# 8 WATER

## 8.1 INTRODUCTION

### 8.1.1 Scope of assessment

Hydro-Environmental Services (HES) was engaged by Malachy Walsh and Partners to undertake an assessment of the potential impacts of a proposed wind farm development at Carrownagowan, Co. Clare (the 'Proposed Development') on water aspects (hydrology and hydrogeology) of the receiving environment. Other "Project" elements, including the grid connection and the replacement forestry lands, are also assessed. Please refer to section 2.3 of chapter 2 for a full description of the overall Project and the proposed development.

The objectives of the assessment are to:

- Produce a baseline study of the existing receiving water environment (surface water and groundwater) at and downstream of the "Project";
- Identify likely significant effects of the proposed development on surface water and groundwater during construction, operational and decommissioning phases;
- Identify mitigation measures to avoid, reduce or offset significant negative direct or indirect effects;
- Assess significant residual effects and cumulative effects of the "Project" and other developments.

### 8.1.2 Methodology

A desk study and a preliminary hydrological review of the Project has been completed. This involved collection of all relevant geological, hydrological, hydrogeological and meteorological data for the area. This included consultation with the following 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 "Catchments" Map Viewer (www.catchments.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 17 (Geology of the Shannon Estuary). Geological Survey of Ireland (GSI, 1999);
- Geological Survey of Ireland (2003) – Lough Graney Groundwater Body Initial Characterization Report;
- OPW Indicative Flood Maps (www.floodmaps.ie);
- Environmental Protection Agency – "HydroTool" Map Viewer (www.epa.ie);
- CFRAM Preliminary Flood Risk Assessment (PFRA) maps (www.cfram.ie); and,
- Department of Environment, Community and Local Government on-line mapping viewer (www.myplan.ie).

### 8.1.3 Site Investigations and Fieldwork

Preliminary drainage mapping, constraints mapping and initial hydrological baseline monitoring were undertaken by HES between August and December 2018. Detailed field mapping and hydrological monitoring continued during 2019. HES staff were on site on 20 man days (15 separate occasions: 18/06/2018, 19/06/2018, 30/08/2018, 24/09/2018, 19/10/2018, 19/11/2018, 26/11/2018, 12/12/2018, 31/01/2019, 01/02/2019, 14/02/2019, 28/03/2019, 13/06/2019, 14/06/2019, and 15/10/2019) during this period, and completed over 170 hours of site work. This fieldwork was carried out on Project lands where the wind farm is proposed.

Field work completed for the Project includes the following:

- Preliminary walkover surveys and hydrological mapping of the proposed development site and the surrounding area were undertaken whereby general water flow directions and drainage patterns were recorded;
- Logs of geological exposures were logged at existing borrow pits, outcrop faces and in stream beds across the proposed development site, peat depth probe data (790 points) from across the proposed development site, and trial pit data (20 no trial pits excavated at turbine locations and other infrastructure locations such as the substation);
- Field hydrochemistry measurements (electrical conductivity, pH, dissolved oxygen and temperature) were taken to determine the origin and nature of surface water flows;
- Surface water sampling was undertaken to determine the baseline water quality of the primary surface waters originating from the proposed development site;
- Installation of 1 no. rainfall gauge to record rainfall at the proposed development site;
- Surface water flow monitoring of the primary streams passing through the proposed development site, continuous and spot measurements of stream and river flows; and,
- Site visits of 3 no. GWS water supply boreholes located within 5 km of the proposed development.
- A survey of culverts at existing watercourse crossings along the grid route was undertaken between January to February 2019, which included taking flow measurements and surface water samples.
- Replacement lands were surveyed in May to August 2019 and a separate report is included in the Biodiversity Appendix (Volume III, Appendix 6-11) which includes information on drainage and aquatic ecology.

### 8.1.4 Assessment Criteria

#### *8.1.4.1 Impact Assessment Methodology*

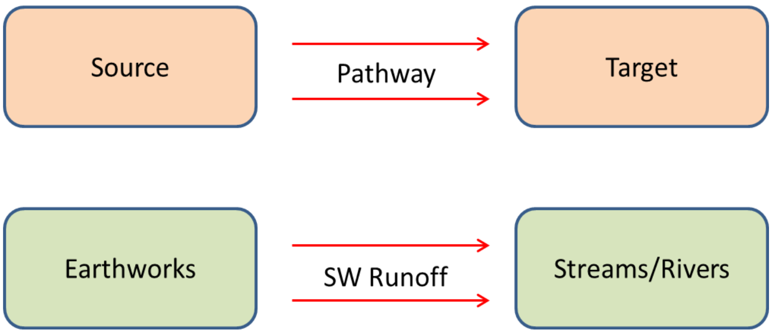
Please refer to Chapter 1 of the EIAR for details on the impact assessment methodology (EPA, 2002, 2003, 2015 and 2017). In addition to the above methodology, the sensitivity of the water environment receptors was assessed on completion of the desk study and baseline study. Levels of sensitivity which are defined in Table 8.1 are then used to assess the potential effect that the Project may have on them.

**Table 8.1 Receptor Sensitivities (adapted from www.sepa.org.uk)**

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

### *8.1.4.2 Overview of Impact Assessment Process*

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




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

- 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,
- Advice Notes on Current Practice in the Preparation of Environmental Impact Statements (EPA, draft 2015).

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

In order to provide an understanding of the stepwise impact assessment process applied below (Section 8.3.2 and 8.3.3), 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, operation, and decommissioning activities which have the potential to generate a source of significant negative impact on the geological and hydrological/ hydrogeological (including water quality) environments.

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

### *8.1.4.3 Relevant Legislation*

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

The requirements of the following legislation are complied with:

- S.I. No. 349 of 1989: European Communities (Environmental Impact Assessment) Regulations, and subsequent Amendments (S.I. No. 84 of 1994, S.I. No. 101 of 1996, S.I. No. 351 of 1998, S.I. No. 93 of 1999, S.I. No. 450 of 2000 and S.I. No. 538 of 2001, S.I. 134 of 2013 and the Minerals Development Act 2017), the Planning and Development Act, and S.I. 600 of 2001 Planning and Development Regulations and subsequent Amendments. These instruments implement EU Directive 2011/92/EU and subsequent amendments, on the assessment of the effects of certain public and private projects on the environment;
- Directives 2011/92/EU and 2014/52/EU on the assessment of the effects of certain public and private projects on the environment, including Circular Letter PL 1/2017: Implementation of Directive 2014/52/EU on the effects of certain public and private projects on the environment (EIA Directive);
- Planning and Development Act, 2000, as amended;
- 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. 293 of 1988: European Communities (Quality of Salmonid Waters) Regulations;
- S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 (as amended by S.I. No. 296/2009; S.I. No. 386/2015; S.I. No. 327/2012; and S.I. No. 77/2019 and giving effect to Directive 2008/105/EC on environmental quality standards in the field of water policy and Directive 2000/60/EC establishing a framework for Community action in the field of water policy) and S.I. No. 722 of 2003 European Communities (Water Policy) Regulations which implement EU Water Framework Directive (2000/60/EC) establishing a framework for the Community action in the field of water policy and provide for implementation of 'daughter' Groundwater Directive (2006/118/EC) on the protection of groundwater against pollution and deterioration. Since 2000 water management in the EU has been directed by the Water Framework Directive (2000/60/EC) (as amended by Decision No. 2455/2011/EC; Directive 2008/32/EC; Directive 2008/105/EC; Directive 2009/31/EC; Directive 2013/39/EU; Council Directive 2013/64/EU; and Commission Directive 2014/101/EU ("WFD"). The WFD was given legal effect in Ireland by the European Communities (Water Policy) Regulations 2003 (S.I. No. 722 of 2003);
- S.I. No. 684 of 2007: Waste Water Discharge (Authorisation) Regulations 2017, resulting from EU Directive 80/68/EEC on the protection of groundwater against pollution caused by certain dangerous substances (the Groundwater Directive);S.I. No. 106 of 2007: European Communities (Drinking Water) Regulations 2007and S.I. No. 122 of 2014: European Communities (Drinking Water) Regulations 2014, arising from EU Directive 98/83/EC on the quality of water intended for human consumption (the "Drinking Water Directive") and EU Directive 2000/60/EC;

- S.I. No. 9 of 2010: European Communities Environmental Objectives (Groundwater) Regulations 2010 (as amended by S.I. No. 389/2011; S.I. No. 149/2012; S.I. No. 366/2016; the Radiological Protection (Miscellaneous Provisions) Act 2014; and S.I. No. 366/2016); and,
- S.I. No. 296 of 2009: The European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009 (as amended by S.I. No. 355 of 2018).

#### *8.1.4.4 Relevant Guidance*

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

- 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 of Environmental Impact Statements);
- Environmental Protection Agency (2003): Advice Notes on Current Practice (in the preparation of Environmental Impact Statements);
- 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 Farm 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;
- Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters (Inland Fisheries Ireland, 2016);
- Good Practice During Wind Farm Construction (Scottish Natural Heritage, 2010);
- PPG1 - General Guide to Prevention of Pollution (UK Guidance Note);
- PPG5 – Works or Maintenance in or Near Watercourses (UK Guidance Note);
- CIRIA (Construction Industry Research and Information Association) 2006: Guidance on 'Control of Water Pollution from Linear Construction Projects' (CIRIA Report No. C648, 2006);
- CIRIA 2006: Control of Water Pollution from Construction Sites - Guidance for Consultants and Contractors. CIRIA C532. London, 2006;
- Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment (DoHPLG, 2018); and
- Environmental Impact Assessment of Projects: Guidance on the preparation of the EIA Report (Directive 2011/92/EU as amended by 2014/52/EU), European Union, 2017.

### 8.1.5 Statement on Limitations and Difficulties Encountered

No difficulties were encountered during preparation of this assessment.

## 8.2 EXISTING RECEIVING ENVIRONMENT

Please note that the baseline environment for the proposed development (wind farm and delivery route) is described below. In addition, and to avoid repetition, we have also described the baseline environment for the Grid Connection Route and the Forest Replacement Lands as these form part of the "Project" as described in section 2.3 of Chapter 2 and in Chapter 3 of this EIAR. The proposed development lands, where the wind farm will be constructed, pose the most potential for impacts and effects. The biggest risk is during the construction phase when earthworks and excavations will be undertaken at the proposed development site. and are the main focus of the assessment. The grid route and the replacement lands are all included where relevant.

### 8.2.1 Project Lands Description

#### *8.2.1.1 Proposed Development Site*

The proposed development site (wind farm and turbine delivery route) is set out in Figure 1-1 of Chapter 1. The wind farm site is located approximately 9km northwest of Killaloe and ~3km southwest of the village of Bodyke, Co. Clare on the north-western slopes of Slieve Bernagh mountains. The total study area is approximately 749.69 hectares (~7.5 km$^2$). The proposed development site is roughly ovaloid in shape, being ~4.7 km long along a NE-SW axis and approximately 2.2 km wide. A small spur ~1.2 km x 0.3 km juts out at the northern edge of the proposed development site. This spur meets an unnamed road which runs east-west through the townlands of Ballydonaghan and Caherhurly. Access to the proposed development site is along this road, via a smaller road which runs south from the crossroads at Caherhurly.

The southern half of the wind farm site slopes steeply in a north-westerly direction from the summit of Slieve Bernagh. Elevation ranges from 370m OD on the southern boundary of the proposed development site to 120m OD at its most northerly border. Two river valleys run in a north-westerly direction through the proposed development site which provide the main drainage routes for site runoff. Most of the proposed development site is covered in blanket bog which has been planted over with coniferous forests.

The delivery route works are located at the northern side of the R352 in the townland of Coolready, approximately 1.1km southwest of Bodyke village, in land between the R352 and R465 in the townland of Coolready and land between the R464 and the L-8221 local road in the townland of Drummod.

#### *8.2.1.2 Grid Route*

The proposed grid route, which is ~25km in length, runs from the proposed Carrownagowan substation to Ardnacrusha. The route follows local roads through Kilbane town to the south of the proposed development site, then along the R446 and R471. From the R471 the route continues south along local roads towards the Ardnacrusha hydroelectric station.

#### *8.2.1.3 Forest Replacement Lands (Ballard, Cooraclare & Trillickacurry)*

The first of the 3 no. proposed replacement land sites is situated at Cooraclare, Co. Clare. The Cooraclare site is located approximately 2.5 km west of Cooraclare town. The Cooraclare site comprises of two separate sections, with a total combined area of approximately 10.78ha. The elevation at the site ranges between 18 and 22 m OD and slopes gently towards the Doonbeg river, along the southern boundary of the Cooraclare site. The site is accessible via an unnamed local road taken 3 km northwest of Cooraclare in the townland of Danganella West. The Cooraclare site is an area of previously cut bog, where all economic removal of peat has been completed. The Cooraclare site is drained to the south by the Doonbeg river (IE_SH_28D020725) which flows northwest towards Doonbeg. Within the western section of the Cooraclare site, a small drain ~150m long, constructed to drain the bog area, runs southwest into the Doonbeg river.

The second of the proposed replacement land sites is located at Ballard, Co. Wicklow. It comprises two individual land areas with a total combined area of 0.37 $km^2$ (37 ha). The lands are situated ~1.2 km west of Ballinaclash and approximately 4.4 km southwest of Rathdrum. The Ballard site is accessible by following the R753 north to Ballinaclash, before turning left in Ballinaclash, heading west out a small Local road for ~1.5 km. The Ballard site is located on the north-eastern slopes of Cushbawn hill, with ground elevation ranging from 160 and 220m OD and the slope to the north / northwest. The lands are drained by a stream which flows north-easterly close to the northern boundary of the Ballard site.

The third proposed replacement lands site is situated at Trillickacurry, Co. Longford. The site is located approximately 1 km southeast of Lisduff crossroads and approximately 3.5 km southeast of Longford town. The Trillickacurry site comprises of three separate sections, with a total combined area of approximately 0.24$km^2$ (24ha). The elevation at the Trillickacurry site ranges between 65 and 75 m OD and slopes gently in a south-easterly direction. The Trillickacurry site is accessible via an unnamed road south at Lisduff crossroads. The Trillickacurry site is an area of previously cut bog, where all economic removal of peat has been completed. The Trillickacurry site is drained to the south by a small stream (Cloonkean stream, IE_SH_26C010900) which flows west along the southern boundary of the Trillickacurry site.

Maps showing the locations of the replacement land sites are presented in Section 2.3.1.3.2 (in Chapter 2).

### 8.2.2 Water Balance

#### *8.2.2.1 Proposed Development /Grid Route*

Average long-term rainfall and evaporation data was sourced from Met Eireann (www.met.ie). The 30-year average rainfall (1981-2010) recorded at Scarriff, approximately 6km north of the proposed wind farm site are presented in Table 8.2.

The closest synoptic weather station where the average potential evapotranspiration (PE) is recorded by Met Eireann is at Shannon Airport, approximately 25 km southwest of the proposed development site. The long-term average PE for this station is 543mm/year. This value is used as a best estimate of the proposed development site PE. Actual Evaporation (AE) at the proposed development site is estimated as 516 mm/year (which is 0.95 × PE).

**Table 8.2 Average long-term rainfall data**

| Station | | X-Coord | | Y-Coord | | Ht (MAOD) | | Opened | | Closed | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scarriff | | 164180 | | 184263 | | 34 | | N/A | | N/A | | |
| Jan | Feb | Mar | Apr | May | Jun | July | Aug | Sept | Oct | Nov | Dec | Total |
| 99 | 86 | 71 | 59 | 60 | 66 | 69 | 82 | 82 | 106 | 94 | 97 | 972 |

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

*Effective rainfall (ER) = AAR – AE*

*= 972mm/year –516mm/year*

*ER = 455 mm/year*

Recharge coefficient estimates from the GSI (www.gsi.ie) indicate a range of between 4 – 25%, an estimate of 10% recharge is taken for the proposed development site as an overall average. This value is for "Peat" with a "High" vulnerability rating. Areas where peat is absent may have slightly higher recharge rates, but on this site, these areas are generally on sloping ground. The high stream density in the area would also suggest that recharge rates are low.

Therefore, annual recharge and runoff rates for the proposed development site are estimated to be 45mm/year (recharge = 10% of 455mm/year) and 410mm/year (runoff) respectively.

**Table** 8-3 presents estimated return period rainfall depths for the area of the Carrownagowan wind farm site (based on a location at the center of the proposed development site). These data are taken from https://www.met.ie/climate/services/rainfall-return-periods and they provide estimated rainfall depths for various storm durations and sample return periods (1-year, 50-year, 100-year etc.).

Please note that the return period rainfall depths, and not the long-term averages, are used in the wind farm drainage design calculations.

**Table 8-3: Rainfall return periods over differing temporal scales**

| Storm Duration | 10-year (mm) | 50-Year (mm) | 100-Year (mm) |
|---|---|---|---|
| 15-min | 12.1 | 18.6 | 22.2 |
| 1-hour | 19.0 | 27.7 | 32.3 |
| 6-hour | 34.0 | 46.1 | 52.3 |
| 12-hour | 42.6 | 56.2 | 63.0 |
| 24-hour | 53.4 | 68.5 | 76.0 |
| 48-hour | 65.3 | 82.3 | 90.5 |

### 8.2.3 Regional Hydrology

#### *8.2.3.1 Proposed Development Site*

The majority of the proposed wind farm site is located in the Bunratty-Ballymacdonnell River sub-catchment, while the western edge of the proposed development site is located within the Bunratty-Killuran sub-catchment. The Bunratty-Ballymacdonnell and the Bunratty-Killuran are sub-catchments of Owenogarney (Ratty) River within the regional Shannon Estuary North catchment.

The northeastern edge of the proposed development site (c 2.5km$^2$), near Croaghnagower, is located within the Graney Anamullahgaun subcatchment, within the regional Lower Shannon catchment. A regional hydrology map is shown as Figure 8-1. (This is included with water chapter figures and maps as Appendix 8-1 of Volume III).

The delivery route sites to the north west of the wind farm are located in the Bunratty-Ballymacdonnell River sub-catchment.

#### *8.2.3.2 Grid Route*

The grid route is located within the same hydrological region (the Lower Shannon catchment) as the proposed wind farm. The grid route extends south towards the southern boundary of the Lower Shannon sub-catchment at Parteen (Ardnacrusha).

#### *8.2.3.3 Forestry Replacement Lands (Ballard Cooraclare, & Trillickacurry)*

The Ballard site is located within the Avonbeg sub-catchment within the regional Avoca Catchment. The general drainage pattern of this catchment is a dendritic network of south-easterly flowing rivers, discharging into the Avoca River towards the southeast of the catchment. A regional hydrology map for the Ballard site is included as Figure 8.2.

The Cooraclare site is situated within the Doonbeg sub-catchment, within the regional Mal Bay catchment. Drainage generally trends south at the Cooraclare site, towards the Doonbeg river. A regional hydrology map for the Cooraclare site is also included on Figure 8.3.

The Trillickacurry site is situated within the Upper Shannon subcatchment, within the regional Shannon catchment. Drainage generally trends north/northwest towards the Shannon river. A regional hydrology map for the Trillickacurry site is also included on Figure 8.4.

### 8.2.4 Local & Site Drainage

#### *8.2.4.1 Proposed Wind Farm*

There are two main rivers which flow northwards through the proposed development site, namely the Carrownagowan River and the Coumnagun River, which converge at the centre of the proposed development site to form the Inchaluchoge River. A smaller unnamed stream flows to the north close to the wind farm site entrance and drains into Lough O'Grady.

A local hydrology map for the wind farm site is shown as Figure 8.5. Both the Carrownagowan River and Coumnagun River, as well as the downstream Inchaluchoge River, drain into the Bunratty-Ballymacdonnell River sub-catchment as delineated by the WFD. The Carrownagowan River and Inchaluchoge River are referred to as the singular Owenogarney River by the EPA (https://gis.epa.ie/EPAMaps/Water).

The Carrownagowan River originates approximately 3 km east of the southern site boundary on Slieve Bernagh. It flows generally westward towards the southern site boundary then changes direction northwards. It flows north for ~1.4km through the proposed development site before joining the Inchaluchoge River. Six tributaries flow north feeding the Carrownagowan river. These tributaries range from approximately 0.6 - 1.2 km long and all drain from the summit of Slieve Bernagh.

The Coumnagun river also originates from the slopes of Slieve Bernagh, approximately 1.5 km south of the south-eastern boundary of the proposed development site. It flows north through a narrow valley towards the south-eastern corner of the proposed development site, before changing course eastward through the proposed development site. The Coumnagun River, along with the Carrownagowan River, converge to form the Inchaluchoge River in the central area of the proposed development site. The Inchaluchoge River flows west for some 3km before joining the Ballymacdonnell River near Ballymacdonnell Bridge.

The far west of the proposed development site drains westward towards the Killuran River within the associated Bunratty-Killuran sub basin. Four tributaries of the Killuran river emerge within the boundary of the proposed development site and these flow west towards the Killuran River.

The Killuran River and the Ballymacdonnell River eventually merge before flowing into Doon Lough which is situated approximately 3.5 km southwest of the proposed development site.

The Anamullaghaun River and associated Graney-Anamullaghaun subcatchment, located within the Shannon Lower subcatchment is mapped as draining the north-eastern edge of the proposed development site. However, drainage mapping on the 6" OSI map indicate two streams which flow towards the Inchaluchoge River from the north-eastern area of the proposed development site. These have been confirmed on site. Therefore, the north-eastern section of the development site actually drains into the Bunratty-Ballymacdonnell catchment, rather than discharging into Graney Anamullaghaun catchment as mapped by the EPA.

Flow data for the rivers emerging from the proposed development site (i.e. the Carrownagowan River, Bunratty-Ballymacdonnell River, and the Owenogarney River) have been extracted from the EPA HydroTool website, and these data are plotted on Figure 8.6. The locations of these flow data points are shown on Figure 8.1.

Monitoring of stream discharge of the main watercourses passing through the proposed development site was undertaken on several occasions between August 2018–June 2019. These data are presented as Table 8-4.

The locations of the monitoring points are presented in Figure 8.5. These measured flows can be considered to be low – medium flows, as no high/extreme rainfall occurred prior to sampling events.

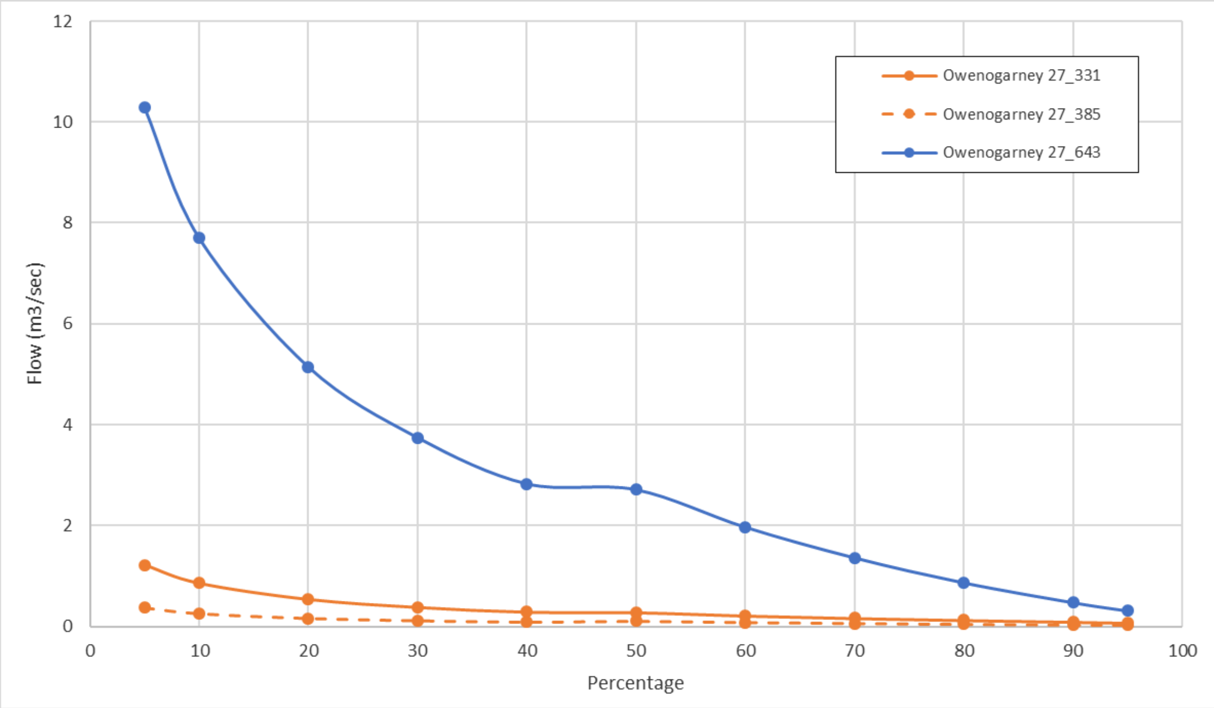



**Figure 8.6: Wind Farm Site Rivers - Flow Duration Data**

**Table 8-4: Surface water flow values for sampling locations on site 30/10/2018-26/11/2018**

| | **R1 (30/08/18)** | **R2 (24/09/18)** | **R3 (19/10/18)** | **R4 (26/11/18)** | **R5 (30/01/19)** | **R6 (13/06/19)** |
|---|---|---|---|---|---|---|
| Sample Location | Flow (l/s) | Flow (l/s) | Flow (l/s) | Flow (l/s) | Flow (l/s) | Flow (l/s) |
| SW1 | 100 | - | - | - | - | - |
| SW3 | 12-15 | 10 | 15 | 30 | - | 15 |
| SW4 | 200 | 150 | | 150 | 800 | 300 |
| SW5 | - | | 4 | - | - | |
| SW6 | 10 | | 7 | 15 | 20 | 10 |
| SW7 | 120 | 153 | 150 | 150 | 300 | 100 |
| SW8 | 70 | - | 40 | 50 | 15 | - |
| SW9 | 2 | - | - | | | - |
| SW10 | 6-8 | | 10 | 10 | | 6 |
| SW12 | 12-15 | - | 20 | - | 14 | - |

Water level monitoring was conducted over a 9-month period (September 2018 – June 2019) in several streams within the proposed development site. Continuous water level loggers were installed at surface water monitoring locations SW4 and SW7, while a water level and depth/velocity logger was installed at SW6. A raingauge was also installed on the proposed development site. Photos of the installed devices along with the staff gauges installed at SW4/SW7 are shown on Figure 8.7.

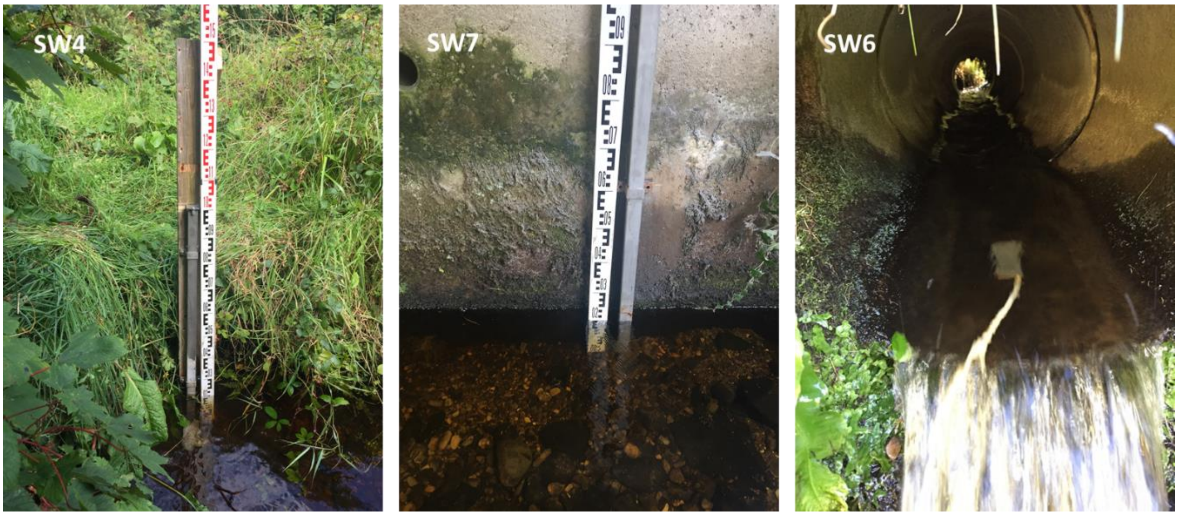



**Figure 8.7: Photos of installed SW monitoring devices and staff gauges (SW4, SW6, and SW7)**

#### 8.2.4.1.1 SW4

A water level logger was installed at a bridge towards the northwest of the proposed development site at SW4. This instrument recorded water level in the river at 15-minute intervals. The water levels at SW4 fluctuated over a ~0.5m range with a mean water level of 0.72m above the river bed. The logger was installed with the base of the logger (where the readings are taken) just above the base of the river. The 95$^{th}$ percentile water level in this river was 0.253 m above the base of the river. The results of the water level monitoring are presented graphically in Figure 8.8.

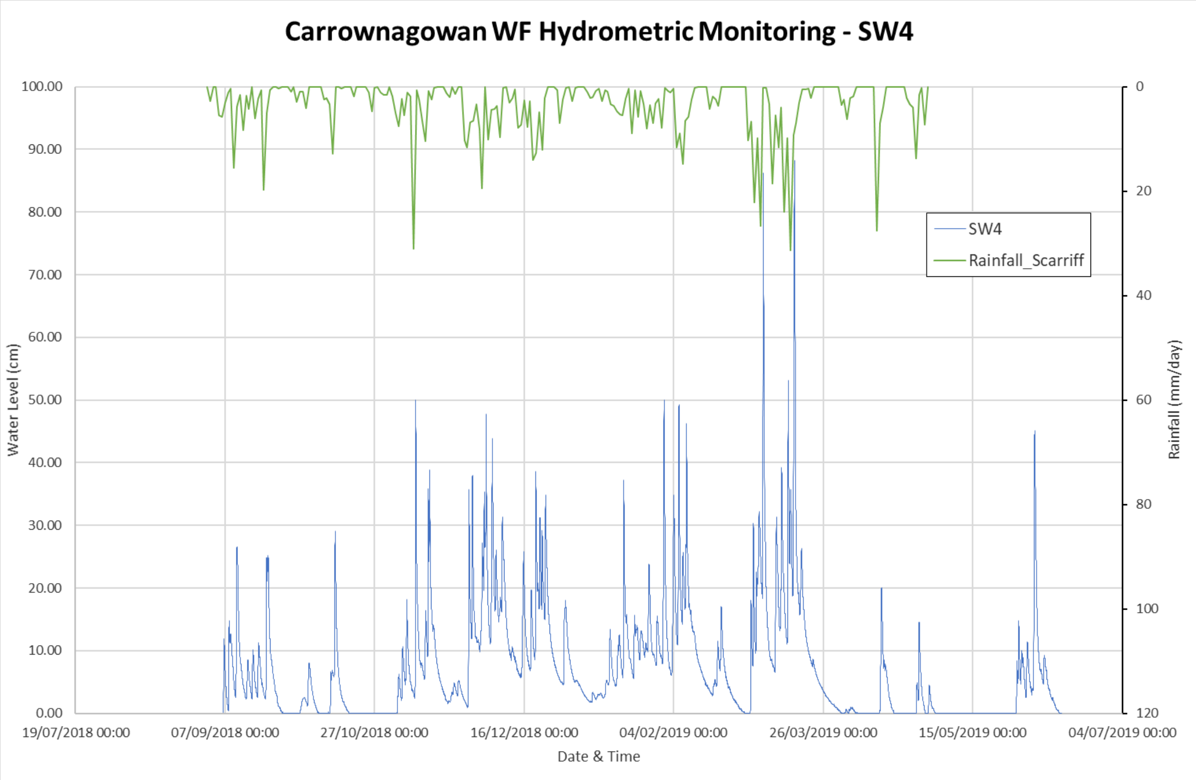



**Figure 8.8: SW4 water level monitoring plot (09/2018 – 06/2018)**

### 8.2.4.1.2 SW7

A water level logger was installed underneath a bridge at SW7 (refer to Figure 8.7). Water levels were recorded at 15-minute intervals over the 9-month period. The logger at SW7 had to be replaced due to technical difficulties with the instrument. The gap in data between the installation of the replacement logger has been modelled using data from both SW4 and SW7. The stage in the river ranged between ~0 - 0.45m above the river base. The average water level was 0.03m and the 95$^{th}$ percentile water level was 0.13m. The results of this monitoring are presented graphically in Figure 8.9.

### 8.2.4.1.3 SW6

A Greyline stingray logger was installed in a concrete culvert pipe at SW6. This logger recorded both the water level and velocity at this location. This data was then used to calculate the flow in the stream. The water level at SW6 ranged between 0 – 0.215 m above the base of the culvert. The average water level was 0.056m above the base, while the 95$^{th}$ percentile level was 0.09m.

The flow recorded at SW6 ranged between 0 – 69 $m^3$/hr. This value of 69 $m^3$/hr was extremely uncommon as the 95$^{th}$ percentile flow for this stream was calculated at 16 $m^3$/hr, while the mean flow was 6.08 $m^3$/hr. The results of this monitoring are presented graphically in Figure 8.10.

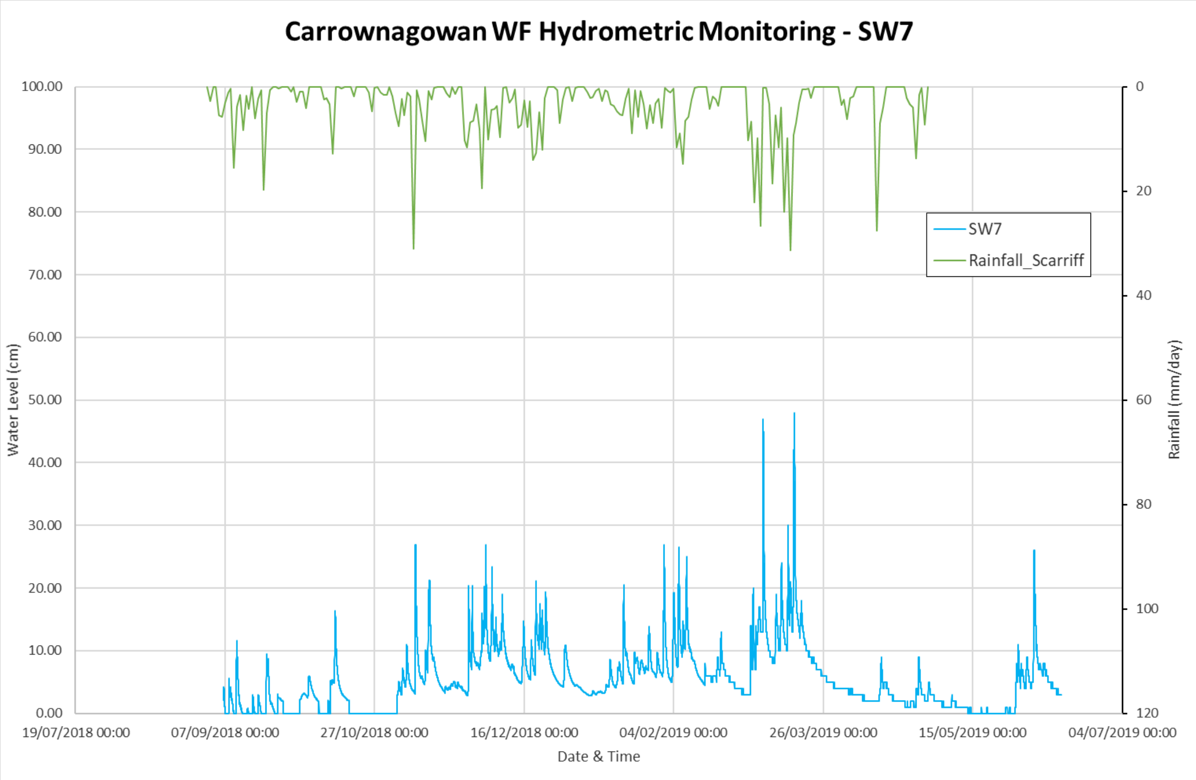



**Figure 8.9: SW7 water level monitoring plot (09/2018 – 06/2018)**

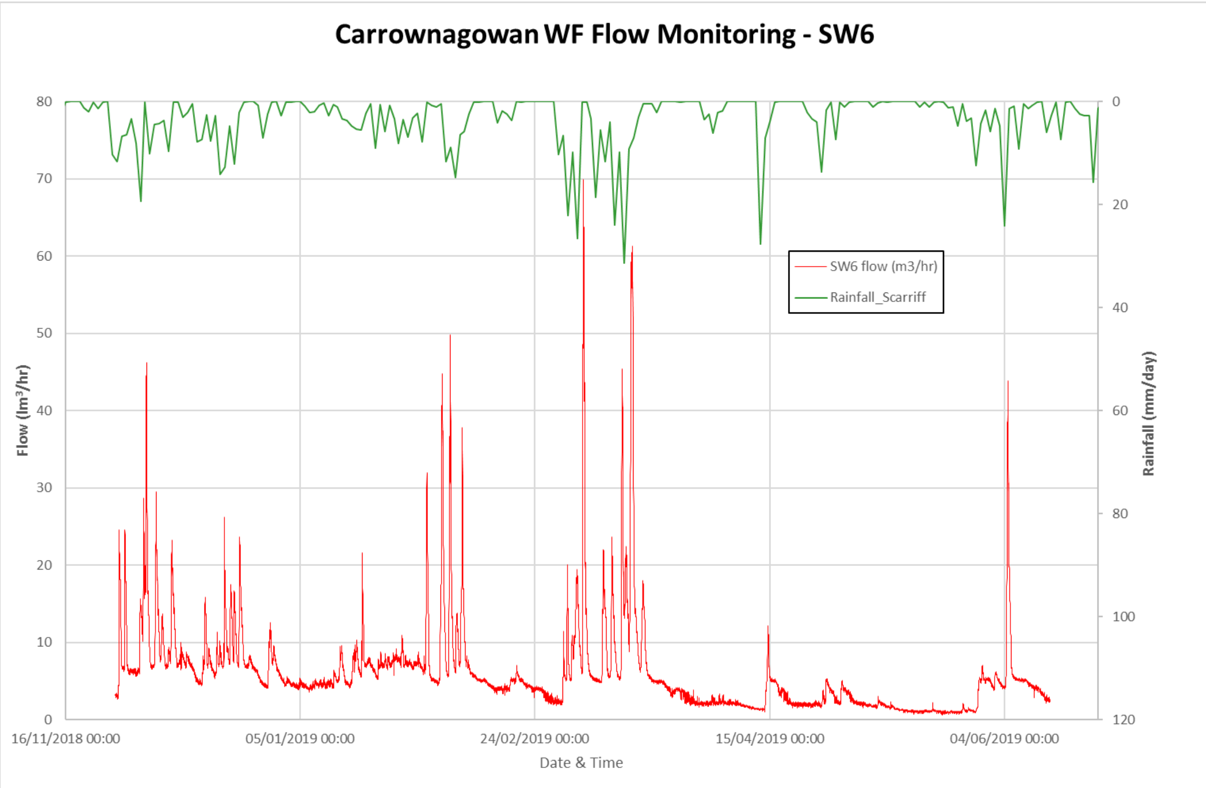



**Figure 8.10: SW6 Stream flow monitoring plot (11/2018 – 06/2019)**

#### *8.2.4.2 Delivery Route*

There are no significant watercourses present at the delivery route work sites.

#### *8.2.4.3 Grid Route*

The grid route is located along existing public roads. Therefore, drainage regimes will remain as before within pre-existing ditches/dykes along these roads. The grid route is drained by the Killuran River, the Broadford River, the Snaty River and the Blackwater River. All of these are located within the Lower Shannon River catchment. A survey of culverts at existing watercourse crossings was undertaken between January to February 2019, which included taking flow measurements and surface water samples. The locations of these sampling points are included in Figure 8.11. Table 8-5 below includes recorded flow measurements along the grid route.

**Table 8-5: Flow measurements at locations along grid route**

| Sample Location | R1 – 30/01/2019 | | R2 – 14/02/2019 | |
|---|---|---|---|---|
| | Flow (l/s) | pH | Flow (l/s) | pH |
| **SW15** | 100 | 7.48 | 90 | 7.78 |
| **SW16** | 200 | 7.21 | 60 | 7.59 |
| **SW17** | 150 | 7.03 | 50 | 7.46 |
| **SW18** | 400 | 6.72 | 100 | 7.57 |
| **SW19** | 150 | 7.29 | 70 | 7.64 |
| **SW20** | 11 | 7.54 | 60 | 7.18 |
| **SW21** | 70 | 7.69 | 30 | 7.78 |
| **SW22** | 450 | 7.37 | 250 | 7.67 |
| **SW23** | 100 | 7.36 | 40 | 7.52 |
| **SW24** | 100 | 7.27 | 40 | 7.5 |

7 of the 10 no. sampling points (SW15 - SW21) along the grid connection were located along an unnamed road, which runs parallel to the R466, east of Broadford. These monitoring points were generally along streams/ small rivers that discharge to the Glenomra River, which flows northwest towards Broadford, adjacent to the R466. Flows ranged from 11 – 400 l/s, with pH ranging between 6.72 – 7.69. 6 of 7 samples had a pH of >7 and can be considered to be generally neutral-basic. The low pH of SW18 is likely related to these waters being sourced from the peat rich high ground of Slieve Bernagh and the high flows of ~400 l/s may reflect some dilution from rainfall which would generally reduce the pH of the waters.

A further 3 no monitoring points (SW22 – SW24) were located along small streams and rivers which join the River Blackwater, north of Ardnacrusha. Flows at these monitoring locations ranged between 100 – 450 l/s.

#### *8.2.4.4 Replacement Lands (Ballard, Cooraclare & Trillickacurry)*

Site drainage at Ballard is via the Ballyeustace stream, which flows along the northern boundary of the Ballard site. The general flow direction of this stream is northeast, where it meets the Avonbeg River approximately 0.5 km north of the site. The Avonbeg river then flows south, converging with the Avoca river ~4km south of Rathdrum.

Site drainage at Cooraclare is along the Doonbeg River (IE_SH_28D020725) which runs along the southern boundary of the Cooraclare site. The ground slopes ~3-4m from the northern to the southern boundary of the Cooraclare site. A small drain runs through the centre of the western section of the Cooraclare site and discharges into the Doonbeg river. The Doonbeg flows west/northwest for approximately 6 km before discharging into Doonbeg Bay.

Site drainage at Trillickacurry is along the Clonkeen Stream (IE_SH_26C010900) which runs along the southern boundary of the Trillickacurry site. The ground slopes approximately 10m from the northern to the southern boundary of the Trillickacurry site. The stream flows west for approximately 1 km before turning north and flowing towards Longford town, where it meets the Camlin River (IE_SH_26S021510) and continues to flow north/northwest before discharging into the Upper Shannon.

### 8.2.5 Assessment of baseline runoff volumes

The proposed wind farm development footprint accounts for only ~4.08% of the total planning application site area shown in Chapter 1, Figure 1.1.

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 and bedrock exposure (Table 8-6). It represents, therefore, the baseline average wettest monthly scenario in terms of volumes of surface water runoff from the study area pre-development.

The surface water runoff co-efficient for the area is estimated to be 95%, based on the predominant peat coverage at the proposed development site. As outlined below, a 1 in 100-year 6-hour return period will be used for drainage design purposes.

The highest long-term average monthly rainfall recorded at Scarriff over the period 1987 – present occurred in October, at 107mm. The average monthly evapotranspiration for the synoptic station at Claremorris over the period 1961-1990 in December was 24.4mm. The calculation is carried out for the entire study area. The balance indicates that a conservative estimate of surface water runoff for the study area during the highest rainfall month is 599,752 $m^3$/month, which equates to an average of 1,643 $m^3$/day, as outlined in Table 8-7.

**Table 8-6: Water Balance and Baseline Runoff Estimates for Wettest Month (October)**

| Water Balance Component | Depth (m) |
|---|---|
| **Average October Rainfall (R)** | 0.107 |
| **Average October Potential Evapotranspiration (PE)** | 0.024 |
| **Average October Actual Evapotranspiration (AE = PE x 0.95)** | 0.023 |
| **Effective Rainfall October (ER = R - AE)** | 0.084 |
| **Recharge co-efficient (5% of ER)** | 0.004 |
| **Runoff (95% of ER)** | 0.08 |

**Table 8-7: Baseline runoff conditions at the proposed site**

| Approx. Area (ha) | Baseline Runoff per month ($m^3$) | Baseline Runoff per day ($m^3$) |
|---|---|---|
| 749.69 | 599,752 | ~1,643 |

### 8.2.6 Flood Risk Identification

#### *8.2.6.1 Wind Farm Site (& Delivery Route Works)*

A site-specific flood risk assessment was completed on the proposed development site (attached as Appendix 8.2). OPW's indicative river and coastal flood map (http://www.floodmaps.ie/www.floodmaps.ie), CFRAM Preliminary Flood Risk Assessment (PFRA) maps (www.cfram.ie), Department of Environment, Community and Local Government on-line planning mapping (www.myplan.ie) and historical mapping (i.e. 6" & 25" base maps) were consulted to identify those areas as being at risk of flooding.

A walkover survey and stream discharge monitoring were conducted between August 2018 and June 2019. Monitoring of flows was undertaken within 7 watercourses throughout the proposed development site. The measured flows are included as Table 8-4.

During the walkover survey of the route there was little evidence of historic out-of-bank flow from within the various river channels. High flows were observed in several channels during site visits following preceding days with heavy rainfall. No localized or regional flooding was observed during these site visits, all flow was contained within the channels.

There are small areas of Alluvium mapped along the various rivers/streams which flow through the proposed development site, indicative of historic out of bank flow. This is particularly evident along the Coumnagun river, with sections of alluvium 40-50m wide mapped in across the channel.

No recurring flood events within the proposed development site were noted from the OPW's river and coastal flood map. A recurring flood event is mapped near Bodyke, approximately 2.3 km north of the proposed development site. This recurring flood event is caused by the Anamullaghaun River which flows northwest towards Bodyke. At its closest, it is approximately 1 km north of the proposed development site.

The PFRA mapping shows the extents of the indicative 100-year flood zone which relates to fluvial (i.e. river) and pluvial (i.e. rainfall) flood events. The 100-year fluvial flood zones mapped within the proposed development site boundary generally occur in close proximity to the stream channel itself. All proposed turbine locations are located at least 75m away from streams and are outside of the indicative fluvial 100-year flood zone.

An area of 1% AEP Pluvial flooding is mapped by OPW at the northern boundary of the proposed development site, approximately 1km south of Caherhurly cross, however as noted by the OPW, the maps offer only an indication and may not be accurate at a local scale. Observations on site during field surveys indicate, due to the sloping nature of the proposed development site and the lack of observed pluvial flooding following rainfall, that the topography and general drainage pattern is unlikely to be susceptible to pluvial flooding.

Based on the information gained through the flood identification process it would appear that parts of the proposed development site immediately surrounding the various river channels are within 1 in 100 year fluvial flood zones (Flood Zone A), however these mapped zones are limited in extent and do not coincide with areas of development. No infrastructure is mapped within 50m of an area designated as Flood Zone A.

A requirement for a Justification test was applied to the proposed development site. Although the development is considered to be a 'Highly vulnerable development', using the matrix of vulnerability, it was determined that the development is 'Appropriate' as all proposed wind farm infrastructure is located within Flood Zone C.

#### *8.2.6.2 Grid Route*

No recurring flood events or other flood risk information was noted during the desk study.

#### *8.2.6.3 Replacement Lands (Ballard, Cooraclare & Trillickacurry)*

No recurring flood events or other potential flood risks were noted during the desk study for Ballard and Trillickacurry replacement land sites.

The majority of the Cooraclare site is mapped within a Flood zone A (1% AEP), with small areas of pluvial flooding also noted within this area. The mapped flood zone A extends north past the local access road to the Cooraclare site.

### 8.2.7 Surface Water Hydrochemistry

#### *8.2.7.1 Proposed Wind Farm*

River Q (i.e. biotic indices ("Q Values") reflect average water quality at any location in a river waterbody) values are available for the Inchaluchoge River (EPA: Owenogarney River) at two locations. River waters achieved a Q value of 4-5 at a bridge located ~1 km north of the proposed development site upstream of Ballymacdonnell (RS27O010100). A further location exists ~1.5 km downstream at Ballymacdonnell Bridge (RS27O010200) where the waters achieved a Q5. The locations of these data points are included on Figure 8.1 (Volume III).

River Waterbody WFD status information is available for the river channels within the area of the proposed development. The Owenogarney river waterbody (IE_SH_27O010100), which includes the Carrownagowan, Inchaluchoge, Coumnagun and Killuran rivers, achieved "Good" status under the WFD 2013-2018. The Graney (Anamullaghaun) river waterbody achieved moderate status under the WFD 2013-2018.

Field hydrochemistry measurements of unstable parameters, electrical conductivity (µS/cm), pH (pH units) and Dissolved Oxygen (DO, mg/L) were taken at locations across the proposed development site (locations shown on Figure 8.5 in Volume III) within surface watercourses on the 30$^{th}$ August 2018, 24$^{th}$ September 2018, 19$^{th}$ October 2018, 26$^{th}$ November 2018, 30$^{th}$ January 2019 and 13$^{th}$ June 2019. The results are listed in Table 8-8 below. Please note that not all locations were sampled during each round, but sampling and monitoring was completed in a random manner to define the baseline surface water environment.

Electrical conductivity values for the samples taken range from 57.5 – 174 µS/cm. This is indicative of surface water which is mainly derived from precipitation, with some minimal input from any groundwater sources. The high EC value of 174 µs/cm recorded at SW9 was observed within a stream with an extremely low flow of ~2 l/s and situated near the northern section of the proposed development site. The high value may be due to these waters flowing at a low velocity over a long period of time, leading to more solids becoming dissolved within the water, or perhaps some input from groundwater as baseflow.

The pH values at the proposed development site ranged from 6-8, with most pH values above 7.5, indicating surface waters which are generally slightly alkaline. The recorded pH of the surface waters is typical for an area of sandstone/conglomerate bedrock, along with subsoils derived from these parent materials.

Dissolved oxygen at the proposed development site ranges from 6.78 to 11.67 mg/l, with the majority of samples taken falling between 10-11 mg/l. These values are typical of unpolluted, well oxygenated surface waters.

Turbidity values range from <1 to 4.5 NTU. This is typical of a surface water streams, with elevations in turbidity caused by heavy rainfall events before returning to ~1 NTU during dry periods.

**Table 8-8: Field hydrochemistry measurements at sampling locations on site.**

| Location | EC (µS/cm) | | pH | | DO (mg/L) | | Turbidity (NTU) | |
|---|---|---|---|---|---|---|---|---|
| | R1 | R2 | R1 | R2 | R1 | R2 | R1 | R2 |
| Date | 30/08/18 | 24/09/18 | 30/08/18 | 24/09/18 | 30/08/18 | 24/09/18 | 30/08/18 | 24/09/18 |
| SW1 | 99 | - | 7.56 | - | 9.97 | - | 1.19 | - |
| SW2 | 103.3 | - | 7.91 | - | 10.19 | - | 3.98 | - |
| SW3 | 94.4 | 85.6 | 7.88 | 8.07 | 10.19 | 10.92 | 3.13 | - |
| SW4 | 9 5 | 85 | 7.8 | 8.01 | 10.33 | 11.1 | 1.33 | - |
| SW5 | - | - | - | - | - | - | 1.32 | - |
| SW6 | - | - | - | - | - | - | 1.9 | 1.87 |
| SW7 | 91.5 | 87 | 7.79 | 7.99 | 10.34 | 10.97 | 1.09 | 4.41 |
| SW8 | 101 | - | 7.69 | - | 9.97 | - | 1.26 | - |
| SW9 | 174 | - | 7.67 | - | 9.43 | - | 0.97 | - |
| SW10 | 57.5 | - | 6.18 | - | 9.81 | - | 3 | - |
| SW11 | 74.7 | - | 7.62 | - | 9.94 | - | 0.42 | - |
| SW12 | 94.5 | - | 7.94 | - | 10.34 | - | 0.27 | - |
| | | | | | | | | |
| | R3 | R4 | R3 | R4 | R3 | R4 | R3 | R4 |
| Date | 19/10/18 | 26/11/18 | 19/10/18 | 26/11/18 | 19/10/18 | 26/11/18 | 19/10/18 | 26/11/18 |
| SW1 | 131.4 | 137.9 | - | - | - | - | - | - |
| SW2 | - | - | - | - | - | - | - | - |
| SW3 | - | 130.8 | 8.02 | 8.13 | 11.02 | 11.25 | 3.51 | 0.43 |
| SW4 | 85.9 | - | - | 7.97 | - | 11.67 | 1.25 | 1.07 |
| SW5 | 102.8 | 95.7 | 6.02 | - | 6.78 | - | 0.72 | |
| SW6 | 141.8 | 135.9 | 7.01 | 7.74 | 10.62 | 11.37 | 1.34 | 1.86 |
| SW7 | 146.8 | 134.5 | 7.99 | 7.97 | 11.01 | 11.38 | 0.47 | 0.51 |
| SW8 | - | - | 7.98 | 7.96 | 11.09 | 11.46 | 0.95 | 1.05 |
| SW9 | 77.2 | 69.7 | - | - | - | - | - | - |
| SW10 | 140 | - | 7.35 | 6.24 | 11.05 | 11.48 | 4.54 | 3.74 |
| SW11 | - | - | - | - | - | - | - | - |
| SW12 | - | - | 8.14 | - | 11.06 | - | 0.27 | - |
| | | | | | | | | |
| | R5 | R6 | R5 | R6 | R5 | R6 | R5 | R6 |
| Date | 30/01/19 | 13/06/19 | 30/01/19 | 13/06/19 | 30/01/19 | 13/06/19 | 30/01/19 | 13/06/19 |
| SW1 | - | - | - | - | - | - | - | - |
| SW2 | - | - | - | - | - | - | - | - |
| SW3 | - | 141.3 | - | 8.12 | - | 11.18 | - | 0.22 |
| SW4 | 89.4 | 141.5 | 7.2 | 8.08 | 12.52 | 11.18 | 2.68 | 1.22 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **SW5** | - | - | - | | | | - | |
| **SW6** | 74.1 | 99.5 | 6.77 | 7.95 | 12.18 | 10.61 | 2.12 | 1.41 |
| **SW7** | 103.7 | 137.2 | 7.51 | 7.83 | 12.16 | 10.92 | 1.85 | 0.89 |
| **SW8** | - | 147.1 | - | 8.25 | - | 10.94 | - | 1.35 |
| **SW9** | - | - | - | - | - | - | - | - |
| **SW10** | 72.4 | 68.2 | 7.67 | 7.81 | 12.59 | 10.6 | 6.3 | 3.91 |
| **SW11** | - | - | - | - | - | - | - | - |
| **SW12** | - | - | - | - | - | - | - | - |

Water samples (for laboratory analysis) were taken from 8 no. locations over 2 no. sampling events across the proposed development site (locations shown on Figure 8.5). Sampling round 1 was conducted on 30th August 2018, and sampling round 2 on 19th October 2018. The results of the laboratory analysis of these samples are presented in Table 8-9 and Table 8-10 alongside the relevant water quality regulations values. Environmental objectives Surface Water Regulations (S.I. 272 of 2009) are shown in Table 8-11. Original laboratory reports are attached in Appendix 8.3.

### Table 8-9: Analytical result of surface water samples on 30/08/2018

| Parameter | EQS | Sample ID | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | SW3 | SW4 | SW5 | SW6 | SW7 | SW8 | SW10 | SW12 |
| TSS (mg/L) | 25(+) | 1.2 | 0.4 | 1.6 | 1.4 | 1.0 | 0.4 | 0 | 0.4 |
| Ammonia (mg/L) | ≤0.065 to ≤ 0.04(*) | 0.02 | 0.02 | 0.04 | 0.02 | <0.02 | <0.02 | 0.03 | 0.02 |
| Nitrite $NO_2$ (mg/L) | - | - | - | - | - | - | - | - | - |
| Ortho-P – P (mg/L) | ≤ 0.035 to ≤0.025(*) | 0.02 | <0.02 | <0.02 | 0.09 | <0.02 | <0.02 | <0.02 | <0.02 |
| Nitrate - $NO_3$ (mg/L) | - | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 |
| Nitrogen (mg/L) | - | - | - | - | - | - | - | - | - |
| Phosphorus (mg/L) | - | 0.1 | <0.10 | <0.10 | 0.15 | <0.10 | <0.10 | <0.10 | <0.10 |
| Chloride (mg/L) | - | 10.7 | 11.7 | 18.4 | 12.1 | 10.6 | 11.4 | 13.6 | 8.6 |
| BOD | ≤ 1.3 to ≤ 1.5(*) | 3 | 2 | 2 | 3 | 1 | 1 | 2 | 1 |

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

### Table 8-10: Analytical results of surface water samples ton 19/10/2018

| Parameter | EQS | Sample ID | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | SW3 | SW4 | SW5 | SW6 | SW7 | SW8 | SW10 | SW12 |
| TSS (mg/L) | 25(+) | 0.2 | 1.2 | 3 | 1.2 | 0 | 0.4 | 1.8 | 0 |
| Ammonia (mg/L) | ≤0.065 to ≤ 0.04(*) | 0.02 | <0.02 | 0.03 | 0.02 | <0.02 | <0.02 | 0.02 | <0.02 |
| Nitrite $NO_2$ (mg/L) | - | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Ortho-P – P (mg/L) | ≤ 0.035 to ≤0.025(*) | <0.02 | <0.02 | <0.02 | 0.05 | <0.02 | <0.02 | <0.02 | <0.02 |
| Nitrate - $NO_3$ (mg/L) | - | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 |
| Nitrogen (mg/L) | - | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| Phosphorus (mg/L) | - | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 |
| Chloride (mg/L) | - | 11.8 | 11.4 | 17.1 | 11.9 | 10.4 | 10.9 | 15.4 | 8.6 |
| BOD | ≤ 1.3 to ≤ 1.5(*) | 3 | 1 | 2 | 2 | 1 | 1 | 1 | 1 |

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

Table 8-11: Chemical conditions supporting biological elements

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

#### 8.2.7.1.1 Wind Farm Surface Water sample results – 30/08/2018

Total suspended solids (TSS) at each location were ranged from 0 to 1.6 mg/l, which is below the water quality standard required by S.I. 293 of 1988 (25mg/L for TSS). Nitrate levels were below laboratory detection limits in all samples (<5.0 mg/l).

Ammonia level ranged between <0.02 – 0.04 mg/l which is within the EQS for "high" status from the Environmental Objectives surface water regulations (S.I. 272 of 2009). Orthophosphate levels were generally below or at the detection limit of 0.02 mg/l, while the sample taken from SW6 exceeded the EQS values for both "high" and "good" status under S.I. 272 of 2009 at 0.09 mg/l.

Total phosphorous ranged between <0.1 – 0.15 which is considered to be a relatively low stable background level.

BOD ranged from 1 -3 mg/l in the 8 no. samples. 3 of the 8 sample results indicate "good" status conditions as per EQS values from S.I. 272 of 2009.

#### 8.2.7.1.2 Wind Farm Surface Water sample results – 19/10/2018

Total suspended solids recorded on 19/10/2018 ranged from 0-1.8 mg/l, similar to those recorded during round 1 of sampling and below the water quality standard (for TSS) required by S.I. 293 of 1988. Nitrate levels within the 8 no. samples were all <0.05 mg/l.

Ammonia levels ranged between <0.02 mg/l – 0.03 mg/l, again within the EQS values set out in S.I. 272 of 2009. Orthophosphate levels were below the detection limit of 0.02 mg/l in 7 of the 8 no. samples. Orthophosphate measured from the sample at SW6 exceeded the EQS values set out in S.I. 272 of 2009 for "good" and "high" status waters.

Total Phosphorous from all 8 no. samples was below the detection limit of 0.1 mg/l.

BOD ranged from 1-3 in the 8 no. samples. 5 of the 8 sample results indicate "good" status conditions as per EQS values from S.I. 272 of 2009.

### *8.2.7.2 Grid Route*

Surface water sampling was undertaken in January/February 2019 along the proposed grid route. 10 no. sampling points were selected along the path of the grid route where waterbodies were intersected. 2 no sampling events were completed, the first on 31st January 2019 and the second on 14th February 2019. Field chemistry and flow estimates were completed on all 10 no. locations, water samples for laboratory analysis were also taken from 4 of the 10 no. locations. The results of the field data and laboratory data are included in Table 8-12 and Table 8-13 respectively. Original laboratory reports are attached in Appendix 8.3.

**Table 8-12: Field chemistry results along grid route sampling locations.**

| Location | EC (µS/cm) | | pH | | DO (mg/l) | | Turbidity | |
|---|---|---|---|---|---|---|---|---|
| Date | 31/01/19 | 14/02/19 | 31/01/19 | 14/02/19 | 31/01/19 | 14/02/19 | 31/01/19 | 14/02/19 |
| | R1 | R2 | R1 | R2 | R1 | R2 | R1 | R2 |
| SW15 | 91.4 | 131.7 | 7.48 | 7.78 | 12.43 | 11.64 | 7.43 | 2.48 |
| SW16 | 102.5 | 142.9 | 7.21 | 7.59 | 12.18 | 11.51 | 8.41 | 2.06 |
| SW17 | 107.2 | 130.6 | 7.03 | 7.46 | 12.12 | 11.31 | 9.35 | 5.03 |
| SW18 | 119.8 | 132.4 | 6.72 | 7.57 | 11.94 | 11.23 | 8.12 | 0.98 |
| SW19 | 130.2 | 130.3 | 7.29 | 7.64 | 11.68 | 11.38 | 11.23 | 2.87 |
| SW20 | 124.9 | 169.2 | 7.54 | 7.18 | 11.89 | 10.06 | 10.65 | 2.59 |
| SW21 | 183.5 | 170.1 | 7.69 | 7.78 | 11.94 | 11.54 | 6.83 | 2.16 |
| SW22 | 135.8 | 186.9 | 7.36 | 7.67 | 11.87 | 11.39 | 9.3 | 4.22 |
| SW23 | 99.2 | 133.1 | 7.37 | 7.52 | 12.15 | 11.29 | 9.1 | 2.19 |
| SW24 | 139.6 | 219.3 | 7.27 | 7.5 | 11.63 | 11.03 | 8.23 | 2.67 |

Electrical conductivity values for the samples taken range from 91.4 – 219.3 µS/cm. This is indicative of surface water, which is mainly derived from precipitation, with some minimal input from any groundwater sources. The highest conductivity value of 219 µs/cm recorded at SW24 was observed within a stream situated in an urban area alongside a road and housing estate near Ardnacrusha, Co. Clare. The higher EC value is most likely due to runoff from this urban area. The lowest value of 91 µs/cm is essentially rainwater.

The pH values ranged from 6.7 -7.8, with most pH values above 7.0, indicating surface waters which are generally neutral to slightly alkaline. The recorded pH of the surface waters is typical for an area of generally carbonate bedrock, along with subsoils derived from these parent materials.

Dissolved oxygen at sampling locations along the grid route ranges from 10 – 12.4 mg/l. These values are typical of unpolluted, well oxygenated surface waters.

**Table 8-13: Analytical results of surface water samples from grid connection on 31/01/2019 (R1) and 14/02/2019 (R2)**

| Parameter | EQS | Sample ID | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | R1 SW15 | R1 SW18 | R1 SW22 | R1 SW23 | R2 SW7 | R2 SW8 | R2 SW10 | R2 SW12 |
| TSS (mg/L) | 25(+) | 88 | 16 | 46 | 36 | 4.4 | 0.8 | 3.6 | 5.6 |
| Ammonia (mg/L) | ≤0.065 to ≤ 0.04(*) | 0.06 | 0.08 | 0.13 | 0.14 | 0.02 | <0.02 | 0.02 | 0.02 |
| Nitrite $NO_2$ (mg/L) | - | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Ortho-P – P (mg/L) | ≤ 0.035 to ≤0.025(*) | <0.02 | <0.02 | <0.02 | 0.04 | <0.02 | <0.02 | <0.02 | <0.02 |
| Nitrate - $NO_3$ (mg/L) | - | 8.3 | 6.2 | <5 | <5 | 20.2 | 7.4 | 12.1 | 6.7 |
| Nitrogen (mg/L N) | - | 6.8 | 1.5 | 2.0 | 2.9 | 4.8 | 1.8 | 2.8 | 1.6 |
| Phosphorus (mg/L) | - | 0.25 | <0.10 | 0.14 | 0.18 | <0.10 | <0.10 | <0.10 | <0.10 |
| Chloride (mg/L) | - | 12.6 | 12.0 | 17.3 | 11.3 | 14.7 | 12.0 | 17.0 | 16.0 |
| BOD | ≤ 1.3 to ≤ 1.5(*) | 10 | 1 | 3 | 3 | 2 | 1 | 1 | <1 |

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

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

##### 8.2.7.2.1 Grid Connection Surface Water sample results – 31/01/2019

Total suspended solids (TSS) recorded on 31st January 2019 at the 4 no. locations were relatively high, ranging from 16 – 88 mg/l. These results are significantly higher than those recorded during round 2 of sampling (14/02/2019), likely a reflection of high flows in the streams following heavy rainfall. The results, in the baseline environment, are above the water quality standards required by S.I. 293 of 1988 (25mg/L TSS). Nitrate levels within the 4 no. samples ranged between <5 mg/l to 8.3 mg/l.

Ammonia levels ranged between 0.06 mg/l – 0.14 mg/l, and are above the EQS values set out in S.I. 272 of 2009 for "good" and "high" status waters. Orthophosphate levels were below the detection limit of 0.02 mg/l in 3 of the 4 no. samples. Orthophosphate measured from the sample at SW23 exceeded the EQS values for "good" and "high" status waters set out in S.I. 272 of 2009 at 0.04 mg/l.

Total Phosphorous from the 4 no. samples ranged from below the detection limit of 0.1 mg/l to 0.25 mg/l.

BOD ranged from 1 to 10 mg/l in the 4 no. samples. The sample from SW15 was recorded at 10 mg/l, significantly above the EQS values set out in in S.I. 272 of 2009.

Chloride ranged from 11.3 to 17.3 mg/l, which is generally considered within the normal range of chloride for surface waters and indicates no issues with pollution from agricultural runoff or other sources.

##### 8.2.7.2.2 Grid Connection Surface Water sample results – 14/02/2019

Total suspended solids recorded on 14th February 2019 at the 4 no. locations ranged from 0.8 – 5.6 mg/l. The general weather conditions on this date and the days preceding sampling were dry. The results are below the water quality standards required by S.I. 293 of 1988 (25mg/L TSS).

Nitrate levels within the 4 no. samples ranged between 7.4 mg/l to 20.2 mg/l, with the highest value recorded at SW15. These values for Nitrate are high compared too expected nitrate concentrations in streams and may indicate some input from agricultural runoff or another nitrate source. Chloride ranged from 12 to 17 mg/l.

Ammonia levels ranged between <0.02mg/l – 0.02 mg/l, below the EQS values set out in S.I. 272 of 2009 for "high" status waters, and also significantly lower than those recorded on 31st January 2019. Orthophosphate levels were below the detection limit of 0.02 mg/l in all of the 4 no. samples.

Total Phosphorous from the 4 no. samples was below the detection limit of 0.1 mg/l.

BOD ranged between <1 – 2 mg/l. 4 of the 8 sample results indicate "good" status conditions as per EQS values from S.I. 272 of 2009.

#### *8.2.7.3 Replacement Lands (Ballard, Cooraclare & Trillickacurry)*

No information available on surface water quality for the replacement land forestry sites. However, there is no development proposed at the lands and sufficient information for assessment.

### 8.2.8 Hydrogeology

#### *8.2.8.1 Proposed Wind Farm (& Delivery Route Works)*

The bedrock at the proposed development site is mapped as Devonian Old Red Sandstone within the northern section of the proposed development site, while the southern end, the bedrock is mapped as Silurian meta-sediments as the elevation rises towards Slieve Bernagh (to the south).

The GSI have classified the Old Red sandstone bedrock unit as a Locally Important Aquifer (LI) – moderately productive only in local zones. The Silurian meta-sediments to the south are within a Poor Aquifer (PI) generally unproductive except for local zones. A bedrock aquifer map is included as Figure 8.12.

Groundwater flow is expected to follow the topography, flowing north/northwest and discharging into the rivers mentioned earlier.

#### *8.2.8.2 Grid Route*

The general hydrogeology along the northern section of the grid route is similar to the proposed wind farm (the bedrock is mapped as Silurian meta-sediments as the elevation rises towards Slieve Bernagh, and the Silurian meta-sediments are within a Poor Aquifer (PI) generally unproductive except for local zones).

However, groundwater flow towards the southern section of the grid route is likely to differ. Groundwater flow is expected to be in a southerly direction towards the Shannon River. Towards the very southern end of the grid route, near Ardnacrusha, there is a transition into a Regionally Important Karstified Aquifer (Rkd) as the mapped bedrock changes to Carboniferous Limestones. A bedrock aquifer map for the grid route is included as Figure 8.13.

#### *8.2.8.3 Replacement Lands (Ballard, Cooraclare & Trillickacurry)*

Cooraclare is located within a Locally Important Aquifer (LI). Groundwater flow is expected to follow the topography, flowing south locally towards the Doonbeg river and west/northwest regionally.

Ballard is located within a Locally Important Aquifer - moderately productive only in local zones (LI). Groundwater is expected to flow northeast towards the town of Ballinaclash, discharging into the Avonbeg river.

Trillickacurry is located within a Locally Important Aquifer (LI). Groundwater flow is expected to follow the topography, flowing west/southwest towards Lough Ree.

A bedrock aquifer map for the replacement land sites is included as Figures 8.14, 8.15, and 8.16 (Volume III).

### 8.2.9 Groundwater Vulnerability

#### *8.2.9.1 Proposed Wind Farm (& Delivery Route Works)*

Groundwater vulnerability at the proposed development site is described by the GSI as High to Extreme (shallow subsoils over bedrock, 0-3m thickness) at the southern section of the proposed development site, near the Slieve Bernagh summit where subsoils are thinner or absent, transitioning to moderate at the northern section of the proposed development site. This variability is likely due to the thicker depth of subsoil on the lower ground near the northern section of the proposed development site.

#### 8.2.9.2 Grid Route

Groundwater vulnerability along the grid route ranges from moderate to high (5-10m of subsoil), dependent on the depth of soil/subsoil.

#### 8.2.9.3 Replacement Lands (Ballard, Cooraclare & Trillickacurry)

Groundwater vulnerability at Cooraclare is mapped as Low to Moderate.

Groundwater vulnerability at Ballard is mapped as High to Extreme. Its proximity to the summit of Cushbawn Hill, leads to shallow subsoils and in some cases bare rock near the site.

Groundwater vulnerability at Trillickacurry is mapped as Low to Moderate.

### 8.2.10 Groundwater Recharge

#### 8.2.10.1 Proposed Wind Farm (& Delivery Route Works)

Groundwater recharge (the amount of rainfall entering the bedrock aquifer that becomes groundwater flow) is mapped as varying between a recharge coefficient of ~22.5% (% of rainfall that enters the groundwater system) at the southern end of the proposed development site, transitioning to ~<5% at the northern end. This transition reflects the groundwater vulnerability and is also dependent on the subsoil thickness, as well as the change in bedrock lithology (type).

#### 8.2.10.2 Grid Route

Groundwater recharge is mapped as varying between 5 – 60%, with the majority of the grid route mapped as ~15%.

#### 8.2.10.3 Replacement Lands (Ballard & Cooraclare)

Groundwater recharge at the Cooraclare site is mapped as having a recharge coefficient of ~4 %, due to the mapped depth of peat.

The Ballard site and surrounding areas are mapped as having a recharge coefficient of 60%.

Groundwater recharge at the Trillickacurry site is mapped as having a recharge coefficient of ~4 %, due to the mapped depth of peat.

### 8.2.11 Groundwater Hydrochemistry

#### 8.2.11.1 Wind Farm Site (& Delivery Route Works)

Data is available on groundwater hydrochemistry from the Tulla-Newmarket GWB (Groundwater Body) report. Groundwater within this aquifer typically have a calcium bicarbonate signature. Groundwaters from the Silurian strata will tend to range from slightly hard to hard (90 – 360 mg/l $CaCO_3$), with alkalinities from 60 to 270 mg/l (as $CaCO_3$) and EC in the range of 260-600 µS/cm. In the ORS aquifers, groundwaters are moderately hard (145-235 mg/l $CaCO_3$), with moderate alkalinities (140-225 mg/l (as $CaCO_3$) and EC in the range of 310-440 µS/cm.

#### 8.2.11.2 Grid Route

There is no available specific information on groundwater hydrochemistry along the grid route. Groundwater chemistry is expected to similar to that of the proposed wind farm site.

#### 8.2.11.3 Replacement Lands (Ballard, Cooraclare & Trillickacurry)

No information available on groundwater hydrochemistry.

## 8.2.12 Peat Water Levels

### *8.2.12.1 Wind Farm site*

Peat water levels and water strikes were recorded during trial pit excavations completed in August 2019 (MWP, 2019) across the proposed development site. A summary of water strikes, and recorded conditions is provided in Table 8-14 below. Groundwater was encountered in 3 no. trial pits (trial pit locations are shown on Figure 8.7) and the water strikes were generally at the base of the peat. In addition to these data and based on experience from our previous work on blanket peat sites, for the purposes of assessment it is assumed that peat water levels are high, and very close to ground level where blanket peat occurs within the wind farm site. Trial pit data and peat augering data indicate this to be the case. The geotechnical assessment of the proposed development site assumes a worst case of all peat being fully saturated (*i.e.* high water table approaching ground level).

**Table 8-14: Groundwater seepages/inflow within trial pits**

| Trial Pit ID | Inflow Depth (m) | Description |
|---|---|---|
| T03 | 2.1m | Groundwater seepage at base of trial pit |
| T05 | 2.5m | Groundwater flowed in quickly at peat interface, caused instability of hole. |
| T07 | 2m | Slow seepage at base of peat |

There is a significant drainage pathway along the boundary of the Slieve Bernagh Bog SAC to the south of the proposed development site. This drainage pathway is man-made and is the firebreak excavation which runs along the edge of the planted lands and separates the planted lands from the open peatland on higher ground. A photograph of this firebreak is included as Plate 8-1 below. A similar fire break also occurs along the eastern boundary of the wind farm site.

**Plate 8-1: Firebreak along boundary of Slieve Bernagh Bog SAC and forested lands (red line), with small section magnified.**

### 8.2.13 Groundwater Body Status

#### *8.2.13.1 Proposed Development (Wind Farm & Delivery route)*

The Tulla-Newmarket GWB has achieved a “Good” status under the WFD 2013-2018.

#### *8.2.13.2 Grid Route*

The grid route passes through the Tulla-Newmarket GWB as above. The southern section passes through the Lough Graney GWB, also receiving a “Good” status under the WFD 2013-2018.

#### *8.2.13.3 Replacement Lands (Ballard, Cooraclare & Trillickacurry)*

Cooraclare is situated within the Miltown Malbay GWB has achieved a “Good” status under the WFD 2013-2018.

Ballard is situated within the Wicklow GWB, which achieved “Good” status under the WFD 2013-2018. The site is approximately 4km northwest and upstream of the Avoca GWB, which achieved “Poor” status, due to historic mining in the area.

Trillickacurry is situated within the Longford-Ballinalee GWB which has achieved “Good” status under the WFD 2013-2018.

### 8.2.14 Designated Sites & Habitats

#### *8.2.14.1 Proposed Wind Farm and Delivery Route Works*

Designated sites include National Heritage Areas (NHAs), Proposed National Heritage Areas (pNHA) Special Areas of Conservation (SACs), candidate Special Areas of Conservation (cSAC) and Special Protection Areas (SPAs). The Proposed Development site is not located within any designated conservation-site.

The proposed wind farm site borders the Slieve Bernagh Bog SAC which extends both north and south of the proposed wind farm site. The southern part of the Slieve Bernagh bog is at a higher elevation (up-gradient) to the proposed development site, therefore no part of the proposed development site will drain towards this section of the SAC bog. The northern part of Slieve Bernagh bog is situated at a lower elevation (down-gradient) than the proposed wind farm, and part of the proposed development site will drain towards this area.

Doon Lough NHA is situated ~3.5km southwest of the proposed development site. The Killuran river and Owenogarney River flow southwest and discharge into Doon Lough.

The Lough Derg (Shannon) SPA is located ~3.7km east of the proposed development site. A designated sites map is attached as Figure 8.17. A summary of potential hydrological connections/ pathways is included below as Table 8-15.

**Table 8-15: Relative distances and connectivity to designated sites**

| Designated Site | Distance to European Site | Hydrological connectivity to European Sites | Groundwater connectivity to European Sites and NHAs |
|---|---|---|---|
| Slieve Bernagh Bog SAC | <1 km | Potential connections exist via SW and GW flows. | Likely, but significant separation exists and baseline conditions between SAC and development locations is highly modified already. |
| Lough Derg SPA | 3.7km | Small section of the proposed development site, towards the north drains to the Graney Anamullaghaun subcatchment, which ultimately discharges to Lough Derg. No infrastructure is proposed in this area of the proposed development site.<br><br>As no development is proposed in this catchment, no impacts wil occur. | Unlikely, groundwater will likely flow west following the local topography and surface water drainage pathways. Any groundwater flows from the northeast of the proposed development site will be very small, and would not be of a volume that could affect water quality in Lough Derg. No infrastructure is proposed in this area of the proposed development site where groundwater can flow towards Lough Derg.<br><br>As no development is proposed in this groundwater catchment that can flow towards Lough Derg, no impacts will occur. |
| Doon Lough NHA | 3.5km as the crow flies, and 7.64km along the Ballymacdonnell River/Owenogarney River. | The Owenogarney and Killuran river both discharge into Doon Lough.<br><br>Potential impacts via surface water on Doon Lough NHA are assessed in Section 8.6.1.9. | Likely, but significant distance between the proposed development site and Doon Lough, as well as low transmissivity in underlying bedrock aquifer means that potential for impacts via groundwater are very low, and can be sceened out at this point. |
| Lough O'Grady pNHA | c. 4.9km to north of T9<br>c. 7.7km to north of Grid Connection | An unnamed stream flows north from the site entrance, and crosses the TDR, and flows on to enter Lough O'Grady.<br><br>Potential impacts via surface water on Lough O'Grady pNHA are assessed in Section 8.6.1.9. | Likely, but there is a significant distance between the proposed development site and Lough O'Grady and only minor works proposed within the catchment to this unnamed stream (i.e. a short section of the TDR and site entrance road upgrade works). |

Conceptual Site model cross-sections between the proposed wind farm site and the surrounding areas of the Slieve Bernagh Bog SAC are attached in Figure 8.18. The assessment below references these cross-sections. Separation distances and elevation differences from specific infrastructure locations to the Slieve Bernagh Bog SAC is shown in Table 8-16.

**Table 8-16: Relative distances and elevation changes to Slieve Bernagh Bog SAC**

| Transect ID | Infrastructure Area | Horizontal Distance from Infrastructure to SAC (m) (┴ to contours) | Min. Ground Elevation Difference (m) | Gradient to SAC |
|---|---|---|---|---|
| X-T1 | Southwest | 312 | 22 | Up-gradient |
| X-T2 | Southwest | 440 | 58 | Up-gradient |
| X-T3 | Southwest | 199.3 | 27.4 | Up-gradient |
| X-T4 | Southwest | 188 | 36 | Up-gradient |
| X-T8 | Southeast | 230 | 28 | Up-gradient |
| X-T12 | Southeast | 275 | 36.6 | Up-gradient |
| X-T13 | Southeast | 164 | 28 | Up-gradient |
| X-T14 | Eastern | 380 | 0 | Across gradient |
| X-T15 | Eastern | 412 | 11 | Across gradient |
| X-T16 | Eastern | 540 | 11 | Across gradient |
| BP3 | Eastern | 509 | 25 | Up-gradient |
| X-T19 | Northern | 432.5 | 25 | Across gradient |
| PMM | Northern | 362 | 15 | Across gradient |

#### *8.2.14.2 Grid Route*

The grid route passes along the boundary of the Slieve Bernagh Bog SAC (within 30m at the northern end of the grid route, the SAC is upgradient of the grid route at this location), as well as the Glenomra Wood SAC near Fahymore (passes along the road within the SAC).

#### *8.2.14.3 Replacement Lands (Ballard & Cooraclare)*

The Cooraclare site is not located near any designated sites or habitats. The closest hydrologically connected Natura 2000 site is the Mid Clare Coast SPA, and Carrowmore Dunes SAC, both begin at the sea shore at Dunbeg at ~8.53km northwest of the Cooraclare site.

The Ballard site is not located near any designated sites or habitats. There are no hydrological connected designated sites downstream of the Ballard site.

The Trillickacurry site is situated within the Derrymore Bog, which is a proposed National Heritage Area, however much of this bog has been removed previously. The closest hydrologically connected Natura 2000 site is the Lough Forbes Complex SAC and Ballykenny-Fisherstown Bog SPA , both begin ~13.7km downstream of the Trillickacurry site.

### 8.2.15 Water Resources

#### *8.2.15.1 Public Supply Sources*

3 no. Group Water Schemes (GWS) are situated north of the wind farm site. Bodyke GWS is situated ~3.3 km north-northwest of the proposed development site, as well as Raheen Road GWS ~4.2 km northeast of the proposed development site and Carrowcore GWS (Ogonelloe) approximately 7 km northeast of the proposed development site.

The GWS supply sources were visited by HES on 16th October 2019. Access was limited to these sites but an on-site appraisal of the hydrogeological regime (topography, bedrock outcrop and surface water drainage pattern) was conducted at these sites, which aided the desk study of these sites. In terms of groundwater flowpaths, these sites are a significant distance from the proposed wind farm site. The proposed wind farm site is dominated by surface water flow rather than groundwater, due to the high stream density. The bedrock aquifer beneath the proposed wind farm site is classified as a Poor aquifer and will generally have poor transmissivity.

A map of water supply sources is included as Figure 8.19. The ZoC areas for Bodyke GWS and Raheen Road GWS are shown on this map relative to the wind farm site boundary. Cross-sections for ground elevations and mapped geology between the wind farm site and the public water supply locations are attached on Figure 8.20. Of note on these sections is the separation distances, the changes in ground elevation and the intermediate surface water streams between the wind farm site and the local public water supply source locations and ZoCs.

A Zone of Contribution (ZoC, area of ground that contributes to groundwater flow towards a borehole or spring) assessment has been completed by the GSI for 2 of the 3 no. GWS. The 2 no. GWS with the completed ZoC assessments are Raheen and Bodyke, the closest sources to the proposed development site. These ZoC's are limited in area extent and do not coincide with the proposed wind farm development site boundary. The Bodyke GWS ZoC is the closest of these two to the proposed development site. This ZoC is ~0.8km from the northern site boundary and ~2.5km from the nearest turbine. The Raheen GWS ZoC boundary is ~4.5km from the northern site boundary. An assessment on the ZoC for the Carrowcore GWS borehole has not yet been completed by the GSI, however given that it is ~7km northeast of the proposed development site and with groundwater from the east of the proposed development site expected to flow west towards Lough Derg, the zone of contribution to this borehole will be at least 6 km from the proposed development.

Similarly, 2 no. public supply boreholes, as well as 1 no. GWS abstraction point exist south of the proposed development site, one PWS (Public Water Scheme) borehole in Broadford, one in Killaloe, as well as a GWS borehole in Killaloe (Creeveroe) and a spring used for public supply in Bridgetown. The borehole at Broadford is located approximately 5km southwest of the proposed development site boundary and available information on this borehole suggests an abstraction rate of ~160 $m^3$/day. The PWS borehole at Killaloe is located 5.7 km southeast of the proposed development site boundary. Available information on this borehole suggests an abstraction rate of ~1,300 $m^3$/day. The GWS scheme borehole is located 6.9 km southeast of the proposed development site at Killaloe (Creeveroe). There are no data on abstraction rates for this borehole. The spring at Bridgetown is located approximately 8 km south of the proposed development site. Available data for this point suggests an abstraction rate of ~60 $m^3$/day.

According to the EPA Abstraction Register there is a surface water abstraction for the Shannon Public Water Supply Scheme from Castle Lake which exists approximately 3km north of Sixmilebridge. Castle Lake is situated on the Owenogarney (Ratty) River approximately 17km downstream of the proposed wind farm site. The majority of the proposed wind farm site drains to the Owenogarney (Ratty) River.

#### *8.2.15.2 Private Water Sources*

Private well locations (accuracy of <50m only) were reviewed using GSI well database (www.gsi.ie). There are 8 no. mapped wells located along roads to the northwest, north, northeast and southwest of the proposed development site (refer to Figure 8.21). Summary data from these wells in presented in Table 8-17.

**Table 8-17: GSI Well Database – Local Well Summary Data**

| GSI ID | Depth (mbgl) | Summary Geology | Yield Class | Use / Owner |
|---|---|---|---|---|
| 1417SEW026 | 23.5 | Bedrock | Moderate | Domestic use only |
| 1417SEW037 | Unknown | Bedrock | Good | Domestic/Agri water supply |
| 1417SEW034 | Unknown | Bedrock | Poor | Domestic/Agri water supply |
| 1417NEW074 | 57.3 | Bedrock | Poor | Domestic/Agri water supply |
| 1417NEW044 | Unknown | Bedrock | - | Domestic use only |
| 1417NEW045 | Unknown | Bedrock | Poor | Domestic use only |
| 1417NEW068 | 39.6 | Bedrock | Poor | Domestic/Agri water supply |
| 1417SEW047 | 45.1 | Bedrock | Poor | Domestic/Agri water supply |

GSI mapped wells with accuracy greater than 50m were not assessed due to the poor information/accuracy regarding their location. To overcome the poor accuracy problem of other GSI mapped wells (>50m accuracy) it is conservatively assumed (for the purpose of assessment only) that every private dwelling in the area (shown on Figure 8.21) has a well supply and this impact assessment approach is described further below. (Please note wells may or may not exist at each property, but the most conservative rationale here is that it is better to assume a well may exist at each downgradient property and assess the potential impacts from the proposed development on such assumed wells, as a worst case scenario, rather than make no assessment and find out later that groundwater wells do actually exist).

The private well assessment undertaken below also assumes the groundwater flow direction underlying the proposed development site mimics topography, whereby flow paths will be from topographic high points (i.e. top of hill) to lower elevated discharge areas at local streams/rivers. The assessment of houses/farms to each element of infrastructure is presented in Table 8-18.

**Table 8-18: Potential Private Wells Down-gradient of the Development Footprint**

| Development Footprint/Infrastructure Location (1) | Distance from Closest Private Dwelling (m) (2) | Location of turbine in relation to the closest dwelling (3) |
|---|---|---|
| T1 | 1,820 | Remote |
| T2 | 1,750 | Remote |
| T5 | 1,370 | Remote |
| T19 | 1,390 | Across gradient, but intermediate streams |
| T16 | 1,000 | Down-gradient, but intermediate streams |
| T14 | 2,090 | Remote |
| Substation | 1,440 | Down-gradient, but intermediate streams |
| Borrow Pit 1 | 1,140 | Down-gradient, but intermediate streams/rivers |
| Borrow Pit 2 | 1,300 | Down-gradient, but intermediate streams/rivers |
| Borrow Pit 3 | 560 | Down-gradient, but intermediate streams |
| Construction Compounds | 1,530 | Down-gradient, but intermediate streams |
| Met Mast | 2,220 | Down-gradient, but intermediate streams/rivers |

Notes:

1. Distance from closest turbine, compound, borrow pit or substation (*i.e.* bedrock excavation). Access roads and the grid connection cable trench are not considered a potential risk due to the shallow nature of the works. The distances listed above are from the nearest wind farm infrastructure within the same surface water catchment as the dwelling.
2. Each dwelling is assumed to have an on-site private water well.
3. Hydraulically up-gradient or remote. Remote meaning there is no dwelling (assumed well) down-gradient of the proposed development infrastructure.

Based on the above approach a number (7 no. as indicated as downstream listed in Table 8-18) of private dwelling houses were identified to be located down-gradient (i.e. downslope) of the proposed wind farm infrastructure development (and in particular turbine and borrow pit locations). This assessment was focused on the turbine locations and borrow pits as this is where the deepest excavations will be required. All excavations required for roads, construction compounds and the substation will be relatively shallow and therefore no significant potential to impact on groundwater supplies will occur.

We are satisfied that the proposed development will not impact in any significant way on any existing down-gradient groundwater wells/springs for the following reasons:

- The large set back distances, and elevation differences between development site and down hill well locations;

- The proposed development will involve relatively shallow excavations, other than at borrow pits;
- The underlying bedrock is a low permeability poor/locally important aquifer (i.e. it is not regionally important, or karstified);
- Surface water is the dominant flow process in the area, not groundwater;
- There is limited mapped faulting in the area;
- There is high drainage density in the area, and down gradient of the wind farm site drainage is generally in a western direction. Most houses and wells are located to the north and northwest;
- Proposed access roads are largely in place already; and,
- The development is distributed across a wide site area.

### 8.2.16 Receptor Sensitivity

Due to the nature of wind farm developments, being near surface construction activities, impacts on groundwater are generally negligible and surface water is generally the main sensitive receptor assessed during environmental impact assessments. The primary risk to groundwater at the proposed development site would be from cementitious materials, hydrocarbon spillage and oil or chemical leakages (assessed at Sections 8.4.2.5 & 8.4.2.7) . 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 proposed development site during the construction and operational phases of the development and mitigation measures are proposed below to deal with these potential minor impacts.

Based on criteria set out in **Table 8.1**, groundwater at the proposed development site is classed as Not Sensitive to pollution because the bedrock is classified as a Poor Aquifer (PI). In addition, the majority of the proposed development site is covered in blanket peat which acts as a protective cover to the underlying aquifer. Any contaminants which may be accidently released on-site are more likely to travel to nearby streams within surface runoff.

Surface waters such as the Owenogarney River and the Coumnagun river (and related lakes downstream) are very sensitive to potential pollution. These rivers and associated lakes are known to be of trout potential and are important locally for fishing (see Biodiversity, Chapter 6).

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

Comprehensive surface water mitigation and controls are outlined below to ensure protection of all downstream receiving waters. Mitigation measures will ensure that surface runoff from the developed areas of the proposed development 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 proposed development site will mimic the existing hydrological regime thereby avoiding changes to flow volumes leaving the proposed development site. These details are discussed further below.

A hydrological constraints map for the proposed development site is shown as Figure 8.22. A self-imposed 75m buffer from streams was applied during the constraints mapping and will be maintained during the construction phase. Apart from the upgrade of existing roads and stream crossings, the proposed development is remote from areas on the proposed development site that have been determined to be hydrologically sensitive. The large setback distance from sensitive hydrological features means they will not be impacted on by excavations/drains etc. It also allows adequate space for the proposed drainage mitigation measures (discussed below) to be properly installed up-gradient of primary drainage features within sub-catchments. This will allow attenuation of surface runoff to be more effective.

## 8.3 CHARACTERISTICS OF THE PROJECT

The project comprises of the following:

- 19 No. Wind Turbines (blade tip height up to 169m) with external transformers.
- 19 No. Wind Turbine foundations and Hardstand areas.
- 1 No. Permanent Meteorological Mast (100m height) and associated hardstand areas.
- 1 No. Substation (110kV) including associated ancillary buildings (electrical building including control, switchgear and metering rooms, and the operational building including welfare facilities, workshop and office).
- Underground electrical collection and SCADA system linking each wind turbine to the on-site project substation.
- Upgraded Site Access
- New and upgraded internal site service roads (8.5km of existing tracks to be upgraded and 11.3km of new service roads to be constructed)
- Provision of an on-site Visitor cabin
- Construction of new roadways and localised widening along turbine delivery route
- Temporary construction site compounds and mobile welfare units
- 3 No. Borrow pits to be used as a source of stone material during construction and for storage of excess excavated peat materials
- 3 No. peat /spoil deposition areas (at borrow pit locations)
- Associated surface water management systems
- Onsite Conifer felling to facilitate infrastructure
- Underground cable for connection to National Electricity Grid
- Replacement replanting lands

### 8.3.1 Development Interaction with the existing forestry drainage network

In relation to hydrological constraints, a conservative self-imposed buffer zone of 75m has being put in place for on-site streams. Manmade forestry drains at the proposed Wind Farm site are not considered a hydrological constraint and therefore no buffering of forestry drains has been undertaken.

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

### 8.3.2 Proposed Drainage Management – Wind Farm site

A site drainage system will be constructed on the proposed Wind Farm site so as to attenuate run-off, guard against soil erosion and safeguard downstream water quality. The drainage system will be implemented along all internal site access roads, storage areas, crane hardstand areas and site construction temporary compounds. Details of the proposed site drainage system are given in **Planning Drawings 19107-5013-A to 19107-5019-A**.

The drainage system will be excavated and constructed in conjunction with the road and crane hardstand construction.

The concepts and details pertaining to the drainage philosophy are described in Chapter 3 (Section 3.17) of the EIAR prepared as part of this planning application.

The following gives an outline of drainage management arrangements:

The surface water run-off drainage system will be implemented along all internal access routes, to separate and collect 'dirty water' run-off from the roadway and to intercept clean over land surface water flows from crossing internal roadways.

To achieve separation, clean water drains will be positioned on the upslope and dirty water drains positioned on the downslope of road sides, with road surfaces sloped towards dirty drains.

Clean water will be piped under both the access roads and downslope collection drains to avoid contamination. Piping the clean water under the service road allows the clean water to follow the course it would have taken before construction thus mimicking the existing surface water over land flow pattern of the proposed development site and thus not altering the natural/existing hydrological regime on site. Noting that the natural hydrology of the wind farm site is already altered by the imposition of the current forestry drainage regime.

Measures addressed in the drainage design include:

- Check dams will be placed at regular intervals, based on slope gradient, along all drains to slow down runoff and to encourage settlement and to reduce scour and ditch erosion.
- Check dams will be constructed in accordance with best practice utilising clean stone at points along the drainage channel during the construction phase to further mitigate against any sediment escaping to nearby watercourses.
- Low gradient drains will be provided. These reduce the velocity of flow in the drains, thus reducing soil and subsoil erosion and reducing hydraulic loading to watercourses.
- Where possible existing drains will remain untouched.
- Regular buffered outfalls that consist of numerous small drains off the main drain which end by fanning out into the surrounding vegetation by tapering drains. The drain will contain hard-core material to entrap suspended sediment.
- Drains carrying construction site runoff will be diverted into settlement ponds, which will promote sediment deposition and reduce hydraulic loading by slowing flow velocities allowing sediment to settle. Settlement ponds have been designed in the form of a three stage tiered pond system. The design of the settling pond system for the proposed development site is detailed in the **Planning Drawings 19107-5013-A to 19107-5019-A**.. These will be maintained

by the contractor to the satisfaction of the client's engineers and IFI for the entire construction period.

- Flow from the settlement ponds will enter the sediment traps where runoff will be cleaned further by a series of graded gravel filters. Silt traps will require regular inspection and cleaning and removed material will be disposed of at an appropriate location such as an on-site borrow pit.
- Drainage ditch outfalls from silt traps will discharge at regular intervals to mimic the natural hydrology by encouraging percolation and by decreasing individual hydraulic loadings from discharge points. The drainage ditches will flow onto the existing ground by fanning out onto the surrounding vegetation via tapering drains.
- The access roads will be graded so that all runoff is directed to the dirty water drains. A low mound will be constructed between the road and the clean water drain to ensure that runoff from the road cannot flow into the clean water system.
- No disturbance will be permitted to the natural vegetative buffer. They can be fenced where necessary.

Best practice and practical experience on other similar projects suggests that in addition to the above outlined drainage plans there are additional site based decisions and plans that can only be made in the field through interaction between the Site Construction Manager, the Project Hydrologist and the Project Geotechnical Engineers. In relation to decisions that are made on site it is important to stress that these will be implemented in line with the associated drainage controls and mitigation measures outlined above and to ensure protection of all watercourses. These details are included in the CEMP and Surface Water Management System for the project (See Appendix 3.1 and Appendix 3-2).

## 8.4 LIKELY SIGNIFICANT EFFECTS

### 8.4.1 Do-Nothing Scenario

Under the Do-Nothing scenario, the area will continue to be used for commercial forestry purposes which will be subject to felling licences and application of Forestry Guidelines. There will be no alteration of the existing hydrological regime.

### 8.4.2 Construction Phase Potential Impacts (pre-mitigation)

#### *8.4.2.1 Clear felling of Coniferous Plantation*

It is estimated that 67.66ha (hectares) in total of existing plantation forestry will be felled to allow for development of the proposed wind farm and Delivery route infrastructure.

The total amount of forestry to be felled accounts for ~9.4% of the forestry coverage at the proposed development site. As part of the ongoing forest cycle at Carrownagowan, these trees would be felled at some stage, whether the wind farm proceeds or not.

Potential impacts during tree felling occur mainly from:

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

**Pathways**: Drainage and surface water discharge routes.

**Receptors**: Downstream surface water quality (in the Carrownagowan River, Cumnagun River, Inchaluchoge River (Ballymacdonnell), Killuran River, and the Owenogarney River) and associated dependent aquatic ecosystems (Doon Lough NHA).

**Pre-Mitigation Potential Impact:** Negative, indirect, moderate, short term, likely impact on surface water quality and dependent aquatic ecosystems.

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

The project which includes the proposed development (wind farm and turbine delivery route) and the grid construction, works activities that will require earthworks resulting in removal of vegetation cover and excavation of peat, mineral subsoil (where present) and bedrock, are detailed in the Civil Engineering Chapter (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;
- Runoff from site roads, borrow pits, substation site, and the development footprint;

- Construction of the grid connection cable trench resulting in entrainment of sediment from the excavations during construction; and,
- Erosion of sediment from emplaced site drainage channels.

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

**Pathways**: Drainage and surface water discharge routes.

**Receptors**: Wind Farm - down-gradient rivers (water quality in the Carrownagowan River, Cumnagun River, Inchaluchoge River (Ballymacdonnell), Killuran River, and the Owenogarney River) and dependent aquatic ecosystems (Lough Doon NHA).

Grid route - down-gradient rivers (water quality in the Killuran River, the Broadford River, the Snaty River and the Blackwater River).

**Pre-Mitigation Potential Impact:** Negative, indirect, significant, short term, likely impact on down-gradient rivers (water quality) and dependent aquatic ecosystems.

#### *8.4.2.3 Potential Impacts on Groundwater Levels and Local Well Supplies During Wind Farm Excavation works & from proposed Borrow Pits*

Dewatering of borrow pits has the potential to impact on local groundwater levels and local supply wells during the construction phase (if located very close by, within 100 to 200m). Release of contaminants within excavations has the potential to impact on groundwater quality of downstream wells.

The proposed 3 no. borrow pit areas comprises outcropping bedrock on elevated ground. No significant groundwater dewatering will be required as rock excavation will progress in a horizontal manner into the side of outcropping bedrock. There will be no significant impacts on local groundwater levels or flows as a result of the proposed borrow pits because there are no/very low dewatering requirements. The main water control requirements at borrow pits will be management of surface water inflows.

The bedrock aquifer in the area of the proposed development is classified as a Poor bedrock aquifer by the GSI. Therefore, due to the natural prevailing geology at the borrow pit sites, the groundwater body underlying the borrow pit is at low risk of contamination originating from extraction operations. Nevertheless, mitigation measures to protect against impacts on groundwater quality arising from the use of hydrocarbons are dealt with in Section 8.4.1.3 below. During the construction phase, potential impacts on groundwater quality within the borrow pits (in the absence of appropriate mitigation measures) are most likely to arise from the use of hydrocarbons.

The topographical and hydrogeological setting of the proposed borrow pits locations means no significant groundwater dewatering is anticipated to be required during the operation of the borrow pits. Moreover, direct rainfall and surface water runoff will be the main inflows that will require water volume and water quality management. We estimated that 95% of water management at borrow pits will be rainfall/surface water, with the remainder being small groundwater inflows. For the avoidance of doubt, we would generally define dewatering as a requirement to permanently drawdown the local groundwater table by means of over pumping, e.g. as would be required for the operation of a bedrock quarry in a valley floor. This example is very different in scale and operation from the proposed operation of a temporary shallow borrow pit on the side of a hill. In order to explain this thoroughly we will outline our reasoning in a series of bullet points as follows:

- Firstly, the borrow pit areas are located on the side of local hills where the ground elevations are between 220 and 420m OD;
- These elevations are above the elevations of the local valleys and streams;
- The proposed borrow pits will be between approximately 8 – 10m below ground level which is notable. However, in the context of the topographical/elevated setting of the borrow pits, this depth range is relatively shallow;
- The local bedrock comprises sandstones and Silurian meta-sediments and is known to be generally unproductive in terms of generating large groundwater flows. This means that groundwater flows will be relatively minor and localised to discrete cracks (faults/fissures/weathered zones) in the bedrock;
- The flow paths (i.e. the distance from the point of recharge to the point of discharge) in this type of geology will be short, localised, and will also be relatively shallow. This is why there is such a high density of surface water streams across the proposed development site;
- No regional groundwater flow regime, i.e. large volumes of groundwater flow, will be encountered at these elevations;
- Therefore, shallow groundwater inflows will largely be fed by recent rainfall, and possibly by limited groundwater seepage from localised shallow bedrock;
- The sloping nature of the ground on the hills where the borrow pits are proposed along with the coverage of soil means groundwater recharge is going to be very low;
- As such the shallow groundwater flow system will be small in comparison to the expected surface water flows from the bog surface;
- This means that there will be a preference for high surface water runoff as opposed to groundwater recharge and flow; and,
- As such, the management of surface water will form the largest proportion of water to be managed and treated.

Relevant environmental management guidelines from the EPA quarry 2006 guidance document – "Environmental Management in the Extractive Industry" in relation to groundwater issues will be implemented during the construction phase. These include:

- Control of suspended solids by settlement in sumps and lagoons;
- Appropriate design of sumps and lagoons;
- Avoidance of scouring at discharge points; and,
- Provide pollution control measures such as bunding in relation to fuel and chemical storage.

In terms of local well supplies, the assessment undertaken in Section 8.2.14 above 3 no. groundwater wells which act as water supply sources for 3 no Group Water Schemes within 7km of the proposed development site. A zone of contribution assessment has been completed for both the Bodyke and Raheen GWS boreholes. These ZoC's are limited in area extent and do not coincide with the proposed development site boundary. The Bodyke GWS ZOC is the closest of these two to the proposed development site. The closest point of this ZOC is ~0.8km from the northern site boundary and ~2.5km from the nearest turbine. The Raheen GWS ZoC boundary is ~4.5km from the northern site boundary.

An assessment on the ZoC for the Carrowcore GWS borehole has not yet been completed by the GSI, however given that it is ~7km northeast of the proposed development site and with groundwater from the east of the proposed development site expected to flow west towards Lough Derg, there will be no impact on the Carrowcore GWS. Therefore, there are no well supplies down-gradient of any proposed development area that can be impacted on.

We have completed an assessment of private wells in Section 8.2.15.2. A number of private dwelling houses were identified to be located down-gradient (i.e. downslope) of the proposed wind farm infrastructure development (and in particular turbine and borrow pit locations).

We are satisfied that the proposed development will not have a significant effect on any existing down-gradient groundwater wells/springs for the following reasons:

- The large set back distances, and elevation differences between development site and downhill well locations;
- The proposed development will involve relatively shallow excavations, other than at borrow pits;
- The underlying bedrock is a low permeability poor/locally important aquifer (i.e. it is not regionally important, or karstified);
- Surface water is the dominant flow process in the area, not groundwater;
- There is limited mapped faulting in the area;
- There is high drainage density in the area, and down gradient of the wind farm site drainage is generally in a western direction. Most houses and wells are located to the north and northwest;
- Proposed access roads are largely in place already; and,
- The development is distributed across a wide site area.

**Pathway:** Groundwater flow paths.

**Receptor:** Down-gradient water supplies (springs and groundwater wells).

**Pre-Mitigation Potential Impact:** Negative, indirect, slight, short term, unlikely impact on down-gradient water supplies.

#### *8.4.2.4 Excavation Dewatering and Potential Impacts on Surface Water Quality*

Some minor groundwater/surface water seepages will likely occur in turbine base excavations and borrow pits, along the grid route trench, and the delivery route works area and these may generate small additional volumes of water to be treated by the runoff management system. Inflows will likely require management and treatment to reduce suspended sediments. No contaminated land was noted at the proposed development site or along the grid route trench?.

**Pathway:** Overland flow and site drainage network.

**Receptor:** Wind farm - Down-gradient surface water quality (in the Carrownagowan River, Cumnagun River, Inchaluchoge River (Ballymacdonnell), Killuran River, and the Owenogarney River).

Grid route - Surface water quality (in the Killuran River, the Broadford River, the Snaty River and the Blackwater River, and associated tributaries).

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

#### *8.4.2.5 Potential Release of Hydrocarbons during Construction and Storage*

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

**Pathway:** Groundwater flowpaths and site drainage network.

**Receptor:** Wind Farm - Groundwater (in the Tulla-Newmarket GWB) and surface water quality (in the Carrownagowan River, Cumnagun River, Inchaluchoge River (Ballymacdonnell), Killuran River, and the Owenogarney River).

Delivery Route - Groundwater (in the Tulla-Newmarket GWB).

Grid route - Surface water flows, stream morphology (in the Killuran River, the Broadford River, the Snaty River and the Blackwater River, and associated tributaries).

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

#### *8.4.2.6 Groundwater and Surface Water Contamination from Wind Farm Wastewater Disposal*

Release of effluent from on site 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:** Wind Farm - Down-gradient well supplies, groundwater quality (in the Tulla-Newmarket GWB) and surface water quality (in the Carrownagowan River, Cumnagun River, Inchaluchoge River (Ballymacdonnell), Killuran River, and the Owenogarney River).

Grid route - Surface water quality (in the Killuran River, the Broadford River, the Snaty River and the Blackwater River, and associated tributaries).

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

#### *8.4.2.7 Release of Cement-Based Products*

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

**Pathway:** Site drainage network.

**Receptor:** Wind Farm - Surface water quality (in the Carrownagowan River, Cumnagun River, Inchaluchoge River (Ballymacdonnell), Killuran River, and the Owenogarney River).

Grid route - Surface water quality (in the Killuran River, the Broadford River, the Snaty River and the Blackwater River, and associated tributaries).

**Pre-Mitigation Potential Impact:** Negative, indirect, moderate, short term, likely impact to surface water quality.

#### *8.4.2.8 Morphological Changes to Surface Watercourses & Drainage Patterns by Watercourse Crossings and Culverts (Proposed development and grid route)*

On the proposed wind farm development site, a number of watercourse crossings will be required, detailed as follows:

- 4 No. of New Clear Span Watercourse Crossings
- 3 No. of New Piped Culvert Crossings
- 6 No. of Existing Piped Culvert Widenings

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

It is proposed that only 7 no. new stream crossings (4 no clear span, and 3 no. piped culvert crossings) and 6 no. existing stream crossing upgrades will be required to facilitate the proposed wind farm development.

Refer to Figure 8.23 for existing and proposed crossing locations.

Along the grid route, a number of additional watercourse crossings will be required, detailed as follows:

- 9 No. Bridge Crossings
- 18 No. Culvert Crossings

Bridge crossings will either be completed by one of the following methods (refer to Section 3.10.2 of the EIAR):

- Crossings over the bridge using standard trefoil formation
- Flatbed formation over bridges
- Directional drilling under bridges and watercourses

**Pathway:** Site drainage network, local streams and rivers.

**Receptor:** Wind Farm - Surface water flows, stream morphology (in the Carrownagowan River, Cumnagun River, Inchaluchoge River (Ballymacdonnell)) and surface water quality (in the Carrownagowan River, Cumnagun River, Inchaluchoge River (Ballymacdonnell), Killuran River, and the Owenogarney River).

Grid route - Surface water flows, stream morphology (in the Killuran River, the Broadford River, the Snaty River and the Blackwater River, and associated tributaries).

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

#### *8.4.2.9 Potential Hydrological Impacts on Designated Sites*

The closest designated site to the proposed development is the Slieve Bernagh Bog SAC (Site code: 002312). This SAC borders the proposed development site and extends both north, east and south of the proposed wind farm development site. The southern part of the Slieve Bernagh bog is at a higher elevation (up-gradient) to the proposed wind farm site, therefore no part of the proposed development site will drain towards this section of the bog. The northern part of Slieve Bernagh bog is situated at a lower elevation (down-gradient) than the proposed wind farm, and part of the proposed development site will drain towards this area. An assessment of elevation differences and hydrological connections is presented in Section 8.2.14. This SAC includes downstream sections of the Killuran and Owenogarney Rivers.

Doon Lough NHA is situated ~3.5km southwest of the proposed development site, but some 7.64km along the shortest connected watercourse from the proposed development site. The Killuran River and Owenogarney River flow southwest from the proposed development site and they both discharge into Doon Lough.

The closest SPA to the proposed development site is the Lough Derg (Shannon) SPA (Site code: 004058). The SPA is located 3.8km east of the proposed development site and is not hydrologically connected to the proposed wind farm development site.

**Southwest - T1, T2, T3 and T4**

The natural slope in this area is from Slieve Bernagh Bog SAC area down towards the forestry site and the proposed wind farm site. The natural elevation changes along this boundary are significant, e.g. between the SAC and proposed T3 location the elevation change is 27.4m, i.e. the ground elevation at the turbine location is 27.4m lower than at the SAC boundary over a separation distance of 199.3m. The SAC is up-gradient of turbines T1, T2, T3 and T4.

In addition, there is a very significant firebreak excavation along this boundary between the SAC and turbines T1, T2, T3 and T4. This excavation ranges from 2-3m deep and 8-10m wide, and mineral soil is exposed at the base of the fire break excavation. The excavation effectively breaks any shallow hydrological link between the peat water levels in the SAC and the downhill area. Peat water drains into the fire break excavation, and discharges to downstream drainage via surface water drainage outlets.

In addition to these prevailing conditions, downhill of the fire break the forestry plantation has an altered drainage regime with mound drains installed in the peat. There is also ongoing tree felling and replanting in this area of the forestry plantation.

Based on separation distances (>150m buffer to SAC boundary), the elevation differences between the SAC boundary and proposed development, the presence of significant bounding fire break, and the existing altered drainage regime there is no potential for alteration of the natural peatland hydrology within the SAC as a result of the proposed wind farm development.

**Southeast - T8, T12, and T13**

The natural slope in this area is from the SAC area down towards the forestry plantation and the proposed wind farm site. The natural elevation changes along this boundary are significant, e.g. between the SAC and proposed T12 location the elevation change is 36.6m, i.e. the ground elevation at the turbine location is 36.6m lower than at the SAC boundary over a distance of ~275m. The SAC is up-gradient of turbines T8, T12, and T13.

In addition, there is a very significant forest road between the SAC and turbines T8, T12, and T13. This excavation ranges from 6-8m wide, and mineral soil is exposed on the upstream side of the forest road excavation. The excavation effectively breaks any shallow hydrological link between the peat water levels in the SAC and the downhill area. Peat water drains into the road drains, and discharges to downstream drainage via surface water drainage outlets.

In addition to these prevailing conditions, downhill of the forest road the forestry plantation has an altered drainage regime with mound drains installed in the peat. There is also ongoing tree felling and replanting in this area of the forestry plantation.

Based on separation distances (>150m buffer to SAC boundary), the elevation differences between the SAC boundary and proposed development, the presence of significant dividing forest road, and the existing altered drainage regime there is no potential for alteration of the natural peatland hydrology within the SAC as a result of the proposed wind farm development .

**Eastern - T14, T15, T16 and BP3**

The natural slope in this area is from the SAC area down towards the existing forestry plantation and the proposed wind farm site. The natural elevation changes along this boundary are moderate, e.g. between the SAC and proposed T15 location the elevation change is ~11m, i.e. the ground elevation at the turbine location is ~11m lower than at the SAC boundary over a distance of ~412m. The SAC is across gradient of turbines T14, T15 and T16, and the SAC is upgradient of BP3.

In addition, there is a very significant firebreak excavation along this boundary between the SAC and turbines T14, T15 and T16 and borrow pit 3. This excavation is approximately ~1-2m deep and 6-8m wide, and mineral soil is exposed within the fire break excavation. The excavation effectively breaks any shallow hydrological link between the peat water levels in the SAC and the downhill area. Peat water drains into the fire break excavation, and discharges to downstream drainage via surface water drainage outlets.

In addition to these prevailing conditions, downhill of the firebreak the forestry plantation has an altered drainage regime with mound drains installed in the peat. There is also ongoing tree felling and replanting in this area of the forestry plantation.

Based on separation distances (>150m buffer to SAC boundary), the elevation differences between the SAC boundary and proposed development, the presence of significant bounding fire break, and the existing altered drainage regime there is no potential for alteration of the natural peatland hydrology within the SAC as a result of the proposed wind farm development.

**<u>Northern - T19, and Met Mast, Delivery Works Areas</u>**

The natural slope in this area is from the Turbine 19 and met mast area down towards the SAC. The natural elevation changes along this boundary are significant, e.g. between the Turbine 19 and the SAC is ~25m, i.e. the ground elevation at the turbine location is ~25m higher than at the SAC boundary over a distance of ~432.5m. The SAC is across gradient of all infrastructure at T19 and the Met Mast.

There is an east-west flowing stream between the proposed development (T19 and Met Mast are the closest proposed infrastructure) and the SAC to the north. All natural drainage in this area flows from east to west towards the Inchaluchoge River. The stream effectively breaks any shallow hydrological link between the water levels in peat to the south of the stream and the SAC to the north. Peat water from the south drains into the existing natural stream.

In addition to these prevailing conditions, within the proposed development the forestry plantation has an altered drainage regime with mound drains installed in the peat. There is also ongoing tree felling and replanting in this area of the forestry plantation.

Based on separation distances (>150m buffer to SAC boundary), the elevation differences between the SAC boundary and the proposed development, the presence of hydrological boundary, and the existing altered drainage regime there is no potential for alteration of the natural peatland hydrology within the SAC as a result of the proposed wind farm development.

**Pathway:** Surface water flowpaths and groundwater levels and flowpaths.

**Receptor:** Down-gradient water quality and designated sites (Lough Derg, Doon Lough NHA, and lough O'Grady pNHA). Upgradient groundwater and peat water levels within Slieve Bernagh Bog SAC.

**Pre-Mitigation Potential Impact:** Negative, indirect, imperceptible, short term, unlikely impact on down-gradient water quality and designated sites (Lough Derg, Doon Lough, and Lough O'Grady). Negative, indirect, imperceptible, long term, unlikely impact on up-gradient groundwater levels and peat water levels within Slieve Bernagh Bog SAC.

#### *8.4.2.10 Grid Connection – Potential Effects on Hydrology of Glenomra Wood SAC*

Approximately 434m of grid route is located within the Glenomra Wood SAC boundary. All of which is located in the existing county road, which while within the designated area, the road itself carries no ecological value. The excavation and reinstatment of the grid route trench along this section will take less than 1 week of work, and the works will be temporary and transient. The shallow nature of the trench excavation works means that no impacts on groundwater will occur, and the main pathway for transmission of impacts to the water environment is via surface water.

**Pathway:** Surface water flowpaths and groundwater levels and flowpaths.

**Receptor:** Water quality at designated site (Glenomra Wood SAC).

**Pre-Mitigation Potential Impact:** Negative, direct, imperceptible, short term, likely impact on surface water quality within Glenomra Wood SAC.

Negative, indirect, imperceptible, long term, unlikely impact on groundwater levels and groundwater quality within Glenomra Wood SAC.

### *8.4.2.11 Use of Siltbuster and Impact on Downstream Surface Water Quality*

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

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

The benefits of using a Siltbuster system in emergency scenarios where all other water treatment systems have proven ineffective are considerable. An example of treatment capability of siltbuster systems from northwest Mayo is provided in Figure 8.26. This is a duration curve of downstream water quality data post siltbuster treatment. The system was setup so that any water not meeting discharge criteria was recycled back to the settlement ponds. The graph shows all data, and only 24 data points out of 1194 records were above 20 mg/L (i.e. recycling, and repeat treatment occurred at these times to ensure compliance at the discharge location).

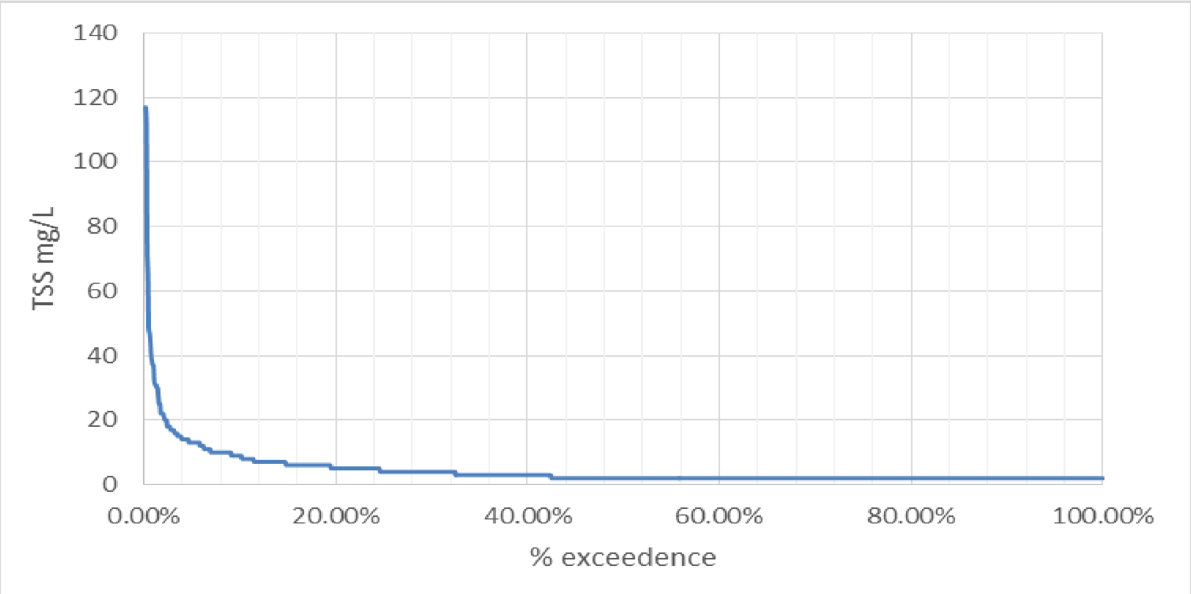



**Figure 8.26: TSS treatment data using Siltbuster systems (with chemical dosing)**

**Pathways:** Drainage and surface water discharge routes.

**Receptors:** Down-gradient rivers (in the Carrownagowan River, Cumnagun River, Inchaluchoge River (Ballymacdonnell), Killuran River, and the Owenogarney River).and associated dependent ecosystems (Doon Lough NHA).

**Pre-Mitigation Potential Impact:** Negative, slight, indirect, temporary, low probability effect.

#### *8.4.2.12 Replacement Forestry Lands*

The replacement forestry lands are either under forestry or previously had forestry (Ballard and Trillackacurry) or constitute agricultural or grassland (Cooraclare). Their use for forestry plantation and replanting is suitable land use.

Existing and future forestry works will be completed under licence and in line with the Department of Agriculture, Food and the Marine, 2019, Standards for Felling and Reforestation to ensure best practice for water quality protection.

**Pathways**: Drainage and surface water discharge routes.

**Receptors**: Down-gradient rivers and streams.

**Pre-Mitigation Potential Impact:** Negative, indirect, imperceptible, likely impact on down-gradient rivers and streams.

#### *8.4.2.13 Turbine Delivery Route*

Turbine delivery route works will require earthworks in 3 no. small areas resulting in removal of vegetation cover and excavation of peat and mineral subsoil (where present), as detailed in the Civil Engineering Chapter (Chapter 3). Potential sources of sediment laden water include:

- Drainage and seepage water resulting from infrastructure excavation;
- Runoff from the road footprint; 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. However, due to the small nature of the proposed works on the turbine delivery route potential impacts will be imperceptible, but mitigation to protect watercourses will be installed. Maximum depth of excavations will be between 0.5 to 2.4mbgl. The distance to local watercourses from these works areas is considerable, so the potential for impact on water quality is low.

Approximately half of the proposed Area 2 land take is located within the ZoC for the Bodyke GWS. Works in this area will be surface based and will not alter groundwater flow and recharge in the area, and therefore will not generate a significant impact on the operational water supply or its associated groundwater system. The area effected is approximately 0.83Ha, and the total area of the Bodyke ZoC is 58.71 Ha, i.e. ~1.4% of the ZoC will have some temporary near surface works completed. There will be no significant impact on groundwater quality or quantity as a result of these works, and no knock on effect on the operation of the Bodyke GWS.

**Pathways**: Drainage and surface water discharge routes.

**Receptors**: Down-gradient rivers (local streams including Drummod_27 (EPA assigned name), and Newtown_27) and dependent aquatic ecosystems (Lough Doon NHA).

Groundwater quality, and groundwater recharge and flow within the ZoC to the Bodyke GWS.

**Pre-Mitigation Potential Impact:** Negative, indirect, imperceptible, short term, unlikely impact on down-gradient rivers (water quality) and dependent aquatic ecosystems.

Negative, indirect, imperceptible, short term, unlikely impact on groundwater recharge and groundwater quality within the ZoC to the Bodyke GWS.

### 8.4.3 Operational Phase - Potential Impacts (pre-mitigation)

Potential impacts on the water environment during operation are limited by virtue of the fact that the site is relatively static during the operational phase, with all construction works being complete, and drainage and runoff will be clean.

There is a potential that runoff rates/volumes might increase due to the increased hardstanding areas created by the wind farm construction, and some minor potential effects from siltation and hydrocarbons in maintenance vehicles, and this potential effect is assessed below.

#### *8.4.3.1 Progressive replacement of Natural surfaces with lower permeability surfaces*

Progressive replacement of the vegetated surface with impermeable surfaces could potentially result in an increase in the proportion and speed of surface water runoff reaching the surface water drainage network. The proposed wind farm footprint comprises turbine hardstanding, upgraded access roads, sub-station and construction compounds. During storm rainfall events, additional runoff coupled with increased velocity of flow could increase hydraulic loading, resulting in erosion of watercourses and impact on aquatic ecosystems.

The emplacement of the proposed permanent development footprint, as described in Chapter 3 of the EIAR, (assuming emplacement of impermeable materials as a worst-case scenario) could result in an average total site increase in surface water runoff of approximately ~1,219 $m^3$/month (Table 8-19). This represents a potential increase of approximately 2.39 % in the average daily/monthly volume of runoff from the proposed development site area in comparison to the baseline pre-development site runoff conditions (refer to Section 8.2.5). This is a very small increase in average runoff and results from the naturally high surface water runoff rates and the relatively small area of the proposed development site being developed, the proposed total permanent development footprint being approximately 30.47 ha, representing ~4.06% of the total study area of 749.69 ha.

The increase in runoff from the proposed development will therefore be negligible. This is even before mitigation measures will be put in place. Therefore, there will be no risk of exacerbated flooding down-gradient of the proposed development site.

Table 8-19: Water Balance and Estimated Development Runoff Volumes

| Baseline Runoff/month ($m^3$) | Baseline Runoff/day ($m^3$) | Permanent Footprint Area ($m^2$) | Footprint Area 100% Runoff ($m^3$) | Footprint Area 95% Runoff ($m^3$) | Net Increase/month ($m^3$) | Net Increase/day ($m^3$) | % Increase from Baseline Conditions ($m^3$) |
|---|---|---|---|---|---|---|---|
| 599,752 | 1,643 | 304,700 | 25,595 | 24376 | 1219 | 39.3 | 2.39% |

The additional volume in all sub-catchments is low due to the fact that the runoff potential from the proposed development site is naturally high (95%), and also that the increase is distributed across the proposed development site, and not at a single point source. Also, this calculation assumes that all hardstanding areas will be impermeable which is unlikely to be the case (because the hardstanding and access roads will not be 100% impermeable, as they are constructed from granular material). The increase in runoff from the proposed development will, therefore, be negligible. This is even before mitigation measures will be put in place.

**Pathway:** Site drainage network.

**Receptor:** Surface waters flows and surface water quality (in the Carrownagowan River, Cumnagun River, Inchaluchoge River (Ballymacdonnell), Killuran River, and the Owenogarney River).

**Pre-Mitigation Impact:** Negative, indirect, slight, permanent, likely impact on surface waters flows and surface water quality.

#### *8.4.3.2 Runoff Resulting in Suspended Solids Entrainment in Surface Waters*

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

These minor activities could, however, result in the release of suspended solids to surface water and could result in an increase in the suspended sediment load, resulting in increased turbidity which in turn could affect the water quality and fish stocks of downstream water bodies (in the Carrownagowan River, Cumnagun River, Inchaluchoge River (Ballymacdonnell), Killuran River, and the Owenogarney River). Potential effects could be significant if not mitigated against.

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

**Pathways:** Drainage and surface water discharge routes.

**Receptors:** Down-gradient rivers (in the Carrownagowan River, Cumnagun River, Inchaluchoge River (Ballymacdonnell), Killuran River, and the Owenogarney River) and associated dependent ecosystems (Doon Lough NHA).

**Pre-Mitigation Potential Impact:** Negative, slight, indirect, temporary, low probability effect.

#### *8.4.3.3 Groundwater and Surface Water Contamination from Wind Farm Wastewater Disposal*

Release of effluent from on site 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:** Wind Farm - Down-gradient well supplies, groundwater quality (in the Tulla-Newmarket GWB) and surface water quality (in the Carrownagowan River, Cumnagun River, Inchaluchoge River (Ballymacdonnell), Killuran River, and the Owenogarney River).

Grid route - Surface water quality (in the Killuran River, the Broadford River, the Snaty River and the Blackwater River, and associated tributaries).

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

### 8.4.4 Decommissioning Phase – Potential Impacts

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

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

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

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

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

### 8.4.5 Risk of major accidents and disasters

Wind farms are not generally associated with major risks regarding the water environment. The main risk would be from a peat landslide, and this issue is addressed in Chapter 9.

### 8.4.6 Cumulative effects

The proposed development site is on land managed for commercial forestry by Coillte. It is proposed that all on-site forestry activities will cease for the duration of the wind farm construction and commissioning phase. Forestry operations, outside of the proposed development site, will resume again post commissioning of the wind farm. As such there will be no cumulative impacts with forestry operations at the proposed development site. The construction of the grid connection is within the public road network and works will only require relatively localised excavation, installation, and construction, progressing along the public road.

To account for the tree felling required as part of the Proposed Development, 3 no. sites across Co. Clare, Co. Longford and Co. Wicklow are proposed for replanting. The existing baseline environment for the forestry replacement lands sites is described in Section 8.2. There is no potential for cumulative effects on the water environment, with regard to the replanting sites. Each site has prior technical approval for forestry. There is limited potential for significant cumulative effects associated with the sites and forestry operations due to their location and scale.

A cumulative impact assessment was undertaken for the Project regarding other wind farm developments. The developments assessed (including their turbines, substations, access roads and all ancillary aspects of the developments) are listed in Table 8-20 and are shown on Figure 8.25. In terms of the potential impacts of developments on downstream surface water bodies, the biggest risk is during the construction phase of the Proposed Development as this is the phase when earthworks and excavations will be undertaken at the proposed development site. However, within 20km of the proposed site inside the River Shannon catchment, 100% of the other wind farm developments are operational. In addition, operational phase drainage mitigation measures will ensure the risk to surface waters during this period is imperceptible to none. Implementation of the proposed drainage mitigation during the construction phase (Section 8.3.2) will ensure there will be no cumulative significant negative effects on the water environment from the project and other wind farm developments and non-wind farm developments (as discussed in Chapter 2) within the River Shannon catchment. Non-wind projects also include exempted development such as OPW arterial and drainage maintenance works. Exempted development includes minor works which have been screened out for EIA and AA.

In terms of cumulative hydrological effects arising from elements of the Proposed Development the potential for effects on water quality or flood flows is low as they are all contained within the proposed development site and therefore will be within the wind farm drainage catchment where all construction water will be attenuated and treated as described above (Sections 8.3, 8.3.2 and Table 8-20).

**Table 8-20: List of Other Developments Assessed for Hydrological Cumulative Impacts**

| Wind Energy Developments | Status | Total Turbine No. | Turbine No. in Shannon Catchment |
|---|---|---|---|
| Derrybrien | Existing | 71 | 9 |
| Curraghgruaige | Existing | 3 | 3 |
| Templederry | Existing | 2 | 2 |
| Knockastanna | Existing | 4 | 4 |
| Vistakon | Existing | 1 | 1 |
| Castlewalter | Permitted | 16 | 16 |
| Bunklmalta | Permitted undergoing JR | 16 | 16 |

In summary, the potential cumulative water quality impacts of the project during the construction and operational phases will not have significant effects on downstream watercourses owing to the environmental protection measures and drainage design of the project described in Section 8.3.2. Furthermore, the wind farms listed in Table 8-20 are all in different local river sub-catchments to the project and therefore significant cumulative effects are not reasonably foreseeable.

Due to the large separation distance between the proposed wind farm site, and other wind farm and non-wind farm related development/projects, and with the application of the proposed construction phase and operational phase drainage plans, no residual cumulative effects will occur.

## 8.5 MITIGATION

### 8.5.1 Construction Phase – Mitigation Measures

#### *8.5.1.1 Clear felling of Coniferous Plantation*

##### 8.5.1.1.1 Mitigation Measures

Best practice methods related to water incorporated into the forestry management and mitigation measures have been derived from:

- Forestry Commission (2004): Forests and Water Guidelines, Fourth Edition. Publ. Forestry Commission, Edinburgh;
- Coillte (2009): Forest Operations and Water Protection Guidelines;
- Coillte (2009): Methodology for Clear Felling Harvesting Operations;
- Department of Agriculture Food and the Marine, Forest Service (Draft): Forestry and Freshwater Pearl Mussel Requirements – Site Assessment and Mitigation Measures; and,
- Department of Agriculture Food and the Marine, Forest Service (2000): Forestry and Water Quality Guidelines. Forest Service, DAF, Johnstown Castle Estate, Co. Wexford.
- Department of Agriculture, Food and the Marine, 2019, Standards for Felling and Reforestation

##### 8.5.1.1.2 Mitigation by Avoidance

There is a requirement in the Forest Service Code of Practice and in the FSC Certification Standard for the installation of buffer zones adjacent to aquatic zones at planting stage. Minimum buffer zone widths recommended in the Forest Service (2000) guidance document "Forestry and Water Quality Guidelines" are shown in Table 8-21.

**Table 8-21: Recommended minimum buffer zone widths**

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

The concept of the use of buffer zones at planting stage for forestry development has been applied to wind farms developments in foestry areas. As such, during the wind turbine construction phase a self-imposed buffer zone of 75m will be maintained for all streams where possible. These buffer zones are shown on Figure 8.22. With the exception of existing road upgrades and proposed stream crossings all proposed tree felling areas are located outside of imposed buffer zones. Approximately 67.66 ha of permanent tree felling will be required within the proposed wind farm development site. Additional mitigation (detailed below) will be carried out where tree felling is required inside the buffer zones.

The large distance between proposed felling areas and sensitive aquatic zones means that potential poor quality runoff from felling areas will be adequately managed and attenuated prior to even reaching the aquatic buffer zone and primary drainage routes. Where tree felling is required in the vicinity of streams, the following additional mitigation measures will be employed.

#### 8.5.1.1.3 Mitigation by Design

All felling will take place prior to site mobilisation for wind farm construction works. So there will be an avoidance of felling works and construction works occurring at the same time. Also, all felling will be completed in line with a felling licence from the Forest Service and with the application of Forestry Guidelines (Department of Agriculture, Food and the Marine, 2019, Standards for Felling and Reforestation), in line with the mitigation outlined below.

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

- Machine combinations will be chosen which are most suitable for ground conditions at the time of felling, and which will minimise soils disturbance;
- Checking and maintenance of roads and culverts will be on-going through any felling operation. No tracking of vehicle through watercourses will occur, as vehicles will use road infrastructure and existing watercourse crossing points. Where possible, existing drains will not be disturbed during felling works;
- Ditches which drain from the proposed area to be felled towards existing surface watercourses will be blocked temporarily, while temporary silt traps will be constructed. No direct discharge of such ditches to watercourses will occur. Drains and sediment traps will be installed during ground preparation. Collector drains will be excavated at an acute angle to the contour (~0.3%-3% gradient), to minimise flow velocities. Main drains to take the discharge from collector drains will include water drops and rock armour, as required, where there are steep gradients, and will avoid being placed at right angles to the contour;

- Sediment traps will be sited in drains downstream of felling areas. Machine access will be maintained to enable the accumulated sediment to be excavated. Sediment will be carefully disposed of in the peat disposal areas. Where possible, all new silt traps will be constructed on even ground and not on sloping ground;
- In areas particularly sensitive to erosion or where felling inside the 75 metre buffer is required, it will be necessary to install double or triple sediment traps. This measure will be confirmed on site during construction;
- Double silt fencing will also be put down slope of felling areas which are located inside the 75 metre buffer zone;
- All drainage channels will taper out before entering the aquatic buffer zone. This ensures that discharged water gently fans out over the buffer zone before entering the aquatic zone, with sediment filtered out from the flow by ground vegetation within the zone. On erodible soils, silt traps will be installed at the end of the drainage channels, to the outside of the buffer zone;
- Drains and silt traps will be maintained throughout all felling works, ensuring that they are clear of sediment build-up and are not severely eroded. Correct drain alignment, spacing and depth will ensure that erosion and sediment build-up are minimized and controlled;
- Brash mats will be used to support vehicles on soft ground, reducing peat and mineral soils erosion and avoiding the formation of rutted areas, in which surface water ponding can occur. Brash mat renewal will take place when they become heavily used and worn. Provision will be made for brash mats along all off-road routes, to protect the soil from compaction and rutting. Where there is risk of severe erosion occurring from natural rainfall events (refer to Section 8.5.1.2.3), extraction will be suspended in advance of forecasted periods of high rainfall;
- Timber will be stacked in dry areas, and outside a local 75 metre watercourse buffer. Straw bales and check dams to be emplaced on the down gradient side of timber storage/processing sites;
- Works will be carried out during periods of no, or low rainfall, in order to minimise entrainment of exposed sediment in surface water runoff;
- Checking and maintenance of roads and culverts will be on-going through the felling operations;
- Refuelling or maintenance of machinery will not occur within 100m of a watercourse. Mobile bowser, drip kits, qualified personnel will be used where refuelling is required; and,
- Branches, logs or debris will not be allowed to build up in aquatic zones. All such material will be removed when felling operations have been completed, but care will be taken to avoid removing natural debris deflectors.

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

**Drain Inspection and Maintenance:**
The following items shall be carried out during inspection pre-felling and after:

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

**Surface Water Quality Monitoring:**
Sampling will be completed before, during and after the felling activity. The 'before' sampling will be conducted within 4 weeks of the felling activity, preferably in medium to high water flow conditions. The "during" sampling will be undertaken once a week or after rainfall events. The 'after' sampling will comprise as many samplings as necessary to demonstrate that water quality has returned to pre-activity status (*i.e.* where an impact has been shown).

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

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

- The above sampling strategy will be undertaken for all on-site sub-catchments streams where tree felling is proposed.

The details of this monitoring are included in the CEMP included with the EIAR at Appendix 3.1.

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

#### 8.5.1.2.1 Mitigation Measures

The key mitigation measure during the construction phase is the avoidance of sensitive aquatic areas where possible. From Figure 8.22 it can be seen that all of the key areas of the Proposed Development site is located significantly away from the delineated buffer zones with the exception of existing road upgrades, proposed stream crossings and existing stream crossings requiring upgrading. Additional control measures, which are outlined further on in this section, will be undertaken at these locations.

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

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

#### 8.5.1.2.2 Mitigation by Design

Details of the proposed site drainage system are given in Planning **Drawings 19107-5013-A to 19107-5019-A**. A Construction and Environmental Management Plan (CEMP) is provided at Appendix 3-1 and a Surface Water Management Plan (SWMP) is provided at Appendix 3-2.

**Source controls:**

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

**In-Line controls:**

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

**Treatment systems:**

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

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

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

- Apart from interceptor drains, which will convey clean runoff water to the downstream drainage system, there will be no direct discharge (without treatment for sediment reduction, and attenuation for flow management) of runoff from the proposed wind farm drainage into the existing site drainage network. This will reduce the potential for any increased risk of downstream flooding or sediment transport/erosion;

- Silt traps will be placed in the existing drains upstream of any streams where construction works / tree felling is taking place, and these will be diverted into proposed interceptor drains, or culverted under/across the works area;

- During the construction phase of the wind farm, runoff from individual turbine hardstanding areas will be not discharged into the existing drain network but discharged locally at each turbine location through stilling ponds and buffered outfalls onto vegetated surfaces;

- Buffered outfalls which will be numerous over the proposed development 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 proposed development site;

- Drains running parallel to the existing roads that requiring widening will be upgraded. Velocity and silt control measures such as check dams, sandbags, oyster bags, straw bales, flow limiters, weirs, baffles, silt fences will be used during the upgrade construction works. Regular buffered outfalls will also be added to these drains to protect downstream surface waters; and,

- Existing culverts will be lengthened where necessary to facilitate road widening. Larger culverts will be installed as required.

**Water Treatment Train**

A final line of defence can be provided by a water treatment train such as a “Siltbuster with chemical treatment” 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 will apply for all of the construction phase.

**Silt Fences**

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

**Silt Bags**

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

#### 8.5.1.2.3 Mitigation by Avoidance

**Pre-emptive Site Drainage Management**

The works program (~18 months) for the construction stage of the development will also take account of weather forecasts and predicted rainfall in particular. Large excavations and movements of peat/subsoil or vegetation stripping will be suspended or scaled back if heavy rain is forecast. The extent to which works will be scaled back or suspended will relate directly to the amount of rainfall forecast.

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

- General Forecasts**:** Available on a national, regional and county level from the Met Eireann website (www.met.ie/forecasts). These provide general information on weather patterns including rainfall, wind speed and direction but do not provide any quantitative rainfall estimates;

- MeteoAlarm: Alerts to the possible occurrence of severe weather for the next 2 days. Less useful than general forecasts as only available on a provincial scale;

- 3-hour Rainfall Maps: Forecast quantitative rainfall amounts for the next 3 hours but does not account for possible heavy localised events;

- Rainfall Radar Images: Images covering the entire country are freely available from the Met Eireann website (www.met.ie/latest/rainfall_radar.asp). The images are a composite of radar data from Shannon and Dublin airports and give a picture of current rainfall extent and intensity. Images show a quantitative measure of recent rainfall. A 3-hour record is given and is updated every 15 minutes. Radar images are not predictive; and,

- Consultancy Service: Met Eireann provide a 24-hour telephone consultancy service. The forecaster will provide interpretation of weather data and give the best available forecast for the area of interest.

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

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

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

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

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

**Management of Runoff from Peat and Subsoil Reinstatement Areas**

The total volume of peat to be extracted is estimated at 131,837 $m^3$. It is proposed that excavated peat will be used for landscaping throughout the proposed development site and any excess peat will be used to reinstate the 3 no. proposed borrow pits. All the proposed borrow pits are located outside the 75m stream and lake buffer zone (refer to Figure 8.22).

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

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

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

**Timing of Site Construction Works**

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

#### 8.5.1.2.4 Monitoring

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

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

During the construction phase field testing and laboratory analysis of a range of parameters with relevant regulatory limits and EQSs will be undertaken for each primary watercourse, and specifically following heavy rainfall events (as outlined in Chapter 6 of the CEMP).

### *8.5.1.3 Potential Impacts on Groundwater Levels and Local Well Supplies During Excavation works & from proposed Borrow Pits*

Based on the assessment outlined in Section 8.4.2.3, no mitigation measures are deemed necessary.

### *8.5.1.4 Excavation Dewatering and Potential Impacts on Surface Water Quality*

#### 8.5.1.4.1 Mitigation by Design:

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

- Appropriate interceptor drainage, to prevent upslope surface runoff from entering excavations will be put in place;
- If required, pumping of excavation inflows will prevent build-up of water in the excavation;
- The interceptor drainage will be discharged to the proposed development site constructed drainage system or onto natural vegetated surfaces and not directly to surface waters;
- The pumped water volumes will be discharged via volume and sediment attenuation ponds adjacent to excavation areas, or via specialist treatment systems such as a Siltbuster unit;
- There will be no direct discharge to surface watercourses, and therefore no risk of hydraulic loading or contamination will occur;
- Daily monitoring of excavations by a suitably qualified person will occur during the construction phase. If high levels of seepage inflow occur, excavation work will immediately be stopped and a geotechnical assessment undertaken; and,
- A mobile 'Siltbuster' or similar equivalent specialist treatment system will be available on-site for emergencies in order to treat sediment polluted waters from settlement ponds or excavations should they occur. Siltbusters are mobile silt traps that can remove fine particles from water using a proven technology and hydraulic design in a rugged unit. The mobile units are specifically designed for use on construction-sites. They can be used in combination with chemical dosing, and these systems are proven to be very effective in management of heavy contaminated site runoff from construction sites. They will be used as a final line of defence if needed.

#### *8.5.1.5 Potential Release of Hydrocarbons during Construction and Storage*

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

- On site re-fuelling of machinery will be carried out using a mobile double skinned fuel bowser. The fuel bowser will travel around the proposed development site by a 4x4 jeep to where machinery is located. The fuel truck (bowser) will also carry fuel absorbent material and pads in the event of any accidental spillages. Mobile towable fuel bowsers (if used) will be parked on a level area in the construction compound when not in use and only designated trained and competent operatives will be authorised to refuel plant on site. Mobile measures such as drip trays and fuel absorbent mats will be used during all refuelling operations;
- Onsite refuelling will be carried out by trained personnel only;
- Fuels stored on site will be minimised. Fuel storage areas if required will be bunded appropriately for the fuel storage volume for the time period of the construction and fitted with a storm drainage system and an appropriate oil interceptor;
- The plant used during construction will be regularly inspected for leaks and fitness for purpose; and,
- An emergency plan for the construction phase to deal with accidental spillages is included within the Construction and Environmental Management Plan (refer to Appendix 3.1). Spill kits will be available to deal with any accidental spillage in and outside the re-fuelling area.

#### *8.5.1.6 Groundwater and Surface Water Contamination from Wastewater Disposal*

##### 8.5.1.6.1 Mitigation By Avoidance

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

#### *8.5.1.7 Release of Cement-Based Products*

##### 8.5.1.7.1 Mitigation By Avoidance

The following mitigation measures are proposed:

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

- The pour site will be kept free of standing water and plastic covers will be ready in case of sudden rainfall event.

### *8.5.1.8 Morphological Changes to Surface Watercourses & Drainage Patterns by Watercourse Crossings and Culverts*

#### 8.5.1.8.1 Mitigation by Design – Proposed Development

Details of the proposed site drainage system are given in Planning **Drawings 19107-5013-A to 19107-5019-A**. A Construction and Environmental Management Plan (CEMP) is provided at Appendix 3-1 and a Surface Water Management Plan (SWMP) is provided at Appendix 3-2.

It proposed that new watercourses crossing will use clear span pre-cast concrete culvert crossings such as a bottomless arch or bottomless box culvert. The design of a clear span pre-cast concrete culvert crossings will ensure that:

- All proposed new stream crossings will be bottomless culverts and the existing banks will remain undisturbed. No in-stream excavation works are proposed and therefore there will be no impact on the stream at the proposed crossing location. In addition the following will be completed:
    a. The existing channel profile within the watercourse will be maintained;
    b. Gradients within the watercourse will not be altered;
    c. There will be unrestricted passage for all size classes of fish by retaining the natural watercourse stream / river bed;
    d. There will be no blockages within the watercourse. The large size of a clear span culvert allows for the passage of debris in the event of flood flow conditions;
    e. The natural watercourse velocity will not be changed;
    f. The clear span of a culvert will ensure that the existing stream / river bank is maintained during construction which will in turn avoid the occurrence of in-stream works;
- Where the proposed underground cabling route follows an existing road or road proposed for upgrade, the cable will pass over or below the culvert within the access road;
- Any guidance / mitigation measures proposed by the OPW or the Inland Fisheries Ireland will be incorporated into the design of the proposed crossings;
- As a further precaution, near stream construction work, will only be carried out during the period permitted by Inland Fisheries Ireland for in-stream works according to the Eastern Regional Fisheries Board (2016) guidance document "Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters", 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); and
- During the near stream construction work double row silt fences will be emplaced immediately down-gradient of the construction area for the duration of the construction phase. There will be no batching or storage of cement allowed in the vicinity of the crossing construction areas.

Where the crossing of an existing natural or artificial drainage / stream channel is unavoidable, a suitable crossing is proposed. This will be in the form of precast concrete or HDPE pipes as detailed in the Planning Drawings.

#### 8.5.1.8.2 Mitigation by Avoidance – Grid Route

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

The purpose of the constraint/buffer zone is to:

- Avoid physical damage to surface water channels;
- Provide a buffer against hydraulic loading by additional surface water run-off;
- Avoid the entry of suspended sediment and associated nutrients into surface waters from excavation and earthworks;
- Provide a buffer against direct pollution of surface waters by pollutants such as hydrocarbons; and,
- Provide a buffer against construction plant and materials entering any watercourse.

General Best Practice Pollution Prevention Measures will also include:

- Protection of the riparian zone watercourses by implementing a constraints zone around stream crossings, in which construction activity will be limited to the minimum, i.e. works solely in connection with duct laying at the stream crossing;
- No stockpiling of construction materials will take place within the constraints zone. No refuelling of machinery or overnight parking of machinery is permitted in this area;
- No concrete truck chute cleaning is permitted in this area;
- Works shall not take place at periods of high rainfall, and shall be scaled back or suspended if heavy rain is forecast;
- Plant will travel slowly across bare ground at a maximum of 5km/hr. Bog mats will be employed to protect tracked areas as necessary;
- Machinery deliveries shall be arranged using existing structures along the public road;
- All machinery operations shall take place away from the stream and ditch banks, apart from where crossings occur. Although no instream works are proposed or will occur;
- Any excess construction material shall be immediately removed from the area and taken to an appropriately licensed facility;
- No stockpiling of materials will be permitted in the constraint zones;
- Spill kits shall be available in each item of plant required to complete the stream crossing; and,
- Silt fencing will be erected on ground sloping towards watercourses at the stream crossings if required.

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

- The area around the drilling fluid batching, pumping and recycling plants shall be bunded using terram and sandbags in order to contain any spillages;
- One or more lines of silt fences shall be placed between the works area and adjacent rivers and streams on both banks;

- Accidental spillage of fluids shall be cleaned up immediately and transported off site for disposal at an appropriately licensed facility; and,
- Adequately sized skips will be used for temporary storage of drilling arisings during directional drilling works. This will ensure containment of drilling arisings and drilling flush.

Mitigation Measures relating to the use and storage of fuels and chemicals in terms of groundwater protection:

- Onsite re-fuelling of machinery will be carried out using a mobile double skinned fuel bowser, as described in Section 8.4.2.5 below. No maintenance of construction vehicles or plant will take place along the grid connection or temporary junction works areas;
- The plant used will be regularly inspected for leaks and fitness for purpose; and,
- Spill kits will be available to deal with accidental spillage.

### *8.5.1.9 Potential Hydrological Impacts on Designated Sites*

#### 8.5.1.9.1 <u>Mitigation Measures</u>

The proposed mitigation to protect downstream and hydrologically connected designated sites will include the following:

- Minimum design buffer zone to SAC of 150m; and,
- Drainage control measures (*i.e.* interceptor drains, swales, stilling ponds) will ensure that the quality of runoff from proposed development areas will be very high. Mitigation for surface water quality protection are outlined in Section 8.5.1.1, Section 8.5.1.2, Section 8.5.1.4, Section 8.5.1.5, Section 8.5.1.6, and Section 8.5.1.7.

### *8.5.1.10 Use of Siltbuster and Impact on Downstream Surface Water Quality*

#### 8.5.1.10.1 <u>Mitigation Measures</u>

Measures employed to prevent overdosing and potential chemical carryover:

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

#### *8.5.1.11 Replacement Forestry Lands*

##### 8.5.1.11.1 Mitigation Measures

The same as those defined in Section 8.4.2.1.

#### *8.5.1.12 Delivery Route*

##### 8.5.1.12.1 Mitigation Measures

The same as those defined in Sections 8.5.1.2, 8.5.1.5, 8.5.1.6, and 8.5.1.7.

### 8.5.2 Operational Phase – Mitigation Measures

#### *8.5.2.1 Progressive replacement of Natural surfaces with lower permeability surfaces*

##### 8.5.2.1.1 Mitigation by Design

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

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

#### *8.5.2.2 Runoff Resulting in Suspended Solids Entrainment in Surface Waters*

Mitigation measures for sediment control are the same as those outlined in Section 8.4.2.2.

Mitigation measures for control of hydrocarbons during maintenance works are similar to those outlined in Section 8.6.1.5. However, there will not be the same volume of vehicles and machinery on site during operation.

#### *8.5.2.3 Groundwater and Surface Water Contamination from Wastewater Disposal*

8.5.2.3.1 Mitigation By Avoidance

The wastewater generated during the operational phase will be managed by a holding tank which is of twin-hull design and fitted with an alarm to indicate levels and when it is due for empty. The holding tank will be emptied by a permitted contractor only.

### 8.5.3 Decommissioning Phase – Mitigation Measures

Some of the impacts will be avoided by leaving elements of the proposed development in place where appropriate as described in Chapter 2. The substation will likely be retained by ESB. The turbine bases will be rehabilitated by covering with local topsoil/peat in order to regenerate vegetation which will reduce runoff and sedimentation effects. Internal roads will remain as forest roads. Mitigation measures to avoid contamination by accidental fuel leakage and compaction of soil by on-site plant will be implemented as per the construction phase mitigation measures.

The potential impacts on the water environment during the decommissioning stage will be similar to those during the construction phase, and as such the proposed mitigation for the Decommissioning Phase are the same as those outlined in Section 8.4.1. Moreover, due to the relative long life of the wind farm infrastructure, it is likely that a revised/updated environmental assessment will be required at the time of decommissioning to account for any changes in baseline conditions at the proposed development site, and potential changes in assessment guidelines and legislation.

## 8.6 RESIDUAL EFFECTS

### 8.6.1 Construction Phase – Residual Effects

#### *8.6.1.1 Clear felling of Coniferous Plantation*

**Residual Effects:** The potential for the release of suspended solids to watercourse receptors is a risk to water quality and the aquatic quality of the receptor. Proven and effective measures to mitigate the risk of releases of sediment and nutrients during tree felling have been proposed above and these will break the pathway between the potential sources and downstream receptors. The residual effect is considered to be - Negative, slight, indirect, temporary, unlikely impact on surface water quality, and dependant ecosystems.

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

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

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

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

#### *8.6.1.3 Potential Impacts on Groundwater Levels and Local Well Supplies During Excavation works & from proposed Borrow Pits*

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

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

#### *8.6.1.4 Excavation Dewatering and Potential Impacts on Surface Water Quality*

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

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

#### *8.6.1.5 Potential Release of Hydrocarbons during Construction and Storage*

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

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

#### *8.6.1.6 Groundwater and Surface Water Contamination from Wastewater Disposal*

**Residual Effects:** No residual impact.

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

#### *8.6.1.7 Release of Cement-Based Products*

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

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

#### *8.6.1.8 Morphological Changes to Surface Watercourses & Drainage Patterns by Watercourse Crossings and Culverts*

**Residual Effects:** With the application of the best practice mitigation outlined above (Section 8.5.1.8), the residual effect at the wind farm site and along the grid route will be - Negative, imperceptible, direct, long term, unlikely impact on stream flows, stream morphology and surface water quality.

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

#### *8.6.1.9 Potential Hydrological Impacts on Designated Sites*

**Residual Effects:** No significant impacts (see impact assessment at Section 8.4.2.9, and discussion at Section 8.2.14). Water level impacts in Slieve Bernagh Bog SAC are prevented by buffering, and also by substantial drainage features between the SAC and the proposed development site. Water quality and hydrological impacts to downstream Doon Lough NHA and Lough O'Grady pNHA will be prevented by implementation of construction phase drainage mitigation as described in Section 8.5.1.1, Section 8.5.1.2,Section 8.5.1.4, Section 8.5.1.5, Section 8.5.1.6, and Section 8.5.1.7. Groundwater impacts and surface water quality impacts to Lough Derg SPA will not occur as there is no proposed development infrastructure in the northeastern part of the proposed development site that drains towards Lough Derg.

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

#### *8.6.1.10 Use of Siltbuster and Impact on Downstream Surface Water Quality*

**Residual Effects:** With the implementation of the dosing technology and the continual monitoring of pre and post treatment water, the appropriate volume of chemical agent can be added to ensure that chemical carryover concentrations are present only in tiny trace amounts which will not cause any . effects to receiving waters or associated aquatic ecology. The residual effect is - Negative, imperceptible, indirect, temporary, low probability effect on downstream water quality (in the Carrownagowan River, Cumnagun River, Inchaluchoge River (Ballymacdonnell), Killuran River, and the Owenogarney River, or Doon Lough NHA).

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

#### *8.6.1.11 Replacement Forestry Lands*

**Residual Effects:** The potential for the release of suspended solids to watercourse receptors is a risk to water quality and the aquatic quality of the receptor. Proven and effective measures to mitigate the risk of releases of sediment and nutrients during forestry replanting works have been proposed above and these will break the pathway between the potential sources and downstream receptors. The residual effect is considered to be - Negative, slight, indirect, temporary, unlikely impact on downstream surface water quality, and dependant ecosystems.

**Significance of Effects:** For the reasons outlined above, no significant effects on the surface water quality will not occur.

#### *8.6.1.12 Delivery Route*

**Residual Effects:** The potential for the release of suspended solids to watercourse receptors is a risk to water quality and the aquatic quality of the receptor. Proven and effective measures to mitigate the risk of releases of sediment have been proposed above and will break the pathway between the potential sources and the receptor. The residual effect will be - Negative, imperceptible, indirect, short term, unlikely impact on down-gradient rivers (i.e. local streams including Drummod_27 (EPA assigned name), and Newtown_27), and dependent aquatic ecosystems (Lough Doon NHA).

**Significance of Effects:** For the reasons outlined above, no significant effects on the surface water quality will not occur.

### 8.6.2 Operational Phase – Residual Effects

#### *8.6.2.1 Progressive replacement of Natural surfaces with lower permeability surfaces*

**Residual Effects:** The proposed development footprint is 30.47 ha, and this equates to ~4.06% of the total site area of 749.69 ha. Runoff from the proposed development is small in comparison to the wider site area. With the implementation of the proposed wind farm drainage measures as outlined above in Section8.5.2.1, the residual effect is - Negative, imperceptible, indirect, long-term, moderate probability effect on all downstream surface water bodies.

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

#### *8.6.2.2 Runoff Resulting in Suspended Solids Entrainment in Surface Waters*

**Residual Effects:** With the implementation, in the operational phase, of the proposed wind farm drainage measures as outlined above, and based on the post-mitigation assessment of runoff, the residual effects are - Negative, imperceptible, indirect, temporary, low probability effect on downstream water quality.

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

#### *8.6.2.3 Groundwater and Surface Water Contamination from Wastewater Disposal*

**Residual Effects:** No residual impact.

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

### 8.6.3 Decommissioning Phase – Residual Effects

The potential impacts associated with the decommissioning works are similar to the construction works but of a reduced magnitude, due to their reduced scale. There will be no likely significant residual effects from the Decommissioning works on the water environment.

## 8.7 CONCLUSIONS

HES have completed a thorough assessment of the proposed development in respect of the water environment.

### 8.7.1 Summary of Effects on Water Environment

We have concluded that no significant impacts on the water environment from the Proposed Development will occur during construction, operation, or during decommissioning phases of the wind farm, the grid connection, and the forestry replanting works.

Our assessment also confirms that there will be no cumulative effects on water environment as a result of the proposed development, the grid connection or the forestry replacement lands when assessed in conjunction with all other existing, approved or proposed projects.

## 8.8 REFERENCES

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