9. HYDROLOGY AND HYDROGEOLOGY

9.1 Introduction

9.1.1 Background and Objectives

Hydro-Environmental Services (HES) was engaged by MKO to carry out an assessment of the potential significant effects of the proposed wind farm development on water aspects (hydrology and hydrogeology) of the receiving environment.

The objectives of the assessment are:

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

9.1.2 Statement of Authority

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

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

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

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

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

9.1.3 Scoping and Consultation

The scope for this chapter of the EIAR has also been informed by consultation with statutory consultees, bodies with environmental responsibility and other interested parties. This consultation process and the List of Consultees is outlined in Section 2.6 of this EIAR. Matters raised by Consultees in their responses with respect to the water environment are summarised in Table 9.1 below.

Table 9.1: Summary of Water Environment Related Scoping Responses

Consultee	Description	Addressed in Section
Geological Survey of Ireland (GSI)	• Assessment of Geohazards required, including peat stability, and groundwater flooding. • GSI have identified 3 local County Geological Sites, Crancreagh Mushroom Rock; Derrinlough Mushroom Rock; and, Drinagh Mushroom Rock. • Assessment of groundwater characteristics/resources and groundwater protection required. • Assessment of mineral resources and aggregates required.	Refer to Chapter 8: Land, Soils and Geology (Appendix 8.1) for a Geotechnical and Peat Stability Assessment. Flooding is addressed in Section 0. Groundwater assessment addressed at Section 9.3.8, Section 9.3.9, Section 9.3.10, Section 9.3.15, Section 9.5.3.2, Section 9.5.3.8, and Section 9.5.3.9. Refer to Chapter 8: Land, Soils and Geology for assessment of aggregate resources.
Department of Culture Heritage and Gaeltacht	• Where archaeological material is to be preserved in-situ, empirical measurements into the future hydrology of the site will be required, e.g. by mean of the use of dip wells (piezometers).	This issue related to Archaeology, but the type of potential monitoring is hydrological.
Department of Agriculture, Food and the Marine	• A response was received but mainly related to felling works.	As felling works does not form a part of this proposal no response is provided.

9.1.4 Relevant Legislation

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

The requirements of the following legislation are also 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 85/337/EEC and subsequent amendments, on the assessment of the effects of certain public and private projects on the environment;
- S.I. No. 293 of 1988: European Communities (Quality of Salmonid Waters) Regulations, resulting from EU Directive 78/659/EEC on the Quality of Fresh Waters Needing Protection or Improvement in order to Support Fish Life;

- S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 (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)

9.1.5 Relevant Guidance

The Hydrology and Hydrogeology chapter of the EIAR is carried out in accordance with guidance oytlined in Chapter 1: Introduction the guidance contained in the following:

- 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;
- Inland Fisheries Ireland (2016): Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters;
- Scottish Natural Heritage (2010): Good Practice During Wind Farm Construction;
- PPG1 - General Guide to Prevention of Pollution (UK Guidance Note);
- PPG5 – Works or Maintenance in or Near Watercourses (UK Guidance Note);
- CIRIA (Construction Industry Research and Information Association) (2006): Guidance on 'Control of Water Pollution from Linear Construction Projects' (CIRIA Report No. C648, 2006);
- CIRIA 2006: Control of Water Pollution from Construction Sites - Guidance for Consultants and Contractors (CIRIA C532, 2006).

9.2 Methodology

9.2.1 Desk Study

A desk study of the proposed development site, third party turbary lands and surrounding area was completed prior to the undertaking of field mapping and walkover assessments. The desk study involved collecting all relevant geological, hydrological, hydrogeological and meteorological data for the area. This included consultation of the following:

- Bord na Móna databases on peat depth and drainage;
- Environmental Protection Agency databases (www.epa.ie);
- Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Met Eireann Meteorological Databases (www.met.ie);
- National Parks and Wildlife Services Public Map Viewer (www.npws.ie);
- Water Framework Directive Map Viewer (www.catchments.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 15 (Geology of Galway-Offaly). Geological Survey of Ireland (GSI, 2003);
- Geological Survey of Ireland (2003) – Banagher Groundwater Body Initial Characterization Report, and Clara GWB Initial Characterization Report;
- OPW Indicative Flood Maps (www.floodinfo.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).

9.2.2 Baseline Monitoring and Site Investigations

A hydrological walkover survey, including detailed drainage mapping and baseline monitoring/sampling, was undertaken by HES between the 5th and 9th April 2019, and again between 9th and 11th September 2019. HES staff have undertaken ~60-man hours of site work. Geotechnical ground investigations and a peat stability assessment were also undertaken by Fehily Timoney & Company (FT) during 2019. The combined geological and hydrogeological dataset collated by HES and FT has been used in the preparation of this EIAR Chapter.

In summary, all site investigations to address the Hydrology and Hydrogeology chapter of the EIAR included the following:

- Walkover surveys and hydrological mapping of the site and the surrounding area were undertaken whereby water flow directions and drainage patterns were recorded;
- A total of 319 peat probes were undertaken by FT & HES in 2019 to determine the thickness and geomorphology of the blanket peat overlying the site;
- A Geotechnical and Peat Stability Assessment was undertaken by FT (Dec 2019a);
- Trial pitting by FT across the site at 69 no. locations;
- A total of 41 no. gouge core sample points were undertaken by HES across the site to investigate peat and mineral soil lithology;
- Field hydrochemistry measurements (electrical conductivity, pH, dissolved oxygen and temperature) and surface water flow measurements were taken to determine the origin and nature of surface water flows surrounding the site;
- A flood risk assessment for the proposed development has been undertaken by HES; and,
- A total of 20 no. surface water samples were taken to determine the baseline water quality of the primary surface waters originating from the proposed development site.

9.2.3 Impact Assessment Methodology

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

In addition to the above methodology, the sensitivity of the water environment receptors was assessed on completion of the desk study and baseline study. Levels of sensitivity which are defined in Table 9.2 are used to assess the potential effect that the proposed development may have on them.

Table 9.2 Receptor Sensitivity Criteria (Adapted from www.sepa.org.uk)

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

9.3 Receiving Environment

9.3.1 Site Description and Topography

The Derrinlough Wind Farm site (“the site”) which is a Bord na Móna peat bog is a combination of two bogs, Clongawny to the west and Drinagh to the east, split by the N62 which runs north-south. The site is located approximately 2km to the south of the village of Cloghan and 7km northeast of Birr in County Offaly. The total site area is approximately 2,360 ha (~23.67km^2).

The Bord na Móna Derrinlough Peat Briquette Factory is located between the two bogs, along the N62 on the eastern side of the road. This plant processes the peat from a number of bogs in the midlands into briquettes and consists of the factory and a number of ancillary buildings. A site compound (known as Clongawny Tea Centre) relating to the currently ceased peat harvesting works exists close to the main site entrance on the western bog site (Clongawny). The majority of the overall site comprises heavily drained cutover raised bog. A number of active industrial rail lines intersect Clongawny and

Drinagh bogs and these railways service the adjacent bogs and the Bord na Móna Derrinlough Peat Briquette Factory.

The topography of the development site is relatively flat with an elevation range of between approximately 53 and 62mOD (metres above Ordnance Datum). Along the majority of the site boundaries, a ~1-2m high peat headland exists which is a remnant of the original bog. These headlands and in some areas remnant peat banks create a boundary berm, forming a basin effect within the extraction areas of the overall bogs. There are some areas of higher ground at the centre and southwest of Clongawny bogs and these are covered with conifer forestry.

The surface of Clongawny bog is drained by a network of northeast / southwest orientated drains that are typically spaced every 15 to 20m. Larger arterial drains run northwest-southeast which connect the smaller field drains. On the western Clongawny bog, these drains typically slope gently towards perimeter settlement ponds and surface water outfalls. Surface water outflows from Clongawny bog are located at the north and north-eastern edges, and also at the south and southwestern boundaries of the site. All bar the northern outfall are drained by gravity.

The surface of Drinagh bog is drained by a network of north / south orientated drains that are typically spaced every 15 to 20m. Larger arterial drains run north-south also, and these connect the smaller field drains. Surface water outflows from Drinagh bog are located at the northwest and southeast. Both outfalls are drained by gravity.

A site location map is included as Figure 1.1.

9.3.2 Water Balance

Long term rainfall and evaporation data was sourced from Met Éireann. The 30-year annual average rainfall recorded at the Banagher rainfall station, located ~4.5km west of the site are presented in Table 9.3.

Table 9.3 Local Average long-term Rainfall Data (mm)

Station		X-Coord		Y-Coord		Ht (MAOD)		Opened		Closed		
Edenderry		200,400		216,000		37		1928		N/A		
Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
80	59	65	54	60	62	58	84	75	85	79	82	842

The closest synoptic station where the average potential evapotranspiration (PE) is recorded is at Birr, approximately 10km south of the site. The long-term average PE for this station is 445mm/yr. This value is used as a best estimate of the site PE. Actual Evaporation (AE) at the site is estimated as 422mm/yr (which is 0.95 × PE).

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

Effective rainfall (ER) = AAR – AE

= 842 mm/yr – 422mm/yr

ER = 420mm/yr

Based on groundwater recharge coefficient estimates from the GSI (www.gsi.ie) an estimate of 18mm/year average annual recharge is given for basin peat in this area (recharge coefficient of ~4%). This means that the hydrology of the site is characterised by very high surface water runoff rates and very low groundwater recharge rates. Therefore, conservative annual recharge and runoff rates for the site are estimated to be 17mm/yr and 403mm/yr respectively.

In addition to average rainfall data, extreme value rainfall depths are available from Met Éireann. A summary of various return periods and duration rainfall depths for the Derrinlough Wind Farm site are presented in Table 9.4

Table 9.4 Drinagh Return Period Rainfall depths (mm)

	Return Period (Years)			
Storm Duration	1	5	30	100
5 mins	3.8	6.6	13.9	17.1
15 mins	6.2	10.9	19.5	28.0
30 mins	7.8	12.3	22.9	32.0
1 hour	10	16.2	26.8	36.5
6 hours	18.6	27.2	40.4	51.5
12 hours	23.6	33.3	47.3	58.9
24 hours	30	40.6	55.5	67.3
2 days	37.1	48.6	63.9	75.8

9.3.3 Regional Hydrology

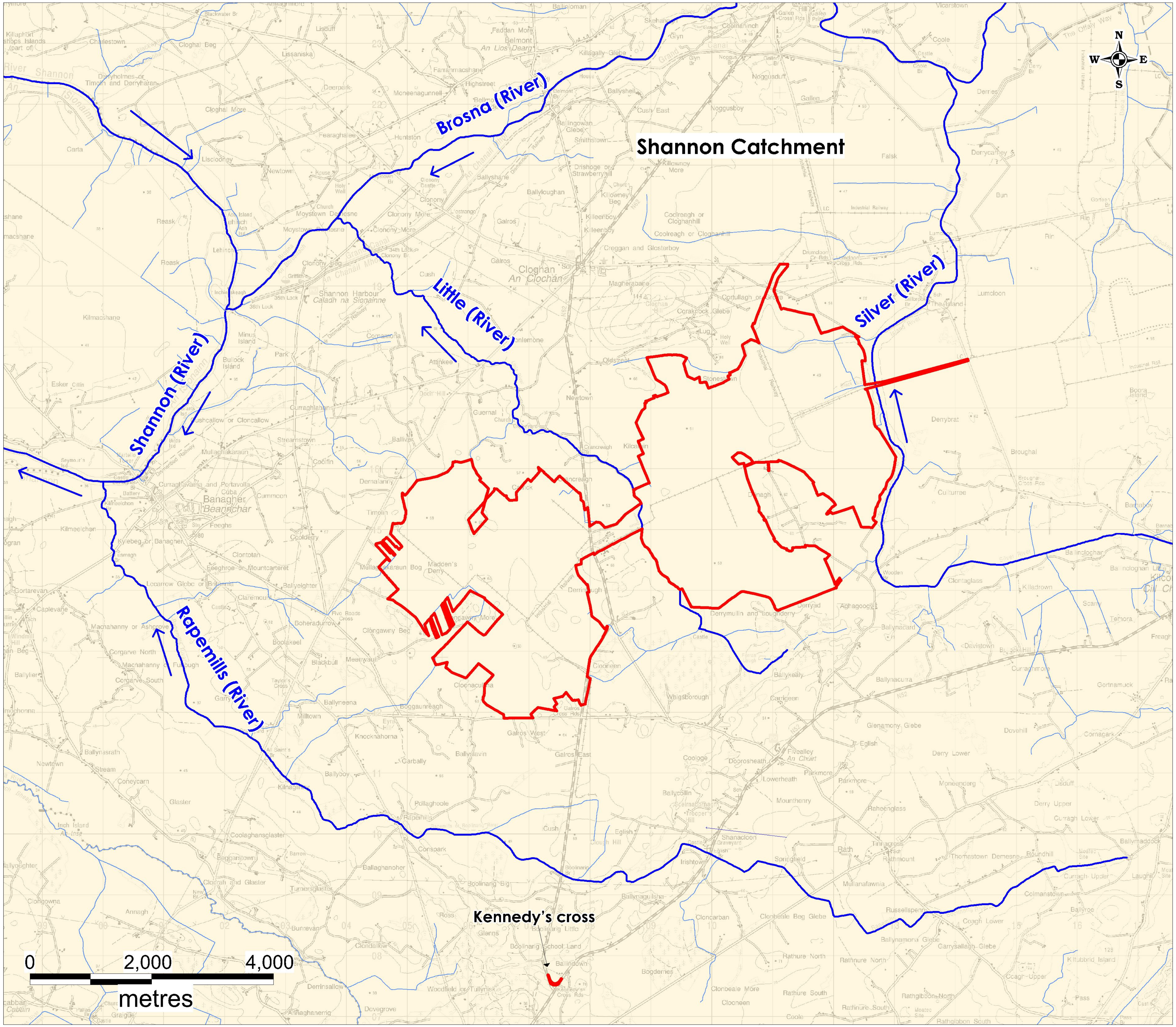
Regionally the proposed development site is located in the River Shannon surface water catchment (IE25_01) within Hydrometric Area 25 of the Shannon International River Basin District. A regional hydrology map is shown as Figure 9.1.

On a more local scale, the majority of the site is located in the Brosna river sub-catchment (Brosna_SC_080). The Little River flows in a northwesterly direction through the centre of the site and crosses the N62 ~1.5km north of the Derrinlough Briquette factory. The Little river discharges to the Brosna river at the confluence in the townland of Moytown Demense, ~5.5km northwest of the site. The Brosna then flows west, where it meets the River Shannon near Shannon Harbour.

The eastern side of the Drinagh bog is mapped within the Brosna_SC_070 sub-catchment. The Silver River flows north through this catchment, along the eastern boundary of the site. It flows north before joining the Brosna river ~3km southeast of Ferbane.

The western edge of the site, within the Clongawny bog, is drained by the Shannon lower sub-catchment (Shannon [Lower]_SC_040). A number of small tributaries flow west/southwest before joining the Rapemills river, which drains the sub-catchment. The Rapemills river then flows north for ~5.5km before entering the Shannon river just west of Banagher.

A local hydrology map is shown as Figure 9.2.



Legend

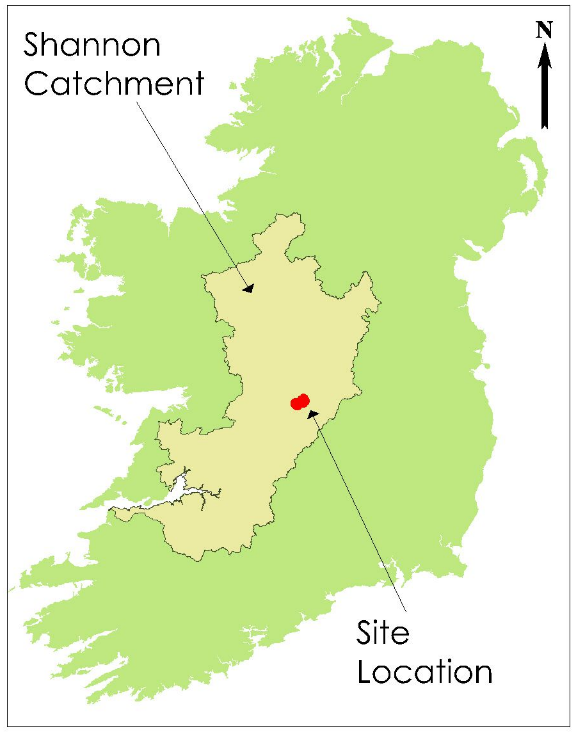
EIAR Site Boundary

Rivers

Rivers / Streams

Flow direction

Key Plan



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Client: Bord na Mona Powergen Ltd

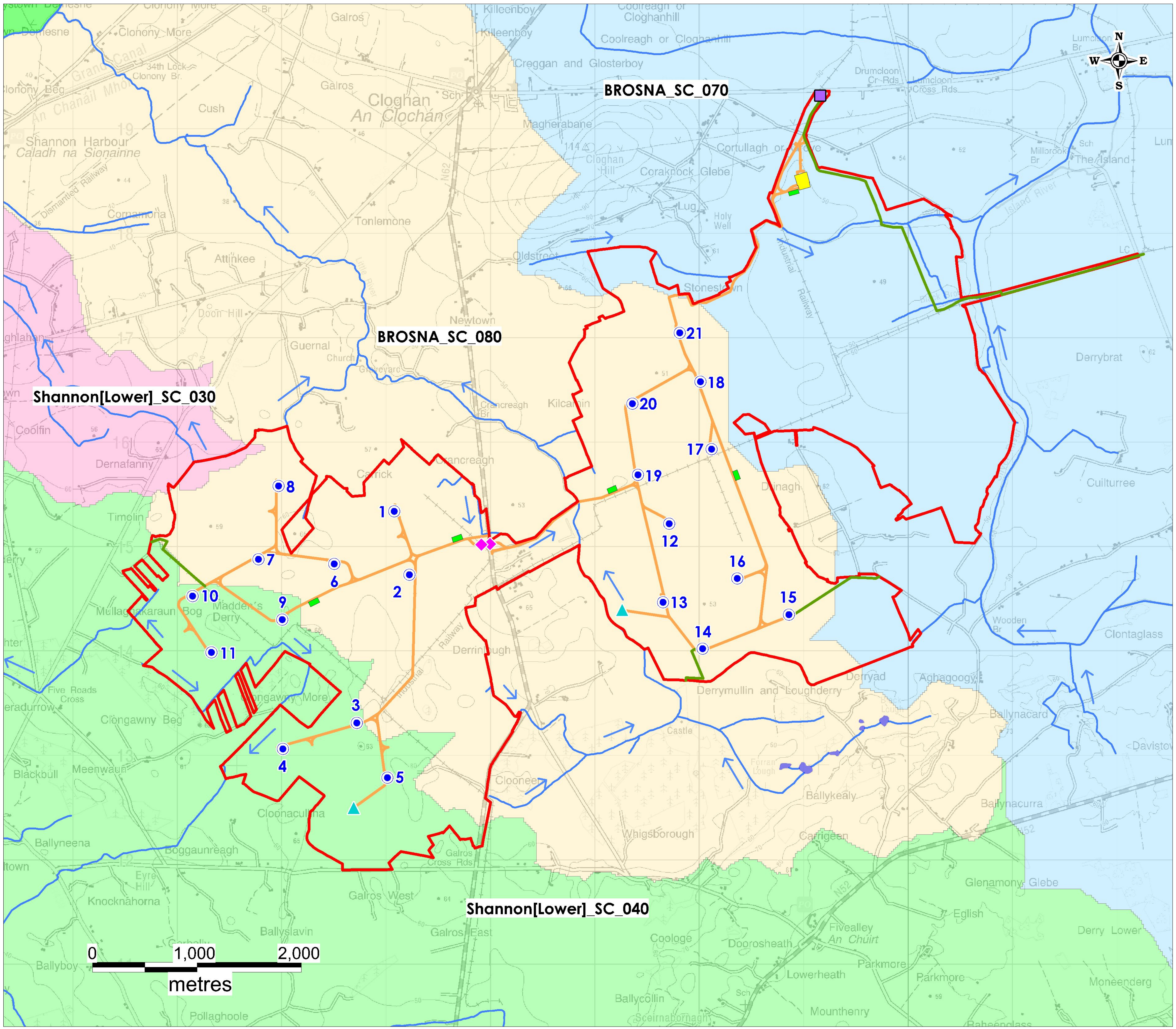
Job: Derrinlough WF, Co. Offaly

Title: Regional Hydrology Map

Figure No: 9.1

Drawing No: P1463-0-0220-A3-901-00A

Sheet Size: A3	Project No: P1463-0
Scale: 1:60,000	Drawn By: GD
Date: 07/02/2020	Checked By: MG



Legend

- EIAR Site Boundary
- Proposed Turbine Location
- Proposed Met Mast Location
- Proposed 110kV Electricity Substation Compound
- Proposed Temporary Construction Compound
- Proposed Amenity Link
- Proposed New Site Roads
- Proposed Visitor Car Park (Operational Phase)
- Proposed Underpass Locations
- Rivers
- Flow Direction

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Client: Bord na Mona Powergen Ltd	
Job: Derrinlough, Co. Offaly	
Title: Local Hydrology Map	
Figure No: 9.2	
Drawing No: P1463-0-0220-A3-902-00A	
Sheet Size: A3	Project No: P1463-0
Scale: 1:35,000	Drawn By: GD
Date: 07/02/2020	Checked By: MG

9.3.4 Site Drainage

In general, the overall site area comprising the two bogs is relatively flat. The topography ranges from ~53 – 62 mOD, with gentle slopes in some locations.

The surface of Clongawny bog is drained by a network of northeast / southwest orientated drains that are typically spaced every 15 to 20m. Larger arterial drains run northwest-southeast which connect the smaller field drains. On the western Clongawny bog, these drains typically slope gently towards perimeter settlement ponds and surface water outfalls. Surface water outflows from Clongawny bog are located at the north and north-eastern edges, and also at the south and southwestern boundaries of the site. All bar the northern outfall are drained by gravity.

The surface of Drinagh bog is drained by a network of north / south orientated drains that are typically spaced every 15 to 20m. Larger arterial drains run north-south also, and these connect the smaller field drains. Surface water outflows from Drinagh bog are located at the northwest and southeast. Both outfalls are drained by gravity.

An existing site drainage map is shown within Figure 9.3.

There are 3 no. pumping stations across the two bogs (P15/006, P15/007, and P15/008). These are identified on the site drainage map (Figure 9.3). Max discharge from the pumping stations are designed to be below greenfield runoff rates and are rated for removal of rainfall events equivalent to 15mm in 1 hour (approx. -5yr return period).

Surface water draining/pumped from the site is routed via large settlement ponds prior to discharge to off-site drainage channels which flow into the local rivers (i.e. Little River and Silver river). A flow diagram of the existing drainage system is shown in Figure 9.4 below.

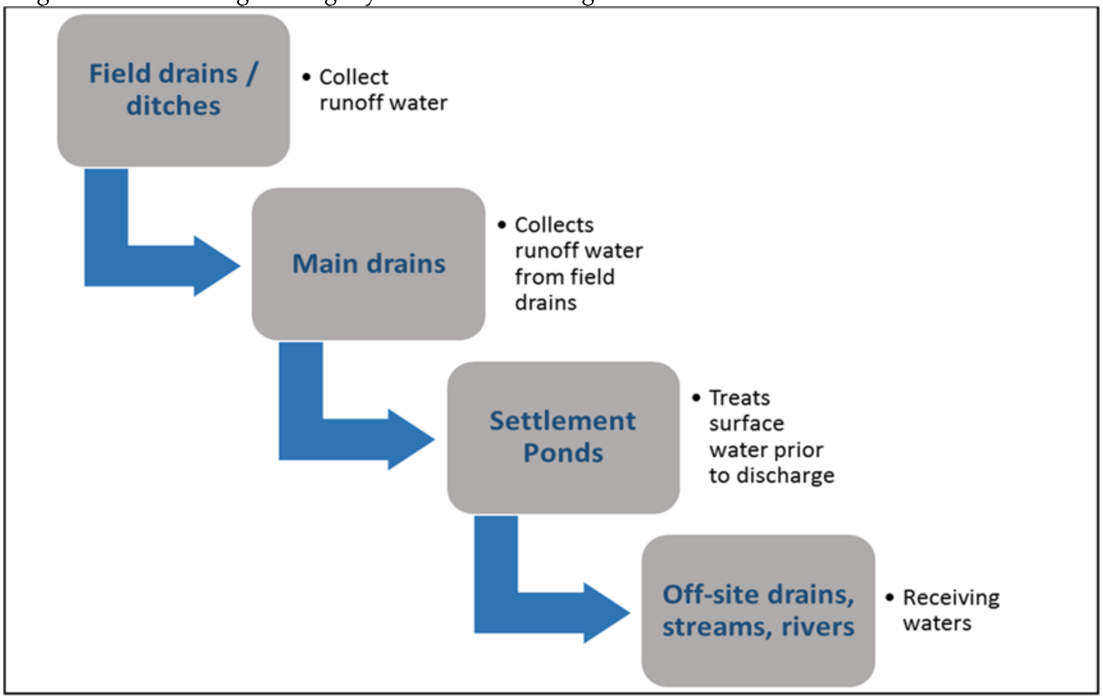
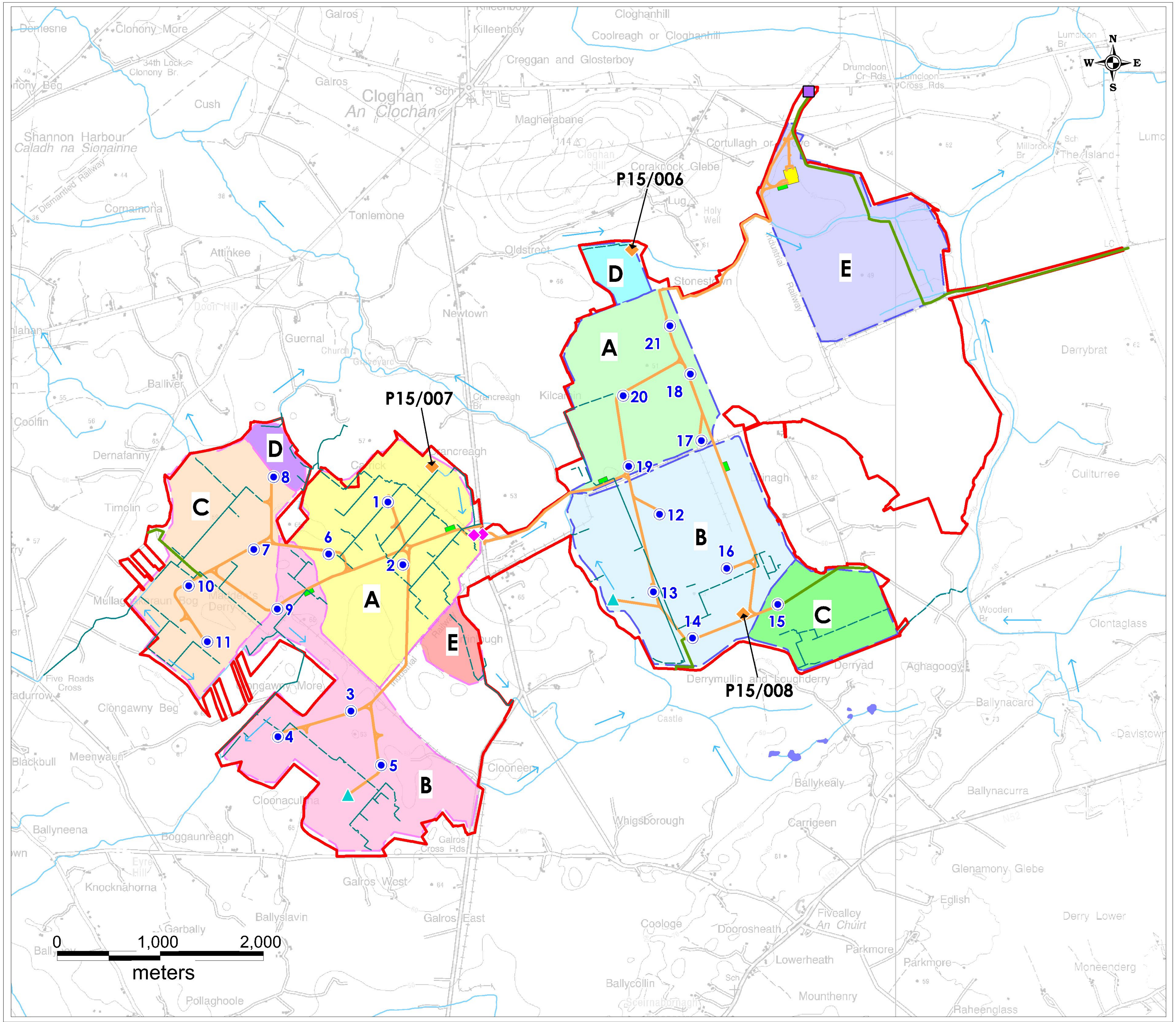


Figure 9.4: Process Flow Diagram for Existing Drainage System



Legend

- EIAR Site Boundary
- Proposed Turbine Location
- Proposed Met Mast Location
- Proposed 110kV Electricity Substation Compound
- Proposed Temporary Construction Compound
- Proposed Amenity Link
- Proposed New Site Roads
- Proposed Visitor Car Park (Operational Phase)
- Proposed Underpass Locations
- Pump Stations
- Piped drains
- Open drains
- Rivers/Streams
- River Flow Direction
- Lakes
- A-E Clongaway Bog Subcatchments
- A-E Drinagh Bog Subcatchments

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Sheet Size: A3	Project No: P1463-0
Scale: 1:35,000	Drawn By: GD
Date: 07/02/2020	Checked By: MG

9.3.5 Baseline assessment of site runoff

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

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

The water balance calculations are carried out for the month with the highest average recorded rainfall minus evapotranspiration, for the current baseline site conditions (Table 9.5). It represents, therefore, the long-term average wettest monthly scenario in terms of volumes of surface water runoff from the site pre-wind farm development. The surface water runoff co-efficient for the site is estimated to be 96% based on the predominant peat coverage (refer to Section 9.3.2).

The highest long-term average monthly rainfall recorded at Banagher over 30 years occurred in the month of December, at 82mm. The average monthly evapotranspiration for the synoptic station at Birr over the same period in December was 2.7mm. The water balance presented in Table 9.6 indicates that a conservative estimate of surface water runoff for the site during the highest rainfall month is 2,008,454m^3/month or 64,798m^3/day for the proposed development site.

Table 9.5: Water Balance and Baseline Runoff Estimates for Wettest Month (December)

Water Balance Component	Depth (m)
Average December Rainfall (R)	0.082
Average December Potential Evapotranspiration (PE)	-0.007
(AE = PE x 0.95)	-0.0067
Effective Rainfall December (ER = R - AE)	0.0887
Recharge (4% of ER)	0.0035
Runoff (96% of ER)	0.0851

Table 9.6: Baseline Runoff for the Site

Study Area	Approx. Area (ha)	Baseline Runoff per Wettest month (m^3)	Baseline Runoff per day (m^3) in wettest month
Development Site	2,360	2,008,454	64,789

9.3.6 Flood Risk Assessment

This section presents an overview of the flood risk assessment undertaken for the proposed development. The full flood risk assessment report for the proposed Derrinlough Wind Farm is provided as Appendix 9.1.

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

No recurring flood incidents within the site boundary were identified from OPW's indicative river and coastal flood map - Refer to Plate 9.1.

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

Much of the site is mapped as "Benefiting Lands". Benefiting lands are defined as a dataset prepared by the Office of Public Works identifying land that might benefit from the implementation of Arterial (Major) Drainage Schemes (under the Arterial Drainage Act 1945, as amended) and indicating areas of land subject to flooding or poor drainage.

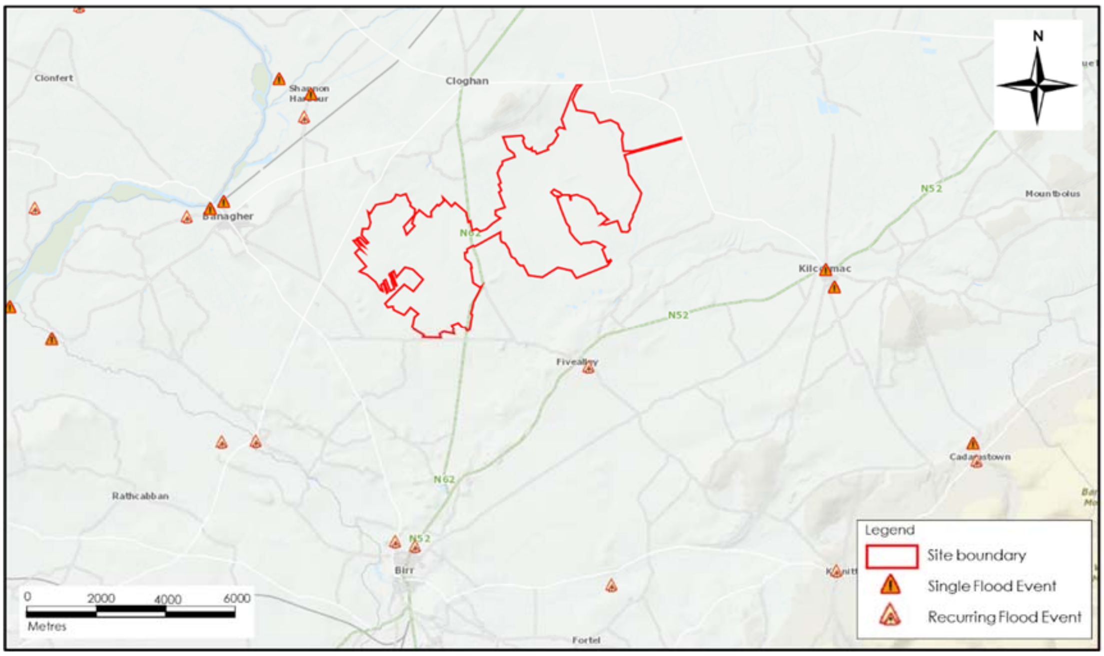


Plate 9.1: OPW's indicative river and coastal flood map.

The PFRA mapping (www.cfram.ie) shows the extents of the indicative 1 in 100-year flood zone which relates to fluvial (i.e. river) flood events (refer to Plate 9.2 below). The vast majority of the proposed development site is located outside of the 1 in 100-year flood zone (Flood Zone A) with the exception of a section on the north-eastern corner of the site and along the eastern and middle boundary of the proposed site. All proposed turbine locations and the access roads are outside of the fluvial indicative 1 in 100-year fluvial flood zone.

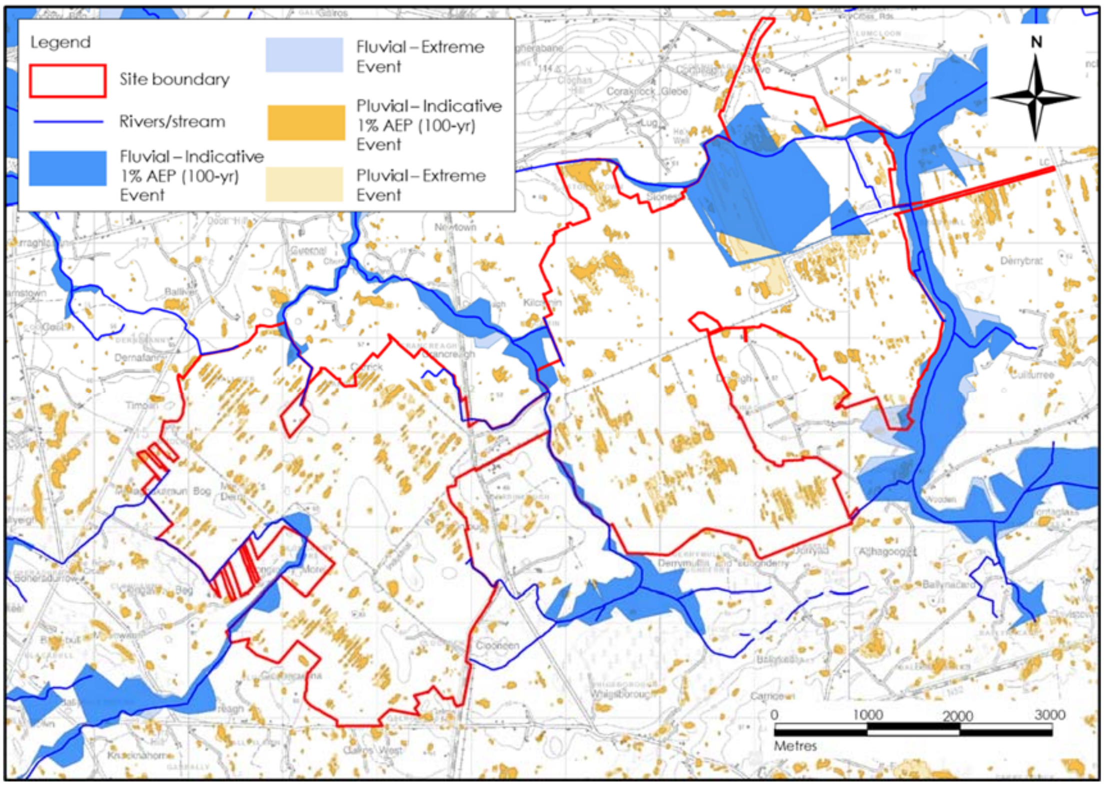


Plate 9.2: Local PFRA flood zone mapping

Also shown on the PFRA mapping is the indicative extent of pluvial flooding (i.e. flooding from rainfall ponding). As seen from Plate 9.2, pluvial flooding appears to occur along the main drainage channels within the site and this is as a result of surface water runoff backing up in the drainage routes when the capacity of the outfalls are exceeded.

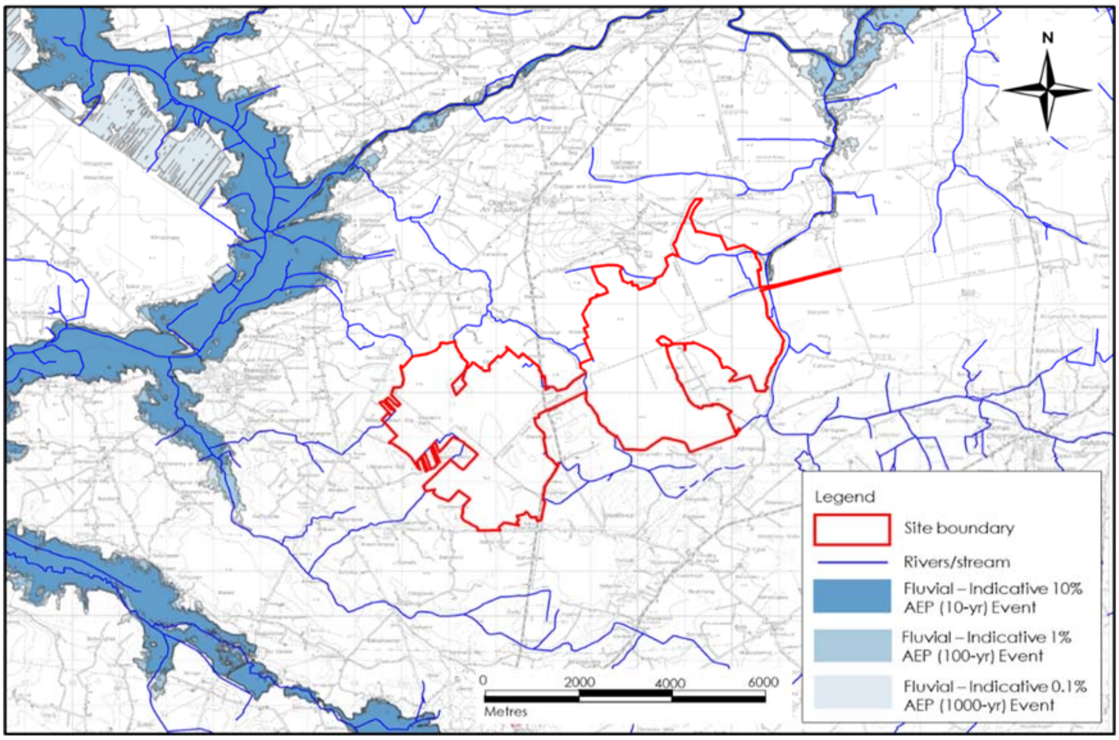


Plate 9.3: Local CFRAM flood zone mapping.

Where complete, the CFRAM OPW Flood Risk Assessment Maps are now the primary reference for flood risk planning in Ireland and supersede the PFRA maps. The proposed development site is not identified on the CFRAM flooding fluvial extent mapping, dated February 2015 as being located in either Flood Zone A or B. Therefore, according to CFRAMs the proposed development is located in Zone C, where the probability of flooding is low. This suggests that the site is suitable for the proposed development in terms of flood risk. The fluvial flood zones areas indicated on the CFRAM mapping are shown on Plate 9.3 above.

9.3.7 Surface Water Quality

Biological Q-rating data for EPA monitoring points on the Silver, Little and Rapemills rivers are shown in Table 9.7 below. Most recent data available (2004 to present) show that the Q-rating for the rivers range from 'Poor' to 'High' in the vicinity of the proposed development site.

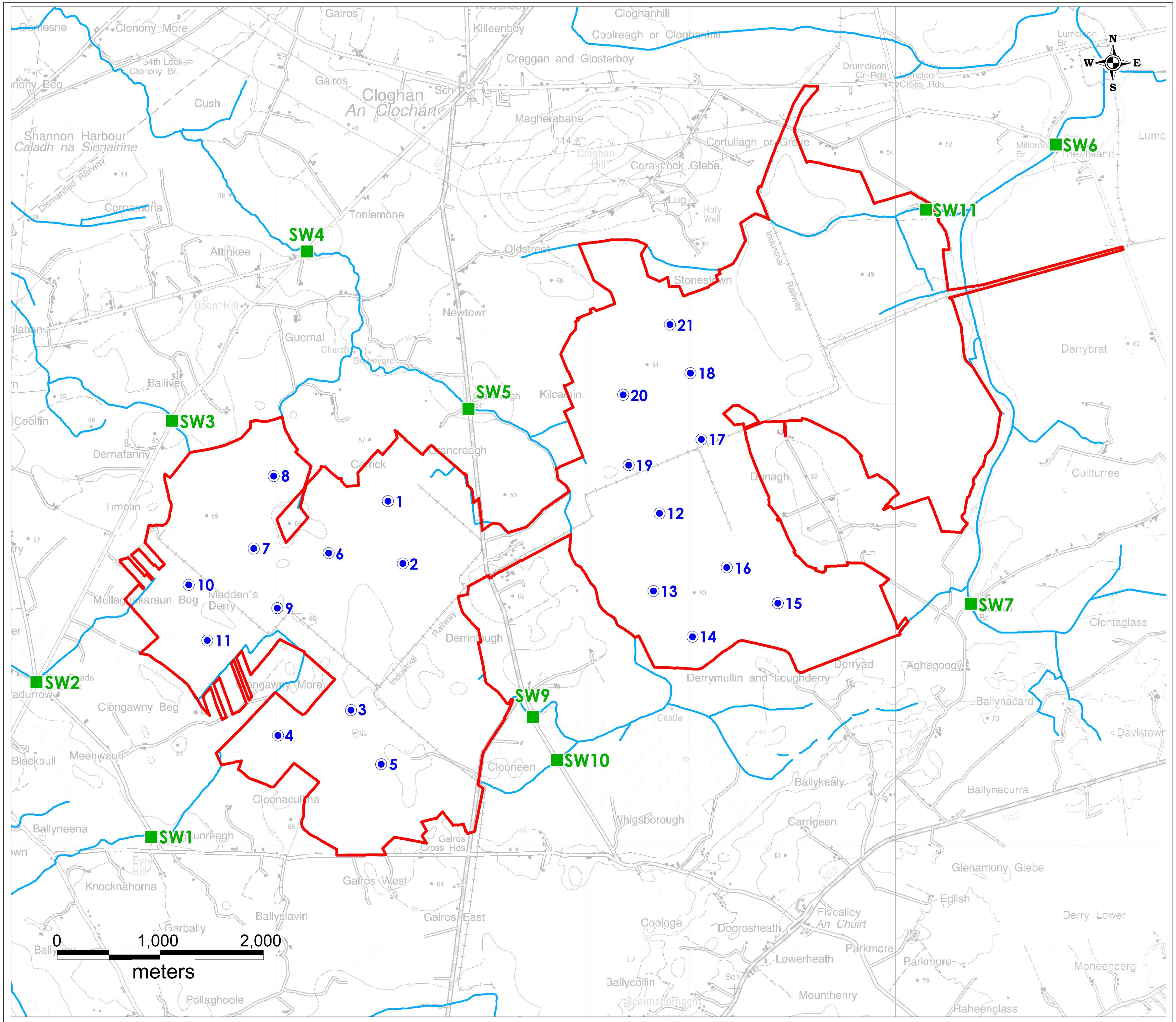
Table 9.7:EPA Water Quality Monitoring Q-Rating Values

Waterbody	Station ID	Easting	Northing	EPA Q-Rating Status
Silver River	RS25S020500	612676	714379	Q4 (Good)
Silver River	RS25S020600	613488	718807	Q4 (Good)
Little River	RS25L010100	607879	716251	Q2-3 (Poor)
Little River	RS25L010200	606245	717799	Q4-5 (High)
Little River	RS25L010400	604145	719835	Q4-5 (High)
Rapemills River	RS25R010300	604767	710225	Q3-4 (Moderate)

Field hydrochemistry measurements of electrical conductivity (µS/cm), pH (pH units), dissolved oxygen (mg/l) and temperature (°C) were taken within surface watercourses downstream of the proposed development (refer to Figure 9.5 for locations). The results are listed (along with estimated flows) in Table 9.8 and Table 9.9. The monitoring locations were typically small streams/rivers which drain towards the larger Shannon river to the north/northwest of the site.

Electrical conductivity (EC) values at the monitoring location ranged between 435 and 697µS/cm. This indicates that a considerable quantity of groundwater is mixing with the surface water runoff from the surface of Clongawny/Drinagh bogs. The source of the groundwater is most likely to be from the mineral subsoils that underlie the peat in this area. The mineral subsoils are likely to have become more exposed in places as a result of peat cutting and installation of drainage channels that extend below the peat layer and into the mineral soil.

The pH values were generally slightly basic, ranging between 7.46 and 8.27. Slightly acidic pH values of surface waters would be typical of peatland environments due to the decomposition of peat. However, the pH is likely higher due to the high temperatures and dry weather which preceded the monitoring.



Legend

EIAR Site Boundary

Proposed Turbine Location

Surface Water Sampling Locations

Rivers/Streams

Note:
Please note there is no sampling point 8.

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Client: Bord na Mona Powergen Ltd

Job: Derrinlough, Co. Offaly

Title: Surface Water Sampling Location Map

Figure No: 9.5

Drawing No: P1463-0-0220-A3-905-00A

Sheet Size: A3	Project No: P1463-0
Scale: 1:35,000	Drawn By: GD
Date: 07/02/2020	Checked By: MG

Table 9.8: Field Parameters - Summary of Surface Water Chemistry Measurements (03/04/2019)

Location ID	Easting	Northing	Temp °C	DO (mg/l)	EC (µS/cm)	pH	Flow (L/s)
SW1	604732	712118	7.4	10.58	624	7.9	200
SW2	603617	713616	7.4	8.96	449.9	7.75	20
SW3	604934	716153	8.7	10.59	527	7.46	-
SW4	606240	717795	8.5	11.75	679	8.19	240
SW5	607806	716268	9.6	8.61	645	7.97	400
SW6	613504	718833	7.3	11.2	653	8.08	1800
SW7	612682	714379	7.5	11.46	678	8.14	450
SW9	608433	713279	7.5	9.53	611	7.68	20
SW10	608669	712861	7.5	11.17	697	8.05	20
SW11	612248	718202	7.3	11.05	554	8.05	120

Table 9.9: Field Parameters - Summary of Surface Water Chemistry Measurements (09/04/2019)

Location ID	Easting	Northing	Temp °C	DO (mg/l)	EC (µS/cm)	pH	Flow (l/s)
SW1	604732	712118	12.2	9.44	596	7.92	150
SW2	603617	713616	11.1	8.39	435.5	8.04	20
SW3	604934	716153	10.4	10.99	537	7.53	10
SW4	606240	717795	11.0	11.6	661	8.27	200
SW5	607806	716268	10.7	9.52	630	7.79	400
SW6	613504	718833	10.2	11.03	638	8.05	1500
SW7	612682	714379	10.3	11.27	653	7.99	500
SW9	608433	713279	11.2	8.57	609	7.63	25
SW10	608669	712861	11.5	10.12	678	8.07	20
SW11	612248	718202	10.3	10.63	546	7.95	100

Surface water samples were also taken at these points for laboratory analysis. Results of the laboratory analysis are shown alongside relevant water quality regulations in Table 9.10 and Table 9.11 below. In addition, the European Communities Environmental Objectives (Surface Waters) Regulations (S.I. No. 272 of 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) are shown in Table 9.12. Original laboratory reports are attached as Appendix 9.2.

Table 9.10: Analytical Results of HES Surface Water Samples (03/04/2019)

Parameter	EQS	Sample ID									
		SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW9	SW10	SW11
Total Suspended Solids (mg/L)	≤25(+)	<5	<5	<5	<5	<5	6	<5	<5	<5	12
Ammonia (mg/L)	-≤0.065 to ≤ 0.04(*)	0.39	0.53	0.02	0.03	0.14	0.04	0.02	0.25	0.03	0.03
Nitrite NO_2 (mg/L)		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	-≤ 0.035 to ≤0.025(*)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrogen (mg/L)	-	14.5	<5.0	12.8	14.3	20.2	20.8	31.8	12.9	17.6	20.4
Phosphorus (mg/L)	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Chloride (mg/L)	-	20.6	21.3	35.3	29	30	21.6	21.3	30.3	37.5	21.1
BOD	≤ 1.3 to ≤ 1.5(*)	<2	<2	<2	<2	2	<2	<2	<2	<2	<2

(+) S.I. No. 293 of 1988: European Communities (Quality of Salmonid Waters) Regulations, resulting from EU Directive 78/659/EEC on the Quality of Fresh Waters Needing Protection or Improvement in order to Support Fish Life
(*) S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 (as amended by S.I. No. 296/2009; S.I. No. 386/2015; S.I. No. 327/2012; and S.I. No. 77/2019 and giving effect to Directive 2008/105/EC on environmental quality standards in the field of water policy and Directive 2000/60/EC establishing a framework for Community action in the field of water policy).

Table 9.11: Analytical Results of HES Surface Water Samples (09/04/2019)

Parameter	EQS	Sample ID									
		SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW9	SW10	SW11
Total Suspended Solids (mg/L)	25(+)	<5	<5	<5	<5	<5	<5	<5	6	<5	<5
Ammonia (mg/L)	≤0.065 to ≤ 0.04(*)	0.38	0.33	0.03	0.13	0.14	0.03	0.04	0.21	0.04	0.04
Nitrite NO_2 (mg/L)		0.12	<0.05	<0.05	<0.05	0.1	<0.05	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	≤ 0.035 to ≤0.025(*)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrogen (mg/L)	-	0.12	<0.05	<0.05	<0.05	0.1	<0.05	<0.05	<0.05	<0.05	<0.05
Phosphorus (mg/L)	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Chloride (mg/L)	-	22	22.3	37.9	35.5	30.1	22.4	22.1	33	39.6	22.2
BOD	≤ 1.3 to ≤ 1.5(*)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2

(+) S.I. No. 293 of 1988: European Communities (Quality of Salmonid Waters) Regulations, resulting from EU Directive 78/659/EEC on the Quality of Fresh Waters Needing Protection or Improvement in order to Support Fish Life

(*) S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 (as amended 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).

Total suspended solids ranged between <5 and 6mg/l. All results were therefore below the limits for both Salmonid and Cyprinid waters.

Ammonia N ranged between 0.02 and 0.53 mg/l, which is generally above the limits for both Salmonid waters and Cyprinid waters. SW1, SW2, SW5 and SW9 were above the limits during both sampling events, while SW4 was elevated on 09th April 2019. The remaining samples were at or below 0.04 mg/l. The presence of elevated ammonia is likely due to natural decomposition of peat.

BOD was less than 2mg/l in all samples, which is below the limits for both Salmonid and Cyprinid waters.

Nitrite ranged between <0.002 and 0.061mg/l and results were typically low which is what would be expected in a peatland environment. In comparison to the Water Framework Directive (2000/60/EC) limits for Salmonid and Cyprinid waters, there were four and one exceedances, respectively.

Nitrate ranged between <5.0 and 31.8 mg/l and results were typically between 10-20 mg/l which is what would be expected in a peatland environment.

In comparison to S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 (as amended by S.I. No. 296/2009; S.I. No. 386/2015; S.I. No. 327/2012; and S.I. No. 77/2019 and giving effect to Directive 2008/105/EC on environmental quality standards in the field of water policy and Directive 2000/60/EC establishing a framework for Community action in the field of water policy) , 9 of 20 results for ammonia N exceeded both the “Good Status” and “High Status” threshold values.

In relation to ortho-phosphate, all samples were at least within the “High Status” with values of <0.02.

*Table 9.12: 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)
Orthophosphate	High status ≤0.025 (mean)
	High status ≤0.025 (mean)
	Good status ≤0.035 (mean)

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

9.3.8 Hydrogeology

The Waulsortian limestones which are mapped to underlie the proposed development site are classified by the GSI (www.gsi.ie) as a Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones (Ll). The limestone bedrock in the area of the proposed development is covered by a substantial thickness of lacustrine and glacial deposits which in turn is overlain by cutaway/cutover peat. The glacial deposits will likely provide the dominant potential pathway for groundwater movement in the proposed development site especially where permeable tills or sands and gravels are present under peat and lacustrine deposits.

Groundwater vulnerability is mapped by the GSI as medium. Groundwater recharge is classified as low with a recharge coefficient of 4% mapped at the site.

Due to the presence of the overlying peat (which results in minimal recharge) and the bulk low permeability of the underlying lacustrine deposits, groundwater movement through the glacial deposits will be relatively slow unless higher permeability sands and gravels are present. Recharge is likely to be limited to the perimeter of the development site where the peat is thin or absent (the presence of peat will prevent rapid recharge to underlying regional groundwater systems). Based on topography and regional surface water drainage flows groundwater flow direction towards the east of the site is likely to be towards the Silver River, while the east of Clongawny bog and west of Drinagh bog likely drains towards the Little River, while the west of Clongawny bog likely drains towards the Rapemills River. A low groundwater gradient is expected.

There is a shallow water table in the peat layer across the site. This is perched and largely isolated from the underlying regional groundwater system (which occurs in underlying till and bedrock).

9.3.9 Groundwater Vulnerability

The vulnerability rating of the bedrock aquifer underlying site is classified as "Moderate" and this is consistent with the presence of basin peat underlain by a substantial depth of lacustrine SILT/CLAY and glacial deposits.

This means there is a low potential for groundwater dispersion and movement within the aquifer, therefore surface water bodies, such as drains and streams, are more vulnerable than groundwater at this site.

9.3.10 Groundwater Hydrochemistry

There is no groundwater quality data for the proposed wind farm site and groundwater sampling would generally not be undertaken for this type of development, as groundwater quality impacts would not be anticipated given the low potential for groundwater dispersion and movement within the aquifer as outlined in the preceding section.

Based on data from GSI on the Clara GWB, groundwaters in this area are typically very hard with a calcium-bicarbonate signature. Hardness generally ranges from 380 – 450 mg/l as $CaCO_3$, with high electrical conductivities (650 – 800 μS/cm).

9.3.11 Water Framework Directive Water Body Status & Objectives

The River Basin Management Plan was adopted in 2018 and has amalgamated all previous river basin districts into one national river basin management district. The River Basin Management Plan (2018 - 2021) objectives, which have been integrated into the design of the proposed wind farm development, include the following:

- Ensure full compliance with relevant EU legislation;
- Prevent deterioration and maintain a 'high' status where it already exists;
- Protect, enhance and restore all waters with aim to achieve at least good status by 2021;
- Ensure waters in protected areas meet requirements; and,
- Implement targeted actions and pilot schemes in focused sub-catchments aimed at (1) targeting water bodies close to meeting their objectives and (2) addressing more complex issues that will build knowledge for the third cycle.

Our understanding of these objectives is that surface waters, regardless of whether they have 'Poor' or 'High' status, should be treated the same in terms of the level of protection and mitigation measures employed, i.e. there should be no negative change in status at all.

Strict mitigation measures (refer to Section 9.5.3 and 9.5.4) in relation to maintaining a high quality of surface water runoff from the development and groundwater protection will ensure that the status of both surface water and groundwater bodies in the vicinity of the site will be at least maintained (see below for WFD water body status and objectives) regardless of their existing status.

9.3.12 Groundwater Body Status

Local Groundwater Body (GWB) and Surface water Body (SWB) status reports are available for download from (www.wfdireland.ie)

The Clara GWB (IE_SE_G_116) underlies most of the development site. This GWB is assigned 'Good Status', which is defined based on the quantitative status and chemical status of the GWB. The Banagher GWB (IE_SH_G_040) underlies the extreme west of the site and is also assigned 'Good Status'.

9.3.13 Surface Water Body Status

A summary of the WFD status and risk result of Surface Water Bodies (SWBs) in which development is proposed (or immediately upstream of) are shown in Table 9.13 below.

The eastern section of the site is drained by the Silver River (IE_SH_25S020700) which achieved 'moderate' status under the WFD 2013-2018. The centre of the site is drained by the River Little (Cloghan) (IE_SH_25L010400) which achieved 'good' status. Both of these rivers flow generally north and discharge to the River Brosna (IE_SH_25B091200) which also achieved 'moderate' status. The Rapemills River which flows west of the site, in a northerly direction towards Banagher has not been assigned a status under the WFD.

Table 9.13: Summary WFD Information for Surface Water Bodies

SWB Code	Water Body	General Physico-Chemical Status	Fish status	Overall Status
IE_SH_25L010400	Little (Cloghan)	Good	Moderate	Moderate
IE_SH_25S020700	Silver	Pass	Moderate	Moderate
IE_SH_25B091200	Brosna	Pass	N/A	Good

9.3.14 Designated Sites and Habitats

Within the Republic of Ireland designated sites include National Heritage Areas (NHAs), Proposed National Heritage Areas (pNHAs), candidate Special Areas of Conservation (SAC) and Special Protection Areas (SPAs). Designated sites within the same surface water catchments as the proposed development site are listed below:

- Lough Coura pNHA (Site Code: 000909), directly south of proposed development site boundary;
- All Saints bog and esker SAC (Site Code: 000566) exists ~3.1km southwest of the proposed development site;
- All Saints bog SPA (Site Code: 004103) exists ~3.1km southwest of the proposed development site;
- Ridge Road, SW of Rapemills SAC (Site Code: 000919), 3.4km south-west of proposed development site;
- River Shannon Callows SAC (Site Code: 000216) exists ~2.3km northwest of the proposed development site this area is also listed as the Middle Shannon NHA; and,
- River Little Brosna Callows SPA (Site Code: 004086) is located ~5km southwest of the proposed site, as well as the River Little Brosna Callows NHA (Site Code: 000564), the SPA boundary also encompasses the area of the All Saints bog and esker.

The proposed development site is indirectly connected via surface water (hydrologically) to the River Shannon Callows SAC/Middle Shannon SPA, through the tributaries of the Shannon which flow north/northwest from the site (Silver, Little and Rapemills Rivers). There is no direct hydrological (surface water) connection to the All Saints bog and esker SAC as a hydraulic boundary exists between the proposed site and the SAC (i.e. the barrier is the River Rapemills). There is no direct hydrological connection to the Ridge Road SW of Rapemills SAC as a hydraulic boundary exists between the proposed site and the SAC (i.e. the barrier is the River Rapemills). There is also no direct hydrological connection to River Little Brosna Callows SPA / River Little Brosna Callows NHA as a hydraulic boundary exists between the proposed site and the SAC (River Rapemills). A summary of potential hydrological pathways (surface water connections) and hydrogeological pathways (groundwater connections) is included below as Table 9.14.

Designated sites in proximity to the proposed development site are listed below and shown on Figure 9.6. Other sites, outside of those listed above are considered to be remote from the proposed development, and as such due to physical and hydrological/hydrogeological separation cannot be affected (from a water perspective) by the proposed development. An impact assessment of these remaining listed sites is completed below at Section 9.5.3.8.

Table 9.14: Relative distances and connectivity to designated sites

Designated Site	Distance to European Site	Hydrological connectivity to European Sites	Groundwater connectivity to Designated / European Sites
Lough Coura pNHA	<1 km, and 320m from T14	No direct connection. Indirect connections exist via surface water (tributaries to Little River).	Groundwater connectivity will be limited due to; 1) significant separation exists to infrastructure development locations; 2) baseline conditions between pNHA and development locations is highly modified already (by drainage and forestry, and presence of N62 roads, and associated drainage); 3) differences in elevation, and 4) shallow depth of proposed works; 5) Groundwater flow is also likely to be towards the northwest in line with local surface water drainage systems; and, 6) the presence of the Little River to the east acting as a hydraulic boundary.
All Saints bog and Esker SAC / All Saints Bog SPA	~3.1km as crow flies	No direct connection. Indirect connections exist via surface water flows (tributaries to Rapemills river, and Rapemills river).	Groundwater connectivity will be limited due to; 1) separation distances; 2) presence of intermediate rivers acting as hydraulic boundaries; 3) differences in elevation; and, 4) shallow depth of proposed works.
Ridge Road, SW of Rapemills SAC	~3.43km at nearest point	No direct connection. Indirect connections exist via surface water flows (tributaries to Rapemills river, and Rapemills river).	Groundwater connectivity will be limited due to; 1) separation distances; 2) presence of intermediate river acting as hydraulic boundaries; 3) differences in elevation; and, 4) shallow depth of proposed works.
River Shannon Callows SAC / Middle Shannon Callows SPA	~2.3km to west along river channel	No direct connection.	Likely, but significant distance between the proposed development site and SAC/SPA, as well as presence

Designated Site	Distance to European Site	Hydrological connectivity to European Sites	Groundwater connectivity to Designated / European Sites
	~7.65km to northwest along river channel	Indirect connections exist via surface water (Little River, Island River, Brosna River, and tributaries to Rapemills river, and Rapemills river).	of several local streams and major rivers (groundwater likely to discharge to Little river, Island River, and Brosna River before reaching the River Shannon).
River Little Brosna Callows SPA / River Little Brosna Callows NHA	~5.5km to southwest as crow flies	No direct connection. No indirect connections exist via surface water.	Groundwater connectivity will be limited due to; 1) separation distances; 2) presence of intermediate rivers acting as hydraulic boundaries; 3) differences in elevation; and, 4) shallow depth of proposed works.

9.3.15 Water Resources

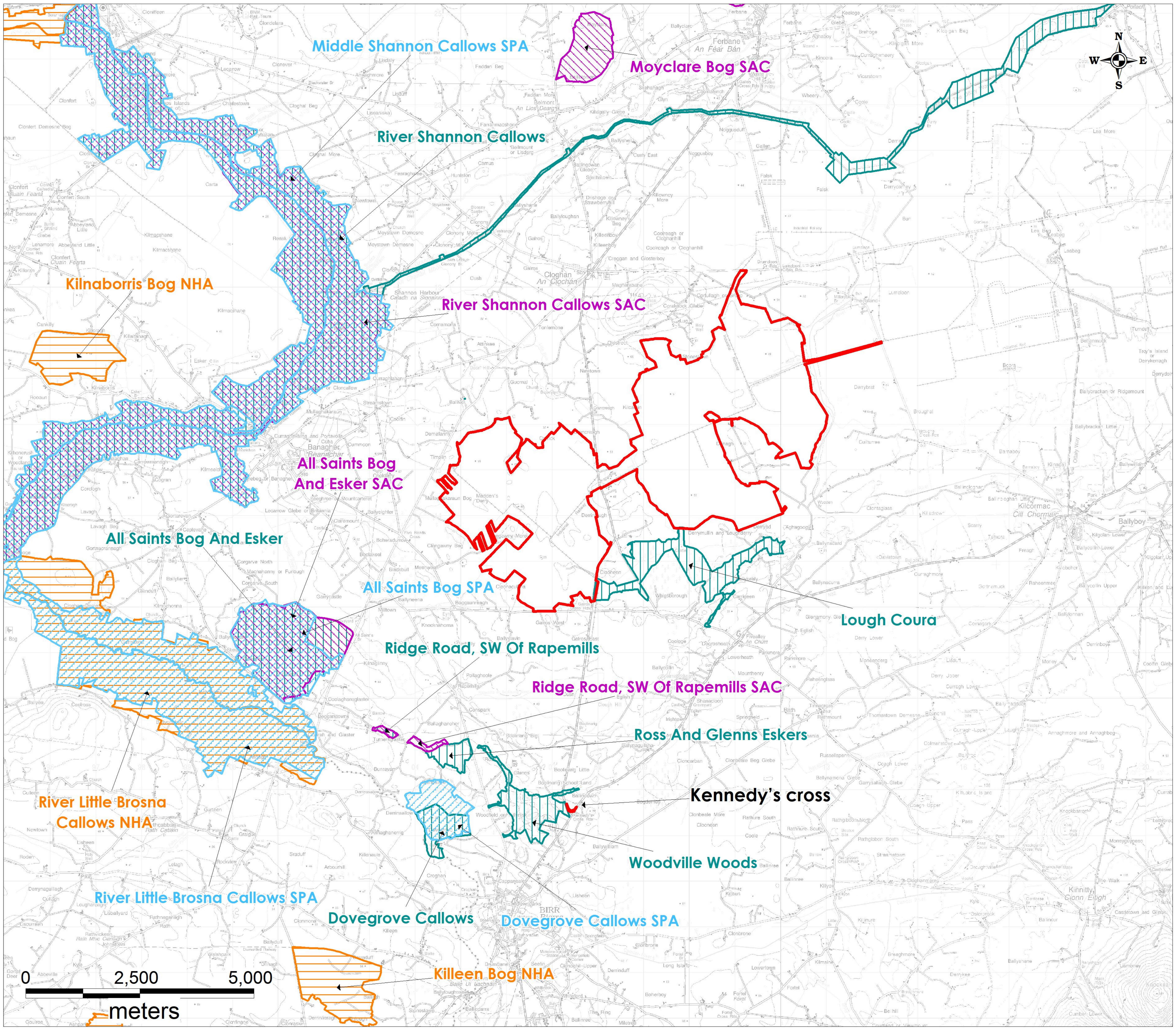
There is 1 no. mapped PWS (Banagher Public Water Supply Scheme) within 3 km of the site. The Banagher PWS is located west of the site, approximately 2 km southeast of Banagher. The mapped source protection zone for this GWS does not fall within the proposed development site boundary.

A search of private well locations (wells with location accuracy of 1–50m were only sought) was undertaken using the GSI well database (www.gsi.ie). 2 no. wells with an accuracy of 1–50m were mapped in the area of the proposed development site, which were mapped as belonging to Bord na Móna and Erin Peat, and are assumed to be water sources used in the production and manufacturing of the peat products. All the wells mapped in the area surrounding the site are mapped only to an accuracy of 1km and therefore assessing potential impacts on these wells cannot be undertaken in any reliable manner.

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 9.7) 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 our 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, rather than make no assessment and find out later that groundwater wells do actually exist).

9.3.16 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 impact assessments. The primary risks to groundwater at the site would be from cementitious materials, hydrocarbon spillage and leakages, potential piling works, and construction of the proposed underpasses. These potential significant effects are assessed in Sections 9.5.3 and 9.5.4. Some of these are common potential impacts on all construction sites (such as road works and industrial sites).



Legend

- EIAR Site Boundary
- SPA
- SAC
- pNHA
- NHA

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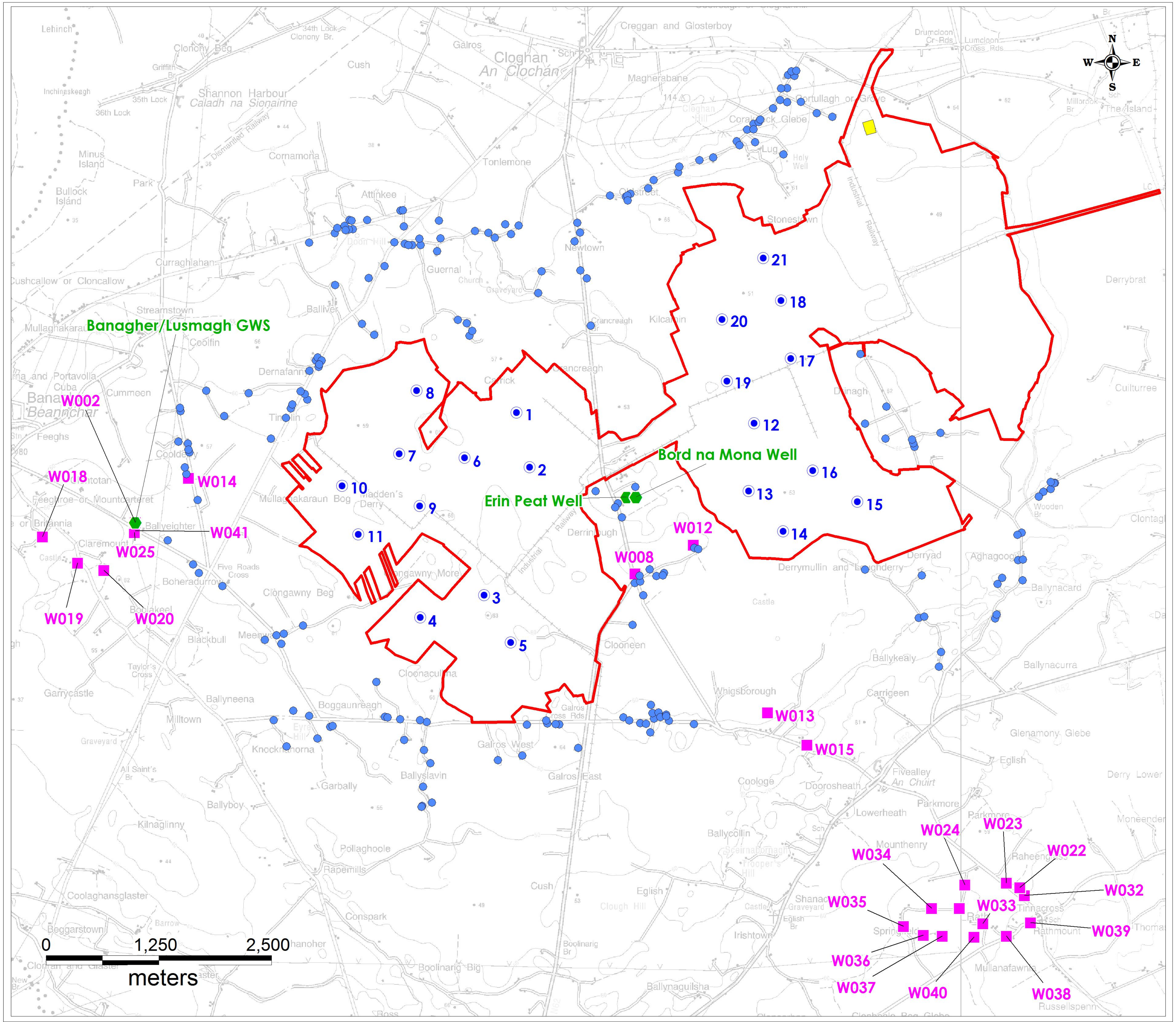
Client: Bord na Mona Powergen Ltd	
Job: Derrinlough, Co. Offaly	
Title: Designated Sites Map	
Figure No: 9.6	
Drawing No: P1463-0-0220-A3-906-00A	
Sheet Size: A3	Project No: P1463-0
Scale: 1:80,000	Drawn By: GD
Date: 07/02/2020	Checked By: MG



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Proposed Substation
- Private Dwelling Locations
- GSi Mapped Wells
- Well Locations

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Client: Bord na Mona Powergen Ltd	
Job: Derrinlough, Co. Offaly	
Title: Local Well Locations Map	
Figure No: 9.7	
Drawing No: P1463-0-0220-A3-907-00A	
Sheet Size: A3	Project No: P1463-0
Scale: 1:40,000	Drawn By: GD
Date: 07/02/2020	Checked By: MG

All potential contamination sources are to be carefully managed at the site during the construction and operational phases of the development and mitigation measures are proposed below (Sections 9.5.3 and 9.5.4) to deal with these potential impacts.

Based on criteria set out in Table 9.2 above, the Locally Important Aquifer can be classed as Sensitive to pollution. The majority of the site, however, is covered in cutover peat which in turn is underlain by silt dominated glacial deposits and these layers act as a protective cover to the underlying bedrock aquifer. The glacial deposits are not mapped as an aquifer, but they are likely to be used locally as a water supply and therefore they can also be classed as Sensitive to pollution. However, due to the presence of the peat and silt/clay layers (which have low permeability and act as a barrier to infiltration), any contaminants which may be accidentally released on-site are more likely to travel to nearby streams within surface runoff.

Comprehensive surface water mitigation and controls are outlined below to ensure protection of all downstream receiving waters. Mitigation measures will ensure that surface runoff from the developed areas of the site will be of a high quality and will therefore not impact on the quality of downstream surface water bodies. Any introduced drainage works at the site will mimic the existing drainage regime (refer to Section 9.5.4.1) thereby avoiding changes to flow volumes leaving the site via the existing outfalls.

9.4 Characteristics of the Proposed Development

The development comprises 21 no. wind turbines, 2 no. anemometry masts, new and upgraded site access roads, 2 no. permanent underpasses, a substation and associated connection to the national grid, temporary construction compounds. A full description of the proposed development is included in Chapter 4 of this EIAR.

9.4.1 Proposed Drainage Management

Runoff control and drainage management are key elements in terms of mitigation against impacts on surface water bodies. Two distinct methods will be employed to manage drainage water within the proposed development. The first method involves 'keeping clean water clean' by avoiding disturbance to existing drainage features, minimising any works in or around artificial drainage features, and diverting clean surface water flow around excavations, construction areas and temporary storage areas. The second method involves collecting any drainage waters from works areas within the site that might carry silt or sediment, and nutrients, to route them towards new proposed silt traps and settlement ponds (or stilling ponds) prior to controlled diffuse release into the existing drainage network. There will be no direct discharges to the existing drains.

During the construction phase, all runoff from works areas (i.e. dirty water) will be attenuated and treated to a high quality prior to being released. A schematic of the proposed site drainage management is shown as Plate 9.4 below. A detailed drainage plan showing the layout of the proposed drainage design elements is shown in Appendix 4.5 of the EIAR.

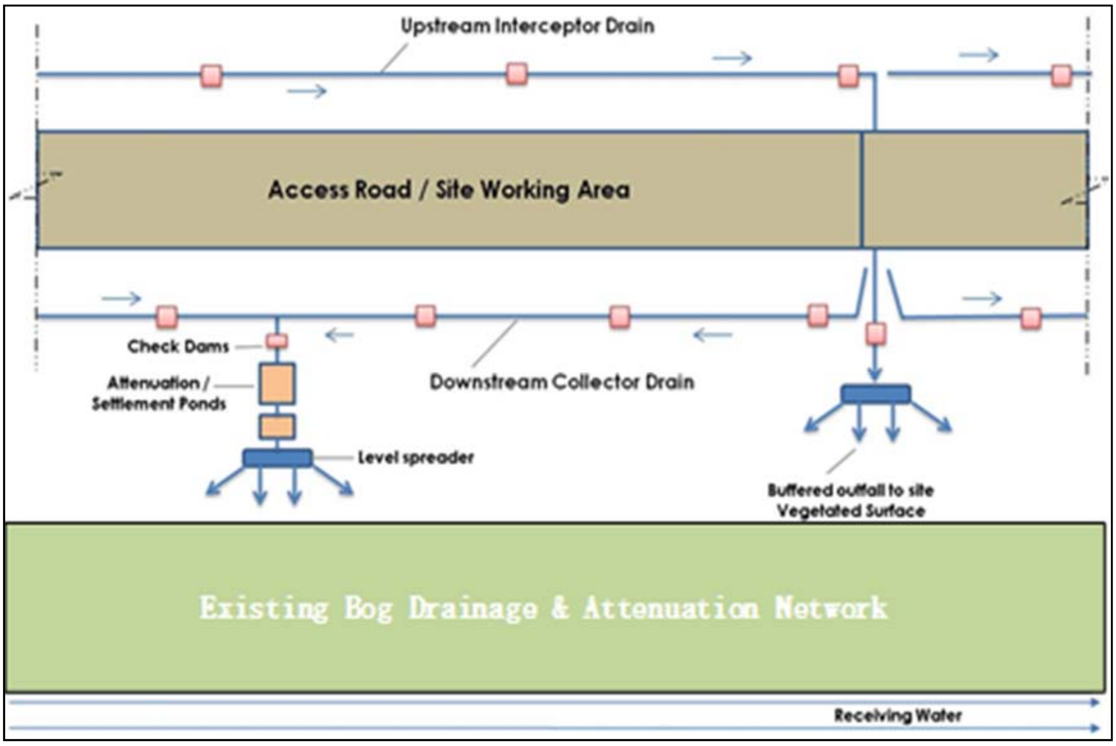


Plate 9.4: Schematic of Proposed Site Drainage Management

9.4.2 Development Interaction with the Existing Bog Drainage Network

The proposed wind farm drainage will not significantly alter the existing drainage regime at the site. Moreover, the proposed drainage system will be fully integrated into the existing bog drainage systems.

Existing field drains and main drains will be routed under/around access tracks using culverts as required.

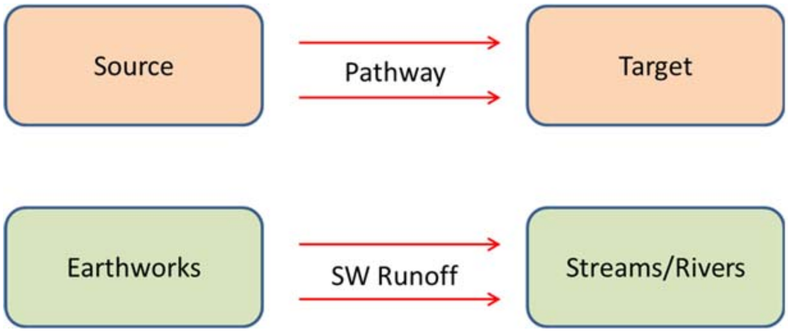
Runoff from access tracks, turbine bases, and developed areas (construction compounds, sub-stations, met masts) will be collected and treated in local (proposed) silt traps and settlement ponds and then discharged to existing peat field drains. From there this water will flow towards the relevant bog site boundaries in existing field drains and main drains, and then be treated further in the existing main (bog) settlement ponds prior to discharge from the proposed development site.

One of the proposed ecological aspects of the drainage design is to re-wet the site in small areas, where possible, to create wet areas as such wetland features which are good for overall site biodiversity. Ponding would occur in these areas to a very shallow depth, and only intermittently following heavy rainfall. No large open bodies of water are proposed, and where intermittent ponding occurs this will be broken up into small areas using peat berms.

9.5 Likely Significant Effects and Associated Mitigation Measures

9.5.1 Overview of Impact Assessment Process

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



As outlined previously, where potential impacts are identified, the classification of impacts in the assessment follows the descriptors set out in the Glossary of effects (EPA, 2017) as outlined in Chapter 1 of this EIAR.

The descriptors used in this environmental impact assessment are those set out in the EPA (2017) Glossary of effects as shown in Chapter 1 of this EIAR.

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

In order to provide an understanding of the stepwise impact assessment process applied below (Section 9.5.3 and 9.5.4), we have presented below a summary guide that defines the steps (1 to 7) taken in each element of the impact assessment process (Table 9.15). The guide also provides definitions and descriptions of the assessment process and shows how the source-pathway-target model and the EPA impact descriptors are combined.

Using this defined approach, this impact assessment process is then applied to all wind farm construction and operation and decommissioning activities.

Table 9.15: Impact Assessment Process Steps

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

9.5.2 Do -Nothing Scenario

If the proposed development were not to proceed, the site would continue to be managed under the requirements of the relevant IPC licence, and existing commercial forestry, telecommunications and wind measurement would continue. The hydrology of the site would remain as it is described in the baseline characterisation. The rail lines that supply peat to Derrinlough Briquette Factory from other bogs adjacent to the proposed wind farm, will continue to be used until the manufacture of peat briquettes ceases.

When peat extraction activity ceases in the Boora Bog Group, a Rehabilitation Plan will be implemented in accordance with the IPC licence requirements, to environmentally stabilise the site through encouragement of re-vegetation of bare peat areas, with targeted active management being used to enhance re-vegetation and the creation of small wetland areas (if required).

9.5.3 Construction Phase - Likely Significant Effects and Mitigation Measures

9.5.3.1 Earthworks Resulting in Suspended Solids Entrainment in Surface Waters

Construction phase activities including access road construction, turbine base/hardstanding construction, construction compound construction, met mast construction, underpass construction, substation construction, cable route excavations, amenity paths construction (also refer to Section 9.5.3.10), turbine delivery route accommodation works, grid connection works (under and overground), entrance locations and amenity car park will require varying degrees of earthworks resulting in excavation of peat and mineral subsoil where present. Potential sources of sediment-laden water include:

- Drainage and seepage water resulting from excavations;
- Stockpiled excavated material providing a point source of exposed sediment; and,
- Erosion of sediment from emplaced site drainage channels.

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

Pathways: Drainage and surface water discharge routes.

Receptors: Down-gradient rivers and associated dependent ecosystems.

Pre-Mitigation Potential Impact: Negative, significant, indirect, temporary, medium probability effect.

Proposed Mitigation by Avoidance:

The key mitigation measure during the construction phase is the avoidance of sensitive hydrological features where possible, by application of suitable buffer zones (i.e. 50m to main watercourses, and 10m to main drains). All of the key proposed development areas are located significantly away from the delineated 50m watercourse buffer zones with the exception of the upgrading of the existing watercourse crossing, new drain crossing and upgrades to existing site access tracks. 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 (river/stream banks and river/stream beds) to watercourses and associated release of sediment;
- Avoid excavations within close proximity to surface watercourses;
- Avoid the entry of suspended sediment from earthworks into watercourses; and,
- Avoid the entry of suspended sediment from the construction phase drainage system into watercourses, achieved in part by ending drain discharge outside the buffer zone and allowing percolation across the vegetation of the buffer zone.

In addition, and as outlined above the wind farm drainage system will link into the existing bog drainage system, and discharge from each of the bog sites via existing large settlement ponds, which are some distance from the proposed development footprint. As such, there is significant distance for wind farm related surface water to travel before it actually reaches the edge of the bogs and joins any receiving waters outside of the overall bog boundaries (Clongawny and Drinagh bogs).

Proposed Mitigation by Design:

Presented below are temporary and long-term drainage control measures that will be utilised during the construction phase of the wind farm. As stated above there is an existing drainage network at the site which comprises field drains, main drains and perimeter settlement ponds. The measures outlined below will be used in conjunction with the existing drainage network to ensure protection of all rivers and streams downstream of the proposed development site.

Source controls:

- Interceptor drains, vee-drains, diversion drains.
- Small working areas, covering temporary stockpiles, weathering off of side-cast peat/spoil, cessation of works in certain areas or other similar/equivalent or appropriate measures.

In-Line controls:

- Interceptor drains, vee-drains, temporary sumps/attenuation lagoons, sediment traps, pumping systems, settlement ponds, temporary pumping chambers, or other similar/equivalent or appropriates 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.

There is an extensive network of drains already existing at the site, and these will be integrated and enhanced as required and used within the wind farm development drainage system. The key elements being the upgrading and improvements to water treatment elements, such as in-line controls and treatment systems, including silt traps and settlement ponds.

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 where possible. This will reduce the potential for any increased risk of downstream flooding or sediment transport/erosion;
- Temporary silt traps will be placed in the existing drains downstream of construction works, and these will be diverted into proposed interceptor drains, or culverted under/across the works area;
- During the operational phase of the wind farm runoff from individual turbine hardstanding areas will be not discharged directly into the existing drain network but discharged locally at each turbine location through field drains, main drains, and existing settlement ponds;
- Buffered outfalls which will be numerous over the site will promote percolation of drainage waters across the bog surface and close to the point at which the additional runoff is generated, rather than direct discharge to the existing drains of the site;
- 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; and,

- Existing culverts will be lengthened where necessary to facilitate access road widening.

Water Treatment Train

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

Silt Fences:

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

Silt Bags:

Silt bags will be used where small to medium volumes of water need to be pumped from excavations (e.g. the proposed underpass locations). As water is pumped through the bag, most of the sediment is retained by the geotextile fabric allowing filtered water to pass through.

Pre-emptive Site Drainage Management:

The works programme 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 peat 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/weekly basis, as required, to allow site staff to direct proposed and planned construction activities:

- General Forecasts: Available on a national, regional and county level from the Met Éireann 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 Éireann 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 Éireann 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 planned works to be safely executed (from a water quality perspective) in the event of forecasting of an impending high rainfall intensity event.

Earthworks should be suspended if forecasting suggests any of the following is likely to occur:

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

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

- Secure all open peat/spoil 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 Storage Areas:

It is proposed that excavated peat will be used for landscaping close to its original extraction point. During the initial placement of peat and subsoil, silt fences, straw bales and biodegradable geogrids will be used to control surface water runoff from the storage areas as required. 'Siltbuster' treatment trains will be employed if previous treatment is not to a high quality.

Timing of Site Construction Works:

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

Proposed Drainage and Water Quality Monitoring

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

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

During the construction phase field testing (visual, supplemented with pH, electrical conductivity, temperature, dissolved oxygen and turbidity monitoring), sampling and laboratory analysis of a range of parameters[1] with relevant regulatory limits and EQSs will be undertaken for each primary watercourse, and specifically following heavy rainfall events (i.e. weekly, monthly and event-based).

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, temporary, low probability effect on downstream water quality and aquatic habitats.

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

[1] example suite: pH (field measured), Electrical Conductivity (field measured), temperature (field measured), Dissolved Oxygen (field measured), Turbidity (NTU) (sonde measured), Flow (m/s), Total Suspended Solids (mg/l), Ammonia, Nitrite (NO_2) (mg/l), Ortho-Phosphate (P) (mg/l), Nitrate (NO_3) (mg/l), Phosphorus (unfiltered) (mg/l), Chloride (mg/l), and BOD (mg/l).

9.5.3.2 Potential Impacts on Groundwater Levels during Excavation Works

No borrow pits are proposed at the site, so no associated dewatering works are proposed. Smaller scale temporary dewatering may occur at some excavations (i.e. turbine bases, cable trenches (underpass is dealt with separately below), and these have the potential to affect local groundwater levels. However, temporary reductions in groundwater levels by temporary dewatering will be very localised and of small magnitude due to the nature and permeability of the local peat and subsoil geology, which comprises moderate to low permeability lacustrine and glacial deposits.

The installation of turbine bases in the underlying glacial deposits is also likely to require some temporary dewatering arrangements, where deeper excavations occur. However, due to the dominance of moderate to low permeability glacial till subsoils and lacustrine deposits below the bogs the impacts on groundwater levels will be localized to the excavation and only for a temporary basis during the construction work. Water level impacts are unlikely to be significant beyond 50m from any excavation.

Pathway: Groundwater flow paths.

Receptor: Groundwater levels.

Pre-Mitigation Potential Impact: Slight, indirect, temporary, low probability effects on local groundwater levels.

Proposed Mitigation Measures by Design:

- There are large separation distances between proposed works and local houses, and associated water wells. The closest houses are at least 750m from proposed turbine bases.
- Similarly, main streams and rivers are at least 200-500m away from any turbine bases, and at these potential effects will be imperceptible; and,
- The proposed underground cable trench is designed to be shallow and will only be approximately 1.2m in depth. At this depth it will only potentially interact with shallow perched water within the peat profile. No interaction with deeper regional groundwater will occur. Therefore, re no impacts on the local groundwater table or flows are anticipated from this element of the development.

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 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 - Imperceptible, indirect, temporary, low probability effects on local groundwater levels.

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

9.5.3.3 Excavation Dewatering and Potential Impacts on Surface Water Quality

Groundwater seepages will likely occur in turbine base, substation and construction compound excavations, and these will create additional volumes of water to be treated by the runoff management system. In some areas, groundwater inflows may be more significant where lenses of sand and gravel are intercepted within the glacial till deposits.

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

The main potential significant effects are as a result of turbidity and suspended solids on downstream surface water receptors. Poor water quality in downstream stream and rivers has the potential to affect aquatic habitats and species (e.g. fish and invertebrates).

Pathway: Overland flow and site drainage network.

Receptor: Down-gradient surface water bodies.

Pre-Mitigation Potential Impact: Negative, significant, indirect, temporary, low probability effects to surface water quality.

Proposed Mitigation by Design:

Management of excavation 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 groundwater in the excavation;
- The interceptor drainage will be discharged to the existing drainage system or onto the bog surface;
- 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 the existing drainage network and therefore no risk of hydraulic loading or contamination will occur; and,
- Daily monitoring of excavations by a suitably qualified person will occur during the construction phase. If high levels of seepage inflow occur, excavation work should immediately be stopped, and a geotechnical assessment undertaken.

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 - Imperceptible, indirect, temporary, low probability effects on local surface water quality and associated aquatic habitats.

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

9.5.3.4 Underpass Dewatering and Potential Effects on Surface Water Quality and Groundwater Levels

Temporary dewatering may occur at the proposed underpass locations, and these have the potential to impact on local groundwater levels by drawdown. Drawdown in water levels can affect baseflow to rivers and streams, and water levels in local groundwater wells. Excavation depths will be in the order of ~3 to ~6.5m. Two underpasses are proposed, and these will require a limited works area and the duration of the installation works will be short (i.e. 4 to 8 weeks). The locations of the proposed underpasses are remote from surrounding houses, so potential impacts on groundwater wells is limited by large separation distances. Any temporary dewatering will be treated and discharged to local surface water so there will be temporary net loss in water volume reaching local streams and rivers. In addition, potential groundwater level effects via drawdown are limited due the local hydrogeological regime which comprises moderate to low permeability lacustrine and glacial deposits. It is likely that permanent drainage at the underpass locations will be by gravity to a local outfall.

In addition, during construction groundwater seepages will likely occur into the underpass construction areas and this will create additional volumes of water to be treated by the runoff management system.

During construction stage, groundwater inflows will likely require management and treatment to reduce suspended sediments. No contaminated land was noted at the site and therefore pollution issues are anticipated in this respect.

The recorded geology at the underpass locations (from trial pit TP/UP) include ~1.1m of peat over firm grey slightly gravelly SILT. A moderate groundwater inflow was recorded at 3.3mbgl. Slight to the east of the N62 (at trial pit TP/CSH2) peat depth was recorded at 0.3m, with firm grey gravelly clay forming the subsoil. No significant groundwater inflows were recorded at this location.

The installation of permanent underpasses in the underlying glacial deposits will require permanent dewatering/gravity drainage arrangements. However, due to the dominance of moderate to low permeability peats, glacial till subsoils and lacustrine deposits below at the underpass locations the impacts on groundwater levels due to these excavations will be localized to the underpass areas. Dewatering impacts will not extend far enough to impact on local sensitive receptors. Water level drawdown impacts are unlikely to be significant beyond 50m from the permanent underpass excavations.

Pathway: Groundwater levels, and flow to local surface water.

Receptor: Down-gradient surface water bodies, and groundwater levels.

Pre-Mitigation Potential Impact: Negative, significant, indirect, temporary, low probability effects to surface water quality. Imperceptible, direct, slight, long term, high probability effect on local groundwater levels.

Proposed Mitigation Measures for Water Quality Protection:

Management of excavation 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 existing drainage system or onto the bog surface;
- The pumped water volumes will be discharged via silt bags and settlement tanks/ponds to adjacent to excavation areas, or via specialist treatment systems such as a "Siltbuster" unit;
- There will be no direct discharge to the existing drainage network and therefore no risk of hydraulic loading or contamination will occur; and,
- Daily monitoring of excavations by a suitably qualified person will occur during the construction phase. If high levels of seepage inflow occur, excavation work should immediately be stopped, and a geotechnical assessment undertaken.

Residual Effects: Due to large separation distances between proposed underpass development works and local groundwater wells, and the relatively shallow nature of the proposed works, and also the prevailing geology of the proposed development site the potential for water level drawdown impacts from the two underpass construction locations at receptor locations is considered negligible. In addition, controls for water treatment prior to release to surface water will be implemented to ensure surface water quality will be maintained. The residual effect is considered to be - Imperceptible, indirect, temporary, low probability effects on local surface water quality. Imperceptible, direct, temporary, low probability effects on local groundwater levels.

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

9.5.3.5 Potential Release of Hydrocarbons during Construction and Storage

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

Pathway: Groundwater flowpaths and site drainage network.

Receptor: Groundwater and surface water.

Pre-Mitigation Potential Impact: Negative, indirect, slight, short term, medium probability effect to local groundwater quality. Indirect, negative, significant, short term, low probability effect to surface water quality.

Proposed Mitigation Measures:

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

Residual Effect: 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, temporary, low probability effect on groundwater and surface water.

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

9.5.3.6 Groundwater and Surface Water Contamination from Wastewater Disposal

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

Pathway: Groundwater flowpaths and site drainage network.

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

Pre-mitigation Effect: Negative, significant, indirect, temporary, low probability effect to surface water quality. Negative, slight, indirect, temporary, low probability effect to local groundwater.

Proposed Mitigation Measures:

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

Residual Effect: During the construction phase no water or wastewater will be sourced on the site, nor discharged to the site, therefore no residual effects are anticipated.

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

9.5.3.7 Release of Cement-Based Products

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

Pathway: Site drainage network.

Receptor: Surface water and peat water hydrochemistry.

Pre-Mitigation Potential Impact: Negative, moderate, indirect, short term, medium probability effect to surface water.

Proposed Mitigation Measures:

- 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;
- No washing out of any plant used in concrete transport or concreting operations will be allowed on-site;
- Where concrete is delivered on site, only the chute will be cleaned, using the smallest volume of water possible. 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 is to be isolated in temporary lined wash-out pits located near proposed site compounds. These temporary lined wash-out pits will be removed from the site at the end of the construction phase;
- Will use weather forecasting to plan dry days for pouring concrete; and,
- Will ensure pour site is free of standing water and plastic covers will be ready in case of sudden rainfall event.

Residual Effect: 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 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, low probability impact.

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

9.5.3.8 Potential Impacts on Hydrologically Connected Designated Sites

The proposed development site is not located within any designated conservation site. As stated in Section 9.3.14 above, the proposed development site is located in the River Shannon regional catchment. Local designated sites, other than those listed in Table 9.14 are considered to be remote from the proposed development, and as such due to physical and hydrological and hydrogeological separation will not be affected by the proposed development. Local designated sites listed in Table 9.14 are assessed below with respect to hydrological connectivity and potential for significant hydrological and hydrogeological effects.

Pathway: Surface water flowpaths, and groundwater levels.

Receptor: Down-gradient water quality and groundwater levels at designated sites.

Impact Assessment – Lough Coura pNHA

Lough Coura pNHA is located to the south of the proposed development site, and it abuts the development site boundary along the southeast of Clongawny bog over ~450m, and again along the southern boundary of Drinagh bog over a distance of ~110m.

The baseline conditions of the land between the pNHA and development locations is highly modified already by drainage and forestry planting and associated drainage.

For the Clongawny bog area, the presence of the N62 road, the bog railway and their associated drainage provide a significant separation from that bog to the pNHA. Also, the nearest turbine is some 970m from the pNHA boundary (mitigation by design). There is a section of high ground between that turbine (T5) and the pNHA area. The proposed works at T5 are relatively shallow in nature and groundwater flow below Clongawny bog is likely, due to local topography and local drainage patterns, to be to the west and northwest away from Lough Coura pNHA

For the Drinagh bog area, the presence of existing bog drainage and drainage associated with local tributaries to the Little River also provide existing hydraulic boundaries to the pNHA. The nearest turbine is some 320m from the pNHA boundary (mitigation by design). The proposed works at T14 are relatively shallow in nature and groundwater flow below Drinagh bog is likely, due to local topography and local drainage patterns, to be to the west and northwest away from Lough Coura pNHA and towards the Little River.

For these various scientific (physical and hydrological) reasons, the potential for hydrological drawdown effects to occur at the pNHA as a result of the proposed wind farm development are negligible.

Impact Assessment – All Saints bog and Esker SAC / All Saints Bog SPA

There are surface water connections between the proposed development site and All Saints bog and Esker SAC / All Saints Bog SPA. These pathways could transfer poor quality surface water that may affect the designated sites. However, detailed mitigation measures for sediment control are outlined in Section 9.5.3.1. In addition, detailed mitigation measures for control of hydrocarbons during construction works are outlined in Section 9.5.3.5. Implementation of the mitigation measures will ensure protection of water quality in receiving waters.

There is also a significant separation distance between the proposed development site and All Saints bog and esker SAC (~3.7km to proposed T4 and T11, the two nearest turbines). Ground elevation at T4 and T11 are ~52mOD and ~54mOD respectively. Ground elevations at All Saints bog and esker SAC range between 35-42mOD. Excavation depths at the development site are in the order of ~3 to 6.5m and piling depths may be in the order of ~8 to 12m. The intermittent nature of the turbine locations (they are not continuous, but are separated by large tracks of open bog) and the large separation distance between the development site and All Saints bog and Esker SAC, and the presence of the intermediate hydraulic boundary (the Rapemills River), allows us to conclude using the physical and scientific data that there will be no significant hydrological or water quality impacts on All Saints bog and Esker SAC / All Saints bog SPA from the proposed wind farm development.

Impact Assessment – Ridge Road, SW of Rapemills SAC

There are no surface water connections between the proposed development site and Ridge Road, SW of Rapemills SAC.

There is also a significant separation distance between the proposed development site and Ridge Road, SW of Rapemills SAC (~4.13km to proposed T4, the nearest turbine). Ground elevation at T4 and T5 are ~53mOD and ~54mOD respectively. Ground elevations at Ridge Road, SW of Rapemills SAC range between 50-55mOD. Excavation depths at the development site are in the order of ~3 to 6.5m and piling depths may be in the order of ~8 to 12m. The intermittent nature of the turbine locations (they are not continuous, but are separated by large tracks of open bog) and the large separation distance between the development site and Ridge Road, SW of Rapemills SAC, and the presence of the intermediate hydraulic boundary (the Rapemills River), allows us to conclude using the physical and scientific data that there will be no significant hydrogeological or water quality impacts on Ridge Road, SW of Rapemills SAC from the proposed wind farm development.

Impact Assessment - River Shannon Callows SAC and Middle Shannon SPA

There are surface water connections between the proposed development site and River Shannon Callows SAC and Middle Shannon SPA. These pathways could transfer poor quality surface water that may affect the designated sites. However, detailed mitigation measures for sediment control are outlined in Section 9.5.3.1. And, detailed mitigation measures for control of hydrocarbons during construction works are outlined in Section 9.5.3.5. Implementation of the mitigation measures will ensure protection of water quality in receiving waters.

Groundwater from below the development site may also discharge as baseflow to the Little River, the Rapemills River (or its tributaries) and Brosna River before entering the River Shannon Callows SAC and Middle Shannon SPA. Groundwater quality and quantity will not be affected by the proposed development as outlined in Section 9.5.3.2, Section 9.5.3.5, Section 9.5.3.7, and Section 9.5.3.9.

Using these physical characteristics and by implementation of proven mitigation measures, we can conclude that there will be no significant hydrological or water quality impacts on River Shannon Callows SAC and Middle Shannon SPA from the proposed wind farm development.

Impact Assessment – River Little Brosna Callows SPA / River Little Brosna Callows NHA

There are no surface water connections between the proposed development site and the River Little Brosna Callows SPA / River Little Brosna Callows NHA, and therefore there is no likelihood of any significant effects arising in the absence of a hydrological link.

There is also a significant separation distance between the proposed development site and River Little Brosna Callows SPA / River Little Brosna Callows NHA (~5.5km as the crow flies). The Rapemills River forms an intermediate hydraulic boundary between the wind farm development and River Little Brosna Callows SPA / River Little Brosna Callows NHA sites. It is not physically possible, due to hydrological separation, for groundwater to flow below the Rapemills River and reach the River Little Brosna. Using these physical and topographical (i.e. scientific) data we can conclude that there will be no likely significant hydrological or water quality impacts on River Little Brosna Callows SPA / River Little Brosna Callows NHA from the proposed development.

Pre-Mitigation Potential Impact: No significant hydrological or hydrogeological effects on designated sites listed in Table 9.14 have been identified.

Residual Effects: For the reasons outlined above we consider there will be no residual effects on all designated sites listed in Table 9.14.

Significance of Effects: For the reasons outlined above, no significant impacts on any designated sites are anticipated.

9.5.3.9 Potential Effects on Local Groundwater Well Supplies

As stated in Section 9.3.8 above, the groundwater flow in the mineral soil deposits (silts, sands and gravels) beneath the peat at the proposed development site is expected to discharge into the Silver River, Rapemills River and the Little River. The most western edge of the site, within the Clongawny bog, likely discharges into the Rapemills river located to the west/southwest of the site. Groundwater flow within the centre of the site, near the N62, will flow towards the Little River, while groundwater flow towards the west of the site, within the Drinagh bog, will discharge towards the Silver River.

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

As shown on Figure 9.7, there are a number of dwellings situated along the N62, along the R435 and other minor roads surrounding the Clongawny bog, as well as dwellings along the R437 and other minor roads surrounding the Drinagh bog.

The dwellings surrounding the Clongawny bog are downgradient of the Rapemills River and smaller tributaries, and it is expected that the majority of groundwater flow discharges to these waterbodies, as well as to the larger drainage ditches around the bog.

The Silver River flows along much of the eastern side of the Drinagh bog, and so acts as a hydraulic boundary for groundwater flow. The majority of the dwellings in this area are situated east of this boundary and therefore no impacts on groundwater flow are expected. The Little River flows along the western edge of the Drinagh bog parallel to the N62 and also acts as a hydraulic boundary and groundwater flow from the western edge of the Drinagh bog, the area of the site situated near the N62 and potentially the eastern edge of the Clongawny bog is also expected to discharge to the Little River.

The wind farm is designed so that it at least 750m from surrounding dwelling houses.

The closest proposed infrastructure up-gradient of the dwellings within the setback distance is shown in Table 9.16 below.

Table 9.16: Potential Private Wells Down-gradient of the Development Footprint

Development Footprint Location	Sub-catchment	Distance from Closest Private Dwelling (m)	Assessment
T10	Rapemills	916	Down-gradient, but large separation distance.
T2	Little	750	Across-gradient, but large separation distance.
T3	Little	750	Down-gradient, but large separation distance.
T20	Little	1,395	Down-gradient, but large separation distance.
Substation	Island River/Brosna	340	Down-gradient

Note:
1. Distance from closest turbine, compound, or substation (i.e. excavation/earthworks location). Access roads and the cable trench nor amenity path are not considered a potential risk due to the shallow nature of those 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 as outlined above (this is for assessment purposes only, wells may or may not actually exist).

The closest proposed infrastructure to these dwellings is the substation which has a setback distance of approximately 340m. Due to the shallow nature of the excavation works associated with the substation, no impacts on groundwater levels or local wells are anticipated.

There are 3 no. proposed turbines potentially upgradient of a private dwelling (well locations assumed but not confirmed). The closest upgradient turbine is over 750m away. Due to the nature of the foundation excavations and the use of cement, the potential impacts on closet down-gradient dwelling (and potential well) is assessed below.

Pathway: Groundwater flowpaths.

Receptor: Groundwater Supplies.

Pre-Mitigation Potential Impact: Negative, imperceptible, indirect, long term, low probability effect.

Impact Assessment

The risk to any potential well source down-gradient of a turbine location from potential contaminant release (i.e. sediment, hydrocarbons, and cement-based compounds) within any excavation at this separation distance is negligible (i.e. 750m). Due to the relatively low bulk permeability of mineral soils beneath the peat (i.e. predominately silts and clays with some interbedded gravels), the low recharge characteristics (due to the overlying peat) and the low groundwater gradients (flat topography), groundwater travel times are expected to be slow. The relatively low permeability and the diffuse nature of groundwater flow in the mineral soils would mean that a pollutant would take months/years to travel this distance as demonstrated below by means of the Darcy mean velocity equation:

$$q = k.i$$

$$v = q/ne$$

$$T = L / v$$

where:

q = specific discharge (m/day)

k = permeability m/day (a value of 20m/day for moderate to low permeability subsoils is used).

ne = porosity (a value of 0.025 is used for silts/clays).

i =slope of the water table in the subsoil can be estimated from on topography (a value of 0.005 is used down-gradient of the turbine (60mOD -55mOD)/1000m = 0.005).

v = Darcy velocity (m/day).

L = Distance (metres).

T = Time of travel (days)

Based on a groundwater flow velocity of 20m/day (2.3×10^{-4} m/s, conservative worst-case estimate), the time of travel (ToT) for a potential pollutant to flow from the development location to the closest dwelling house (i.e. 750m) would be in the order of 5 years. During this time any discharge would be assimilated and attenuated by natural groundwater flow and diluted by rainfall recharge. Also, any entrained sediment would be filtered within the low permeability subsoils. Therefore, the risk posed to potential well sources at this distance from potential spills and leaks from excavations is negligible.

In addition, there are proposed mitigation measures (outlined above) that will minimise and prevent potential groundwater contamination from hydrocarbons and other chemicals (refer to Sections 9.5.3.5, 9.5.3.6, and 9.5.3.7).

Residual Effects: For the reasons outlined in the impact assessment above (separation distances, and prevailing geology, topography and groundwater flow directions), we consider the residual effects to be - negative, imperceptible, indirect, long term, low probability effect in terms of quality or quantity.

Significance of Effects: For the reasons outlined above, no significant impacts on potential groundwater supplies are anticipated.

9.5.3.10 Potential Impacts of the Proposed Amenity Links

A total of approximately 18km of amenity pathways (including walkways and cycleways, and carpark) will be provided as part of the construction of the proposed development. The amenity pathways will be mainly located on the proposed internal road network. The roads will be re-purposed following construction to form the amenity pathways, in addition to being used for maintenance access during operation. The amenity pathways will have a gravel/crushed stone finish surface. Figure 4.30 outlines the final configuration of the internal roads with the cycleway included in the layout plan.

In addition, approximately 6.5 km of dedicated amenity pathways are proposed to provide access points/links into and out of the site as follows:

- Internal link to R437 allowing further access to Drinagh and Derrybrat to facilitate potential future connection to Lough Boora Parklands.
- Link from the R357 and L7009 providing connectivity to the local Stonestown and wider Cloghan area.
- Link to the L7005 providing connectivity to the local Drinagh area.
- Link to the Bord na Móna boundary in Clongawny West to facilitate potential future connection to the R438.
- Link to the Bord na Móna boundary in southwest Drinagh to facilitate potential future connection to the proposed Whigsborough Walkway.

In addition to the amenity pathway, a new public car park will be provided for recreational use during the operational stage. The car park will be located adjacent to the proposed access off the R357, immediately north of the proposed substation.

The amenity access points off the R357 and L7009 are discussed in Section 4.4.1. Only these access points will be available to public during the operational phase. As outlined in Section 4.3.3, amenity connectivity between Clongawny and Drinagh Bogs will be via an underpass beneath the N62 only.

Pathway: Extraction/excavation of soil/subsoil.

Receptor: Surface water quality and groundwater quality.

Pre-Mitigation Potential Impact: Negative, slight, indirect, low probability, short-term effect on surface water quality and groundwater quality.

Proposed Mitigation Measures:

Detailed mitigation measures for sediment control are outlined in Section 9.5.3.1. And, detailed mitigation measures for control of hydrocarbons during construction works are outlined in Section 9.5.3.5.

Residual Effect: For the reasons outlined in the impact assessment above, we consider the residual effects to be - Negative, imperceptible, indirect, low probability, short-term effect on surface water and groundwater quality.

Significance of Effects: For the reasons outlined above, no significant effects on surface water and groundwater quality are anticipated.

9.5.3.11 Potential Effects of the Proposed Haul Route Junction Works

A new temporary arrangement will be required at Kennedy's Cross, located in the townland of Ballindown, (junction of the N52 and N62 National Secondary Roads), comprising construction of a new road across third party lands, to facilitate the delivery of turbine components and other abnormal loads. The proposed new road will measure approximately 160 metres in length and have a 6-metre running width.

Pathway: Extraction/excavation of soil/subsoil.

Receptor: Surface water quality and groundwater quality.

Pre-Mitigation Potential Impact: Negative, slight, indirect, low probability, temporary effect on surface water quality and groundwater quality.

Proposed Mitigation Measures:

Detailed mitigation measures for sediment control are outlined in Section 9.5.3.1. And, detailed mitigation measures for control of hydrocarbons during construction works are outlined in Section 9.5.3.5.

Residual Effect: Based on the implementation of proven mitigation, as outlined above, we consider the residual impacts to be - Negative, imperceptible, indirect, low probability, temporary effect on surface water and groundwater quality.

Significance of Effects: For the reasons outlined above, no significant effects on surface water and groundwater quality are anticipated.

9.5.4 Operational Phase - Likely Significant Effects and Mitigation Measures

9.5.4.1 Progressive Replacement of Natural Surface with Lower Permeability Surfaces

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

The emplacement of the proposed permanent development footprint, as described in Chapter 4 of the EIAR, (assuming emplacement of impermeable materials as a worst-case scenario) could result in an average total site increase in surface water runoff of approximately 1,213 m^3/month (Table 9.17). This represents a potential increase of approximately 0.06 % in the average daily/monthly volume of runoff from the site area in comparison to the baseline pre-development site runoff conditions (Table 9.6). This is a very small increase in average runoff and results from the naturally high surface water runoff rates and the relatively small area of the site being developed, the proposed total permanent development footprint being approximately 34.2ha, representing 1.45% of the total study area of ~2,360 ha.

Table 9.17: Baseline Site Runoff V Development Runoff

Development Type	Site Baseline Runoff/month (m^3)	Baseline Runoff/day (m^3)	Permanent Hardstanding Area (m^2)	Hardstanding Area 100% Runoff (m^3)	Hardstanding Area 96% Runoff (m^3)	Net Increase/month (m^3)	Net Increase/day (m3)	% Increase from Baseline Conditions (m^3)
Wind Farm	2,008,454	64,789	342,000	30,318	29,106	1,213	39	0.06%

The additional volume is low due to the fact that the runoff potential from the site is naturally high (96%). Also, the calculation assumes that all hardstanding areas will be impermeable which will not be the case as access tracks will be constructed of permeable stone aggregate. The increase in runoff from the proposed development will, therefore, be negligible. This is even before mitigation measures will be put in place.

Pathway: Site drainage network.

Receptor: Surface waters and dependent ecosystems.

Pre-Mitigation Potential Impact: Negative, slight, indirect, permanent, moderate probability effect on all downstream surface water bodies.

Proposed Mitigation by Design:

As the part of the proposed wind farm drainage design, it is proposed that runoff from the proposed infrastructure will be collected locally in new proposed silt traps, settlement ponds and vegetated buffer areas prior to release into the existing drainage network. The new proposed drainage measures will then create significant additional attenuation to what is already present. The operational phase drainage system will be installed and constructed in conjunction with the existing bog drainage network and will include the following:

- 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 into downstream field drains;
- Collectors drains will be used to gather runoff from access roads and turbine hardstanding areas of the site, likely to have entrained suspended sediment, and channel it to new local settlement ponds for sediment settling;
- On 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/roadside 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 access road 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 existing drains;
- Settlement ponds will be designed in consideration of the greenfield runoff rate, existing bog settlement ponds will also buffer discharges from the two bog (Clongawny and Drinagh); and,
- Finally, all surface water runoff from the development will have to pass through the settlement ponds at the existing bog outfall locations.

Post-Mitigation Impact Assessment

As stated in Section 9.3.4 above there are existing surface water control measures at the bog which comprise high level bog surface drains, low level main drains and settlement ponds. All these existing drainage measures offer some surface water attenuation during rainfall events. However, as the part of the proposed wind farm drainage (which is outlined further in Section 9.4.1 and Section 9.4.2 above), it is proposed that runoff from the proposed infrastructure will be collected locally in new proposed silt traps, settlement ponds and vegetated buffer areas prior to release into the existing drainage network. The new proposed drainage measures will then in effect create significant additional attenuation to what is already present at the site. The net effect of this will be a reduction in the overall runoff coefficient of the bog as demonstrated by the use of the Rational Method in Table 9.18 below. Based on a conservative reduction in the runoff coefficient from 0.96 to 0.85 for the overall site, there would a potential 11.4% reduction in runoff volumes from the site. This assessment demonstrates that there will be no risk of exacerbated flooding down-gradient of the site as a result of the proposed wind farm development. The proposed development will in effect retain water within the bog for longer periods.

Table 9.18: Surface Water Runoff Assessment for Proposed Wind Farm Drainage

Site Area	C (1)	Area (m^2)	Rc (2)	100-Year 6hr Rainfall Depth (m)	Runoff Volume (m^3)	Total Site Runoff Volume (m^3)
Without Wind Farm Drainage Control						
Undeveloped Area	2.78	23,258,000	0.96	0.0515	1,149,876	1,167,489
Development Footprint	2.78	342,000	1.00	0.0515	17,613	
With Wind Farm Drainage Control						
Undeveloped Area	2.78	23,258,000	0.85	0.0515	1,018,119	1,034,851
Development Footprint	2.78	342,000	0.95	0.0515	16,732	
Estimated Potential Reduction in Site Runoff Volumes (%)						11.4%

Notes: 1 – Constant, 2- Runoff Coefficient

Residual Effect: With the implementation of the proposed wind farm drainage measures as outlined above, and based on the post-mitigation assessment of runoff, we consider that residual effect are - Negative, imperceptible, indirect, long-term, moderate probability effect on all downstream surface water bodies.

Significance of Effects: For the reasons outlined above, no significant effects on downstream flood risk is anticipated.

9.5.4.2 Runoff Resulting in Suspended Solids Entrainment in Surface Waters

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

These minor activities could, however, result in the release of suspended solids to surface water and could result in an increase in the suspended sediment load, resulting in increased turbidity which in turn could affect the water quality and fish stocks of downstream water bodies. Potential effects could be significant if not mitigated 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 and associated dependent ecosystems.

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

Proposed Mitigation Measures:

Mitigation measures for sediment control are the same as those outlined in Section 9.5.3.1.

Mitigation measures for control of hydrocarbons during maintenance works are similar to those outlined in Section 9.5.3.5.

Residual Effects: With the implementation of the proposed wind farm drainage measures as outlined above, and based on the post-mitigation assessment of runoff, we consider that residual effect 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 are anticipated.

9.5.4.3 Potential Effects on Local Groundwater Well Supplies from Operation of Abstraction Well at Proposed Substation

It is proposed to install a groundwater well adjacent to the substation in accordance with the Institute of Geologists Ireland, *Guide for Drilling Wells for Private Water Supplies* (IGI, 2007). The well will be flush to the ground and covered with a standard manhole. A pump house is not currently envisaged as an in-well pump will direct water to a water tank within the roof space of the control building (subject to final design). Bottled water will be supplied for drinking, if required. The proposed abstraction volume from the well will be small, as there will only be intermittent use of welfare facilities at the substation. For the purpose of our assessment we have assumed a worst-case abstraction of $1m^3$/week.

As presented in Table 9.16 above, the closest dwelling to the proposed substation location is ~340m. Based on this separation distance, and the very low abstraction rate proposed from the substation groundwater well, and also based on the type of underlying geology (limestone bedrock aquifer, (*c.f.* Section 9.3.8),

Pathway: Groundwater volume and water level drawdown.

Receptor: Local groundwater supplies.

Pre-Mitigation Potential Impact: Neutral, imperceptible, indirect, long-term, low probability effect on local groundwater volumes and water levels.

No mitigation is proposed, as the proposed abstraction is such a small volume.

Residual Effects: For the reasons outlined in the impact assessment above (separation distances, and prevailing geology), we consider the residual effects to be none.

Significance of Effects: For the reasons outlined above, no significant impacts on local groundwater supplies from operation of the proposed substation well are anticipated.

9.5.4.4 Assessment of Potential Health Effects

Potential health effects are associated with negative impacts (i.e. contamination) on public and private water supplies and potential flooding. There are no mapped public or group water scheme groundwater protection zones in the area of the proposed wind farm site. The Banagher PWS abstraction is located west of the site, approximately 2 km southeast of Banagher. The mapped source protection zone for this GWS does not fall within the proposed development site boundary. Notwithstanding this, the proposed site design and mitigation measures ensures that the potential for impacts on the groundwater environment are not significant

Flooding of property can cause inundation with contaminated flood water. Flood waters can carry waterborne disease and contamination/effluent. Exposure to such flood waters can cause temporary health issues. The Flood Risk Assessment has also shown that the risk of the proposed wind farm contributing to downstream flooding is also very low, as the long-term plan for the site is to retain and slow down drainage water within the existing site. On-site drainage control measures will ensure no downstream increase in flood risk.

9.5.5 Decommissioning Phase - Likely Significant Effects and Mitigation Measures

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

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

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

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

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

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

9.5.6 Assessment of Cumulative Effects

A cumulative impact assessment was undertaken regarding other wind farm developments and non-wind farm developments located within a 20km radius and inside the River Shannon catchment. The wind farm developments assessed are listed in Table 9.19 below and are shown on Figure 9.8. Non-wind farm developments that have been assessed are listed in Section 2.5.

In terms of the potential impacts of developments on downstream surface water bodies (e.g. Sliver River, Rapemills River, Little River, Little Brosna River and River Shannon), 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 sites. However, within 20km of the proposed site inside the River Shannon catchment, a high majority (54%) of the other windfarm developments are operational, therefore construction phase impacts with the proposed Derrinlough WF are not anticipated. It is also anticipated that the Cloghan wind farm will be built in advance of the proposed Derrinlough wind farm, and therefore the relative construction periods will not overlap. However, a worst-case scenario would be that the Cloghan wind farm and Derrinlough WF are constructed at the same time, and this is assessed below.

In terms of operational phase hydrological effects, the total number of turbines that could potentially be operating within a 20km radius of the site inside the River Shannon catchment is 43 no. (which includes 21 no. from the proposed Derrinlough WF). The total catchment area of the River Shannon within a 20km radius of the proposed site is ~1,384km^2 and therefore this equates to 1 turbine for approximately every ~32km^2 which would not be considered high density. Therefore, effects on catchment hydrology and water quality are not be expected.

The construction of the wind farm grid connection works will only require relatively localised excavation works within the site boundary and therefore will not contribute to any significant cumulative effects on the water environment.

Implementation of the proposed drainage mitigation during the construction phase (Section 9.5.3) will ensure there will be no cumulative significant adverse impacts on the water environment from the proposed development and other wind farm developments (including a concurrent construction of Cloghan wind farm) and non-wind farm developments within the River Shannon catchment. Non-wind projects also include exempted development such as OPW arterial and drainage maintenance works.

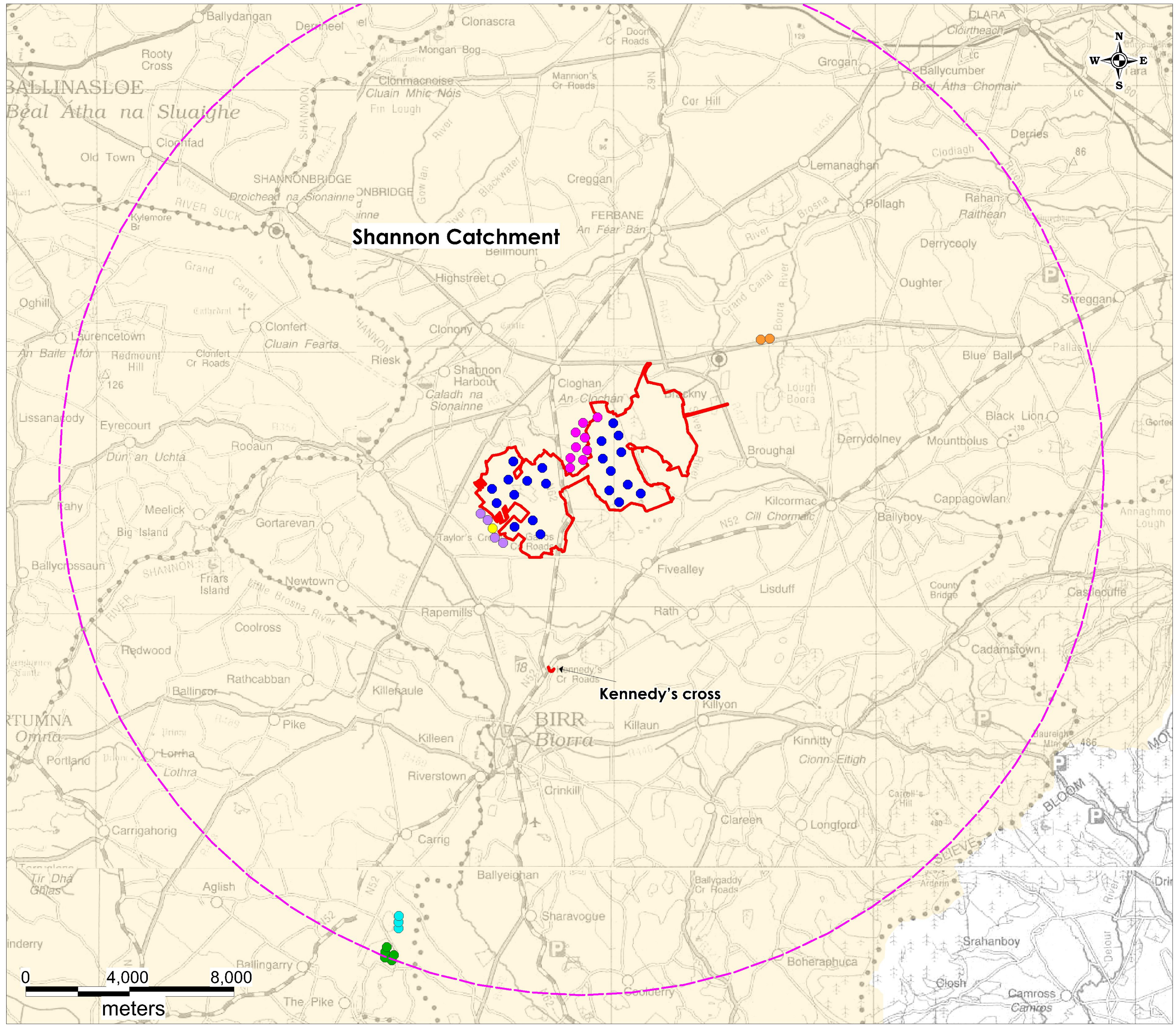
In terms of cumulative hydrological effects arising from elements of the Proposed Development no significant effects on water quality or flood flows are expected as they are all contained within the site and therefore will be within the wind farm drainage catchment where all construction water will be attenuated and treated as described above (Sections 9.5.3 and 9.5.4).

Table 9.19: Other Wind Farm Developments in the River Shannon catchment within a 20km radius of the site

Catchment Area	Wind Farm Name	Status	Potential No. of Turbines in Catchment
River Shannon	Skehanagh WF	5 no. Existing	5
	Carrig WF	3 no. Existing	3
	Meenwaun WF	4 no. Existing	4
	Meenwaun WF	1 no. Permitted	1
	Cloghan WF	9 no. Permitted	9
Potential Total			**22**

9.5.7 Post Consent Monitoring

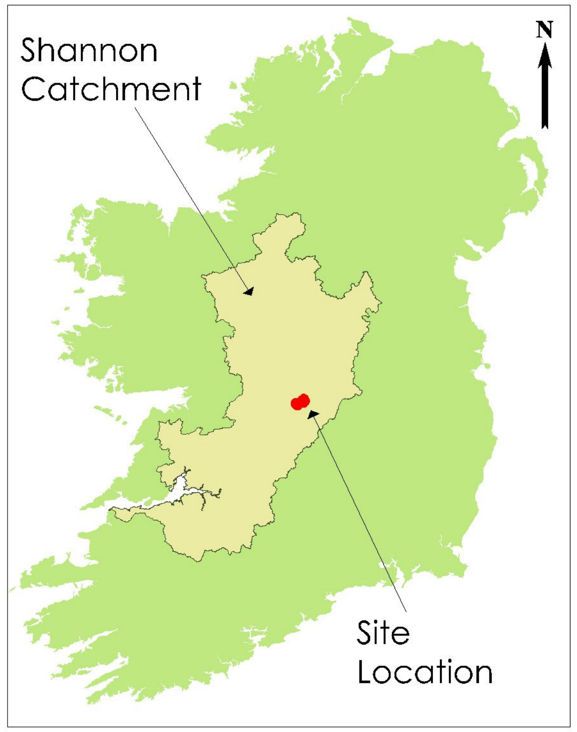
None required.



Legend

- EIAR Site Boundary
- Derrinlough WF (Proposed)
- Carrig WF (Existing)
- Cloghan WF (Permitted)
- Leabeg WF (Existing)
- Meenwaun WF (Existing)
- Meenwaun WF (Permitted)
- Skehanagh WF (Existing)
- 20km radius from the site

Key Plan



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Client: Bord na Mona Powergen Ltd	
Job: Derrinlough WF, Co. Offaly	
Title: Cumulative Assessment Map	
Figure No: 9.8	
Drawing No: P1463-0-0220-A3-908-00A	
Sheet Size: A3	Project No: P1463-0
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