to pollution because the bedrock is generally relatively impermeable and classified as a poor aquifer. In addition, the majority of the site is overlain by thick, low permeability boulder clay which acts as a protective cover to the underlying aquifer. Any contaminants which may be accidentally released on-site are more likely to travel to nearby streams within surface runoff.

Surface waters such as the Bunnoe, Annalee and Finn are classed as High to Very High Importance and are very sensitive to potential contamination. These rivers and associated lakes are known to be of trout potential and are important locally for fishing.

The designated sites that are hydraulically connected (surface water flow paths only) to the proposed wind farm development include Lough Oughter and Associated Loughs (SAC, SPA and pNHA) and Upper Lough Erne which is a designated ASSI and SAC and therefore have Extremely High Importance. These designated sites can be considered very sensitive in terms of potential impacts.

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

Local domestic wells can be considered to have Low Importance and the public water supply abstraction at Ballyhaise town has a Medium to High Importance.

A hydrological constraints map for the wind farm site is shown as **Figure 7.2**. A self-imposed 50m buffer from streams was applied where possible during the project design and constraints mapping and will be maintained during the construction phase. Apart from the arterial access track and Site Entrance 1, the proposed access road between T1 and T5, the southern corner of the 110kV substation and the watercourse crossing locations, the majority of the proposed development areas (including all turbine locations) are located outside of areas that have been assessed to be hydrologically sensitive.

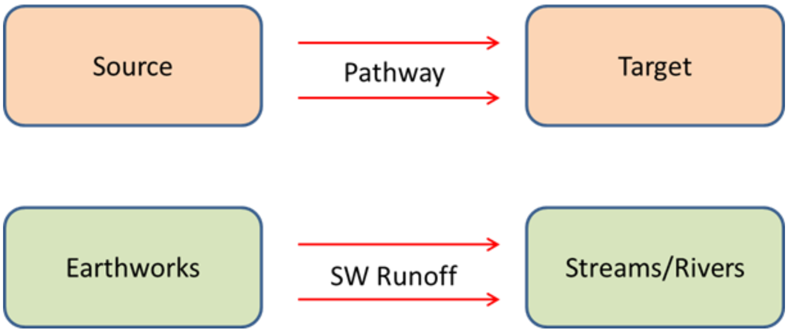
The hydrological buffer will ensure that the proposed drainage mitigation measures (discussed below) can be installed up-gradient of primary drainage features within sub-catchments to facilitate appropriate, efficient and effective attenuation of surface water runoff.

7.4 Description of Likely Effects

The likely effects of the proposed development are set out below, with mitigation measures that will be put in place to eliminate or reduce them are providing in following sections.

7.4.1 Overview of Impact Assessment Process

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



Where likely 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):-

- Draft Guidelines on the Information to be Contained in Environmental Impact Assessment Reports (EPA, 2017);
- Advice Notes on Current Practice in the Preparation of Environmental Impact Statements (EPA, 2003); and,
- Guidelines on the Information to be contained in Environmental Impact Statements (EPA, 2002).

The description process clearly and consistently identifies the key aspects of any likely 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 (**Sections 7.4.3 and 7.4.4**), 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 construction and operation activities which have the potential to generate a source of significant adverse impact on the hydrological and hydrogeological (including water quality) environments.

Step 1	Identification and Description of Potential Impact Source This section presents and describes the activity that brings about the likely 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 likely 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.

7.4.2 Do Nothing Scenario

Current land use agricultural practices will continue. Land drainage carried out in will continue to function and may be extended in some areas.

7.4.3 Construction Phase

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

Construction phase activities that will require earthworks resulting in removal of vegetation cover and excavation of soil and mineral subsoil (where present) are detailed in **Chapter 3**. Potential sources of sediment laden water include:-

- Drainage and seepage water resulting from infrastructure excavation;
- Stockpiled excavated material providing a point source of exposed sediment;
- Construction of the grid connection options including cable trench and pole structures 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. The likely effects are assessed to be significant if not mitigated against.

Pathways: Drainage and surface water discharge routes.

Receptors: Down-gradient streams, rivers and dependant ecosystems.

Pre-Mitigation Impact: Indirect, negative, significant, temporary, likely impact.

7.4.3.2 Likely Impacts on Groundwater Levels and Local Well Supplies During Excavation works

Dewatering of deep excavations (such turbine foundations) has the potential to impact on local groundwater levels and nearby wells (if present). However, groundwater level effects are assessed to be minimal (if any) due the existing local hydrogeological regime as outlined above and further discussed below.

No groundwater level effects are anticipated from the construction of the grid connection options, including underground cabling trench or pole install works, due to the shallow nature of the excavations (i.e. ~1-2m). The haul route upgrade works do not present a risk either as all works are at existing ground level and do not require excavations at depth.

Pathway: Groundwater flowpaths.

Receptor: Groundwater levels / flow paths.

Pre-Mitigation Impact: Indirect, negligible, slight, short term, unlikely impact.

The deepest excavation works will be centred around the 8 no. turbine foundations. The turbine foundations will be gravity design, and are unlikely to require any piling, and will be constructed on the underlying stiff boulder clay deposits. Foundations depths are expected to be between ~3m in depth.

Trial pits (3.5 – 4m in depth) undertaken at each of the turbine locations encountered stiff boulder clay deposits. No bedrock was encountered. The boulder clay was observed to have very low permeability characteristic (i.e. CLAY dominated subsoil with no preferential flow paths such as sand or gravel lens) with no groundwater inflows/seepages noted.

The hydrogeological setting of the proposed turbine locations means no significant groundwater dewatering is anticipated to be required during the excavation of the foundations. Moreover, direct rainfall and surface water runoff will be the main inflows that will require water volume and water quality management.

In terms of local well supplies, the assessment undertaken at **Section 7.3.13** above identified no potential wells down-gradient of turbine locations. Based on the well impact assessment and the nature of the local hydrogeological regime, impacts on local well supplies are not anticipated and, therefore, no specific mitigation or monitoring measures, other than best practice construction methodologies, are proposed.

7.4.3.3 Excavation Dewatering and Likely Impacts on Surface Water Quality

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

Pathway: Overland flow and site drainage network.

Receptor: Down-gradient surface water bodies.

Pre-Mitigation Impact: Indirect, negative, moderate, temporary, unlikely impact to surface water quality.

7.4.3.4 Potential Release of Hydrocarbons during Construction and Storage

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

Pathway: Groundwater flowpaths and site drainage network.

Receptor: Groundwater and surface water.

Pre-Mitigation Impact: Indirect, negative, slight, short term, unlikely impact to local groundwater quality. Indirect, negative, significant, short term, likely impact to surface water quality.

7.4.3.5 Groundwater and Surface Water Contamination from Wastewater Disposal

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

Pathway: Groundwater flowpaths and site drainage network.

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

Pre mitigation Impact: Indirect, negative, significant, temporary, unlikely impact to surface water quality. Indirect, negative, slight, temporary, unlikely impact to local groundwater.

7.4.3.6 Release of Cement-Based Products

Concrete and other cement-based products are highly alkaline and corrosive and can have significant adverse impacts on water quality. They generate very fine, highly alkaline silt (pH 11.5) that can physically damage fish by burning their skin and blocking their gills. A pH range of ≥6 to ≤ 9 is set in S.I. No. 293 of 1988 Quality of Salmonid Water Regulations, with artificial variations not in excess of ± 0.5 of a pH unit. Entry of cement based products into the site drainage system, into surface water runoff, and hence to surface watercourses or directly into watercourses represents a risk to the aquatic environment. Freshwater ecosystems are dependent on stable near neutral pH hydrochemistry. They are extremely sensitive to the introduction of high pH alkaline waters into the system. The batching of wet concrete on site and washing out of transport and placement machinery are the activities most likely to generate a risk of cement based pollution.

Pathway: Site drainage network.

Receptor: Surface water hydrochemistry and ecosystems;

Pre-Mitigation Impact: Indirect, negative, moderate, brief, likely impact to surface water.

7.4.3.7 Morphological Changes to Surface Water Courses & Drainage Patterns

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

7 no. watercourse crossings will be required within the wind farm site; 5 no. are in the Annalee River catchment and 2 no. is in the Finn River catchment. The watercourses proposed for crossing are either 1st or 2nd order streams. Some minor diversions of manmade drains will also be required around the footprint of the proposed 110kV substation site. Refer to **Figure 7.1** for the proposed crossing locations.

Pathway: Site drainage network.

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

Pre-mitigation Impact: Negative, direct, slight, long term, likely impact.

7.4.3.8 Potential Hydrological Impacts on Designated Sites

The only designated site within the Republic of Ireland that is hydrologically connected to the proposed development is Lough Oughter and Associated Loughs (SAC, SPA and pNHA). Only the Annalee River drains into Lough Oughter and Associated Loughs SAC (the Finn River does not) and the downstream distance from the proposed development to the SAC is approximately 20km.

Within Northern Ireland, Upper Lough Erne is a designated ASSI and SAC. Both the Annalee River and the Finn River drain into Upper Lough Erne and the downstream distance from the proposed development to the SAC/ASSI is approximately 45km in the Annalee River where most of the development is proposed (including all 8 no. turbines). The SAC/ASSI is located approximately 15km downstream of the development via the Finn River.

Due to the significant downstream distance of the designated sites, any likely surface water effects are unlikely to be significant due to dilution/assimilation capacity effects over such distances. Notwithstanding this, surface water management and mitigation is proposed to protect local surface water and avoid adverse downstream surface water quality effects.

Pathway: Surface water flowpaths.

Receptor: Down-gradient water quality and designated sites.

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

7.4.3.9 Surface Water Quality Impacts on the Ballyhaise Public Water Supply (PWS)

There is a public water supply surface water abstraction from the Annalee River at Ballyhaise town (Source ID 0200PUB1005) which is approximately 20km downstream of the proposed wind farm site. The majority of the wind farm site (including all 8 no. turbines), Shankill grid connection route option, the 110kv substation option and some of the haul route works are located in the Annalee River surface water catchment and the construction phase, therefore, has the potential to result in adverse water quality effects through the release of pollutants.

Pathway: Streams/rivers

Receptor: Ballyhaise PWS

Pre-Mitigation Impact: Indirect, negative, imperceptible, temporary, likely impact.

7.4.4 Operational Phase

Activities during the operational phase of the proposed development will be significantly reduced compared to the construction phase, with extremely limited sources for likely adverse hydrological effects.

7.4.4.1 Progressive Replacement of Natural Surface with Lower Permeability Surfaces

Progressive replacement of the vegetated surface with impermeable surfaces could potentially result in an increase in the proportion of surface water runoff reaching the surface water drainage network. The permanent development footprint comprises turbine hardstands, access tracks, substation and compound amongst others. During 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.

Receptor: Surface waters and dependant ecosystems.

Pre-Mitigation Impact: Direct, negative, moderate, permanent, likely impact.

As determined in **Section 7.3.14** above, a potential increase of 0.15% in the average daily/monthly volume of runoff could occur from the landholding area when compared to the baseline pre-development site runoff conditions. This is a negligible increase in average runoff and results from a relatively small area of natural surface being replaced with lower permeability materials. i.e. the proposed total permanent development footprint is approximately 6.8ha, representing 1.8% of the total landholding area of 375ha.

The increase in runoff from the developed site will therefore be negligible which, even in the absence of mitigation measures, confirms that there will be no risk of exacerbated flooding down-gradient of the site.

7.4.5 Decommissioning Phase

Decommissioning phase impacts are likely to be very similar to construction phase impacts but the overall likelihood for impact will be much lower as less excavation work will be taking place. Some of the effects will be reduced or avoided by retaining some elements of the proposed development where appropriate; for example, access tracks within the site may be retained for agricultural uses.

7.4.6 'Worst-Case' Scenario

The 'worst-case' for hydrological effects is assessed to comprise the contamination of surface water features during the construction, operational and decommissioning phases, which in turn could affect the ecology and quality of the downstream surface water bodies. Also, it is assessed that localised groundwater contamination from spillages or hydrocarbons and other pollutants could occur. However, best practice construction methodologies and dedicated mitigation measures will be put in place to prevent this 'worst-case' scenario from arising.

7.4.7 Cumulative Effects

The main potential for cumulative effects is assessed to be hydrological (surface water quality) rather than hydrogeological (groundwater). Due to the hydrogeological setting of the site (i.e. thick deposits of low permeability boulder clay overlying a poor bedrock aquifer) and the near surface nature of construction activities, cumulative impacts with regard groundwater quality or quantity arising from the proposed development are assessed as not likely.

In terms of cumulative hydrological impacts arising only from elements of the proposed development (wind farm infrastructure, 3 no. grid connection options and haul route works), no likely significant effects are expected for the reasons described below. It should also be reiterated that only 1 no. of the grid connection options will be constructed and there is no likelihood for in-combination effects between the identified options.

Firstly, if the Clones 38kV grid connection route option is constructed, the likelihood for cumulative hydrological effects is negligible due to the fact that the majority of the proposed wind farm site is located in a separate surface water catchment to that of the grid connection route. The short UGL section of the Clones grid connection route option (at the on-site substation) is located in the same catchment as the wind farm (Annalee River), but the UGL section is remote from local streams with no requirement for watercourse crossing works. Therefore, and in consideration of the surface water protection measures outline below, adverse water quality impacts are not anticipated.

If either of the Shankill 38kV or the 110kV grid connection options are constructed, the likelihood for cumulative hydrological effects is greater due to the fact that they are located in the same surface water catchment as the vast majority of the proposed wind farm site infrastructure (i.e. Annalee River catchment). However, due to the construction methodologies, construction programme (i.e. the poles will not be put up all at the same time), nature of the OHL and the transient nature of the works along the Shankill route within the catchment over several kilometres, significant surface water quality impacts are not anticipated. Similarly, significant surface water quality impacts arising from the 110kV substation option are not assessed as likely to occur as a result of the construction methodologies to be implemented, the surface water control measures to be put in place, the general adherence to the 50m hydrological buffer except for a small section of the 110kV substation compound and1 no. existing culvert crossing on the public road.

The haul route works are distributed between the Annalee River catchment and the Finn River catchment and due to the relatively minor and localised nature of the works, it is assessed that they (the works) will not contribute to any significant cumulative hydrological effects.

A hydrological cumulative impact assessment of the proposed development was undertaken with regard in-combination effects with other projects and plans, including wind energy developments, located in the Annalee River and Finn River catchments within a 20km radius of the proposed wind farm site.

There are no non-wind farm projects within 20km of the proposed development with the likelihood to contribute to significant cumulative hydrological impacts. A number of projects, identified at **Chapter 1**, also have the potential to result in cumulative hydrological effects; however, the mitigation measures outlined below will ensure that the proposed development will not result in any likely significant effects and it is assessed that there is no potential for interaction with other developments or for in-combination effects to occur. With regard to the Finn River catchment, there are no other wind farm developments (existing, permitted or proposed) within a 20km radius of the site and therefore hydrological cumulative impacts within the Finn River catchment are not assessed as likely.

Wind farm developments within 20km in the Annalee River catchment are listed in **Table 7.16** below.

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

All turbines locations (8 no.) at the proposed development are located within the Annalee River catchment. The total number of turbines that could potentially be operating inside a 20km radius within the Annalee River catchment is 78 no. (8 no. from the proposed development and 70 no. from other developments as shown in **Table 7.16** above).

The total area of the Annalee River catchment (inside a 20km radius) is ~600km^2 and therefore this equates to one turbine for approximately every 7.7km^2 which is considered imperceptible in terms of likely cumulative hydrological impacts. This turbine density calculation is also conservative as it does not include the area of the remainder of the catchment outside the 20km radius. In addition, it should be noted that all of the other wind farm developments are already operational and therefore these developments are not assessed as likely to contribute to cumulative hydrological impacts as construction is complete.

Implementation of the proposed hydrological mitigation measures will ensure there will be no cumulative significant adverse impacts on the water environment from the proposed development and therefore the likelihood for hydrological cumulative impacts is assessed to be negligible.

Wind Energy Developments	Total Turbine No.	Turbine No. in Catchment
Carrickallen WF (Operational)	10	10
Mullananalt WF (Operational)	5	5
Bindoo & Mountain Lodge WF (Operational)	55	55
Total	**70**	**70**

Table 7.16: List of Other Developments Assessed for Hydrological Cumulative Impacts in the Annalee River Surface Water Catchment

7.5 Mitigation & Monitoring Measures

7.5.1 Construction Phase

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

Mitigation by Avoidance

The key mitigation measure during the construction phase is the avoidance of sensitive aquatic areas where possible by using a 50m buffer. From **Figure 7.2**, it can be seen that apart from the arterial access track, the access track between T1 and T5, the southern corner of the 110kV substation and the watercourse crossing locations, the proposed development areas (including all the turbine locations and spoil deposition areas) are sited away from areas that have been determined to be hydrologically sensitive. As described in **Chapter 3**, specific mitigation measures, incorporated into the design of the development and through implementation of best practice methodologies (discussed below) will be employed where work inside buffer zones is proposed.

The generally large setback distance from sensitive hydrological features means that sufficient space is provided for the installation of proposed drainage mitigation measures (discussed below) and to ensure their effective operation. The proposed buffer zone will ensure:-

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

Mitigation by Prevention

The following section details the measures which will be put in place during the construction phase to ensure that surface water features are protected from the release of silt or sediment and to ensure that all surface water runoff is fully attenuated to avoid the discharge of dirty water.

- Source controls to limit the likelihood for 'dirty water' to occur:-
  - Interceptor drains, vee-drains, diversion drains, flume pipes, erosion and velocity control measures such as use of sand bags, oyster bags filled with clean washed gravel, filter fabrics, and other similar/equivalent or appropriate systems;
  - Small working areas, covering stockpiles, weathering off stockpiles, cessation of works in certain areas or other similar/equivalent or appropriate measures.
- In-Line controls to ensure appropriate management of silt laden water:-
  - Interceptor drains, vee-drains, oversized swales, erosion and velocity control measures such as check dams, sand bags, oyster bags, straw bales, flow limiters, weirs, baffles, silt bags, silt fences, sedimats, filter fabrics, and collection sumps, temporary sumps/attenuation lagoons, sediment traps, pumping systems, settlement ponds, temporary pumping chambers, or other similar/equivalent or appropriate systems.
- Treatment systems to fully attenuate silt laden waters prior to discharge:-
  - Temporary sumps and attenuation ponds, temporary storage lagoons, sediment traps, and settlement ponds, and proprietary settlement systems such as Siltbuster, and/or other similar/equivalent or appropriate systems.

It should be noted for this site that an extensive network of land drains already exists, and these will be integrated and enhanced as required and used within the wind farm development drainage system. The integration of the existing land drainage network and the proposed wind farm network is common practice in wind energy developments and will also result in benefits to surrounding agricultural lands.

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

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

Water Treatment Train

A final line of defence can be provided by a water treatment train such as a "Siltbuster", if required. If the discharge water from construction areas fails to be of a high quality, 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 water treatment train will apply for the entirety 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 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 to provide an additional layer of protection in these areas.

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 or sedimats (sediment entrapment mats, consisting of coir or jute matting) placed at the silt bag location to provide further treatment of the water outfall from the silt bag. Sedimats will be secured to the ground surface using stakes/pegs. The sedimat will extend to the full width of the outfall to ensure all water passes through this additional treatment measure.

Management of Runoff from Soil Deposition Areas

It is proposed that excavated soil and subsoil will be used for reinstatement and landscaping throughout the site and any excess material will be placed in 2 no. spoil deposition areas at the wind farm site. The majority of surplus material arising from the grid connection options will also be placed in the soil deposition areas; while all excess material from the haul route upgrade works will be disposed off at a licensed facility.

Both proposed spoil deposition areas are located outside the 50m stream buffer zone (refer to **Figure 7.2**).

During the initial placement of spoil in the deposition areas, silt fences, straw bales and biodegradable matting will be used to control surface water runoff. Drainage from overburden deposition areas will ultimately be routed to an oversized swale and a number of settlement ponds and a 'Siltbuster' with appropriate storage and settlement capacity, designed for a 1 in 100-year 6-hour return period, before being discharged to the on-site drains.

Spoil deposition areas will be sealed with a digger bucket and vegetated as soon possible to reduce sediment entrainment in runoff. Once re-vegetated and stabilised, soil/subsoil deposition areas will no longer be a likely source of silt laden runoff. Settlement ponds will be left in place until the areas have stabilised.

OHL Installation Works

Silt fences will be placed down-gradient of the proposed OHL pole locations during construction work within 50m of a stream/river.

All material at the pole locations will be backfilled and reinstated at the pole locations. The bare ground will be re-seeded immediately after the works to prevent erosion. If required, the silt fencing will be left in place until the ground has re-vegetated and the established root structure will prevent erosion.

UGL Installation Works

Temporary silt fencing/silt trap arrangements will be placed within existing roadside/field drainage features along the route to remove any suspended sediments from the works area. The trapped sediment will be removed and disposed at an appropriate licenced facility. The bare ground re-seeded/reinstated immediately and silt fencing temporally left in place if necessary.

Pre-emptive Site Drainage Management

The works programme for the initial construction stage of the development will also take account of weather forecasts, and predicted rainfall in particular. Large excavations and movements of soil/subsoil or vegetation stripping will be suspended or scaled back if prolonged or intense 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;
- Meteo Alarm: Alerts to the possible occurrence of severe weather for the next 2 days. Less useful than general forecasts as only available on a provincial scale;
- 3 hour Rainfall Maps: Forecast quantitative rainfall amounts for the next 3 hours but does not account for possible heavy localised events;
- Rainfall Radar Images: Images covering the entire country are freely available from the Met Eireann website (www.met.ie/latest/rainfall_radar.asp). The images are a composite of radar data from Shannon and Dublin airports and give a picture of current rainfall extent and intensity. Images show a quantitative measure of recent rainfall. A 3 hour record is given and is updated every 15 minutes. Radar images are not predictive; and,
- Consultancy Service: Met Eireann provide a 24 hour telephone consultancy service. The forecaster will provide interpretation of weather data and give the best available forecast for the area of interest.

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

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

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

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

- Secure all open excavations;
- Provide temporary or emergency drainage to prevent back-up of surface runoff; and,

- Avoid working during heavy rainfall and for up to 24 hours after heavy events to ensure drainage systems are not overloaded.

Timing of Site Construction Works

The Construction of the site drainage system will be carried out, at the respective location, prior to other activities being commenced. The construction of the 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 functional for all subsequent construction works.

Monitoring

Prior to the commencement of development, a detailed Site Drainage Plan (SDP) and Surface Water Management Plan (SWMP) will be prepared to detail the siting and composition of the surface water management measures. The respective Plans, which will form part of the detailed Construction Environmental Management Plan (CEMP), will be agreed in writing with the Planning Authority.

The SWMP will also include a programme for the monitoring of surface waters in the vicinity of the construction site by a designated Environmental Manager. The monitoring programme will comprise field testing and laboratory analysis of a range of agreed parameters. The civil works contractor, who will be responsible for the construction of the site drainage system, and Environmental Manager will undertake regular inspections of the drainage system to ensure that all measures are functioning effectively. 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.

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 and disposed of in an appropriate manner.

7.5.1.2 Excavation Dewatering and Potential Impacts on Surface Water Quality

The management of excavation dewatering (pumping) 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;
- The interceptor drainage will be discharged to the site constructed drainage system or onto natural vegetated surfaces and not directly to surface waters;
- If required, pumping of excavation inflows will prevent build up of water in the excavation;
- The pumped water volumes will be discharged via volume and sediment attenuation ponds adjacent to excavation areas, or via specialist treatment systems such as a Siltbuster unit;
- There will be no direct discharge to surface watercourses, and therefore no risk of hydraulic loading or contamination will occur;
- Daily monitoring of wind farm excavations by the Environmental Manager will occur during the construction phase. If high levels of seepage inflow occur, excavation work at this location will cease immediately and a geotechnical assessment undertaken; and,

- A mobile 'Siltbuster' or similar equivalent specialist treatment system will be available on-site for emergencies in order to treat sediment polluted waters from settlement ponds or excavations should they occur. Siltbusters are mobile silt traps that can remove fine particles from water using a proven technology and hydraulic design in a rugged unit. The mobile units are specifically designed for use on construction-sites. They will be used as final line of defence if needed.

7.5.1.3 Potential Release of Hydrocarbons during Construction and Storage

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

- The volume of fuels or oils stored on site will be minimised. All fuel and oil will be stored in an appropriately bunded area within the temporary construction compound. Only an appropriate volume of fuel will be stored at any given time. The bunded area will be roofed to avoid the ingress of rainfall and will be fitted with a storm drainage system and an appropriate oil interceptor;
- All bunded areas will have 110% capacity of the volume to be stored;
- On site re-fuelling of machinery will be carried out using a mobile double skinned fuel bowser. The fuel bowser, a double-axel custom-built refuelling trailer will be re-filled at the temporary compound and will be towed around the site by a 4x4 jeep to where plant and machinery is located. No refuelling will be permitted at works locations within the 50m hydrological buffer. The 4x4 jeep will also be fully stocked with 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 to avoid any accidental leakages;
- All plant and machinery used during construction will be regularly inspected for leaks and fitness for purpose;
- Spill kits will be readily available to deal with and accidental spillage in;
- All waste tar material arising from road cuttings (from trenching or other works in public roads) will be removed off-site and taken to a licensed waste facility. Due to the potential for contamination of soils and subsoils, it is not proposed to utilise this material for any reinstatement works; and
- An outline emergency plan for the construction phase to deal with accidental spillages is contained within the Outline Construction and Environmental Management Plan (**Annex 3.7**). This emergency plan will be further developed prior to the commencement of development, and will be agreed with the Planning Authority as part of the detailed CEMP.

7.5.1.4 Groundwater and Surface Water Contamination from Wastewater Disposal

- Measures to avoid contamination of ground and surface waters by wastewaters will comprise:-The provision of self contained port-a-loos (chemical toilets) with an integrated waste holding tank will be installed at the site compound, maintained by the providing contractor, and removed from site on completion of the construction works;
- Water supply for the site office and other sanitation will be brought to site and removed after use to be discharged at a suitable off-site treatment location; and,
- No water will be sourced on the site, nor will any wastewater be discharged to the site.

7.5.1.5 Release of Cement-Based Products

The following mitigation measures are proposed to ensure that the release of cement-based products is avoided:-

- No batching of wet-cement products will occur on site. Ready-mixed concrete will be brought to site as required and, where possible, emplacement of pre-cast products, will take utilised;
- All watercourse crossings will utilise pre-cast products and the use of wet-cement products within the hydrological buffer will be avoided insofar as possible;
- Where concrete is delivered on site, only the chute will be cleaned, using the smallest volume of water practicable. Chute cleaning will be undertaken at lined cement washout ponds with waters being tankered and stored in the temporary construction compound, removed off site and disposed of at an approved licensed facility. No discharge of cement contaminated waters to the construction phase drainage system or directly to any artificial drain or watercourse will be allowed;
- Weather forecasting will be used to ensure that prolonged or intense rainfall is not predicted during concrete pouring activities; and,
- The pour site will be kept free of standing water and plastic covers will be ready in case of sudden rainfall event.

7.5.1.6 Morphological Changes to Surface Water Courses & Drainage Patterns

The following mitigation measures are proposed:-

- Where possible, all proposed new stream crossings will be clear span bridges (bottomless culverts) and the stream beds will remain undisturbed. No in-stream excavation works at the crossing locations are proposed and therefore there will be no impact on the stream at the proposed crossing location;
- Where wind farm electrical cabling connecting to the 110kV substation follows the public road, the cable will pass above or below the existing culvert and will not directly interfere with the culvert;
- At the time of construction, all guidance/best practice requirements of the Office of Public Works (OPW) or Inland Fisheries Ireland will be incorporated into the design/construction of the proposed watercourse/culvert crossings;
- As a further precaution, in-stream construction work, will only be carried out during the period permitted by Inland Fisheries Ireland for in-stream works according to the Eastern Regional Fisheries Board (2004) guidance document "Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites", i.e., May to September inclusive. This time period coincides with the period of lowest expected rainfall, and therefore minimum runoff rates. This will minimise the risk of entrainment of suspended sediment in surface water runoff, and transport via this pathway to surface watercourses (any deviation from this will be done in discussion with the IFI);
- During the near stream construction works, double row silt fences will be emplaced immediately down-gradient of the construction area for the duration of the construction phase;
- All new river crossings and watercourse diversions (watercourses mapped on OSI mapping) will require a Section 50 license application to the OPW in accordance with the Arterial Drainage Act 1945. The river/stream crossings will be designed in accordance with OPW guidelines/requirements on applying for a Section 50 consent; and,

- All drain diversion work will be carried out during periods of low flow in order to reduce sedimentation effects on downstream watercourses. Where diversions are required, the revised routing of drainage channels will be constructed prior to the disturbance of the existing channel. The revised channel will be constructed to replicate the hydraulic capacity of the existing channel. Appropriate control measures will be implemented along the revised channel to ensure that any sediment entrained along the channel is treated.

7.5.1.7 Potential Hydrological Impacts on Designated Sites

The proposed mitigation measures for protection of surface water quality, which will include buffer zones and robust drainage control measures (i.e. interceptor drains, swales, settlement ponds), will ensure that the quality of runoff from proposed development areas will be very high.

As stated in **Section 7.4.3.1** above, there could potentially be an "imperceptible, temporary, low probability impact" on local streams and rivers which, if occurs, would be extremely localised and of a very short duration (i.e. hours). Therefore, and as further mitigated by the measures outlined in the preceding sections, significant indirect hydrological or water quality effects on the downstream Lough Oughter and Associated Loughs (SAC, SPA and pNHA) and Upper Lough Erne (ASSI and SAC) are not anticipated.

7.5.1.8 Surface Water Quality Impacts on the Ballyhaise Public Water Supply (PWS)

Due to the substantial downstream distance from the proposed site to the PWS (~20km) and the very large regional catchment area of the Annalee River upstream of the abstraction point (~750km^2), significant pre-mitigation impacts on surface water quality at the abstraction location are not assessed as likely.

It should be noted that this assessment has not accounted for, considered or relied upon the assimilative capacity of streams or rivers to naturally reduce potential water quality impacts. The likely impacts on surface water quality of local streams are assessed to be imperceptible to slight and only on a temporary basis. Given the comprehensive suite of water quality protection measures which have been outlining in the preceding sections, water quality impacts on the Ballyhaise PWS are not anticipated and thus specific mitigation measures, additional to those outlined previously, are not required.

7.5.2 Operational Phase

7.5.2.1 Progressive Replacement of Natural Surface with Lower Permeability Surfaces

The operational phase drainage system of the proposed wind farm, and selected substation option, will be installed during the construction phase as described below:

- Interceptor drains will be installed up-gradient of all 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 tracks, turbine hardstanding areas and substation compound areas which may contain entrained suspended sediment, and channel it to settlement ponds for sediment settling;

- On steep sections of access track, transverse drains ('grips') will be constructed, where appropriate, in the surface layer of the track to divert any runoff off the road into swales/road side drains;
- Check dams will be used along sections of access tracks drains to intercept silts at source. Check dams will be constructed from a 40mm non-friable crushed rock or similar;
- Settlement ponds, emplaced downstream of track swale sections, turbine locations and the selected substation option, will buffer volumes of runoff discharging from the drainage system during periods of high rainfall, by retaining water until the storm hydrograph has receded, thus reducing the hydraulic loading to watercourses; and,
- Settlement ponds will be designed in accordance the greenfield runoff rate requirements; and,
- Imported rock for construction purposes and road surfacing will be strong, well-graded limestone which will be resistant to erosion and have a low likelihood to generate fines in hardstand runoff.

The operation of the electricity lines, associated with the overhead and underground grid connection options, will not result in any likely hydrological or water quality effects and therefore do not require mitigation measures.

7.5.3 Decommissioning Phase

As in the construction phase, temporary surface runoff control measures will again be put in place during decommissioning works. The drainage system will remain operational during the decommissioning phase and will serve to treat any sediment laden surface water run-off due to a renewed disturbance of soils. Following decommissioning, re-vegetation will be implemented as soon as practible and monitored to ensure vegetation is established.

7.6 Residual Effects

7.6.1 Construction Phase

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

Following the implementation of appropriate mitigation measures, as outlined above, the residual effect is assessed to be a negative, indirect, imperceptible, short term, likely impact and no significant effects on water quality are assessed as likely.

7.6.1.2 Likely Impacts on Groundwater Levels and Local Well Supplies During Excavation works

Significant effects on groundwater levels/flows or groundwater supplies are not anticipated as a result of the proposed development. It is concluded, therefore, that likely significant effects will not arise.

7.6.1.3 Excavation Dewatering and Likely Impacts on Surface Water Quality

Residual effects, following the implementation of mitigation measures, are assessed to be indirect, imperceptible, short term and no likely significant effects on surface water quality are anticipated.

7.6.1.4 Likely Release of Hydrocarbons during Construction and Storage

Following the implementation of appropriate mitigation measures, as outlined above, the residual effect is assessed to be indirect, negative, imperceptible, short term and unlikely.

No significant effects on surface water or groundwater quality are assessed as likely.

7.6.1.5 Groundwater and Surface Water Contamination from Wastewater Disposal

No significant residual effects are assessed as likely to occur.

7.6.1.6 Release of Cement-Based Products

Residual effects, following the implementation of mitigation measures, are assessed to be negative, indirect, imperceptible, short term and unlikely.

No significant effects on surface water quality are assessed as likely to occur.

7.6.1.7 Morphological Changes to Surface Water Courses & Drainage Patterns

Significant effects due to morphological changes, occurring as a result of watercourse crossings or drain diversions, are not assessed to result in significant residual effects. Residual effects are anticipated to be negative, direct, imperceptible, short term and likely.

7.6.1.8 Likely Hydrological Impacts on Designated Sites

No significant residual effects are assessed as likely to occur.

7.6.1.9 Surface Water Quality Impacts on the Ballyhaise Public Water Supply (PWS)

No significant residual effects are assessed as likely to occur.

7.6.2 Operational Phase

7.6.2.1 Progressive Replacement of Natural Surface with Lower Permeability Surfaces

Following the implementation of appropriate mitigation measures, as outlined above, the residual effect is assessed to be direct, neutral, long term and likely; however, significant effects are not likely.

7.6.3 Decommissioning Phase

No likely significant residual effects on the hydrological environment or on water quality are envisaged during the decommissioning stage of the proposed development.

7.6.4 Transboundary Effects

The proposed wind farm development site is located within ~5km of the Northern Ireland border and therefore is proposed in river catchments that extend into Northern Ireland. However, due to the significant downstream distance to the Northern Ireland border (17km for the Finn River and >40km for the Annalee River) and the non-significant post mitigation water quality effects at the wind farm site (i.e. "imperceptible, temporary, low probability impact") no likely downstream transboundary effects are anticipated.

7.7 Summary

During each phase of the proposed development (construction, operation and decommissioning) a number of activities will take place on the site of the proposed development, some of which will have the potential to significantly affect the hydrological regime or water quality at the site or its vicinity. These significant potential effects generally arise from sediment input from runoff and other pollutants such as hydrocarbons and cement based compounds, with the former having the most potential for impact.

Surface water drainage measures, pollution control and other preventative measures have been incorporated into the project design to minimise any likely adverse impacts on water quality and downstream designated sites. A self imposed 50m hydrological buffer was used during the layout of the proposed development, thereby avoiding sensitive hydrological features insofar as possible.

The management of surface water is 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. This will be achieved by avoidance methods (i.e. stream buffers) and design methods (i.e. surface water treatment measures).

Preventative measures also include fuel and concrete management and a waste management plan which will be incorporated into the detailed CEMP to be prepared prior to the commencement of development.

Overall, the proposed development presents no likelihood for significant effects on surface or groundwater quality following the implementation of the proposed mitigation measures. Additionally, this assessment has determined that there is no likelihood for significant cumulative or transboundary effects to arise due to the construction, operation or decommissioning of the proposed development.