Planning and Environmental Consultants

Environmental Impact Assessment Report (EIAR)

Killoshulan Wind Farm, Co. Killkenny

Chapter 9 – Hydrology and Hydrogeology



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GLOSSARY OF TERMS AND ACRONYMS

Term	Definition
Abstraction	The removal of water from a surface water body or groundwater source.
Aquifer	A geological formation capable of storing and transmitting groundwater.
Baseline Environment	The existing environmental conditions against which potential impacts are assessed.
Bedrock Aquifer	An aquifer contained within fractured or weathered bedrock.
Biotic (Q) Rating	EPA ecological classification system based on aquatic macroinvertebrates used to assess river water quality.
Buffer Zone	An undeveloped strip adjacent to a watercourse designed to protect water quality.
Catchment	The land area that drains rainfall to a common river, lake or estuary.
CFRAM	Catchment Flood Risk Assessment and Management.
COD (Chemical Oxygen Demand)	A measure of the oxygen required to chemically oxidise organic matter in water.
Construction and Environmental Management Plan (CEMP)	A document outlining environmental protection measures to be implemented during construction.
Dewatering	Temporary removal of groundwater or surface water to facilitate excavation.
DO	Dissolved Oxygen.
Drain	Manmade watercourse.
Drainage Management Plan	Design strategy for collecting, treating and controlling runoff from a development.
Ecological Status	Overall ecological condition of a waterbody as defined under the Water Framework Directive.
Electrical Conductivity (EC)	Indicator of the concentration of dissolved ions in water.
EPA	Environmental Protection Agency.
Environmental Impact Assessment Report (EIAR)	Report assessing the likely significant environmental effects of a proposed development.
Flood Risk Assessment (FRA)	Assessment of flood risk to and from a proposed development.

Flow Duration Curve	Graph showing the percentage of time specified flow rates are equalled or exceeded.
Geomorphology	Study of landforms and the processes that shape rivers and landscapes.
Geological Survey Ireland (GSI)	National geological agency responsible for geological and hydrogeological information.
Grab Sample	A single water sample collected at a specific location and time.
Groundwater	Water stored beneath the ground within soil and rock.
Groundwater Body (GWB)	A distinct volume of groundwater defined under the Water Framework Directive.
Groundwater Vulnerability	The ease with which contaminants can reach groundwater from the land surface.
Horizontal Directional Drilling (HDD)	Horizontal drilling technique used to install services beneath rivers or roads without open excavation.
Hydrochemistry	Chemical characteristics of groundwater or surface water.
Hydrogeology	Study of groundwater occurrence, movement and quality.
Hydrology	Study of the occurrence, movement and distribution of surface water.
Hydromorphology	Physical characteristics of rivers including channel form, flow and connectivity.
IFI	Inland Fisheries Ireland.
Impermeable Surface	Surface that does not readily permit infiltration, such as concrete or asphalt.
IPC Licence	Integrated Pollution Control Licence issued by the EPA.
Karst	Landscape developed in soluble rocks such as limestone, characterised by underground drainage, swallow holes and springs.
Lidar	Laser-based surveying technology used to produce detailed topographic models.
Mitigation Measure	Action taken to avoid, reduce or offset adverse environmental effects.
NHA	Natural Heritage Area.
NIFM	National Indicative Fluvial Mapping.
NPWS	National Parks and Wildlife Service.
NTU	Nephelometric Turbidity Units
OPW	Office of Public Works.

Peat Probing	Investigation used to determine peat depth and stratigraphy.
Permeability	Ability of soil or rock to transmit water.
pH	Measure of the acidity or alkalinity of water.
Public Water Supply (PWS)	Water supply serving the public, usually operated by Uisce Eireann.
Receiving Environment	Existing environment that may be affected by the proposed development.
Residual Effect	Environmental effect remaining after mitigation has been applied.
River Basin Management Plan (RBMP)	National plan for implementing the Water Framework Directive.
Runoff	Water flowing across the ground surface following rainfall.
SAC	Special Area of Conservation designated under the Habitats Directive.
Sediment	Soil or particulate matter transported by flowing water.
Settlement Pond	Pond designed to remove suspended solids by allowing particles to settle.
Siltbuster	Proprietary treatment system used to remove suspended solids from construction water.
SPA	Special Protection Area designated under the Birds Directive.
SoPA	Source Protection Area - An area delineated around a groundwater source to identify where land-use activities could affect the quality or quantity of water reaching that source.
Surface Water	Rivers, streams, lakes, canals and other waters at the ground surface.
Surface Water Body (SWB)	A river, lake, transitional or coastal waterbody defined under the Water Framework Directive.
SuDS (Sustainable Drainage Systems)	Drainage techniques designed to mimic natural drainage and manage runoff sustainably.
Suspended Solids (TSS)	Fine particles suspended within water that contribute to turbidity.
Turbidity	Measure of water clarity caused by suspended particles.
Water Framework Directive (WFD)	European legislation requiring protection and improvement of the ecological and chemical status of water bodies.
Water Quality	Physical, chemical and biological characteristics of water.
Watercourse	Any natural or artificial channel conveying water.

Wetland	Area where water is the primary factor controlling soils and ecological communities.
ZoC	The area of land through which rainfall and other recharge enters the groundwater system and contributes to a groundwater supply, such as a well or spring.

9. HYDROLOGY AND HYDROGEOLOGY

9.1 Introduction

9.1.1 Background and Objectives

Hydro-Environmental Services (HES) was engaged by MKO to carry out an assessment of the potential likely and significant effects (if any) of the Killoshulan Wind Farm (Proposed Project) at Killoshulan and adjacent townlands near Freshford, Co. Kilkenny, on water aspects (hydrology and hydrogeology) of the receiving environment.

The Proposed Project (Proposed Wind Farm and Proposed Grid Connection) is described in full in Chapter 4 of this EIAR.

Where the 'Proposed Project' is referred to this encompasses the entirety of the project for the purposes of this EIA in accordance with the EIA Directive. The Proposed Project is described in detail in Chapter 4 of this EIAR.

Where the 'Proposed Wind Farm' is referred to, this refers to turbines (Proposed Turbines) and associated foundations and hardstanding areas, including entrances and access roads, underground cabling, permanent meteorological mast, temporary construction compounds, turbine delivery accommodation works, spoil management areas, borrow pit, tree felling, site drainage, operational stage signage, battery energy storage system (BESS), biodiversity enhancement areas and all ancillary works and apparatus. The Proposed Wind Farm is described in detail in Chapter 4 of this EIAR.

Where the 'Proposed Grid Connection' is referred to, this refers to the on-site 110kV Substation, all ancillary works and underground 110kV grid connection cabling connecting to the existing Ballyragget 110kV Substation, Co. Kilkenny, and all ancillary works and apparatus. The Proposed Grid Connection is described in detail in Chapter 4 of this EIAR.

- The 'Proposed 110kV Substation' refers to the new proposed onsite electricity infrastructure proposed within Frankford or Ballykieran townland, Co. Kilkenny comprising 2 no. control buildings and the electrical substation components necessary to consolidate the electrical energy generated by each wind turbine and export that electricity from the onsite 110kV substation to the national grid.
- The 'Proposed 110kV Underground Cabling' refers to new proposed 110kV underground electrical cabling connection from the 'Proposed 110kV Substation' to the existing 110kV Ballyragget substation, in the townland of Moatpark, approximately 1km north of Ballyragget, Co. Kilkenny. The underground electrical cabling route measures approximately 12.6km in length, the majority of which is located within the curtilage of the public road network.

Where the 'Site' is referred to, this relates to the primary study area for the EIAR, as delineated by the EIAR Site Boundary in green as shown on Figure 1-1 of the EIAR and encompasses an area of approximately 796 hectares. Where the 'Proposed Wind Farm site' is referred to, this relates the EIAR Site Boundary without the corridor that encompasses the Proposed 110kV underground cabling route.

The objectives of the assessment are:

- Produce a baseline study of the existing water environment (surface water and groundwater natural resources) in the area of the Proposed Project;

- Identify likely significant effects of the Proposed Project on surface water and groundwater natural resources during the construction, operational and decommissioning phases of the Proposed Project;
- Propose mitigation and monitoring measures to avoid, reduce or offset significant negative effects;
- Assess significant residual effects following the implementation of mitigation measures; and,
- Assess the potential cumulative effects of the Proposed Project itself as well as other local developments (as described in Chapter 2 of this EIAR).

9.1.2 Statement of Authority

Hydro-Environmental Services (HES) are a specialist geological, hydrological, hydrogeological and environmental practice that 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 wetland hydrology and wind farm 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 David Broderick and Michael Gill.

David Broderick (P. Geo., BSc, H. Dip Env Eng, MSc) is a Hydrogeologist with over 20 years' experience in both the public and private sectors. Having spent two years working in the Geological Survey of Ireland working mainly on groundwater and source protection studies David moved into the private sector. David has a strong background in groundwater resource assessment, karst hydrology and hydrogeological/hydrological investigations in relation to developments such as quarries and wind farms. David has completed over 25 Source Protection Assessments for the GSI/NFGWSs, and for Irish Water and for private developments across the country in a wide variety of hydrogeological settings. David has completed numerous geology and water sections for input into EIARs for a range of commercial developments. David has worked on the EIS/EIARs for Ballyouskill Wind Farm, Clonberne Wind Farm, and Cooloo Wind Farm, and over 60 other wind farm related projects across the country. David worked on his first wind energy project in 2010, and he has continued to work on similar projects since then.

Michael Gill (P. Geo., B.A.I., MSc, Dip. Geol., MIEI) is a Civil/Environmental Engineer and Hydrogeologist with over 26 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments of wind farms in Ireland. He has also managed EIAR assessments for infrastructure projects and private residential and commercial developments. Michael has completed over 30 Source Protection Assessments for the GSI/NFGWSs, and for Irish Water, and for private developments across the country in a wide variety of hydrogeological settings. In addition, he has substantial experience in wastewater engineering and site suitability assessments, contaminated land investigation and assessment, karst hydrology/hydrogeology, water resource assessments, surface water drainage design and SUDs design, and surface water/groundwater interactions. For example, Michael has worked on the EIS/EIARs for Ballydermot Wind Farm, Seven Hills Wind Farm, Carrownagowan Wind Farm, and over 100 other wind farm related projects across the country. Michael worked on his first wind energy project in 2003, and he has continued to work on similar projects since then.

9.1.3 Scoping and Consultation

The scope for this chapter of the EIAR has also been informed by consultation with statutory consultees, bodies with environmental responsibility and other interested parties. This consultation process and the list of Consultees is outlined in Section 2.7 of this EIAR. Subject 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	Matters Raised - Description	Addressed in Sections
Geological Survey of Ireland (GSI)	*"Our records show that there is a groundwater drinking water abstraction, Balief Group Water Scheme, with a zone of contribution/source protection area within the wind farm site boundary. Key to groundwater protection in general, and protection of specific drinking water supplies, is preventing ingress of runoff to the aquifer. Design of drainage will need to be cognisant of the group water scheme and the interactions between surface water and groundwater as well as run-off.* *Appropriate design should be undertaken by qualified and competent persons to include mitigation measures as necessary, such as SUDs or other drainage mitigation measures. Any excavation should ensure that groundwater flow within the zone of contribution to the groundwater abstraction points is not disrupted, resulting in diminished yields. Note that there could be other groundwater abstractions in the locality for which Geological Survey Ireland has not undertaken studies, and a robust assessment should be undertaken by qualified and competent persons including a survey of all current wells and water abstractions within the vicinity.* *Given the nearby drinking water source (Group Water Scheme), the effects of any potential contamination as a result of the project would need to be assessed.*	Sections 9.3.15.1, 9.3.15.2, 9.5.2.1, 9.5.2.11 & 9.5.3.3
Kilkenny County Council	*"Hydrology, hydrogeology study area to extend outside the site boundary and include watercourses to receive surface water from the proposed wind farm site* *Details of bedrock, overburden, vulnerability, groundwater flows, aquifer and catchment areas shall be considered including both for excavation for foundations and also for laying of cabling for grid connection;* *Mitigation measures for construction works including prevention of sediment and or fuel run off getting into watercourses(including drains, streams etc.) which could adversely impact on species and aquatic environment;*	Sections 9.3.3, 9.3.4, 9.3.4.1, 9.3.15, 9.4.1, 9.5.2.6, 9.5.2.7, 9.3.14

Consultee	Matters Raised - Description	Addressed in Sections
	Discharge location(s), water treatment processes (e.g. hydrocarbon, oil/petrol interceptors traps etc) during construction process; *Potential impact on surface waters and surface water sources from proposed development including accidental spillages;* *Regard to EU directive 96/82/EC to prevent major industrial accidents involving substances and to limit the consequences of accidents on people and the environment;* *Advised to consult with and take advice as appropriate from Health and Safety Authority;* *Additional mitigation requirements where risk of potential impacts cannot be eliminated;* *Stormwater management, foul water management and fire management for overall development;* *Potential significant impacts to drinking water sources shall be identified and assessed (public and group water);* *Cumulative effects with other developments, including but not limited to other wind farms, shall be assessed for all water receptors;* *Watercourses and wetlands adjacent to the application site to be surveyed for protected species and any other development adjacent to or surrounding; in particular potential impacts on the Loughans SAC and any potential cumulative impacts with proposed and permitted windfarm developments in the area;* *Demonstration of water conservation and reuse measures during construction and operation shall be provided (can be provided as part of CEMP);*	
Uisce Éireann	*The proposed development is located within the drinking water abstraction catchment (DWAC) for the Kilkenny City (Troyswood) Water Supply, with the abstraction point located approximately 17.7 km downstream on the River Nore (Nore_170).* *While the separation distance is significant and the associated risk is low, the abstraction remains a sensitive receptor and must be appropriately assessed.* *Identify and assess all potential impacts arising from the proposed development on Uisce Éireann abstraction points, including the Kilkenny City (Troyswood) Water Supply.*	Section 9.3.3, 9.3.4, 9.3.4.1, 9.3.4.2, 9.3.8, 9.3.9.6, 9.3.15.3, 9.3.16 & 9.5.2 **Appendix 9-4 WFD Compliance Assessment**

Consultee	Matters Raised - Description	Addressed in Sections
	• *Clearly identify sensitive receptors and establish Source–Pathway–Receptor linkages.* • *Assess the potential risks to water quality and demonstrate how the proposed development, particularly during construction, will avoid any deterioration in raw water quality at the abstraction point.* *The EIAR should include a detailed assessment of the hydrological and hydrogeological regime and pathways within and downstream of the site, noting that the development is located within the Nore catchment.* *The applicant shall include mitigation measures for any identified impacts on water sources within the EIAR, Construction Environmental Management Plan (CEMP) and associated documents.* *The applicant shall demonstrate that the development will not result in deterioration of water quality, in line with Water Framework Directive objectives".*	
National Federation of Group Water Scheme (NFGWS)	*"Looking at the maps, I don't believe* [sic] *the proposed windfarm is within a ZOC of 3 group water schemes that are south of Spahill but there may be networks traversing across this area especially around the R693. Would it be ok to share this document with the relevant GWS and get feedback directly from them?".*	Sections 9.3.15.1, 9.5.2.1 and 9.5.3.3
Inland Fisheries Ireland (IFI)	*"The proposed development is located in the Nore catchment, in particular in the catchment areas of the following surface water bodies (Gorteenahilla_010, Nuenna_010 and Nuenna_020). All are part of or connect directly to the Barrow – Nore SAC.* *Article 5 of the Surface Water Regulations (SI 272 of 2009) states that there should be no deterioration in Ecological Status. Article 28 (2) of the Regulations states that a surface water body whose status is determined to be less than Good shall be restored to at least Good status. The proposed surveys / reports must demonstrate how this project would cause no deterioration to the above surface water bodies and is consistent with their restoration to good ecological status where this is required.*	Sections 9.3.3, 9.3.4, 9.3.13, 9.3.16, 9.4.1, 9.5.2.13 **Appendix 9-4 WFD Compliance Assessment**

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:

- Planning and Development Act 2000 (as amended);
- Planning and Development Regulations, 2001 (as amended);
- S.I. No 296/2018: European Union (Planning and Development) (Environmental Impact Assessment) Regulations 2018 which transposes the provisions of the EIA Directive as amended by the Directive 2014/52/EU into Irish Law;
- S.I. No. 94/1997: European Communities (Natural Habitats) Regulations, resulting from EU Directives 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (the Habitats Directive) and 79/409/EEC on the conservation of wild birds (the Birds Directive);
- S.I. No. 293/1988: Quality of Salmon Water Regulations;
- S.I. No. 272/2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009, as amended, and S.I. No. 722/2003 European Communities (Water Policy) Regulations, as amended, which implement EU Water Framework Directive (2000/60/EC) and provide for the implementation of 'daughter' Groundwater Directive (2006/118/EC);
- S.I. No. 41/1999: Protection of Groundwater Regulations, resulting from EU Directive 80/68/EEC on the protection of groundwater against pollution caused by certain dangerous substances (the Groundwater Directive);
- S.I. No. 294/1989: Quality of Surface Water Intended for Abstraction (Drinking Water), resulting from EU Directive 74/440/EEC concerning the quality required of surface water intended for the abstraction of drinking water in the Member States (repealed by 2000/60/EC in 2007);
- S.I. No. 99/2023: European Communities Environmental Objectives (Drinking Water) (Amendment) Regulations 2023;
- S.I. No. 287/2022: European Communities Environmental Objectives (Groundwater) (Amendment) Regulations 2016;
- S.I. No. 9/2010: European Communities Environmental Objectives (Groundwater) Regulations 2010 as amended;
- S.I. No. 272/2009: European Communities Environmental Objectives (Surface Water) Regulations 2009 as amended; and,
- S.I. No. 77/2019: European Communities Environmental Objectives (Surface Water) (Amendment) Regulations 2019.

9.1.5 Relevant Guidance

The Water Section of the EIAR is carried out in accordance with guidance contained in the following:

- Wind Energy Development Guidelines for Planning Authorities, 2006 (the Guidelines (DoEHLG, 2006) and the Draft Revised Wind Energy Development Guidelines (DoEHLG, 2019);
- Environmental Protection Agency (2022): Guidelines on the Information to be Contained in Environmental Impact Assessment Reports;
- European Commission (2017): Environmental Impact Assessment of Projects – Guidance on the Preparation of the Environmental Impact Assessment Report;
- 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;
- 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 Watercourses;
- Good Practice During Wind Farm Construction (Scottish Natural Heritage, 2010);
- 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);
- OPW (2009) The Planning System and Flood Risk Management;
- DOE/NIEA (2015): Wind Farms and Groundwater Impacts – A guide to EIA and Planning Considerations;
- Guidance on the preparation of the EIA Report (Directive 2011/92/EU as amended by 2014/52/EU), (European Union, 2017);
- Land Types for Afforestation (Forest Service, 2016b);
- Forest Protection Guidelines (Forest Service, 2002);
- Forest Operations and Water Protection Guidelines (Coillte, 2013);
- Forestry and Water Quality Guidelines (Forest Service, 2000b); and,
- Forests and Water, Achieving Objectives under Ireland's River Basin Management Plan 2018-2021 (DAFM, 2018).

9.2 Methodology

9.2.1 Desk Study

A desk study of the Site and Water Study Area (refer to Section 9.2.6 below for description) was completed prior to the undertaking of field mapping, walkover assessments and site investigations. The desk study involved collecting all relevant geological, hydrological, hydrogeological and meteorological data for the Site and Water Study area. This included consultation and review of the following:

- Environmental Protection Agency databases (www.epa.ie);
- Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Met Eireann Meteorological Databases (www.met.ie);
- National Parks and Wildlife Services Public Map Viewer (www.npws.ie);
- EPA/Water Framework Directive Map Viewer (www.catchments.ie);
- Bedrock Geology 1:100,000 Scale Map Series;
- Geological Survey of Ireland – Groundwater Body Initial Characterization Reports;
- OPW Past Flood Event Mapping (www.floodinfo.ie);
- OPW Flood Extents Mapping (CFRAM) and National Indicative Fluvial Mapping (NIFM) (www.floodinfo.ie/map/floodmaps);
- GSI/EPA Group Water Scheme and Public Water Scheme Zone of Contribution Reports; and,

- Aerial Photography, OSI 1:5000- and 6-inch base mapping.

9.2.2 Baseline Monitoring and Site Investigations

A walkover survey, including geological mapping, field-based karst mapping and investigations of the Site, were undertaken by David Broderick of HES (refer to Section 9.1.2 above for qualifications and experience) on 3rd August 2022, 17th January 2023 and 20th & 21st January, 4th June, 23rd September and 2nd October 2026.

Five phases of site investigation were carried out at the Wind Farm site as described below:

Phase 1 investigations comprised of 13 no. trial pits carried out by Gavin & Doherty Geosolutions (GDG) between 15th and 17th November 2022 (refer to **Appendix 8-1** for the GDG logs).

Phase 2 investigations, consisting of monitoring well drilling at 2 no. locations (MW1 and MW2), was undertaken on 20th and 21st January 2026, under the supervision of Hydro-Environmental Services (HES). (refer to **Appendix 8-4** for the well logs).

Phase 3 investigations, consisting of rotary core drilling (10 no. locations BH1, BH2, BH3, BH4, BH4A, BH5, BH5B, BH6, BH7 and BH8), was undertaken in May 2026 by Ground Investigations Ireland Ltd (GII). During April 2026 geophysical surveys were carried by Apex Geophysics Limited (Apex). Refer to **Appendix 8-2** for the GII and Apex reports.

Phase 4 investigations, consisting of additional rotary core drilling (3 no. locations BH4-T4-NW, BH4-ALT-T4 and BH5-ALT-T5) and geophysical surveying (1 no. location) was undertaken in July 2026 by GII and Apex respectively (**Appendix 8-2**).

Phase 5: follow-up confirmatory drilling on 2nd October 2026 where 5 no. investigation holes were drilled by downhole hammer under the supervision of HES and FT. The boreholes were carried out at locations recommended by the Apex geophysical survey (T01-PBH1, T02-PBH1 and T02-PBH2) and micro-siting purposes (BH2A & BH2B). Refer to **Appendix 8-4** for the drilling logs.

The following assessment/management plans were prepared by Fehily Timoney and Company (FT) as part of the EIAR.

- Ground Investigation Report (**Appendix 8-2**)
- Karst Assessment Report (**Appendix 8-3**)

Site investigations that informed the Hydrology and Hydrogeology Section of the EIAR included the following:

- Walkover surveys, field-based karst mapping and hydrological mapping of the Site area was undertaken by HES whereby water flow directions and drainage patterns were recorded;
- Trial pitting (13 no.) by GDG and gouge cores (10 no.) by HES to investigate soil, peat and mineral subsoil lithology;
- Field based karst feature mapping by FT and follow-up surveys by HES;
- Investigation drilling (7 no. boreholes and 13 no. rotary coreholes) to determine the full geological profile of the Site (i.e. soil, mineral subsoil and bedrock profile) and groundwater conditions;
- 2D Resistivity (ERT) and Seismic surveys at each of the 10 no. turbine locations by Apex Geophysics Limited, including 1 no. micro gravity location;
- Continuous groundwater level monitoring at the 6 no. investigation boreholes/monitoring wells by means of in-situ data loggers (pressure transducers);

- Field hydrochemistry measurements (electrical conductivity, pH, dissolved oxygen and temperature) were taken to determine the origin of surface water flows (2 no. rounds); and,
- Surface water (2 no. rounds) and groundwater sampling (1 no. round) for baseline and hydrological/hydrogeological characterisation purposes.

9.2.3 Impact Assessment Methodology

The EPA document '*Guidelines on the information to be contained in Environmental Impact Assessment Reports*' (EPA, 2022), criteria for the assessment of likely significant effects require that likely effects are described with respect to their quality (i.e. negative, positive or neutral), significance, extent, context, probability, duration, frequency and reversibility.

The descriptors used in this environmental impact assessment are those set out in the EPA (2022) as shown in Section 1.7.3 of Chapter 1 of this EIAR.

In addition, the importance of the water environment receptors was assessed using NRA (2008) guidance on completion of the desk study and baseline study. Levels of importance which are defined in **Table 9-2** and **Table 9-3** below for hydrology and hydrogeology are used to assess the potential effect that the Proposed Project may have on them.

Table 9-2: Estimation of Importance of Hydrology Criteria (NRA, 2008).

Importance	Criteria	Typical Example
Extremely High	Attribute has a high quality or value on an international scale	River, wetland or surface water body ecosystem protected by EU legislation, e.g. 'European sites' designated under the Habitats Regulations or 'Salmonid waters' designated pursuant to the European Communities (Quality of Salmonid Waters) Regulations, 1988.
Very High	Attribute has a high quality or value on a regional or national scale	River, wetland or surface water body ecosystem protected by national legislation – NHA status. Regionally important potable water source supplying >2500 homes. Quality Class A (Biotic Index Q4, Q5). Flood plain protecting more than 50 residential or commercial properties from flooding. Nationally important amenity site for a wide range of leisure activities.
High	Attribute has a high quality or value on a local scale	Salmon fishery Locally important potable water source supplying >1000 homes. Quality Class B (Biotic Index Q3-4). Flood plain protecting between 5 and 50 residential or commercial properties from flooding.
Medium	Attribute has a medium quality or value on a local scale	Coarse fishery. Local potable water source supplying >50 homes Quality Class C (Biotic Index Q3, Q2-3). Flood plain protecting between 1 and 5 residential or commercial properties from flooding.

Importance	Criteria	Typical Example
Low	Attribute has a low quality or value on a local scale	Locally important amenity site for small range of leisure activities. Local potable water source supplying <50 homes. Quality Class D (Biotic Index Q2, Q1) Flood plain protecting 1 residential or commercial property from flooding. Amenity site used by small numbers of local people.

Table 9-3: Estimation of Importance of Hydrogeology Criteria (NRA, 2008).

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

The impact assessment presented in Section 9.5 is based on the assessment of the magnitude of the predicted impact on the respective hydrological and hydrogeological attributes as detailed in **Table 9-4** (hydrology) and **Table 9-5** (hydrogeology).

Finally, **Table 9-6** below presents a matrix of significance versus magnitude (NRA, 2008) which allows for the determination of the resulting significance of effects.

Table 9-4: Criteria for Rating Impact Significance – Estimation of Magnitude of Impact on Hydrology Attributes (Source: NRA, 2008).

Magnitude of Effect	Criteria	Typical Example
Large Adverse	Results in loss of attribute and /or quality and integrity of attribute	Loss or extensive change to a waterbody or water dependent habitat Increase in predicted peak flood level >100mm Extensive loss of fishery Calculated risk of serious pollution incident >2% annually Extensive reduction in amenity value
Moderate Adverse	Results in impact on integrity of attribute or loss of part of attribute	Increase in predicted peak flood level >50mm Partial loss of fishery Calculated risk of serious pollution incident >1% annually Partial reduction in amenity value
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute	Increase in predicted peak flood level >10mm Minor loss of fishery Calculated risk of serious pollution incident >0.5% annually Slight reduction in amenity value
Negligible	Results in an impact on attribute but of insufficient magnitude to affect either use or integrity	Negligible change in predicted peak flood level Calculated risk of serious pollution incident <0.5% annually
Minor Beneficial	Results in minor improvement of attribute quality	Reduction in predicted peak flood level >10mm Calculated reduction in pollution risk of 50% or more where existing risk is <1% annually
Moderate Beneficial	Results in moderate improvement of attribute quality	Reduction in predicted peak flood level >50mm Calculated reduction in pollution risk of 50% or more where existing risk is >1% annually
Major Beneficial	Results in major improvement of attribute quality	Reduction in predicted peak flood level >100mm

Table 9-5:Criteria for Rating Impact Significance – Estimation of Magnitude of Impact on Hydrogeology Attributes (Source: NRA, 2008).

Magnitude of Effect	Criteria	Typical Example
Large Adverse	Results in loss of attribute and /or quality and integrity of attribute	Removal of large proportion of aquifer Changes to aquifer or unsaturated zone resulting in extensive change to existing water supply springs and wells, river baseflow or ecosystems Potential high risk of pollution to groundwater from routine run-off Calculated risk of serious pollution incident >2% annually
Moderate Adverse	Results in impact on integrity of attribute	Removal of moderate proportion of aquifer

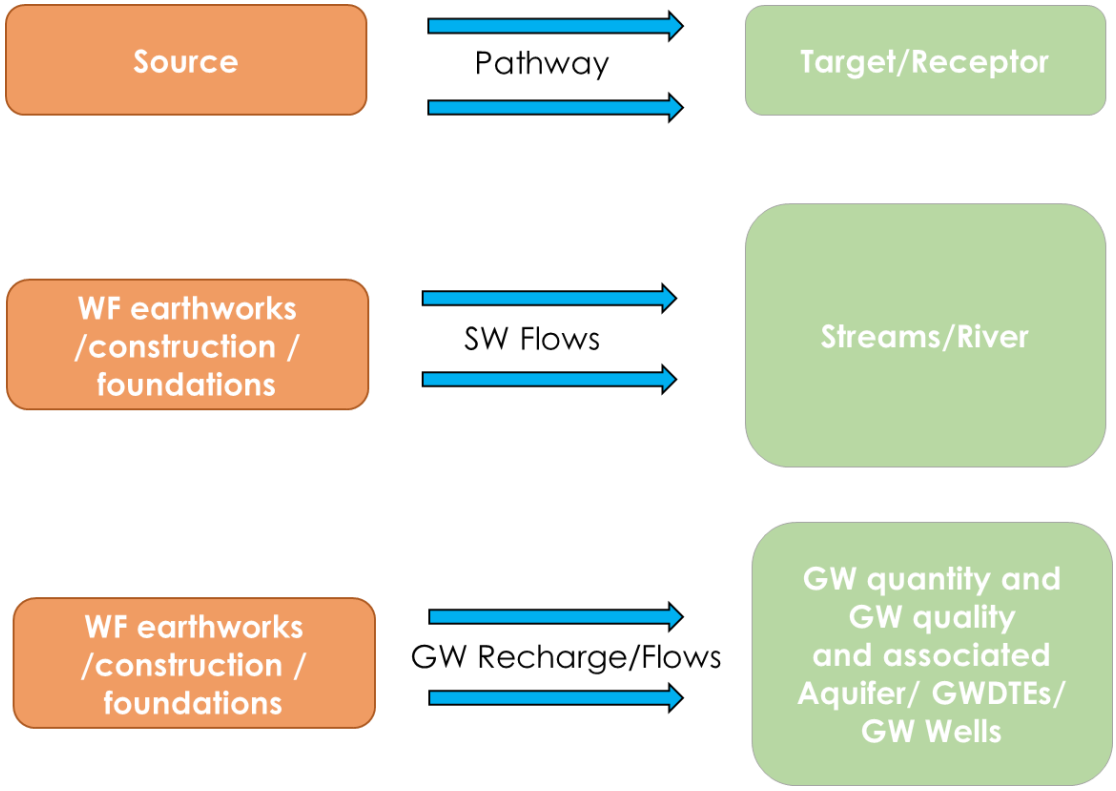
Magnitude of Effect	Criteria	Typical Example
	or loss of part of attribute	Changes to aquifer or unsaturated zone resulting in moderate change to existing water supply springs and wells, river baseflow or ecosystems Potential medium risk of pollution to groundwater from routine run-off Calculated risk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

Table 9-6: Rating of Significant Environmental Impacts in an EIS (EIAR) (Source: NRA, 2008).

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

9.2.4 Overview of Impact Assessment Process

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



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

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

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

In order to provide an understanding of the stepwise impact assessment process applied below (Section 9.5), we have firstly presented below a summary guide in **Table 9-7 t**hat 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 construction and operation and decommissioning activities which have the potential to generate a source of significant adverse impact on the geological and hydrological/ hydrogeological (including water quality) environments.

Table 9-7: Impact Assessment Process Steps (derived from EPA Guidance Document, 2022).

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

9.2.5 Limitations and Difficulties Encountered

No significant difficulties were encountered during preparation of this assessment. The combination of published information, site surveys, intrusive investigations, geophysical surveys and groundwater monitoring provides a robust basis for characterising the Site and assessing potential effects.

Local variability in ground conditions, particularly in limestone areas, has been considered in the interpretation of the findings and the proposed design and mitigation measures.

The EIAR has include a detailed assessment of the hydrological and hydrogeological regime and pathways within and downstream of the Site.

9.2.6 Water Study Area

The Water Study Area for assessing the potential zone of impact is the Nore_SC_070, Goul_SC_010 and Nore_SC_060 sub-catchments. The Proposed Project is mainly located in the Nore_SC_070 as described below.

The Proposed Wind Farm site is located in the Nore_SC_070. The Proposed Grid Connection is located mainly in the Nore_SC_070 with a very short section (60m) in the Nore_SC_060 sub-catchments. Development in the Goul_SC_010 is limited to the TDR works areas only.

In terms of hydrological cumulative effects (refer to Section 9.5.7 below), the study area is limited to the Nore_SC_070 because the proposed works in the Goul_SC_010 and Nore_SC_060 sub-catchments are small and are not likely to contribute to significant cumulative effects.

The Nore_SC_070 sub-catchment, which is shown on **Figure 9-1** below (Regional Hydrology Map), covers an area of approximately 155km^2. The Nore_SC_070 sub-catchment in the area of the Proposed Wind Farm site is drained by the Nuenna River which flows into the River Nore approximately 9km downstream of the Proposed Wind Farm site.

The surface water catchment area of the River Nore upstream of the Nore_SC_070 sub-catchment is approximately 1,100km^2 (the River Nore upstream catchment is nearly 7 times that of the Nore_SC_070 sub-catchment).

Refer to Section 9.3.4.2 below for a comparison of percentile surface water flows in the River Nore and Nuenna River.

The Nuenna River, which drains a large portion of the Nore_SC_070 sub-catchment (including the Proposed Wind Farm site), is also a focal point for groundwater discharge in this area and therefore the Nuenna River catchment also covers groundwater cumulative effects.

9.3 Receiving Environment

9.3.1 Site Description and Topography

The Proposed Wind Farm is located approximately 4km west of the village of Freshford, 3.7km northeast of the village of Urlingford, Co. Kilkenny and approximately 15km northwest of Kilkenny City. Co. Kilkenny.

The Proposed Wind Farm site, which is 573ha (hectares) in area, comprises predominately agricultural grassland on the southern half, while the northern half is predominately coniferous forestry with some grassland on the northeastern portion. Five Proposed Turbines are located on grassland (T1 to T4 and T9) while five are in forestry (T5 to T8 and T10).

The topography of the Proposed Wind Farm site is hilly with a number of separate high points/peaks ranging in elevations from approximately 300 to 316m OD (metres above Ordnance Datum). The summit ridge of Spahill (310m OD) defines the northwestern boundary of the Proposed Wind Farm site. Clomantagh Hill (349m OD) is located to the southwest of the Proposed Wind Farm site.

The surrounding wider landscape is generally flat and low-lying (<150m OD). The Nuenna River valley is located to the southeast of the Proposed Wind Farm site, where the ground elevation along the channel of the river ranges from approximately 100 to 120m OD.

The southern half of the Proposed Wind Farm site slopes steadily in an easterly/southeasterly towards the Nuenna River. The ground elevation at the Proposed Wind Farm site entrance on the R693 Regional Road at the southeast of the Proposed Wind Farm site is at approximately 120m OD. The northern half of the Proposed Wind Farm site slopes in more moderate manner in an easterly/ northeasterly direction from the summit of Spahill (310m OD) at the northwestern Site boundary down to an elevation of approximately 220m OD at the Proposed 110kV Substation and Proposed BESS location, on the northeast of the Proposed Wind Farm site.

The Proposed 110kV Underground Cabling, which measures approximately 12.6km in length, will connect into the existing Ballyragget 110kV Substation, located approximately 10km to the northeast of the Proposed Wind Farm site ('as the crow flies'). The Proposed 110kV and Proposed BESS is located on improved grassland on the northeast of the Proposed Wind Farm site at an elevation of 220m OD.

Approximately 770m of the Proposed 110kV Underground Cabling is proposed within National Roads (N77), 9.6km proposed within Local Roads, 650m proposed within the Proposed Wind Farm internal road network and approximately 1.5km proposed within agricultural lands in Frankford or Ballykieran, and Moatpark, Co. Kilkenny.

In the townland of Ballyconra, the underground cabling route will leave the N77 National Road and travel east through agricultural land for 60m before passing beneath the River Nore via a Horizontal Directional Drilling (HDD) mechanism.

Turbine Delivery Route (TDR) temporary accommodation works are required at 4 no. locations along the R693 to the southwest of the Proposed Wind Farm site.

9.3.2 Water Balance

Long term Average Annual Rainfall (AAR) and evaporation data was sourced from Met Éireann (www.met.ie). The 30-year annual average rainfall (1980 - 2010) recorded at Johnstown Garda Station rainfall station, located ~3.3km west of the Proposed Wind Farm Site, are presented in **Table 9-8.** The AAR for this station over this period is 868mm/year.

Table 9-8: Local Average long-term (1980 – 2010) Rainfall Data (mm).

Station		X-Coord		Y-Coord		Ht (MAOD)		Year Start		Year End		
Johnstown G.S.		230200		166200		137		n/a		n/a		
Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
96	70	65	55	64	55	55	73	73	88	81	93	868

Met Éireann also provide a grid of average annual rainfall for the entire country for the period of 1991 to 2020. Based on this more site-specific modelled rainfall values, the average annual rainfall at the Proposed Wind Farm site ranges from 960 to 1,007mm/year (this is considered to be the most accurate estimate of average annual rainfall from the available sources). The maximum average of 1,007mm/year is used in the below water balance assessments.

The closest synoptic[1] station where the average potential evapotranspiration (PE) is recorded is at Kilkenny, ~16km southeast of the Proposed Wind Farm site. The long-term average PE for this station is 459mm/year. This value is used as a best estimate of the site PE. Actual Evaporation (AE) at the Site is estimated as 436mm/year (which is 0.95 × PE).

The effective rainfall (ER)[2] represents the water available for runoff and groundwater recharge. The ER for the Proposed Wind Farm site is calculated as follows:

$$\text{Effective rainfall (ER)} = \text{AAR} - \text{AE}$$

$$= 1{,}007\text{mm/year} - 436\text{mm/year}$$

$$\text{ER} = 571\text{mm/year}$$

The GSI groundwater recharge coefficient estimates (www.gsi.ie) for the Proposed Wind Farm site range from 22% to 85%. The estimated recharge range largely reflects the variation in the bedrock

1 Meteorological station at which observations are made for synoptic meteorology and at the standard synoptic hours of 00:00, 06:00, 12:00, and 18:00.
2 ER – Effective Rainfall is the excess rainfall after evaporation which produces overland flow and recharge to groundwater.

geology, with the northern half of Proposed Wind Farm site mapped as Namurian shales (22% recharge) and the southern half pure bedded limestones (85% recharge).

These bedrock types differ in their aquifer properties, with the Namurian shales being poorly productive and the limestones regionally important and karstified. The hydrogeology of the Proposed Wind Farm site is discussed further below in Sections 9.3.8 and 9.3.9 respectively.

The northern half of the Proposed Wind farm site has a high density of manmade drainage reflecting the poor recharge characteristics of the Namurian shales, while the southern half has a notable absence of surface drainage due to high recharge rates into the underlying limestone. The hydrology and hydrogeology of the Proposed Wind Farm site is discussed further below in Sections 9.3.4.1 and 9.3.9 respectively.

Met Éireann's Translate Project (https://www.met.ie/science/translate) provides projections for a range of future climate change scenarios, as Ireland's future climate will depend on global greenhouse gas emissions reductions. The severity of any future climate change will depend on the degree of future warming. In a 1.5°C world, average winter and summer precipitation rates are projected to be 3.54mm/day and 2.15mm/day respectively in Co. Kilkenny. Meanwhile, in a 4°C world, the average winter and summer precipitation rates in Co. Kilkenny are projected to be 3.90mm/day and 1.93mm/day respectively.

In addition to average rainfall data, extreme value rainfall depths are available from Met Éireann. **Table 9-9** below presents return period rainfall depths for the area of the Proposed 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, 5-year, 30-year and 100-year).

Table 9-9: Return Period Rainfall Depths (mm) for the Proposed Project site.

Return Period (Years)				
Storm Duration	1	5	30	100
5 mins	4.2	7	11.8	16.4
15 mins	6.3	10.2	16.8	22.8
30 mins	8.2	13	21	28.1
1 hour	10.7	16.6	26.1	34.6
6 hours	21.2	31.1	46.3	59.3
12 hours	27.5	39.7	57.8	73
24 hours	35.8	50.6	72.2	89.9
2 days	44.4	60.6	83.4	101.6

9.3.3 Regional and Local Hydrology

The Site is located in the regional River Nore catchment within Hydrometric Area 15 of the South-Eastern River Basin District (SERBD). The River Nore flows in a southerly direction approximately 9km to the east of the Proposed Wind Farm site.

A regional hydrology map is shown as **Figure 9-1.**

On a more local scale the Proposed Wind Farm site and most of the Proposed 110kV Underground Cabling (12km of 12.6km) are located in the Nore_SC_070 sub-catchment. Within the Nore_SC_070,

the Proposed Wind Farm site and approximately 4.8km (of the total 12.6km) of the Proposed 110kV Underground Cabling are located within the Nuenna River catchment (Nuenna_010, Nuenna_020 and Gorteenahilla_010 sub-basins). The Nuenna River flows in an easterly direction approximately 0.6km to the southeast of the Proposed Wind Farm site prior to merging with River Nore approximately 9km further downstream.

The remainder of Proposed 110kV Underground Cabling (7.8km) is located in the Lisdowney_010, Nore_120, Nore_140 and Nore_150 sub-basins which drain directly into the River Nore downstream of Ballyragget town.

Approximately 60m of the Proposed 110kV Underground Cabling near Ballyragget 110kV Substation is located in the Nore_SC_060 sub catchment within the Nore_020 sub-basin.

The TDR works areas are located in the Goul_SC_010 within the Goul_030 sub-basin.

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

9.3.4 Project Site Existing Drainage

9.3.4.1 Surface Water Drainage Regime

The northern half of the Proposed Wind Farm site is drained by the EPA mapped Foyle South Stream (Gorteenahilla_010 river waterbody) which rises south of Spahill located on the northwest of the Proposed Wind Farm site. The Foyle South Stream flows easterly off-site and into the Nuenna River approximately 6.5km downstream of the Proposed Wind Farm site.

Proposed Turbine locations T4 to T10, proposed borrow pit, spoil management area, Proposed 110kV Substation and Proposed BESS are mapped within Foyle South Stream catchment (Gorteenahilla_010 sub-basin). There are 3 no. proposed watercourse crossings on the Foyle South Stream required for Proposed Wind Farm infrastructure. Drainage at the Proposed Wind Farm site is shown on **Figure 9-3** below.

In addition to the Foyle South Stream, there is also a high-density of manmade drainage on the north of the Proposed Wind Farm site associated with the forestry and agricultural lands which have naturally poorly draining soils and subsoils. The lands on the north of the Proposed Wind Farm site have poor natural drainage due to being underlain by mudstone/siltstone bedrock which has low permeability (i.e. low groundwater recharge rates).

In contrast, the southern portion of the Proposed Wind Farm site has little or no surface water drainage because of high groundwater recharge rates (high rainfall infiltration/acceptance) due to being underlain by limestone of regional aquifer importance.

The EPA mapped Clomantagh Lower Stream emerges from southerly facing forested slopes on the south of the Proposed Wind Farm site. However, shortly after leaving the Proposed Wind Farm site, the Clomantagh Lower Stream drains to ground (i.e. losing stream) when the watercourse flows off the mudstone bedrock and onto the more permeable limestone. Please note there is no Proposed Wind Farm infrastructure within the Clomantagh Lower Stream catchment (Nuenna_010 sub-basin).

The valley further downstream of the Clomantagh Lower Stream sink, which runs to the southeast of the Proposed Wind Farm site, is largely dry (due to underground drainage) except following periods of heavy rainfall events. The Clomantagh Lower Stream valley drains south (largely underground) towards the Nuenna River where several GSI mapped karst springs are located. These springs are well

documented in a number of GSI/EPA source protection reports[3] for group water schemes in this area. These springs are known to contribute to a high proportion of flow in the Nuenna River. These springs and the hydrogeology of the Proposed Wind Farm site is discussed further in Section 9.3.8 below.

There are also several enclosed depressions/dolines and 4 no. sink holes (i.e. karst features) on the south half of the Proposed Wind Farm site which were previously mapped by the GSI, prior to further field-based mapping by HES and FT. Refer to Section 9.3.9 below for information on karst features.

However, due to the elevated topography and sloping nature of the Proposed Wind Farm site, the swallow holes only act as a very localised drainage function (i.e. they do not act as sinks for streams/watercourses, just very localised runoff). All Proposed Wind Farm infrastructure on the south of the Proposed Wind Farm site is at least 30m from a surface mapped enclosed depression or sink hole. Please note, the GSI apply a 30m buffer for groundwater vulnerability rating mapping and for land spreading exclusion zones.

Along the Proposed 110kV Underground Cabling there are 6 no. EPA mapped watercourse crossings, with 5 no. being existing bridges/culverts along public roads and the 6th a proposed HDD crossing below the River Nore near Ballyragget.

Refer to **Figure 9-2** (Local Hydrology) for watercourse crossing locations along the Proposed Grid Connection underground cable route.

[3] GSI/Tobin (2013) Establishment of Groundwater Zones of Contribution, Clomantagh Killoshulan Group Water Scheme, Co. Kilkenny.

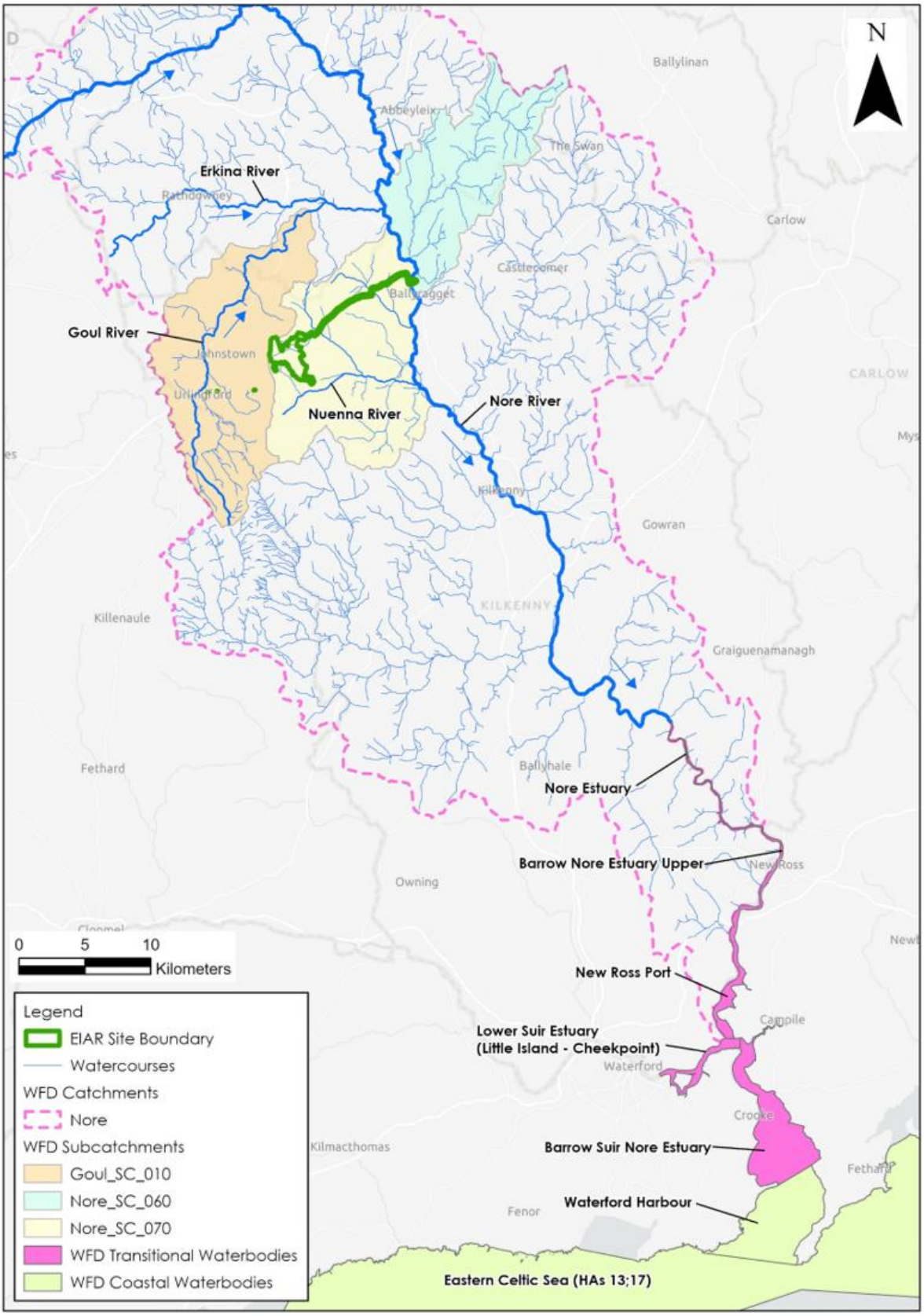


Figure 9-1: Regional Hydrology Map.

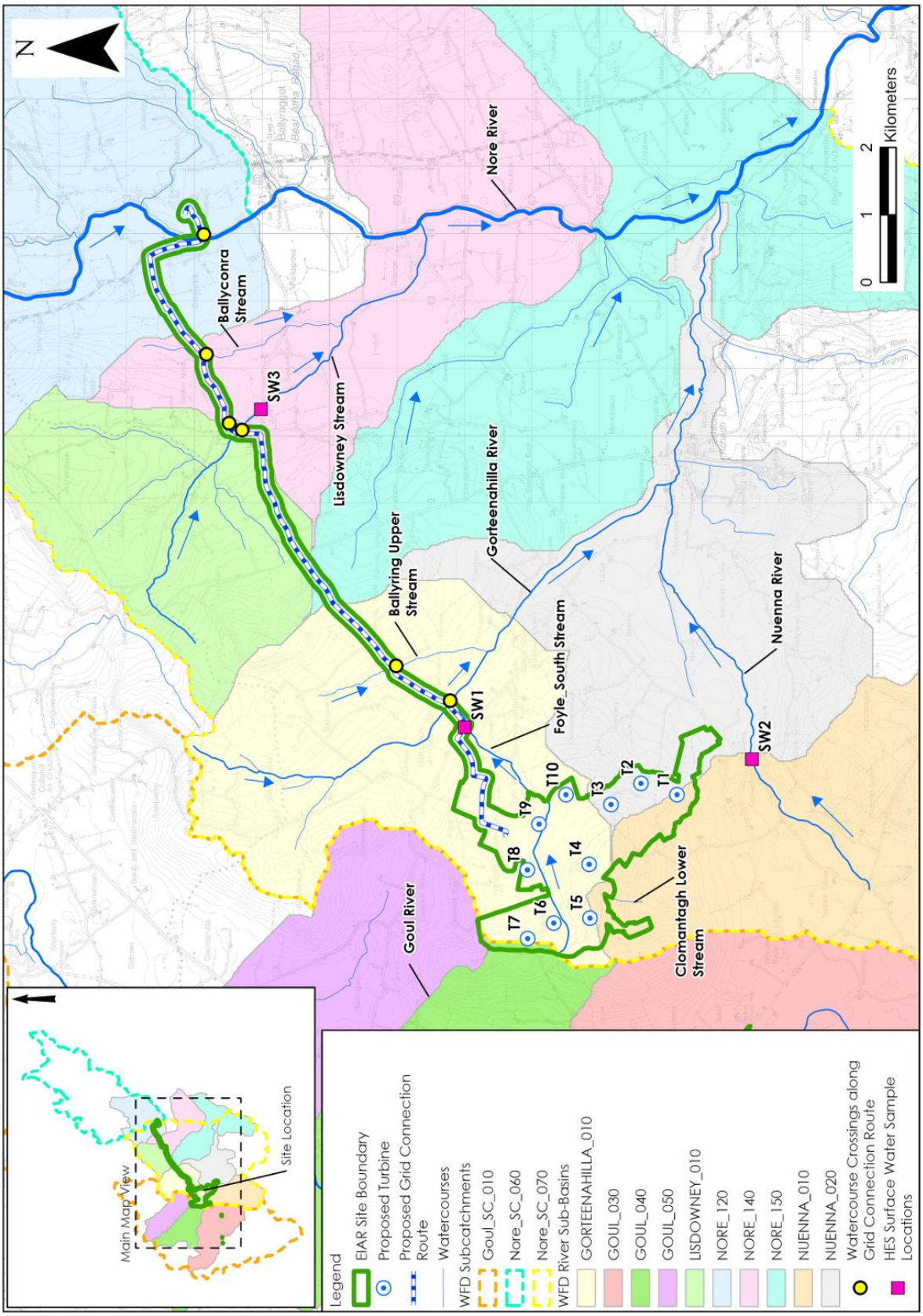


Figure 9-2: Local Hydrology Map.

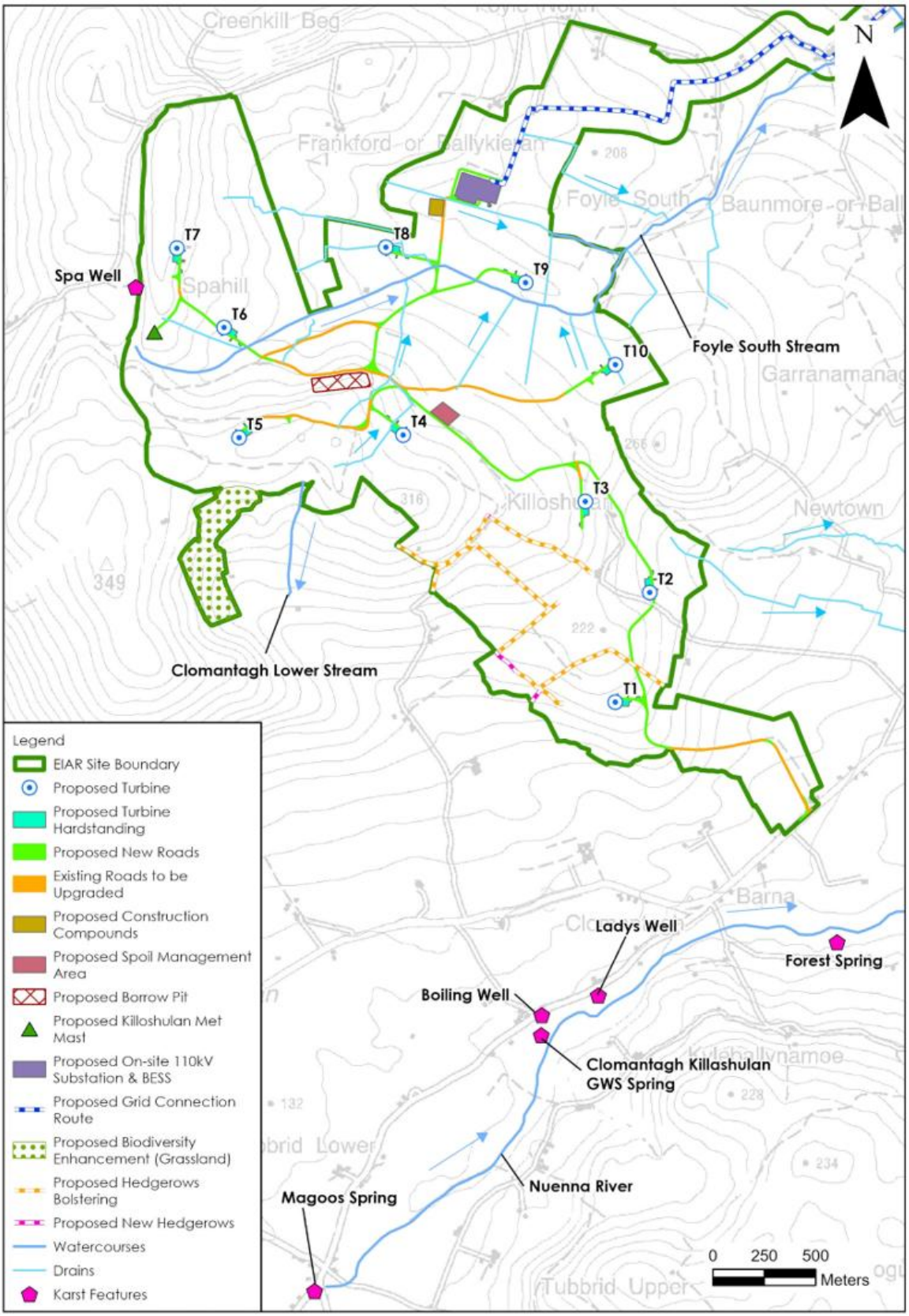


Figure 9-3: Proposed Wind Farm Site Drainage Map

9.3.4.2 Surface Water Flows

EPA's Hydrotool, available on www.catchments.ie, was consulted in order to estimate flow volumes in the downstream watercourses. The Hydrotool dataset contains estimates of naturalised river flow duration percentiles. Several nodes were consulted in the vicinity and downstream of the Site on the Nuenna River and the downstream River Nore.

Figure 9-4 below presents the estimated flow duration curves for each of the consulted Hydrotool Nodes downstream of the Site. Selected percentiles flows are shown in **Table 9-10.**

The flows in the River Nore upstream of the Nore/Nuenna confluence (Node_1862) are 30 times that of the Nuenna River at Freshford (Node 15_1029).

Table 9-10: EPA Percentile Flows for the Nuenna River and River Nore.

River	Node	Location	%ile Flow (m^3/sec)			
			10%	50%	80%	95%
Gorteenahilla River	Node 15_309	D/s of eastern part of the Proposed Wind Farm Site	0.547	0.137	0.049	0.025
Gorteenahilla River	Node 15_75	U/s of its confl with Nuenna River	0.876	0.225	0.076	0.036
Nuenna River	Node 15_1456	D/s of southeastern part of the Proposed Wind Farm Site	0.169	0.048	0.015	0.006
Nuenna River	Node 15_1029	U/s Freshford and D/s of all the Proposed Wind Farm Site	1.58	0.493	0.217	0.119
River Nore	Node 15_1862	U/s of its confl with Nuenna River	45.312	12.8843	5.791	3.114
River Nore	Node 15_945	D/s of its confl with Nuenna River	50.819	13.87	6.199	3.266

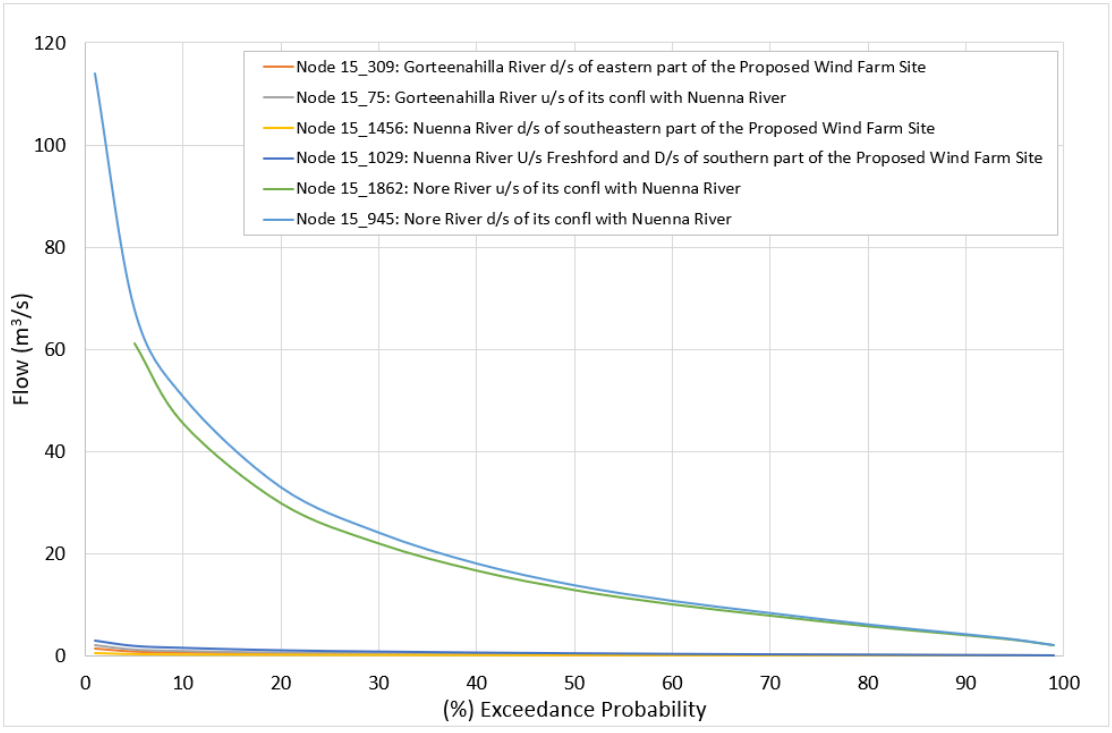


Figure 9-4: River Nore and Nuenna River Percentile Flows

9.3.5 Baseline Assessment of Proposed Wind Farm Site Runoff

This section undertakes a long-term water balance assessment and surface water runoff assessment for the baseline conditions at the Proposed Wind Farm site (573ha).

The rainfall depths used in this water balance, which are long term averages, are not used in the design of the sustainable drainage system for the Proposed Wind Farm site. The Proposed Wind Farm site drainage design is based on the 10-year return period rainfall event as described further in Sections 9.4.1 and 9.5.2.3 below.

The water balance calculations are carried out for the month (October) with the highest average recorded rainfall minus evapotranspiration, for the current baseline site conditions (**Table 9-11**).

The highest long-term average monthly rainfall (site-specific modelled rainfall values – 1991 to 2020) is 107mm over October. The average monthly evapotranspiration for the closest synoptic station at Kilkenny over the same period in October was 16.8mm.

The water balance represents the long-term average wettest monthly scenario in terms of volumes of surface water runoff from the Proposed Wind Farm site pre-development (573ha). The average surface water runoff co-efficient for the Proposed Wind Farm site is estimated to be 46% (refer to Section 9.3.2 above).

The water balance presented in **Table 9-11** and **Table 9-12** indicates that a conservative estimate of surface water runoff for the Wind Farm site during the highest rainfall month is 239,963m^3/month or 7,741m^3/day for the Proposed Wind Farm site.

Table 9-11: Water Balance and Baseline Runoff Estimates for Wettest Month (1991 – 2020).

Water Balance Component	Depth (m)
Average Highest Monthly Rainfall (R)	0.107
Average Potential Evapotranspiration (PE)	0.0168
Average Actual Evapotranspiration (AE = PE × 0.95)	0.01596
Effective Rainfall (ER = R - AE)	0.0910
Average Recharge (54% of ER)	0.0492
Average Runoff (46% of ER)	0.0419

Table 9-12: Baseline Runoff for the Wind Farm site.

Water Balance Area	Approx. Area (ha)	Baseline Runoff per Wettest month (m^3)	Baseline Runoff per day (m^3) in wettest month
Proposed Wind Farm site	573	239,963	7,741

9.3.6 Flood Risk Assessment

This section is a summary of a site-specific Flood Risk Assessment (FRA) undertaken for the Site. The full FRA report is attached **Appendix 9-1**.

OPW's River Flood Extents Mapping, National Indicative Fluvial Mapping, Past Flood Event mapping (https://www.floodinfo.ie/map/floodmaps/), historical mapping (i.e. 6" & 25" base maps) and GSI Groundwater/Surface Water Flood Maps were consulted to identify those areas of the Site as being potentially at risk of fluvial, pluvial and surface water flooding. Several walkover surveys were also conducted as part of the site-specific FRA.

No recurring flood incidents within the Proposed Wind Farm site or along the Proposed Grid Connection underground cabling were identified from OPW's Past Flood Event Mapping (Refer to **Figure 9-5).**

The closest past flood event to the Proposed Wind Farm site is at The Loughan Turlough (Flood ID 742), located 2.7km to the southwest of the Proposed Wind Farm site. The flooding is reported as recurring and the source is the groundwater (i.e. turlough).

There are 3 no. past flood events mapped near Freshford, located 3.5km to the east of the Proposed Wind Farm site. Single flood events were recorded on 27/12/2015 (Flood ID: 13446) and 16/03/2018 (Flood ID: 13620), with the reported source being the river. A recurring flood event (Flood ID: 2814) is also recorded at Freshford with the source also being fluvial (i.e. river).

There was no identifiable map text on local available historical mapping for the Proposed Wind Farm site to indicate flood risk. However, some area in the eastern part of the Proposed 110kV Underground Cabling is identified as "liable to floods" along the River Nore floodplain at the proposed HDD crossing location.

There is no OPW CFRAM River Flood Extents Mapping available for the stretch of the Nuenna River at the Proposed Wind Farm site. The nearest downstream CFRAM fluvial flood zones for the Nuenna River are mapped 3.5km downstream of Freshford. CFRAM flood zones are mapped along the River Nore at the Proposed 110kV Underground Cabling HDD crossing location. Refer to **Figure 9-6** for CFRAM and NIFM flood zone mapping.

National Indicative Fluvial Mapping (NIFM) is available for Nuenna River at the Proposed Wind Farm site, but no mapped fluvial flood zones encroach the Proposed Wind Farm site. There are NIFM flood zones mapped along the Proposed 110kV Underground Cabling at the larger watercourse crossing locations such as the Gorteenahilla Stream and Lisdowney Stream.

The GSI Maximum Historic Groundwater Flood Maps and Winter 2015/2016 Surface Water Flooding Maps have no historic flood zones mapped within the Proposed Wind Farm site.

The nearest Maximum Historic Groundwater Flood is mapped Loughan Turlough, 2.7km to the southwest of the Proposed Wind Farm site. The closest Winter 2015/2016 Surface Water Flooding is mapped at Freshford.

Based on the information gained through the flood identification process it is apparent that the Proposed Wind Farm site and the majority of the Proposed 110kV Underground Cabling is located in Fluvial Flood Zone C with the Proposed 110kV Underground Cabling HDD River Nore underground crossing mapped in Flood Zone A and B as wells as section at the Gorteenahilla Stream and Lisdowney Stream bridge crossings.

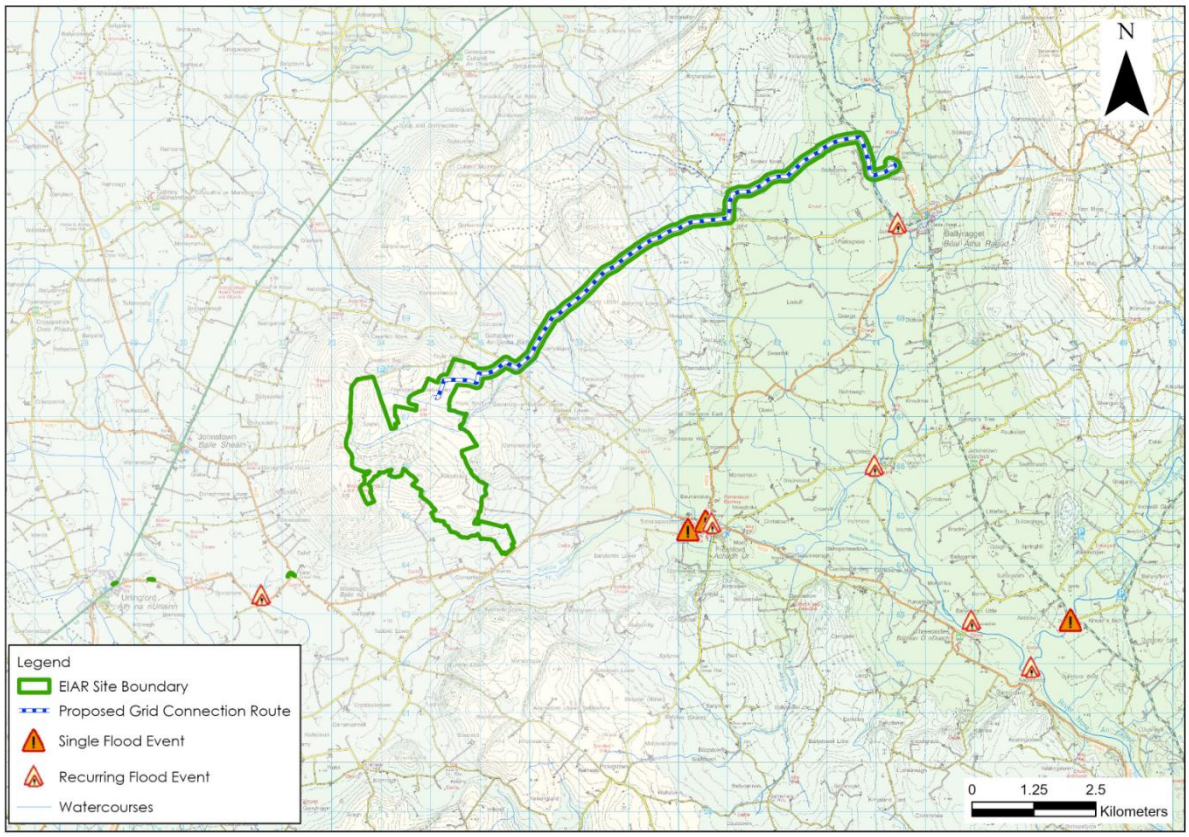


Figure 9-5: OPW Past Flood Event Mapping.

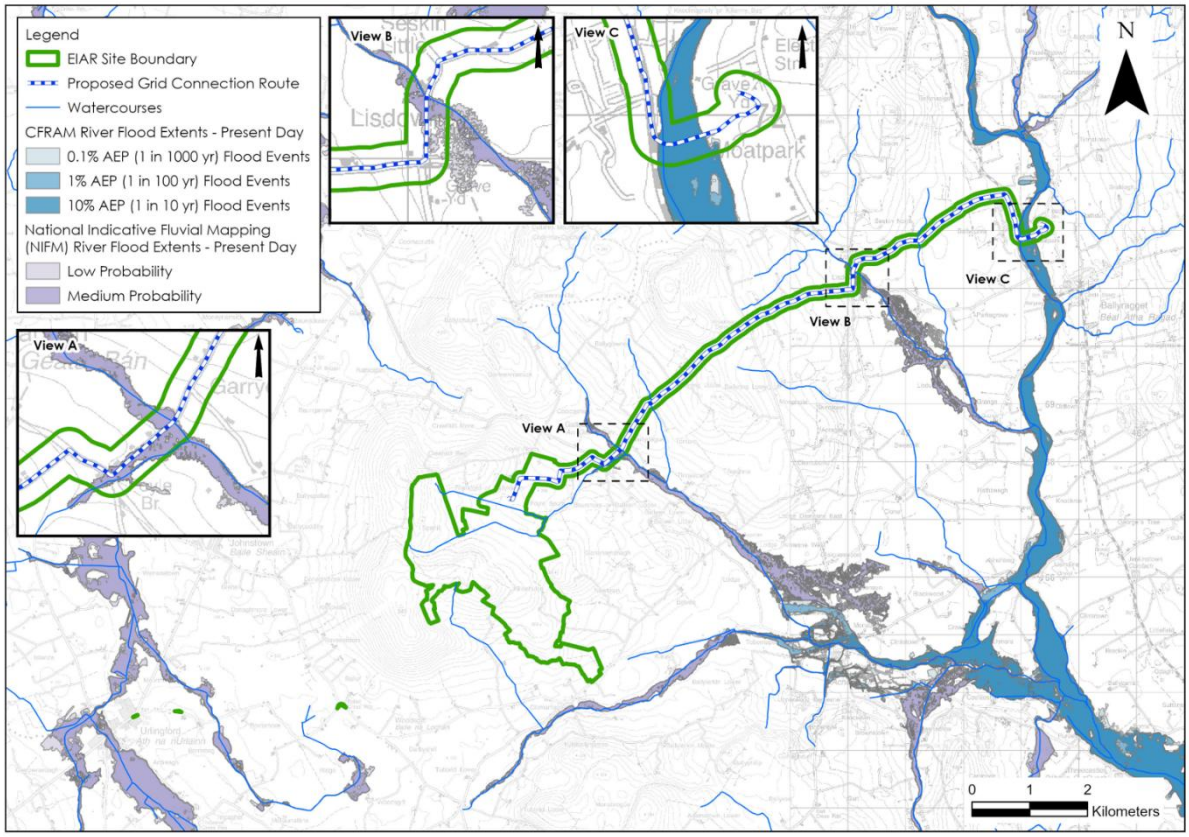


Figure 9-6: OPW NIFM and CFRAM Mapping.

9.3.7 Surface Water Quality

9.3.7.1 EPA Biological Q-Rating Data

Biological Q-rating data for EPA monitoring points on watercourses downstream of the Site are shown in **Table** 9-13 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 show that the Q-rating for the Gorteenahilla at bridge north of Balleen, Nuenna at bridge d/s Clomantagh, Goul at 2nd bridge u/s Aghmacart bridge and Nore river at Threecastles Bridge is "Moderate" in the vicinity and downstream of the Site.

Further downstream, the Nuenna at Freshford bridge and Goul river at bridge near Newtown Mills have achieved "Poor" status while the Nore river at Bridge in Ballyragget have achieved "Good" status.

Table 9-13: EPA Biological Q-Rating Data.

Waterbody	Station Name (ID)	Easting	Northing	Year	EPA Q-Rating Status
Gorteenahilla	Bridge North of Balleen (RS15G080300)	238237	167333	2025	Q3-4 (Moderate)
Nuenna	Bridge d/s Clomantagh (RS15N020100)	236268	163711	2025	Q3-4 (Moderate)
Nuenna	Freshford Bridge	240690	164836	2025	Q3 (Poor)
Goul	2nd Bridge u/s Aghmacart Bridge (RS15G020360)	231553	173521	2025	Q3-4 (Moderate)
Goul	Bridge near Newtown Mills (RS15G020500)	236355	177363	2025	Q3 (Poor)
Erkina	Durrow Bridge (RS15E010550)	240891	177473	2025	Q3-4 (Moderate)
Nore	Bridge in Ballyragget (RS15N011500)	244524	170820	2022	Q4 (Good)
Nore	Threecastles Bridge	245821	162679	2025	Q3-4 (Moderate)

9.3.7.2 Surface Water Quality Monitoring

Surface water sampling and field hydrochemistry (measurements of electrical conductivity (µS/cm), pH (pH units), and dissolved oxygen (%)) were taken at 3 no. locations (SW1 – SW3) within surface watercourses downstream of the Site on 4th June and 23rd September 2026 (refer to **Figure 9-2** for sampling locations). SW1 is located on the Foyle South Stream, SW2 on the Nuenna River and SW3 on the Lisdowney Stream. Field hydrochemistry results are presented in **Table 9-14** below.

Electrical conductivity values for the Foyle South Stream (SW1) are much lower than the Nuenna River (SW2) and Lisdowney Stream (SW3). This is due to the Foyle South Stream catchment being non-calcareous bedrock (mudstone/siltstone), while the other catchment are limestone (calcareous). pH values were in the similar range for both watercourses.

Dissolved oxygen saturation ranged between 85 and 96%. The dissolved oxygen levels would be typical for a High Status river and exceed the required dissolved lower limit of 80% (Surface Waters) Regulations 2009 (as amended).

Table 9-14: Field Hydrochemistry Data.

Location	EC (µS/cm)		pH [H^+]		Dissolved Oxygen %	
	04/06/2026	23/09/2026	04/06/2026	23/09/2026	4/06/2026	23/09/2026
SW1	220	241	8.1	7.9	85	89
SW2	620	687	7.8	7.7	94	93
SW3	657	660	7.9	7.9	92	96

Surface water grab sampling was also conducted at monitoring locations SW1 – SW3 on the dates referred to above. Results of laboratory analysis are shown in **Table 9-15** and **Table 9-16** below alongside relevant Environmental Quality Standards (EQS) values for surface water. Laboratory reports are presented in **Appendix 9-2.**

Table 9-15: Analytical Results of HES Surface Water Samples (04/06/2026).

Parameter	EQS	Sample ID		
		SW1	SW2	SW3
Total Suspended Solids (mg/L)	25(+)	<5	<5	<5
Ammonia N (mg/L)	Good Status: ≤0.065 High Status ≤ 0.04(*)	<0.02	<0.02	<0.02
Nitrite NO_2 (mg/L)	-	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	Good Status ≤ 0.035 to High Status: ≤0.025(*)	<0.02	<0.02	<0.02
Nitrate - NO_3 (mg/L)	-	<5	35	35.4
Phosphorus (mg/L)	-	<0.10	<0.10	<0.10
Nitrogen (mg/L)	-	2.4	8.8	8.2
Chloride (mg/L)	-	13.9	17.4	17.3
BOD (mg/L)	Good Status: ≤ 1.5 High Status: ≤ 1.3(*)	<2	1	<2

(+) S.I. No. 293 of 1988: Quality of Salmon Water Regulations.
(*) S.I. No. 272/2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 (as amended).

Table 9- 16: Analytical Results of HES Surface Water Samples (23/09/2026).

Parameter	EQS	Sample ID		
		SW1	SW2	SW3
Total Suspended Solids (mg/L)	25(+)	15	320	3
Ammonia N (mg/L)	Good Status: ≤0.065 High Status ≤ 0.04(*)	0.02	<0.02	<0.02
Nitrite NO_2 (mg/L)	-	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	Good Status ≤ 0.035 to High Status: ≤0.025(*)	<0.02	<0.02	<0.02

Parameter	EQS	Sample ID		
		SW1	SW2	SW3
Nitrate - NO_3 (mg/L)	-	<5	32.8	31
Phosphorus (mg/L)	-	<0.10	<0.10	<0.10
Nitrogen (mg/L)	-	<1.0	18	7.2
Chloride (mg/L)	-	17.9	17.7	17.7
BOD (mg/L)	Good Status: ≤ 1.5 High Status: ≤ 1.3(*)	<2	<2	<2

(+) S.I. No. 293/1988: Quality of Salmon Water Regulations.
(*) S.I. No. 272/2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 (as amended).

9.3.8 Regional & Local Hydrogeology

GSI bedrock aquifer mapping is shown as **Figure 9-7** below.

The northern portion of the Proposed Wind Farm site (including Proposed Turbine locations T5 - T10, borrow pit, Proposed 110kVSubstation and Proposed BESS) is located in the Lisdowney Groundwater Body (GWB) which comprises Namurian Shales bedrock. According to WFD mapping the Lisdowney GWB has 'poorly productive' bedrock. Site investigation carried out on the northern portion of the Proposed Wind Farm site confirm the presence of mudstone and siltstone bedrock which is consistent with Namurian Shales. Refer to Section 9.3.9.3 below for a summary of site investigations carried out at the Proposed Wind Farm site. Also, refer to the Land, Soils and Geology Chapter (Chapter 8) for details on the investigations carried out.

The southern portion of the Proposed Wind Farm site (including Proposed Turbine locations T1 – T4) is located in the Durrow Groundwater Body (GWB) which comprises Dinantian Pure Bedded Limestones. According to WFD mapping the Durrow GWB is 'karstic'. Site investigations carried out on the southern portion of Proposed Wind Farm site confirm the presence of limestone bedrock at turbine locations T1 to T3 but not T4. Mudstone bedrock was encountered directly below turbine location T4 (where the GSI have limestone mapped).

Within the Lisdowney GWB, the Namurian Shales are classified by the GSI as a Poor Aquifer (Pl - bedrock which is generally unproductive except for local zones). According to the GWB description[4], groundwater will flow from the elevated areas of hills. The hydraulic gradient will be a close reflection of the surface topography since the groundwater table is close to the surface. Groundwater flow paths in this GWB will typically be short (30 - 300m). There is both diffuse and point recharge to this GWB, albeit very limited.

Groundwater will discharge locally to nearby streams and rivers crossing the aquifer and also to small springs and seeps. Owing to the poor productivity of the aquifers in this GWB it is unlikely that any major groundwater surface water interactions occur. Baseflow to rivers and streams is likely to be relatively low.

The underlying poorly productive mudstone bedrock is consistent with the high-density of manmade drainage on the north of the Proposed Wind Farm site. The lands on the north of the Proposed Wind Farm site have poor natural drainage due to being underlain by mudstone/siltstone bedrock which has low permeability and low groundwater recharge rates.

[4] Lisdowney GWB: Summary of Initial Characterisation (GSI, not dated)

Within the Durrow GWB, the Dinantian Pure Bedded Limestones are classified by the GSI as a Regionally Important Karstified Aquifer (diffuse flow). According to the GWB description[5] karstification is predominantly a near-surface phenomenon in the GWB and is likely to concentrate within 20 m of the top of the rock in this formation. Most groundwater flow is likely to be concentrated in this upper zone.

Within the Nuenna River valley (in which the southern half of the Proposed Wind Farm site is located), the GWB discharges via several large karst springs located along the Nuenna River channel. Therefore, there is a strong groundwater surface water interactions within the limestones. GSI karst feature mapping is shown on **Figure 9-8** below.

Groundwater flow patterns and groundwater discharge zones/springs in the Nuenna River valley have been studied and documented in a number of source protection reports prepared on behalf of the GSI for group water scheme sources in this area. The most relevant to the Proposed Wind Farm site is the report prepared for the Clomantagh/Killoshulan (Balief) Group Water Scheme (GWS)[6] which has information on groundwater flows within Nuenna River valley.

The southern half of the Proposed Wind Farm site (including Proposed Turbines T1 to T4) is located in the Clomantagh/Killoshulan (Balief) GWS source protection area. Refer to Section 9.3.15.1 below for further discussion on group water schemes.

The Nuenna River flows in an east/northeasterly direction to the south of the Proposed Wind Farm site. The Nuenna River is a known groundwater discharge zone for the limestone aquifer in this area. Groundwater discharges via several springs located along the river channel. The largest of these springs, all of which are located to the south of the Proposed Wind Farm site along the Nuenna valley floor, include the Clomantagh Killoshulan GWS Spring, Magoo Springs, Castle Spring (Toberpatrick), Boiling Well, Ladies Well and Forest Spring. These springs are known to be the main contributors to flows in the Nuenna River according to studies carried out by the GSI. GSI karst feature mapping is shown on **Figure** 9-8 below.

There have been several groundwater tracer tests carried out in the area by Walsh (2011)[7], which show positive connections between swallow holes and enclosed on the valley sides down to the Nuenna River springs. All but one of these confirmed tracer line connections are on the southern side of the Nuenna River valley (valley side opposite to that of the Proposed Wind Farm site). The one positive tracer connection from the north of the Nuenna River is from an enclosed depression/doline located on the south of the Proposed Wind Farm site. Karst features within the Proposed Wind Farm site are discussed in Section 9.3.9 below. Refer to **Figure 9-8** below for GSI positive tracer lines.

In addition, one of the main springs, Boiling Well is located close to where the Clomantagh Lower Stream discharges into the Nuenna River channel, suggesting the groundwater catchment area to the Boiling Well is likely the Clomantagh Lower Stream. Groundwater baseflow from the Clomantagh Lower Stream emerges at Boiling Well. As stated in Section 9.3.4.1 above, there is no Proposed Wind Farm infrastructure in the Clomantagh Lower Stream catchment.

Dillon (2012) and Cawley (1990)[8] prepared groundwater level contour mapping for the Nuenna River valley which shows that the general flow direction is from west to east along the valley, which is the

[5] Durrow GWB: Summary of Initial Characterisation (GSI, not dated)

[6] GSI/Tobin (2013) Establishment of Groundwater Zones of Contribution, Clomantagh Killoshulan Group Water Scheme, Co. Kilkenny

[7] Walsh, P. 2011. Investigation of point recharge, flow and nutrient levels in a lowland karst system in the South-east of Ireland. MSc Thesis TCD.

[8] *Cawley, A. The Hydrogeological Analysis of a Karst Aquifer System. M.Sc. Thesis, 1990*

direction of surface water flows in the Nuenna River. Therefore, once groundwater flows from the valley sides down towards the Nuenna River it starts to flow easterly and emerge as baseflow in the Nuenna River. Refer to **Figure 9-9** below for the groundwater level contour mapping taken from Dillon (2012) and Cawley (1990) and superimposed on OSI 1:50,000 scale mapping.

The western (upstream) boundary of groundwater flows within Nuenna River valley is near the topographic divide with the neighbouring Borrisbeg Stream (EPA Code: 15B18) catchment which is a tributary of the Goul River (Goul_SC_010).

The Borrisbeg Stream (Goul_SC_010), which emerges from The Loughans turlough, is located in the River Goul catchment which drains northerly to the west of the Proposed Wind Farm site. There is Proposed Wind Farm infrastructure located within the River Goul catchment and therefore there is no surface water drainage towards the Borrisbeg Stream or The Loughans turlough.

The Loughans Turlough is a Groundwater Dependent Terrestrial Ecosystem (GWDTE) and is discussed further in Section 9.3.14 below.

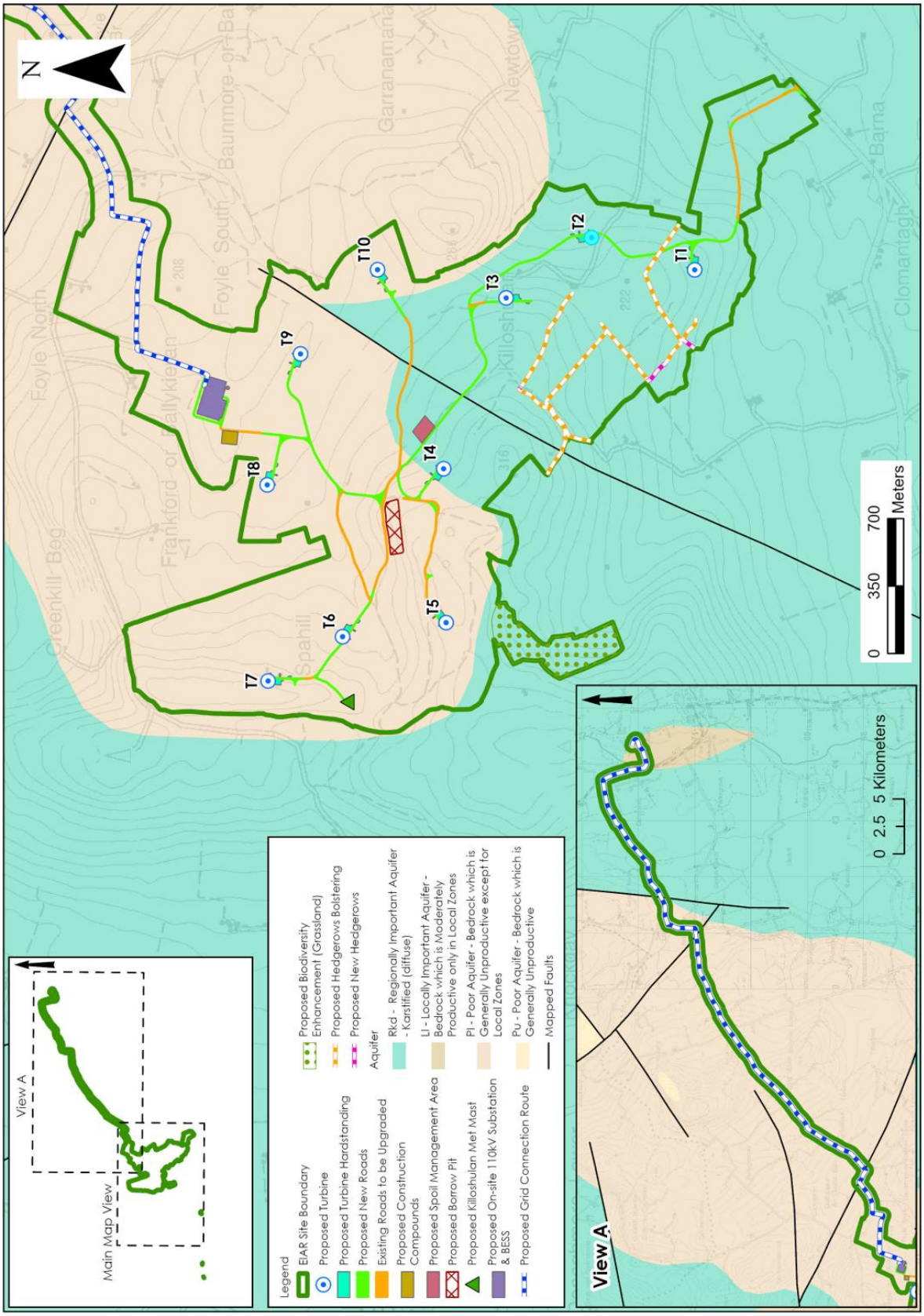


Figure 9-7: GSI Aquifer Mapping.

9.3.9 Site Hydrogeology

9.3.9.1 GSI Karst Feature Mapping

A total of 25 no. karst features are mapped by GSI (karst database) within the Proposed Wind Farm site EIAR boundary, or very close to the boundary. GSI mapped karst features are shown in **Figure 9-8** below.

The southern portion of the Proposed Wind Farm site is located in the Clomantagh/Killoshulan (Balief) Group Water Scheme groundwater source protection area and therefore field-based mapping has been completed by the GSI (or its subcontractors) in the past within the Proposed Wind Farm site.

The GSI mapped features include:

- 16 no. enclosed depressions (dolines);
- 5 no. swallow holes; and
- 4 no. springs.

Firstly, the GSI map a cluster of 13 no. enclosed depressions (dolines) within grassland centrally on the southern portion of the Proposed Wind Farm site. Several of these enclosed depressions are arranged in a general north-south trending alignments which suggest a north-south trending structural feature (fault/fracture line) that has potentially been subject to solution weathering (i.e. karstification). Dye tracing by Walsh (2011) confirmed groundwater flow along this structure towards the Nuenna River (refer to **Figure 9-8** for tracer lines).

One of the enclosed depressions along the enclosed depressions alignment was used as a tracer injection point by Walsh (2011) and this revealed a positive connection with the Nuenna River to the southeast. There was no positive connection with any of the mapped larger springs downslope of the Proposed Wind Farm site (i.e. Clomantagh Killoshulan GWS Spring, Boiling Well, Lady's Well etc) and therefore the connection to the Nuenna River is likely via diffuse groundwater flow (baseflow) or other smaller unmapped spring/seeps.

Nonetheless, the positive tracer connection provides evidence of groundwater flow paths in this area of the Proposed Wind Farm site is southeasterly towards the Nuenna River. The groundwater flow direction is consistent with the local topography (refer to Section 9.3.9.4 below for more discussion on groundwater levels).

All Proposed Turbine locations are setback more than 100m from these GSI mapped enclosed depressions, with the closest turbine location being T3 (~100m away). Proposed Turbine location T3 has been investigated by drilling and geophysical surveys (Refer to Section 9.3.9.3 below for investigation summary), with no evidence of subsurface karst features detected by either method.

4 no. swallow holes are mapped by the GSI approximately 350 - 400m to the east/ northeast of proposed turbine T4, with 1 no. located in grassland and the other 3 no. in the adjacent forestry. Field based surveys carried out by HES/FT (Section 9.3.9.2 below) did not find any evidence of the 3 no. swallow holes in the adjacent forestry which suggests that they might have been backfilled during forestry operations. There was also no evidence of any past surface water drainage function either which suggests that they may have just been dolines. A section of proposed access track runs approximately 30m to the north (downslope) of these GSI mapped swallow holes. Even those these 3 no. swallow holes in the forestry were not identified, it is assumed they are there and have included as a site constraint (refer to Section 9.3.16 below).

The 1 no. swallow hole mapped within grassland, approximately 350m to the northeast of Proposed Turbine T4 exists (as confirmed by field-based surveys). Again this 'swallow hole' has no surface water drainage function which suggests it may be only a collapsed doline.

There is one other swallow hole mapped on the southwest of the Proposed Wind Farm site within the Clomantagh Lower Stream catchment. As stated previously, the Clomantagh Lower Stream valley drains south (largely underground) and discharges into the Nuenna River. The river confluence is at the same location of Boiling Well, suggesting that Boiling Spring is fed by groundwater baseflow from the Clomantagh Lower Stream. There is no Proposed Wind Farm infrastructure development in the Clomantagh Lower Stream catchment.

There are 4 no. 'karst springs' mapped along the western facing slopes of Spahill on the northwest of the Proposed Wind Farm site (the springs are located just outside of the Site). One of these springs (referred to 'Spa Well') has an archaeological/heritage significance as it has apparent health healing properties due to minerals such iron being rich in the water.

Field hydrochemistry analysis of the Spa Well spring discharge by HES would suggest it's not a karst spring due to low dissolved mineral content (i.e. low electrical conductivity in the range of 200µS/cm). The source of the spring water is likely from the mudstone bedrock and not the pure limestone, hence the high iron levels which is evident as residue at the spring outfall. Similar electrical conductivity levels were recorded in the Foyle South Stream which drains the northern portion of the Proposed Wind Farm site (see Section 9.3.7.2 above). Refer to Section 9.3.11 for groundwater quality data.

Overall, the GSI surface mapped karst features at Proposed Wind Farm site have been avoided by the proposed infrastructure. All Proposed Turbine locations on the south of the Proposed Wind Farm site (i.e. T1 to T4) are at least 100m from GSI mapped karst feature. This is in excess of 30m karst buffer used by the GSI in groundwater vulnerability mapping.

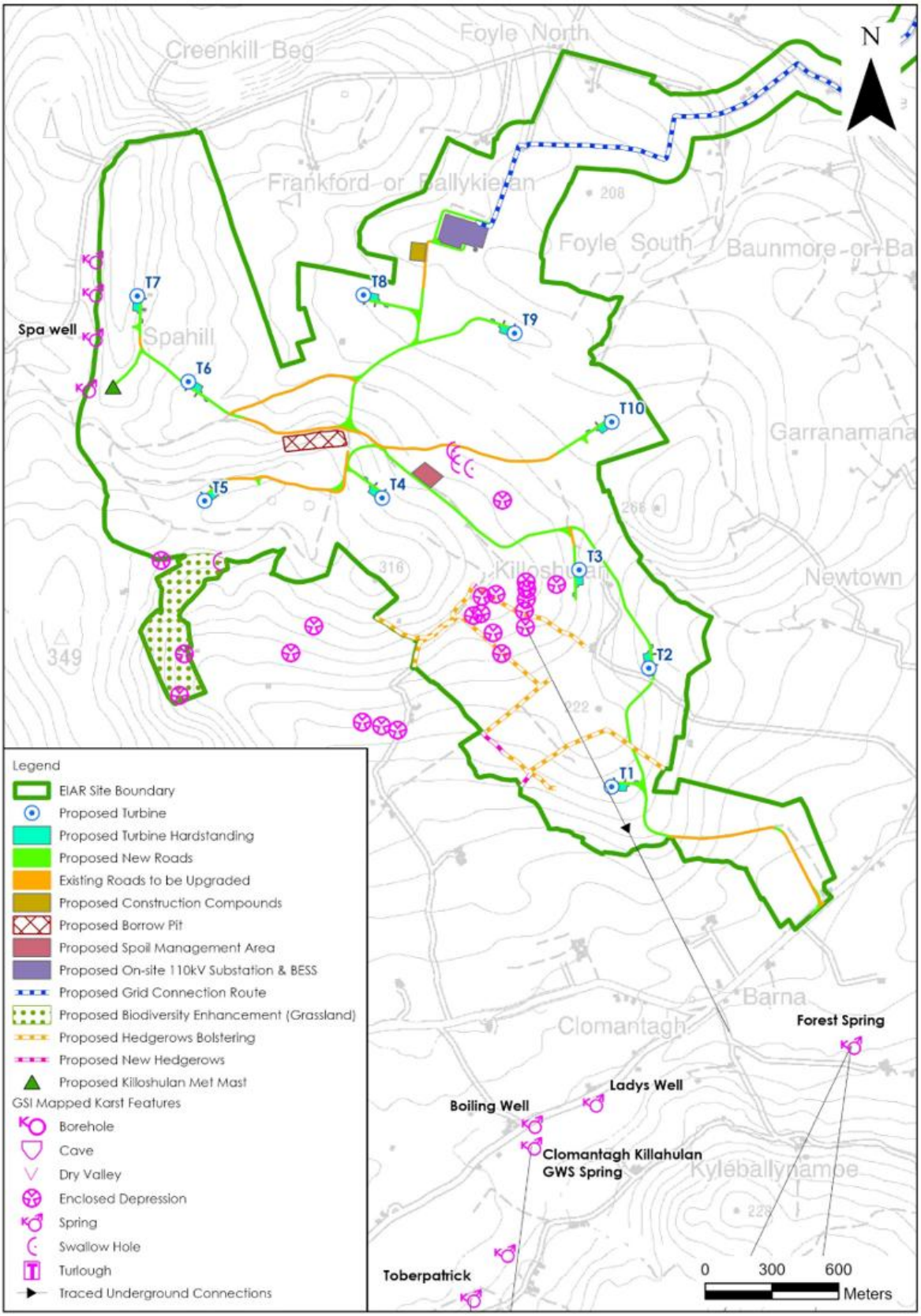


Figure 9-8: GSI Karst Feature Mapping.

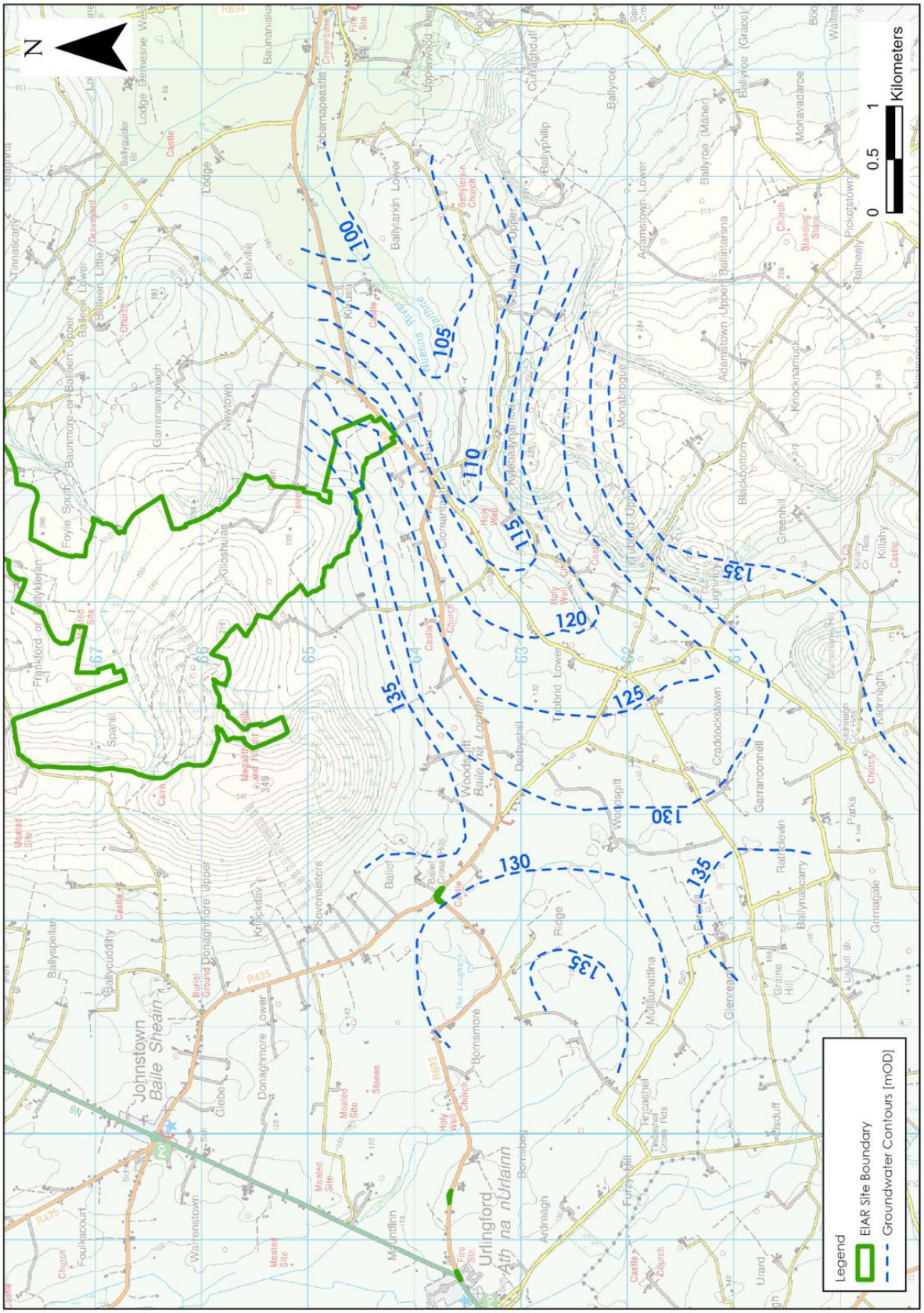


Figure 9-9: Groundwater Contour Mapping by Dillon and Cawley (Source: Contours taken from GSI/Tobin 2013 [9])

[9] *GSI/Tobin (2013) Establishment of Groundwater Zones of Contribution, Balief/Clomantagh Group Water Scheme, Co. Kilkenny*

9.3.9.2 Field Based Karst Mapping

As the GSI karst database is not exhaustive, systematic field-based mapping was carried out by FT as part of the Karst Assessment (**Appendix 8-3),** along with follow up field-based surveys by HES. Refer to **Figure 9-10** for karst feature surveyed during the field-based mapping.

Previously unmapped karst features were identified within a 100m distance of Proposed Turbine location T4, which included enclosed depressions and exposed karstified rock. Proposed Turbine T4, which is underlain by mudstone and not limestone as confirmed by site investigation (refer to Section 9.3.9.3 below for summary), is setback at least 30m from these mapped features. Proposed Turbine T4 location was micro-sited away from this feature during the layout optimisation phase.

As discussed above, of the 4 no. swallow holes mapped by the GSI approximately 350m to the northeast of Proposed Turbine T4, only 1 no. was identified on the ground during surveys. This suggests that the others might have been backfilled during forestry operations. There was no evidence of any past surface water drainage function either which suggests that they may have just been dolines. It is assumed they are present but not visible.

Some additional dolines, possible sink hole and the losing reach of the Clomantagh Lower Stream losing stream were identified on the southwest of the Proposed Wind Farm site. All these mapped features are located in the Clomantagh Lower Stream catchment where there is no Proposed Wind Farm infrastructure.

All Proposed Wind Farm infrastructure located on or adjacent to limestone bedrock (i.e. Proposed Turbines T1 to T4 and associated access roads) have undergone systematic field-based karst surveys.

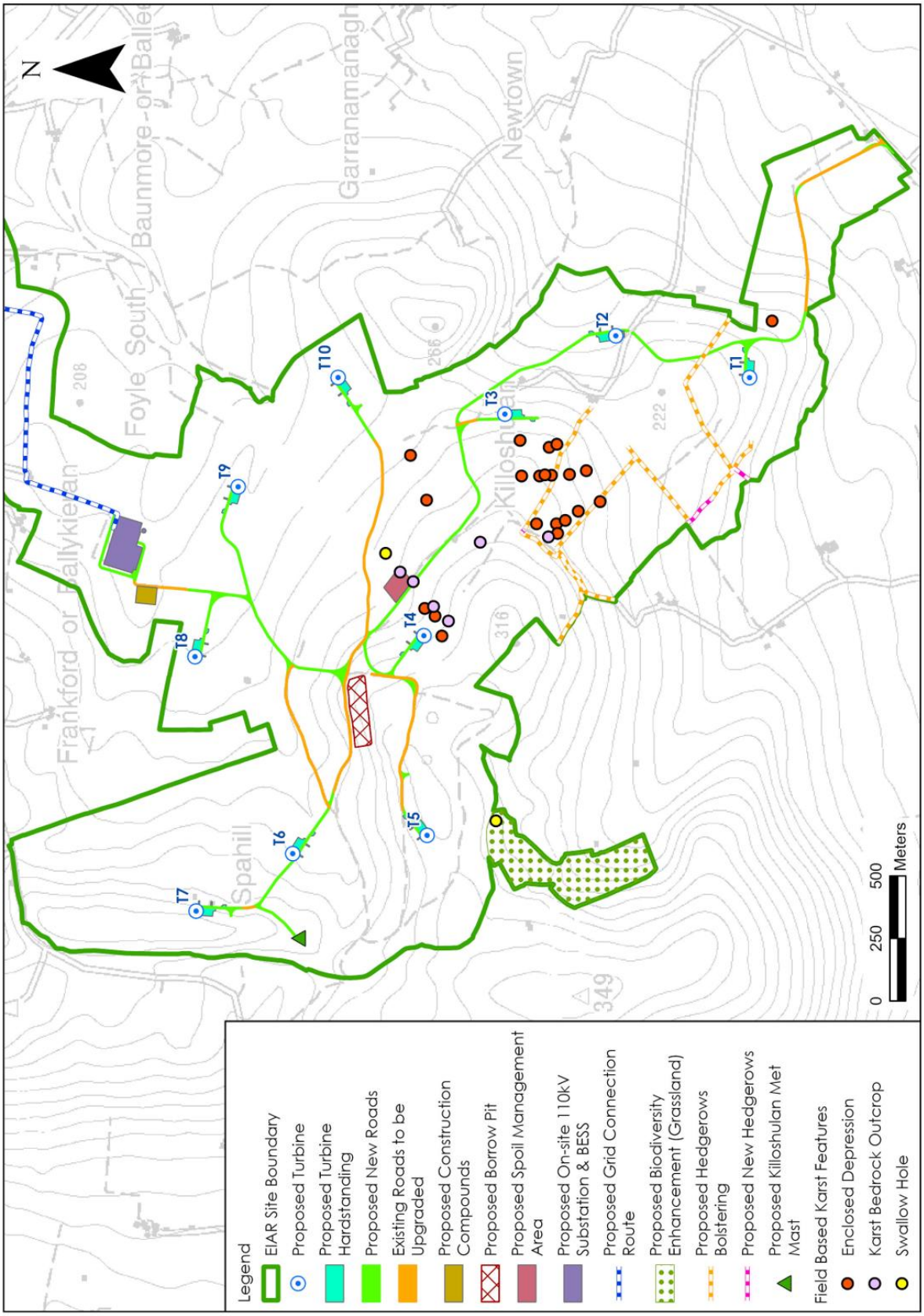


Figure 9-10: Field Based Karst Feature Survey.

9.3.9.3 Site Investigations Summary

The following is a summary of the geophysical surveys (2D Electrical Resistivity Tomography and Seismic Refraction Profiling) and investigation drilling carried out at the Proposed Wind Farm site. Refer to **Figure 8-2** of the Land, Soils and Geology Chapter for borehole locations.

As explained in the Land, Soils and Geology Chapter (Chapter 8), Proposed Turbine locations T1 to T4 were specifically targeted for investigation drilling as they are mapped by the GSI to be underlain by pure limestone bedrock which shows evidence of karstification.

Drilling was also carried out at Proposed Turbine T9 and the proposed borrow pit to confirm the presence of non-calcareous bedrock (siltstone/mudstone) which is mapped across the northern half of Proposed Wind Farm site. Geophysical surveys were carried out at all 10 no. proposed turbine locations.

Key findings of the site investigation are as follows:

- LIMESTONE bedrock was encountered below Proposed Turbine locations T1, T2 and T3 during the drilling investigations which is consistent with GSI bedrock mapping;
- MUDSTONE and SILTSTONE bedrock was encountered below Proposed Turbine T9 and proposed borrow pit respectively which is also consistent with GSI mapping;
- The proven MUDSTONE bedrock below Proposed Turbine T4 is contrary to the GSI mapping which has limestone mapped at the turbine location; and,
- At the other Proposed Turbine locations where no investigation drilling was carried out (i.e. T5 to T8 and T10), geophysical surveys interpret the underlying bedrock as MUDSTONE which is consistent with GSI mapping (and the drilling carried out at T9 and the borrow pit on the north of the Proposed Wind Farm site).

From hydrogeological impact assessment interest, a commentary of the site investigations carried out at turbines T1 to T4 is provided below. Hydrogeologically, Proposed Turbines T5 to T10 are located on low permeability, poorly productive mudstone bedrock with no risk of karstification.

Turbine T1

Geophysical surveys carried out at turbine T1 interpreted '*moderately to slightly weathered/fractured/karstified LIMESTONE'* over *'weathered/fractured to fresh LIMESTONE'* below the proposed turbine foundation.

The investigation drilling carried out at turbine T1 (BH1) encountered strong, argillaceous, slightly to moderately weathered LIMESTONE with no evidence of shallow (epikarst) or deep karst weathering. In addition, the trial pit carried out locally by GDG (TP01) identified no epikarst weathering at the location of Proposed Turbine T1.

However, anomalies in the geophysics surveys indicated possible clay infill or DOLOMITISED LIMESTONE approximately 20m to the north of turbine T1. A second such anomaly was detected at a significant depth below ground level (approximately 12mbgl) at the turbine location itself.

Geophysics recommended confirmatory borehole T01-PBH1, which was drilled by downhole hammer approximately 50m to the north of T1, encountered clay infill between 7.6 and 10mbgl. The deeper underground anomaly was not investigated by drilling due to it being approximately 15mbgl, which will ensure at least 6m of competent LIMESTONE below the turbine base foundation.

As illustrated on the annotated ERT and Seismic Refraction profile (**Appendix 8-5**), the T1 turbine foundation can be constructed on competent limestone and will have no interaction with either of these clay infills.

Turbine T2

Geophysical surveys carried out at turbine T2 interpret *'Moderately to slightly weathered /fractured /karstified LIMESTONE'* below the proposed turbine foundation.

However, the investigation drilling carried out at Proposed Turbine T2 (BH2) encountered strong, fresh to slightly weathered LIMESTONE with occasional clay infilled fracture with no evidence of shallow (epikarst) or deep karst weathering. In follow up investigation drilling at the T2 foundation location (BH2B), strong, competent, pale grey LIMESTONE was encountered down to a depth of 18mbgl.

Also, the trial pit carried out by GDG (TP03) identified no epikarst weathering at the location of turbine T2.

Similar to Proposed Turbine location T1, anomalies in the geophysics surveys indicated possible clay infill or DOLOMITISED LIMESTONE were detected at ground level 15m to the north and 5m to the east of the proposed turbine location.

Two geophysics confirmatory boreholes (T02-PBH1 & T02-PBH2) were drilled approximately 40m to the northeast and 43m to the east respectively of turbine T2 to investigate the presence of a clay infill along the geophysical survey lines. Both boreholes encountered clay infill (boulder clay) from ground level down to 20mbgl (EoH) which was the maximum drilling depth.

However, as illustrated on the annotated ERT and Seismic Refraction profile (**Appendix 8-5**), the T2 turbine foundation can be constructed on competent limestone and will have no interaction with either of these clay infills.

Turbine T3

The geophysical surveys carried out at turbine T3 interpret *'moderately to slightly weathered/fractured LIMESTONE'* over '*slightly weathered to fresh LIMESTONE'*. The bedrock interpretation across the profiles is uniform fresh limestone with no anomalies indicating karst or otherwise.

The investigation drilling carried out at T3 (BH3) are consistent with the geophysical survey, where medium strong, thickly bedded, argillaceous, weathered LIMESTONE was encountered. In addition, some shallow MUDSTONE was encountered above the LIMESTONE. The T3 turbine foundation can be constructed on competent limestone.

Turbine T4

3 no. rotary core boreholes (BH5, BH5B and BH-ALT-T5) were carried out at Proposed Turbine location T4 during the layout optimisation. The aim of the optimisation was to move T4 away from some enclosed depressions and exposed limestone which is located to the southeast of the proposed turbine location. The Proposed Turbine T4 location now keeps a 30m distance from these karst features, while in fact the proposed turbine itself sits over mudstone bedrock and not limestone.

The bedrock below Proposed Turbine location T4 is mapped as pure bedded limestone by the GSI. However, the investigation drilling shows that there is a geological contact (overlap) between the LIMESTONE and MUDSTONE at this location with MUDSTONE overlapping the LIMESTONE.

BH-ALT-T5 was drilled at the Proposed Turbine T4 base location where 18m of MUDSTONE (2.25 to 20.2mbgl) overlies LIMESTONE. The MUDSTONE is described as weak to very weak and weathered. The underlying LIMESTONE is described as strong and slightly weathered. The other two rotary core

boreholes drilled in the area of Proposed Turbine T4 (BH5 and BH5B) encountered MUDSTONE down to the maximum drilling depths of 10 and 15mbgl respectively.

9.3.9.4 Groundwater Levels & Flow Directions

There are three existing investigation boreholes (BH-B, BH-C and BH-E) located within the Clomantagh Lower Stream catchment immediately to the southwest of the Proposed Wind Farm site. Refer to **Figure 9-11** below for groundwater level monitoring locations at the Proposed Wind Farm site.

Automated groundwater level data is available for BH-B and BH-C since July 2025 (refer **Figure 9-12** below for water level graphs). Manual groundwater levels were recorded in BH-E.

In addition, automated groundwater level monitoring was carried out at the southern portion of the Proposed Wind Farm site at monitoring wells MW1 and MW2, along with at investigation boreholes BH1 and BH4A. Manual groundwater levels were recorded in BH5-ALT-T5. Groundwater level monitoring at the Proposed Wind Farm site commenced in April 2026. Refer to **Figure 9-12** below for all groundwater level graphs.

Depth to groundwater level (mbgl) at 6 no. of the 8 no. monitoring locations generally ranged between 10 to 20mbgl. The groundwater level elevations (m OD) generally correspond to topography/ground slope with the overall groundwater level gradient being southeasterly towards the Nuenna River. The Nuenna River is a known groundwater discharge zone in this area. Refer to **Figure 9-13** for plan view of groundwater levels in mbgl and mOD.

However, at two locations (MW2 & BH-B), the depth to groundwater level is significantly greater than the other 6 no. locations and the reasons for this is likely due to enhanced bedrock permeability resulting from deep karst weathering that reduces the groundwater level. Preferential groundwater flows along high permeability weathered zones maintain a reduced groundwater level at these locations. The groundwater level at MW2 is generally 60mbgl (~209m OD) and at BH-B is 40mbgl (207m OD).

MW2 is located immediately to the northwest of the cluster of 13 no. enclosed depressions (dolines) within grassland centrally on the southern portion of the Proposed Wind Farm site. As stated previously, several of these enclosed depressions are arranged in a general north-south trending alignments which suggest a north-south trending structural feature (fault/karst weathered zone). Also, dye tracing by Walsh (2011) demonstrated a groundwater flowpath between these enclosed depressions and the Nuenna River (Section 9.3.8 above). The reduction in groundwater levels at MW2 also suggests preferential flow along this north/south structural feature towards the Nuenna River.

A similar high permeability zone (preferential groundwater flowpath) along the Clomantagh Lower Stream valley is also suggested by the deep groundwater level (40mbgl) recorded in BH-B, which is located on the western slopes of the Clomantagh Lower Stream valley.

Groundwater levels in the nearby BH-C borehole, which is located on the eastern slopes of the Clomantagh Lower Stream (200m away), are typically much shallower 10-12mbgl. Both boreholes are at similar ground level elevations (c. 240m OD) but recorded significantly different groundwater levels.

The significant difference in groundwater level elevations suggest a high permeability karst weathered zone within the Clomantagh Lower Stream valley that reduces the groundwater level at BH-B but not at BH-C.

This is consistent with Clomantagh Lower Stream being ‘losing stream’ due to preferential groundwater flowpaths in the underground karst bedrock underlying the valley that flow towards the Nuenna River. The likely groundwater discharge point is Boiling Well at the Clomantagh Lower Stream/Nuenna River channel confluence.

From a source-pathway-receptors perspective these zones are significant potential groundwater pathways to downstream receptors such as the Nuenna River and the Clomantagh/Killoshulan (Balief) GWS spring.

As stated previously, there is no Proposed Wind Farm infrastructure within the Clomantagh Lower Stream catchment. The closest Proposed Turbine to the Clomantagh Lower Stream catchment is T5 which is underlain by mudstone and therefore there is no risk of karstification. The Clomantagh Lower Stream catchment has been avoided by the Proposed Project.

Also as stated above, all Proposed Wind Farm infrastructure is located at least 100m away from the enclosed depression alignment further north on the Proposed Wind Farm site.

Refer to Section 9.3.9.5 below which discusses further the potential north-south trending structural feature (fault/karst weathered zone) along enclosed depressions alignment on the south of the Proposed Wind Farm site.

Table 9-17: Proposed Wind Farm site Groundwater Level Summary Data.

Location	Ground Level (m OD)	Min WL (m OD)	Max WL (m OD)	Range (m)
MW1	220.032	202.32	203.67	1.35
MW2	271.039	209.14	210.02	0.88
BH1	205.7	190.24	191.70	1.46
BH4A	266.68	251.32	253.90	2.58
BH-B	247.9	206.65	208.8	2.15
BH-C	241.36	230.039	232.45	2.41

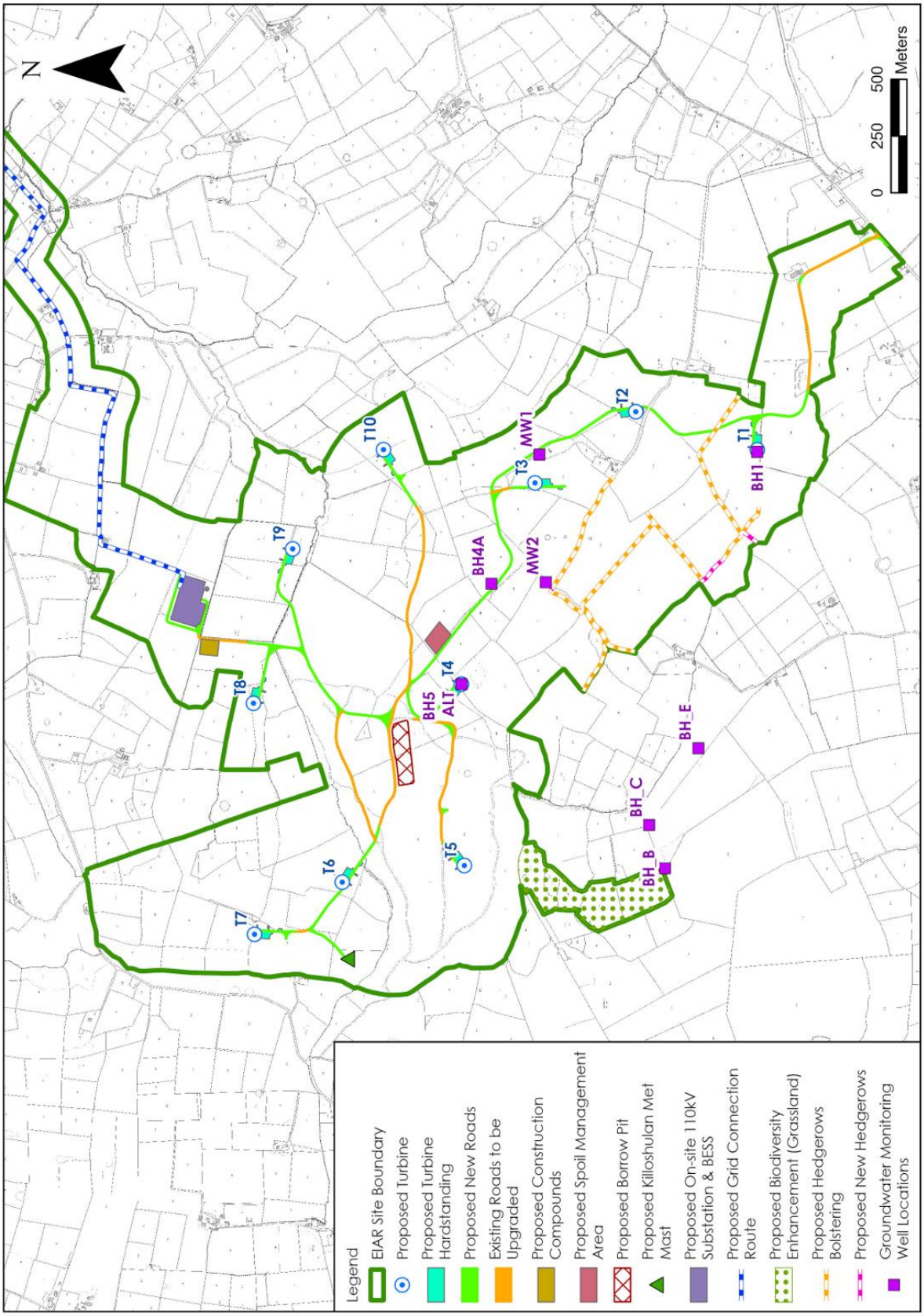


Figure 9-11: Proposed Wind Farm site Groundwater Level Monitoring Locations.

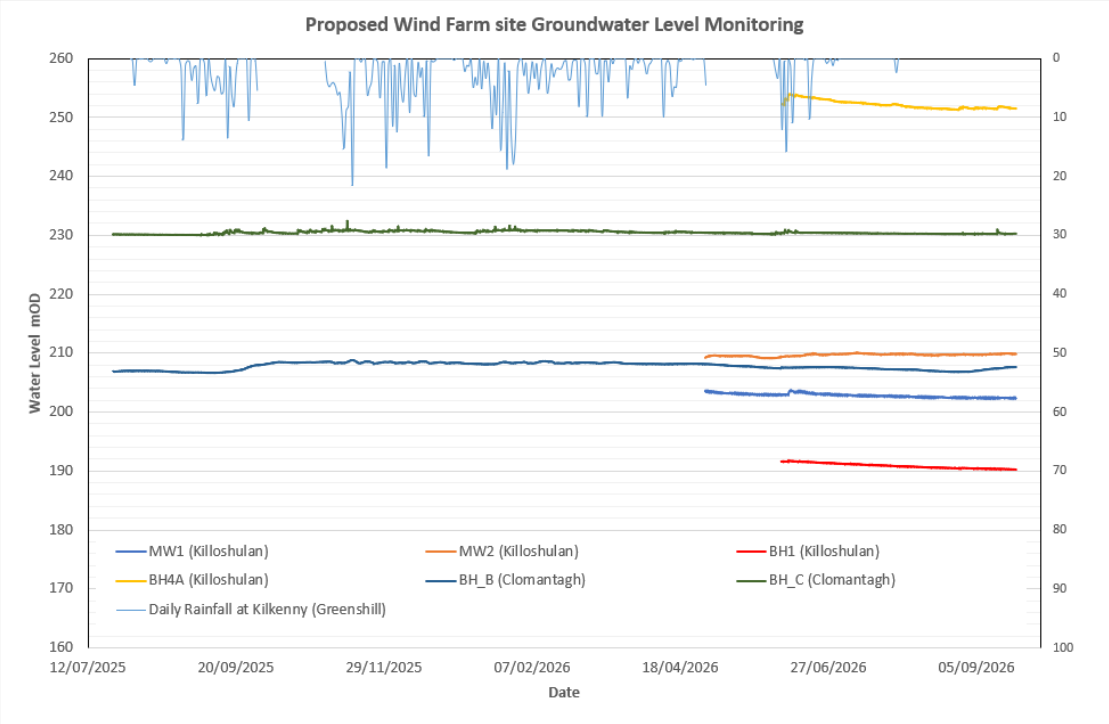


Figure 9-12: Proposed Wind Farm Site Groundwater Level Graphs

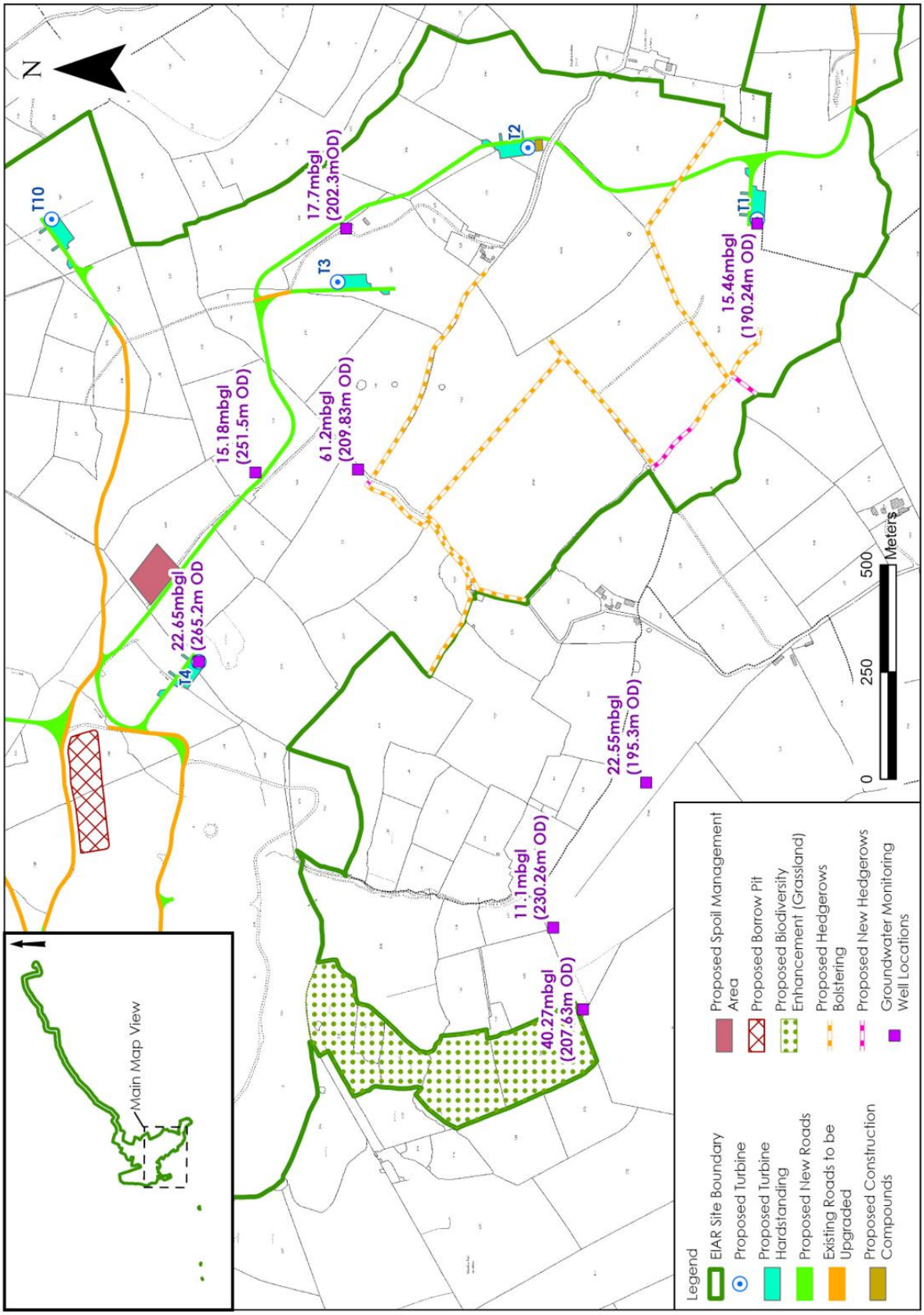


Figure 9-13: Proposed Wind Farm site Groundwater Level Depths and Elevations (September 2026).

9.3.9.5 Former Proposed Turbine Location T4

As stated in the Land, Soils and Geology Chapter (Chapter 8), Investigations (drilling and geophysics) at a former turbine T4 location (turbine now dropped from Proposed Project layout as discussed in Section 3.2.5.2.2 of Chapter 3 Site Selection and Reasonable Alternatives) encountered significant evidence of subterranean karst weathering (large clay infills and weathered limestone).

Please note that this does not relate to the current turbine T4 in the Proposed Project layout which is at a different location of the Proposed Wind Farm site. The Proposed Project T4 is underlain by mudstone as summarised in Section 9.3.9.3 above. The former turbine T4 location is c.460m to the southeast of the Proposed Project T4 location.

Investigation boreholes (BH04 and BH4NW) and geophysics indicated widespread karst weathering at the proposed footprint of the former T4 and was therefore dropped from the layout for geotechnical and environmental reasons. Refer to the Land, Soils and Geology Chapter for investigation locations.

Former turbine T4 is located approximately 250m to the northwest of the cluster of 13 no. enclosed depressions (dolines) within grassland centrally on the southern portion of the Proposed Wind Farm site. From the investigations carried out at the former T4 turbine location, it appears that the subterranean karst identified at the former T4 is likely to be a continuation of the structural feature/weathered zone causing the north/south trending enclosed depression alignment.

Therefore, this structural alignment was mapped as a hydrogeological constraint, and no further development of turbines was considered for the area of the Proposed Wind Farm site.

9.3.9.6 Hydrogeological Conceptual Model

The hydrogeological characteristics of the northern and southern portion of the Proposed Wind Farm site differ and therefore are discussed separately below.

Northern Portion:

- Northern portion of the Proposed Wind Farm underlain by MUDSTONE/SILTSTONE bedrock;
- Bedrock classified as a Poor Aquifer by the GSI;
- A depth of 11.5m overburden confirmed by investigation drilling. Geophysics suggest shallower bedrock on the northwest (3-4m) and deeper to the northeast (~20m);
- Aquifer characterised by poorly productive bedrock and low groundwater recharge rates;
- Shallow groundwater table as indicated by the poorly draining soil and high-density manmade drainage network;
- Dominant surface water drainage regime as indicated by the drainage density;
- Groundwater level gradients corresponding close to topography; and,
- Groundwater flow direction in an easterly/northeastern direction based on topography.

Southern Portion:

- Southern portion of the Proposed Wind Farm underlain by pure bedded LIMESTONE bedrock;
- Bedrock classified as a Regionally Important Karstified Aquifer by the GSI;
- Subsoils depths typically less than 1m with some exposed bedrock;
- Lack of surface water drainage indicate high groundwater recharge rates;
- Based on site observations, recharge likely to be predominately diffusive rather than point source;

- Surface karst features present (enclosed depressions and swallow holes), but due to the elevated topography and sloping ground have only very localised drainage function/recharge function (i.e. upslope runoff only);
- Groundwater levels typically measured at approximately 10 - 20mbgl, with elevations (m OD) typically corresponding to topography and slope;
- Groundwater level elevations show general groundwater flow direction towards the Nuenna River to the southeast (refer to **Figure 9-13**).
- The Nuenna River is a known groundwater discharge zone in this area as confirmed by GSI source protection studies;
- Previous dye tracing carried out at the Proposed Wind Farm site show groundwater connections to the Nuenna River, downslope to the southeast (refer to **Figure 9-8**)
- Underground preferential groundwater flowpaths expected to correspond to the north/south trending enclosed depression alignment;
- Also, preferential groundwater flowpaths expected along the Clomantagh Lower Stream catchment towards the Nuenna River;
- The two identified potential groundwater flowpaths have been avoided by the Proposed Project turbine layout; and,
- The groundwater flow direction along the Nuenna River to the southeast of the Proposed Wind Farm site is easterly (refer to **Figure 9-9).**

9.3.10 Groundwater Vulnerability

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

The GSI groundwater vulnerability rating of the Proposed Wind Farm site ranges from 'Moderate' to 'Extreme (X)'. Proposed turbine locations T1 to T7 are mapped as 'Extreme (X)', while turbine locations T8 to T10 are mapped as 'High'. A 'Moderate' vulnerability rating is mapped on the northeast of the Proposed Wind Farm site near the Proposed 110kV Substation and Proposed BESS (refer to **Table 9-18** below for GSI groundwater vulnerability). The GSI mapped vulnerability rating is generally consistent with site investigations.

In addition, on the south of the Proposed Wind Farm site, swallow holes and enclosed depressions are assigned an 'Extreme' vulnerability rating which is applied using a 30m buffer around the feature as best practice.

With the exception of a short section of proposed access road (as described in Section 9.3.9.2 above), all Proposed Wind Farm infrastructure is located outside karst feature 30m buffer zone. Refer to Section 9.3.16 and **Figure 9-16** below for site specific hydrological constraints mapping.

Table 9-18 : Groundwater Vulnerability and Subsoil Permeability and Thickness (Groundwater Protection Schemes Report 1999).

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

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

9.3.11 Groundwater Quality Hydrochemistry

Groundwater sampling of monitoring well MW1 (Proposed Wind Farm site) and Boiling Well (Sample Ref: GW1) was carried out on 24th September 2026. Original Laboratory certificates are shown in **Appendix 9-3.**

The hydrochemistry (i.e. metals and major cations/anions) was similar in both samples. Levels of nutrients (i.e. nitrate, nitrite, ammonia and orthophosphate) were very low in both samples. There was no exceedance of the groundwater or surface water regulations MAC threshold values.

Electrical conductivity (µS/cm) was slightly higher in GW1 (672 µS/cm) compared to MW1 (525µS/cm) and this is likely due to 'younger' recharged groundwater at higher ground elevations with less dissolved minerals. pH values were near/at neutral (7.0 -7.2). TSS were below the laboratory detection limit.

As stated in Section 9.3.9.1 above, there are 4 no. 'karst springs' mapped along the western facing slopes of Spahill on the northwest of the Proposed Wind Farm site (the springs are located just outside of the EIAR site boundary). One of these springs (referred to 'Spa Well') has an archaeological/heritage significance as it has apparent health healing properties due to minerals such iron being rich in the water.

Field hydrochemistry analysis of the Spa Well spring discharge by HES would suggest it's not a karst spring due to low dissolved mineral content (i.e. low electrical conductivity in the range of 206µS/cm). The electrical conductivity in MW1 and Boiling Well were >500-600µS/cm in terms of comparison.

The source of the spring water is likely from the mudstone bedrock and not the pure limestone, hence the high iron levels which is evident as residue at the spring outfall.

Similar electrical conductivity levels were recorded in the Foyle South Stream which drains the northern portion of the Proposed Wind Farm site (see Section 9.3.7.2 above).

9.3.12 Groundwater Body Status

Local Groundwater Body (GWB) status information is available online (www.catchments.ie) and are summarised in **Table 9-19** below. Please refer to the WFD Compliance Assessment report (attached as **Appendix 9-4**) for the complete assessment.

The Lisdowney GWB and Durrow GWB underlie the Proposed Wind Farm site, while the Kilkenny-Ballynakill Gravels GWB and Rathdowney GWB underlie the Proposed Grid Connection underground cable route.

All GWBs achieved a "Good" status in the latest WFD cycle (2019-2024). With the exception of Durrow GWB, all are 'not at risk' of failing to achieve their WFD objectives. Durrow GWB is 'at risk' of failing to achieve its WFD objectives, with agriculture as identified significant pressure on this GWB.

Table 9-19: Groundwater Body Status and Risk for the Proposed Project.

GWB	Overall Status 2013-2018	Overall Status 2016-2021	Overall Status 2019-2024	Risk Status 3rd Cycle	Pressures
Lisdowney	Good	Good	Good	Not at risk	None
Durrow	Poor	Poor	Good	At risk	Agriculture

GWB	Overall Status 2013-2018	Overall Status 2016-2021	Overall Status 2019-2024	Risk Status 3rd Cycle	Pressures
Killkenny-Ballynakill Gravels	Good	Good	Good	Not at risk	None
Rathdowney	Good	Good	Good	Not at risk	None

9.3.13 River Water Body Status

Local River Waterbody status and WFD risk classification are available from (www.catchments.ie) and are summarised in **Table 9-20** below. Please refer to the WFD Compliance Assessment report (attached as **Appendix 9-4**) for the complete assessment.

The Proposed Wind Farm site and the Proposed 110kV Underground Cabling are drained by the Gorteenahilla_010 which have achieved "Moderate" status in the latest WFD cycle (2019-2024) and is 'at risk' of failing to achieve its WFD objectives with Forestry and Agriculture as identified significant pressure on this SWB. The southern portion of the Proposed Wind Farm site is drained by Nuenna_010 and Nuenna_020 river sub-basin. The Nuenna_010 have achieved "Moderate" status in the latest WFD cycle and is 'at risk' with agriculture as identified significant pressure on this SWB which the Nuenna_020 have achieved "Poor" status in the latest WFD cycle and is 'at risk' of failing to achieve its WFD objectives with Agriculture and Urban wastewater as identified significant pressure on this SWB.

The TDR accommodation works are mapped within the Goul_030 river sub-basin and the northwestern part of the Proposed Wind Farm Site is mapped within the Goul_040 and Goul_050 river sub-basin. The Goul_030 and Goul_050 have achieved "Moderate" status in the latest WFD cycle and is 'at risk' of failing to achieve its WFD objectives with agriculture as identified significant pressure on these SWBs while the Goul_040 have achieved "Poor" status in the latest WFD cycle and is 'at risk' of failing to achieve its WFD objectives with Forestry and agriculture as identified significant pressure on this SWB.

Downstream of the Goul_050, the Goul_060 have achieved "Poor" status in the latest WFD cycle and is 'at risk' with Agriculture and Hydromorphology as identified significant pressure, the Erkrina_050 have achieved "Moderate" status and is 'at risk' with Agriculture as identified significant pressure and the Nore_110 have achieved "Good" status and is 'not at risk' of failing to achieve its WFD objectives.

The Proposed 110kV Underground Cabling is drained out by the Lisdowney_010, Nore_120, Nore_140 and Nore_150 river sub-basins. The Lisdowney_110 have achieved "Moderate" status in the latest WFD cycle and is 'at risk' of failing to achieve its WFD objectives with agriculture as identified significant pressure in this SWB. The Nore_120, 150 and 170 have achieved "Moderate" status while the Nore_130, 140 and 160 have achieved "Good" status in the latest WFD cycle. In terms of risk status, the Nore_120 is 'at risk' and the Nore_130 to 170 are 'not at risk' of failing to achieve its WFD objectives. Agriculture is identified significant pressure on Nore_120.

Table 9-20: River Waterbody Status and Risk for the Proposed Project.

SWB	Overall Status 2013-2018	Overall Status 2016-2021	Overall Status 2019-2024	Risk Status 3rd Cycle	Pressures
Gorteenahilla_010	Poor	Moderate	Moderate	At risk	Forestry and Agriculture
Lisdowney_010	Good	Moderate	Moderate	At risk	Agriculture

SWB	Overall Status 2013-2018	Overall Status 2016-2021	Overall Status 2019-2024	Risk Status 3rd Cycle	Pressures
Nuenna_010	Moderate	Moderate	Moderate	At risk	Agriculture
Nuenna_020	Moderate	Poor	Poor	At risk	Agriculture and Urban wastewater
Goul_030	Moderate	Moderate	Moderate	At risk	Agriculture
Goul_040	Moderate	Poor	Poor	At risk	Forestry and Agriculture
Goul_050	Moderate	Moderate	Moderate	At risk	Agriculture
Goul_060	Poor	Poor	Poor	At risk	Agriculture and Hydromorphology
Erkrina_050	Moderate	Moderate	Moderate	At risk	Agriculture
Nore_110	Good	Good	Good	Not at risk	None
Nore_120	Good	Moderate	Moderate	At risk	Agriculture
Nore_130	Good	Good	Good	Not at risk	None
Nore_140	Good	Good	Good	Not at risk	None
Nore_150	Good	Good	Moderate	Not at risk	None
Nore_160	Good	Good	Good	Not at risk	None
Nore_170	Good	Good	Moderate	Not at risk	None

9.3.14 Designated Sites and Habitats

Within the Republic of Ireland designated sites include Natural Heritage Areas (NHAs), Proposed Natural Heritage Areas (pNHAs), Special Areas of Conservation (SAC) and Special Protection Areas (SPAs). A map of designated sites in the local area is shown as **Figure 9-14** below.

Spahill and Clomantagh Hill SAC (Site Code:000849) is located immediately to the northwest and southwest of the Proposed Wind Farm site. Proposed Wind Farm site infrastructure is setback more than 0.3km from this designated site, with the closest Proposed Turbine being T5 on the southwest of the Proposed Wind Farm site. On the northwest of the Proposed Wind Farm site, the closest turbine (T7) is setback 0.55km from the SAC.

Spahill and Clomantagh Hill SAC has no water dependent habitats. Nonetheless there is no hydrological or hydrogeological connectivity between the Proposed Wind Farm site and this SAC. To the southwest of the Proposed Wind Farm site, the SAC occupies the summit of Clomantagh Hill which is higher in elevation than any of the adjacent Proposed Wind Farm site infrastructure. The Proposed Wind Farm site and the SAC are also separated by the Clomantagh Lower Stream catchment to the southwest.

To the northwest of the Proposed Wind Farm site, the SAC occupies an area of Spahill that is located within a separate surface water catchment (i.e. River Goul) to that of the Proposed Wind Farm infrastructure. There is no potential for surface water or groundwater flows towards the SAC to the northwest of the Proposed Wind Farm site. Also, please note the northwestern and southwestern portion of the Proposed Wind Farm site is underlain by mudstone and therefore there is no risk of karstification.

Cullahill Mountain SAC, which is also not a water dependent habitat, is located 2.7km to the northwest of the Proposed Wind Farm site. The Proposed Wind Farm site and Cullahill Mountain SAC are separated by a tributary of the River Goul which runs in a valley to the northwest of the Proposed Wind Farm site.

The Loughans SAC (Site Code:000407), which is a turlough (karst) and a groundwater dependent terrestrial ecosystem (GWDTE), is located approximately 2.7km to the southwest of the Proposed Wind Farm site. The proposed TDR works on the R693 at Balief Cross Roads is approximately 100m from the SAC boundary.

However, for the reasons presented below, it can be assessed with certainty that there is no hydrological or hydrogeological connectivity between the Proposed Wind Farm site and The Loughans SAC:

- The Loughans SAC is located in a separate surface water catchment (i.e. River Goul) to that of the Proposed Wind Farm site;
- The closest Proposed Turbine(T5) is 3km away from the SAC and is underlain by mudstone bedrock (no potential for karstification);
- The closest Proposed Turbine location underlain by potentially karstified limestone (T1) is 3.9km away;
- Groundwater level monitoring carried out in the limestone bedrock on the southern portion of the Proposed Wind Farm site shows a southeasterly gradient towards the Nuenna River (the SAC is located to the southwest);
- Groundwater dye tracing carried out by Walsh (2011) also shows a southeasterly groundwater flow direction from the Proposed Wind Farm site towards the Nuenna River;
- Groundwater level contour mapping by Dillon (2012) and Cawley (1990) show an easterly groundwater flow direction along the Nuenna River valley (the SAC is located to the west of the Nuenna River valley and within a separate catchment);
- The Clomantagh Lower Stream valley to the southwest of the Proposed Wind Farm site will act as a hydrogeological boundary between the Proposed Wind Farm site and the SAC.
- Groundwater flow in the Clomantagh Lower Stream valley discharges into the Nuenna River to the southeast of the Proposed Wind Farm (thereby preventing groundwater flowing south-westerly from the Proposed Wind Farm towards the SAC.

The River Barrow and River Nore SAC (Site Code:002162) is located approximately 9km to the east and downstream of the Proposed Wind Farm site via the Nuenna River. The Proposed 110kV Underground Cabling drains to the River Barrow and River Nore SAC.

Also, the Proposed 110kV Underground Cabling crosses under the River Nore near Ballyragget where HDD will be employed to place the cable below the river channel to avoid any physical contact with the river or the River Barrow and River Nore SAC.

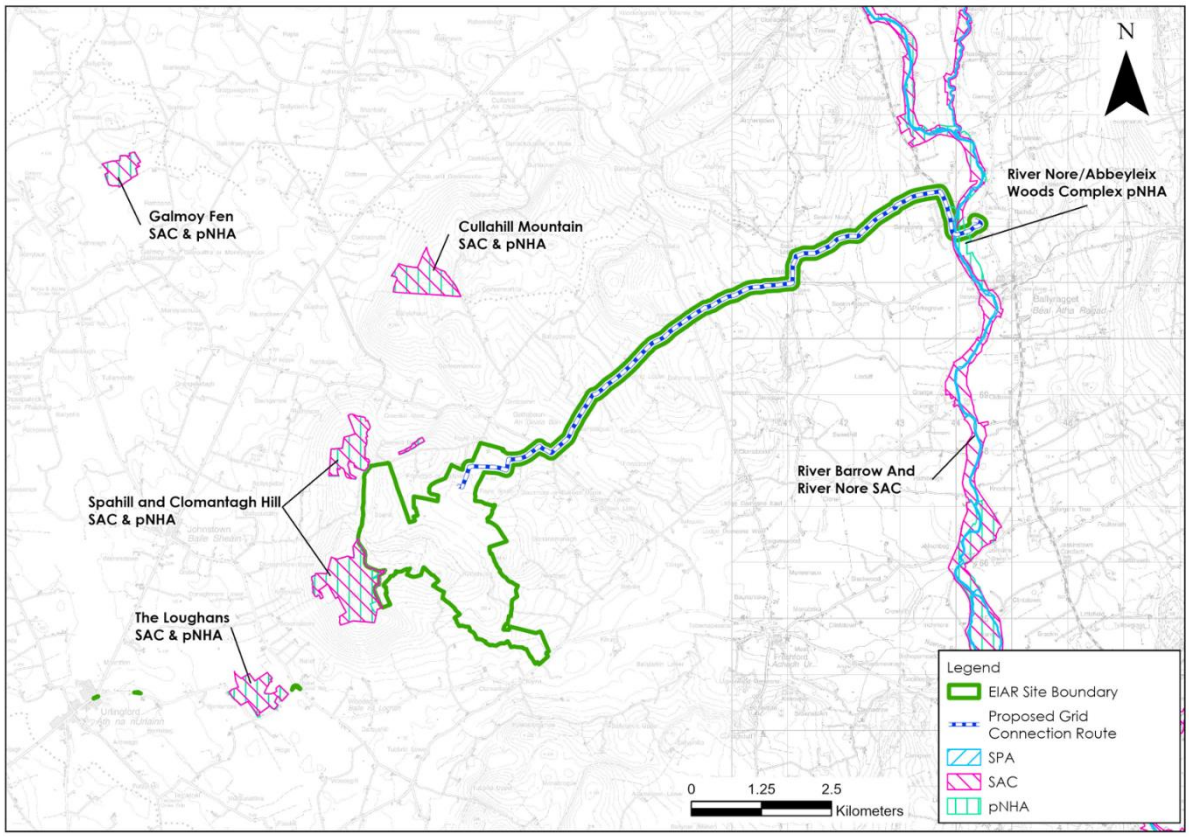


Figure 9-14: Local Designated Sites.

9.3.15 Water Resources

9.3.15.1 Public/Group Water Schemes

The southern portion of the Proposed Wind Farm site is located in Clomantagh Killoshulan (Balief) Group Water Scheme (GWS) Source Protection Area (SoPA). Refer to **Figure 9-15** below for SoPA mapping which is available online and documented in GSI/Tobin (2013) '*Establishment of Groundwater Zones of Contribution, Clomantagh Killoshulan Group Water Scheme, Co. Kilkenny'.*

The Clomantagh Killoshulan GWS is supplied from a single spring located in Kyleballynamoe townland, approximately 1.3km to the southeast of the Proposed Wind Farm site. The spring is one of several springs that discharge into the Nuenna River along this stretch of river to the southeast of the Proposed Wind Farm site.

The scheme serves about 20 domestic connections with a reported average usage of approximately 70 m^3/day (approximately 15 hours pumping per day). The total spring discharge is estimated between 2000–4000 m^3/day. The spring water is chlorinated and there is access to an untreated water tap in the pump house.

Groundwater dye tracing carried out by Walsh (2011) established several positive links to the source spring from swallow holes located on the southern side of the Nuenna River valley but none on the northern side of the valley where the Proposed Wind Farm site is located.

Although there has been no positive link with the enclosed depressions within the Proposed Wind Farm site, GSI/Tobin (2013) states '*the catchment to the northeast of the GWS and Boiling Spring cannot be ruled out'.* The catchment to the northeast of the spring includes the southern portion of the Proposed Wind Farm site.

Infrastructure elements of the Proposed Wind Farm site inside the SoPA include 4 no. turbines locations (T1 to T4). Only Proposed Turbines T1 to T3 are located on limestone, T4 is located on mudstone.

Balief/Clomantagh GWS and Urlingford/Johnstown PWS source protection zones are located 1.3km and 3.2km respectively to the southwest of the Proposed Wind Farm site. There is no Proposed Wind Farm or Proposed Grid Connection infrastructure within either of these source protection areas. However, the TDR (R693) briefly passes through both source protection zones where some minor road alterations are required. There are 1 no. proposed accommodation works areas within each of the source protection areas.

In addition, the Proposed 110kV Underground Cabling passes through the Ballyconra Public Water Supply (PWS) source protection area for approximately 1.8km. The underground cable will be contained within the carriageway of the public road when inside the mapped groundwater protection area. The PWS source is a wellfield (4 no. boreholes) located approximately 0.85km to the southeast of the Proposed 110kV Underground Cabling.

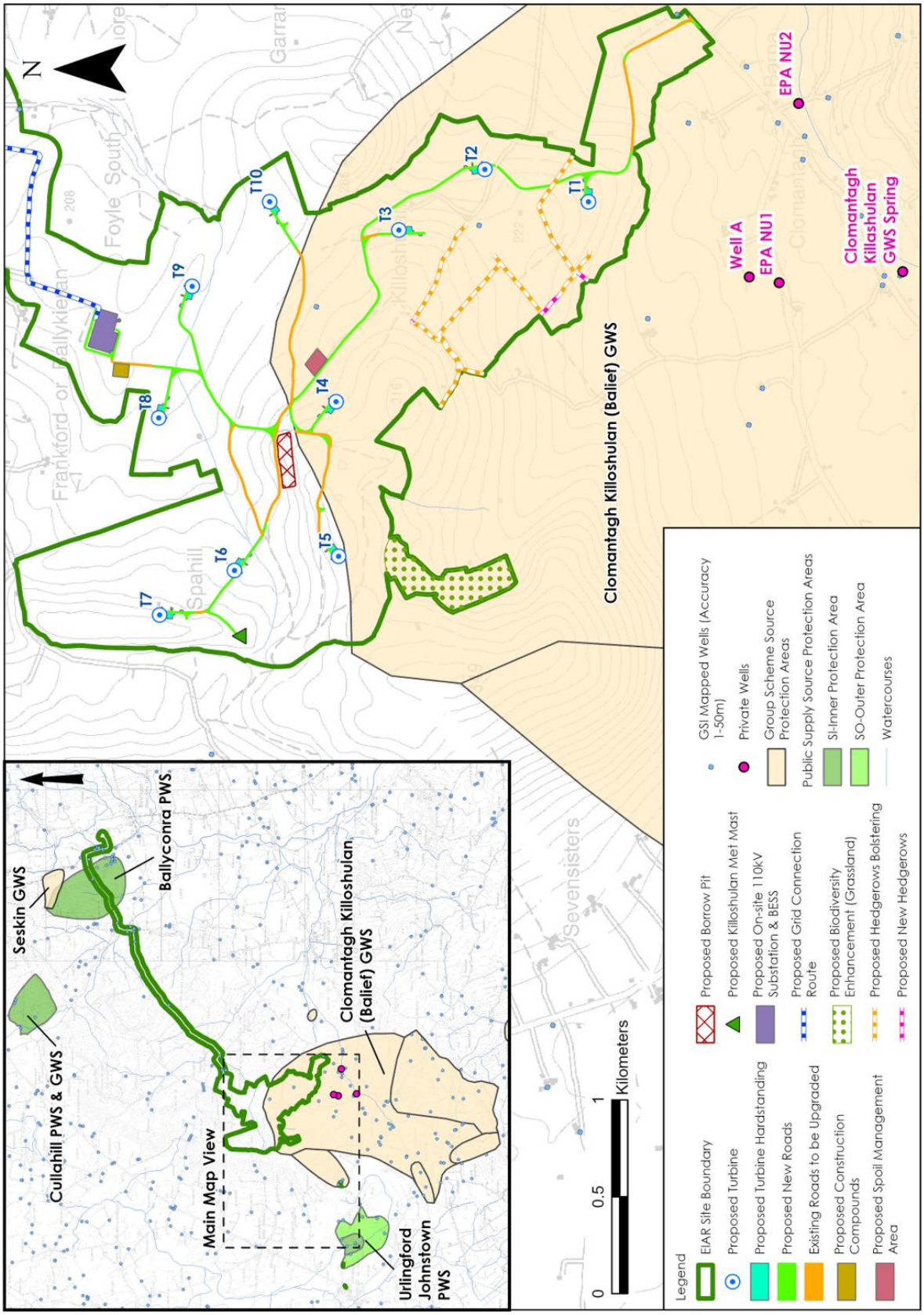


Figure 9-15: Groundwater Source Protection Areas & Groundwater Supplies.

9.3.15.2 Private Domestic Wells

A search of private well locations on the GSI well database (www.gsi.ie) shows there are several private wells (farm and domestic) located down-gradient of the Proposed Wind Farm site towards the general east. The wells consist of dug wells and boreholes. A high portion of the wells to the southeast are dug wells which is consistent with a shallow groundwater table and the presence of springs along the Nuenna River channel. Refer to **Figure 9-15** above for GSI mapped private wells.

Also located to the southeast of the Proposed Wind Farm site are 2 no. separate EPA groundwater monitoring locations which comprise of clusters of deep and shallow wells at each location (NU1 & NU2).

All the private wells located to the southeast of the Proposed Wind Farm site (including the EPA wells) exist within the mapped Clomantagh Killoshulan (Balief) GWS SoPA. From an impact assessment perspective these wells are assessed collectively in Section 9.5.2.1 below.

Due to the nature of the Proposed 110kV Underground Cabling being within the carriageway of public roads outside the Proposed Wind Farm site, no assessment on potential wells located along the Proposed 110kV Underground Cabling was carried out due to the lack of potential effects.

9.3.15.3 Surface Water Resources

The Proposed Project is located within the drinking water abstraction catchment (DWAC) for the Kilkenny City (Troyswood) Water Supply, with the abstraction point located approximately 17.7 km downstream on the River Nore (Nore_160). The abstraction point is on the Nore_160 and not the Nore_170 as stated by Uisce Eireann.

The separation distance is significant and the associated risk is low according to Uisce Eireann (refer to **Table 9-20** below).

9.3.16 Receptor Importance & Sensitivity

Due to the nature of Proposed Wind Farm and Proposed Grid Connection developments being near surface construction activities, impacts on groundwater are generally negligible and surface water is generally the main sensitive receptor assessed during impact assessments.

However, it is acknowledged that the southern portion of the Proposed Wind Farm site (including Proposed Turbines T1 to T3) is underlain by pure limestone which is mapped by the GSI as a Regionally Important Karstified Aquifer with an Extreme groundwater vulnerability rating. There are also surface karst features present at the Proposed Wind Farm site which may provide direct recharge pathways to the aquifer and downstream receptors such as the Nuenna River and Clomantagh/Killoshulan GWS source spring and other private wells.

The Regionally Important Karstified Aquifer is therefore of High Importance and can be considered very sensitive to effects. The importance classification is based on (NRA, 2008) criteria as shown on Table 9-2 and Table 9-3 above).

The primary risk to groundwater at the Site would be from sediment in runoff, hydrocarbon and cement spillage and leakages at excavations locations. These are common potential impacts at all construction sites (such as road works and industrial sites). These potential contamination sources will be carefully managed at the Site during the construction; operational and decommissioning phases of the Proposed Project and mitigation measures are proposed below to deal with these common hazards.

Any contaminants which may be accidentally released on the northern portion of the Proposed Wind Farm site (which is underlain by mudstone and poorly draining soils) are more likely to travel to nearby streams within surface water runoff. The relatively low permeability of the glacial deposits means contaminants are unlikely to reach the bedrock and will instead disperse with the glacial deposits and would remain localised to the source or would be removed as runoff during wet periods. The Poor Bedrock Aquifer on the north of the Proposed Wind Farm site is therefore of Low Importance and not likely to be sensitive to significant effects.

The majority of the Proposed 110kV Underground Cabling is within the carriageway of public roads and due to the shallow nature of the trench excavation, effects on groundwater quality/flows is not expected.

Surface water receptors such as the Foyle South Stream, Gorteenahilla Stream and Nuenna River are considered to have High Importance and sensitive to effects. The downstream River Nore, located 9km downstream of the Proposed Wind Farm site and along the Proposed 110kV Underground Cabling, also has High Importance, but due to the downstream distance from the Proposed Wind Farm site and large flows will be much less sensitive to significant effects.

It is acknowledged that the Clomantagh Killoshulan (Balief) GWS source is an important local water supply that serves a local population in the area, and that it is classified as an extremely sensitive water supply source. Considering the sources High Importance and potential sensitivity to impacts from the Proposed Project, specific hydrogeological investigation/monitoring was undertaken to assess the potential effects of the Proposed Project.

Balief/Clomantagh GWS and Urlingford/Johnstown PWS source are not hydrogeological connected to the Proposed Wind Farm or Proposed 110kV Underground Cabling and are therefore scoped out for further assessment.

Ballyconra Public Water Supply (PWS) source protection area is intercepted by the Proposed Grid Connection. However, due to the underground cable being within the carriageway of a public road within the source protection area, the shallow nature of the trench works (1.2m) and the setback distance from the supply boreholes (0.8km), the Ballyconra PWS is scoped out for further assessment as no effects are likely.

Similarly, the Kilkenny City (Troyswood) Water Supply abstraction from the River Nore is scoped out for further assessment due to its significant downstream from the Proposed Wind Farm (17.7km) and the large flows in the River Nore (Refer to Table 9-10) meaning no effects are likely due to dilution effects. Nonetheless, the mitigation proposed in this chapter will ensure protection of this source.

Mitigation measures, as outlined in Section 9.5 below, will ensure that surface runoff from the developed areas of the Site will be of a high quality and will therefore not impact on the quality of downstream surface water or groundwater bodies. Any introduced drainage works at the Site will mimic the existing hydrological/hydrogeological regime thereby avoiding changes to flow volumes leaving the Site.

Downstream designated sites such as the River Barrow and River Nore SAC have Extremely High Importance and very sensitive to effects. As assessed in Section 9.3.14 above, there is no surface water or groundwater connectivity with The Loughans SAC and the Proposed Wind Farm or the Proposed Grid Connection. However, the TDR (R693) briefly passes through surface water catchment of The Loughan turlough and is therefore scoped in for further assessment.

A hydrological/hydrogeological constraints map for the Proposed Wind Farm site is shown as **Figure 9-16**. The map shows that the majority of Proposed Wind Farm infrastructure, including all proposed turbine locations (with the exception of 3 no. watercourse crossings) are located away from areas on the Proposed Wind Farm site that have been determined to be hydrologically sensitive. This

has been illustrated by applying a 50m buffer to Foyle South Stream which flows through the Proposed Wind Farm site.

The large setback distance (>50m) from sensitive hydrological features means they will not be impacted by excavations/drains etc. It also allows adequate room for the proposed drainage mitigation measures (discussed below) to be properly installed up-gradient of primary drainage features. This will allow attenuation of surface runoff to be more effective.

Also, in line with GSI groundwater vulnerability mapping practices, a 30m[10] buffer has been applied to all swallow holes and enclosed depressions on the south of the Proposed Wind Farm site, where all Proposed Wind Farm drainage outfall will be located outside of these karst buffer zones.

Lastly, the potential north/south trending structural alignment running along the former T4 turbine location towards the enclosed depression alignment to the southeast is mapped as a hydrogeological constraint and no further development of turbines was considered for this area of the Proposed Wind Farm site.

[10] Please note a 15m buffer is required under the European Union (Good Agricultural Practice For Protection of Water) Regulations 2022 (S.I. 113/2022), therefore a 30m buffer is very conservative.

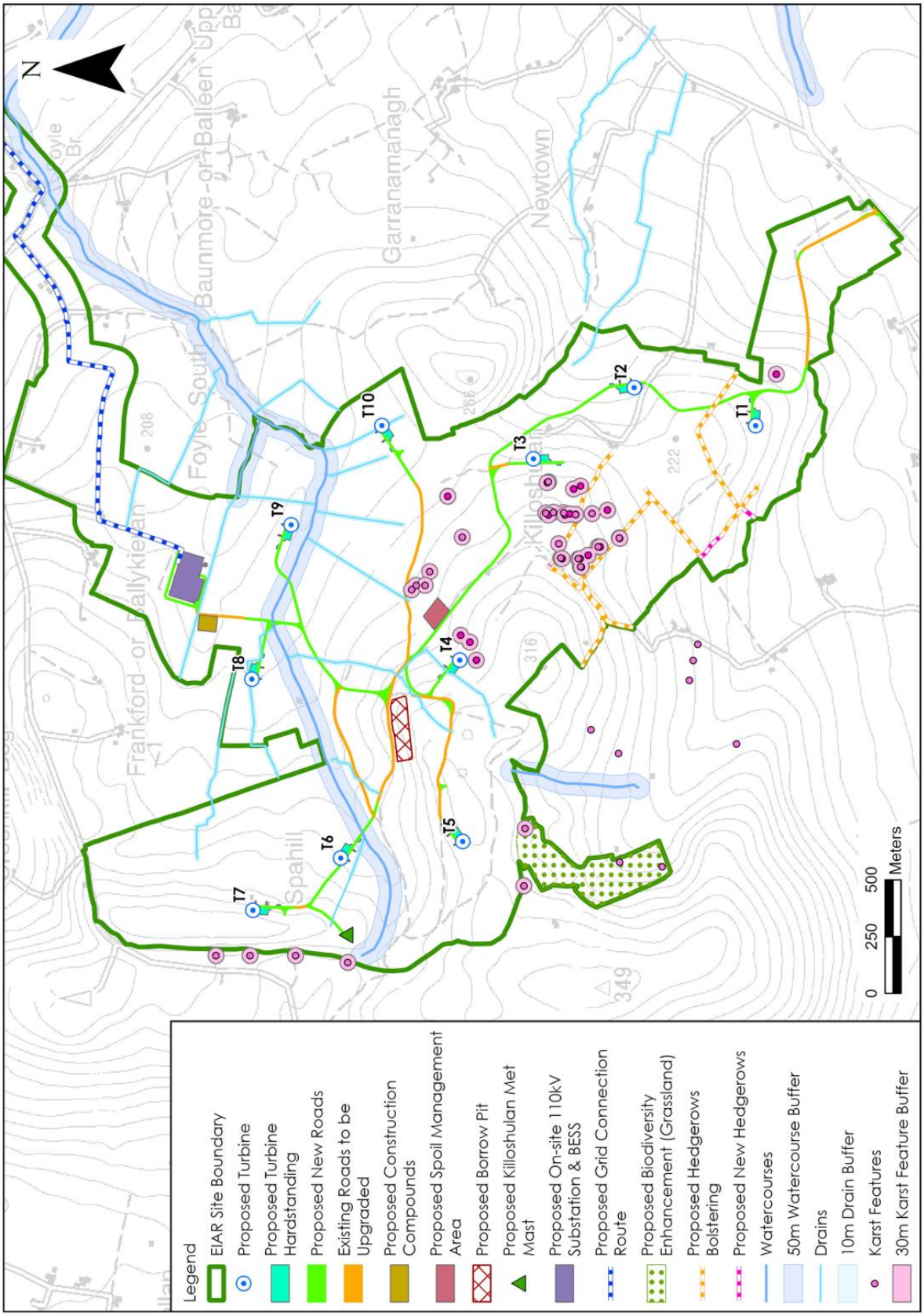


Figure 9-16: Hydrological and Hydrogeological Constraints Map.

9.4 Characteristics of the Proposed Project

Please refer to Section 4.1 of the EIAR for a description of the Proposed Project (i.e. Proposed Wind Farm and Proposed Grid Connection).

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

- Establishment of 2 no. temporary construction compounds, which will involve minor regrading of soil/subsoil and the emplacement of hardstand. Welfare facilities will be provided at the primary temporary construction 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 the excavate and replace technique. This will involve the use of aggregate from an on-site borrow pit;
- Construction of the 10 no. crane hardstand areas and turbine assemblage areas will utilise ground bearing foundations;
- 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;
- Grey water will be supplied by rainwater harvesting at the substation and water tankered to site where required. Bottled water will be used for potable supply;
- Construction of 10 no. turbine foundations, which are expected to be gravity foundation design;
- Cabling between turbine locations and the on-site substation will involve the excavation of a shallow trench (approximately 1.2m deep), placement of ducting and backfilling;
- Construction of 3 no. new watercourse (natural) crossings (clear span bridge design);
- Tree felling (27.5ha) for the purposes of turbine and access road construction clearance which will be carried out under felling licence;
- Establishment of 1 no. spoil repository area; and,
- Turbine haul route upgrade works along the R693 at 4 no. locations.

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

- Approximately 12.6km of an underground cabling route between the proposed 110kV substation and the existing Ballyragget substation involving the excavation of a double 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);
- Construction of the Proposed 110kV Substation with a subsoil bearing foundation. Welfare facilities will be provided at the substation ;
- Construction of a BESS at the Proposed 110kV Substation location;
- 5 no. existing watercourse bridge/culvert crossings along the public road section of the cable route with the cable being placed in the bridge/culvert decking or by means of Horizontal Directional Drilling (no in-stream works are proposed at any existing crossing location); and,
- Also, an underground cabling crosses under the River Nore near Ballyragget where horizontal directional drilling (HDD) will be employed to place the cable below the river channel to avoid any physical contact with the River Nore or the River Barrow and River Nore SAC.

9.4.1 Proposed Drainage Management

Runoff control and drainage management are key elements in terms of mitigation against impacts on surface water bodies. Two distinct methods will be employed to manage drainage water within the 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 Site that might carry silt or sediment, and nutrients, to route them towards stilling ponds prior to controlled diffuse release over vegetated surfaces. There will be no direct discharges to surface waters.

During the construction phase all runoff from works areas (i.e. dirty water) will be attenuated and treated to a high quality prior to being released. A schematic of the proposed site drainage management is shown as **Figure 9-17** below.

Also, due to the presence of enclosed depressions and swallow hole features at the Proposed Wind Farm site (refer to **Figure 9-10** above), all surface water drainage outfalls at level spreaders will be outside the 30m karst feature buffer zones. As stated previously, none of the potential enclosed depressions or swallow holes at the Proposed Wind Farm site show any significant hydrological/drainage function.

A detailed drainage plan showing the layout of the proposed construction and operational drainage design elements as shown in **Figure 9-17** and in **Appendix 4-3**.

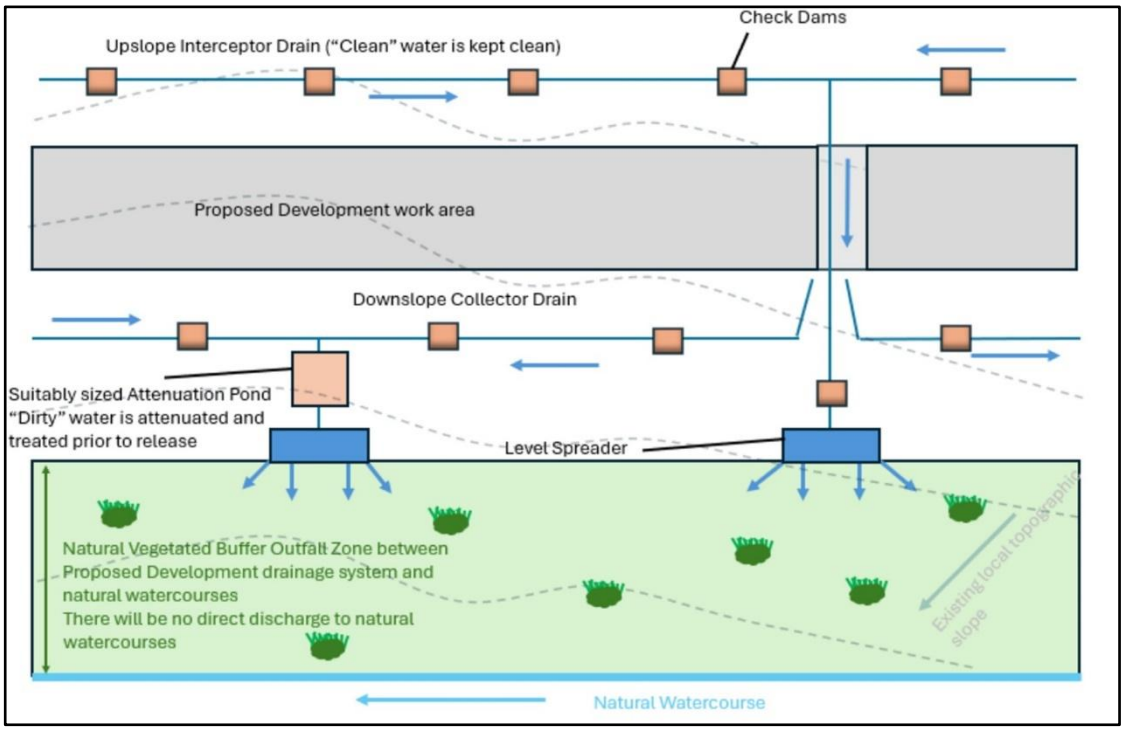


Figure 9-17: Schematic of the Proposed Drainage Management.

9.5 Likely Significant Effects and Mitigation Measures

The potential impacts of the Proposed Project and mitigation measures that will be put in place to eliminate or reduce them are set out below.

9.5.1 'Do-Nothing' Scenario

If the Proposed Project were not to proceed, the existing land use practices including forestry and agricultural activities will continue at the Site. Forestry will be felled as it reaches maturity. Re-planting of these areas with coniferous plantation is likely to occur. Surface water drainage carried out in areas of agriculture, forestry and bogland will continue to function and may be extended in some areas.

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

9.5.2 Construction Phase – Likely Significant Effects and Mitigation Measures

9.5.2.1 Potential Effects on the Clomantagh/Killoshulan (Balief) Group Water Scheme and Other Local Wells (Proposed Wind Farm)

Proposed Wind Farm infrastructure inside the mapped source protection area (SoPA) includes 4 no. turbines locations (T1 to T4). As stated previously only Proposed Turbine locations T1 to T3 are underlain by limestone bedrock. Proposed Turbine location T4 is underlain by mudstone bedrock as confirmed by site specific drilling.

From hydrogeological impact assessment interest, a detailed commentary of the site investigations carried out at Proposed Turbines T1 to T4 is provided in Section 9.3.9.3 above. The investigations demonstrate that Proposed TurbineT1 to T3 foundations can be constructed on competent limestone and away from the nearby identified potential subsurface karst features. Proposed Turbine T4 will be constructed on mudstone bedrock.

In terms of potential effects, quantity effects (i.e. flows/spring discharge volumes) could potentially arise due to deep excavations, dewatering etc in the bedrock aquifer that supplies groundwater to the spring and other private wells.

Due to the nature of the groundwater flows to the spring (i.e. likely deep bedrock conduit flow), significantly deep excavations, for example turbine base constructed below the top of bedrock, could have the potential to significantly affect flows to the source springs and other private wells.

Potential groundwater quality effects at the Site would be mainly from hydrocarbon and cement spillage and leakages as well as sediment in surface water runoff at excavations locations.

The likely magnitude of effects on the GWS (NRA, 2008), which is given a High Importance, is Small Adverse.

Pathways: Groundwater flowpaths, karst features and recharge (quality effects), and alteration/disruption of groundwater conduits/flowpaths in the bedrock aquifer (quantity and quality effects).

Receptors: Clomantagh/Killoshulan GWS and other local private wells within the GWS SoPA (refer to Section 9.3.15.2 above).

Pre-Mitigation Potential Impact: Negative, slight, indirect, temporary, unlikely effect on GWS and other local wells source quality and quantity.

Impact Assessment/Proposed Mitigation Measures:

Assessment of Quantitative Effect (i.e. flow volumes to the source springs) and Proposed Mitigation Measures

Groundwater level monitoring carried out at the Proposed Wind Farm site, show that groundwater levels are deep in the limestone, approximately 10 to 20mbgl (refer to **Figure 9-13** for illustration). The proposed turbine base excavations (gravity base foundation) will be a maximum 3mbgl. As stated previously, the proposed borrow pit is not located inside the SoPA and therefore no excavations deeper than 3m will be required within the SoPA (source protection area).

Therefore, there is no potential for disruption of groundwater flows towards the spring source by turbine base excavations.

Assessment of Quality Effect and Proposed Mitigation Measures

In order for potential contaminants (i.e. oils, fuels, cements, sediments etc) to reach the source abstraction point from the Proposed Wind Farm site construction areas, a groundwater flowpath (pathway) must be present. Karst features, which are present on the southern portion of the Proposed Wind Farm site, are potential pathways that have been thoroughly investigated; and avoided as part of Proposed Wind Farm layout.

Mitigation By Design:

Avoidance of Ground Surface Karst features:

All mapped enclosed depressions and swallow holes at the Proposed Wind Farm site have been avoided by the Proposed Wind Farm infrastructure.

All Proposed Wind Farm infrastructure surface water drainage outfalls at level spreaders will be located outside the 30m karst feature buffer zones (enclosed depressions and swallow holes).

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 outside of 30m karst feature buffer zones. Refer to Section 9.5.2.3 below for drainage mitigation details.

Avoidance of Subsurface Karst features:

Detailed drilling and geophysical surveys have been carried out to investigate the potential presence of sub surface karst features at Proposed Turbines T1 to T4.

Investigations carried out at the Proposed Turbines T1 to T2 identified potential subsurface karst features (clay infills) near both turbines (refer to Section 9.3.9.3 above for commentary on the investigations.
No evidence of karst was found at turbine location T3.

However, as illustrated on the annotated ERT and Seismic Refraction profile (**Appendix 8-5**), the T1 and T2 turbine foundations can be constructed on competent limestone and will have no interaction with any potential subsurface karst feature. The required cut and fill at each turbine location will also have no interaction with any potential subsurface karst feature (see following mitigation below). Turbine T3 will be constructed on competent limestone and turbine T4 on mudstone bedrock.

Cut and Fill Design Measures:

Due to the presence of shallow limestone bedrock in the areas around T1, T2, T3 and locally at T4, the proposed earthworks associated with the access roads and hardstands has been designed in such a way as to minimise the cutting (excavation) extents and depths. Where possible infilling is emphasised out over cut. Refer to **Table 8-13** of Chapter 8 (Land, Soils and Geology) which show that infill volumes significantly exceed cut volumes and therefore this mitigation approach has been achieved.

This preserves the existing overburden cover present above the limestone bedrock, maintaining the current topographic regime, and as such does not increase the risk of karst reactivation or exposure.

This has included a bespoke hardstand layout for turbine T3 which omits the blade fingers, in order to avoid significant cutting at this location. The alignment of the access roads has also avoided the mapped karst features in this area which lowers the risk of drainage associated with the access roads leading to reactivation of karst.

Construction Phase Karst Protocol:

A karst protocol, provided in Appendix E of the FT Karst Assessment Report shown in **Appendix 8-3** of the EIAR], has been developed to translate the karst risk to the construction stage. In all cases the formation level is to be checked by the Resident Engineer (RE) for any local soft / weak or loose areas. The RE is to be notified if any soft / weak or loose areas are identified.

Due to potential karst risks around Proposed Turbines T1 and T2 and extending along the access road towards turbine T4, the following investigations shall be carried out:

- Formations for embankments or cuttings to be proof rolled and observed for signs of weakness; and,
- Formations for structure (turbine) foundations to be proof rolled as above. The excavation shall be extended to rock head (where feasible) in areas where the karst risk is high or where evidence of karst features is encountered during overburden excavation.

Water Quality Protection/Pollution Prevention Measures:

The following mitigation is proposed at all construction works areas inside the Clomantagh/Killoshulan (Balief) GW SoPA:

- No storage of fuels, oils, cements, or chemicals will be permitted within the SoPA;
- Refuelling of mobile plant (i.e. diggers, dumpers etc) will only be permitted outside the SoPA;
- Refuelling of large immobile plant (i.e. cranes) will only be carried out with a refuelling truck that will be removed from SoPA immediately after use;
- Spill kit stations will be present at each turbine location (T1 to T4);
- A geotextile liner will be placed below the founding layer (lean mix concrete) where concrete is to be poured. These both prevent vertical loss of wet concrete at turbine bases;
- Use of perimeter shuttering at turbine bases to prevent lateral loss of wet concrete;
- All temporary cement washout lagoons will be located outside the SoPA;
- No wind farm drainage will be released inside the 30m karst buffer;
- There will be clear signage in place inside the SoPA to remind construction workers that the area is inside a drinking water protection area; and,
- A double silt fence perimeter will be placed around all nearby karst features.

In addition, engagement with local landowners will occur and downstream monitoring of local private wells will occur whilst construction activities take place.

Residual Effect: Due to the local hydrogeological and hydrological regime, along with the proposed design measures and mitigation measures, the residual effect is negative, imperceptible, indirect, temporary, unlikely effect on Clomantagh/Killoshulan GWS and other local wells source quality and quantity.

Significance of Effects: Due to the local hydrogeological/hydrological regime and with the application of the mitigation outlined above, no significant effects on the Clomantagh/Killoshulan GWS or local private wells will occur.

9.5.2.2 Clear Felling of Coniferous Plantation and Potential Surface Water Quality Effects (Proposed Wind Farm)

Felling works only relate to the Proposed Wind Farm element and not the Proposed Grid Connection. Only the Proposed Wind Farm is assessed herein.

In total, approximately 27.5 hectares of forestry (conifer plantation (WD4)) will be felled to accommodate Proposed Wind Farm infrastructure

Of the 27.5ha to be felled, only 0.0471ha is located inside a 50m watercourse buffer zone of the Foyle South Stream on the north of the Proposed Wind Farm site.

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

Potential impacts during tree felling occur mainly from:

- Exposure of soil and subsoils due to vehicle tracking 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.

The likely magnitude of effects on the river waterbodies (NRA, 2008), which are given a High Importance, is Negligible to Small Adverse.

Pathways: Drainage and surface water discharge routes.

Receptors: Surface waters (Foyle South Stream, Gorteenahilla Stream and Nuenna River) and associated dependent ecosystems.

Pre-Mitigation Potential Effect: Indirect, negative, imperceptible to slight, temporary, likely effect on surface water quality.

Proposed Mitigation Measures:

All felling operations will conform to current best practice Forest Service regulations, policies and strategic guidance documents as well as Coillte and DAFM guidance documents, including the specific

guidelines listed below, to ensure that felling, planting and other forestry operations result in minimal potential negative effects to the receiving environment.

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

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 9-21**.

Table 9-21: 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 Proposed Wind Farm construction phase a self-imposed buffer zone of 50 metres will be maintained for the Foyle South Stream where possible. These buffer zones are shown on **Figure 9-16** above. Only approximately 0.0471ha of tree felling is required inside a 50m buffer zone.

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 (i.e., handheld or mechanical) will be chosen which are most suitable for ground conditions 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 (approximately 0.3%-3% gradient), to minimise flow velocities. Main drains to take the discharge from collector drains will include water drops and rock armour, as required, where there are steep gradients, and will avoid being placed at right angles to the contour;

- Sediment traps will be sited in drains downstream of felling areas. Machine access will be maintained to enable the accumulated sediment to be excavated. Sediment will be carefully disposed of in the peat disposal areas. Where possible, all new silt traps will be constructed on even ground and not on sloping ground;
- All drainage channels will taper out before entering the 50m buffer zone. This ensures that discharged water gently fans out over the buffer zone before entering the aquatic zone, with sediment filtered out from the flow by ground vegetation within the zone. On erodible soils, silt traps will be installed at the end of the drainage channels, to the outside of the buffer zone;
- Drains and silt traps will be maintained throughout all felling works, ensuring that they are clear of sediment build-up and are not severely eroded. Correct drain alignment, spacing and depth will ensure that erosion and sediment build-up are minimized and controlled;
- Brash mats will be used to support vehicles on soft ground, reducing peat and mineral soils erosion and avoiding the formation of rutted areas, in which surface water ponding can occur. Brash mat renewal will take place when they become heavily used and worn. Provision will be made for brash mats along all off-road routes, to protect the soil from compaction and rutting. Where there is risk of severe erosion occurring, extraction will be suspended during periods of high rainfall;
- Timber will be stacked in dry areas, and outside a local 50 metre watercourse buffer. Straw bales and check dams to be emplaced on the down gradient side of timber storage/processing sites;
- Works will be carried out during periods of no, or low rainfall, in order to minimise entrainment of exposed sediment in surface water run-off;
- Checking and maintenance of roads and culverts will be on-going through the felling operation;
- Refuelling or maintenance of machinery will not occur within 50m of a watercourse. Mobile bowser, drip kits, qualified personnel will be used where refuelling is required;
- A permit to refuel system will be adopted;
- 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;
- Crossing of streams will not be permitted;
- Trees will be cut manually from along streams and using machinery to extract whole tree; and,
- Travel only perpendicular to and away from stream.

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 pre-felling inspections and after:

- Communication with tree felling operatives in advance to determine whether any areas have been reported where there is unusual water logging or bogging of machines;
- Inspection of all areas reported as having unusual ground conditions;
- Inspection of main drainage ditches and outfalls. During pre-felling inspections, the main drainage ditches shall be identified. Ideally the pre-felling inspection shall be carried out during rainfall;

- Following tree felling all main drains shall be inspected to ensure that they are functioning;
- Extraction tracks near drains need to be broken up and diversion channels created to ensure that water in the tracks spreads out over the adjoining ground;
- Culverts on drains exiting in 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 commencing, preferably in medium to high water flow conditions. The "during" sampling will be undertaken once a week or after rainfall events. The 'after' sampling will comprise as many samplings as necessary to demonstrate that water quality has returned to pre-activity status (i.e., where an impact has been shown).

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

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

Also, daily surface water monitoring forms will also be utilised at every works site near any watercourse. These will be taken daily and kept on site for record and inspection.

Residual Effect: The potential for the release of suspended solids to watercourse receptors during tree felling is a risk to water quality and the aquatic quality of the receptor. Proven forestry best practice measures to mitigate the risk of releases of sediment have been proposed above and will break the pathway between the potential sources and the receptor. The mitigation measures will ensure that surface water runoff from the site will be equivalent to baseline conditions and will therefore have no potential impact on the status, ecology or hydromorphology of downstream waters.

The residual effect of the Proposed Wind Farm will be negative, imperceptible, indirect, temporary, likely effect on downstream water quality and aquatic habitats.

Significance of Effects: With the application of the mitigation outlined above, no significant effects on the surface water quality will occur.

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

There will be earthworks required for both the Proposed Wind Farm and Proposed Grid Connection (Proposed Project) and therefore both are assessed herein.

Proposed Project construction phase activities that will require earthworks resulting in the removal of vegetation cover and excavation of soil and mineral subsoil (where present) are detailed in Chapter 4 the Description of the Proposed Project. Potential sources of sediment laden water include:

- Drainage and seepage water resulting from infrastructure excavation;
- Stockpiled excavated material providing a point source of exposed sediment;
- Construction of the underground cable trench resulting in the entrainment of sediment from the excavations during construction; and,
- Erosion of sediment from emplaced site drainage channels.

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

The likely magnitude of effects on the river waterbodies (NRA, 2008), which are given a High Importance, is assessed as Small Adverse to Moderate Adverse

Pathways: Drainage and surface water discharge routes.

Receptors: Down-gradient streams and rivers (Foyle South Stream, Nuenna River, Lisdowney Stream and Gorteenahilla Stream and River Nore) and dependent ecosystems.

Pre-Mitigation Potential Effect: Indirect, negative, moderate to significant, short-term, likely effect on surface water quality.

Mitigation by Avoidance:

The key mitigation measure during the construction phase of the Proposed Wind Farm is the avoidance of sensitive aquatic areas where possible from **Figure 9-16** it can be seen that all of the key areas of the Proposed Wind Farm infrastructure are actually significantly away from the 50m delineated buffer zones with the exception of proposed new roads, 3 no. proposed crossings on the Foyle South Stream.

Additional control measures, which are outlined further on in this section, will be undertaken at these locations within buffers.

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 operated effectively. The proposed buffer zone will:

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

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 appropriate systems.

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

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

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

- Apart from interceptor drains, which will convey clean runoff water to the downstream drainage system, there will be no direct discharge (without treatment for sediment reduction, and attenuation for flow management) of runoff from the Proposed Project drainage into the existing site drainage network. This will reduce the potential for any increased risk of downstream flooding or sediment transport/erosion;
- Silt traps will be placed in the existing drains upstream of any streams where construction works / tree felling is taking place, and these will be diverted into proposed interceptor drains, or culverted under/across the works area;
- Runoff from individual turbine hardstanding areas will not be discharged into the existing drain network but discharged locally at each turbine location through stilling ponds and buffered outfalls onto vegetated surfaces;
- Buffered outfalls which will be numerous over the site will promote percolation of drainage waters across vegetation and close to the point at which the additional runoff is generated, rather than direct discharge to the existing drains of the site; and,
- Drains running parallel to the existing roads requiring widening will be upgraded, widening will be targeted to the opposite side of the road. 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.

Pre-commencement Temporary Drainage Works

Prior to the commencement of new road/hardstand (or road upgrades) the following key temporary drainage measures will be installed:

- All existing dry drains that intercept the proposed works area will be temporarily blocked down-gradient of the works using temporary check dams/silt traps;
- Clean water diversion drains will be installed upgradient of the works areas;
- Check dams/silt fence arrangements (silt traps) will be placed in all existing drains that have surface water flows and also along existing roadside drains; and,
- A double silt fence perimeter will be placed down-slope of works areas that are located inside the 50m watercourse and 10m drain buffer zones such as at watercourse crossings.

Water Treatment Train:

A final line of defence will be provided by a water treatment train such as a "Siltbuster". If the discharge water from construction areas fails to be of a high quality during regular inspections, then a filtration treatment system (such as a 'Siltbuster' or similar equivalent treatment train (sequence of water treatment processes) will be used to filter and treat all surface discharge water collected in the dirty water drainage system. This will apply for all of the construction phase.

Silt Fences:

Silt fences will be emplaced within drains down-gradient of all construction areas. Silt fences are effective at removing heavy settleable solids. This will act to prevent entry to water courses of sand and gravel sized sediment, released from excavation of mineral sub-soils of glacial and glacio-fluvial origin, and entrained in surface water runoff. Inspection and maintenance of these 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 placed within drains down-gradient of all construction areas inside the 50m 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, the majority of the sediment is retained by the geotextile fabric allowing filtered water to pass through. Silt bags will be used with natural vegetation filters or sedimats Sediment entrapment mats, consisting of coir or jute matting, will be placed at the silt bag location to provide further treatment of the water outfall from the silt bag. Sedimats will be secured to the ground surface using stakes/pegs. The sedimat will extend to the full width of the outfall to ensure all water passes through this additional treatment measure.

Settlement Ponds:
The Proposed Wind Farm infrastructure footprint has been divided into drainage catchments (based on topography, outfall locations, and catchment size) and stormwater runoff rates based on the 10-year return period rainfall event were calculated for various catchment areas in order to size the settlement ponds as shown in **Table 9-22** below.

The 10-year return period rainfall event is a recommendation of the IFI relating to other recent wind farm projects (i.e. Cahermurphy Wind Farm, Co. Clare - Planning Ref P20/658).

The location and dimensions of proposed settlement ponds are shown on the Proposed Wind Farm site drainage plan drawings (**Appendix 4-2**).

Table 9-22: Settlement Pond Design.

POND SIZE W [M] X L [M] X D [M]			TRACK/HARDSTAND CATCHMENT SIZE (M^2)		
RETURN PERIOD	10 YRS	STORM DURATION	500	1000	2000
6HR RETENTION FOR COARSE SILT		6 HRS	3.4 X 10.6 X 1 M	4.8 X 15.0 X 1 M	6.9 X 21.0 X 1 M
11HR RETENTION FOR MEDIUM SILT		12 HRS	3.8 X 12.0 X 1 M	5.5 X 16.5 X 1 M	7.5 X 24.2 X 1 M
24HR RETENTION FOR FINE SILT		24 HRS	4.2 X 13.8 X 1 M	6.2 X 18.6 X 1 M	8.6 X 27.0 X 1 M

Level Spreaders and Vegetation Filters:
The purpose of level spreaders is to release treated drainage flow in a diffuse manner, and to prevent the concentration of flows at any one location thereby avoiding erosion. Level spreaders are not intended to be a primary treatment component for development surface water runoff. They are not stand-alone but occur as part of a treatment train of systems that will reduce the velocity of runoff prior to be released at the level spreader. In the absence of level spreaders, the potential for ground erosion is significantly greater than not using them.

Vegetation filters are essentially end-of-line polishing filters that are located at the end of the treatment train. In fact, vegetation filters are ultimately a positive consequence of not discharging directly into watercourses which is one of the mitigation components of the drainage philosophy. This makes use of the natural vegetation of the Site to provide a polishing filter for the Wind Farm drainage prior to reaching the downstream watercourses.

Again, vegetation filters are not intended to be a single or primary treatment component for treatment of works area runoff. They are not standalone but are intended as part of a treatment train of water quality improvement/control systems (i.e. source controls→check dams→silt traps→settlement ponds→level spreaders →silt fences→vegetation filters).

Pre-emptive Site Drainage Management

The works programme for the entire construction stage of the Proposed Project 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 provides a 24-hour telephone consultancy service. The forecaster will provide an interpretation of weather data and give the best available forecast for the area of interest.

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

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

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

Management of Runoff from the Spoil Management Area:
It is proposed that excavated spoil will be used for landscaping where required. The excess material will then be placed in 1 no. Spoil Management Area.

The Spoil Management Area is located outside of 50m watercourse buffers and also outside of 30m karst feature buffers (enclosed depression or sink holes).

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

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

Drainage from spoil storage areas will ultimately be routed to an oversized swale and a number of stilling ponds with appropriate storage and settlement designed for a 1 in 10-year return period before being discharged to the on-site drains.

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

Timing of Site Construction Works:

Construction of the 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 construction 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. Checks will be carried out on a daily basis.

During the construction phase field testing and laboratory analysis of a range of parameters with relevant regulatory limits and EQSs will be undertaken for each primary watercourse, and specifically following heavy rainfall events (as per the CEMP is included in **Appendix 4-3** of this EIAR).

Residual Effect: 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 mitigation measures will ensure that surface water runoff from the site will be equivalent to baseline conditions and will therefore have no potential impact on the status, ecology or hydromorphology of downstream waters.

The residual effects of the Proposed Project will be negative, imperceptible, indirect, short-term, likely effect on down-gradient rivers, water quality, and dependent ecosystems.

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

9.5.2.4 Potential Impacts on Groundwater Levels During Excavations (Proposed Project)

There will be excavations required for both the Proposed Wind Farm and Proposed Grid Connection (Proposed Project) and therefore both are assessed herein.

Dewatering of the deepest excavations (i.e., turbine bases and borrow pit) have the potential to impact only briefly on local groundwater levels temporarily during construction works.

Groundwater level impacts will only be brief and temporary. Effects will not be significant due to the temporary nature of the works and local geological and hydrogeological regime as outlined below.

Trench excavations along the Proposed 110kV Underground Cabling are shallow (0 – 1.5m below ground level) and therefore not likely to impact groundwater levels. In addition, horizontal directional drilling (HDD) at the watercourse crossings will have no potential to affect groundwater levels as no pumping is required.

The likely magnitude of effects on the groundwater bodies (NRA, 2008), which are given a Medium to High Importance, is assessed as Negligible to Small Adverse.

Pathway: Groundwater flowpaths.

Receptor: Groundwater levels (Lisdowney GWB, Durrow GWB, Kilkenny-Ballynakill Gravels GWB and Rathdowney GWB and local bedrock aquifers)

Pre-Mitigation Potential Effect: Direct, negative, imperceptible to slight, brief, likely effect on local GWBs. No significant effects on the GWBs will occur due to the small dewatering requirements.

Impact Assessment:

No groundwater level impacts are predicted from the construction of the Proposed Grid Connection (including Proposed 110kV Substation, Proposed BESS or HDD) infrastructure due to the shallow nature of the excavations (i.e. 0 -approximately 1.5m).

Turbine foundations will be gravity base, with a maximum depth of 3mbgl. On the south of the Proposed Wind Farm no dewatering will be required at Proposed Turbine location T1 to T4, due to deep groundwater levels within the limestone bedrock (>10mbgl) or mudstone bedrock (T4).

Also, due to the low permeability nature of the glacial till overburden (CLAY/SILT) and underlying poorly productive SILTSTONE/MUDSTONE bedrock on the north of the Proposed Wind Farm site, significant groundwater inflows into turbine excavations (T5 to T10) or the proposed borrow pit will not occur.

In addition, any effects on groundwater levels will only be for a temporary basis during the foundation construction work. Groundwater level effects are unlikely to be significant beyond 10m from the turbine base excavation. Gravity foundations are proposed at all Proposed Turbine locations.

Residual Effect: Due to the prevailing hydrogeology at the Site, the local and temporary nature of the proposed works, the residual effects of the Proposed Project on groundwater levels will be negative, imperceptible, direct, brief, likely effect.

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

9.5.2.5 Excavation Dewatering and Potential Impacts on Surface Water Quality (Proposed Project)

Pumping water from excavations might be required for both the Proposed Wind Farm and Proposed Grid Connection (Proposed Project) and therefore both are assessed herein.

Some minor groundwater/surface water seepages will likely occur in turbine base excavations and cabling trenches, and this will create additional volumes of water to be treated by the runoff management system. Cable trenching might require removal of water prior to backfilling.

Inflows will likely require management and treatment to reduce suspended sediments. No contaminated land was noted at the Site and therefore baseline contamination does not occur.

The likely magnitude of effects on river waterbodies (NRA, 2008), which are given a High Importance, is assessed as Small Adverse.

Pathway: Overland flow and site drainage network.

Receptor: Down-gradient surface water bodies (Foyle South Stream, Lisdowney Stream, Nuenna River and Gorteenahilla Stream)

Pre-Mitigation Potential Impact: Indirect, negative, slight to moderate, temporary, likely effect to surface water quality.

Proposed Mitigation Measures:

Management of excavation inflows 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 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 silt bags or silt buster;
- There will be no direct discharge to surface watercourses, and therefore no risk of hydraulic loading or contamination will occur;
- Daily monitoring of excavations by a suitably qualified person will occur during the construction phase. If high levels of seepage inflow occur, excavation work will immediately be stopped and a geotechnical assessment undertaken;
- At the turbine locations adequately sized settlement ponds will be constructed to treat pumped water prior to discharge into a local manmade drain;
- A mobile 'Siltbuster' or similar equivalent specialist treatment system can be made available at turbine locations for emergencies in order to treat sediment polluted waters from settlement ponds or excavations should they occur. Siltbusters are mobile silt traps that can remove fine particles from water using a proven technology and hydraulic design in a rugged unit. The mobile units are specifically designed for use on construction-sites. They will be used as final line of defence if needed.

Residual Effect: 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 of the Proposed Project will be negative, imperceptible, indirect, temporary, likely effect on local surface water quality.

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

9.5.2.6 Potential Release of Hydrocarbons During Construction and Storage (Proposed Project)

Hydrocarbons will be required for both the Proposed Wind Farm and Proposed Grid Connection (Proposed Project) and therefore both are assessed herein.

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.

The likely magnitude of effects on river waterbodies and groundwater bodies (NRA, 2008), which are given a Medium to High Importance, is assessed as Small Adverse

Pathway: Groundwater flowpaths and site drainage network.

Receptor: Groundwater (Lisdowney GWB, Durrow GWB, Kilkenny-Ballynakill Gravels GWB and Rathdowney GWB and local bedrock aquifers) and surface water (Foyle South Stream, Lisdowney Stream, Nuenna River and Gorteenahilla Stream)

Pre-Mitigation Potential Effect:

Indirect, negative, slight to moderate, short term, unlikely effect to local groundwater quality and surface water quality.

Proposed Mitigation Measures:

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

- On site re-fuelling of machinery will be carried out using a dedicated fuel truck. The fuel truck will also carry fuel absorbent material and pads in the event of any accidental spillages;
- Mobile measures such as drip trays and fuel absorbent mats will be used during all refuelling operations;
- On-site refuelling will be carried out by trained personnel only;
- A permit to fuel system will be put in place;
- Fuels stored on site will be minimised. Fuel storage areas if required will be bunded appropriately for the fuel storage volume for the time period of the construction and fitted with a storm drainage system and an appropriate oil interceptor;
- The plant used during construction will be regularly inspected for leaks and fitness for purpose; and,
- An emergency plan for the construction phase to deal with accidental spillages will be included within the Construction and Environmental Management Plan (**Appendix 4-3**). Spill kits will be available to deal with and accidental spillage in and outside the re-fuelling area.

Residual Effect: The potential for the release of hydrocarbons to groundwater and watercourse receptors is a risk to surface water and groundwater quality, and also the aquatic quality of the surface water receptors. Proven and effective measures to mitigate the risk of releases of hydrocarbons have been proposed above and will break the pathway between the potential source and each receptor. The mitigation measures will ensure that surface water runoff from the site will be equivalent to baseline conditions and will therefore have no potential impact on the status or ecology of downstream waters.

The residual effect of the Proposed Project will be negative, imperceptible, indirect, short-term, unlikely impact to local surface water and groundwater quality.

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

9.5.2.7 Groundwater and Surface Water Contamination from Wastewater Disposal (Proposed Project)

Wastewater management will be required for both the Proposed Wind Farm and Proposed Grid Connection (Proposed Project) and therefore both are assessed herein.

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.

The likely magnitude of effects on river waterbodies and groundwater bodies (NRA, 2008), which are given a Medium to High Importance, is assessed as Small Adverse to Moderate Adverse.

Pathway: Groundwater flowpaths and site drainage network.

Receptor: Groundwater quality (Lisdowney GWB, Durrow GWB, Kilkenny-Ballynakill Gravels GWB and Rathdowney GWB and local bedrock aquifers) and surface water quality (Foyle South Stream, Lisdowney Stream, Nuenna River and Gorteenahilla Stream)

Pre mitigation Effect:

Indirect, negative, moderate, temporary, unlikely effect to surface water quality and surface water quality.

Proposed Mitigation Measures:

- It is proposed to manage wastewater from the staff welfare facilities in the control buildings by means of a sealed storage tank, with all wastewater being tankered off site by permitted waste collector to wastewater treatment plants. It is not proposed to treat wastewater on-site.

Residual Effect: No residual effects of the Proposed Project.

Significance of Effects: No significant effects on surface water or groundwater quality will occur.

9.5.2.8 Release of Cement-Based Products

Cement will be required for both the Proposed Wind Farm and Proposed Grid Connection (Proposed Project) and therefore both are assessed herein.

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 ± 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 on site and washing out of transport and placement machinery are the activities most likely to generate a risk of cement-based pollution.

The likely magnitude of effects on river waterbodies and groundwater bodies (NRA, 2008), which are given a Medium to High Importance, is assessed as Small Adverse to Moderate Adverse.

Pathway: Site drainage network.

Receptor: Surface water hydrochemistry.

Pre-Mitigation Effect: Indirect, negative, moderate, short term, unlikely effect to surface waters (Foyle South Stream, Lisdowney Stream, Nuenna River and Gorteenahilla Stream) and GWBs (Lisdowney GWB, Durrow GWB, Kilkenny-Ballynakill Gravels GWB and Rathdowney GWB).

Proposed Mitigation Measures:

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

Residual Effect: The potential for the release of cement-based products or cement truck wash water to groundwater and watercourse receptors is a risk to surface water and groundwater quality, and also the aquatic quality of the surface water receptors. Proven and effective measures to mitigate the risk of releases of cement-based products or cement truck wash water have been proposed above and will break the pathway between the potential source and each receptor. The mitigation measures will ensure that surface water runoff from the Site will be equivalent to baseline conditions and will therefore have no potential impact on the status or ecology of downstream waters. The residual effect will be negative, imperceptible, indirect, short-term, unlikely effect to surface water quality.

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

9.5.2.9 Morphological and Hydrological Effects due to New Watercourse Crossing Works (Proposed Wind Farm)

New watercourse crossings (i.e. bridges/culverts) or upgrades of existing crossings will only be required at the Proposed Wind Farm site and not the Proposed Grid Connection. Only the Proposed Wind Farm is assessed herein.

Diversion, culverting and bridge crossing of surface watercourses can result in morphological changes, changes to drainage patterns and alteration of aquatic habitats. Construction of structures over water

courses has the potential to significantly interfere with water quality and flows during the construction phase.

Construction of 3 no. new watercourse crossing (clear span bridge design) and will be required to facilitate the Proposed Wind Farm Site development infrastructure. Crossings are required on the Foyle South Stream (3 no.).

The likely magnitude of effects on river waterbodies (NRA, 2008), which are given a High Importance, is assessed as Negligible to Small Adverse.

Pathway: Site drainage network.

Receptor: Surface water flows (Foyle South Stream), stream morphology and water quality.

Pre-Mitigation Potential Impact: Negative, direct, imperceptible to slight, long term, likely effect on surface water flows and drainage patterns.

Proposed Mitigation Measures:

- All proposed 3 no. new stream crossings will be bottomless or clear span structures and the existing banks will remain undisturbed. No in-stream excavation works are proposed and therefore there will be no direct impact on the stream at the proposed crossing location;
- Where the proposed cable route follows an existing road or road proposed for upgrade, the cable will pass over or below the culvert within the access road;
- All guidance / mitigation measures proposed by the OPW or the Inland Fisheries Ireland11 is incorporated into the design of the proposed crossings;
- As a further precaution, near stream construction work, will only be carried out during the period permitted by Inland Fisheries Ireland for in-stream works according to the Eastern Regional Fisheries Board (2004) guidance document "Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites", i.e., May to September inclusive. This time period coincides with the period of lowest expected rainfall, and therefore minimum runoff rates. This will minimise the risk of entrainment of suspended sediment in surface water runoff, and transport via this pathway to surface watercourses (any deviation from this will be done in discussion with the IFI);
- During the near stream construction work double row silt fences will be emplaced immediately down-gradient of the construction area for the duration of the construction phase. There will be no batching or storage of cement allowed in the vicinity of the crossing construction areas; and,
- All new river/stream crossings will require a Section 50 application (Arterial Drainage Act, 1945). The river/stream crossings will be designed in accordance with OPW guidelines/requirements on applying for a Section 50 consent.

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

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

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

9.5.2.10 Potential Hydrological Effects on Designated Sites (Proposed Project)

Designated sites are located downstream to both the Proposed Wind Farm and Proposed Grid Connection. Therefore, both are assessed herein.

The River Barrow and River Nore SAC (Site Code:002162) is located approximately 9km to the east and downstream of the Proposed Wind Farm site via the Nuenna River.

Also, the Proposed 110kV Underground Cabling crosses under the River Nore near Ballyragget where horizontal directional drilling (HDD) will be employed to place the cable below the river channel to avoid any physical contact with the river or the River Barrow and River Nore SAC.

As assessed in Section 9.3.14 above, there is no surface or groundwater connectivity with The Loughans SAC and the Proposed Wind Farm or the Proposed Grid Connection, but the TDR works are located within the Loughans turlough catchment.

The likely magnitude of effects on SACs (NRA, 2008), which are given an Extremely High Importance, is assessed as Negligible

Pathway: Surface water and groundwater flowpaths.

Receptor: River Barrow and River Nore SAC and The Loughans SAC.

Pre-Mitigation Potential Effect: Indirect, negative, imperceptible, short-term, likely effect on downstream SACs.

Impact Assessment & Proposed Mitigation Measures:

Drainage mitigation measures for surface water quality protection during the construction phase are summarised again below: (Please refer to Sections 9.5.2.2, 9.5.2.3 & 9.5.2.5 above for the full description of these measures and how they will be applied).

- The proposed mitigation measures which will include 50m buffer zones for avoidance of sensitive hydrological features (streams and rivers);
- 30m karst feature buffers;
- Pre-construction drainage control measures;
- Robust drainage control measures (i.e. interceptor drains, swales, settlement ponds and treatment trains such as Siltbuster) will ensure that the quality of runoff from Proposed Project areas will be very high;
- Best practice measures with regard use of oils, fuels (Section 9.5.2.6) and cement-based compounds (Section 9.5.2.8);
- Mitigation relating to HDD works are presented in Section 9.5.2.15 below which will be applied during the River Nore crossing; and
- Pre-commencement Temporary Drainage Works (Section 9.5.2.3) will be used at the TDR works areas.

As stated in Section 9.5.2.2 above, there could potentially be a residual “imperceptible, short term, likely effect” 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 downstream The River Barrow and River Nore SAC will not occur. No effects to The Loughans SAC are likely either.

Residual Effect: No effects on local designated sites from the Proposed Project.

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

9.5.2.11 Potential Effects on Local Groundwater Well Supplies from Excavations (Proposed Project)

There will be excavations required for both the Proposed Wind Farm and Proposed Grid Connection (Proposed Project) and therefore both are assessed herein.

In the area of the Proposed Wind Farm site, private dwelling houses (potential well locations) are mainly located along public roads to the southeast and northeast of the Proposed Wind Farm site.

Please refer above to the impact assessment carried out for the Clomantagh/Killoshulan GWS ZoC (Section 9.5.2.1) which also applies to potential private wells located to the southeast of the Proposed Wind Farm site. All the private wells located to the southeast of the Proposed Wind Farm are also located in the Clomantagh/Killoshulan GWS ZoC and are assessed collectively with the GWS. Likewise, all proposed mitigation for the GWS also applies to the private wells.

Construction of the Proposed Grid Connection will not have the potential to affect local wells due to the shallow nature of the works at the substation, cable route and end mast locations.

Groundwater flow direction on the north of the Proposed Wind Farm site (i.e. Proposed Turbines T5 to T10, as well as the proposed borrow pit) are expected to be easterly/northeasterly based on topography due to localised groundwater flows in the poor bedrock aquifer (30 - 300m flowpaths are likely).

The closest distance between a Proposed Turbine location and a downstream dwelling house (potential well) on the north of the Proposed Wind Farm site is >740m. In order to be conservative and following the worst-case assumption, we have assumed that all dwellings in the surrounding lands have a private groundwater well.

However, due to the relatively shallow nature of the deepest excavations (3 – 10m), the >740m setback distance from potential wells and short groundwater flowpaths (<300m), significant effects on private wells are unlikely on the north of the Proposed Wind Farm site.

The likely magnitude of effects on local wells (NRA, 2008), which are given a Medium Importance, is assessed as Negligible

Pathway: Groundwater flowpaths.

Receptor: Private Groundwater Supplies.

Pre-Mitigation Potential Impact: Negative, imperceptible, indirect, short-term, unlikely effect on local wells.

Impact Assessment:

It has been assessed that the Proposed Project site will not impact in any significant way on any potential down-gradient private wells to the northeast of the Proposed Wind Farm site for the following reasons:

- The large set back distances between turbine locations and downstream potential well locations (>740m);
- Short groundwater flowpaths (<300m);
- The proposed project will involve relatively shallow excavations (3 – 10mbgl) where ground elevations are high (>200m OD);
- The low permeability of the glacial deposits in which the turbine gravity base foundations will be constructed;
- The low recharge characteristics of the underlying SILTSTONE/MUDSTONE aquifer that underlies the north of the Proposed Wind Farm site;

- Localised groundwater flow patterns in the glacial deposits which is towards local streams that flow through the Site;
- Groundwater flow patterns are expected towards the watercourses that drain the Proposed Wind Farm site; and,
- The shallow excavation depths required for Proposed 110kV Underground Cabling , Proposed 110kV Substation and Proposed BESS.

'Spa Well' which has an archaeological/heritage significance is located on the far northwest of the Proposed Wind Farm site. There are no Proposed Turbine locations upslope of the spring and therefore no effects on Spa Well are expected. The closest Proposed Turbine (T7) is approximately 300m away from Spa Well. A high ridge of mudstone bedrock separates Spa Well from Proposed Turbine T7.

Residual Effects: For the reasons outlined in the impact assessment above (separation distances, and prevailing geology, topography and groundwater flow directions), it has been assessed the Proposed Project has no potential to impact on local groundwater wells.

Significance of Effects: For the reasons outlined above, no impacts on groundwater supplies will occur.

9.5.2.12 Turbine Delivery Route Works (Proposed Wind Farm)

TDR works will only be required for Proposed Wind Farm and not the Proposed Grid Connection. Only the Proposed Wind Farm is assessed herein.

Minor earthworks are required for the TDR. These include for temporary accommodation works at 4 no. locations along the R693. These TDR works are described in Section 4.4 of the EIAR.

The likely magnitude of effects on river waterbodies (NRA, 2008), which are given a High Importance, is assessed as Negligible.

Pathway: Surface water flowpaths.

Receptor: Down-gradient surface water quality (River Goul, Nuenna River and The Loughans turlough)

Pre-Mitigation Potential Impact: Indirect, negative, imperceptible, short term, likely effect on surface water quality.

Proposed Mitigation Measures:

- All works are minor and localised and cover very small areas;
- These works are distributed over a wide area;
- All works are temporary in nature; and,
- Application of the Pre-Construction Drainage Measures (see Section 9.5.2.3) for surface water quality protection.

Residual Effect: 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 of the Proposed Project is no significant effect.

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

9.5.2.13 Effects of Construction Works on the WFD Status of Downstream Waterbodies (Proposed Project)

Refer to **Appendix 9-4** for the WFD Compliance Assessment Report.

Both the Proposed Wind Farm and Proposed Grid Connection have the potential to affect WFD status. Therefore, both are assessed herein.

WFD status and Risk Results for downstream river waterbodies and the underlying GWBs are presented in Sections 9.3.12 above.

Due to the hydrogeological regime on the north of the Proposed Wind Farm site (low recharge and poorly productive bedrock), the potential to negatively affect the WFD status of the GWB is very low, even in the absence of mitigation. The Durrow GWB on the south of the Proposed Wind Farm site is more vulnerable due to it being a Regionally Important Karstified Aquifer with extreme groundwater vulnerability.

Our understanding of the objectives of the WFD is that surface waters, regardless of whether they have 'Poor' or 'High' status, should be treated the same in terms of the level of protection and mitigation measures employed, i.e. there should be no negative change in status at all. This is reflected in the strict mitigation measures in relation to maintaining a high quality of surface water from the Proposed Project will ensure that the status of surface waterbodies in the vicinity of the Proposed Project will be at least maintained regardless of their existing status.

The likely magnitude of effects on river waterbodies and groundwater bodies (NRA, 2008), which are given a Medium to High Importance, is assessed as Small Adverse.

Pathways: Drainage and surface water discharge routes.

Receptors: River waterbodies (Foyle South Stream, Nuenna River, Lisdowney Stream and Lismaine Stream) and GWBs (Lisdowney GWB, Durrow GWB, Killkenny-Ballynakill Gravels GWB and Rathdowney GWB).

Pre-Mitigation Potential Effect: Indirect, negative, slight, temporary, unlikely effect on river waterbody and GWB WFD status.

Proposed Mitigation Measures:

Project design measures and comprehensive groundwater mitigation and drainage control measures for works within the Clomantagh/Killoshulan Group Water Scheme ZoC are provided in Section 9.5.2.1.

Comprehensive surface water mitigation and drainage controls are outlined in Section 9.5.2.2 (Felling of Coniferous Plantations), Section 9.5.2.3 (Earthworks), Section 9.5.2.5 (Excavation Dewatering), Section 9.5.2.6 (Hydrocarbons), Section 9.5.2.8 (Cement-based Products) and Section 9.5.2.9 (Morphological Changes to Watercourses). These will ensure the protection of surface water quality and flows in all downstream receiving watercourses.

Residual Effect: The potential for the release of suspended solids, hydrocarbons, cement-based products or altered flows to watercourse receptors is a risk to water quality and the aquatic quality of the receptor. Proven and effective mitigation measures have been proposed and will break the pathway between the potential pollutant sources and the receptor. The mitigation measures will ensure that surface water runoff from the site will be equivalent to baseline conditions and will therefore have no potential impact on the status, ecology or hydromorphology of waters.

Residual Effect: The residual effect of the Proposed Project is negative, imperceptible, indirect, short-term, unlikely impact on down gradient rivers, water quality, dependent ecosystems and GWBs.

Significance of Effects: For the reasons outlined above, and with the implementation of the proposed mitigation, no significant effects on waterbody WFD status will occur.

9.5.2.14 Use of Siltbuster and Impacts on Downstream Surface Water Quality (Proposed Project)

Both the Proposed Wind Farm and Proposed Grid Connection could benefit from the use of a siltbuster. Therefore, both are assessed herein.

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

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

The benefits of using a Siltbuster system in emergency scenarios where all other water treatment systems have proven ineffective are considerable. An example of treatment capability of siltbuster systems from northwest Mayo is provided in **Figure 9-18**. This is a duration curve of downstream water quality data post siltbuster treatment. The system was setup so that any water not meeting discharge criteria was recycled back to the settlement ponds. The graph shows all data, and only 24 data points out of 1194 records were above 20 mg/L (i.e. recycling, and repeat treatment occurred at these times to ensure compliance at the discharge location).

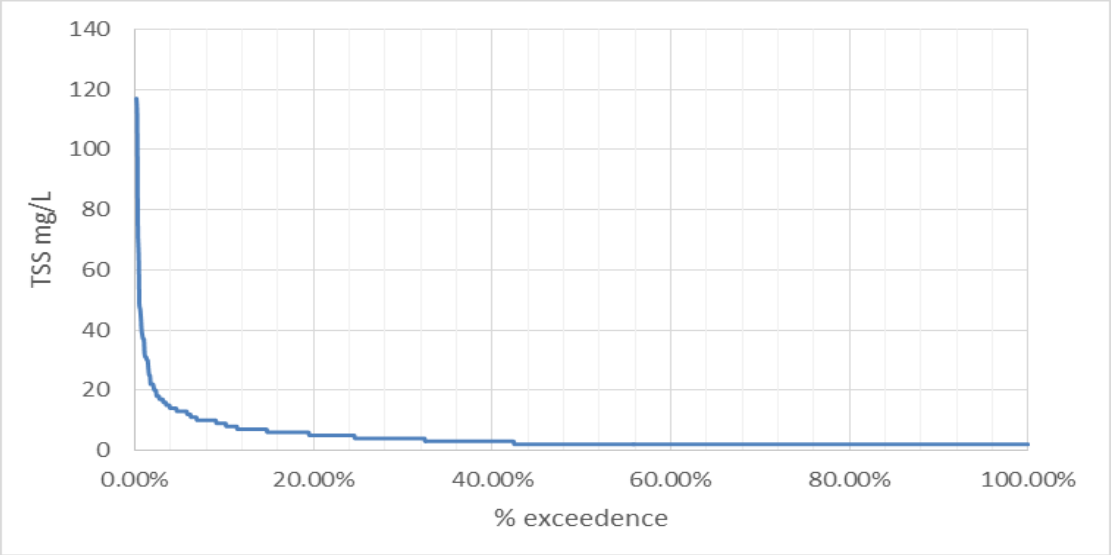


Figure 9-18: TSS treatment data using Siltbuster systems (with chemical dosing).

The magnitude of impact (NRA, 2008) is assessed as Slight Adverse.

Pathways: Drainage and surface water discharge routes.

Receptors: Down-gradient rivers Foyle South Stream, Lisdowney Stream, Nuenna River and Gorteenahilla Stream and designated sites and associated dependent ecosystems.

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

Mitigation Measures:

Measures employed to prevent overdosing and potential chemical carryover:

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

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

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

9.5.2.15 Potential Surface Water Quality Effects of the Proposed 110kV Underground Cabling Earthworks and Watercourse Crossings (Proposed Grid Connection)

The Proposed Grid Connection comprises the Proposed 110kV Substation, approximately 12.6km of Proposed 110kV Underground Cabling and 6 no. existing EPA watercourse crossings along public roads and a HDD crossing below the River Nore.

Placement of the cable within the crossing structure or HDD will be used (i.e. no instream works).

The magnitude of impact (NRA, 2008) is assessed as Small Adverse.

Pathway: Surface water flowpaths/groundwater paths.

Receptor: Down-gradient water quality (Nuenna River, River Nore, Foyle South Stream, Lisdowney Stream and Gorteenahilla Stream).

Pre-Mitigation Potential Effect: Negative, slight, indirect, temporary, likely effect to surface water quality.

Proposed Mitigation Measures:

Pre-commencement Temporary Drainage Works:

Prior to the commencement of substation, cable trenching or access road works the following key temporary drainage measures will be installed:

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

The following mitigation measures are proposed for the underground cabling watercourse crossing works:

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

Fracture Blow-out (Frac-out) Prevention and Contingency Plan for HDD:

- The drilling fluid/bentonite will be non-toxic and naturally biodegradable (i.e. Clear Bore Drilling Fluid or similar will be used);
- The area around the drilling fluid batching, pumping and recycling plants will be bunded using terram and/or sandbags to contain any potential spillage;
- One or more lines of silt fencing will be placed between the works area and the adjacent river;
- Spills of drilling fluid will be cleaned up immediately and transported off-site for disposal at a licensed facility;
- Adequately sized skips will be used where temporary storage of arisings are required;
- The drilling process / pressure will be constantly monitored to detect any possible leaks or breakouts into the surrounding geology or local watercourse;
- This will be gauged by observation and by monitoring the pumping rates and pressures. If any signs of breakout occur, then drilling will be immediately stopped;
- Any frac-out material will be contained and removed off-site;
- The drilling location will be reviewed, before re-commencing with a higher viscosity drilling fluid mix; and,
- If the risk of further frac-out is high, a new drilling alignment will be sought at the crossing location.

Residual Effect: 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 of the Proposed Project will be negative, imperceptible, direct, long term, likely effect on surface water quality.

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

9.5.2.16 Biodiversity Enhancement and Management Plan (BEMP)

A Biodiversity Enhancement and Management Plan (BEMP) has been prepared for the Proposed Project and is included as Appendix 6-4 of this EIAR. This plan has been developed to offset the loss of habitats identified within the Proposed Wind Farm site and further enhance the biodiversity of the Proposed Wind Farm and its environs. The following enhancement measures are proposed:

- Grassland Enhancement
- Hedgerow Bolstering
- Proposed new hedgerows

Pathway: Enhancement measures and targeted revegetation.

Receptor: Site habitats

Pre-Mitigation Potential Impact: Positive, slight, direct, permanent likely effect of BEMP.

Mitigation Measures:

A site-specific monitoring and evaluation programme will be implemented to ensure that the success of the proposed measures remains long-term. It will also assist in situations where the habitat establishment may not have been successful by providing evidence of shortcomings, allowing a revised management plan to be formulated. Monitoring results will be reported by the Project Ecologist within an Annual Environmental Report. Reports detailing the monitoring works carried out, the results obtained and a review of their success, along with any suggestions for amendments to the plan will be prepared. The enhancement plan will be updated and amended where required to improve the efficacy of the enhancement work.

Residual Effect: The likely residual effect of the Proposed Project on Site habitats following the implementation of the BEMP is a slight, positive, direct, permanent effect on habitats.

Significance of Effects: For the reasons outlined above, all effects will be positive.

9.5.3 Operational Phase – Likely Significant Effects and Mitigation Measures

9.5.3.1 Removal of Vegetation Cover and Progressive Replacement of Natural Surface with Low Permeability Surfaces (Proposed Project)

Hardstand emplacement will be required at both the Proposed Wind Farm and Proposed Grid Connection (i.e. Proposed 110kV Substation) Both assessed herein.

The potential for increased surface water runoff is the primary potential impact during the operational phase of the Proposed Project.

Progressive replacement of the vegetated surface with impermeable surfaces will decrease the permeability of the ground within the Site footprint (i.e., turbine bases, hardstandings, and to a lesser extent the new access roads) and Proposed 110kV Substation and Proposed BESS.

The emplacement of the Proposed Wind Farm footprint, as described in Chapter 4 of the EIAR, (assuming emplacement of impermeable materials as a worst-case scenario) could result in an average total site increase in surface water runoff of approximately 8,161m^3/month (**Table 9-23**). This represents a potential increase of approximately 3.4% in the average daily/monthly volume of runoff from the Proposed Wind Farm site 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 overall Proposed Wind Farm site being developed. Specifically, the permanent Proposed Wind Farm footprint is approximately 16.6ha, representing 2.9% of the Proposed Wind Farm site of 573ha.

Also, this calculation assumes that all hardstanding areas will be impermeable, which is considered to be a conservative assumption. The increase in runoff from most of the development catchment will therefore be imperceptible and this is before mitigation measures will be put in place. This water balance assessment demonstrates that even in the absence of mitigation, the potential to alter the water balance of the Site or downstream hydrology/morphology is imperceptible.

Table 9-23: Baseline Site Runoff V Development Runoff.

Baseline Runoff/month (m^3)	Baseline Runoff/day (m^3)	Permanent Footprint Area (m^2)	Footprint Area 100% Runoff (m_3) (m^3)	Footprint Area 46% Runoff (m^3)	Net Increase/month (m^3)	Net Increase/day (m^3)	% Increase from Baseline Conditions
239,963	7,741	166,000	15,113	6,952	8,161	263	3.4

The magnitude of impact (NRA, 2008) is assessed as Negligible.

Pathway: Site drainage network.

Receptor: Surface waters (Nuenna River, Foyle South Stream and Gorteenahilla Stream) and dependent ecosystems.

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

Proposed Mitigation by Design:

The proposed drainage philosophy outlined in Section 9.4.1 states that runoff control and drainage management are key elements in terms of mitigation against impacts on surface water bodies. Two distinct methods will be employed to manage drainage water within the Proposed Project. The first being 'keeping clean water clean' and the second involving the collection of any drainage waters from work area and to route them towards stilling ponds prior to controlled diffuse release over vegetated surfaces. The second method relates to proposed design measures that will prevent road surface and other hardstand areas acting as preferential flowpaths. All development site runoff will be collected, attenuated, treated and then released in a diffuse and regular manner that does not significantly change the natural drainage regime/hydrology of the site.

The operational phase drainage system of the Proposed Project will be installed and constructed in conjunction with the road and hardstanding construction work as described below and as shown on the drainage drawings (**Appendix 4-2**) submitted with this planning application:

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

These measures will ensure all surface water runoff from upgraded roads and new road surfaces (including hardstands and turbine base areas) will be captured and treated prior to discharge/release. Settlement ponds, check dams and buffered outfalls will prevent roads acting as preferential flowpaths by providing attenuation and water quality treatment.

Residual Effect: Direct, neutral, long term, likely effect of the Proposed Project on surface waters.

Significance of Effects: No significant effects on surface water quantity will occur during the operational phase of the Proposed Project.

9.5.3.2 Runoff Resulting in Suspended Solids Entrainment in Surface Waters

Site runoff will occur at both the Proposed Wind Farm site and Proposed Grid Connection. Both assessed herein.

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

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

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

The magnitude of impact (NRA, 2008) is assessed as Small Adverse.

Pathways: Drainage and surface water discharge routes.

Receptors: Down-gradient rivers (Foyle South Stream and Nuenna River) and associated dependent ecosystems.

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

Proposed Mitigation Measures:

The mitigation measures outlined in Sections 9.5.2.3 & 9.5.3.1 will ensure all surface water runoff from upgraded roads and new road surfaces (including hardstand and turbine base areas) will be captured and treated prior to discharge/release. Settlement ponds, check dams and buffered outfalls will prevent roads acting as preferential flowpaths by providing attenuation and water quality treatment.

It is proposed that bedrock from off-site sources will be used to construct the sub-base layer of proposed upgraded and new access roads, hardstand areas and turbine base areas. Once installed the subbase layer will be overlain by a clean capping layer of high-grade stone material which will be sourced from local quarries also.

Residual Effects: With the implementation of the proposed drainage measures as outlined above, and based on the post-mitigation assessment of runoff, residual effects are - Negative, imperceptible, indirect, temporary, unlikely effect on downstream water quality.

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

9.5.3.3 Potential Effects on the Clomantagh/Killoshulan Group Water Scheme and Other Local Wells (Proposed Project)

During the operational phase, the potential for effects is much more limited than those associated with the construction phases as there is no further excavation/movement of soil/subsoil and the drainage system is fully constructed and operational.

Potential effects on the spring mainly include groundwater quality with regard contaminants such as oils and fuels.

The magnitude of impact (NRA, 2008) is assessed as Negligible.

Source: Oils, fuels and Chemicals

Pathway (s): Recharge and surface water flowpaths.

Receptor: Clomantagh/Killoshulan Group Water Scheme and Other Local Wells

Pre-Mitigation Potential Impact: Indirect, negative, imperceptible, long term, unlikely impact to Clomantagh/Killoshulan Group Water Scheme and Other Local Wells.

Impact Assessment

As outlined above, the potential for effects during the operational phase of the Proposed Project is much reduced as there are no further construction activities along with the associated potential sources such as hydrocarbons/cement/ exposure of subsoils/bedrock.

During the operational phase of the Proposed Project, the only regular plant which will be required on site will be maintenance/inspection vehicles (jeeps/vans/quads) and these will not be refuelled on-site.

Any hydrocarbons (oil) present within the turbine generator and gear box will be enclosed within a bund with 110% capacity. There will be no storage of fuels, oils and chemicals inside any of the turbines.

Automated oil leak detectors will be placed in each of the Proposed Turbines which will allow early detection of even the smallest leaks of oil or hydraulic fluid that may arise from components such as the transformer or gearbox.

The automated detection system will then rapidly notify the wind farm operator by cloud-based systems. This early detection system will prevent large leaks of oil or hydraulic fluid.

Residual Effect: With the mitigation measures associated with drainage management and the protection of water quality, combined with the lack of any construction type activities no residual effect of the Proposed Project will occur. No residual effect on Clomantagh/Killoshulan Group Water Scheme and Other Local Wells.

Significance of the Effect: For the reasons outlined above, no significant effects will occur.

9.5.4 Decommissioning Phase - Likely Significant Effects and Mitigation Measures (Proposed Project)

The potential impacts associated with decommissioning of the Proposed Project will be similar to those associated with construction but of a reduced magnitude, due to the reduced scale of the proposed decommissioning works in comparison to construction phase works. A description of the decommissioning works is contained in Chapter 4 of this EIAR.

During decommissioning, it will be possible to reverse or at least reduce some of the potential effects caused during construction, and to a lesser extent operation, by rehabilitating constructed areas such as turbine bases and hard standing areas. This will be done by covering with peatland vegetation/scraw or poorly humified peat to encourage vegetation growth and reduce run-off and sedimentation.

The Site roadways will be kept and maintained following decommissioning of the turbine infrastructure, as these will be utilised by ongoing forestry works and by local farmers.

The electrical cabling connecting the site infrastructure to the Proposed 110kV Substation will be removed, while the ducting itself will remain in-situ rather than excavating and removing it, as this is considered to have less of a potential environmental impact, in terms of soil exposure, and thus on the possibility of the generation of suspended sediment which could enter nearby watercourses.

The Proposed Turbines will be removed by disassembling them in a reverse order to their erection. This will be completed using the same model cranes as used in their construction. They will then be transported off-site along their original delivery route. The disassembly and removal of the turbines will not have an impact on the hydrological/hydrogeological environment at the Site.

Other impacts such as possible soil compaction and contamination by fuel leaks will remain but will be of reduced magnitude than the construction phase because of the smaller scale of the works and reduced volumes on-site.

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

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

Some of the impacts will be avoided by leaving elements of the Proposed Project in place where appropriate. The Proposed 110kV Substation will be retained by EirGrid as a permanent part of the

national grid. The turbine bases will be rehabilitated by covering with local topsoil/peat in order to regenerate vegetation which will reduce runoff and sedimentation effects. Mitigation measures to avoid contamination by accidental fuel leakage and compaction of soil by on-site plant will be implemented as per the construction phase mitigation measures.

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

9.5.5 Risk of Major Accidents and Disasters (Proposed Project)

The GSI Landslide database (www.gsi.ie) does not record any historic landslides in the vicinity of the Site or in the surrounding lands.

Karst bedrock potentially presents a risk on the southern portion of the Proposed Wind Farm site. The findings of the Karst Risk assessment indicate that the majority of the Proposed Wind Farm site infrastructure areas can be rated as having a Negligible risk (i.e. turbines T5 to T10, borrow pit and associated access roads) due to it being underlain by mudstone/siltstone bedrock. T4 which is also underlain by mudstone, is assigned a Low risk.

Proposed Turbine location T3 is rated as Medium risk, while T1 and T2 are rated as High risk due to the presence of limestone evidence of karst features nearby. A karst protocol for the Proposed Project is provided in **Appendix 8-3**.

For potential fires at the BESS compound a Fire Risk Management & Emergency Response Plan has been prepared for Proposed Wind Farm (refer to **Appendix 4-4**).

To safeguard the local environment (and downstream human receptors) from contaminated runoff during a potential fire event, specialised site bunding and a dedicated retention tank will capture firefighting water so it can be sampled, treated, or safely removed by hazardous waste contractors. Refer to **Appendix 4-4** for the Fire Risk Management & Emergency Response Plan.

Flooding can also result in downstream MADs. However, due to the small scale of the Proposed Project footprint with regard the overall Site area, the naturally high runoff rates, the avoidance of fluvial flood zones (see Section 9.3.6 and **Appendix 9-1**) and with the implementation of the proposed mitigation measures, the increased flood risk associated with the Proposed Project is imperceptible.

9.5.6 Assessment of Potential Health Effects (Proposed Project)

Potential health effects arise mainly through the potential for surface and groundwater contamination which can have negative effects on public and private water supplies. A portion of the Proposed Project site is located inside the Clomantagh/Killoshulan Group Water Scheme SoPA, but investigations have been carried out to assess the risk (see Section 9.5.2.1) posed by the Proposed Project. Notwithstanding this, the Proposed Project design and mitigation measures ensures that the potential for effects on the water environment will not be significant.

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

A site-specific Flood Risk Assessment (**Appendix 9-1**) has been carried out for the Proposed Project, summarised in Section 9.3.6. The lack of Proposed Project infrastructure encroachment into flood zones, combined with the assessment of changes in permeable surfaces (Section 9.5.3.1) demonstrates

that the risk of the Proposed Project contributing to downstream flooding is imperceptible. On-site (construction and operation phase) drainage control measures will ensure no downstream increase in local flood risk.

9.5.7 Cumulative Effects (Proposed Project)

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

The main likelihood of cumulative effects is assessed to be hydrological (surface water quality) rather than hydrogeological (groundwater).

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

The cumulative Water Study area is delineated by the catchment of the Nore_SC_070 which has an area of approximately 155km^2. Downstream of the Nore_SC_070 (i.e. River Nore itself) no cumulative hydrological effects are likely due to the combined large upstream catchment area (>1,000km^2) and the very high dilution effects afforded by such a large regional catchment (refer to Section 9.3.4.2 above for flow comparison in the Nuenna and Nore Rivers.

The surface water catchment area of the River Nore upstream of the Nore_SC_070 sub-catchment is approximately 1,100km^2 (the River Nore upstream catchment is nearly 7 times that of the Nore_SC_070 sub-catchment).

9.5.7.1 Cumulative Effects with Agriculture

According to Corine land cover mapping (www.epa.ie) (2018) the Nuenna River catchment is a largely agricultural catchment.

Agricultural practices such as the movement of soil and the addition of fertilizers and pesticides can lead to nutrient losses and the entrainment of suspended solids in local surface watercourses. This can have a negative effect on local and downstream surface water quality.

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

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

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

9.5.7.2 Cumulative Effects with Commercial Forestry

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

Given that most of the main off-site forestry plantations are located a significant distance from the Proposed Wind Farm site, the likelihood of significant potential effects occurring is very small.

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

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

9.5.7.3 Cumulative Effects with One Off Housing Developments

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

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

9.5.7.4 Cumulative Effects with Other Wind Farms

In addition to the Proposed Project, 3 no. other wind farms have been identified within the Nore_SC_070 catchment/cumulative study area (refer to **Table 9-24**). Within these existing (Lisdowney Wind Farm) and proposed wind farms (Gathabawn WF & Seskin WF) there are a total of 14 no. turbines potentially situated within the Nore_SC_070 / cumulative study area.

In terms of operational phase, the total number of wind turbines that could potentially be operating in the cumulative study area is 24 no. (10 no. from Proposed project and 14 no. turbines from the other wind farms).

The total area of the Nore_SC_070 catchment is c. 155km^2 which equates to 1 no. turbine per approximately 6.4km^2 which is considered not significant in terms of likely cumulative hydrological effects on the Nore_SC_070.

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

Therefore, due to the dispersed nature/setback distance of the other wind farms along with the implementation of the proposed mitigation measures for the Proposed Project (listed in **Table 9-24**) there will be no cumulative effects associated with the construction, operational or decommissioning phases of the Proposed Project and other wind farms within the cumulative study area.

Table 9-24: List of Other Wind Farm Developments Assessed for Hydrological Cumulative Effects.

Catchment	Wind Energy Development (Status)	Total Turbine No.	Turbine No. in Nore_SC_070
Nore_SC_070	Lisdowney Wind Farm (Existing)	4	2
	Gathabawn WF (Proposed)	12	4
	Seskin WF (Proposed)	8	8
Totals		**24**	**14**