9. HYDROLOGY AND HYDROGEOLOGY

9.1 Introduction

9.1.1 Background and Objectives

Hydro-Environmental Services (HES) was engaged by McCarthy Keville O'Sullivan (MKO) to carry out an assessment of the potential effects of the Proposed Development on water aspects (hydrology and hydrogeology).

This Chapter provides a baseline assessment of the environmental setting of the Proposed Development, as described in Chapter 4 in terms of the water environment (hydrology and hydrogeology) and discusses the potential effects that the construction and operation of the Proposed Development will have. Where required, appropriate mitigation measures to limit any identified significant impacts to the water environment are recommended.

Please note that in this chapter we refer to the Wind Farm Site (15 no. turbines, access roads, onsite substation borrow pit, temporary construction compound, forestry felling and all associated works), and the Grid Connection Route (26km long running from the proposed wind farm site to Mullingar substation where upgrade works are proposed), and the Proposed Development study area. Other elements of the Project are referenced accordingly (*i.e.* replacement planting lands).

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 (PGeo, 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 (BSc, MSc) is a hydrogeologist with three 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 assessment has been informed by consultation with statutory consultees, bodies with environmental responsibility and other interested parties as summarised in Section 2.6 of Chapter 2 of the EIAR. Consultation responses relating to the water environment were received from the Geological Survey of Ireland and the OPW. 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 2 local County Geological Sites (CGS) near the grid route; Lough Derravaragh and Portnashangan Quarry ,as well as 2 no. CGSs near the wind farm site; Lough Kinale and Derragh Lough & Rock of Curry and Hill of Mael • 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. Geological Heritage Sites are address in Chapter 8, Section 8.3.6 Flooding is addressed in Section 9.3.6. Groundwater assessment addressed in Sections 9.3.8, 9.3.9, 9.3.10, 9.3.13, 9.4.1.3, 9.4.1.4, 9.4.1.5, 9.4.1.6 and 9.4.1.10. Refer to Chapter 8: Land, Soils and Geology for assessment of aggregate resources.
OPW	• Proposed site is located in lands that benefit from the River Inny Catchment Drainage Scheme. There may be a risk of flooding at this location. • The OPW requests that a 10m wide strip be retained adjacent to the channels to permit access for maintenance. Strip should not be fenced, paved or landscaped in a manner that would prevent access by maintenance plant.	• Benefitting lands and flood risk is dealt with in Section 9.3.6 and in the Flood Risk Assessment included as Appendix 9-1. • No works are proposed which would alter the ability of maintenance plant to reach/maintain the river/drain channels. 10m strip will be maintained at all times.

9.1.4 Relevant Legislation

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

The requirements of the following legislation are complied with:

- S.I. No. 349 of 1989: European Communities (Environmental Impact Assessment) Regulations, and subsequent Amendments (S.I. No. 84 of 1994, S.I. No. 101 of 1996, S.I. No. 351 of 1998, S.I. No. 93 of 1999, S.I. No. 450 of 2000 and S.I. No. 538 of 2001, S.I. 134 of 2013 and the Minerals Development Act 2017), the Planning and Development Act, and S.I. 600 of 2001 Planning and Development Regulations and subsequent Amendments. These instruments implement EU Directive 85/337/EEC and subsequent amendments, on the assessment of the effects of certain public and private projects on the environment;
- Directives 2011/92/EU and 2014/52/EU on the assessment of the effects of certain public and private projects on the environment, including Circular Letter PL 1/2017: Implementation of Directive 2014/52/EU on the effects of certain public and private projects on the environment (EIA Directive);
- Planning and Development Act, 2000, as amended;
- Planning and Development Regulations, 2001 (as amended);
- S.I. No 296 of 2018: European Union (Planning and Development) (Environmental Impact Assessment) Regulations 2018 which transposes the provisions of Directive 2014/52/EU into Irish law;
- S.I. No. 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)

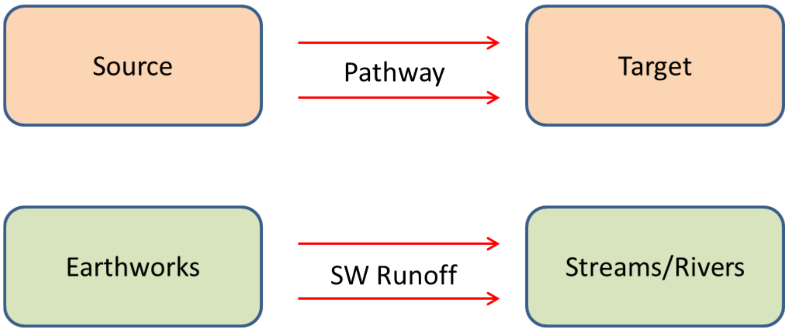
9.1.5 Relevant Guidance

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

- Environmental Protection Agency (September 2015): Draft - Advice Notes on Current Practice (in the preparation of Environmental Impact Statements);
- Environmental Protection Agency (September 2015): Draft – Revised Guidelines on the Information to be Contained in Environmental Impact Statements;
- Environmental Protection Agency (August 2017): Draft Guidelines on the Information to be Contained in Environmental Impact Assessment Reports;
- Environmental Protection Agency (2003): Advice Notes on Current Practice (in the preparation of Environmental Impact Statements);
- Environmental Protection Agency (2002): Guidelines on the Information to be Contained in Environmental Impact Statements;
- Institute of Geologists Ireland (2013): Guidelines for Preparation of Soils, Geology & Hydrogeology Chapters in Environmental Impact Statements;
- National Roads Authority (2008): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;
- Department of Environment, Heritage and Local Government (DoEHLG); Wind Energy Development Guidelines for Planning Authorities (2006);
- Forestry Commission (2004): Forests and Water Guidelines, Fourth Edition. Publ. Forestry Commission, Edinburgh;
- Coillte (2009): Forest Operations & Water Protection Guidelines;
- Forest Services (Draft) Forestry and Freshwater Pearl Mussel Requirements – Site Assessment and Mitigation Measures;
- Forest Service (2000): Forestry and Water Quality Guidelines. Forest Service, DAF, Johnstown Castle Estate, Co. Wexford;
- COFORD (2004): Forest Road Manual – Guidelines for the Design, Construction and Management of Forest Roads;
- Inland Fisheries Ireland (2016): Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters;
- 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. London, 2006;
- Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment (DoHPLG, 2018); and,
- Guidance on the preparation of the EIA Report (Directive 2011/92/EU as amended by 2014/52/EU), (European Union, 2017).

9.1.6 Overview of Impact Assessment Process

The conventional source-pathway-target model (see below, top) was applied to assess potential effects on downstream environmental receptors (see below, bottom as an example) as a result of the Wind Farm Site and Grid Connection Route.



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

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

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 9.4), a summary guide is presented in Table 9-2, which defines the steps (1 to 7) taken in each element of the impact assessment process. The guide also provides definitions and descriptions of the assessment process and shows how the source-pathway-target model and the EPA impact descriptors are combined.

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

Table 9-2: 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.

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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 4	Pre-mitigation Impact:	Impact descriptors which describe the magnitude, likelihood, duration and direct or indirect nature of the potential impact before mitigation is put in place.
Step 5	Proposed Mitigation Measures:	Control measures that will be put in place to prevent or reduce all identified significant adverse impacts. In relation to this type of development, these measures are generally provided in two types: (1) mitigation by avoidance, and (2) mitigation by (engineering) design.
Step 6	Post-Mitigation Residual Impact:	Impact descriptors which describe the magnitude, likelihood, duration and direct or indirect nature of the potential impacts after mitigation is put in place.
Step 7	Significance of Effects:	Describes the likely significant post-mitigation effects of the identified potential impact source on the receiving environment.

9.2 Methodology

9.2.1 Desk Study

A desk study of the Wind Farm Site, Grid Connection Route 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:

- Environmental Protection Agency database (www.epa.ie);
- Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Met Eireann Meteorological Databases (www.met.ie);
- National Parks & Wildlife Services Public Map Viewer (www.npws.ie);
- Water Framework Directive Map Viewer (www.catchments.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 12 (Geology of Longford Roscommon); Geological Survey of Ireland (GSI, 1999);
- Geological Survey of Ireland - Groundwater Body Characterisation Reports;
- OPW Indicative Flood Maps (www.floodmaps.ie);
- Environmental Protection Agency – "Hydrotool" Map Viewer (www.epa.ie);
- CFRAM Preliminary Flood Risk Assessment (PFRA) maps (www.cfram.ie); and,
- Department of Environment, Community and Local Government on-line mapping viewer (www.myplan.ie).

9.2.2 Baseline Monitoring and Site Investigations

A hydrological walkover survey, including detailed drainage mapping and baseline monitoring/sampling, was undertaken by HES on 13th to 15th December 2016, 2nd February, 8th March, and 23rd March 2017. Further field surveys were carried out by HES on the 06th and 07th November 2019, and on 23rd September, and 15th and 22nd October 2020. Hydrological and hydrogeological data used in this assessment includes:

- Walkover surveys and hydrological mapping of the Wind Farm Site, Grid Connection Route, turbine delivery route, link road and the surrounding areas were undertaken whereby water flow directions and drainage patterns were recorded;
- A preliminary flood risk assessment for the Proposed Development footprint area (refer to Appendix 9-1);
- A total of over 250 no. peat probes were undertaken by AGEC Ltd., FTCO and HES to determine the thickness and geomorphology of the raised bog peat overlying the Wind Farm Site (refer to Appendix 8-1 and 8-2);
- Additional probing at 80 no. locations was completed along the Grid Connection Route, where priority sections with peat substrate required investigation (refer to Appendix 4-4);
- 8 no. trial pits were completed near the borrow pit and substation at the Wind Farm Site by HES in December 2016;
- 11 no. window sample cores were taken at the Wind Farm Site by HES in December 2016;
- 6 no. sets of shallow and deep piezometers were installed at the Wind Farm Site by HES in December 2016;
- Seasonal water level monitoring in installed piezometers and boreholes was completed;
- An initial geotechnical assessment of peat stability for the Wind Farm Site was completed by AGEC Ltd (April, 2017) and this was updated (FTCO) to include the additional turbines in 2020 (refer to Appendix 8-1);
- A geotechnical assessment and peat stability assessment for 3 no. priority sections of the Grid Connection Route where peat substrate exists was completed by AGEC Ltd (May, 2017) (refer to Appendix 4-4);
- 13 no. rotary core boreholes were drilled at turbine locations and at the substation by GII;
- A geophysical survey was carried out along the Grid Connection Route by Apex Geophysics in October 2019 (refer to Appendix 4-5);
- Field hydrochemistry measurements (electrical conductivity, pH and temperature) were taken to determine the origin and nature of surface water flows at the Wind Farm Site;
- Surface water sampling at 4 no. surface water locations were undertaken to determine the baseline water quality of the primary surface waters originating from the proposed wind farm site;
- Field hydrochemistry measurements were undertaken at 20 no. locations along the grid route, with surface water samples being taken at 10 of these 20 no. locations;
- Groundwater levels were dipped within existing piezometers at the Wind Farm Site and at turbine location boreholes which were near former piezometers (September – October 2020);
- Field hydrochemistry measurements (electrical conductivity, pH and temperature) were taken to determine the origin and nature of surface water flows at 5 no. locations (4 no. previous locations plus additional sampling near T15); and,
- A total of 15 no. surface water samples were undertaken to determine the baseline water quality of the primary surface waters originating from the Wind Farm Site (September - October 2020).

9.2.3 Impact Assessment Methodology

Please refer to Chapter 1 of the EIAR for details on the impact assessment methodology used in this EIAR (EPA, 2002 & 2003). 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 9-3 are then used to assess the potential effect that the Proposed Development may have on them.

Table 9-3: 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

9.3.1.1 Wind Farm Site

The Wind Farm Site is located approximately 2.4 kilometres north of Coole village and approximately 3.5 kilometres south of the village of Finnea. The townlands in which the Wind Farm Site and Grid Connection Route, are listed in Table 1-1 in Chapter 1 of this EIAR. The Wind Farm Site comprises primarily commercial cutover peat, with some areas of forestry (T5 & T14), along with T15 located within an agricultural field. The Wind Farm Site is located within the Upper Shannon (26F) catchment within Hydrometric Area 26. Three separate, but adjacent, peat basins form the majority of the overall Wind Farm Site, and these are located to the east of the Inny River.

The total Wind Farm Site measures approximately 530 hectares. For the purposes of the Environmental Impact Assessment Report (EIAR), where the 'Wind Farm Site' is referred to, this refers to the study area for the proposed wind farm development, as delineated in the EIAR maps. The actual site boundary for the purposes of the planning application occupies a smaller area. The footprint of the

Proposed Development measures approximately 26.4 hectares, which represents only 5% of the Wind Farm Site. The Grid Connection Route is dealt with separately and is identified as such.

The majority of the Wind Farm Site is comprised of a peat bog, and the elevation of the site ranges between approximately 60m OD and 66m OD. Lough Bane, a proposed National Heritage Area (pNHA) is located immediately northeast of the peat harvesting area at the Wind Farm Site. The site is also partially bound by the Inny River to the west, agricultural land to the south and east, and coniferous forestry and a peat bog to the north. The River Glore intersects the northern section of the Wind Farm Site as it flows from southeast to northwest.

9.3.1.2 Grid Connection

The Grid Connection Route passes along public roads between Monktown, Coole, and Irishtown, Mullingar. The Grid Connection Route is located within both the Upper Shannon (26F) and Lower Shannon (25A) catchments within Hydrometric Area 26. The Grid Connection Route begins along the R396, ~ 3km northwest of Coole in the townland of Monktown and passes south along the L1826 to Multyfarnham along the western edge of Lough Derravaragh and adjacent to the River Inny. It then continues south along the N4, adjacent to the eastern side of Lough Owel and the River Gaine.
It terminates at the existing Mullingar 110kV Substation in Irishtown, Mullingar. The Grid Connection Route has a length of ~26km.

9.3.2 Water Balance

Long term rainfall and evaporation data was sourced from Met Éireann. The long-term average rainfall (1981 - 2010) recorded at Granard, 8km to the northwest of the Wind Farm Site, are presented in Table 9-4.

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

Station		X-Coord		Y-Coord		Ht (MAOD)		Opened		Closed		Total
Granard		233700		281300		N/A		N/A		N/A		
Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
96.7	72.6	81.9	67.3	64.6	75.8	70.9	88.1	81.1	103.1	95	102	999.1

The closest synoptic station[1] where the average potential evapotranspiration (PE) is recorded is at Mullingar, approximately 16km southwest of the Wind Farm Site. The long-term average PE for this station is 446mm/year. This value is used as a best estimate of the site PE. Actual Evaporation (AE) at the site is estimated as 424mm/year (which is 0.95 × PE).

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

Effective rainfall (ER) = AAR – AE

= 999 mm/year – 424mm/year

ER = 575mm/year

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 at the Wind Farm Site (recharge coefficient of ~4%). This means that the hydrology of the Wind Farm Site is characterised by very high surface

[1] *A station at which meteorological observations are made for the purposes of synoptic (large spatial scale) analysis*

water runoff rates and very low groundwater recharge rates. Therefore, conservative annual recharge and runoff rates for the Wind Farm Site are estimated to be 18mm/year and 557mm/year (i.e. 575mm/year – 18mm/year = 557mm/year) respectively.

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

Table 9-5: Return Period Rainfall Depths for the Wind Farm site

Duration	10-year Return Period	50-Year Return Period	100-Year Return Period
15 min	14.5	24.4	30.3
1 hour	21.7	34.7	42.2
6 hour	36.5	54.8	64.8
12 hour	44.7	65.4	76.6
24 hour	54.7	78.0	90.4
48 hour	63.7	87.9	100.5

9.3.3 Regional Hydrology

9.3.3.1 Wind Farm Site

On a regional scale, the Wind Farm Site is located in the Inny River surface water sub-catchment, which is in the Upper Shannon catchment within Hydrometric Area 26 of the Shannon International River Basin District (SIRBD). A regional hydrology map is shown as Figure 9-1.

On a more local scale, the Wind Farm Site is located in the Inny River sub-catchment and two sub basins of the Inny River (refer to Figure 9-2). The majority of the Wind Farm Site is within the Inny_050 sub basin with a small section in the south of the Wind Farm Site near the R396 within the Inny_060 sub basin. The Inny River flows in a southerly direction along the western boundary of the Wind Farm Site and discharges into Lough Derraverragh approximately 7.5km downstream of the proposed Wind Farm Site.

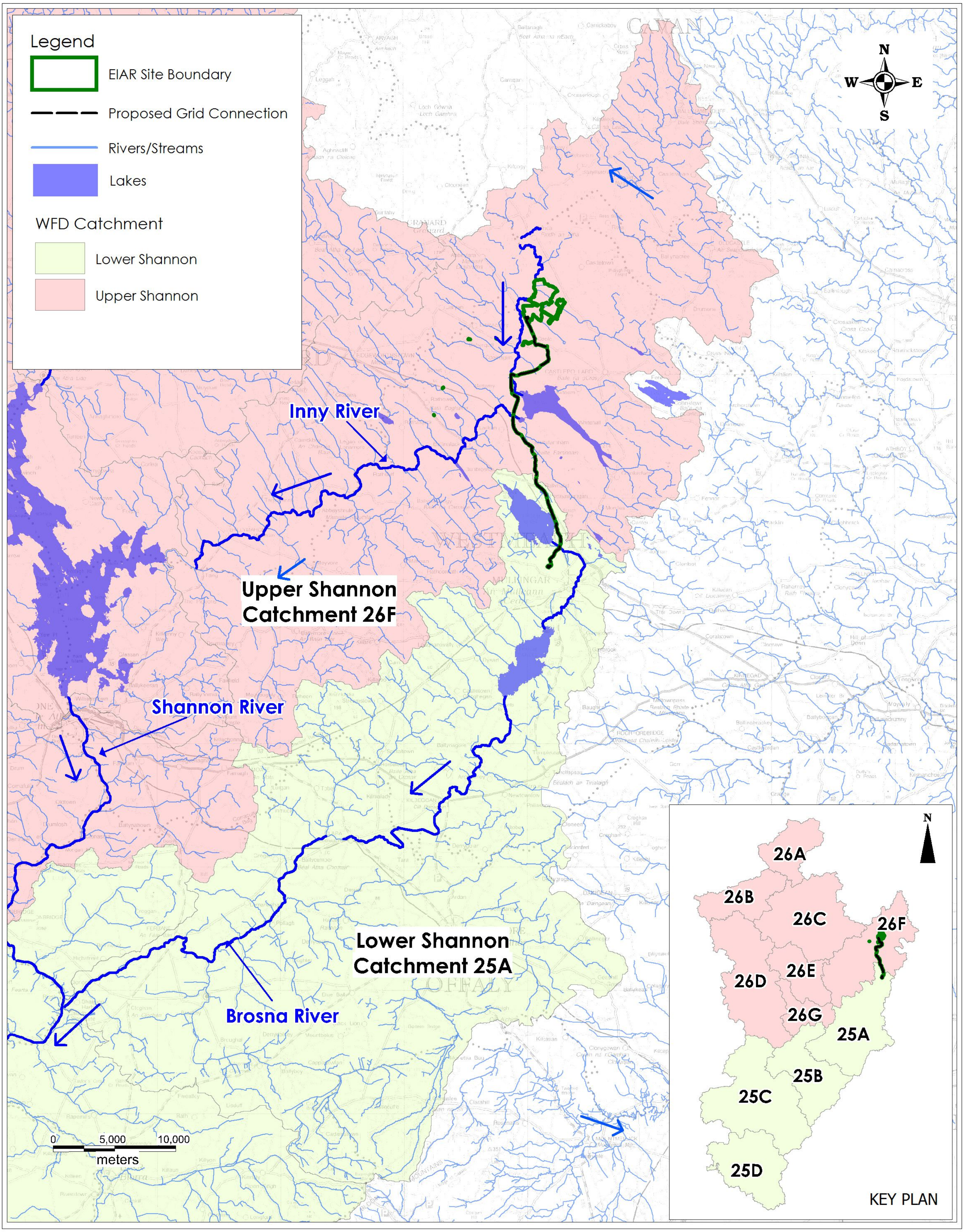
The western section of the Wind Farm Site drains directly to the Inny River via a number of settlement ponds and outfall channels which are discussed further below in the site drainage section. The River Glore flows from across the northern section of the Wind Farm Site from east to west and merges with the Inny River on the western boundary of the Wind Farm Site. The proposed borrow pit is located within the River Glore catchment.

A drain (henceforth known as drain D1), which divides the northern basin in two sections, discharges directly to the Inny River northwest of the Wind Farm Site. Lough Bane, proposed Natural Heritage Area (pNHA) is located adjacent to the northern boundary of the Proposed Development site; however, no part of the Proposed Development footprint is located within the pNHA. Lough Bane itself is located approximately 180 metres north of the internal access road between Turbines T2 and T4. An unnamed small dystrophic lake is located on the northwestern corner of the site (these lakes are discussed in further detail below).

The proposed link road is located within the Inny River catchment, and the junction improvement works are also located within sub-catchments to the Inny River.

The Inny River flows south from the Wind Farm Site into Lough Derraverragh approximately 7.5km downstream of the site. Local hydrology maps are discussed and referenced in 9.3.4 below.

Based on the EPA flow duration curve for ungauged catchments the 95%ile flow of the Inny River upstream of the proposed wind farm site is reported to be 0.83m^3/s while the 50%ile flow is reported to be 5.7m^3/s.



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Scale: 1:400,000	Project No: P1320-2
Drawn By: GD / Checked By: MG	Drawing No: P1320-2-0121-A4-901-00A

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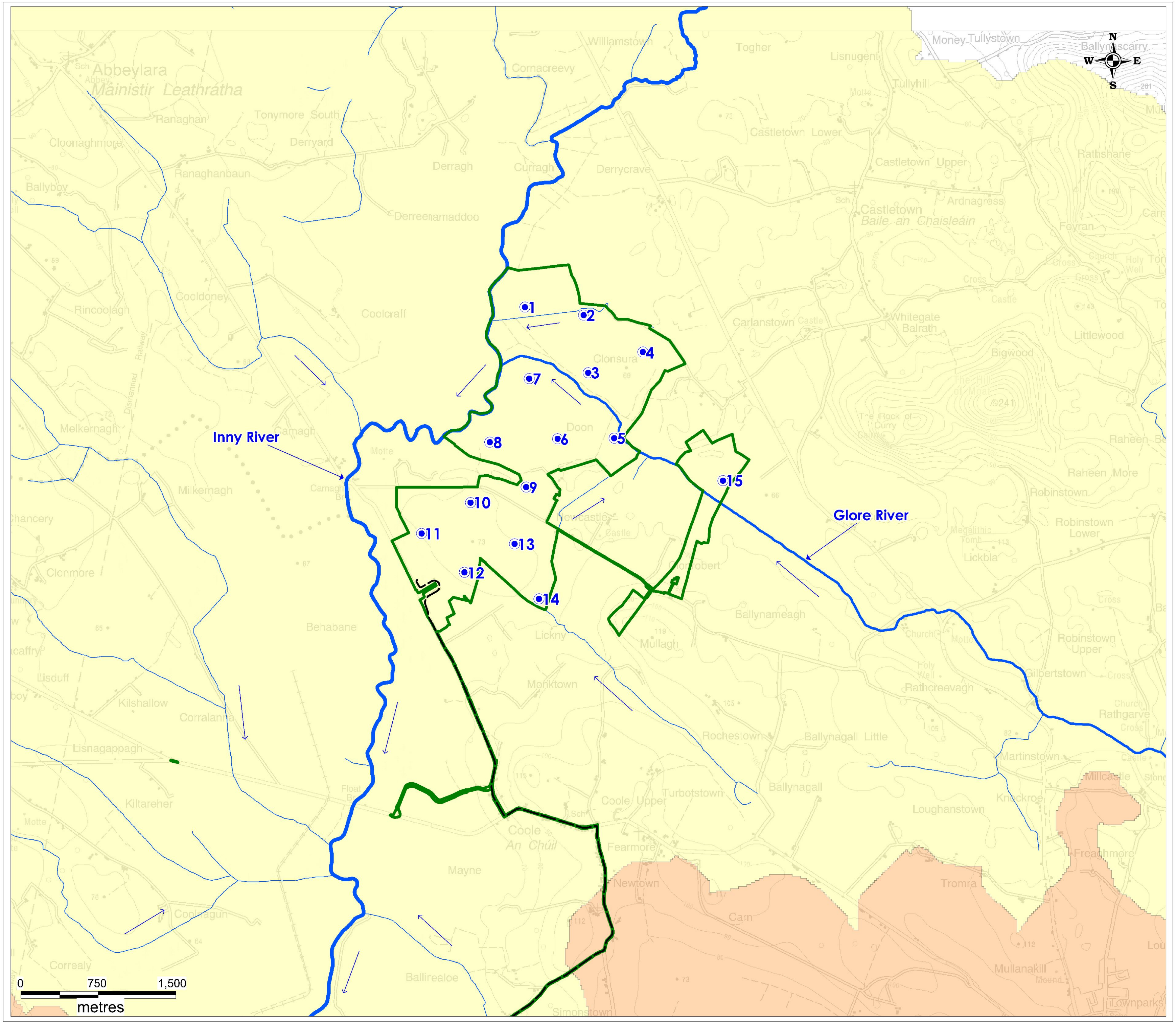

Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Proposed Grid Connection
- Rivers/Streams

WFD Subcatchments

- Inny[Shannon]_SC_020
- Inny[Shannon]_SC_030

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Client: MKO	
Job: Coole WF, Co. West Meath	
Title: Wind Farm Site Local Hydrology Map	
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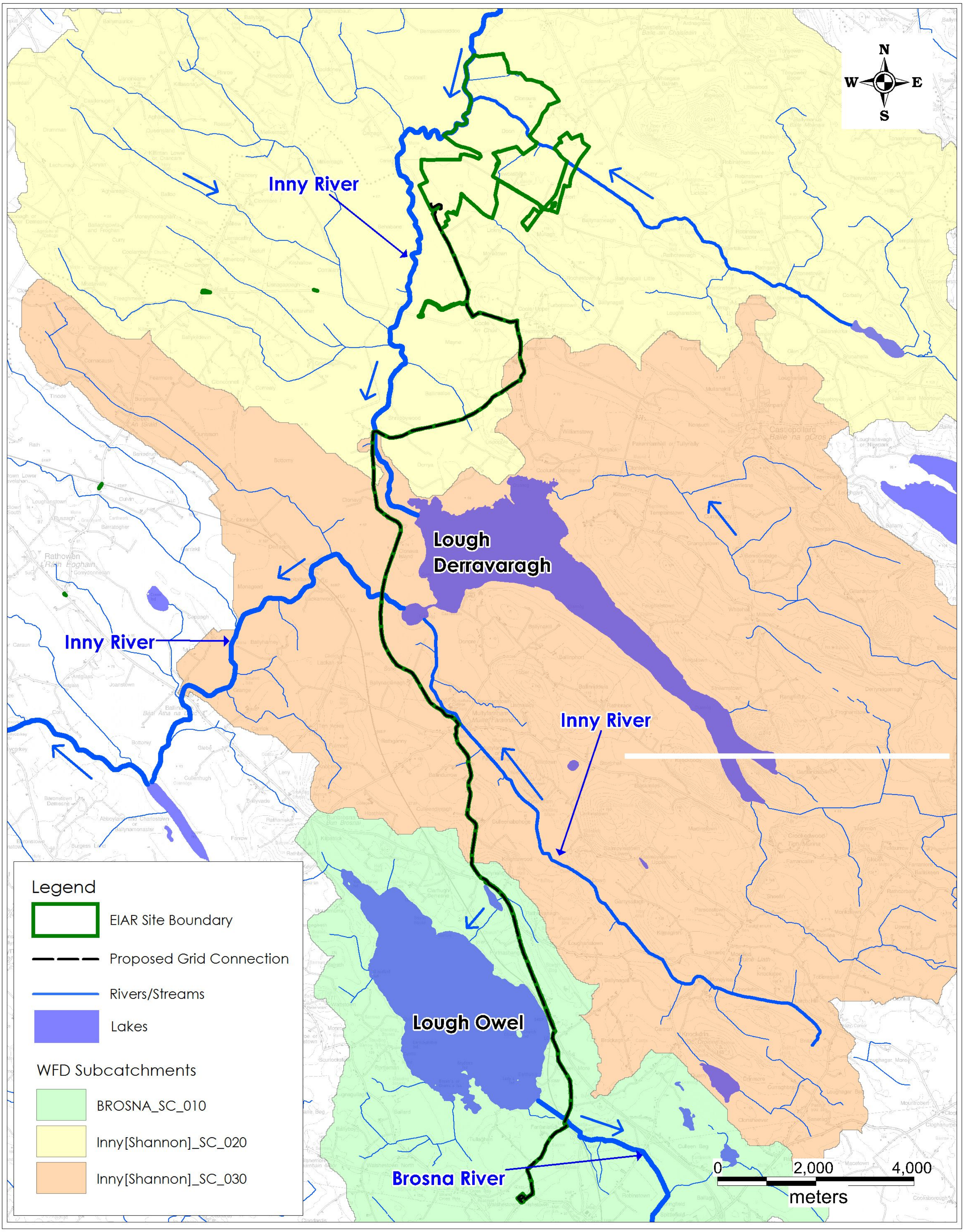

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Date: 07/01/2021	Title: Grid Route Local Hydrology Map
Scale: 1:100,000	Project No: P1320-2
Drawn By: GD / Checked By: MG	Drawing No: P1320-2-0121-A4-903-00A

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9.3.3.2 Grid Connection

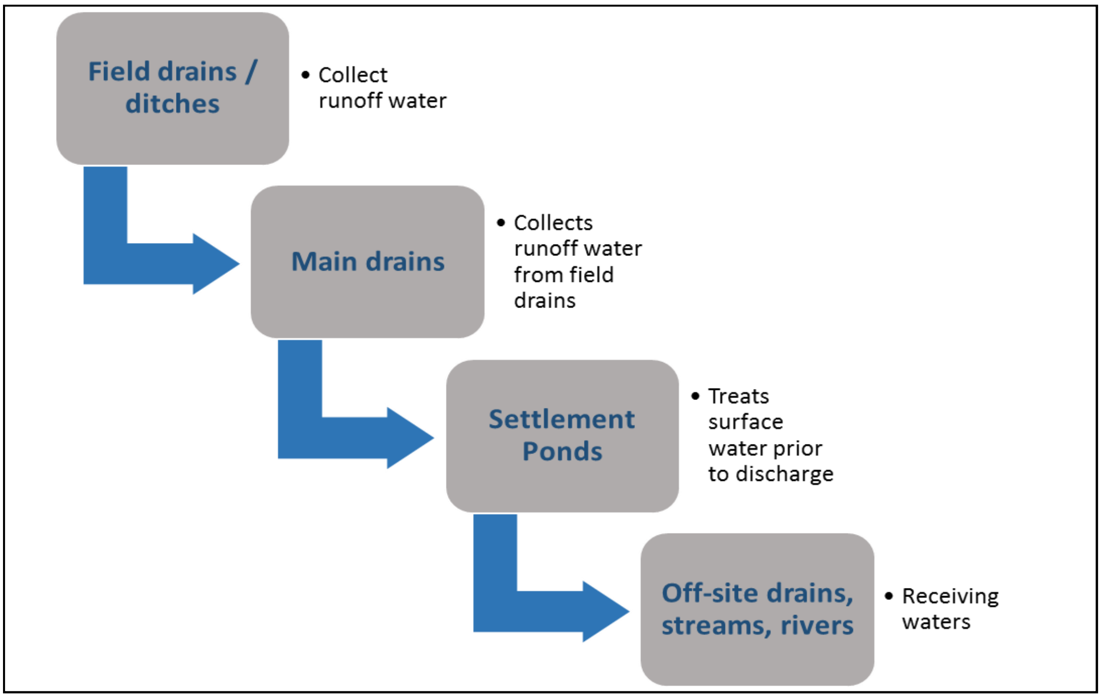
The Grid Connection Route is located within the Shannon International River Basin District. With respect to regional hydrology, the Grid Connection Route is located in 2 no. regional surface water catchments (the River Inny and the River Brosna) and 3 no. regional surface water sub-catchments (refer to Figure 9-3). The southern section of the Grid Connection Route, along the eastern edge of Lough Owel and on to Mullingar (~8km long) is located within the Brosna sub-catchment (Brosna_SC_010) within the regional Lower Shannon catchment (25A). The area north of Lough Owel to the northern edge of Lough Derravargh is located within the Inny sub-catchment (Inny[Shannon]_SC_030). North of Lough Derravargh, towards Coole, falls within the boundary of the Inny sub-catchment (Inny[Shannon]_SC_020). Both of these subcatchments are located within the regional Upper Shannon Catchment (26F).

9.3.4 Wind Farm Site Drainage Overview

The Wind Farm Site has parallel-running peat drains that are spaced approximately every 12-15 meters on the bog surface for surface water runoff removal. Surface water runoff collected in these drains is conveyed to a headland silt trap, from where it flows into a larger boundary drain and then onto a sedimentation basin for retention and controlled discharge. The parallel running bog surface drains are only approximately 1.5m deep and therefore do not intercept the mineral subsoil underlying the peat. These internal field drains are deepened as harvesting progresses. The larger boundary drains are generally deeper and were noted to regularly intercept the mineral subsoils.

A generalised drainage process flow diagram of the existing bog drainage systems is shown as Plate 9-1.

Plate 9-1: Existing generalised surface water drainage route within Coole bog



9.3.5 Wind Farm Site Drainage

As discussed, the majority of the Wind Farm Site is spread over 3 separate peat basins, and these have their own separate drainage systems. However, the format of the drainage systems in each of the 3 basins are generally the same and is outlined in the sections below. Turbine T15 is located within an area of agricultural (rough grazing) land to the east of the peat basins, on the eastern side of the Glore River.

9.3.5.1 Wind Farm Site - Northern Basin

The surface of the cutover bog is drained by a network of southwest / northeast orientated field drains that are typically spaced every 15 to 20m. There are 5 no. main outfalls (N-OF1 to N-OF5), which are preceded by a series of settlement ponds. The southern portion of the northern basin drains to Glore River, and the northern and northwestern elements of the bog drains into a main drain that flows directly into the Inny River (west of the basin). The existing drainage layout for the northern central basin is shown as Figure 9-4. [Please note that not all the internal field drains are shown, but they exist at 15-20m intervals as shown on the aerial photograph]. Turbines T1-T4 are located within this basin.

Based on Ordnance Survey historical 6" and 25" mapping[2] for the area it appears that Lough Bane was approximately 50% bigger than its current plan size. The historical maps show that Lough Bane extended much further south towards the boundary of the Wind Farm Site. The maps also show an outfall from the southwestern end of the lake into drain D1 which passes through the site in a westerly direction towards the Inny River. This outfall was located during a walkover of the Wind Farm Site and no discharge was noted, presumably because the southern end of the lake now exists much further to the north. No other outfall from the present-day lake was noted during walkover surveys, however it should be noted that the lake was visited over a dry winter and it may be larger during wetter periods.

Based on the walkover survey and the topographic survey, the catchment to Lough Bane is relatively small with no input from streams noted. Input to the lake is most likely from direct rainfall landing on the water body and runoff from the adjacent land (i.e. ombrotrophic). The hydrochemistry (refer to Table 9-9 in Section 9.3.7.1) also indicates that the lake is fed by rainfall with little or no input from mineral groundwater flows (i.e. oligotrophic hydrochemistry). The unnamed small dystrophic lake also appears to be an isolated feature with a localised surface water catchment.

In terms of drainage connections between the harvesting area and Lough Bane, there appears to be no connection apart from the potential outfall from the lake to drain D1. The presence of perimeter boundary drains and intermediate high banks (uncut sections of high bog) means that there is no runoff from the harvesting area into Lough Bane. This also applies for the dystrophic lake.

Drainage drawings are included as Appendix 9-3.

9.3.5.2 Wind Farm Site - Central Basin

The surface of the cutover bog is drained by a network of southwest / northeast orientated field drains that are typically spaced every 15 to 20m. There are 4 no. main outfalls (C-OF1 to C-OF4), which are preceded by a series of settlement ponds. The southern and western half of this central basin drains to Glore River, and the eastern half of the bog drains into the Inny River. The existing drainage layout for the central basin is shown as Figure 9-5. [Please note that not all the internal field drains are shown, but they exist at 15-20m intervals as shown on the aerial photograph]. Turbines T6-T8 are located within this basin, while turbine T5 is located in an area of coniferous forestry along the eastern margin of the basin.

[2] *Maps are dated between 1829 and 1842.*

Legend

- EIAR Site Boundary
- Headland Drains
- Field Drains
- Settlement Pond (SP)
- Outflow (N-OF/C-OF/S-OF)
- Turbine Locations
- Rivers/Streams
- Lakes
- River/Drain Crossing

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Title: Site Drainage Map (Northern basin)	
Client: MKO	
Job: Coole WF, Co. West Meath	
Project No: P1320-2	
Figure No: 9-4	
Sheet Size: A4	
Drawing No: P1320-2-0120-A4-904-00A	
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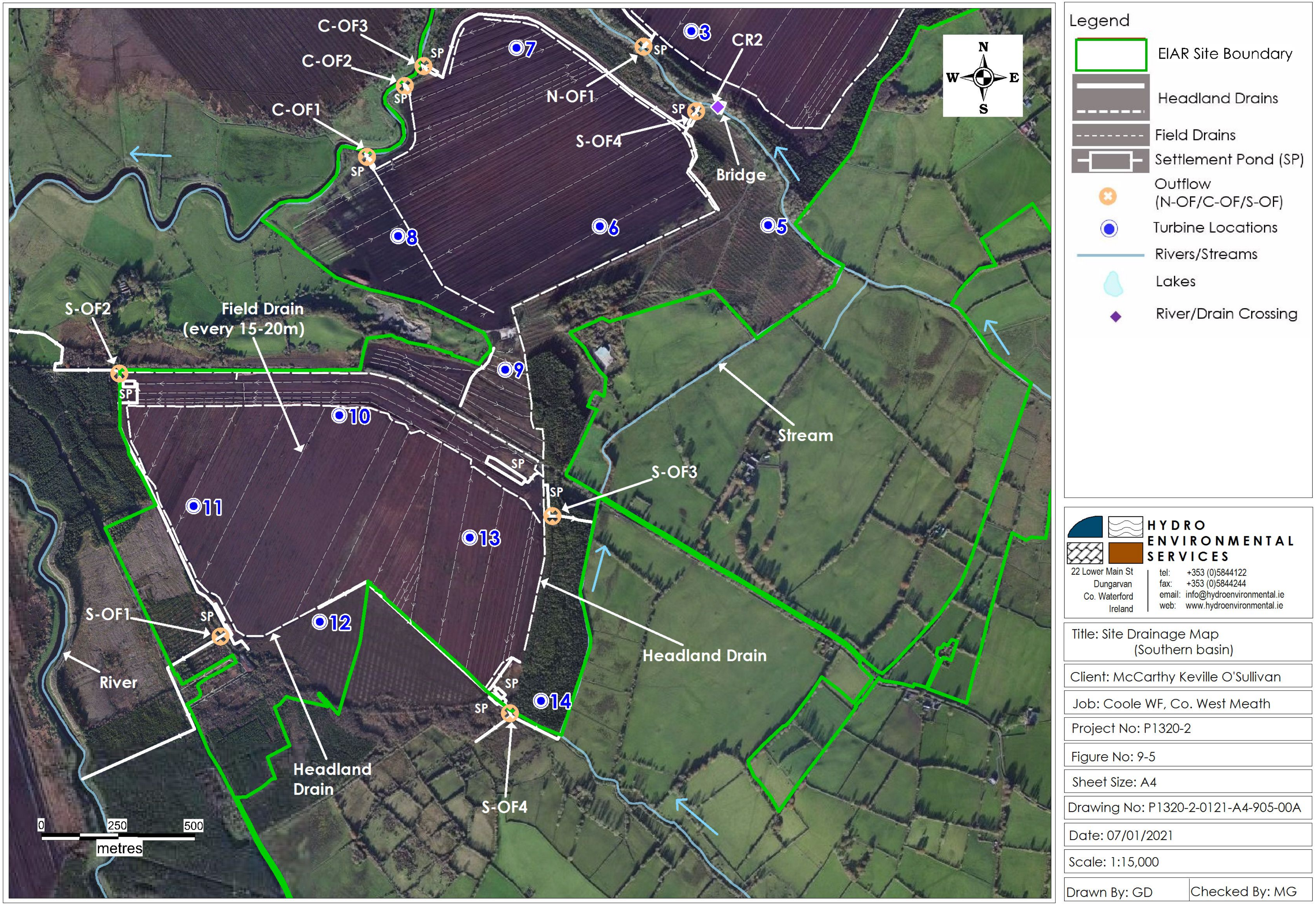

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Title: Site Drainage Map (Southern basin)	
Client: McCarthy Keville O'Sullivan	
Job: Coole WF, Co. West Meath	
Project No: P1320-2	
Figure No: 9-5	
Sheet Size: A4	
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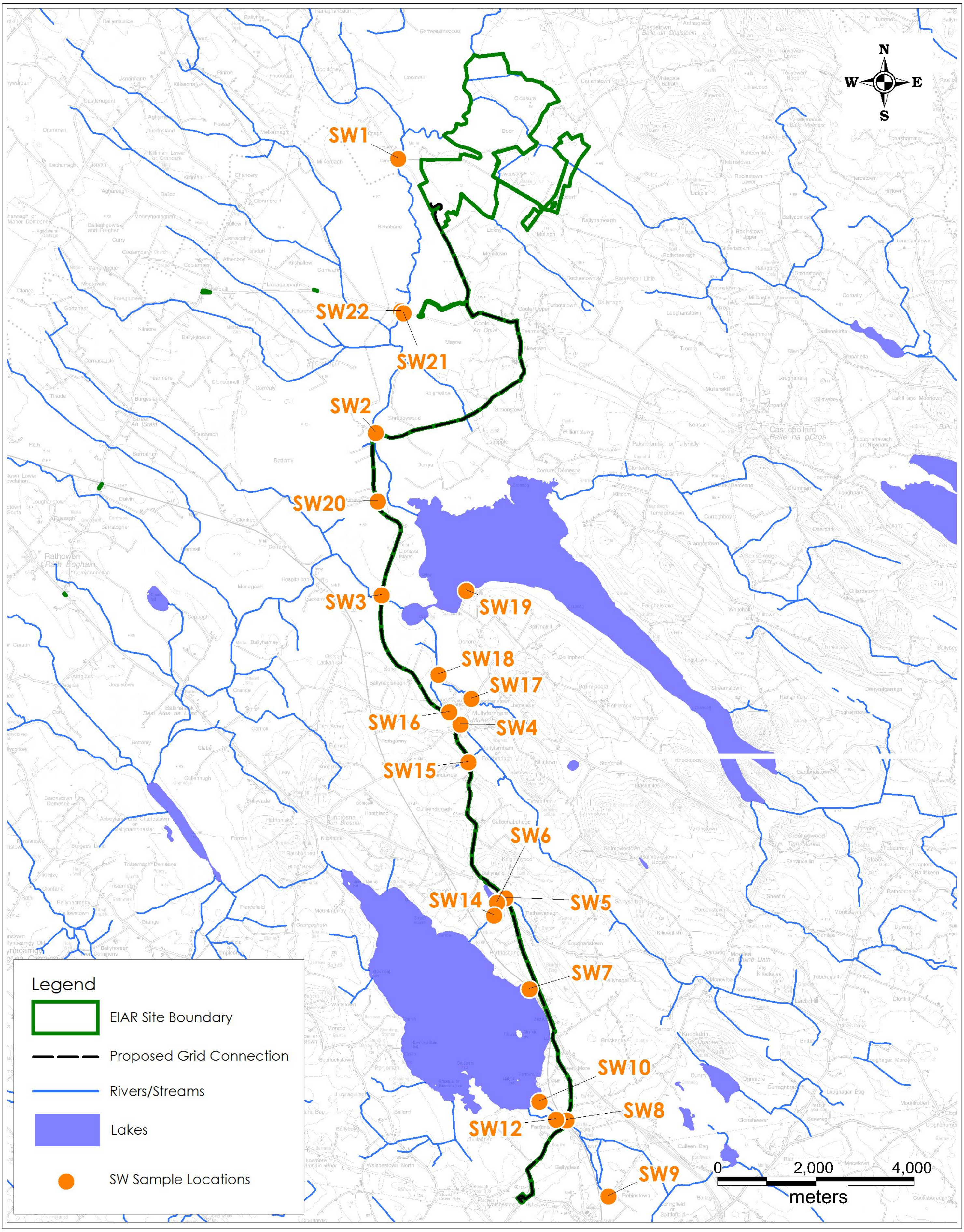

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Date: 07/01/2021		Title: Grid Route SW Sample Location Map
Scale: 1:100,000		Project No: P1320-2
Drawn By: GD	Checked By: MG	Drawing No: P1320-2-0121-A4-906-00A

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9.3.5.3 Wind Farm Site - Southern Basin

The surface of the cutover bog is drained by a network of south-southwest / north-northeast orientated field drains that are typically spaced every 15 to 20m. There are 4 no. main outfalls (S-OF1 to S-OF4), which are preceded by a series of settlement ponds. The western half of this southern basin drains to the Inny River, and the eastern half of the bog drains to the east and enters a tributary to the Glore River, which itself is a tributary to the Inny River. The existing drainage layout for the southern basin is shown on Figure 9-5. [Please note that not all the internal field drains are shown, but they exist at 15-20m intervals as shown on the aerial photograph]. Turbines T9-T13 are located within this basin, while turbine T14 is located in an area of coniferous forest along the southeastern margin of the basin.

9.3.5.4 Grid Connection Route

There are four main rivers within the 3 no. subcatchments which drain the area along the Grid Connection Route.

The River Brosna is located south of the existing Mullingar 110kV Substation. The River Brosna flows south southwest towards Lough Ennel located ~ 4km southwest of Mullingar. These watercourses are all located within the Brosna subcatchment.

The River Gaine flows north northwest from its headwaters near the townland of Knockdrin, close to Brittas Hill and Brittas Lough, ~ 5.5km northeast of Mullingar. The river flows towards Multyfarnham and continues on towards Lough Derravaragh where it discharges at the northwestern tip of the lake. There is a topographical divide between much of the River Gaine and the Grid Connection Route, with high ground (~100-140 mOD) in the townland of Loughanstown, Rathlevanagh and Knightswood. The River Gaine flows through a valley on the far side (east) of this topographical high. The topography gradually decreases north of these townlands. The Grid Connection Route and the River Gaine are at similar elevations near Multyfarnham. From ~ 1km south of Multyfarnham to the townland of Ballynaclonagh (~2.2km northwest of Multyfarnham), drainage from the L1826 and Grid Connection Route will be in the direction of the River Gaine.

The Inny River consists of 2 no. separate river channels. For ease of readership these will be referred to as their subcatchment prefixes (Inny_020 and Inny_030).

The first of which, the Inny_030, flows west-southwest from Lough Derravaragh, ~2,2 km north of Multyfarnham, to Ballinalack. This river channel is within the Inny[Shannon]_SC_030 subcatchment. Due to the nature of the local and regional topography, there is only an area of ~ 0.5km^2 which may drain from the area of the Proposed Development to the River Inny, and drainage from much of this area will likely discharge into Lough Derravaragh before reaching the river channel itself.

The second channel of the River Inny is located within the Inny[Shannon]_SC_020 subcatchment. This river flows south from Lough Kinale, located ~8.5km north of Coole, to the northwestern tip of Lough Derravaragh. The river flows through a generally flat topographical area, which is typically bog land. Surface water along the route of the proposed grid connection will drain towards ~6.5km of this river channel.

A local hydrology map is shown as Figure 9-3.

A summary of the sub-catchments along with relevant Proposed Development infrastructure and significant existing drainage features/routes are shown in Table 9-6.

Along the Grid Connection Route there are numerous manmade drains situated parallel to the roadside. It is likely in places that natural drainage pathways will have been diverted slightly for road and agricultural drainage purposes.

Monitoring of stream discharge in the main streams passing along the Grid Connection Route was undertaken in November 2019 and these data are presented in Table 9-7 below. The flows are generally a mix of typical lowland mature, wide watercourses and smaller streams which feed these watercourses. The locations of the monitoring points are shown in Figure 9-6.

Table 9-6: Summary of Regional/Local hydrology & Proposed Windfarm Infrastructure

Regional Catchments	Sub-catchment	Main Development Infrastructure	Primary Drainage Features
Shannon Upper	Inny_SC_030	~9.9km of grid route	Inny River (West)
	Inny_SC_020	~8km of grid route 1 no. Substation	Inny River (North)
Shannon Lower	Brosna	~8km of grid route	River Brosna

Table 9-7: Surface Water Flow Monitoring Data

Location	Round 1	Round 2
	Flow (litres/sec)	Flow (litres/sec)
SW1	5000	5000
SW2	6000	6500
SW3	7500	7500
SW4	600	700
SW5	<5	<5
SW8	300	320
SW9	150	150
SW12	10	5
SW14	30	60
SW15	40	80
SW16	600	700
SW17	<5	<5
SW18	<10	~6-7
SW20	10	10
SW21	>20	20

Location	Round 1	Round 2
SW22	6000	6500

R1- 06/11/2019, R2- 07/11/2019

9.3.6 Flood Risk Assessment

9.3.6.1 Wind Farm Site

A Flood Risk Assessment of the proposed Wind Farm Site has been carried out by HES, the results of which are presented in full in Appendix 9-1 of this EIAR. 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 Proposed Development site boundary were identified from OPW's indicative river and coastal flood map. Recurring flooding incidences are mapped to west of the site on the R396 near Abbeylara where fluvial flooding occurs after heavy rain. From August 2004 a flood event is recorded south of the site at Coole relating to surface water flow.

Identifiable map text on local available historical 6" or 25" mapping for the Proposed Development study area identify lands that are "liable to flood" along the eastern bank of the Inny River where it borders the development site.

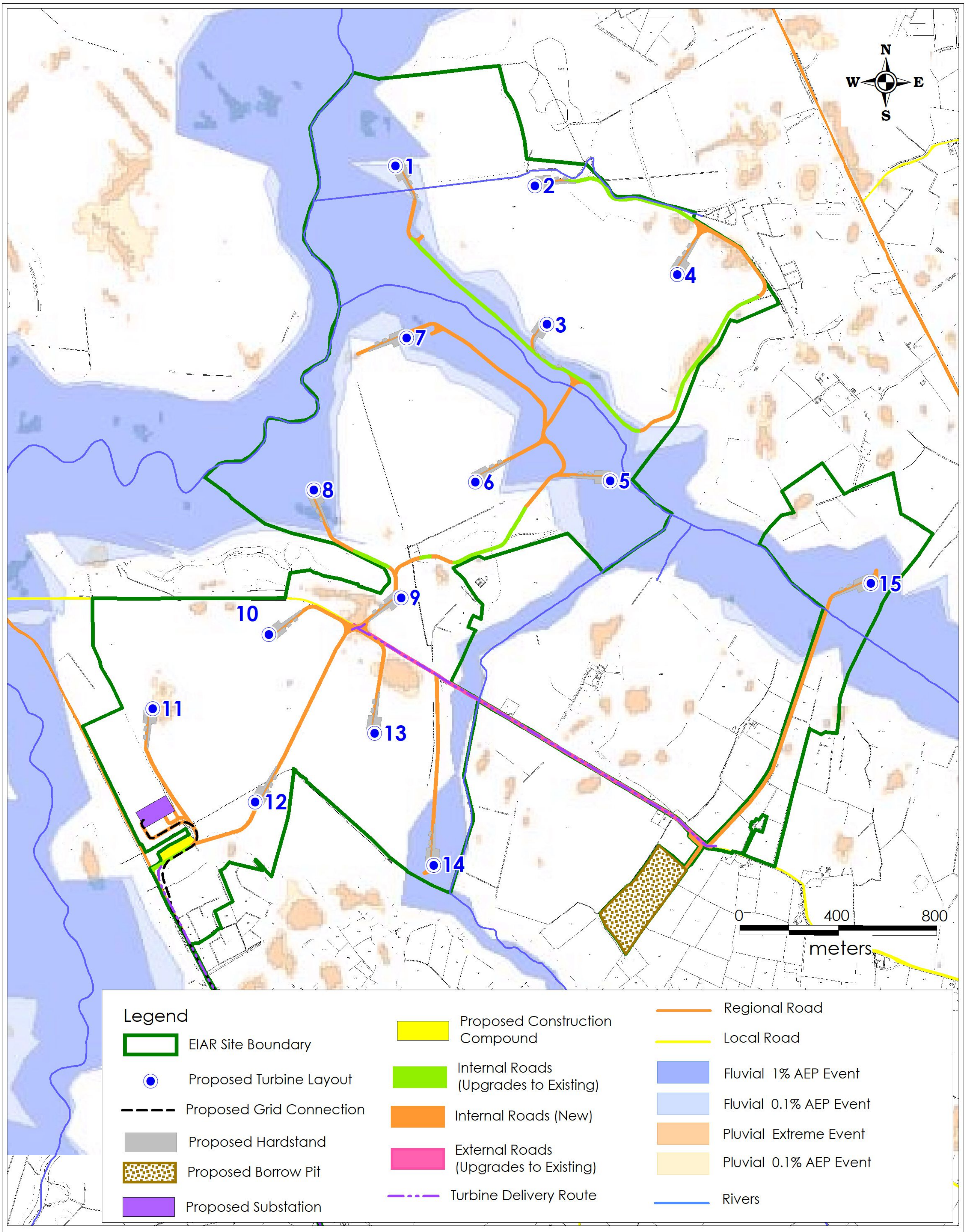
The land on the banks of the River Glore and Inny River within the site are mapped as "Benefiting Lands". Benefiting lands are defined as a dataset prepared by the Office of Public Works identifying land that might benefit from the implementation of Arterial (Major) Drainage Schemes (under the Arterial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

The PFRA mapping (www.cfram.ie) (maps no. 286 and 287) shows the extents of the indicative 1 in 100-year flood zone which relates to fluvial (i.e. river) and pluvial (i.e. rainfall) flood events. A section (~28% of the overall development site) of the Wind Farm Site is located inside of the 1 in 100-year flood zone where the Inny River flows along the site's western boundary and also where the River Glore flows east to west across the Wind Farm Site. These mapped flood areas include the locations of T1, T5, T7 and T8. This section of mapped flood extents also encroaches into the land area near T15 along the Glore river and T14 near the Monkstown stream.

Also shown on the PFRA mapping (refer to Figure 9-7) is the indicative extent of pluvial flooding (i.e. flooding from rainfall ponding). As seen, pluvial flooding appears to occur in a number of locations within the Wind Farm Site.

There are sections (28% of site) of the Wind Farm Site within the 100-year and 1000-year flood zones (Flood Zone A and B respectively), including the locations of T1, T5, T7, T8, T14 and T15. However, based on the flood risk assessment (see Appendix 9-1), it is important to note that local knowledge and topographical data indicates that all proposed areas of wind farm related infrastructure are likely located within Flood Zone C. A Justification Test is provided for the area of the Proposed Development located within mapped areas of Flood Zone A and B and presented in Appendix 9-1.

The proposed onsite substation is located in an area that may be prone to shallow surface water ponding, due to existing restricted drainage. Raised formation level and improved drainage from this area will ensure no future flooding of this area.



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Drawn By: GD / Checked By: MG	Drawing No: P1320-2-0121-907-A4-00A	email: info@hydroenvironmental.ie web: www.hydroenvironmental.ie

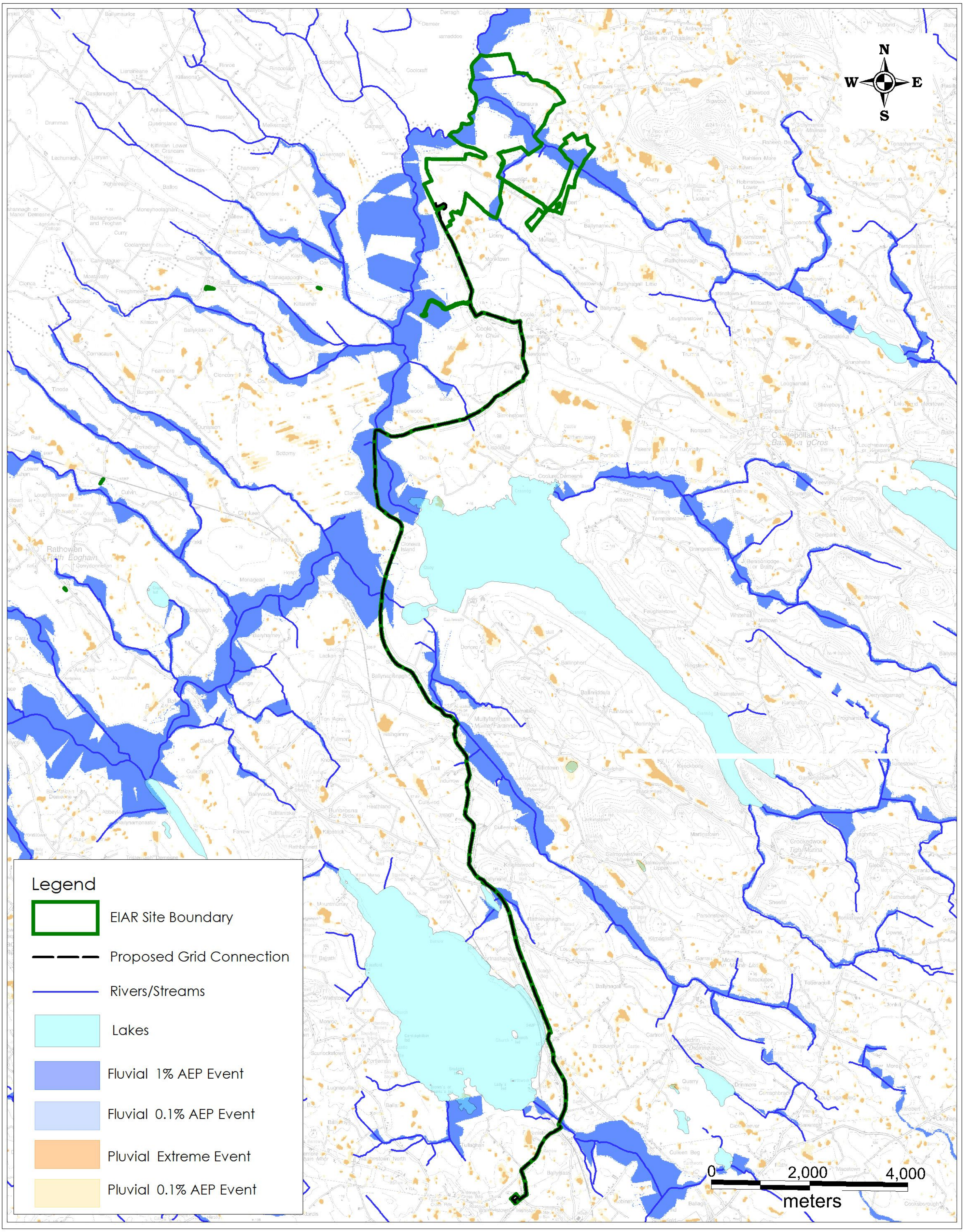

Figure No: 9-8	Client: MKO
Sheet Size: A4	Job: Coole WF, Co. West Meath
Date: 07/01/2021	Title: Grid Route Flood Risk Map
Scale: 1:100,000	Project No: P1320-2
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Finally, the risk of the Wind Farm Site contributing to downstream flooding is also very low, as the long-term plan for the Wind Farm Site is to retain and slow down drainage water within the existing bog basins. Drainage measures on the site will include swales, silt traps, settlement ponds, field drains and headland drains. This is discussed further below.

9.3.6.2 Grid Connection Route

The OPW's indicative river and coastal flood map (www.floodmaps.ie), CFRAM Preliminary Flood Risk Assessment (PFRA) maps (www.cfram.ie), Department of Environment, Community and Local Government on-line planning mapping (www.myplan.ie) and historical mapping (i.e. 6" & 25" base maps) were consulted to identify those areas as being at risk of flooding.

1 no. recurring flood event is recorded in the village of Multyfarnham, as well as 1 no. single flood event in the village of Coole. No other flood incidents are recorded along the Grid Connection Route on the OPW's indicative river and coastal flood map. Please note that not all local flooding issues are recorded on the OPW database.

The PFRA mapping shows the extents of the indicative 100-year flood zone which relates to fluvial (i.e. river) and pluvial (i.e. rainfall) flood events. The 100-year fluvial flood zones mapped along the Grid Connection Route generally occur in close proximity to the stream channel itself. Areas mapped within Fluvial Flood Zone A (1% AEP) exist at the southern tip of Lough Owel, at Ballynafid Lake, in the village of Multyfarnham and along the Inny River from the village of Coole to the northwestern edge of Lough Derravaragh (Refer to Figure 9-8).

The Department of Environment, Community and Local Government on-line mapping viewer (www.myplan.ie.) has areas indicated as "fluvial flooding" in the close proximity of streams and rivers which pass along the Grid Connection Route. There are several small areas along the Grid Connection Route which are mapped as prone to pluvial flooding (Figure 9-8).

Historical 6" and 25" maps for the Grid Connection Route were consulted to identify areas that are "prone to flooding". The area where the River Inny (N) reaches Lough Derravaragh, as well as the areas surrounding Ballynafid Lake are mapped as "liable to flooding" within the 6" Cassini map.

An existing issue relating to flooding and reported surface water ingress on to private property on the road outside the existing Mullingar Substation at Irishtown, Mullingar, Co. Westmeath has been identified by 3rd parties. This existing issue appears to relate to the capacity of a holding tank/attenuation pond (storm water), which is said to overflow during periods of high rainfall, causing surface water to back up along the road. This is discussed further and assessed in Section 9.4.5.

9.3.7 Surface Water Quality

9.3.7.1 Wind Farm Site

Q-rating status data for EPA monitoring points on the Inny River and the River Glore are shown on Table 9-8 below. The Q-Rating is a water quality rating system based on both the habitat and the invertebrate community assessment and is divided into status categories ranging from 0-1 (Poor) to 4-5 (Good/High). Most recent data available (2004 to present) show that the Q-rating for the Inny River upstream of the site at Finnea Bridge is Poor. Downstream of the site at Camagh Bridge and Shrubbywood the Q-rating is reported as Moderate and Good respectively. Q-rating for the River Glore is only available upstream of the Wind Farm Site, with Q-rating for the closest upstream station (Rockbrook) being reported as Good.

Table 9-8: EPA Water Quality Monitoring Q-Rating Values

Waterbody	EPA Location Description	Easting	Northing	EPA Q-Rating Status
Inny	Finnea Bridge	240,210	281,415	Poor
Inny	Camagh Bridge	239,160	275,620	Moderate
Inny	Bridge near Shrubbywood	238,740	270,050	Good
Glore	Bridge at Rockbrook	24,4350	274,176	Good
Glore	Stonestown Bridge	247,415	272,996	Poor

Field hydrochemistry measurements of unstable parameters, electrical conductivity (µS/cm), dissolved oxygen (mg/L), pH (pH units) and temperature (˚C) were taken at various locations in surface watercourses and drainage features at the Wind Farm Site on 15th December 2016 and 8th March 2017, with follow up measurements on 23rd September and the 15th and 22nd October 2020. The combined results are listed in Table 9-9.

Table 9-9: Field Parameters – Wind Farm Summary of Surface Water Chemistry Measurements

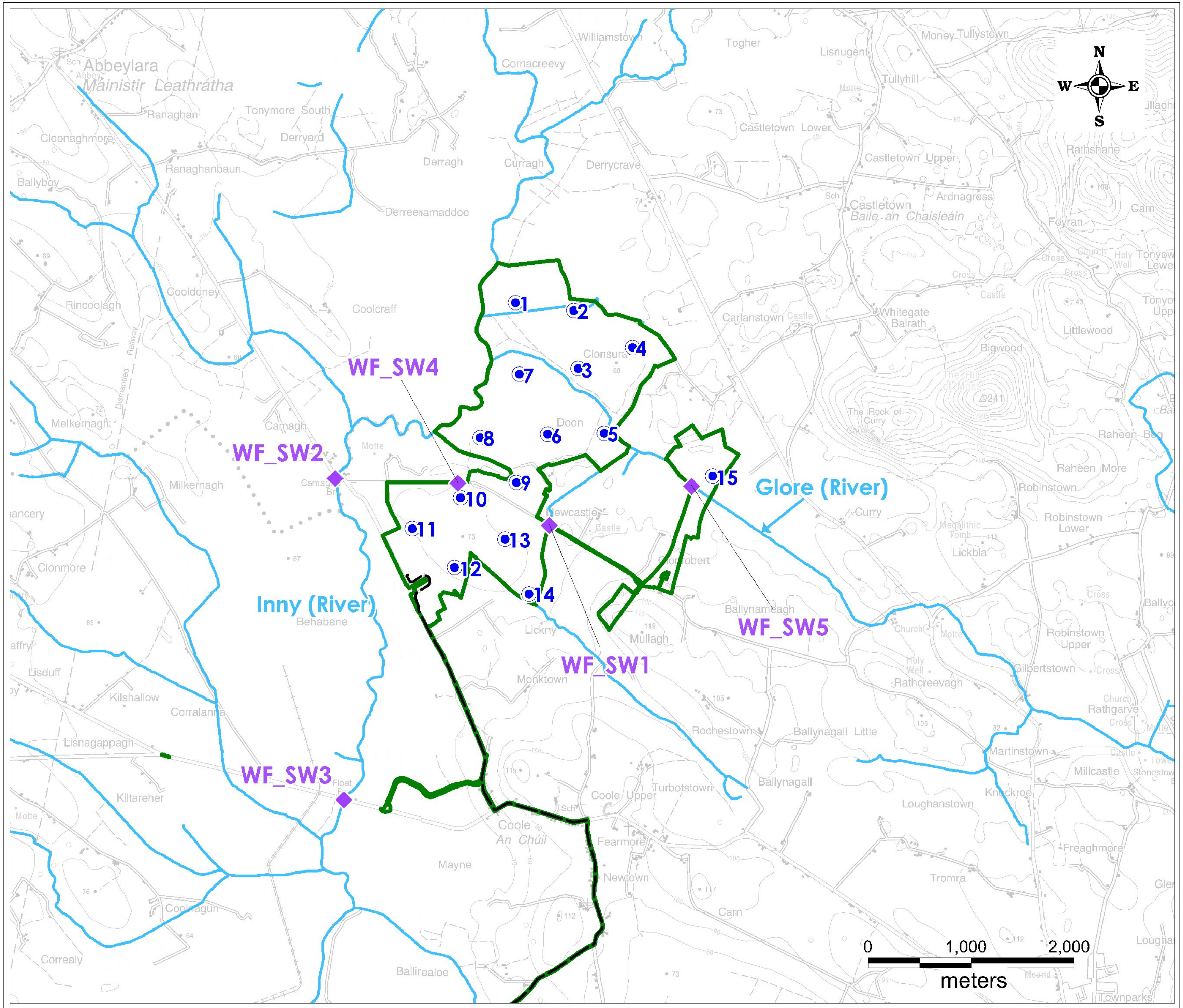
Location	Conductivity (µS/cm)	pH	Temp	Oxygen (mg/L)
S. Basin 1*	609	7.7	14.8	6.9
S. Basin 3*	103	8.0	18.1	4.5
Lough Bane*	62	8.1	16.5	3.6
Dystrophic lake*	48	8.2	18.5	4.03
S-OF1 (15/12/16)	132	7.3	10.3	-
C-OF3 (15/12/16)	85	7.1	10.1	-
N-OF4 (15/12/16)	165	7.6	9.8	-
SW01 (08/03/17)	395	7.6	10.0	-
SW02 (08/03/17)	422	7.71	7.9	-
SW03 (08/03/17)	410	7.82	8.3	-
SW04 (08/03/17)	566	7.69	10.5	-
SW01 (23/09/20)	558	7.98	10.6	6.17
SW02 (23/09/20)	424	8.01	14.2	8.87
SW03 (23/09/20)	429	8.03	14.6	8.88
SW04 (23/09/20)	100.3	6.74	12.5	6.49
SW05 (23/09/20)	660	8.0	12.3	8.98
SW01 (15/10/20)	507	7.91	9.3	8.31
SW02 (15/10/20)	425	7.97	10	10.0
SW03 (15/10/20)	438.6	7.92	10.7	11.07
SW04 (15/10/20)	160.1	7.07	9.5	10.23
SW05 (15/10/20)	654	8.08	9.9	10.42

Location	Conductivity (µS/cm)	pH	Temp	Oxygen (mg/L)
SW01 (22/10/20)	683	7.92	9.6	8.71
SW02 (22/10/20)	432.9	7.71	10.2	9.03
SW03 (22/10/20)	459.9	7.58	10.6	9.43
SW04 (22/10/20)	156.2	6.76	8.7	10.02
SW05 (22/10/20)	662	7.99	9.8	9.61

** Data taken from previous study completed at this site (25th June 2013).*

The electrical conductivity of the surface waters in the settlement basins ranged between 85 and 609µS/cm. The relatively high electrical conductivity values indicate that mineral subsoil groundwater makes up a varying percentage of the overall water within some settlement basins. Many of the main boundary drains surrounding the Wind Farm Site were noted to intercept the underlying mineral subsoils and therefore seepages of groundwater into the boundary drains is most likely occurring. The electrical conductivity of the water in Lough Bane and the dystrophic lake indicate that lakes are solely rainwater fed with little or no input from mineral groundwater flows.

Surface water samples were also taken on 8th March 2017, in the main watercourses surrounding the bog basins (SW01-SW04), with subsequent sampling on 23rd September 2020, 15th and 22nd October 2020, with a further sampling point added (SW05) near the proposed T15 location. Electrical conductivities are within the expected range, varying from 100.3 to 660 µS/cm. The pH is typical of watercourses in the region, ranging between 6.74 and 8.01. Dissolved oxygen was monitored during the 2020 rounds of sampling, with a healthy DO concentration of 6.49 – 8.98 mg/l. The locations of the sampling points are shown on Figure 9-9.
Results of the laboratory analysis from samples taken on 8th March 2017 are shown alongside relevant water quality regulations in below. Results from follow up sampling in September and October 2020 are also shown in Table 9-11. 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 included as Appendix 9-2.



Legend

- EIAR Site Boundary
- Turbine Location
- Proposed Grid Route
- Surface Water Sampling Location
- Rivers/Streams

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Title: Wind Farm Site Sampling Location Map	
Client: MKO	
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Project No: P1320-2	
Figure No: 9-9	
Sheet Size: A4	
Drawing No: P1320-2-0121-A3-909-00A	
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Scale: 1:50,000	
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Table 9-10: Analytical Results of HES Surface Water Samples (March 2017)

Parameter	EQS	Sample ID			
		SW1 08/03/17)	SW2 (08/03/17)	SW3 (08/03/17	SW4 (08/03/17)
Total Suspended Solids (mg/L)	≤25(+)	<5	16	7	8
Ammonia (mg/L)	-≤0.065 to ≤ 0.04(*)	0.12	0.06	0.07	0.16
Nitrite NO_2 (mg/L)		<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	-≤ 0.035 to ≤0.025(*)	0.02	0.03	0.03	0.03
Nitrate - NO_3 (mg/L)	-	9.81	<5.0	<5.0	5.7
Phosphorus (mg/L)	-	<0.10	<0.10	<0.10	<0.10
Total Nitrogen (mg/L)	-	2.8	1.2	1.2	1.3
Chloride (mg/L)	≤ 1.3 to ≤ 1.5(*)	13.5	13.9	13.4	9.8
BOD		<5.0	<5.0	<5.0	<5.0

Table 9-11: Analytical Results of HES Surface Water Samples (September & October 2020)

Parameter	EQS	Sample ID									
		SW1 (22/09/20)	SW2 (22/09/20)	SW3 (22/09/20)	SW4 (22/09/20)	SW5 22/09/20	SW1 (15/10/20)	SW2 (15/10/20)	SW3 (15/10/20)	SW4 (15/10/20)	SW5 (15/10/20)
Total Suspended Solids (mg/L)	≤25(+)	<5	<5	5	<5	28	<5	<5	<5	<5	<5
Ammonia (mg/L)	-≤0.065 to ≤ 0.04(*)	0.09	0.04	0.03	0.04	0.03	0.11	0.04	0.04	0.75	0.02
Nitrite NO_2 (mg/L)		<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
Nitrate - NO_3 (mg/L)	-	<5.0	<5.0	7.5	<5.0	12.6	<5.0	<5.0	<5.0	<5.0	5.3
Phosphorus (mg/L)	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Nitrogen (mg/L)	-	1.2	1.7	<1	<1	1.3	1.6	1.6	1.2	2.3	1.8
Chloride (mg/L)	≤ 1.3 to ≤ 1.5(*)	13.3	14.7	15.3	13.0	13.1	11.8	14.2	14.4	7.0	12.2
BOD		<1	1	1	2	3	1	2	1	2	1

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

2017 Sampling Round

Total suspended solids ranged between <5 and 16mg/L which is below the limits for both Salmonid and Cyprinid waters.

Ammonia-N ranged between 0.06 and 0.16mg/L, which is above the limits for both Salmonid waters and Cyprinid waters. The presence of elevated ammonia is due to natural decomposition of peat.

BOD was less than 5mg/L in all samples, which is below the limits for Cyprinid waters but potentially exceeds the threshold limit for salmonid waters.

Nitrite was below the laboratory detection limit of 0.05mg/L in all samples. The results are typically low which is what would be expected for surface water in a peatland environment.

Nitrate ranged between <5.0 and 9.8mg/L which is relatively low and like nitrate, this is what would be expected for surface water in a peatland environment.

2020 Sampling Round

Total suspended solids are generally between <5 and 5mg/L, with one reported high result of 28 mg/l in SW5 (River Glore) on the 23rd September 2020. This result of 28 mg/l is above the limits for both Salmonid and Cyprinid waters and is most likely due to high antecedent rainfall which tends to increase suspended solids in all rivers. The remaining 9 no. results are below these threshold limits. The long term average suspended solids level is likely well below the threshold value of 25 mg/l. This level of suspended solids is relatively good in the context of Irish river waters, particularly in peat rich areas.

Ammonia-N generally ranged between 0.03 and 0.11mg/L, which exceeds the "high" status limits for both Salmonid waters and Cyprinid waters of 0.04 mg/l in some cases. At SW4, Ammonia levels were 0.75 mg/l on 15/10/2020, which is likely due to sampling error with the sample containing a high concentration of very fine peat particles. The presence of elevated ammonia is due to natural decomposition of peat. The Ammonia levels in these waters is generally low and is relatively good in the context of Irish stream and river waters, particularly in peat rich areas.

BOD was at or below 1mg/L in 6 of 10 no. samples, which is below the limits for Cyprinid and Salmonid waters. The remaining sample values ranged between 2-3 mg/l.

Nitrate ranged between <5.0 and 12.6mg/L which is relatively low and this is what would be expected for surface water in a peatland environment. Orthophosphate was below the detection limit of 0.02 mg/L in all samples.

*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).

9.3.7.2 Grid Connection Route

Q-rating data for EPA monitoring points are available for 7 no. points along the Grid Connection Route. 3 no. points are located along the River Inny_020. A Q3-4 rating was achieved ~3km north of Coole, while a Q4-5 rating was achieved ~ 1 km west of Coole and a Q4 rating ~ 2.5 km southwest of Coole. The river then discharges into Lough Derravaragh downstream of these points.

Q ratings are also available along the River Gaine. The river achieved a Q-4 rating at a monitoring point within the village of Multyfarnham and a Q rating of 3-4 ~0.5 km north of Multyfarnham.

Q ratings for the River Inny_030 are available from a monitoring point approximately 3 km north of Multyfarnham, on the western edge of Lough Derravaragh. The river achieved a Q rating of 3-4 at this point. The river then flows downstream towards Ballinalack. A Q4 rating is achieved at a monitoring point located in Ballinalack.

Field hydrochemistry measurements of unstable parameters, electrical conductivity (µS/cm), pH (pH units) and temperature (°C) were taken at locations along the Grid Connection Route (refer to Figure 9-6 for sampling locations) within surface watercourses over 2 no. sampling events in November 2019. The results are listed in Table 9-13 below.

Electrical conductivity (EC) values for surface waters at the site area ranged between 188.8 and 703 µS/cm. This indicates that there is a wide variation in input from typical surface water (rainwater) and groundwater, with groundwaters typically having higher conductivity values in the region of 600-700 µS/cm. The lakes typically have an EC of 300-400 µS/cm, which indicates a relatively large input from groundwater, which is also evident in the pH of the lake waters.

The pH values, which ranged between 6.71 and 8.84, had an overall average value of 7.74 which is slightly basic and likely related to the basic nature of the Limestone bedrock in the area. Generally, the values were >7.5, with the highest values typically being observed in the lakes along the proposed route (Lough Derravaragh and Lough Owel) and the streams emerging from these waterbodies.

Dissolved Oxygen ranged between 2.9 to 12.38 mg/l, with an average of 8.5 mg/l. This is typical of relatively aerated surface waters. Turbidity ranged from 0.61 to 20.5 NTU and was generally higher on the 7th of November, following heavy rain on the previous day.

Table 9-13: Grid Connection Route- Summary of Surface Water Chemistry Measurements

Location	EC (µS/cm)		pH		Dissolved Oxygen (mg/L)		Turbidity (NTU)	
	Round 1	Round 2	Round 1	Round 2	Round 1	Round 2	Round 1	Round 2
SW1	410.2	414.1	7.8	7.84	7.88	9.67	2.3	2.42
SW2	426.8	431.5	7.32	7.3	9.81	9.47	4.06	2.32
SW3	438.9	444	7.83	7.69	8.09	8.81	2.13	2.78
SW4	606	644	7.68	7.63	8.24	7.7	3.05	3.48
SW5	637	572	7.75	7.66	5.92	6.25	7.7	4.6
SW6	395.2	266.9	7.99	7.76	8.8	5.28	19.7	20.5

Location	EC (µS/cm)		pH		Dissolved Oxygen (mg/L)		Turbidity (NTU)	
	Round 1	Round 2	Round 1	Round 2	Round 1	Round 2	Round 1	Round 2
SW7	243.8	268.9	8.84	8.32	12.38	11.94	0.61	0.82
SW8	383.3	390.5	7.71	8.22	10.52	10	2.54	2.04
SW9	403.8	384	7.55	7.87	9.86	9.21	3.87	1.48
SW10	270.9	248.4	8.41	8.45	11.09	11.7	0.88	3
SW12	703	691	7.4	7.27	3.5	2.9	12.8	10.7
SW14	619	458	7.74	7.32	9.61	9.72	6.84	7.98
SW15	649	490	8.6	8.16	11.05	11.41	6.3	12.2
SW16	666	639	7.7	7.61	8.38	7.6	3.68	3.16
SW17	681	661	7.42	7.52	6.53	6.48	4.7	3.61
SW18	325	311	7.33	7.3	6.75	5.99	3.24	5.6
SW19	387.2	394	8.14	8.2	11.32	10.87	1.46	0.93
SW20	251.1	263.2	6.71	6.75	3.6	4	19.8	17.4
SW21	409.8	394.7	7.82	7.74	10.54	10.06	14.2	11.8
SW22	202.7	188.8	7.79	7.72	10.08	9.13	3.67	2.81

R1- 06/11/2019, R2-07/11/2019

Please note locations SW11 and SW13 were not monitored.

Two rounds of surface water sampling for laboratory analysis were completed at 10 of the 20 no. monitoring locations along the proposed grid route (See Table 9-14 and Table 9-15 below for the locations sampled). The sampling results for the Grid Connection Route are discussed separately below.

Results of analysis are shown alongside relevant water quality regulations. In addition, relevant Environmental Objectives Surface Water Regulations (S.I. 272 of 2009) threshold values are shown in Table 9-12. Laboratory reports are shown as Appendix 9-2.

Table 9-14: Analytical Results of Surface Water Samples (Grid Connection Route Round 1)

Parameter	EQS	Sample ID									
		SW1	SW2	SW3	SW4	SW6	SW7	SW9	SW10	SW14	SW12
Total Suspended Solids (mg/L)	25(+)	3.00	3.00	13.00	3.00	2.00	<1	1.20		1.00	3.00
Ammonia (mg/L)	≤0.065 to ≤ 0.04(*)	0.08	0.08	0.08	0.05	0.05	0.05	0.06	0.06	0.03	0.04
Nitrite NO_2 (mg/L)	-	<0.05	<0.05	0.10	<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	0.03
Nitrate - NO_3 (mg/L)	-	<5.0	<5.0	17.00	18.20	<5.0	<5.0	<5.0	<5.0	<5.0	23.80
Nitrogen (mg/L)	-	2.30	4.20	3.80	6.40	<1.0	<1.0	1.90	<1.0	<1.0	7.20
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)	-	14.80	14.70	19.10	15.40	20.30	14.40	14.60	14.30	27.50	21.90
BOD	≤ 1.3 to ≤ 1.5(*)	3.0	2.0	4.0	2.0	3.0	1.0	<2	<2	1.0	2.0

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

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

Table 9-15: Analytical Results of Surface Water Samples (Grid Connection Route Round 2)

Parameter	EQS	Sample ID									
		SW1	SW2	SW3	SW4	SW6	SW7	SW9	SW10	SW14	SW12
Total Suspended Solids (mg/L)	25(+)	11	3	16	4	15	<1	1	7	6	16
Ammonia (mg/L)	≤0.065 to ≤ 0.04(*)	0.07	0.08	0.07	0.06	0.04	0.04	0.05	0.04	0.04	0.05
Nitrite NO_2 (mg/L)	-	<0.05	<0.05	0.09	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	≤ 0.035 to	<0.02	<0.02	<0.02	0.03	0.08	<0.02	<0.02	<0.02	<0.02	0.12

Parameter	EQS	Sample ID									
		SW1	SW2	SW3	SW4	SW6	SW7	SW9	SW10	SW14	SW12
	≤0.025(*)										
Nitrate - NO3 (mg/L)	-	<5.0	<5.0	6.20	15.50	<5.0	<5.0	<5.0	<5.0	10.70	12.30
Nitrogen (mg/L)	-	<1.0	2.50	2.50	3.70	<1.0	<1.0	1.10	<1.0	<1.0	4.30
Phosphorus (mg/L)	-	<0.10	<0.10	<0.10	<0.10	0.16	<0.10	<0.10	<0.10	0.20	0.10
Chloride (mg/L)	-	15.20	14.60	18.70	15.10	<4.0	15.70	14.50	14.50	20.20	16.70
BOD	≤ 1.3 to ≤ 1.5(*)	3.0	2.0	3.0	1.0	3.0	<1	1.0	2.0	2.0	3.0

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

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

Round 1 of Sampling (Grid Connection Route)

Total suspended solids (TSS) at all sampling locations were all less than 25mg/l, the threshold value for both Salmonid and Cyprinid waters. TSS ranged from <1 mg/l to 13 mg/l, with the highest values recorded at SW3, north of Multyfarnham. All other values were at or below 3mg/l. Nitrite was below the detection limit of 0.05 mg/l in all but one sample, recorded at SW3 with a value of 0.1 mg/l. Nitrate values ranged from below the detection limit of 5mg/l to 23.8 mg/l. The highest values were recorded in or just north of the village of Multyfarnham and may be due to landuse activities in this area.

Ortho-phosphate was below the laboratory detection limit of 0.02mg/L in 8 of 10 locations, with the samples at SW4 and SW15 returning a value of 0.04mg/l. These locations are both in Multyfarnham.

In comparison to the Environmental Objectives Surface Water Regulations (S.I. 272 of 2009), 2 of 10 results for ammonia N were within the "Good Status" threshold. The remaining samples all exceeded both the "Good" and "High" status thresholds.

In relation to ortho-phosphate, again, all values were within either the "Good" or "High" status thresholds.

BOD ranged from 1 to 4 mg/l. Generally, the BOD results were outside of the "Good status" and "High status" thresholds. The results of round 1 sampling are presented in Table 9-14.

Round 2 of Sampling (Grid Connection Route)

Total suspended solids at all sampling locations during round 2 (07/11/2019) ranged from <1 to 16 mg/l. Again, the highest values were recorded in, and just north of the village of Multyfarnham. 9 of 10 no. samples returned Nitrite values below the detection limit of 0.05 mg/l, while SW3 returned a value of 0.09 mg/l. Nitrate ranged between <5 mg/l to 15.5 mg/l with the highest values recorded at SW4 and SW15, both of these locations are in Multyfarnham.

Ortho-phosphate ranged between <0.02 and 0.12mg/L, while phosphorus was below the detection limit of 0.1 mg/l in 7 of 10 no. samples, but rose to 0.2 mg/l at SW14. Ammonia values ranged between 0.04 and 0.08 mg/L which slightly exceeds the threshold values for Salmonid and Cyprinid waters.

In comparison to the Environmental Objectives Surface Water Regulations (S.I. 272 of 2009), 7 of 10 sample results for ammonia N were within the "good" and "High Status" threshold while BOD generally exceeded both the "Good" and "High" status.

The results of round 2 sampling are presented in Table 9-15.

9.3.8 Hydrogeology

9.3.8.1 Wind Farm Site

The Geological Survey of Ireland (GSI) classifies the Dinantian Upper Impure Limestones (DUIL) as a Locally Important Aquifer (LI – Bedrock which is generally moderately productive only in local zones). The site is underlain by the Inny Groundwater Body (GWB).

While no local hydrogeological data is available for this groundwater body, permeability will generally decrease rapidly with depth in this limestone and shale aquifer type. In general, transmissivities will be in the range 2-20m^2/d, with median values occurring towards the lower end of the range (GSI, 2004). The effective thickness of the aquifer is likely to be within 15m of the top of rock, comprising a weathered zone of 5m and a further zone of interconnected fissures of 10m below. Significantly higher permeabilities are likely to be found in fault zones and areas which have undergone structural deformation, which are associated with higher yielding wells. Aquifer storativity will be low in this bedrock unit (GSI, 2004).

Groundwater flow occurs mainly in faults and joints. Most groundwater flow probably occurs in an upper shallow weathered zone. Below this in the deeper zones water-bearing fractures and fissures are less frequent and less well connected. Groundwater in this GWB is generally unconfined. Local groundwater flow is towards the rivers and streams, and flow paths are usually between 30 and three hundred metres in length.

9.3.8.2 Grid Connection Route

The underlying bedrock along the Grid Connection Route is mapped as being predominantly Lucan Formation - Dark limestone & shale (Calp), with Derravaragh Cherts (Cherty limestone and minor shale) mapped within the centre of the Grid Connection Route between Lough Owel and Multyfarnham (refer to Chapter 8 – Land, Soils & Geology, Figure 8-5.).

The GSI has classified the Lucan Formation as a Locally Important Aquifer (Bedrock which is Moderately Productive only in Local Zones), while the Derravaragh Cherts are mapped as a Locally Important Aquifer - Karstified.

The Grid Connection Route passes through 3 no. groundwater bodies as delineated by the EPA/GSI. These are the Inny GWB[3], mapped within the area of Mullingar and north of Multyfarnham, the Derravaragh GWB located within the same area as the Derravaragh Cherts and the Lough Owel Groundwater Dependent Terrestrial Ecosystem (GWDTE) which is coincident with the Grid Connection Route along the eastern edge of Lough Owel (along the N4) These rocks are described as being devoid of intergranular permeability, with groundwater flow occurring in fault fractures and joints where present. Groundwater paths are suggested to be short, generally 30-300m with groundwater discharging to local streams and to Lough Allen.

[3] GWB (Groundwater Body) - The Groundwater Body (GWB) is the management unit under the Water Framework Directive (WFD). Groundwater bodies are subdivisions of large geographical areas of aquifers so that they can be effectively managed in order to protect the groundwater and linked surface waters.

The Inny GWB is described as comprising "low permeability rocks where the effective thickness of the aquifer is likely to be within 15 m of the top of the rock, comprising a weathered zone of a few metres and a zone of interconnected fissures below this of about 10 m thick. Deeper flow can occur in areas that have undergone a high degree of structural deformation and faulting, where the resulting fissures have remained open." Transmissivities are estimated to be in the range of 13-27 m^2/day.

Groundwater flow within the Derravaragh GWB is described as follows: *"Most groundwater flow is thought to occur in the upper 30 m of the rock, in a highly weathered layer a couple of metres thick, and a zone of interconnected fissures below this. However deeper water strikes are possible. There is some karstification in the highly weathered upper layer, however this is variable, present in some areas and absent in others"*. The Derravaragh GWB is described as having less shale than the surrounding Lucan Formation (Inny GWB) and there is likely karstification in places.

No further information is available on the Lough Owel GWDTE[4]. The River Inny GWB is classified as "Not at Risk" under the WFD 2013-2018 while the Derravaragh Cherts are classified as "At Risk", likely due to the karst potential within this aquifer.

Base flow contribution to streams, rivers and lakes are likely to be high, as evident from the relatively high pH and conductivity values recorded at sampling locations (refer to Table 9-13).

Groundwater flow is expected to follow the topography and, in relation to the Grid Connection Route, will be generally towards Lough Owel from the area around Irishtown, Mullingar as far north as Multyfarnham. Groundwater flow from Multyfarnham to Coole will be generally in the direction of Lough Derravaragh, although there will likely be some local groundwater flow in the direction of the River Inny and River Gaine.

A regional groundwater body map for the Wind Farm Site and Grid Connection Route is shown as Figure 9-10.

9.3.9 Groundwater Hydrochemistry

9.3.9.1 Wind Farm Site

There are no groundwater quality data for the Wind Farm Site and groundwater sampling would generally not be undertaken for this type of development in terms of EIAR reporting, as groundwater quality impacts would not be anticipated.

Based on data from GSI publication Calcareous/Non calcareous classification of bedrock in the Republic of Ireland (WFD, 2004), alkalinity generally ranges from 250 to 350 mg/l (as $CaCO_3$) and hardness ranges from 380 to 450 mg/L (hard to very hard). The underlying formations largely contain calcium bicarbonate type water. Electrical conductivities in these bedrock units are high will typically range from 650 to 800 μS/cm (GSI, 2003).

9.3.9.2 Grid Connection Route

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

[4] *GWDTE – Groundwater Dependent Terrestrial Ecosystem i.e Wetlands, Turloughs, Dune slacks etc.*

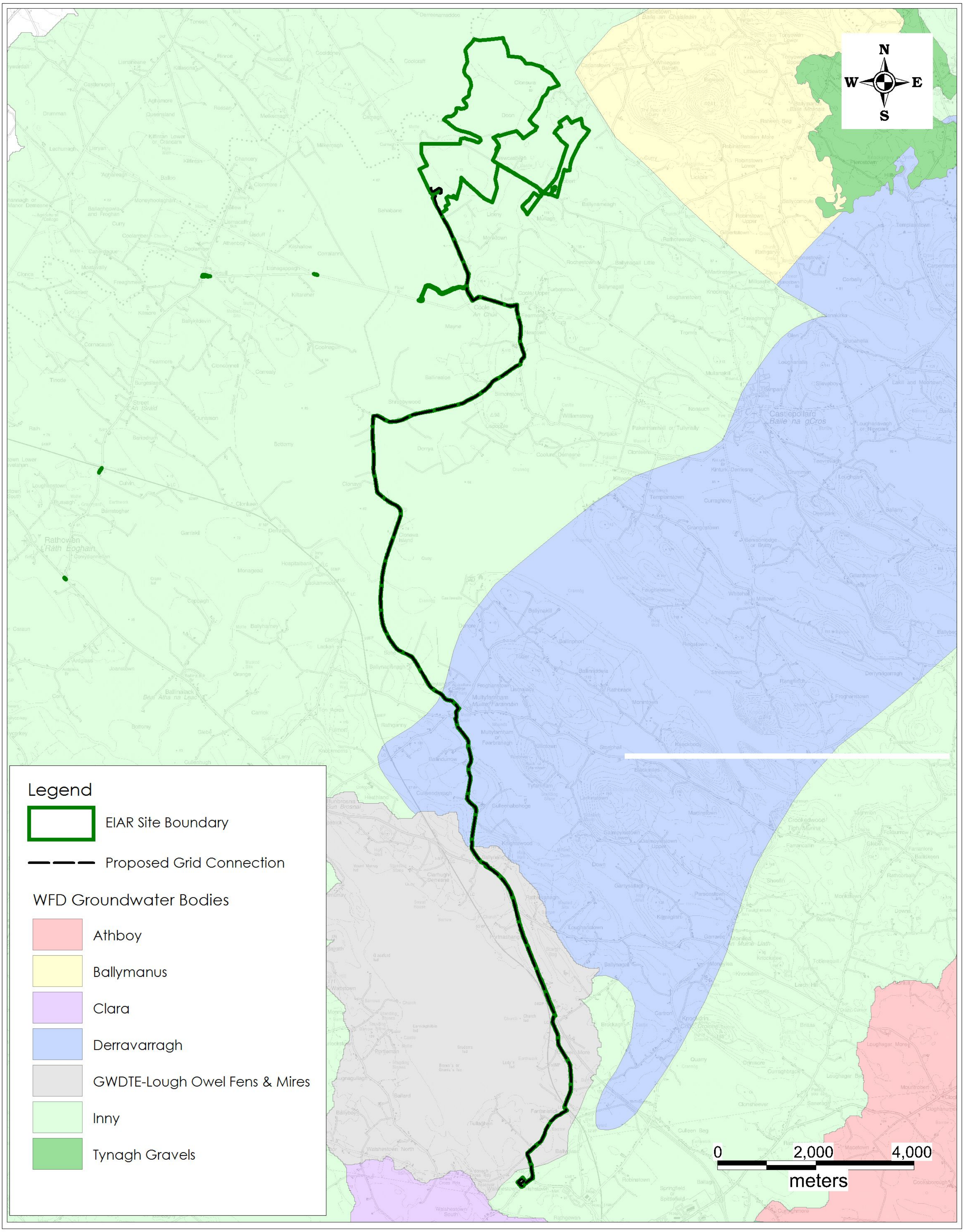

Figure No: 9-10	Client: MKO
Sheet Size: A4	Job: Coole WF, Co. West Meath
Date: 07/01/2021	Title: Groundwater Bodies Map (WF/GR)
Scale: 1:100,000	Project No: P1320-2
Drawn By: GD / Checked By: MG	Drawing No: P1320-2-0121-A4-910-00A

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Based on data from the Initial Characterisation Reports on the GWB's, the groundwater is expected to have a Calcium-Bicarbonate signature. The Inny GWB Report suggests that the groundwater is likely "Hard to Very Hard (typically ranging between 380–450 mg/l), and high electrical conductivities (650–800 µS/cm) are often observed. Alkalinity is also high, but less than hardness (250-370 mg/l as $CaCO_3$)".

9.3.10 Groundwater Body Status

9.3.10.1 Wind Farm Site

Local Groundwater Body and Surface water Body status and risk result are available from (www.catchments.ie).

The Inny Groundwater Body (GWB: IE_SH_G_110) predominantly underlies the Wind Farm Site. It is assigned 'Good Status'[5] under the WFD 2013-2018 (www.wfdireland.ie), this applies to both quantitative status and chemical status.

9.3.10.2 Grid Connection Route

Local Groundwater Body (GWB) status information are available (www.catchments.ie).The Lough Owel GWDTE is described as being "Not at Risk" under the WFD 2013-2018. The Derravaragh GWB is classified as "At Risk", the Inny GWB is classified as "Not at Risk".

9.3.11 Surface Water Body Status

9.3.11.1 Wind Farm Site

The Proposed Development site is located in the Inny River Waterbody (Inny_050) within the WFD Upper Shannon catchment. The River water quality status (2013 – 2018) for Inny at the location of the proposed site is Moderate with a risk result of "At Risk".

9.3.11.2 Grid Connection Route

Local Surface water Body status and risk result are available from (www.catchments.ie).

The Grid Connection Route site is located within the Inny_030 subcatchment, the Inny_020 subcatchment and the Brosna_010 subcatchment.

The River Gaine within the Inny_030 subcatchment is classified as "At Risk" under the WFD 2013-2018. The River Inny risk status is under review in this subcatchment.

The Inny River within the Inny_020 subcatchment is described as "Not at Risk" under the WFD 2013-2018.

The Brosna river, which runs through Mullingar, within the Brosna_010 subcatchment is described as "At Risk" under the WFD 2013-2018.

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[5] *'Status' means the condition of the water in the waterbody. It is defined by its chemical status and its ecological status, whichever is worse. Waters are ranked in one of 5 classes: High, Good, Moderate, Poor and Bad (WFD, 2010).*

9.3.12 Designated Sites and Habitats

9.3.12.1 Wind Farm Site

In the Republic of Ireland, designated sites include proposed National Heritage Areas (pNHAs), National Heritage Areas (NHAs), Special Areas of Conservation (SAC) and Special Protection Areas (SPA's). The Proposed Development site is not located within any designated site.

Lough Bane which is located on the northeastern boundary of the Wind Farm Site, and is hydraulically connected to the Wind Farm Site, is a proposed NHA (pNHA). Refer to the Chapter 6: Biodiversity: Flora & Fauna for further details relating to Lough Bane. A designated site map for the area is shown as Figure 9-11.

Features with an ecological significance within the boundary of the Wind Farm Site include the dystrophic lake on the northwestern corner of the Wind Farm Site and an area of intact raised bog that surrounds the lake. Refer to the Chapter 6: Biodiversity: Flora & Fauna for further details.

The proposed link road and junction works are remote from any designated sites.

9.3.12.2 Grid Connection Route

The Grid Connection Route is not located within any designated site. However, Garriskil Bog SAC (Site Code: 000679) is located near the Grid Connection Route along L1826, on the opposite side of the River Inny. The Garriskil bog is divided into two land areas, the second of which is located ~ 1.5km west of the Grid Connection Route. At its closest point the Garriskil Bog SAC boundary is ~50m from the Grid Connection Route along the L1826. A small stream (tributary of the River Inny) exists, ~ 230m south of the bridge to the north of the SAC boundary. This stream flows east and is culverted under the L1826.

The Lough Owel SAC (Site Code: 000688) is located ~75m from the Grid Connection Route, along the N4, ~7.5 km northwest of Mullingar. The extents of the SAC encroach on the N4 road. This is considered a GIS mapping oversight, as the road does not provide any sort of Annex I/Annex II habitat which would be linked to the Lough Owel SAC. The road (and Grid Connection Route) are situated at ~104mOD, while Lough Owel is situated ~75m west of the road at an elevation of 96 mOD.

The Scragh Bog SAC is ~ 250m east of the Lough Owel SAC, on the opposing side of the N4.

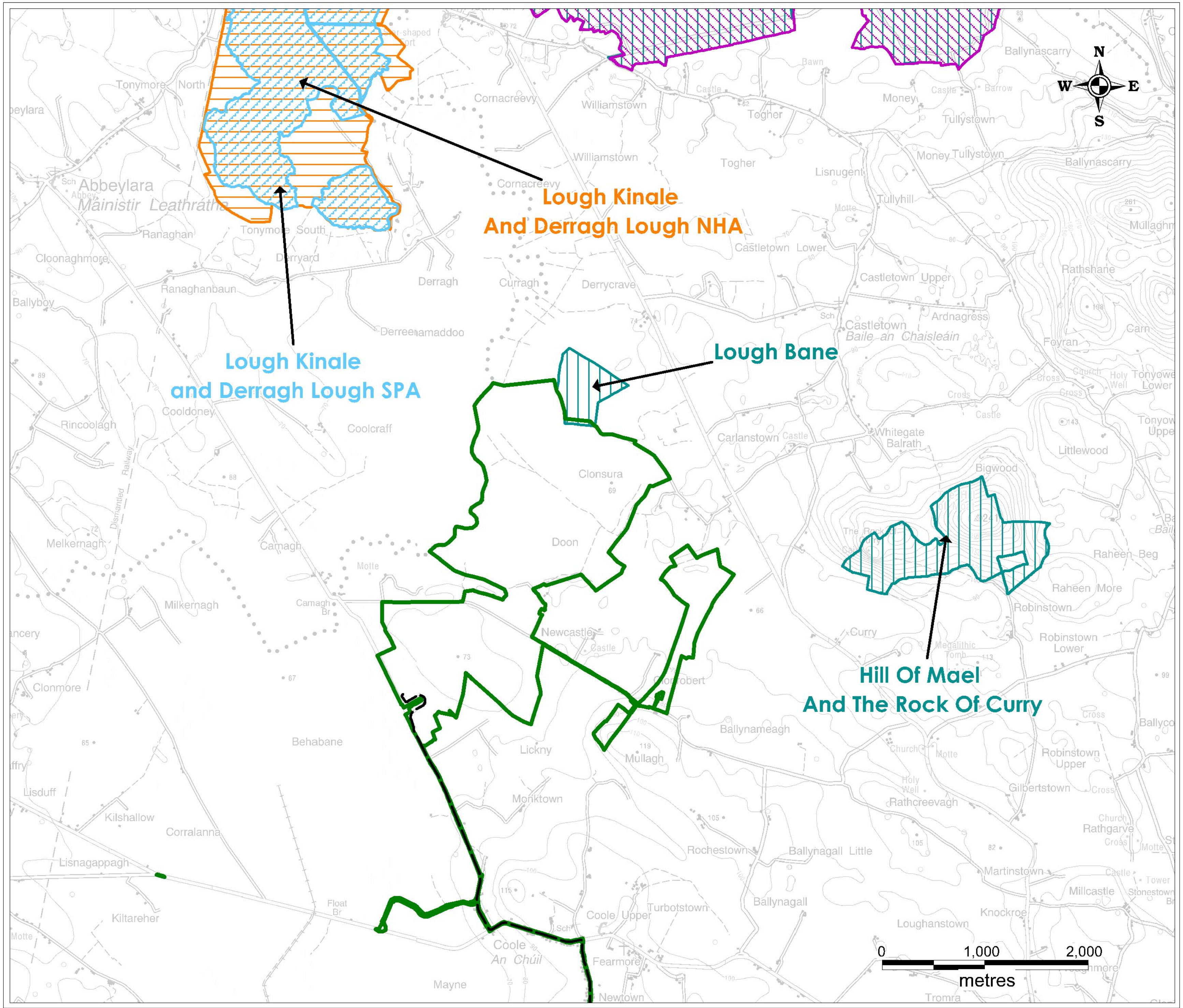
Lough Derravaragh NHA is mapped ~450m from the public road (Grid Connection Route) at its closest point. The road is at an elevation of ~61.5 mOD, while the lake is at an elevation of ~60 mOD.

Lough Derravaragh (004043), Lough Owel (004047) and Garriskil Bog (004102) are all designated as SPA's. They are also designated as NHA's (Site Codes: 000684, 000688 and 000679 respectively), along with Scragh Bog NHA (Site Code: 000692).

Ballynafid Lake and Fen, located towards the northeast of Lough Owel and adjacent to the N4 is designated as a NHA (Site Code: 000673). Again, the extents of the Lake and Fen extend out past the N4 road, however this is considered a GIS oversight, as the road and surrounding made ground does not constitute the habitat described under the NHA description.

The Grid Connection Route passes within existing public roads close to Lough Derravaragh NHA, Derravaragh SPA, Ballynafid Lake and Fen pNHA, Lough Owel pNHA, Lough Owel SPA, Lough Owel SAC, Scragh Bog SAC and Scragh Bog pNHA.

Designated sites near the Grid Connection Route are shown in Figure 9-12.



Legend

- EIAR Site Boundary
- Proposed Grid Route
- SPA
- SAC
- pNHA
- NHA

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Title: Designated Sites Map (WF Site)

Client: MKO

Job: Coole WF, Co. West Meath

Project No: P1320-2

Figure No: 9-11

Sheet Size: A4

Drawing No: P1320-2-0121-A4-911-00A

Date: 07/01/2021

Scale: 1:50,000

Drawn By: GD | Checked By: MG

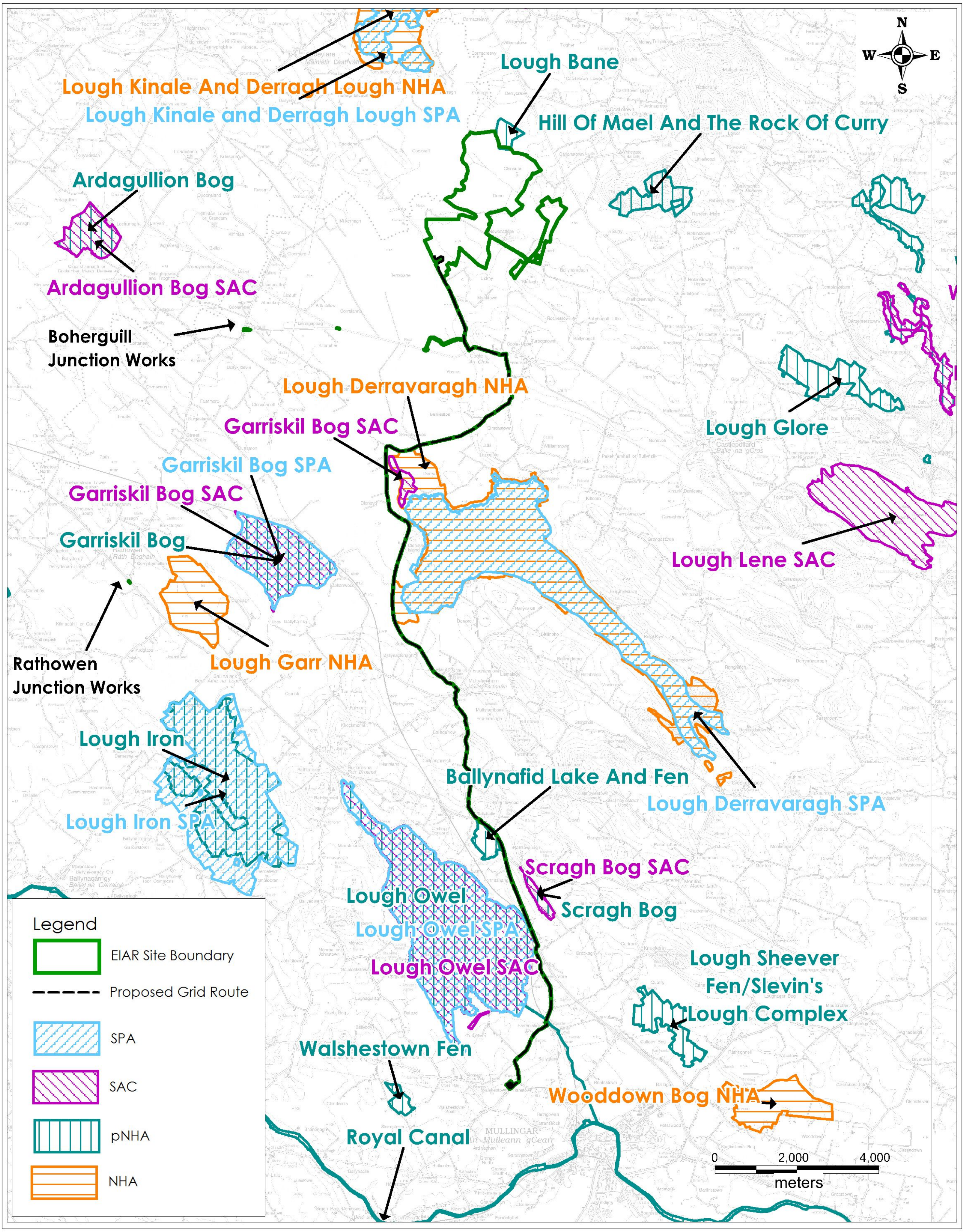

Figure No: 9-12		Client: MKO
Sheet Size: A4		Job: Coole WF, Co. West Meath
Date: 07/01/2021		Title: Designated Sites Map (GR)
Scale: 1:120,000		Project No: P1320-2
Drawn By: GD	Checked By: MG	Drawing No: P1320-2-0121-A4-912-00A

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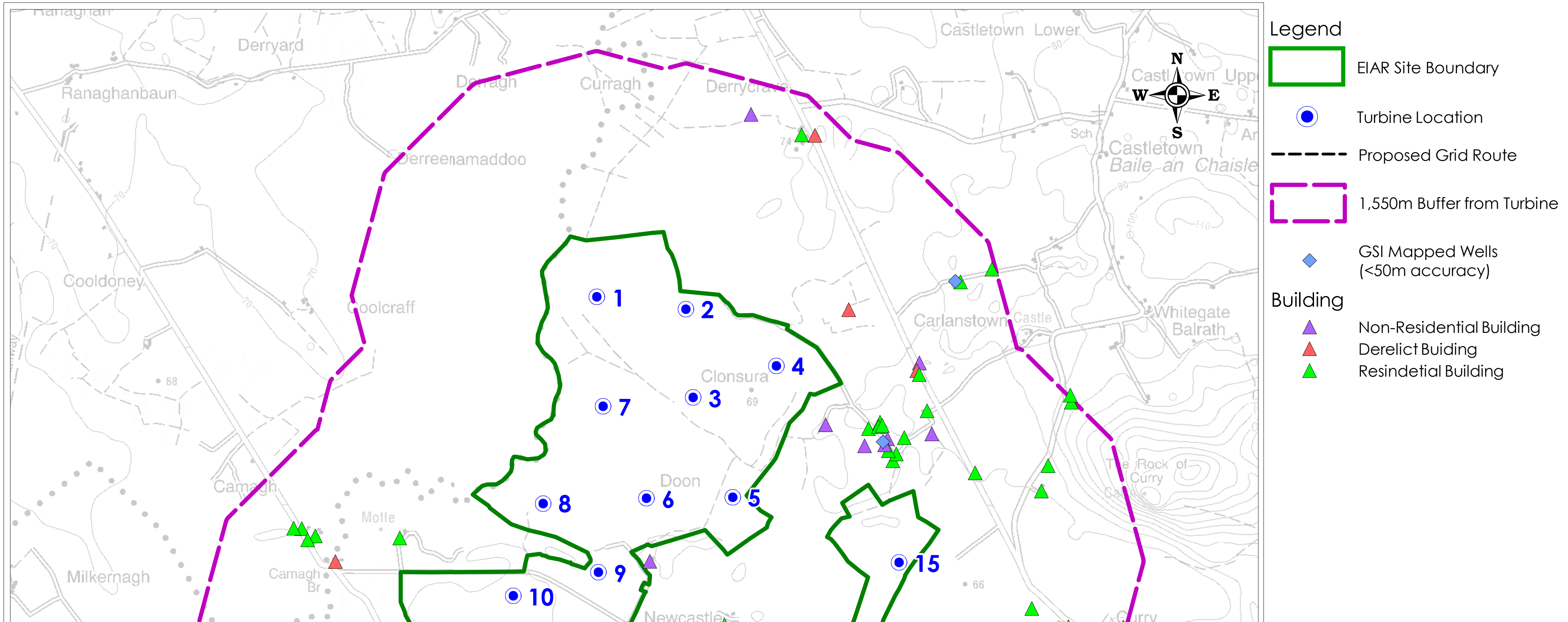

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Title: Nearby GW Wells Map (WF)

Client: MKO

Job: Coole WF, Co. West Meath

Project No: P1320-2

Figure No: 9-13

Sheet Size: A4

Drawing No: P1320-2-0121-A4-913-00A

Date: 07/01/2021

Scale: 1:30,000

Drawn By: GD | Checked By: MG

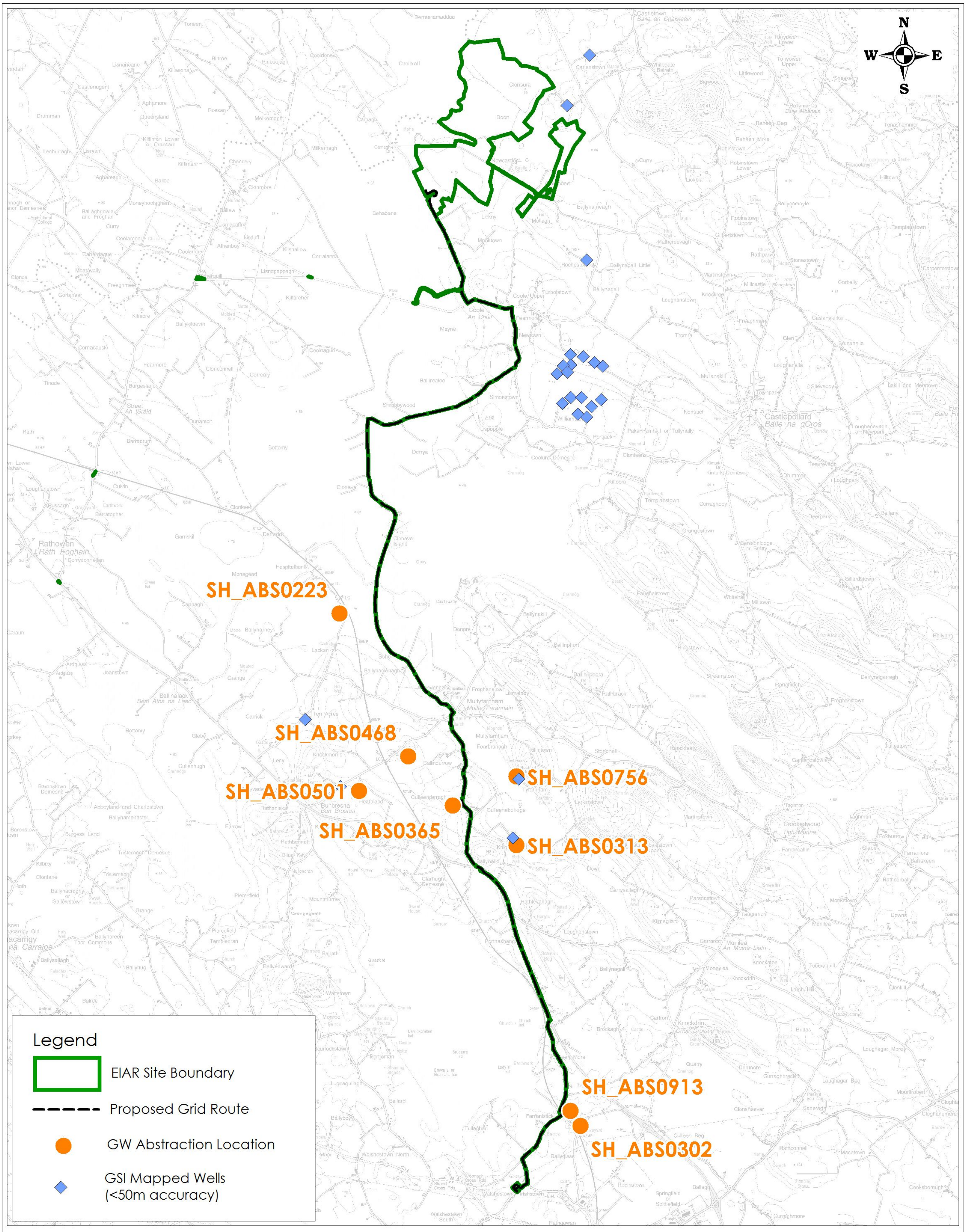

Figure No: 9-14		Client: MKO
Sheet Size: A4		Job: Coole WF, Co. West Meath
Date: 07/01/2021		Title: Nearby GW Wells Map (GR)
Scale: 1:100,000		Project No: P1320-2
Drawn By: GD	Checked By: MG	Drawing No: P1320-2-0121-A4-914-00A

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9.3.13 Water Resources

9.3.13.1 Wind Farm Site

There are no mapped public or group water scheme groundwater protection zones in the area of the Wind Farm Site. A search of private well locations (accuracy of 1 – 50m only) was undertaken using the GSI well database (www.gsi.ie). No wells with an accuracy of 1 – 50m were mapped in the area of the Wind Farm Site.

To overcome the poor accuracy problem of other GSI mapped wells it is assumed that every private dwelling in the area has a well supply and this impact assessment approach is described further below. Potential wells at private dwellings were identified.

The private well assessment undertaken below also assumes the groundwater flow direction in the aquifer underlying the Wind Farm Site mimics topography, whereby flowpaths will be from topographic high points to lower elevated discharge areas at streams and rivers. Using this conceptual model of groundwater flow, dwellings that are potentially located down-gradient of the Proposed Development footprint are identified. The groundwater flow direction in the area of the Wind Farm Site is in a south westerly direction towards the Inny River.

Shown on Figure 9-13 are the locations of private dwellings in the vicinity of the Wind Farm Site and Development study area. There are no private dwelling houses located down-gradient of the Wind Farm Site and therefore there is no potential to impact on groundwater supplies.

In addition, the risk to any potential future well source in the vicinity of the Wind Farm Site from potential contaminant release within any excavation is negligible. Due to the relatively low bulk permeability of mineral soils beneath the peat (i.e. predominately silts, shell marl, and lacustrine clays with some interbedded sands, gravels and underlying glacial tills), the low recharge characteristics (due to the overlying peat) and the low groundwater gradients (flat topography), groundwater travel times are expected to be extremely slow.

It is also proposed that piling will take place on the Wind Farm Site and therefore this limits the potential for impact on groundwater levels, and groundwater quality as there will be no significant excavation dewatering. The piles themselves will be drilled into relatively low permeability anoxic environment, so their ability to leach and change local groundwater chemistry will be very low.

9.3.13.2 Grid Connection Route

There are no surface water abstractions mapped within 10 kilometres of the Grid Connection Route. There are a number of mapped groundwater supplies including group schemes within 2 kilometres of the Proposed Development site. These abstractions are listed in Table 9-16.

Table 9-16: Nearby groundwater abstractions to Grid Connection Route.

Abstraction Code	Location	Abstraction Details	Distance to proposed grid route	Drainage Direction
SH_ABS0302	St Brigids Well, Mullingar	Group Water Scheme	420m	Upgradient of grid route
SH_ABS_0913	Taughmon GWS, Farranistick, Mullingar	Group Water Scheme	200m	Upgradient of grid route

Abstraction Code	Location	Abstraction Details	Distance to proposed grid route	Drainage Direction
SH_ABS0313	Toberachrin, Knightswood, Co. Westmeath	Group Water Scheme	950m	Upgradient of grid route
SH_ABS0365	Clonhugh, Co. Westmeath	Private	280m	Upgradient of grid route
SH_ABS0756	Tyfarnham, Co. Westmeath	Multyfarnham Group Water Scheme	1.03 km	Upgradient of grid route – River Gaine in between
SH_ABS0468	Ballindurrow, Co. Westmeath	Private	1.12 km	Upgradient of grid route
SH_ABS0501	Meathland, Co. Westmeath	Private	2 km	Upgradient of grid route
SH_ABS0223	Lackanwood, Co. Westmeath	GWS	750m	Upgradient of grid route

8 no. groundwater wells, were identified within 2 kilometre of the Grid Connection Route. 6 no. of these wells are used by group water schemes, while the remaining 2 no. wells are for private use. All of these wells are located upgradient of the Grid Connection Route and groundwater will not flow from the Grid Connection Route in the direction of these wells. The locations of these abstractions are shown in Figure 9-14.

According to the EPA Abstraction Register (http://watermaps.wfdireland.ie/HydroTool/Viewer) there are no registered public or private surface water abstractions downstream of the proposed development.

Due to the shallow nature of the Grid Connection Route trench works impacts on groundwater flows and levels are not anticipated, however the potential for impacts on groundwater quality from fuels and other chemicals during the construction phase exists. This assessment applies to any groundwater wells that exist along the Grid Connection Route. All individual groundwater wells are not identified or audited, but this is not considered necessary considering the very shallow depth of the works and the lack of potential for any significant impact. The Grid Connection Route trench is shallow in nature, and will not intercept the bedrock groundwater table, as excavations are generally within the overburden. The construction works along the Grid Connection Route trench are transient and temporary. The works are similar in nature to water pipe laying works, or underground electricity cable works which are completed along roads across the country. Standard mitigation measures in respect of normal construction site risks to groundwater quality are outlined in Section 9.4.1.

9.3.14 Peat Water Level Monitoring Data

Phreatic pipes (6 no.) and piezometer pipes (6 no.) were installed at 6 locations across the Wind Farm Site during site investigation works in 2017. These locations are shown in Chapter 8 (Figure 8-2). During follow up walkover surveys in 2020, it was discovered that some of these monitoring points had been destroyed/lost (likely from vehicles driving over them). 13 no. rotary core boreholes were drilled by GII in July 2020 with monitoring well installations completed in 12 no. of these. Water level dips were taken from boreholes near T2 & T9, as these were near the location of previous piezometers which had been damaged by machinery.

Details regarding screened interval depths and water level monitoring data are summarized in Table 9-17. Logs for the installations are attached in Appendix 8-2.

The water levels indicate a general downward water gradient within the peat profile, and also show a relatively high phreatic peat water table at all locations despite the installed drainage.

Groundwater levels within these monitoring points were measured during follow up walkover surveys on 23rd September 2020 and the 15th and 22nd October 2020. These data, along with historical groundwater level data are summarised in Table 9-17.

The deep groundwater levels within the piezometers generally range between ~ 1.2 to 3.5 mbgl, while the shallower phreatic water level ranges between 0.19 – 1.09 mbgl.

Table 9-17: Peat Water Level Monitoring Data

ID	Type	WS ID	Screen Interval (mbgl)	Water Level (mbgl)	Water Level (mbgl)	Water Level (mbgl)	Water Level (mbgl)	Water Level (mbgl)	Water Level (mbgl)	Water Level (mbgl)
				Dec 16*	02/02/17	02/02/17	02/02/17	02/02/17	02/02/17	02/02/17
T1-P1	P	WS01	4.0-5.0	dry	1.58	1.61	1.64	1.69	1.71	1.69
T1-PH1	P-T	WS01	0-1.0	0.95	1.02	1.04	1.09	1.33	1.23	1.15
T1-1-P1	P	WS101	5.0-5.3	dry	1.22	1.23	1.25	1.29	1.28	1.29
T1-1-PH1	PT	WS101	0-1.35	0.22	0.21	0.22	0.25	0.34	0.31	0.26
T2-P1	P	WS02	3.0-4.0	3.68	2.34	2.35	2.38	**	**	**
T2-PH1	PT	WS02	0-1.0	0.95	0.98	0.99	1.08	**	**	**
T2-1-P1	P	WS100	4.0-5.0	dry	1.23	1.24	1.22	1.26	1.33	1.35
T2-1-PH1	PT	WS100	0-1.35	0.52	0.48	0.46	0.63	0.83	0.82	0.58
T2-BH***	BH	-	0-8.55	-	-	-	-	2.22	2.58	2.52
T9-P1	P	WS09	8.0-8.8	dry	3.55	2.73	2.38	**	**	**
T9-PH1	PT	WS09	0-0.95	0.55	0.22	0.23	0.25	**	**	**
T9-BH***	BH	-	0-1.38	-	-	-	-	dry	dry	Dry
C1-P1	P	WS1-C	0.93-1.23	0.72	0.54	0.55	0.78	0.79	0.81	0.76
C1-PH1	PT	WS1-C	0-0.8	0.28	0.19	0.19	0.28	0.35	0.4	0.33

**December 2016 measurements were taken on 14th, 15th and 16th December after installation of pipes at each location. These December measurements do not represent static water levels as equilibrium would not have been achieved so soon after installation.*
*** - Piezometer removed since SI works in 2017*
****- New borehole for 2020 SI works*
P = piezometer, PT = Phreatic Tube, BH = borehole

9.3.15 Receptor Sensitivity

9.3.15.1 Wind Farm Site

Due to the nature of wind farm developments, being mostly near surface construction activities (apart from piled foundations, but even these are relatively shallow in terms of underlying geology and groundwater flow), effects on groundwater are generally negligible and surface water is generally the main sensitive receptor assessed during impact assessments. The primary risk to groundwater at the Wind Farm Site would be from cementitious materials, hydrocarbon spillage and leakages. These are common potential risks on all construction sites (such as road works and industrial sites), which can be omitted by way of mitigation. All potential contamination sources are to be carefully managed at the Wind Farm Site during the construction and operational phases of the Proposed Development and mitigation measures are proposed below to deal with these potential risks.

Based on criteria set out in Table 9-3 above, the Locally Important Aquifer can be classed as Sensitive to pollution. The majority of the Wind Farm Site however is covered in cutover peat which in turn is underlain by lake sediments and silty/clayey 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, any contaminants which may be accidently released on-site are more likely to travel to nearby streams within surface runoff. Comprehensive surface water mitigation and controls are outlined below to avoid this occurring and to ensure protection of all downstream receiving waters.

Mitigation measures will ensure that surface runoff from the developed areas of the Wind Farm 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 Wind Farm Site will mimic the existing drainage regime thereby avoiding changes to flow volumes leaving the Wind Farm Site via the existing outfalls.

9.3.15.2 Grid Connection Route

Due to the nature of the Grid Connection Route and substation development, being mostly near surface construction activities (apart from piled foundations at substation), impacts on groundwater are generally negligible and surface water is generally the main sensitive receptor assessed during impact assessments. The primary risk to groundwater at the site would be from cementitious materials, hydrocarbon spillage and leakages. These are common potential impacts on all construction sites (such as road works and industrial sites). All potential contamination sources are to be carefully managed at the Wind Farm Site during the construction and operational phases of the Proposed Development and mitigation measures are proposed below to deal with these potential minor impacts.

Based on criteria set out in Table 9-3, groundwater along the majority of the Grid Connection Route can be classed as Sensitive to pollution because the bedrock is likely to have moderate to high permeability in upper weathered zones, and it is classified as a Locally Important Aquifer. The section of the Grid Connection Route within the Derravaragh GWB can be classed as Sensitive, as there may be areas where the bedrock is karstified, although karstified rock would not be encountered at the depths of construction works (~1.2m). In general, it is likely that any contaminants which may be accidently released during the construction would preferentially travel to nearby streams within surface runoff.

Surface waters such as the River Inny are very sensitive to potential contamination. These rivers and associated lakes are known to be of trout potential and are important locally for fishing (see Chapter 6 Biodiversity: Flora and Fauna). The River Gaine is less sensitive as it achieved a Poor Biological status under the WFD 2010-2015, in comparison to the Good and Moderate status of the River Inny (SC_020 and SC_030 respectively).

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

9.3.16 Development Interaction with the Existing Bog Drainage Network of the Wind Farm Site

The general design approach to wind farm layouts in existing peat extraction land is to utilise and integrate new drainage with the existing drainage infrastructure where possible.

9.3.17 Proposed Drainage Management

Runoff control and drainage management are key elements in terms of mitigation against effects on surface water bodies. Two distinct methods will be employed to manage drainage water within the Wind Farm Site. The first method involves 'keeping clean water clean' by avoiding disturbance to natural drainage features, minimising any works in or around artificial drainage features, and diverting clean surface water flow around excavations, construction areas and temporary storage areas. The second method involves collecting any drainage waters from works areas within the Wind Farm Site that might carry silt or sediment, and nutrients, to route them towards settlement ponds (or stilling ponds) prior to controlled diffuse release over vegetated surfaces. There will be no direct discharges to surface waters. During the construction phase all runoff from works areas (i.e. dirty water) will be attenuated and treated to a high quality prior to being released. A detailed drainage plan showing the layout of the proposed drainage systems is shown in the design drawings included in Appendix 9-3 of the EIAR.

9.4 Characteristics of the Proposed Development

The Provided Development comprises of the following:

- Up to 15 No. wind turbines with a tip height of up to 175 metres and all associated foundations and hardstanding areas;
- 1 no. onsite electrical substation including a control building, associated electrical plant and equipment, welfare facilities and a wastewater holding tank;
- 1 no. temporary construction compound;
- Provision of new site access roads, upgrading of existing access roads and hardstand areas;
- Excavation of 1 no. borrow pit;
- All associated underground electrical and communications cabling connecting the turbines to the proposed onsite substation;
- Laying of approximately 26km of underground electricity cabling to facilitate the connection to the national grid from the proposed onsite substation located in the townland of Camagh to the existing 110kV Mullingar substation located in the townland of Irishtown;
- Upgrade works to the existing 110kV Mullingar substation consisting of the construction of an additional dedicated bay to facilitate connection of the cable;
- Construction of a link road between the R395 and R396 Regional Roads in the townland of Coole to facilitate turbine delivery;
- Junction improvement works to facilitate turbine delivery, at the N4 junction with the L1927 in the townland of Joanstown, on land to the South East of railway line level crossing on the L1927 in the townland of Culvin, the L1927 and L5828 junction in the townland of Boherquill and the L5828 and R395 junction in the townland of Corralanna;
- Site Drainage;

- Forestry Felling;
- Signage, and;
- All associated site development works.

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

- Opening of the proposed borrow pit, which will involve the stripping of topsoil/subsoil and the rock breaking/ripping, and subsequent processing, of 251,915m^3 of suitable rock to create aggregate for use on site in access tracks and hardstand construction. Runoff and discharge from the borrow pit has the potential to impact on surface water quality.
- Establishment of the site compound, which will involve minor regrading of peat and the placement of the construction compound using a floated technique where possible. Welfare facilities will be provided at the site compounds. Wastewater effluent will be collected in a wastewater holding tank and periodically emptied by a licenced contractor.
- Construction of the site access tracks will use both excavated and floated technique. Floating tracks will be used at the Wind Farm Site for the majority of new tracks, as well as upgrading of existing tracks. This will involve the use of aggregate, sourced from the on-site borrow pit and imported from local quarries where required. Construction of these access tracks has the potential to impact on surface water quality.
- Construction of the crane hardstand areas and turbine assemblage areas are assumed to be floated apart from at T5 and T15. This too will involve the use of aggregate, sourced from the onsite borrow pit and imported from local quarries where required. Construction of these areas has the potential to impact on surface water quality.
- With the exception of turbines T5 and T15, all turbines and their associated crane hardstand areas are likely to require a piled foundation as a result of the depth of peat and soft lacustrine deposits present. In addition it is likely that a piled foundation will be required for the substation building. The substation platform and construction compound platform will likely be constructed using floating techniques. Runoff and pumping from this area could impact on groundwater and surface water quality during construction.
- Settlement ponds where constructed will be volume neutral, i.e. all material excavated will be used to form side bunds and landscaping around the ponds. There will be no excess material from settlement pond construction. The material will also be reinstated during decommissioning.
- Estimated volumes of peat to be removed at T5 and T15 and for upgrading of access/link roads are estimated at approximately 4,630m^3.
- Construction of the onsite substation and parking area will likely be completed using a floated technique. Welfare facilities will be provided at the substation.. Construction of the onsite substation and associated parking area has the potential to impact on surface water quality.
- Grey water will be supplied by rainwater harvesting and water tankered to site where required. Bottled water will be used for potable supply.
- Construction of the turbine foundations, which will require large volumes of concrete (approximately 550m^3 per turbine foundation plus approximately 50m^3 of lean-mix concrete for the blinding layer), placing demand on local concrete batching plants / quarries. Concrete could impact on surface water and groundwater quality.
- Cabling between turbine locations and the onsite substation. This will involve the excavation of a shallow trench (approximately 1.2m deep), placement of ducting and backfilling with aggregate, lean-mix concrete and excavated material, as appropriate (depending on the location of the cable trench). These works have the potential to impact on surface water quality.
- Cabling between the onsite substation and the Mullingar 110 kV Substation. This will involve the excavation of a trench along the public road, placement of ducting and backfilling with lean-mix concrete and compacted engineered fill. These works have the potential to impact on surface water quality.
- Link Road, Junction Accommodation and Public Road Works, including:

1: N4/L1927 junction at Joanstown - temporary hardcore surfacing area and visibility splays. The proposed area for temporary hardcore surfacing measures approximately 0.03 hectares.
2: Railway Line Level Crossing on the L1927 – no alteration of crossing, swept path analysis indicates turbine vehicles will be able to negotiate this crossing with Temporary removal of the existing hedgerow and hardsurfacing South of the railway line to the East.
3: L1927/L5828 right turn at Boherquill - temporary hardcore surfacing area and visibility splays, widen northeastern corner of junction. Proposed hardcore area measures 0.31 Ha
4: Right turn from L5828 onto R395 - no alteration of road, swept path analysis indicates turbine vehicles will be able to negotiate this crossing with minor impacts on sections of grass verges requiring temporary hardcore.
5&6: Site access junctions A and B that provide access/egress onto proposed link road (linking R395 and R396) - with temporary hardcore surfacing and visibility splays at the turning areas. The proposed area for surfacing measures 0.34 hectares.
7: Site access junction C that provides access to the site from the R396 - temporary hardcore surfacing area and visibility splays will be required at this junction. The proposed area for hardcore surfacing measures 0.21 hectares.
8: Site access junction D which crosses the L5755 - no alteration of road, swept path analysis indicates turbine vehicles will be able to negotiate this crossing with minor impacts on sections of hedge (over-sail) and grass verges.
9: Site access junction E which provides access to Turbine T14 located south of L5755 - temporary hardcore surfacing area and visibility splays will be required at this junction. The proposed area for hardcore surfacing measures 0.21 hectares.
10: Site access junction F, access junction off the L5755 to / from the proposed borrow pit - visibility splays will be required at this junction
11: Site access junction G which provides access to turbine number 15 situated to the north of the L5755 - temporary hardcore surfacing area and visibility splays will be required at this junction. The proposed area for hardcore surfacing measures 0.8 hectares.

- The proposed link road measures 1.2 kilometres in length, and will traverse land currently occupied by commercial cutover peat and agricultural grassland between the R395 and R396 Regional Roads.
- Tree felling and replanting. 2 no. turbines are located in commercial forestry (T5 & T14) which will require felling, and replanting of forestry at alternative replacement lands. While this work will be done with Forestry Service licenses and approvals, the works could result in soil/subsoils erosion.

9.4.1 Construction Phase Potential Impacts

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

Construction phase activities including access road/link road construction, construction compound, turbine base/hardstanding construction, onsite substation construction and Grid Connection Route cable trench excavation will require earthworks resulting in removal of vegetation cover and excavation/landscaping of small volumes of peat and mineral subsoil where present. The proposed construction design for the Wind Farm Site including piled foundations and floating roads minimises the potential of impacts from this source. Only minor excavation of peat is proposed where required. Potential sources of sediment laden water include:

- Drainage and seepage water resulting from road and turbine base excavation;
- Stockpiled excavated material providing a point source of exposed sediment;

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

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

Pathways: Drainage and surface water discharge routes.

Receptors: Down-gradient rivers (River Inny, Glore river, and Monkstown stream) and dependent ecosystems.

Pre-Mitigation Potential Impact: Indirect, negative, significant, temporary, medium probability impact.

Proposed Mitigation Measures:

Wind Farm Site: The key mitigation measure during the construction phase is the avoidance of sensitive aquatic areas where possible, by application of suitable buffer zones (i.e. 50m to main watercourses, and 10m to main drains). From Figure 9-4 and Figure 9-5, it can be seen that all of the key proposed development areas within the Wind Farm Site 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 tracks. Additional control measures, which are outlined further on in this section, will be undertaken at the proposed watercourse and drain crossing locations.

Grid Connection Route: The majority of the Grid Connection Route is >50m from any nearby watercourse, apart from a section of the N4 alongside Lough Owel and at bridges along the Grid Connection Route. It is proposed to limit any works in any areas located within 50m of any watercourse/waterbody including the stockpiling of excavated soils and subsoils.

There are a total of 16 no. watercourse crossings along the Grid Connection Route, as shown in Figure 4-26 of Chapter 4. There are 7 no. river/stream crossings (Locations No. 2, 3, 4, 10, 14, 15 & 16), with the remaining crossings being classified as culverts. All the crossings are existing bridges and culverts along the public road.

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

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

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

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

Mitigation by Design:

- Source controls:
  - Interceptor drains, vee-drains, diversion drains, flume pipes, erosion and velocity control measures such as use of sand bags, oyster bags filled with gravel, filter fabrics, and other similar/equivalent or appropriate systems.
  - Small working areas, covering stockpiles, weathering off stockpiles, cessation of works in certain areas or other similar/equivalent or appropriate measures.
- In-Line controls:
  - Interceptor drains, vee-drains, oversized swales, erosion and velocity control measures such as check dams, sand bags, oyster bags, straw bales, flow limiters, weirs, baffles, silt bags, silt fences, sedimats, filter fabrics, and collection sumps, temporary sumps/attenuation lagoons, sediment traps, pumping systems, settlement ponds, temporary pumping chambers, or other similar/equivalent or 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.

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

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

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

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

Silt Fences:
Silt fences will be emplaced within drains down-gradient of all construction areas. Silt fences are effective at removing heavy settleable solids. This will act to prevent entry to watercourses of sand and

gravel sized sediment, released from excavation of mineral sub-soils of glacial and glacio-fluvial origin, and entrained in surface water runoff. Inspection and maintenance of these structures during construction phase is critical to their functioning to stated purpose. They will remain in place throughout the entire construction phase. Double silt fences will be emplaced within drains down-gradient of all construction areas inside the hydrological buffer zones.

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

Pre-emptive Site Drainage Management:
The works programme for the initial construction stage of the development will also take account of weather forecasts, and predicted rainfall in particular. Large excavations and movements of peat/subsoil or vegetation stripping will be suspended or scaled back if heavy rain is forecast. The extent to which works will be scaled back or suspended will relate directly to the amount of rainfall forecast.

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

- General Forecasts: Available on a national, regional and county level from the Met Eireann website (www.met.ie/forecasts). These provide general information on weather patterns including rainfall, wind speed and direction but do not provide any quantitative rainfall estimates;
- MeteoAlarm: Alerts to the possible occurrence of severe weather for the next 2 days. Less useful than general forecasts as only available on a provincial scale;
- 3 hour Rainfall Maps: Forecast quantitative rainfall amounts for the next 3 hours but does not account for possible heavy localised events;
- Rainfall Radar Images: Images covering the entire country are freely available from the Met Eireann website (www.met.ie/latest/rainfall_radar.asp). The images are a composite of radar data from Shannon and Dublin airports and give a picture of current rainfall extent and intensity. Images show a quantitative measure of recent rainfall. A 3 hour record is given and is updated every 15 minutes. Radar images are not predictive; and,
- Consultancy Service: Met Eireann provide a 24 hour telephone consultancy service. The forecaster will provide interpretation of weather data and give the best available forecast for the area of interest.

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

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

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

Management of Runoff from Peat and Subsoil Storage Areas:
It is proposed that excavated peat will be used for landscaping where required. Peat excavation will only occur in the area of T5.

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

Where required temporary peat/subsoil storage areas will be sealed with a digger bucket and vegetated as soon possible to reduce sediment entrainment in runoff.

Management of Runoff from the Grid Connection Route and existing road upgrade areas:
Where construction of the Grid Connection Route is undertaken along sections of proposed access road or existing roads requiring upgrade, the Wind Farm Site drainage infrastructure (as outlined above) will be in place to manage and control runoff from the trench excavation area. Where the cable trench is to be constructed off-road (within the Wind Farm Site) or along public roads surface water control measures such as silt fences will be employed when work is required within hydrological buffer zones. These control measures will also be put in place at the points of existing road upgrades *i.e.* at the junction of N4 and L1927.

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

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

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

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

Post-Mitigation Residual Impact: 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, indirect, imperceptible, temporary, low probability impact on the water environment within the Wind Farm Site, along the Grid Connection Route and near other ancillary works (River Inny, Glore River, River Deel, Monkstown stream, Lough Derravaragh).

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

9.4.1.2 Clear Felling of Coniferous Plantation

It is estimated that 16.36ha (hectares) in total of existing forestry will be felled to allow for development of the Wind Farm Site. The area to be felled as part of the proposed wind farm accounts for just 5.5 % of the existing forestry.

Potential impacts during tree felling occur mainly from:

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

Pathways: Drainage and surface water discharge routes.

Receptors: Surface waters and associated dependent ecosystems.

Pre-Mitigation Potential Impact: Indirect, negative, moderate, temporary, high probability impact.

Proposed Mitigation Measures:

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

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

Mitigation by Avoidance:
There is a requirement in the Forest Service Code of Practice and in the FSC Certification Standard for the installation of buffer zones adjacent to aquatic zones at planting stage. Minimum buffer zone widths recommended in the Forest Service (2000) guidance document “Forestry and Water Quality Guidelines” are shown in Table 9-18.

Table 9-18: Minimum Buffer Zone Widths (Forest Service, 2000)

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

During the Wind Farm Site construction phase a buffer zone of 50m will be maintained for all streams and lakes where possible, and a 10m buffer will be applied to main drains.

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

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

- Machine combinations will be chosen which are most suitable for ground conditions at the time of felling, and which will minimise soils disturbance;
- Checking and maintenance of roads and culverts will be on-going through any felling operation. No tracking of vehicle through watercourses will occur, as vehicles will use road infrastructure and existing watercourse crossing points. Where possible, existing drains will not be disturbed during felling works;
- Ditches which drain from the proposed area to be felled towards existing surface watercourses will be blocked, and temporary silt traps will be constructed. No direct discharge of such ditches to watercourses will occur. Drains and sediment traps will be installed during ground preparation. Collector drains will be excavated at an acute angle to the contour (~0.3%-3% gradient), to minimise flow velocities. Main drains to take the discharge from collector drains will include water drops and rock armour, as required, where there are steep gradients, and should avoid being placed at right angles to the contour;
- Sediment traps will be sited in drains downstream of felling areas. Machine access will be maintained to enable the accumulated sediment to be excavated. Sediment will be carefully disposed of in the peat disposal areas. Where possible, all new silt traps will be constructed on even ground and not on sloping ground;
- In areas particularly sensitive to erosion, it may be necessary to install double or triple sediment traps. This measure will be reviewed on site during construction;
- All drainage channels will taper out before entering the aquatic buffer zone. This ensures that discharged water gently fans out over the buffer zone before entering the aquatic zone, with sediment filtered out from the flow by ground vegetation within the zone. On erodible soils, silt traps will be installed at the end of the drainage channels, to the outside of the buffer zone;
- Drains and silt traps will be maintained throughout all felling works, ensuring that they are clear of sediment build-up and are not severely eroded. Correct drain alignment, spacing and depth will ensure that erosion and sediment build-up are minimized and controlled;
- Brash mats will be used to support vehicles on soft ground, reducing peat and mineral soils erosion and avoiding the formation of rutted areas, in which surface water ponding can occur. Brash mat renewal should take place when they become heavily used and worn. Provision should be made for brash mats along all off-road routes, to protect the soil from compaction and rutting. Where there is risk of severe erosion occurring, extraction should be suspended during periods of high rainfall;
- Timber will be stacked in dry areas, and outside a local 50m watercourse buffer. Straw bales and check dams to be emplaced on the down gradient side of timber storage/processing sites;
- Works will be carried out during periods of no, or low rainfall, in order to minimise entrainment of exposed sediment in surface water run-off;
- Checking and maintenance of roads and culverts will be on-going through the felling operation;
- Any diesel or fuel oils stored at the temporary site compounds will be bunded. The bund capacity will be sufficient to contain 110% of the storage tank's maximum capacity;
- Refuelling or maintenance of machinery will not occur within 100m of a watercourse. Mobile bowser, drip kits, qualified personnel will be used where refuelling is required; and,

- Branches, logs or debris will not be allowed to build up in aquatic zones. All such material will be removed when harvesting operations have been completed, but care will be taken to avoid removing natural debris deflectors.

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

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

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

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

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

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

Post-Mitigation Residual Effects: Forestry works are completed in accordance with guideline standards that all aim to protect surface water quality and aquatic habitats. With the application of the mitigation outlined above, we consider the residual effect to be: Indirect, negative, slight, temporary, low probability impact.

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

9.4.1.3 Potential Impacts on Groundwater Levels During Excavation Works and from Proposed Borrow Pit

Wind Farm Site
Dewatering (by pumping) of the borrow pit (is not proposed, it will be drained by gravity to its lowest point) has the potential to impact on local groundwater levels. However, groundwater level impacts are not anticipated to be significant due the local hydrogeological regime (i.e. locally important aquifer and high local groundwater table, and significant distances to any potential off site receptors such as wells or natural rivers/streams) which comprises relatively low permeability glacial deposits.

Grid Connection Route
Dewatering of deep excavations have the potential to impact on local groundwater levels. No groundwater level impacts are anticipated from the construction of the Grid Connection Route cabling trench due to the shallow nature of the excavation (i.e. ~1.2m). Any excavation dewatering required for directional and horizontal drilling at the rail crossing and other watercourse crossings will be relatively shallow and temporary in nature.

Pathway: Groundwater flowpaths.

Receptor: Groundwater levels.

Pre-Mitigation Potential Impact: Direct, negligible, slight, short term, low probability impact on local groundwater levels.

Impact Assessment
The proposed borrow pit at the Wind Farm Site will extract bedrock below the local groundwater table and therefore there is some moderate potential to impact on local groundwater levels. However, the proposed borrow pit is located on an elevated area of ground, which can be drained by gravity. The pit will be relatively shallow (10-15m), and therefore the potential for groundwater level impacts to extend significant distances from the pit is negligible. An estimation of the proposed zone of influence of the borrow pit dewatering is made using Sichardt's equation. A conservative permeability of range of between 0.13 and 1.3 m/day issued, and this indicates a potential zone of influence of between 56 and 177m. There is one local well located to the northeast of the proposed borrow pit, and this is no longer in use. There are no other know wells within a 177m radius of the proposed borrow pit, therefore potential for impact is limited.

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

The Grid Connection Route cable trench depth will only be approximately 1.2 m in depth and therefore no impacts on the local groundwater table or flows are anticipated. The trench will be backfilled with excavated material and/or hardcore material, depending on site conditions. Therefore there will be no net loss of permeability across the 1.2m depth.

No groundwater impacts at haul route junction upgrade works are anticipated, as these works are all occurring at ground level, and will not intercept the groundwater table.

Post-Mitigation Residual Effects: Due to large separation distances between the Proposed Development works and water wells, 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 - Indirect, negligible, imperceptible, temporary, low probability impact on local groundwater levels.

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

9.4.1.4 Excavation Dewatering and Potential Impacts on Surface Water Quality

Wind Farm Site
Groundwater seepages will likely occur in turbine base excavations at Turbine T5 and this will create additional volumes of water to be treated by the drainage management system.

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

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

Pathway: Overland flow and site drainage network.

Receptor: Down-gradient surface water bodies.

Pre-Mitigation Potential Impact: Indirect, negative, significant, temporary, low probability impact to surface water quality.

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

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

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

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

9.4.1.5 Potential Release of Hydrocarbons during Construction and Storage

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

Pathway: Groundwater flowpaths and site drainage network.

Receptor: Groundwater and surface water.

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

Proposed Mitigation Measures:
Mitigation by Design

- Onsite re-fuelling of machinery will be carried out using a mobile double skinned fuel bowser. The fuel bowser, a double-axel custom-built refuelling trailer will be re-filled off site (Wind Farm Site and Grid Connection Route), and will be towed around the site by a 4x4 jeep to where machinery is located. The 4x4 jeep 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;
- Refuelling or maintenance of machinery will not occur within 100m of a watercourse;
- Fuels stored on site will be minimised;
- Any diesel or fuel oils stored at the temporary site compound will be bunded. The bund capacity will be sufficient to contain 110% of the storage tank's maximum capacity;
- The electrical control building at the Wind Farm Site 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; and,
- An emergency plan for the construction phase to deal with accidental spillages will be contained within Environmental Management Plan. Spill kits will be available to deal with accidental spillages.

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

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

9.4.1.6 Groundwater and Surface Water Contamination from Wastewater Disposal

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

Pathway: Groundwater flowpaths and Grid Connection Route/Wind Farm Site drainage network.

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

Pre mitigation Potential Impact
Indirect, negative, significant, temporary, low probability impact to surface water quality.
Indirect, negative, slight, temporary, low probability impact to local groundwater.

Proposed Mitigation Measures (By Avoidance)

- The site compound for the Wind Farm Site will be used for the construction of the Grid Connection Route;
- Port-a-loos with an integrated waste holding tank will be used at the site compound, maintained by the providing contractor, and removed from Wind Farm Site on completion of the construction works;
- Water supply for the Wind Farm Site office and other sanitation will be brought to site and removed after use from the Wind Farm Site to be discharged at a suitable off-site treatment location; and,
- No water will be sourced on the Wind Farm Site, or discharged to the Wind Farm Site.

Post-Mitigation Residual Effects: No residual impact

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

9.4.1.7 Release of Cement-Based Products

Concrete and other cement-based products are highly alkaline and corrosive and can have significant negative impacts on water quality. They generate very fine, highly alkaline silt (pH 11.5) that can physically damage fish by burning their skin and blocking their gills. A pH range of $\geq 6 \leq 9$ is set in S.I. No. 293 of 1988 Quality of Salmonid Water Regulations, with artificial variations not in excess of $\pm$ 0.5 of a pH unit. Entry of cement based products into the site drainage system, into surface water runoff, and hence to surface watercourses or directly into watercourses represents a risk to the aquatic environment. Peat ecosystems are dependent on low pH hydrochemistry. They are extremely sensitive to introduction of high pH alkaline waters into the system. Batching of wet concrete at the Wind Farm Site/along the Grid Connection Route and washing out of transport and placement machinery are the activities most likely to generate a risk of cement based pollution. Placed concrete in turbine bases and foundations can have minor local impacts on groundwater quality over time. However, due to limited surface area of exposed concrete, the anoxic conditions below ground, and the high rate of dilution from the wider groundwater system relative to the small volumes of groundwater that would come in contact with the concrete, the potential for impacts are low.

Pathway: Site drainage network, groundwater flow.

Receptor: Surface water and peat water hydrochemistry, and groundwater chemistry.

Pre-Mitigation Potential Impact: Indirect, negative, moderate, short term, medium probability impact to surface waters such as the River Inny, Glore river, River Deel and Monkstown stream.

Indirect, negative, imperceptible, long term, low probability impact to local groundwater quality.

Proposed Mitigation Measures
Mitigation by Avoidance:

- No batching of wet-cement products will occur on site/along the grid route works or near other ancillary construction activities. 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 need to 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 directed into a dedicated concrete wash out pit. Decommissioning of this pit will occur at the end of the construction phase and water and solids will be tanked and removed from the site to a suitable, non-polluting, discharge location;
- All concrete will be paced in shuttering and will not be in contact with soils or groundwater until after it has set;
- Use weather forecasting to plan dry days for pouring concrete; and,
- Ensure pour site is free of standing water and plastic covers will be ready in case of sudden rainfall event.

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

Post-Mitigation Residual Effects: The potential for the release of cement-based products or 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, Indirect, imperceptible, short term, low probability impact to surface water, Indirect, negative, imperceptible, long term, low probability impact to local groundwater quality.

Significance of Effects: No significant effects on surface water or groundwater quality are anticipated.

9.4.1.8 Morphological Changes to Surface Watercourses and Drainage Patterns

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

It is proposed that 1 no. existing watercourse crossings will be upgraded and 2 no. new watercourse crossings will be required to facilitate the wind farm access roads within the Wind Farm Site. These crossing are further described in Section 4.8.3 of Chapter 4 and included in Figures 4-23 to 4-25.

Along sections of proposed and existing access roads, the Grid Connection Route cable will be constructed within the road crossing. Section 4.8.7.5 in Chapter 4 of this EIAR details the water crossing locations along the proposed Grid Connection Route, and describes the proposed crossing construction methodology. Additional details are presented below.

Pathway: Site drainage network.

Receptor: Surface water flows and stream morphology (River Glore and unnamed tributaries).

Pre-Mitigation Potential Impact: Negative, direct, slight, long term, high probability impact on surface watercourses near the watercourse crossings.

Proposed Mitigation Measures (By Design):

- Where possible all proposed new stream crossings will be bottomless culverts and the existing banks will remain undisturbed. No in-stream excavation works are proposed and therefore there will be no impact on the stream at the proposed crossing location;
- Within the Wind Farm Site where the Grid Connection Route runs adjacent to a proposed access road or an existing access road proposed for upgrade, the Grid Connection Route cable will pass over the culvert (where one exists or is proposed) within the access road;
- Where a Grid Connection Route cable stream crossing is required, the cable will pass over the watercourse via suspended ducting thereby avoiding any morphological impacts;
- Any guidance / mitigation measures proposed by the OPW or the Inland Fisheries Ireland will be incorporated into the design of the proposed crossings. A 10m buffer is applied to the main drain (i.e. drain D1) to allow for future OPW maintenance;
- Works will be completed in accordance with the requirements of "*Inland Fisheries Ireland (2016): Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters";* and,
- All access road river/stream crossings will require a Section 50 application (Arterial Drainage Act, 1945). The river/stream crossings will be designed in accordance with OPW guidelines/requirements on applying for a Section 50 consent.

Post-Mitigation Residual Effects: With the application of the best practice mitigation outlined above, and through compliance with the Section 50 consenting process, we consider the residual effect to be - Neutral, direct, negligible, short term, high probability impact.

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

9.4.1.9 Potential Hydrological Impacts on Designated Sites

Possible effects include water quality impacts which could be significant if mitigation is not put in place. Dewatering was also a potential concern within the Wind Farm Site, but this is eliminated as a result of the proposed piling construction methods proposed.

Wind Farm Site
Lough Bane is located up-gradient of the Wind Farm Site and therefore its water quality cannot be affected by the proposed construction works. In addition the water levels provided in Table 9-17 indicate that peat water gradients are downwards, and there is a high bank and at least 3 no. deep drainage channels between the location of T2 and Lough Bane to the north. Despite the drainage, the phreatic water levels on the high bank (T2-1-PH1) are close to ground level (~0.5-0.8mbgl), and this is at least 2m above the ground level at T2. The presence of the high bank and the deep drains will isolate the works at T2 from causing any hydrological impact at Lough Bane. In addition, the proposed method of construction is likely piling, and this will limit hydrogeological and dewatering impacts.

Grid Connection Route
The Grid Connection Route passes within existing public roads close to Lough Derravaragh NHA, Derravaragh SPA, Ballynafid Lake and Fen pNHA, Lough Owel pNHA, Lough Owel SPA, Lough Owel SAC, Scragh Bog SAC and Scragh Bog pNHA. There are no designated sites near or down

gradient of the proposed onsite substation. Cabling between the onsite substation and the Mullingar 110 kV Substation will involve the excavation of a shallow trench along the public road, placement of ducting and backfilling with lean-mix concrete and compacted engineered fill. These works have the potential to impact on surface water quality. Surface water quality impacts are further addressed in Section 9.4.1.1 above. The proposed grid connection trench will be ~1.2m deep. The relative depth of the trench in relation to the distance (and hydraulic gradients) between the designated sites means that the potential for effects is not significant. This is further emphasised by cross sections of the road/cable trench and designated site areas as discussed in Section 9.3.12 and included in Appendix 9-4.

Gariskil Bog SAC
At its closest point the Gariskil Bog SAC boundary is ~60m from the Grid Connection Route along the L1826. The road (and Grid Connection Route) is ~ 2.5m lower than the raised bog that forms the SAC (refer to Appendix 9-4: Cross Section X1 – X2). The River Inny exists between the edge of the bog and the public road and acts as a hydraulic boundary to groundwater flow. A small stream (tributary of the River Inny) exists, ~ 230m south of the bridge to the north of the SAC boundary. This stream is culverted under the L1826. The stream flows east, while drainage from the bog will flow west towards the River Inny.

Lough Owel SAC/SPA/pNHA
The road (and Grid Connection Route) are situated at ~104mOD, while Lough Owel is situated ~75m west of the road at an elevation of 96 mOD. The ~75m distance from the road to the lake is taken up with grass verge and some small shrubbery/rough grassland, as well as a rail line and drain. Any rainfall /surface water along the section of road adjacent to Lough Owel is currently filtering through this area of vegetation, infiltrating into the soil, before slowly discharging to the drain or lake as seepage. A cross section of the Lough Owel SAC and the public road is included as Cross section X5 of Appendix 9-4.

Ballynafid Lake and Fen NHA
A cross section across the existing public road to the lake (Appendix 9-4, Cross section X4) shows the road ~5m higher than the Ballynafid Lake, again with a considerable amount of grass verge and shrubbery in the intervening ~300m to the lake (although the pNHA is mapped as ~37m from the road). There is no direct pathway for surface water flow from the public road/Grid Connection Route to the Ballynafid lake, any excess surface water would infiltrate to ground within several metres of the road, based on permeability/groundwater recharge values mapped by the GSI.

Scragh Bog SAC/Scragh Bog pNHA
The Scragh Bog SAC/pNHA is situated ~320m from the Grid Connection Route at its closest point. Land-use between the Grid Connection Route and the Scragh bog is typically agricultural with some residential dwellings along the N4 road. There is a considerable amount of grass verge/shrubbery along the N4 roadside. Given the distance relative to the ~1.2m trench and the intervening land use, there is no direct or indirect hydrological pathway to the Scragh Bog SAC/pNHA, any excess surface water would infiltrate to ground within several metres of the road, based on permeability/groundwater recharge values mapped by the GSI.

Lough Derravaragh SPA/NHA
Lough Derravaragh is situated 450m from the Grid Connection Route at its closest point (Appendix 9-4, Cross Section X5). The intervening land-use is a mixture of agricultural land, forestry and marsh along the banks of the lake. The River Inny flows from the northwestern edge of Lough Derravargh and a bridge over this river exists along the L1826. The River Inny flows from the lake, therefore the hydraulic gradient is away from Lough Derravaragh at this bridge. Due to the significant distance between the Grid Connection Route and Lough Derravaragh and the shallow nature of the trench there is no surface water/ groundwater pathway between the Grid Connection Route and the Lough Derravaragh SPA/NHA.

Pathway: Surface water and shallow groundwater flowpaths.

Receptor: Down-gradient water quality and designated sites.

Pre-Mitigation Potential Impact: Indirect, negative, negligible, temporary, low probability.

Impact Assessment and Proposed Mitigation Measures

Wind Farm Site:

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

As stated in Impact Section 9.4.1.1 above, there could potentially be an "imperceptible, temporary, low probability impact" on local streams and rivers but this would be very localised and over a very short time period (i.e. hours). Therefore, significant direct, or indirect impacts on downstream designated sites distant from the Wind Farm Site are not anticipated.

Grid Connection Route:

As the designated sites mentioned above are topographically below the level of the Grid Connection Route (apart from the Gariskil Bog SAC), mitigation measures must be put in place during the construction phase.

There is a significant separation distance between the Grid Connection Route and the designated sites listed, in terms of the scale of the grid trench (0.6m wide). There are no direct pathways present and there is generally a considerable amount of vegetation between the Grid Connection Route and the SAC boundary which acts as a buffer zone. Mitigation measures are outlined in Section 9.4.1.1 to Section 9.4.1.8 above which, when implemented, will provide the necessary protection to these hydrologically sensitive areas.

The proposed mitigation measures which will include drainage control measures, sediment control measures and mitigation measures related to spills/chemical releases will ensure that the quality of runoff from along the Grid Connection Route during construction will be good. The closest point of intersection between the Grid Connection Route and a designated site is near the northwest corner of Lough Derravaragh where the Grid Connection Route passes along the L1826, adjacent to the Gariskil Bog SAC. Due to the shallow nature of the trench (~1.2m) and the location of the Grid Connection Route hydraulically downgradient of the Gariskil Bog, there will be no hydrological impact on the designated site.

As stated in Impact Section 9.4.1.1 above, there could potentially be an "imperceptible, short term, likely impact" on local streams and rivers but this would be very localised and over a very short time period (i.e. hours). Therefore, significant direct, or indirect impacts on the SACs, SPAs, NHAs, and pNHAs will not occur.

The hydrological regime locally will not be affected by the proposed works and so the regime of the SACs, SPAs, NHA and pNHAs will not be affected.

- No significant dewatering is proposed during construction. Any pumping required will be temporary and at a very shallow depth.
- All building and trenching works are proposed at or very near existing ground levels with minimal ground disturbance proposed.
- No deep foundations are required or are proposed. As such there will be no interruption or blocking of shallow or deep groundwater pathways below the site.

Post-Mitigation Residual Effects: For the reasons outlined above, and in conjunction with the implementation of the mitigation measures, no hydrological or hydrogeological impacts on designated sites are anticipated.

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

9.4.1.10 Potential Groundwater and Surface Water Impacts due to Temporary Junction Works and Directional Drilling works

Minor haul route works are required at 11 no. locations listed below, however all proposed road works are small-scale and localised, and no significant water quality impacts are anticipated.

- N4/L1927 junction at Joanstown - temporary hardcore surfacing area and visibility splays.
- Railway Line Level Crossing on the L1927 – Temporary hedgerow removal and hardsurfacing South and East of the rail line.
- L1927/L5828 right turn at Boherquill - temporary hardcore surfacing area and visibility splays
- Right turn from L5828 onto R395 – Temporary hardsurfacing in the road verge
- Site access junctions A and B that provide access/egress onto proposed link road (linking R395 and R396) - with temporary hardcore surfacing and visibility splays at the turning areas.
- Site access junction C that provides access to the site from the R396
- Site access junction D which crosses the L5755 - no alteration of road
- Site access junction E which provides access to Turbine T14 located south of L5755
- Site access junction F, access junction off the L5755 to / from the proposed borrow pit
- Site access junction G which provides access to turbine number 15 situated to the north of the L5755

Due to the shallow nature of the Grid Connection Route trench and temporary junction works impacts on groundwater flows and levels are not anticipated, however there is a potential for impacts on groundwater quality from fuels and other chemicals during the construction phase. Directional drilling will be required along public roads for the Grid Connection Route. Mitigation measures are outlined below.

Pathway: Surface water and groundwater flow paths.

Receptor: Down-gradient water quality.

Pre-Mitigation Potential Impact: Indirect, negative, slight, temporary, low probability impact on surface water quality.
Indirect, negative, slight, temporary, low probability impact on groundwater quality.

Proposed Mitigation Measures
The following mitigation measures are proposed:

Mitigation by Avoidance:

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

The purpose of the constraint zone is to:

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

General Best Practice Pollution Prevention Measures will also include:

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

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

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

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

- Onsite re-fuelling of machinery will be carried out using a mobile double skinned fuel bowser, as described in Section 9.4.1.5. No maintenance of construction vehicles or plant will take place along the grid connection or temporary junction works areas;
- The plant used will be regularly inspected for leaks and fitness for purpose; and,
- Spill kits will be available to deal with accidental spillage.

Post-Mitigation Residual Effect: The temporary junction improvement works and directional drilling has the potential to negatively impact the local surface water and groundwater, through increased sediment supply to the river channel, and the potential for fuel/oil spills which could impact surface water and groundwater. Proven and effective measures to mitigate the risk of excess runoff and fuel/oil spills have been proposed above and will break the pathway between the potential source and each receptor. The residual effect is considered to be - Indirect, negative, imperceptible, temporary, low probability impact on surface water quality.

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

9.4.1.11 Assessment of Potential Health Effects

Wind Farm Site

Potential health effects are associated with negative impacts 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 Wind Farm Site. Notwithstanding this, the proposed site design and mitigation measures ensures that the potential for impacts on the water environment generally is low.

The Flood Risk Assessment has also shown that the risk of the Wind Farm Site 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 bog basins. Drainage measures on the site will include swales, silt traps, settlement ponds, field drains and headland drains as described earlier in the chapter.

Grid Connection Route

Potential health effects from the Grid Connection Route and substation works are associated with negative impacts (i.e. contamination) on public and private water supplies and potential alteration of flooding risks. An assessment of potential impacts on private and public water supplies is completed at Section 9.3.13, and no significant effects are anticipated. Therefore, no health effects are likely to occur.

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 Identification (undertaken at Section 9.3.6 has also shown that the risk of the Grid Connection Route and substation works contributing to downstream flooding is also very low, as the works footprint is small, the works are for the most part along existing roads, and the duration of the works is short. On-site (construction phase) drainage control measures will ensure no downstream increase in local flood risk.

9.4.2 Operational Phase Impacts

9.4.2.1 Progressive Replacement of Natural Surface with Lower Permeability Surfaces

Progressive replacement of the peat and vegetated surfaces with impermeable surfaces could potentially result in an increase in the proportion of surface water runoff reaching the surface water drainage network. The footprint comprises 15 no. turbine hardstandings, new and upgraded access roads, and the onsite substation. During storm rainfall events, additional runoff coupled with increased velocity of flow could increase hydraulic loading, resulting in erosion of watercourses and impact on aquatic ecosystems.

The emplacement of the proposed permanent development footprint within the Wind Farm Site, assuming emplacement of impermeable materials as a worst-case scenario, could result in an average total site increase in surface water runoff of 924 m^3/month at the Wind Farm Site (Table 9-19). This represents a potential increase of 0.22 % in the average daily/monthly volume of runoff from the study area in comparison to the baseline pre-development site runoff conditions. This is a very small increase in average runoff and results from a relatively small area of the site being developed, the proposed total permanent development footprint being approximately 26.4ha, representing ~5 % of the total study area of 530ha.

The water balance undertaken in this section is for baseline characterisation purposes along with an assessment of potential runoff changes as a result of the Proposed Development footprint. The rainfall depths presented in this section, which are long term averages, are not used in the design of the sustainable drainage system for the wind farm. A 1 in 10 year 6 hour return period will be used for design purposes.

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 9-19 - Table 9-21). 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 97% based on the predominant peat coverage.

The highest long term average monthly rainfall recorded at Granard occurs in October, at 103mm. This is a monthly average for the period 1981-2010. The average monthly evapotranspiration for the synoptic station at Mullingar over the same period in October was 16.2mm. The water balance indicates that a conservative estimate of surface water runoff for the Wind Farm Site during the highest rainfall month is 418.818m^3/month or 13,510m^3/day.

Table 9-19: Water Balance and Baseline Runoff Estimates for Wettest Month (October)

Water Balance Component	Depth (m)
Average October Rainfall (R)	0.103
Average October Potential Evapotranspiration (PE)	0.0162
Average October Actual Evapotranspiration (AE = PE x 0.95)	0.0154
Effective Rainfall (ER = R - AE)	0.0876
Recharge (3% of ER)	0.0035
Runoff (97% of ER)	0.0841

Table 9-20: Baseline Runoff for the Wind farm Site

Approx. Area (ha)	Baseline Runoff per month (m^3)	Baseline Runoff per day (m^3)
498	418,818	13,510

Table 9-21: Wind Farm Site 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	418,818	13,510	264,000	22,202	23,126	924	30.8	0.22

The additional volume in all outfall sub-catchments is low due to the fact that the runoff potential from the site is naturally high (97%). 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. Therefore, there will be no risk of exacerbated flooding down-gradient of the Wind Farm Site.

The proposed grid connection route will result in the emplacement of lower permeability surfaces in areas where the trench is excavated along the roadside verge (rather than within the existing road hardstanding). As a worst case scenario, it is assumed that the grid connection trench will be emplaced within the verge across the entire 26km length. In reality, the trench will be within the boundaries of the proposed floating roads within the Wind Farm site and within the existing road width along parts of the grid route to the Mullingar substation.

The same baseline calculation is applied to the grid connection trench along the 26km course with a ~0.6m nominal width (refer to Table 9-22 and Table 9-23). Average recharge potential along the grid route is ~60%.

Table 9-22: Baseline Runoff for the Grid connection route

Approx. Area (ha)	Baseline Runoff per month (m^3)	Baseline Runoff per day (m^3)
1.56 (26km (l) x 0.6m (w))	546.6	17.6

Table 9-23: Grid connection route Baseline Runoff V Development Runoff

Development Type	Baseline Runoff/month (m^3)	Baseline Runoff/day (m^3)	Hardstanding Area 100% Runoff (m^3)	Hardstanding Area 100% runoff/day (m^3)	Net Increase/month (m^3)	Net Increase/day (m^3)
Grid Route	546.6	17.6	1366.5	44.08	820	26

The additional volume of runoff per day during the highest month of effective rainfall is 26m^3, or ~1000 litres/km. This volume of water is negligible in terms of the scale of flows in the subcatchments the grid route passes through. Larger rivers, such as the River Inny tend to have flows at the scale of 5-10 m^3/second, therefore the net effect is considered to be negligible due to the limited flows and the overall scale of the 0.6m trench in terms of the subcatchments. Also, the calculation assumes that all hardstanding areas will be impermeable which will not be the case as the surface topsoil within the verge will be reinstated where possible, which provides an initial permeable surface for rainfall infiltration. The increase in runoff from the Proposed Grid Connection route will therefore be negligible. This is even before mitigation measures will be put in place.

Pathway: Site drainage network, grid route (road) drainage network.

Receptor: Surface waters and dependent ecosystems.

Pre-Mitigation Potential Impact: Direct, negative, moderate, permanent, moderate probability impact on downstream surface water bodies (River Inny, Monkstown stream, Glore River).

Impact Assessment

As determined in Table 9-21 above there could be a potential increase in runoff of 0.22 % in the average daily/monthly volume of runoff from the study area in comparison to the baseline pre-development site runoff conditions. This is a very small increase in average runoff and results from a relatively small area of the study area being developed, the proposed total permanent development footprint being approximately 26.4ha, representing ~5% of the total study area of 530ha.

The increase in runoff from the Proposed Development will therefore be negligible. This is even before mitigation measures will be put in place. Therefore, there will be no risk of exacerbated flooding down-gradient of the Wind Farm Site.

Long term it is expected that runoff from the overall Wind Farm Site will reduce (refer to Section 4.3 of the Flood Risk Assessment attached in Appendix 9-1) due to increased attenuation in on-site peatland drainage systems.

Proposed Mitigation Measures

Mitigation by Design:

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

- Runoff from individual turbine hardstanding areas will not be discharged into the existing drain network, but discharged locally at each turbine location through settlement ponds and buffered outfalls onto vegetated surfaces;
- Interceptor drains will be installed up-gradient of all proposed infrastructure to collect clean surface runoff, in order to minimise the amount of runoff reaching areas where suspended sediment could become entrained. It will then be directed to areas where it can be re-distributed over the ground by means of a level spreader;
- Swales/road side drains will be used to collect runoff from access roads and turbine hardstanding areas of the site, likely to have entrained suspended sediment, and channel it to settlement ponds for sediment settling;
- On steep sections of access road transverse drains ('grips') will be constructed where appropriate in the surface layer of the road to divert any runoff off the road into swales/road side drains;
- Check dams will be used along sections of access road drains to intercept silts at source. Check dams will be constructed from a 4/40mm non-friable crushed rock;
- Settlement ponds, emplaced downstream of road swale sections and at turbine locations, will buffer volumes of runoff discharging from the drainage system during periods of high rainfall, by retaining water until the storm hydrograph has receded, thus reducing the hydraulic loading to watercourses; and,
- Settlement ponds will be designed in consideration of the greenfield runoff rate.

Post-Mitigation Residual Effects: With the implementation of the proposed Wind Farm Site 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 surface water quality or quantity are anticipated.

9.4.2.2 Drainage at Onsite Substation

A surface water drainage system will be installed at the proposed onsite substation. This has the potential to discharge silt laden water to the receiving environment. A water supply for the onsite substation will also be required. Rainwater will be harvested at the Wind Farm Site to cater for water supply needs during operation. This has the potential to reduce water flows to local streams/rivers. An on-site wastewater system will be required during the operation of the onsite substation. Effluent from this system could leak to ground or overflow and enter surface water at the Wind Farm Site.

Pathway: Site drainage network, surface water quality, groundwater quality.

Receptor: Surface water, groundwater and dependent ecosystems.

Pre-Mitigation Potential Impact: Indirect, negative, slight, permanent, low probability impact.

Impact Assessment

Surface water drainage from the sub-station area will be managed in a dedicated drainage system. Rainwater will be harvested at the site to cater for water supply needs during operation, and wastewater will be held in a sealed on site tank, and there will be no proposed discharge to ground at the sub-station site.

Proposed Mitigation Measures

The proposed onsite substation will be located on the south west of the Wind Farm Site. It is proposed to drain the onsite substation using shallow swales, with a stilling pond at the end of the swale run. The stilling pond will remain in place following the construction period. At the upslope side of the onsite substation overland flows will be intercepted in channels and discharged diffusely over vegetated areas. A suitable permanent petrol and oil interceptor will be installed to deal with all onsite substation surface water drainage.

A rainwater harvesting system will be used for toilet flushing at the Substation Control Building in the Wind Farm Site. There will be a very small net loss of water to local streams but this will be imperceptible over the course of a year.

It is proposed to install a sealed underground holding tank for effluent (wastewater) from the onsite substation building. The tank shall be routinely emptied by a licensed contractor. A level sensor will be installed in the tank which shall be linked to the on-site SCADA system. Should the level of the tank rise to a predetermined 'high 'level a warning shall appear on the overall SCADA system for the Wind Farm Site and automatic notification shall be sent to the facility manager. A formal service agreement will be entered into with a suitably permitted waste contractor, in relation to the servicing and de-sludging of the wastewater holding tank on site. There will be no discharge of wastewater to ground at the Wind Farm Site, and therefore there is no potential to impact groundwater or surface water quality.

Post-Mitigation Residual Effects: Mitigation measures have been incorporated into the drainage design to minimise suspended sediment within the drainage runoff. An underground sealed tank will be used for holding waste-water from the onsite substation. Following implementation of the mitigation measures outlined above, the residual impact is considered to be- Indirect, negative, imperceptible, permanent, low probability impact.

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

9.4.3 Decommissioning Phase Potential Impacts

Wind Farm Site

In the event of decommissioning of the Wind Farm Site, similar activities to the construction phase are carried out.

Potential impacts would be similar to the construction phase but to a lesser degree. There would be increased trafficking and an increased risk of disturbance to underlying soils at the Wind Farm Site, during the decommissioning phase, in this instance, leading to the potential for silt laden run-off entering receiving watercourses from the wheels of vehicles. Any such potential impacts would be likely to be less than during the construction stage as the drainage swales would be fully mature and would provide additional filtration of runoff. Any diesel or fuel oils stored on site would be bunded. In the event of decommissioning of the Coole Wind Farm, the proposed access tracks may be used in the decommissioning process.

Following decommissioning of the Wind Farm Site, turbine foundations, hardstanding areas and site tracks will be rehabilitated, i.e. left in place, covered over with local peat soil/scraw (i.e. peat vegetation sod) and allowed to re-vegetate naturally, if required. The internal site access tracks may be left in place, subject to agreement with Westmeath County Council and the landowner. It is considered that leaving these areas in-situ will cause less environmental damage than removing and recycling them.

Removal of this infrastructure would result in considerable disturbance to the local environment in terms of disturbance to underlying soils and an increased sedimentation (if turbine foundations, access tracks and hardstandings are being reinstated there is a risk of silt laden run-off entering the receiving watercourses), erosion, dust, noise, traffic and an increased possibility of contamination of the local water table. However, if removal is deemed to be required all infrastructure will be removed with mitigation measures similar to those during construction being employed.

It is proposed that underground cables will be cut back and left in place.

The onsite substation will remain in place as it will be under the ownership of the ESB. There are no impacts associated with this.

Grid Connection Route

The cabling along the Grid Connection Route will also remain in place and as such there will be no impacts associated with this.

A Decommissioning Plan has been prepared (Appendix 4-11) the detail of which will be agreed with the local authority prior to any decommissioning. The Decommissioning Plan will be updated prior to the end of the operational period in line with decommissioning methodologies that may exist at the time and will agreed with the competent authority at that time. The potential for effects during the decommissioning phase of the proposed renewable energy development has been fully assessed in the EIAR.

9.4.4 Do-Nothing Scenario

An alternative land-use option to developing the Proposed Development would be to leave the site as it is under its current planning permission. As detailed in Section 2.5.1 in Chapter 2 of this EIAR, a wind energy project comprising of 13 turbines and all associated infrastructure has current planning permission on the Proposed Development site. The permitted wind energy project was designed to co-exist and operate in conjunction with and independently of land-use practices of commercial peat-harvesting and forestry to minimise impacts. Whilst there would be a change of land use within the footprint of the Proposed Development, to facilitate the wind turbines and infrastructure, this was found to be an acceptable part of the permitted development.

This EIAR assesses the potential for peat extraction works on the site to continue as a worst-case scenario. The Proposed Development has been designed to operate on this site in conjunction with any peat extraction activities. When peat extraction ceases, a site rehabilitation plan will be required which would be likely to encourage revegetation of bare peat areas, with targeted active management being used to enhance re-vegetation and the creation of small wetland areas. Due to the small footprint of the Proposed Development in the context of the entirety of the commercial peat extraction area, a rehabilitation plan where required would take account of the wind farm infrastructure. In doing so, the environmental effects in terms of emissions are likely to be neutral.

Surface water drainage carried out in areas of peat extraction and forestry will continue to function and may be extended in some areas. The existing surface water drainage pattern within proposed junction improvement areas would remain the same. The impact on hydrology and water quality would remain largely unaltered as a result. The section of the Proposed Development site that does not form part of the currently permitted wind energy development site has a current-land use practice of low-intensity pastoral agriculture. An alternative land-use option to developing a renewable energy project at this section of the Proposed Development site would be to leave the site as it is, with no changes made to the current land-use practices of low intensity pastoral agriculture. The environmental effects of this are considered to be neutral.

A second potential Do Nothing scenario exists for this project i.e. assuming that the permitted development is not constructed. In this scenario the existing baseline environment will evolve in one of two potential ways, either the peat extraction ceases prior to construction and a rehabilitation plan is developed or the peat extraction continues and then a rehabilitation plan is developed.

In implementing the 'Do-Nothing' alternative, however, the opportunity to capture an additional part of Westmeath's valuable renewable energy resource would be lost, as would the opportunity to contribute in a more meaningful way to meeting Government and EU targets for the production and consumption of electricity from renewable resources and the reduction of greenhouse gas emissions. The opportunity to generate additional local employment and investment would also be lost. It is likely that the trends of population decline and rural deprivation that have been recorded within the Study Area would continue in the absence of investment, as discussed in Section 5 of this EIAR on Population and Human Health. Overall, the potential impact of this is considered to be long term, negative and slight.

The commercial peat harvesting works, forestry, low-intensity pastoral agriculture and public road use can continue in conjunction with the proposed use of the site.

9.4.5 Cumulative Impacts

Wind Farm Site

Both the Wind Farm Site and the Grid Connection Route are located in the River Shannon catchment. However, in terms of hydrological cumulative impacts arising from the Wind Farm Site infrastructure and the Grid Connection Route, none are anticipated as the Grid Connection Route is along the carriageway of public roads and there are no proposed in-stream works at any of the watercourse crossing locations as all the proposed 16 no. crossing locations are at existing bridges or culverts.

Minor haul route works are required at 11 no. locations (as listed in Section 9.4.1.10) however all proposed road widening works are small scale and localised and cumulative effects are not anticipated.

A hydrological cumulative impact assessment regarding other wind farm and non-wind farm developments within the River Shannon catchment within a 20km radius of the Wind Farm Site was also undertaken. There are only 2 no. turbines (1 no. existing and 1 no. proposed) within 20km of the proposed Wind Farm Site. A summary of the wind farm developments is shown in Table 9-24 below. No non-wind farm developments were identified as having a potential cumulative impact with the Proposed Development.

Table 9-24: Wind Farm Developments in the River Shannon catchment (within 25km of the proposed Coole wind farm site)

Catchment Area	Wind Energy Development	No. of Turbines	Proposed/Existing	Distance to Coole WF Site
River Shannon	Ballyjamesduff Wind Farm	1	Proposed	~16km

Catchment Area	Wind Energy Development	No. of Turbines	Proposed/Existing	Distance to Coole WF Site
	Ballyjamesduff Wind Farm	1	Existing	~17km

Therefore, the total number of turbines that could potentially be operating inside a 20km radius within the River Shannon catchment, including the proposed Coole 15 no. turbines is 17.

The catchment area of the River Shannon within a 20km radius of the site is ~900km^2 and therefore this equates to one turbine for approximately every ~53km^2 which is considered imperceptible in terms for potential cumulative hydrological impacts.

In relation to non-wind farm developments, the majority of local developments relate to the provision and/or alteration of one-off housing and agricultural developments.

Applications which are not of an individual domestic or agricultural nature in the vicinity of the EIAR study area include the following:

Peat Operations

- Pl Ref. 88/313: Planning application to retain peat moss processing plant and buildings at Doon, Castlepollard. The planning authority granted planning permission on 10th February 1989.

Other Applications

- Pl Ref. 011/2043: Planning application relating to Turbotstown House for alterations to the existing structure.
- Pl. Ref.81/699: Planning application for erection of a 38 kV sub-station at Tromra. The Planning Authority granted permission on the 29th October 1981.

All the local non-wind developments in the vicinity of the Proposed Development study area are small scale and localised in nature and impacts on water quality or flows (surface water or groundwater) are not expected. Therefore, hydrological cumulative impacts with respect to the Proposed Development are also not expected.

Regardless, implementation of the proposed drainage mitigation will ensure there will be no cumulative significant adverse impacts on the water environment during construction from the Proposed Development, and other wind farm developments and non-wind farm developments within the River Shannon catchment.

During the operational phase of the Proposed Development all excavation and construction related work will have ceased and therefore there is no potential for water quality impacts from these sources. Also, the proposed wind farm drainage measures will create significant additional attenuation to what is already present at the Wind Farm Site. The Wind Farm Site will retain water within the bog for longer periods and therefore will improve overall surface water runoff quality and reduce downstream flood risk. No cumulative adverse impacts on the water environment due to the Proposed Development are expected during the operational phase.

No significant cumulative impacts on the hydrology and hydrogeology environment are envisaged during the decommissioning stage.

Grid Connection Route

The hydrological impact assessment undertaken above in this chapter outlines that significant effects are unlikely due to the localized nature of the construction works. Impacts on the water environment will not extend beyond the immediate vicinity of the Grid Connection Route excavations.

In relation to the historical flood issues near the existing Mullingar 110kV Substation, a site visit has been conducted in this area, and the local drainage has been mapped. The issue appears to arise from surface water runoff from upgradient houses/hardstands and the road surface, flowing down the local road and backing up along near the existing substation and down gradient houses. This is an existing road drainage issue which appears to be linked to insufficient capacity of the storm water holding tank/attenuation pond. The Grid Connection Route trench is temporary, and the existing road surface will be reinstated once the grid cable is installed. No new road surface or hardstanding is proposed. As such the road surface will not be permanently altered. The installation of the Grid Connection Route will not alter the prevailing or baseline hydrology at the existing Mullingar Substation and will have neither a positive or negative impact on this existing issue.

Therefore, no cumulative impacts between the Grid Connection Route and the associated substation, and the Wind Farm Site on the water environment are anticipated.