9. HYDROLOGY AND HYDROGEOLOGY

9.1 Introduction

CDM Smith Ireland Ltd was engaged by MKO Ireland (MKO), on behalf of Glenora Wind Farm DAC, to assess the potential likely and significant hydrological and hydrogeological effects of the Proposed Development on the receiving water environment (surface water and groundwater).

The Proposed Development was described in detail in Chapter 4 of this EIAR, and location and layout maps were presented in **Figure 4-1a** and **Figure 4-1b**.

The assessment of likely significant effects is based on:

- Requirements for preparation of this Chapter 9, per relevant legislation and guidance referred to in Section 9.1.4.
- Publicly available data and information relevant to baseline hydrological and hydrogeological conditions.
- Site-specific baseline data generated from site investigations and site walkover surveys described in Section 9.2.2.

The assessment is guided by the source-pathway-receptor model of environmental risk assessment that underpins water protection initiatives in Ireland.

In this Chapter 9:

- The term 'Proposed Development' refers to the project in its entirety, including the grid connection route.
- The terms 'Wind Farm Site' or 'Site' refers to the Proposed Development, excluding the grid connection. Hence, it refers to the Proposed Development within Glenora Forest which will accommodate the new wind farm infrastructure.
- The terms 'EIAR redline boundary' and 'EIAR boundary' defines the geographic extent of the Proposed Development, as presented in Chapter 2.
- The term 'development footprint' refers to the land that will be subject to the proposed infrastructure within the Wind Farm Site.

9.1.1 Statement of Authority

This Chapter 9 was prepared by Henning Moe of CDM Smith Ireland Ltd. He is a registered professional geologist (P. Geo.) with the Institute of Geologists of Ireland and has more than 30 years of practical experience. He has worked on several projects for EPA related to the implementation of the European Union Water Framework Directive (WFD). This included working with EPA's Catchment Science and Management Unit to prepare guidance on Investigative Assessments of rural catchments involving a wide range of environmental pressures and mitigation measures, including those associated with peat- and forestry-related activity. Henning has also worked with both the National Parks and Wildlife Service (NPWS) and the Pesticide Control and Forestry Services of the Department of Agriculture, Food and Marine (DAFM). For MKO, he prepared the Hydrology and Hydrogeology chapter for a proposed 21 turbine wind farm at Sheskin, Co. Mayo. With MKO, he assisted with the review of potential impacts of planned improvement works along the Kiltiernan-Ballinderreen Flood Mitigation Scheme on Natura 2000 sites. For Kerry County Council, he reviewed flood risk downstream of a proposed major quarry development based on a discharge of 25,000 m^3/d. For Uisce Éireann, Henning peer-reviewed the hydrology and hydrogeology chapters of the EIAR for the Shannon Pipeline project which traverses more than 25 km of peatland. For Bord na Móna, he led the preparation of the Soils, Geology and Hydrogeology, and Water chapters for a proposed expanded landfill development within Timahoe Bog in Co. Kildare.

Henning was supported by Dr Jon Hunt who contributed technically to the planning stage drainage plan. Jon has 20 years of experience which has included mapping upland and peat terrains through his geological research (e.g., mapping 34 km^2 at 1:10,560 scale in upland areas of the west of Ireland), and managing flood risk assessments of housing developments using modelling techniques and mitigation measures to alleviate potential downstream risks and impacts.

Technical review was provided by Ruairi O'Carroll BE MEng Sc CEng MIEI, a chartered engineer with over 20 years of experience in the management and delivery of environmental and engineering projects. Ruairi has prepared feasibility studies, preliminary reports and assessment studies for a range of water and environmental projects, and has extensive expertise in the preparation of tender documents, procurement and contract management.

9.1.2 Objectives

The objectives of this Chapter 9 are to:

- Present the methodology that was applied to assess potential and likely significant effects of the Proposed Development.
- Describe baseline conditions of the Wind Farm Site in terms of its hydrology and hydrogeology.
- Identify likely significant effects of the Proposed Development on surface water and groundwater resources, and related water-dependent habitats, during construction, operational and decommissioning phases.
- Identify and describe suitable and proposed mitigation measures that will be implemented to avoid, reduce or offset any likely significant negative effects.
- Assess likely significant residual effects.
- Assess cumulative effects of the Proposed Development after mitigation measures are implemented, in association with other relevant projects that are outlined in Chapter 2.

9.1.3 Scope and Consultation

As described in Chapter 2 of this EIAR, scoping was undertaken during the preparation of this EIAR. Scoping responses are included in **Appendix 2-1**. Inputs from consultees have informed the preparation of content in this Chapter 9. Key matters that were raised in respect of hydrology and hydrogeology are summarised in **Table 9-1**.

Table 9-1 Summary of Hydrological and Hydrogeological Matters Raised by Consultees

Consultee	Matters Raised	Addressed in Chapter Section
Mayo County Council	Provide information on slopes, soil types, bedrock, depth to bedrock, depth to groundwater, depth of peat.	Section 9.3.8
	Show and discuss the existing drainage on site relative to proposed development including roads, access tracks, turbines hard stand areas and grid connections. This shall include drainage associated with forestry and turf cutting.	Chapter 2, Chapter 4, Appendix 4-4
	Provide details of site management relative to watercourses in the area. This should have regard to the requirements of the Water Framework Directive, and any relevant River Basin Management Plan This should include	Appendix 4-1, Appendix 4-4, Section 9.4.2, Section 9.4.3

Consultee	Matters Raised	Addressed in Chapter Section
	impact of downstream water body status. The development should have regard to any Priority Areas for Action and High-Status Objective water bodies in the area.	
	The hydrological context for the overall site should be set out, together with a delineation of individual subcatchments within the Proposed Development associated with each turbine, including slope, drainage and proximity to same. This should include the location and flow direction of all drains and streams on site. Pathways to watercourses and drains should be clearly identified, mapped.	Section 9.3, Appendix 4-4
	Access track and road any associated water crossing and details of how these will be designed and constructed to reduce impacts on the receiving environment.	Appendix 4-1, Appendix 4-4, Sections 9.3.13, 9.4.2
	Grid connection and any associated water crossing and details of how these will be designed and constructed to reduce impact on the receiving environment.	Chapter 4
	Establish baseline water quality condition prior to works commencing on site.	Section 9.3.7
Inland Fisheries Ireland (IFI)	In summary, and with regard to this Chapter 9, the IFI request the following to be addressed: › Water quality › Surface water hydrology › Sediment transport	Sections 9.3.3, 9.3.4., 9.3.5, 9.3.7, 9.4.2
	The EIS should assess the potential impacts the proposed development may have including, damage to the aquatic and associated riparian habitat, pollution of water, introduction of non-native species, site hydrology and interference with upstream and downstream movement of aquatic life. The assessment should include all aspects of the development, forestry, roads, borrow pits, silt ponds, grid connection etc.	Chapter 6, Section 9.4.2
	A construction and operational phase water quality and habitat monitoring programme must be put in place.	Section 9.3.14, Chapter 6
	A site survey must be carried out identify all watercourses including drains/minor watercourses. IFI recommends a minimum width of 15metres from a drains/minor watercourse to low risk parts of the construction site with larger buffer zones required for more sensitive habitats and higher risk operations.	Appendix 4-4, Sections 9.3.13, 9.4.2
	Assessment of the impacts on the hydrology of the site must be carried out particularly where excavations including excavations for road construction are being proposed. It is important	Appendix 4-4, Appendix 9-2, Sections 9.4.2, 9.4.3

Consultee	Matters Raised	Addressed in Chapter Section
	that natural flow paths are not interrupted or diverted in such a manner as to give rise to erosion. The proposed site crosses three catchments there must be no diversion of waters from one catchment into another.	
	The impact of site drainage must be assessed including the pumping of waters from excavations such as turbine excavations. Settlement ponds and other silt treatment/mitigation measures must be engineered to ensure sufficient retention times are provided for sediment settlement. The silt traps should be designed to minimise the movement of silt especially during intense precipitation events where silt traps may be hydraulically overloaded. It is essential that they are located with good access to facilitate monitoring, sampling and maintenance. A license to discharge to waters may be required from the local authority.	Appendix 4-1, Appendix 4-4, Section 9.4.2, Appendix 9-2
	The impact of site offices and the services should form part of the EIA. Details should be provided in relation to the management of construction phase pollutants including cement waste, such as cement truck wash out, hydrocarbons and any other toxic materials.	Section 9.4.2.8, 9.4.2.10, 9.4.3.1
	Should works be approved a detailed method statement addressing the issues outlined above, including all mitigations measures, precautions and environmental incident procedures must be forwarded to Inland Fisheries Ireland before works commence. The IFI publication: Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites should be followed. https://www.fisheriesireland.ie/documents/624-guidelines-on-protection-of-fisheries-during-construction-works-in-and-adjacent-to-waters/file.html	Section 9.1.4, noting that the later 2016 IFI publication "Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters" has also been referenced.
Geological Survey Ireland (GSI)	GSI provided a list of publicly available datasets to be considered.	Chapters 8 and 9 throughout make use of GSI reference materials and publicly available maps.
Development Applications Unit (DAU) of the Department of Tourism, Culture, Arts, Gaeltacht, Sport, and Media	Observations to assist identify potential impacts on European sites, other nature conservation sites, and biodiversity and environmental protection in general. Topics to be covered by assessment of effects: › Drainage › Extraction/quarrying › Tree felling › Surface waters › Wetlands › Flood plains › Natura 2000 sites	Section 9.3.13, Sections 9.4.2, 9.4.3, Appendix 9-1, Appendix 9-3, Appendix 4-4

Consultee	Matters Raised	Addressed in Chapter Section
	- Other designated sites - Positions, locations and sizes of construction infrastructure and mitigation such as settlement ponds, disposal sites and construction compounds.	
	Construction work should not be allowed to impact on water quality and measures should be detailed in the EIAR to prevent sediment and/or fuel runoff from getting into watercourses which could adversely impact on aquatic species.	Sections 9.4.2, 9.4.3, Appendix 4-3 (CEMP)
	Assessment and monitoring results from nearby windfarms should be considered. Cumulative impact from all windfarms in the area needs to be assessed and the data from surrounding sites needs to be considered in the assessment of impacts.	Section 9.4.5
Environmental Health Service (EHS) (Mayo)	All drinking water sources, both surface and groundwater (including private wells) shall be identified. Any potential impacts to these drinking water sources shall be assessed. Details of bedrock, overburden, vulnerability, groundwater flow and gradients, inner and outer zones of protection and catchment areas should all be considered when assessing potential impacts and possible mitigation measures. The EHS would recommend that all information is gathered by means of a site survey as desktop studies do not always accurately reflect the current use of water resources.	Sections 9.3.8, 9.3.9, 9.4.2.12

9.1.4 Relevant Legislation and Guidance

This Chapter 9 was prepared in accordance with the legislation itemised in Chapter 1 (Introduction) and the following guidance documents:

- Environmental Protection Agency (2022). Guidelines on the Information to be Contained in Environmental Impact Assessment Report
- Institute of Geologists Ireland (2013): Guidelines for Preparation of Soils, Geology & Hydrogeology Chapters in Environmental Impact Statements.
- National Roads Authority (2009): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes.
- Inland Fisheries Ireland (2016): Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters.
- Eastern Regional Fisheries Board (2003): Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites.
- Scottish Natural Heritage (2010): Good Practice During Wind Farm Construction.
- LAWPRO/EPA (2022). An Overview of Catchment Science and Management. A Guidance Handbook, Volumes 2 and 3. Local Authority Waters Programme and Catchment Science and Management Unit, Environmental Protection Agency.
- PPG1 - General Guide to Prevention of Pollution (UK Guidance Note).
- PPG5 – Works or Maintenance in or Near Watercourses (UK Guidance Note).
- CIRIA (Construction Industry Research and Information Association) (2006): Guidance on 'Control of Water Pollution from Linear Construction Projects' (CIRIA Report No. C648, 2006).

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

9.2 Assessment Methodology

9.2.1 Desk Study

A desk study of the Wind Farm Site and potential receiving environment was completed which involved collecting relevant data and information from publicly available sources, namely:

- OPW Flood Risk Information, including the CFRAM Flood Risk Assessment mapping (www.floodinfo.ie).
- Environmental Protection Agency (EPA) 'Water' web viewer and databases related to implementation of the Water Framework Directive (WFD) - https://gis-stg.epa.ie/EPAMaps/Water and www.catchments.ie
- EPA and Office of Public Works (NPWS) stream gauging station data.
- Geological Survey of Ireland (GSI) map coverages available on their web viewer.
- EPA and Teagasc soils maps.
- Historical aerial imagery and mid-19th century 6-inch and 25-inch sheets from Ordnance Survey Ireland.
- National Parks and Wildlife Services Public Map Viewer (www.npws.ie).
- Met Eireann rainfall and evapotranspiration data and maps.

Publicly available reports (e.g. from GSI) and journal (research) articles were also used, and are referenced throughout this Chapter 9.

9.2.2 Baseline Monitoring and Site Investigations

Data and findings from past site investigations were also used to help prepare the description of baseline conditions in this Chapter 9, specifically:

- Groundwater level monitoring data from 24 no. piezometers installed across the Proposed Development area, covering the period June 2020 and May 2021, as presented in the site investigation report by Fehiley and Timoney Co. (FT, 2021).
- Peat depth data obtained from a high-level peat probing campaign which was conducted in tandem with the groundwater monitoring (FT, 2021).
- Surface water quality data derived from sampling at five select locations within the Proposed Development Site in September 2020, November 2020, January 2021, March 2021, and May 2021 (FT, 2021).

Site walkover surveys were also conducted by CDM Smith (Jon Hunt, Henning Moe – see Section 9.1.1) in July 2021 and June 2023 during rainfall events, with a focus on the existing site drainage. This supplemented site walkover surveys reported by FT in February and May 2020 (FT, 2021).

Related data and findings are presented in subsequent sections.

9.2.3 Assessment Attributes and Terminology

Using the information from the desk study and site investigations, the assessment of likely significant effects of the Proposed Development considers:

- The importance and environmental sensitivity of the receiving environment, per **Table 9-2** (hydrology) and **Table 9-3** (hydrogeology).

- The effects classification terminology of EPA (2022), per **Table 9-4**, noting that descriptors of effects include quality (negative, positive or neutral), significance, probability/likelihood, duration and/or frequency, and type.
- The proximity and probability of effects, per **Table 9-5**.

Table 9-2 Estimation of Importance of Hydrology Attributes (NRA, 2009)

Importance	Criteria	Examples
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 >2,500 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 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. Locally important amenity site for wide range of leisure activities.
Medium	Attribute has a medium quality or value on a local scale	Coarse fishery. Local potable water source supplying >50 homes. Quality Class C (Biotic Index Q3, Q2-3). Flood plain protecting between 1 and 5 residential or commercial properties from flooding.
Low	Attribute has a low quality or value on a local scale	Locally important amenity site for small range of leisure activities. Local potable water source supplying <50 homes. Quality Class D (Biotic Index Q2, Q1). Flood plain protecting 1 residential or commercial property from flooding. Amenity site used by small numbers of local people.

Table 9-3 Estimation of Importance of Hydrogeological Attributes (NRA, 2009)

Importance	Criteria	Examples
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.

Table 9-4 Effect Classification Terminology (EPA, 2022)

Impact Characteristic	Term	Description
Quality	Positive	A change which improves the quality of the environment
	Neutral	No effects or effects that are imperceptible, within normal bounds of variation or within the margin of forecasting error.
	Negative	A change which reduces the quality of the environment.
Significance	Imperceptible	An effect capable of measurement but without significant consequences.
	Not significant	An effect which causes noticeable changes in the character of the environment but without significant consequences
	Slight	An effect which causes noticeable changes in the character of the environment without affecting its sensitivities
	Moderate	An effect that alters the character of the environment in a manner consistent with existing and emerging baseline trends
	Significant	An effect, which by its character, magnitude, duration or intensity alters a sensitive aspect of the environment
	Very significant	An effect which, by its character, magnitude, duration or intensity significantly alters most of a sensitive aspect of the environment
	Profound	An effect which obliterates sensitive characteristics
Extent and Context	Extent	Describe the size of the area, number of sites and the proportion of a population affected by an effect

	Context	Describe whether the extent, duration, or frequency will conform or contrast with established (baseline) conditions
Probability	Likely	Effects that can reasonably be expected to occur because of the planned project if all mitigation measures are properly implemented
	Unlikely	Effects that can reasonably be expected not to occur because of the planned project if all mitigation measures are properly implemented
Duration and Frequency	Momentary	Effects lasting from seconds to minutes
	Brief	Effects lasting less than one day
	Temporary	Effects lasting less than one year
	Short-term	Effects lasting 1-7 years
	Medium-term	Effects lasting 7-15 years
	Long-term	Effects lasting 15-60 years
	Permanent	Effects lasting over 60 years
	Reversible	Effects that can be undone, for example through remediation or restoration
	Frequency	Describe how often the effect will occur (once, rarely, occasionally, frequently, constantly – or hourly, daily, weekly, monthly, annually)
Types	Indirect	Effect on the environment, which are not a direct result of the project, often produced away from the project site or because of a complex pathway
	Cumulative	The addition of many minor or insignificant effects, including effects of other projects, to create larger, more significant effects.
	'Do Nothing'	The environment as it would be in the future should the subject project not be carried out
	'Worst Case'	The effects arising from a project in the case where mitigation measures substantially fail
	Indeterminable	When the full consequences of a change in the environment cannot be described.
	Irreversible	When the character, distinctiveness, diversity or reproductive capacity of an environment is permanently lost
	Residual	The degree of environmental change that will occur after the proposed mitigation measures have taken effect
	Synergistic	Where the resultant effect is of greater significance than the sum of its constituents

Table 9-5 Additional Impact Characteristics Considered

Impact Characteristic	Degree/Nature	Description
Proximity	Direct	An impact which occurs within the area of the proposed project, as a direct result of the proposed project.
	Indirect	An impact which is caused by the interaction of effects, or by off-site developments.
Probability	Low	A low likelihood of occurrence of the impact.
	Medium	A medium likelihood of occurrence of the impact.
	High	A high likelihood of occurrence of the impact.

9.3 Existing Environment

9.3.1 Physiographic Setting, Topography and Land Use

The Wind Farm Site is situated within Glenora Forest in an upland blanket bog setting on the south facing slopes of Maumakeogh (elevation 379 metres above Ordnance Datum (mOD)). The topography within the Wind Farm Site (**Figure 14-8**) ranges from approximately 330 mOD along the northern EIAR redline boundary to approximately 120 mOD on the southern EIAR redline boundary by the Altderg and Keerglen Rivers. The grid connection route follows existing roadways to the grid connection location at Tawnaghmore, which is sited at an elevation of approximately 75 mOD.

Topographic slope within the Wind Farm Site (**Figure 9-1**) generally ranges from <2 to approximately 15 degrees, but steeper slopes exist locally, including certain sections of streams where erosion has cut into subsoils. Detailed descriptions of slope at planned infrastructure locations are provided in **Appendix 8-1**.

Land use within the Wind Farm Site is predominantly commercial forestry, operated by Coillte. Both mature and young plantations, as well as open peatland, are present across the Site.

9.3.2 Regional and Local Drainage

At the regional scale, the Wind Farm Site occupies headwater subcatchments of the Owenmore and Ballinglen Rivers. As shown in **Figure 9-2**, the Owenmore River drains to Tullaghan Bay, approximately 27 km straight-line distance to the southwest of the Site. The Ballinglen River drains to Bunatrahir Bay, approximately 8 km straight-line distance to the northeast of the Site. The Owenmore River catchment[1] encompasses a total area of approximately 300 km^2 and the Ballinglen River catchment[2] encompasses a total area of approximately 44 km^2.

The grid connection route from the Wind Farm Site follows existing roads that pass through subcatchments of the Glencullin, Ballinglen, and Cloonaghmore Rivers (**Figure 9-2**). The Glencullin River discharges to Bunatrahir Bay while the Cloonaghmore and Moyne Rivers discharges to Killala Bay.

The headwaters of the Owenmore and Ballinglen Rivers within the Wind Farm Site are (**Figure 9-3**):

- The Altderg River, which incorporates the drainages of the Glenora River from the east and Fiddaunfrankagh Stream from the north. The Altderg River flows south and merges with Inagh River to become the Oweninny River which continues south to become the Owenmore River after its merger with Sheskin River.
- The Keerglen River, which flows east to Ballinglen River. The Keerglen River is fed by several small, unnamed streams which flow south from within the eastern part of Glenora Forest.

The headwaters of the Glencullin River, which includes the Sralagagh River, also originate within Glenora Forest but are outside the Wind Farm Site (**Figure 9-3**).

[1] Defined by EPA's Water Framework Directive (WFD) subcatchments Owenmore(Mayo)_SC_010, Owenmore(Mayo)_SC_020 and Owenmore(Mayo)_SC_030
[2] Part of WFD subcatchment Glencullin[NorthMayo]_SC_010, specifically incorporating WFD river sub-basins Ballinglen_010, Ballinglen_020, and Keerglen_010.

All of the named headwater streams in Glenora Forest originate as a series of bog seeps and springs at higher elevation. The seeps and springs are clearly marked as 'rises' on the 6-inch sheets from OSI which show the original, natural drainage pattern in the area in the mid-19th Century.

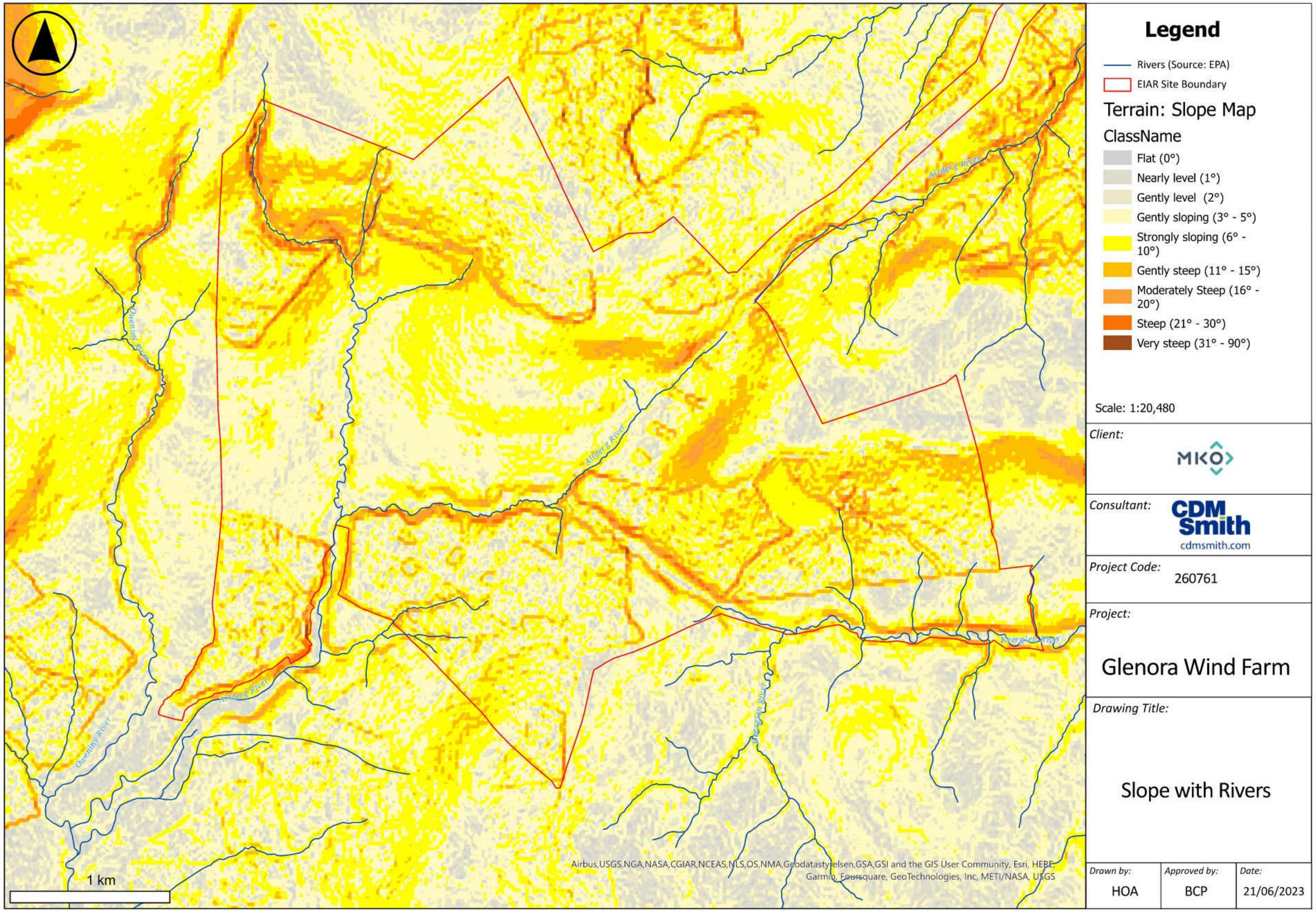

Figure 9-1 Topographic Slope Across the Wind Farm Site

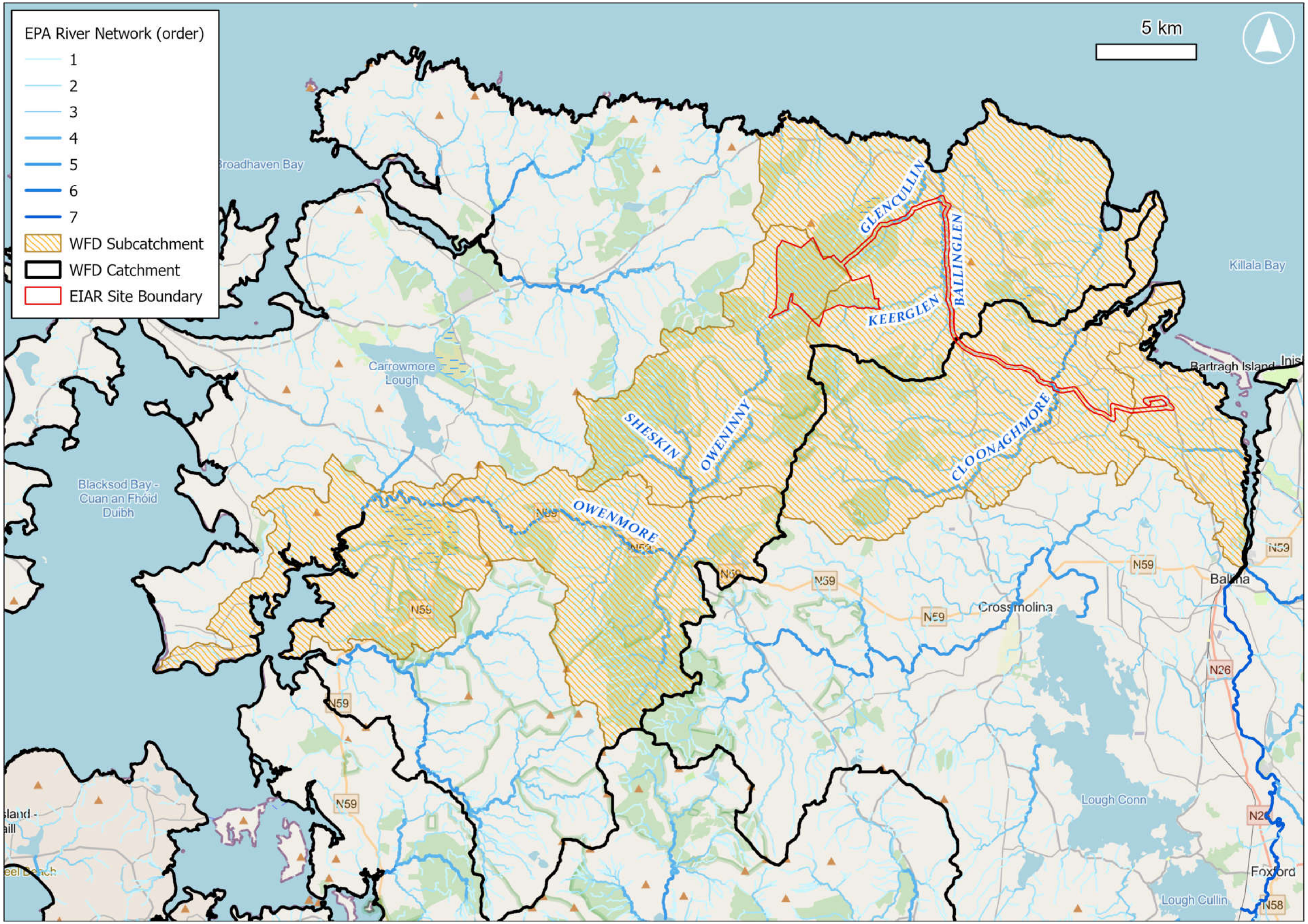

Figure 9-2 Regional Drainage and WFD Subcatchments Linked to the Proposed Development

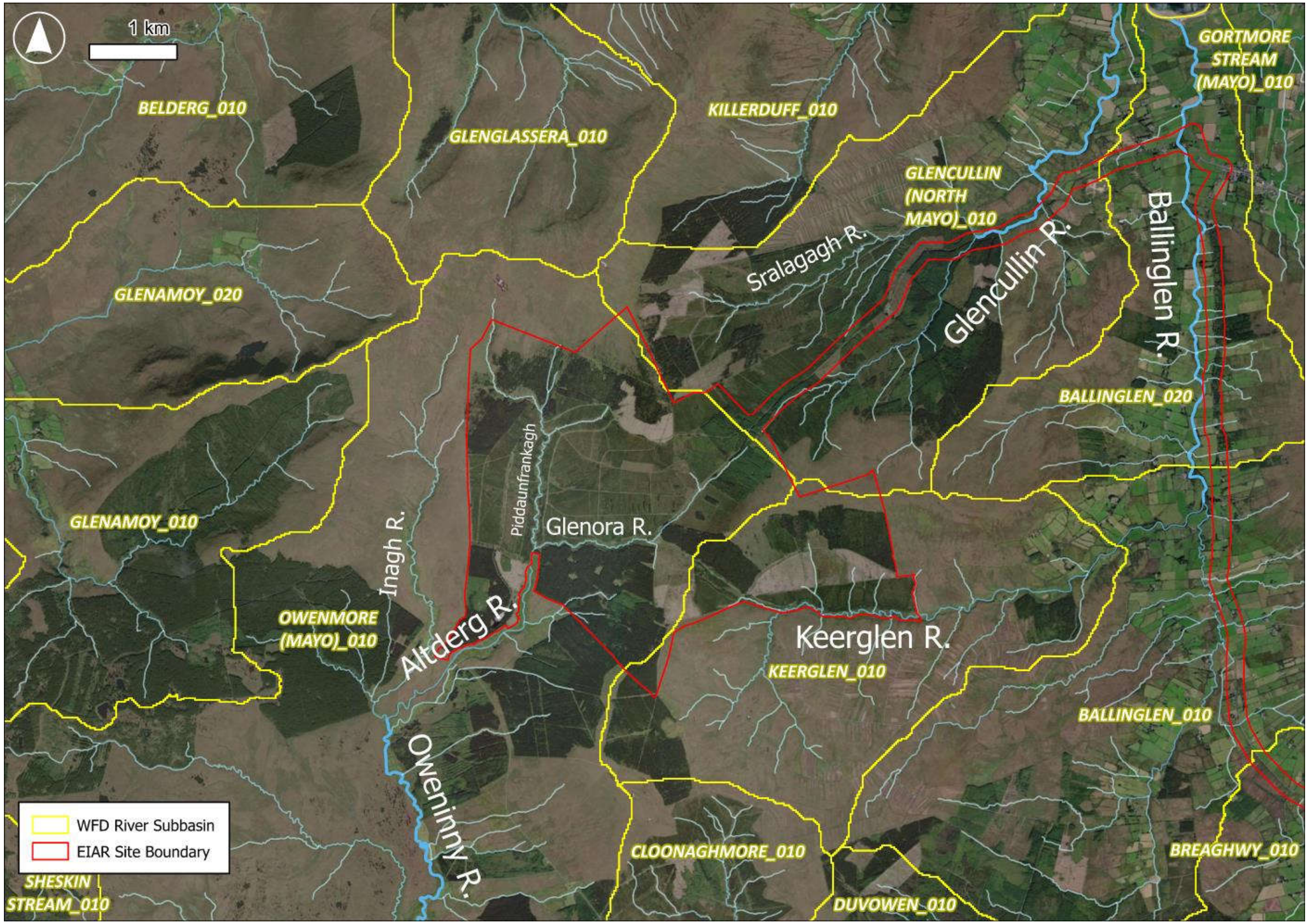

Figure 9-3 Local Streams Associated Within and Near the Wind Farm Site

9.3.3 Site Drainage

The Wind Farm Site is drained as part of ongoing forestry management. Drainage ditches serve to lead greenfield and road runoff to local watercourses. Within forestry plantations, furrows between rows of plantations (**Photo1**) and fire breaks (**Photo 2**) serve to direct greenfield runoff to drains, watercourses directly, and also to bog areas in topographic depressions on lower grounds.

Drainage ditches are principally dug channels which run both parallel to access roads and at angles to plantations. The water that flows in such ditches is directed across roadways via pipe culverts (**Photo 3**). Pipes are made of HDPE or concrete and range between 300 mm and 600 mm in diameter. The water that is conveyed across roads is led to streams or is dispersed across low-lying grounds downslope of culvert locations. Where drainage ditches are absent, excess runoff may flow across roads, where it subsequently disperses naturally across lands downslope of the roads.

Some of the drainage ditches are heavily vegetated, depending on slope and position within the landscape. In all cases, ditches are observed to readily transmit flow. In higher slope areas, where the energy of water flow is greater, streambanks show signs of erosion (**Photo 4**). The erosion is both of the peat and the subsoils, and is likely caused by quickly rising water levels during storm events.

While most ditches are shallow (<1 m deep), they can also cut through the peat into the underlying subsoils (**Photo 5**).

The existing roads within Glenora Forest are constructed from crushed stone, partly to allow water to infiltrate (**Photo 6**). Nevertheless, road runoff is generated and transmitted into drainage ditches during significant, high-intensity rainstorms (**Photo 7**).

The streams within the Wind Farm Site are small, generally less than 3 m wide (and mostly less than 1 m wide) and up to 2 m deep (below ground surface). Stream substrates can often be observed to be coarse, incorporating gravel, boulders and cobble, owing to higher-energy flow events, particularly in headwater positions. Streams are bordered by forestry, heath and/or wet grassland vegetation which helps to trap suspended sediments carried by greenfield runoff. Suspended sediment loads in streams appear mainly to be mobilised by streambank erosion and road runoff.

Finally, in the southwestern corner of Glenora Forest especially, there are quaking bog areas and the 'Altderg Lough' which occupy subtle topographic depressions (see Chapter 6 of this EIAR). These features are a natural part of the blanket bog system and have their own small runoff catchments, mainly from the west. No infrastructure is proposed in the subcatchments of these features.

9.3.4 Potential Receptor Identification

Potential river water bodies that could be affected by the Proposed Development are listed in **Table 9-6** and shown in **Figure 9-4.** With regard to the Owenmore River catchment, the sections of rivers that are considered particularly relevant to this EIAR are the headwaters which originate in Glenora Forest and which extend to the Oweninny and Keerglen Rivers.

Potential groundwater bodies (**Figure 9-5**) that could be affected by the Proposed Development are:

- Bangor (code IE_WE_G_0052)
- Belmullet (code IE_WE_G_0057)
- Bellacorick-Killala (code (code IE_WE_G_0041)

Photo 1: Signs of Drainage Along Furrows Within Plantations (Source: CDM Smith)

Photo 2: Drainage Along Firebreaks (Source: MKO)

Photo 3: Examples of Pipe Culverts (Source, FT)

Photo 4: Eroded Streambanks and Exposed Subsoils

Photo 5: Drainage Ditch With Exposed Subsoil Beneath Peat (Source: FT)

Photo 6: Crushed Aggregate Road, Pipe Culvert Across Road, and Drainage Ditches on Both Sides of Road

Photo 7: Suspended Sediments in Road Runoff Entering Drainage Ditch, 18 June 2023

Table 9-6 Potential Surface Water Receptors

Watercourse	WFD River Water Body	WFD Subcatchment	Comment
Wind Farm Site			
Fiddaunfrankagh R.	Owenmore(Mayo)_010 (IE_WE_33O040050)	Owenmore[Mayo]_SC_010	
Glenora R.			
Altderg R.			From confluence of Fiddaunfrankagh R. and Glenora R.
Oweninny R.			From confluence of Altderg R. and Inagh R.
Owenmore R.	Owenmore(Mayo)_020 (IE_WE_33O040200)		Continuation of Oweninny R. downstream of the confluence between Oweninny R. and Sheskin R. Ultimately discharges to Tullaghan Bay
Unnamed streams	Keerglen_010 (IE_WE_33K010200)	Glencullin[NorthMayo]_SC_010	Headwater streams flowing south from eastern part of Glenora Forest to Keerglen R.
Keerglen R.			Flows into Ballinglen R.
Ballinglen R.	Ballinglen_010 (IE_WE_33B010100		Downstream of Keerglen R. Flows into Bunatrahir Bay
Grid Connection Route			
Sralagagh R.	Glencullin (North Mayo)_010 (IE_WE_33G020200)	Glencullin[NorthMayo]_SC_010	Merges with Glencullin R. downstream
Glencullin R.			Flows into Bunatrahir Bay
Ballinglen R.	Ballinglen_020 (IE_WE_33B010200)		Flows into Bunatrahir Bay
	Ballinglen_010 (IE_WE_33B010100)		
Rathroe R.	Breaghwy_010 (IE_WE_34B060600)	Cloonaghmore_SC_010	Merges with Cloonaghmore R. downstream
Cloonaghmore R.	Cloonaghmore_040 (IE_WE_34C030200)		
	Cloonaghmore_050 (IE_WE_34C030270)		Flows into Cloonaghmore estuary, which is part of the larger Killala Bay
Moyne R.	Moyne_010 (IE_WE_34M190890)	Abbeytown_SC_010	Flows into Killala Bay

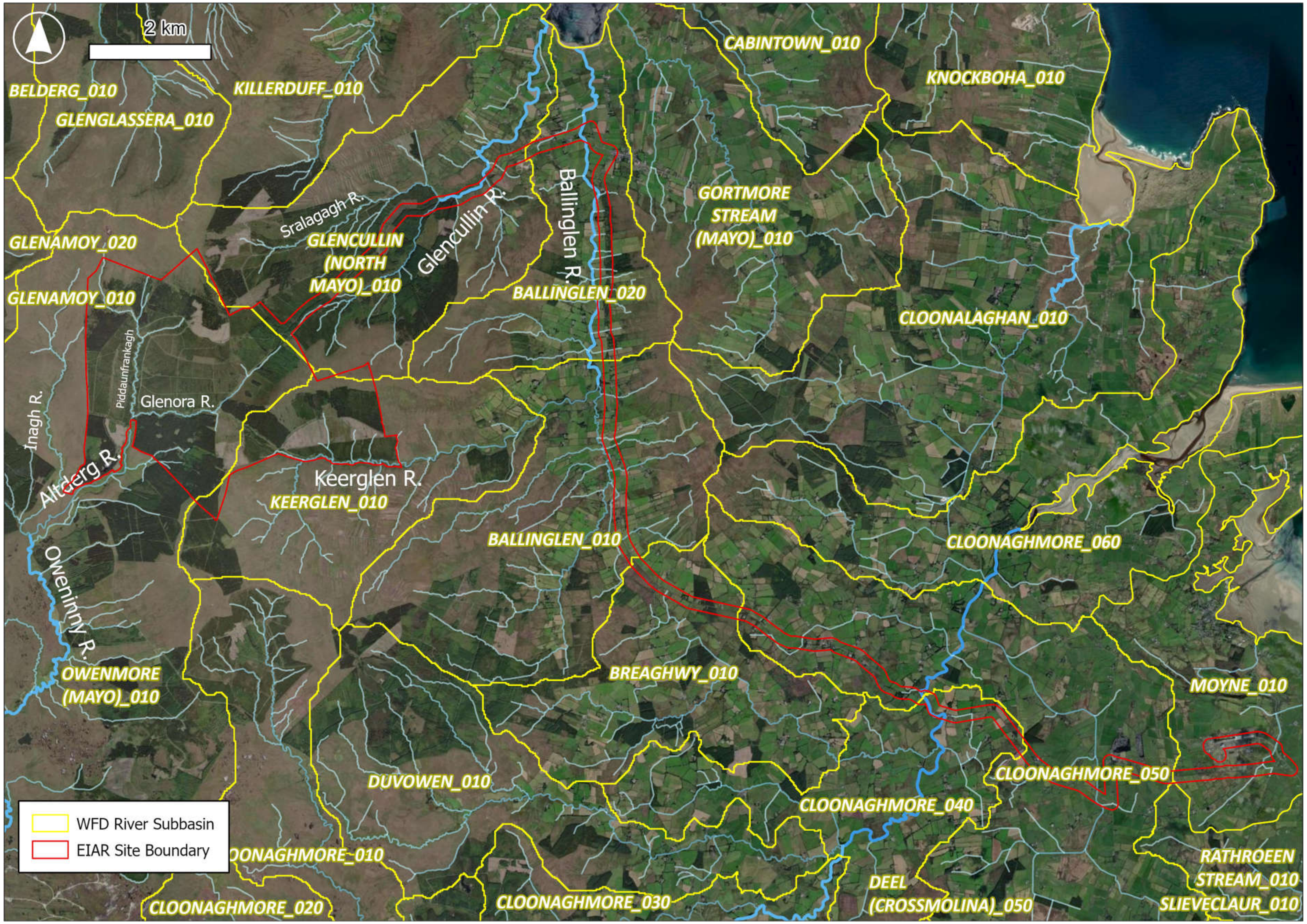

Figure 9-4 Potential River Water Body Receptors

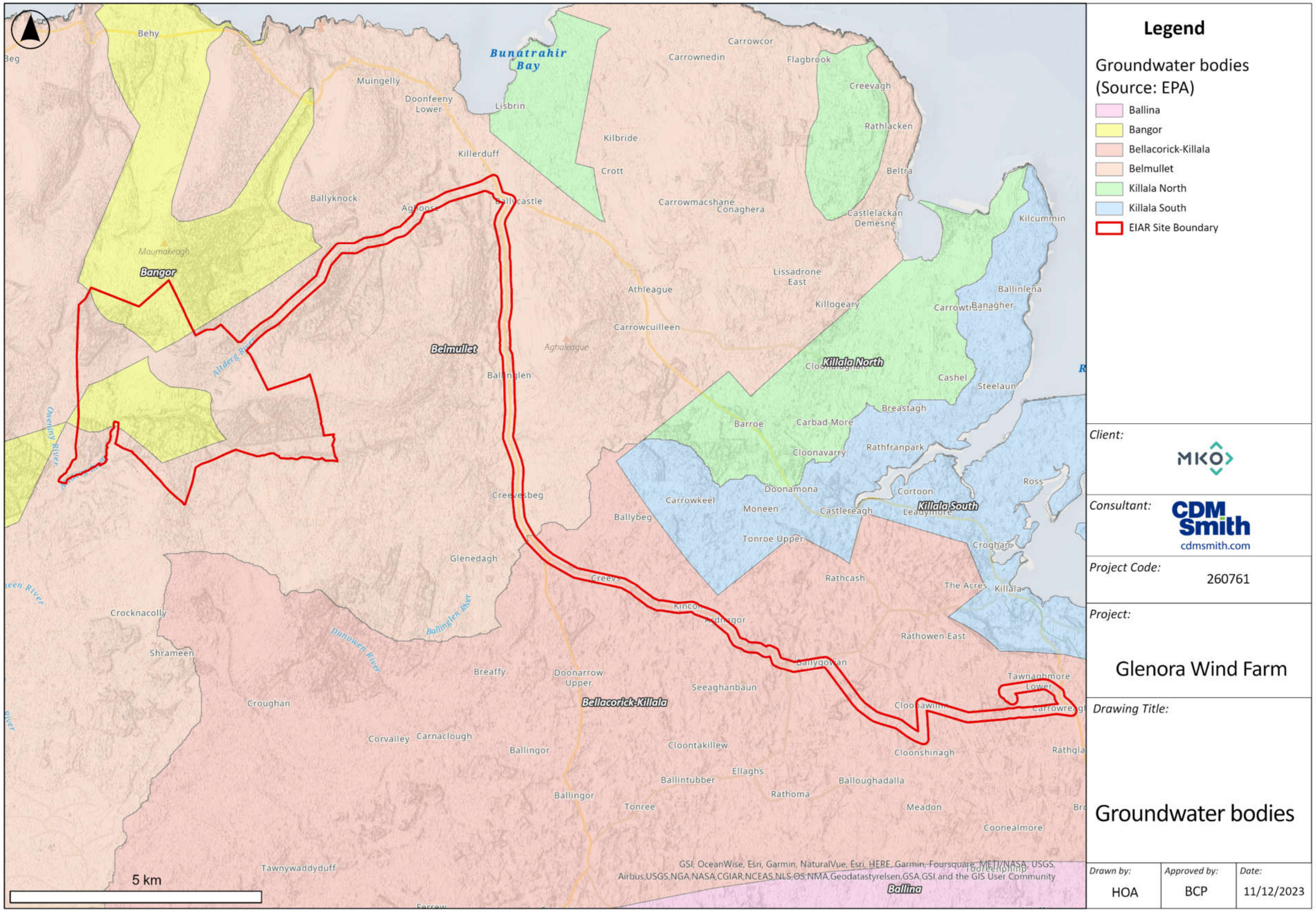

Figure 9-5 Groundwater Bodies (Source: GSI)

9.3.5 Water Balance Components

Natural drainage and streamflows are influenced by rainfall, runoff and recharge. Runoff, which is influenced by rainfall events and the physical attributes of subcatchments, influences the drainage design of the Proposed Development. To estimate runoff, both long-term annual average and return period characteristics must be defined.

9.3.5.1 Long Term Annual Average Rainfall, Runoff and Recharge

The nearest synoptic weather station (to the Wind Farm Site) with long-term rainfall and evaporation data is Belmullet. This station is near sea level and approximately 37 km west-southwest of the Site. The mean annual rainfall for the 30-year period 1981-2010 is 1,248 mm, and as presented in **Table 9-7**, the wettest month historically is October.

Table 9-7 Mean Monthly Rainfall, Belmullet Synoptic Weather Station, 1981-2010

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean monthly total	134.0	97.1	99.2	72.0	70.4	72.1	79.0	101.9	101.8	145.9	134.0	137.4
Greatest daily total	44.7	31.3	25.6	25.9	42.2	38.9	33.2	49.5	62.6	79.6	43.0	41.7
Mean no. days with >= 5.0mm	10.0	7.0	7.0	4.0	4.0	4.0	5.0	6.0	6.0	10.0	10.0	9.0

The Wind Farm Site is situated at a higher elevation than the synoptic weather station at Belmullet, at a mean elevation of approximately 250 mOD. This means that rainfall at the Proposed Development Site will be slightly higher than at Belmullet. Following a rule of thumb of 100 mm of rainfall per 100 m increase elevation, the mean annual rainfall in the Wind Farm Site is expected to approach 1,500 mm.

Based on EPA's Qube model of river flows in ungauged catchments in Ireland (available from EPA's 'Water' web viewer[3], the long-term annual average rainfall (AAR) at the southern end of the Proposed Development Site is approximately 1850 mm/year, at an elevation of approximately 150 mOD. Potential evapotranspiration (PET) is approximately 400 mm/year. Using these figures, effective rainfall (ER), which represents the rainwater that is available for runoff and groundwater recharge, is approximately:

ER = AAR – PET = 1,850 – 400 = 1,450 mm/year

Based on the national groundwater recharge map prepared by GSI, 10% or less of ER is recharged to the bedrock aquifer. For an ER of 1,450 mm/year and a recharge coefficient of 10%, groundwater recharge would be 145 mm/year. This value exceeds the recharge 'cap' of 100 mm/year which GSI assigns to 'poorly productive bedrock aquifer' and which underlies the site (Section 9.3.8). Poorly productive bedrock may not have the physical characteristics and capacity to accept all of the available, infiltrating water. Hence, excess recharge is 'rejected', which enhances flow via shallow pathways, including runoff.

Accordingly, it is inferred that long term average groundwater recharge to bedrock is approximately 100 mm/year at the Wind Farm Site, and the remainder of water, ca. 1,350 mm/yr, is available as runoff and shallow flow through peat and subsoils. This implies that the runoff potential exceeds 90% of long-term effective rainfall. The hydrology of the Wind Farm Site is, therefore, characterised by high runoff rates and low groundwater recharge. Waterlogged peat will enhance lateral runoff of rainwater to streams.

[3] https://gis-stg.epa.ie/EPAMaps/Water

Climate change projections for Ireland are provided by Regional Climate Models (RCM's) downscaled from larger Global Climate Models (GCM). Projections for the period 2041-2060 (mid-century) are available from Met Eireann (Gleeson et al, 2013). The data indicates a projected overall annual decrease in rainfall of approximately 4% (compared to the 30-year average, 1981-2010) but with an increase in the frequency of heavy precipitation events and a winter season increase in rainfall of up to 8%, subject to qualifiers about levels of uncertainty and confidence in projections.

9.3.5.2 Baseline Assessment of Runoff

Long-term average runoff volumes were calculated further for the Wind Farm Site by considering:

- The estimated long-term (30-year) average annual rainfall at the Site (ca. 1,850 mm/yr).
- Applying an escalation factor of 1.1 to account for higher rainfall due to climate change.
- Evapotranspiration, to estimate the effective rainfall.
- Applying a 90% runoff coefficient to the effective rainfall value.
- Multiplying the resulting depth of water to the Wind Farm Site to obtain an average runoff volume.

The calculation is presented in **Table 9-8** below.

Table 9-8 Estimated Long-term Average Annual Runoff

Item	Value	Comment
Long-term average annual rainfall	1,850 mm/yr	Sourced from EPA's Qube model
Escalated rainfall	2,035 mm/yr	Accounts for climate change in future, with a net increase in rainfall totals
Mean annual evapotranspiration	400 mm/yr	From Met Eireann national map of Potential evapotranspiration
Effective rainfall	2,035 - 400 mm/yr = 1,635 mm/yr	Effective rainfall = available recharge
Runoff coefficient	90%	10% is groundwater recharge
Baseline runoff depth	1,635 mm/yr × 90% = 1,472 mm/yr	Rounded
Wind Farm Site	12.90 km^2	Excluding the grid connection route[1]
Long-term average annual runoff	12.90 km^2 × 1,472 m/yr = 18,982,350 m^3/yr, or 52,000 m^3/d, or 0.60 m^3/s.	

Note:
[1] The grid connection route covers a narrow linear path which is on lower elevation and slope, and does not materially affect the overall estimation of runoff.

9.3.5.3 Streamflow

Runoff contributes to streamflow. Estimates of streamflow were obtained from EPA's Qube model for naturalized streamflow in ungauged catchments.[4] The Wind Farm Site, indicated by the redline boundary in **Figure 9-6**, is covered by the two Qube model catchments, shown as the shaded light green areas across Glenora Forest (deep green), as extracted from EPA's 'Water' web viewer.

The Qube model catchment on the top of **Figure 9-6** (node 33_2632) represents the area that contributes runoff and flow to the Altderg River. The Qube model catchment on the bottom (node 33_1811) represents the area that contributes runoff and flow to Keerglen River. It is noted that only about 25% of the catchment of node 33_1811 is within the Wind Farm Site. Within the Wind Farm Site, the two Qube model catchments cover areas of approximately 11.46 and 3.3 km^2, respectively, for a total combined area of 14.76 km^2.

[4] https://www.epa.ie/our-services/monitoring--assessment/freshwater--marine/rivers/water-level-and-flow-data/

The model-derived flow percentiles for the two Qube model catchments are presented in **Figure 9-7**. Flood flow conditions are represented towards the left side of the graph while low flow conditions are represented towards the right. As an example, a flow percentile of 10 in **Figure 9-7** represents the flow that is exceeded 10% of the time (at Qube model nodes 'CD 33_2632' and 'CD 33_1811', indicated by the red crosses in **Figure 9-6**).

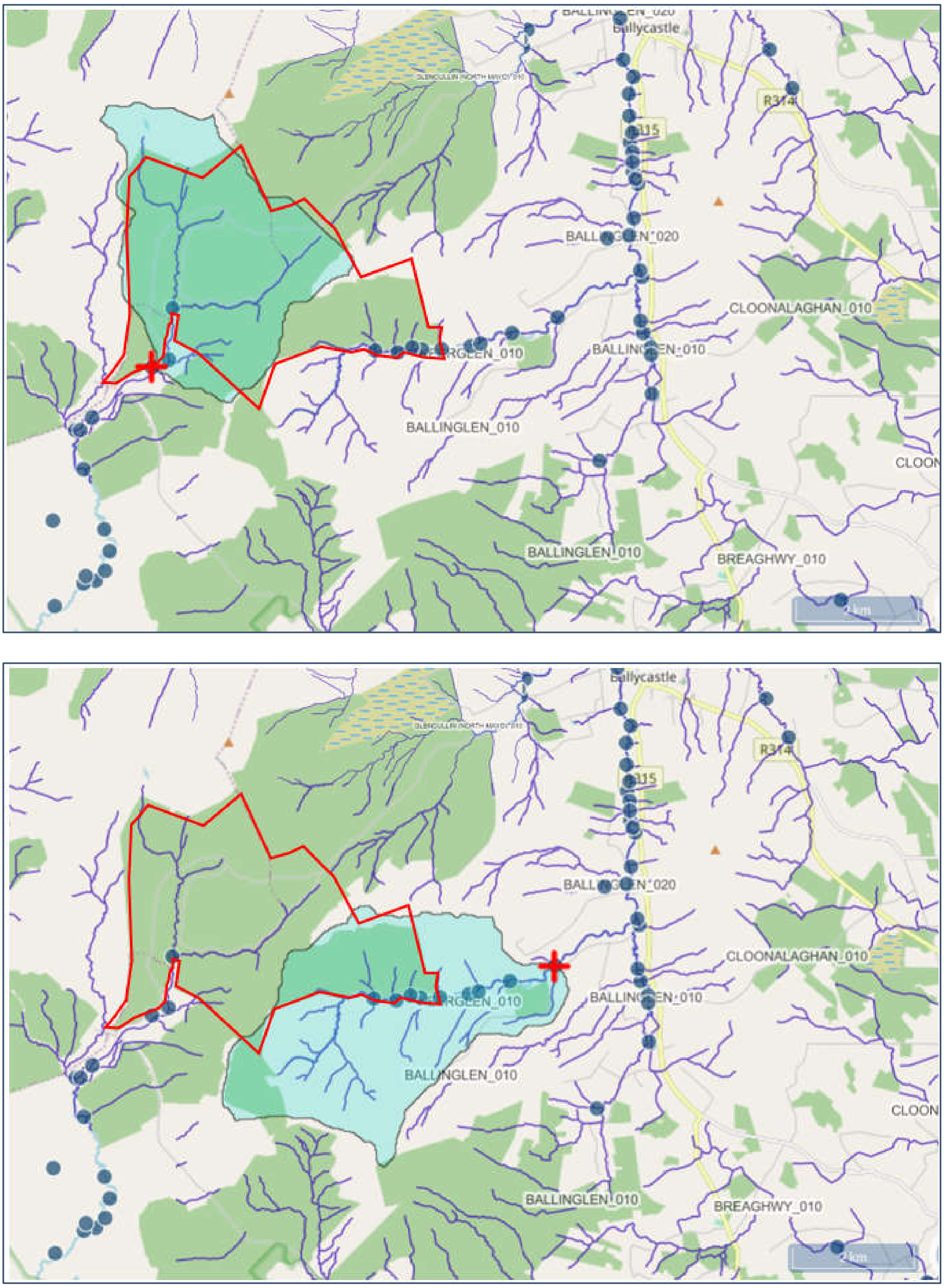

Figure 9-6 Locations and Catchments of Qube Model Nodes 33_2632 (red cross, top) and 33_1811 (red cross, bottom)

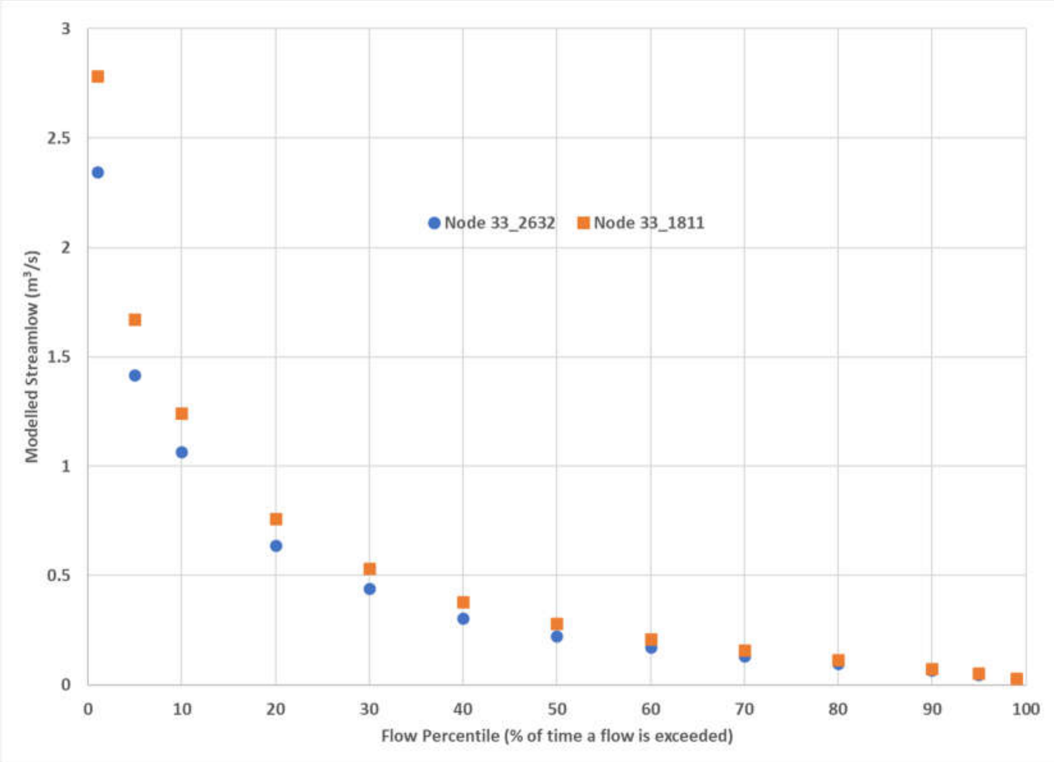

Figure 9-7 Model-Estimated Flow Percentiles for Streams That Drain the Wind Farm Site

Based on **Figure 9-7**:

- Modelled peak streamflows, represented by the 1-percentile flow, are 2.35 and 2.78 m^3/s, respectively in the two catchments.
- Mean estimated streamflows, which is approximated by the 30-percentile flow (LAWPRO/EPA, 2022), are 0.44 and 0.53 m^3/s, respectively.

Low-flow conditions, which are generally defined by the estimated 95-percentile flows, are approximately 0.05 m^3/s in both cases. The mean streamflow values are considerably higher than the estimated long-term average annual runoff, which means that long-term annual average runoff is not a useful metric, requiring further consideration of rainfall characteristics, notably storm-based rainfall (intensity-duration-frequency).

The wide range of estimated streamflow in **Figure 9-7** is characteristic of 'flashy' catchments in which both runoff and streamflow respond quickly to rainfall events. In such catchments, both individual storm events and antecedent (particularly wet) hydrological conditions can significantly influence runoff rates.

Because approximately 25% of the catchment area of Qube model node 33_1811 is within the Wind Farm Site, the area-proportional flow from the tributaries that flow south to Keerglen River within the Site are approximately 25% of the modelled flow at node 33_1811. Hence, the total mean streamflow that exits the Wind Farm Site is estimated to be, approximately:

$$0.44\ m^3/s + (0.53\ m^3/s \times 25\%) = 0.57\ m^3/s$$

For the runoff coefficient of 90%, an estimated 0.51 m^3/s (i.e., 90% of the 0.57 m^3/s total mean flow) represents mean annual runoff from the Wind Farm Site. The remaining 10% is contributed by groundwater baseflow. Adjusted for the total combined runoff contributing area of 14.76 km^2, the mean specific runoff associated with the Wind Farm Site is (0.51 m^3/s divided by 14.76 km^2) = 0.035 $m^3/s/km^2$.

The Qube-modeled mean monthly flows are depicted in **Figure 9-8** for the two model catchments, showing significantly higher mean monthly flows in winter compared to summer, reflecting the higher rainfall conditions in the winter season.

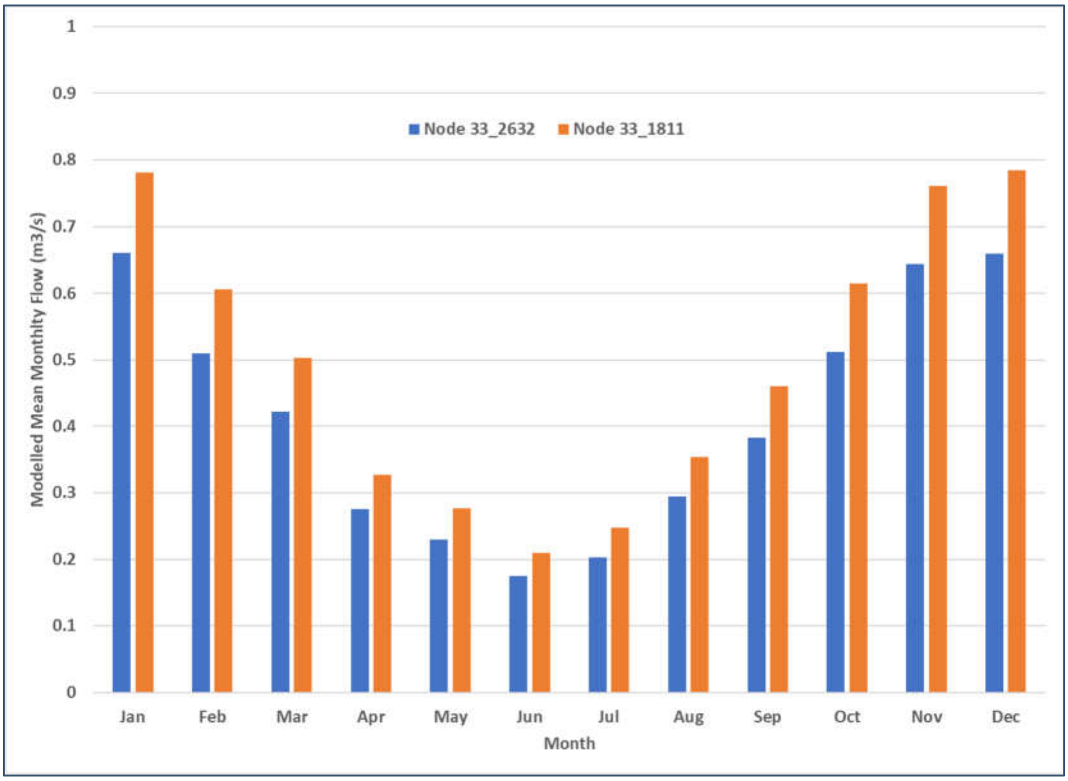

Figure 9-8 Model-Estimated Mean Monthly Flows in the Two Streams That Drain the Proposed Development Area

9.3.5.4 Rainfall Return Periods

Table 9-9 below presents return period rainfall depths for the Wind Farm Site, specifically at Irish Grid coordinate 103510E/335644N near the centre of the Site. The data were sourced from Met Eireann and provide rainfall depths for a range of storm durations and return periods. These values were sourced to compute design runoff rates (see Section 9.3.13).

9.3.6 Summary of Flood Risk Assessment

A preliminary flood risk assessment (FRA) of the Proposed Development is presented in **Appendix 9-1**. The FRA sources information from i) preliminary flood risk maps prepared by the Office of Public Works (OPW), ii) groundwater flood maps prepared by Geological Survey Ireland (GSI), and iii) historical 6-inch sheets and 25-inch basemaps that are available from Ordnance Survey Ireland (OSI).

9.3.6.1 Wind Farm Site

The area covered by the Wind Farm Site was not considered in OPW's Catchment Flood Risk Assessment and Management (CFRAM) Programme. However, as shown in **Figure 9-9**, OPW's National Indicative Fluvial flood risk maps show coincident "*medium probability*" and "*low probability*" flood extents along sections of the Altderg and Keerglen Rivers. The section along Altderg River extends to the southern boundary of the Wind Farm Site. The section on Keerglen River follows the southeastern boundary but does not extend into the Wind Farm Site.

Table 9-9 Rainfall (mm) Return Periods for Irish Grid Location 103510E, 335664N (Source: Met Eireann)

Duration		Years															
		0.5	1	2	3	4	5	10	20	30	50	75	100	150	200	250	500
5	mins	3.0	4.2	4.9	5.9	6.6	7.1	8.9	10.9	12.2	14.1	15.7	17.0	19.0	20.6	21.8	N/A
10	mins	4.2	5.9	6.8	8.2	9.2	9.9	12.4	15.2	17.0	19.6	21.9	23.7	26.5	28.6	30.4	N/A
15	mins	4.9	6.9	8.0	9.7	10.8	11.7	14.6	17.8	20.0	23.1	25.8	27.9	31.2	33.7	35.8	N/A
30	mins	6.5	9.1	10.4	12.5	13.9	15.0	18.5	22.4	25.1	28.7	32.0	34.5	38.4	41.4	43.9	N/A
1	hours	8.6	11.8	13.5	16.1	17.8	19.1	23.4	28.2	31.4	35.8	39.7	42.6	47.2	50.8	53.7	N/A
2	hours	11.3	15.4	17.5	20.7	22.8	24.4	29.7	35.5	39.3	44.5	49.2	52.7	58.1	62.3	65.8	N/A
3	hours	13.3	18.0	20.4	24.0	26.4	28.2	34.1	40.6	44.8	50.7	55.8	59.7	65.7	70.3	74.0	N/A
4	hours	14.9	20.1	22.7	26.7	29.3	31.3	37.6	44.7	49.2	55.5	61.0	65.2	71.6	76.5	80.5	N/A
6	hours	17.6	23.5	26.5	30.9	33.8	36.1	43.2	51.1	56.1	63.1	69.2	73.8	80.8	86.2	90.7	N/A
9	hours	20.7	27.4	30.8	35.8	39.1	41.6	49.7	58.4	64.0	71.7	78.4	83.5	91.3	97.2	102.1	N/A
12	hours	23.3	30.6	34.3	39.8	43.4	46.1	54.8	64.2	70.3	78.6	85.8	91.2	99.5	105.8	111.0	N/A
18	hours	27.4	35.7	40.0	46.1	50.2	53.2	62.9	73.5	80.2	89.3	97.3	103.3	112.4	119.3	125.0	N/A
24	hours	30.7	39.9	44.5	51.2	55.6	58.9	69.5	80.8	88.0	97.8	106.4	112.8	122.5	129.9	135.9	156.5
2	days	41.2	52.0	57.4	65.1	70.1	73.9	85.6	98.0	105.8	116.3	125.4	132.2	142.3	150.0	156.2	177.2
3	days	50.3	62.6	68.6	77.1	82.6	86.7	99.5	112.9	121.3	132.5	142.1	149.3	160.0	168.0	174.5	196.2
4	days	58.7	72.2	78.8	88.1	94.0	98.5	112.2	126.5	135.4	147.2	157.3	164.8	176.0	184.4	191.2	213.7
6	days	74.4	90.1	97.7	108.3	115.0	120.0	135.3	151.2	160.9	174.0	184.9	193.1	205.2	214.2	221.4	245.5
8	days	89.2	106.8	115.2	126.9	134.3	139.8	156.6	173.8	184.4	198.4	210.1	218.9	231.7	241.3	248.9	274.3
10	days	103.4	122.7	131.9	144.6	152.6	158.6	176.6	195.1	206.4	221.3	233.7	243.0	256.5	266.6	274.7	301.3
12	days	117.2	138.1	148.0	161.7	170.3	176.6	195.9	215.4	227.4	243.1	256.2	265.9	280.1	290.6	299.1	326.8
16	days	144.1	167.9	179.2	194.5	204.1	211.2	232.6	254.2	267.3	284.5	298.8	309.3	324.7	336.0	345.1	374.8
20	days	170.4	196.9	209.3	226.2	236.7	244.5	267.8	291.1	305.3	323.8	339.1	350.3	366.8	378.8	388.5	420.0
25	days	202.9	232.4	246.1	264.8	276.3	284.8	310.2	335.6	350.9	370.9	387.3	399.4	417.0	429.9	440.2	473.6

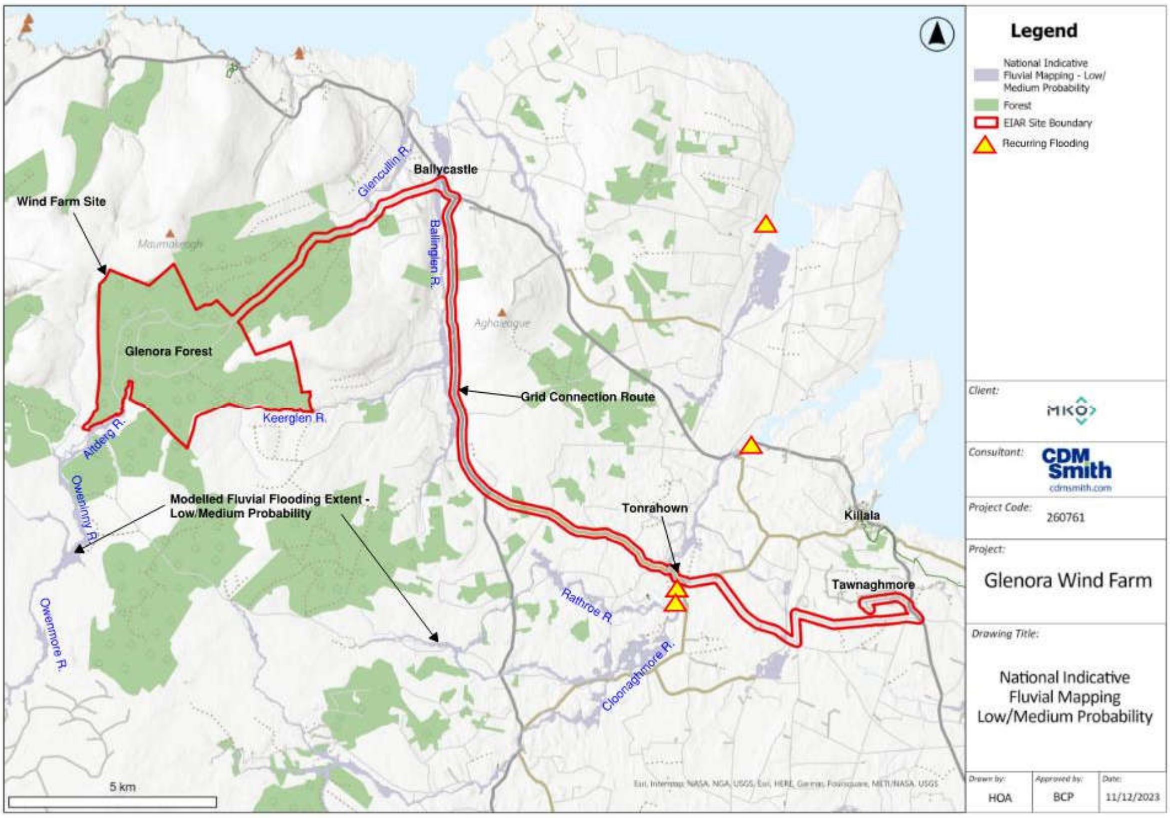

Figure 9-9 Recorded Flood Events and Modelled Extent of "Medium" and "Low" Probability" Fluvial Flood Risk (Source: OPW)

OPW defines "*medium probability"* flooding as a *"modelled extent of land that might be flooded by rivers (fluvial flooding) during a theoretical or 'design' flood event with an estimated probability of occurrence, rather than information for actual floods that have occurred in the past.*" In this instance, the probability of occurrence is 100:1, which is a 100-year return period event, noting that this does not account for possible effects of climate change. The "*low probability*" flood risk extent is defined by a 1,000:1 probability of occurrence, or a 1000-year return period event.

There are no records of historical flooding or recurring flood incidents with the Wind Farm Site. The nearest recorded flooding on a river that is hydrologically linked with the Wind Farm Site is on the Owenmore River, between Bellacorick and Bangor Erris, more than 20 km downstream of the Wind Farm Site.

GSI's mapping does not show any groundwater flooding in vicinity of the Wind Farm Site. Historical OSI 6- or 25-inch sheets for the Wind Farm Site do not identify any lands that are "liable to flood".

With the exception of roads and road crossings on lower ground, all infrastructure within the Wind Farm Site is located outside and above the OPW-modelled 1,000- and 100-year return period flood levels. As such, all planned infrastructure is located in Flood Zone C (Low Risk).

Roads that cross streams within the Wind Farm Site incorporate pipe culverts and an existing single-span bridge (on Altderg River). Flood risk at culvert crossings will be accommodated by designing conservatively for 1 in 100 year storm flow events (**Appendix 9-2**).

9.3.6.2 Grid Connection Route

The area that is traversed by the grid connection route is also not considered in OPW's Catchment Flood Risk Assessment and Management (CFRAM) Programme. However, OPW's National Indicative Fluvial flood risk maps show coincident "*medium probability*" and "*low probability*" flood extents along the Glencullin, Ballinglen, and Cloonaghmore Rivers, as reproduced in **Figure 9-9**. The grid connection route follows existing roadways which are at higher elevations than the rivers, and outside the indicative flood extents, which means that the grid cable will remain above the OPW-modelled 1,000- and 100-year return period flood levels. At locations where the grid cable crosses rivers with identified flood risk, cable crossings will be accommodated by existing bridges or horizontal direction drilling beneath streambeds. Neither creates or involves flood risk.

The recurring flood events on the Cloonaghmore River (**Figure 9-9**) is upstream of where the grid connection route crosses the river.

9.3.7 Surface Water Quality

Surface water samples were collected at 5 locations within the Wind Farm Site in September 2020, November 2020, January 2021, March 2021, and May 2021 (FT, 2023). The sample locations are shown in **Figure 9-10**, and the reported results are presented in **Table 9-10**.

Nutrient concentrations (ammonia, nitrate and orthophosphate) are generally low to non-detected in nearly all samples. For example, total ammonia concentrations were below the limit of detection (LOD, <0.01 mg/L as N) in 22 of the 25 samples that were collected. The three detections ranged from 0.017 mg/L at Location 2 to 0.025 mg/L at Location 5. The data overall do not indicate any specific water quality issue, and taken together, the sample results are consistent with water bodies that meet the default WFD 'Good' chemical status objective, whereby all results comply with environmental quality standards (EQSs) for at least 'Good' chemical status (per the European Communities Environmental Objectives (Surface Waters) (Amendment) Regulations 2022, S.I. No. 288/2022).

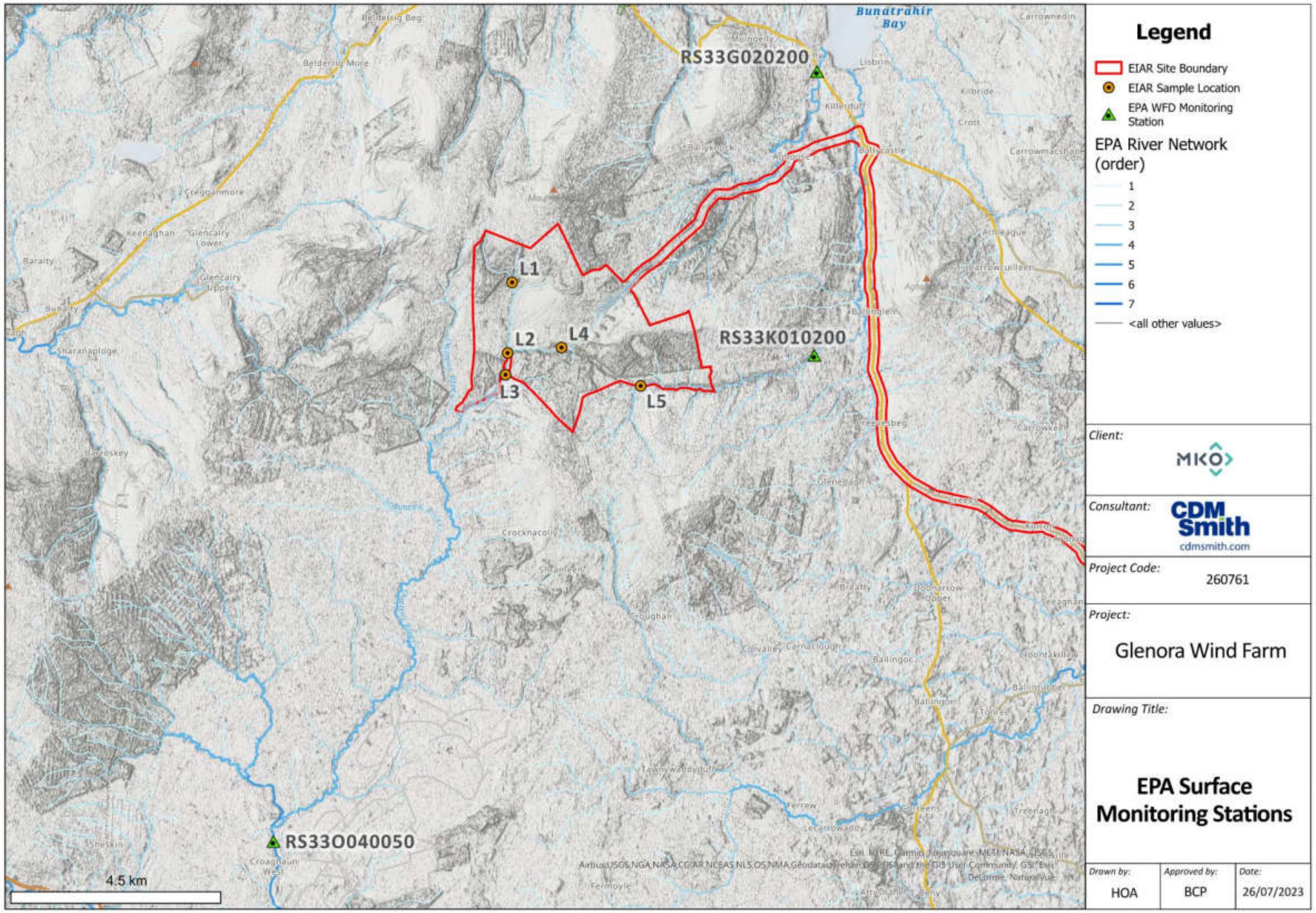

Figure 9-10 Surface Water Sample Locations

Table 9-10 Surface Water Quality at 5 Locations In the Wind Farm Site, 2020-2021 (Source: FT, 2022)

Parameter	Unit	Location 1					Location 2					Location 3				
		29-Sep-20	26-Nov-20	27-Jan-21	31-Mar-21	27-May-21	29-Sep-20	26-Nov-20	27-Jan-21	31-Mar-21	27-May-21	29-Sep-20	26-Nov-20	27-Jan-21	31-Mar-21	27-May-21
Aluminium (dissolved)	mg/L	0.058	0.079	0.063	0.091	0.045	0.09	0.085	0.066	0.098	0.046	0.074	0.096	0.071	0.092	0.046
Alkalinity (as $CaCO_3$)	mg/L	32.7	<30	<30	<30	43.9	38.6	<30	<30	<30	54.1	48.7	<30	<30	<30	66.4
Ammonia as N	mg/L	<0.01	<0.01	0.018	<0.01	<0.01	<0.01	<0.01	0.017	<0.01	0.014	<0.01	<0.01	<0.01	<0.01	<0.01
BOD_5	mg/L	<2	–	<2	<2	<2	<2	–	<2	<2	<2	<2	–	<2	<2	<2
Chloride	mg/L	16.9	14.7	10.9	17.7	19.4	18.7	15.5	11.4	18.9	20.7	19.6	16.6	15.3	19.3	21.7
COD	mg/L	18	–	14	28	10	33	–	21	35	15	43	–	31	38	25
Conductivity @ 20°C	µS/cm	144	–	<132	432	136	142	–	<132	<132	151	165	–	<132	<132	303
Dissolved Oxygen	mg/L	9.44	–	10.89	10.14	10.48	9.41	–	10.9	10.22	10.42	9.13	–	10.87	10.49	10.66
Iron (dissolved)	mg/L	0.269	0.216	0.157	0.201	0.271	0.624	0.32	0.23	0.291	0.493	0.947	0.48	0.323	0.339	0.717
Total Nitrogen	mg/L	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
Nitrite as N	mg/L	<0.005	<0.005	0.079	0.079	0.079	<0.005	<0.005	0.065	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nitrate as N	mg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Orthophosphate as P	mg/L	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	0.042	<0.025
pH	mg/L	7.68	–	7.42	7.02	7.55	7.55	–	7.24	6.99	7.65	7.7	–	7.17	6.97	7.83
Phosphorus, Total as P	mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
TON as N	mg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Total Suspended Solids	mg/L	<2	<2	<2	<2	2	<2	<2	<2	<2	<2	<2	2	<2	<2	2
Turbidity	NTU	0.38	–	0.88	1.49	0.96	0.38	–	0.91	1.24	0.74	0.85	–	1.17	1.24	0.84

Parameter	Unit	Location 4					Location 5				
		29-Sep-20	26-Nov-20	27-Jan-21	31-Mar-21	27-May-21	29-Sep-20	26-Nov-20	27-Jan-21	31-Mar-21	27-May-21
Aluminium (dissolved)	mg/L	0.711	0.091	0.071	0.147	0.051	0.067	0.091	0.068	0.089	0.049
Alkalinity (as $CaCO_3$)	mg/L	81.5	<30	<30	<30	102	62.6	<30	<30	<30	76.3
Ammonia as N	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.025	<0.01	<0.01	<0.01
BOD_5	mg/L	<2	–	<2	<2	<2	<2	–	<2	<2	<2
Chloride	mg/L	20.3	17.6	16.2	18.9	22.2	19.5	16.4	15.4	18.4	20.9
COD	mg/L	43	–	30	42	24	35	–	25	37	18
Conductivity @ 20°C	µS/cm	230	–	<132	<132	222	198	–	<132	158	181
Dissolved Oxygen	mg/L	9.49	–	10.78	10.06	10.69	9.52	–	10.72	10.03	10.73
Iron (dissolved)	mg/L	0.957	0.538	0.385	0.378	0.676	0.781	0.422	0.275	0.295	0.532
Total Nitrogen	mg/L	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
Nitrite as N	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nitrate as N	mg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Orthophosphate as P	mg/L	<0.025	<0.025	<0.025	0.042	<0.025	<0.025	<0.025	<0.025	0.049	<0.025
pH	mg/L	7.75	–	7.41	7.11	7.9	7.75	–	7.33	7.02	7.87
Phosphorus, Total as P	mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
TON as N	mg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Total Suspended Solids	mg/L	<2	5	5	4	2	4	<2	5	4	3
Turbidity	NTU	1.24	–	1.38	1.32	0.98	1.01	–	1.02	1.67	0.96

Publicly available surface water quality data from EPA were also reviewed, notably from three monitoring stations that are part of EPA's national WFD monitoring programme, as follows:

- Station ID RS33O040050 on the Owenmore River (**Figure 9-10**). This station is situated c. 12 km south-southwest of the Wind Farm Site, downstream of the Altderg River which exits Glenora Forest to the south. EPA's records cover the period 2007 to present.
- Station ID RS33K010200 on the Keerglen River (**Figure 9-10**). This station is situated c.5.5 km east and downstream of the Wind Farm Site. EPA's records cover the period 2016 to present.
- Station ID RS33G020200 on the Glencullin River (**Figure 9-10**). This station is situated c.7.5 km northeast of the Wind Farm Site. EPA's records cover the period 2007 to present. This station is not hydrologically downstream of infrastructure within the Wind Farm Site, but the data nevertheless reflects a subcatchment which originates within Glenora Forest. For this reason, it was included in the baseline description for purposes of comparison with the Owenmore and Keerglen Rivers.

The EPA data are summarised in **Table 9-11**. In short, the data show:

- Low nutrient concentrations
- Well oxygenated and low biological oxygen demand conditions
- Variable and wide-ranging true colour concentrations
- Variable alkalinity concentrations, although average alkalinity values are <100 mg/l (as $CaCO_3$), *i.e.* low, at each location.

Additionally, average concentrations for total ammonia, orthophosphate (ORP), BOD_5 are below annual average (AA) EQSs for WFD "Good" chemical status. Results for individual water quality parameters are presented below. The WFD status classification of river water bodies and groundwater bodies linked to the Proposed Development is presented in **Appendix 9-3**.

9.3.7.1 Total Ammonia

Total ammonia concentrations are shown in **Figure 9-11**. Sample results are generally below limits of detection (LOD, which is either 0.02 or 0.03 mg/L as N, depending on the sample). The vast majority of data, hence also annual averages, are below the AA-EQS of 0.065 mg/L as N for WFD "Good" chemical status. The maximum recorded value in the datasets is 0.78 mg/l in 2020, which is considered a single outlier detection (thus not shown in **Figure 9-11**).

9.3.7.2 Orthophosphate

Orthophosphate concentrations are shown in **Figure 9-12**. Sample results are generally below limits of detection (LOD, mostly at 0.01 mg/L as P). The vast majority of data, hence also annual averages, are below the AA-EQS of 0.035 mg/L as N for WFD "Good" chemical status. The maximum recorded value in the datasets is 0.096 mg/l in 2008.

9.3.7.3 SEC

SEC values are shown in **Figure 9-13**. Recorded values range from <100 to approximately 500 µS/cm and tend to show summer maxima and winter minima, likely reflecting higher rainfall and flow in winter. SEC is generally lower at the Owenmore River station compared to the other two stations, owing to a greater surface water influence in a much larger subcatchment at this location.

Table 9-11 Summary of EPA Water Quality Data, WFD Monitoring Stations

			Subcatchment: Owenmore (Mayo)_010 River: Owenmore EPA Station ID: RS33O040050 EPA Station name: Br SE Srahnakilly					Subcatchment: Keerglen_010 River: Keerglen EPA Station ID: RS33K010200 EPA Station name: Bridge N.E. of Doondragon					Subcatchment: Glencullin (North Mayo)_010 River: Glencullin EPA Station ID: RS33G020200 EPA Station name: Killerduff Bridge					
Parameter	Unit	LOD[1]	Min	Max	Average[2]	n[3]	n>LOD	Min	Max	Average	n	n>LOD	Min	Max	Average	n	n>LOD	AA-EQS[4]
Total Alkalinity (as $CaCO_3$)	mg/l	8-10	<8	92.00	30.84	73	64	11.00	266.00	90.90	39	39	<8	193.00	68.84	76	76	
Total Hardness (as $CaCO_3$)	mg/l	10	14.00	102.00	42.25	73	63	19.00	269.00	102.51	39	39	30.00	214.00	85.53	76	76	
Biological Oxygen Demand (5-day)	mg/l	1	<1	4.10	0.84	71	30	<1	3.60	0.90	37	16	<1	1.90	0.78	74	28	≤1.5
Chloride	mg/l	2	9.82	46.00	22.36	73	73	7.98	39.00	20.29	39	39	8.71	42.80	24.32	76	76	
Electrical Conductivity @ 25°C	µS/cm	15	29.00	266.00	140.86	72	72	78.00	565.00	249.16	38	38	95.00	461.00	221.57	75	75	
Total Ammonia (NH_3 as N)	mg/l	0.02	<0.02	0.085	0.015	73	10	<0.02	0.032	--	39	4	<0.02	0.770	0.023	76	6	≤0.065
Nitrate (as N)	mg/l	0.2	<0.2	1.50	--	36	1	<0.2	0.570	0.142	36	8	<0.2	0.210	--	36	1	
Nitrite (as N)	mg/l	0.004	<0.004	0.014	--	71	1	<0.004	0.016	--	37	1	<0.004	0.013	--	71	1	
Total Oxidisable Nitrogen (as N)	mg/l	0.2	<0.2	1.500	--	73	1	<0.2	0.560	0.138	39	8	<0.2	0.200	--	76	1	
Ortho-Phosphorus (as P)	mg/l	0.01	<0.01	0.019	0.006	73	8	<0.01	0.015	0.007	39	12	<0.01	0.098	0.013	76	40	≤0.035
pH	pH units	2	6.10	8.10	7.18	72	72	7.00	8.10	7.63	38	38	6.70	8.50	7.68	75	75	
True Colour	mg/l Pt Co	5	32.00	402.00	166.58	73	73	22.00	293.00	139.97	39	39	12.00	412.00	159.21	76	76	
Dissolved Oxygen	% Sat	1	89.00	116.00	99.41	70	70	48.00	120.00	97.47	36	36	50.00	125.00	100.23	73	73	>80<120
Dissolved Oxygen	mg/l	0.1	8.20	12.70	10.83	33	33	5.00	13.00	10.69	35	35	5.50	13.00	10.92	35	35	

Notes:
[1] LOD = limit of detection
[2] Averages not calculated if number of detections (n>LOD) is ≤4. Averages calculated using half the LOD where results are <LOD.
[3] n – number of samples
[4] Annual Average Environmental Quality Standard for WFD Good Status classification of river water bodies, per the European Communities Environmental Objectives (Surface Waters) (Amendment) Regulations 2022, S.I. No. 288/2022 as amended.

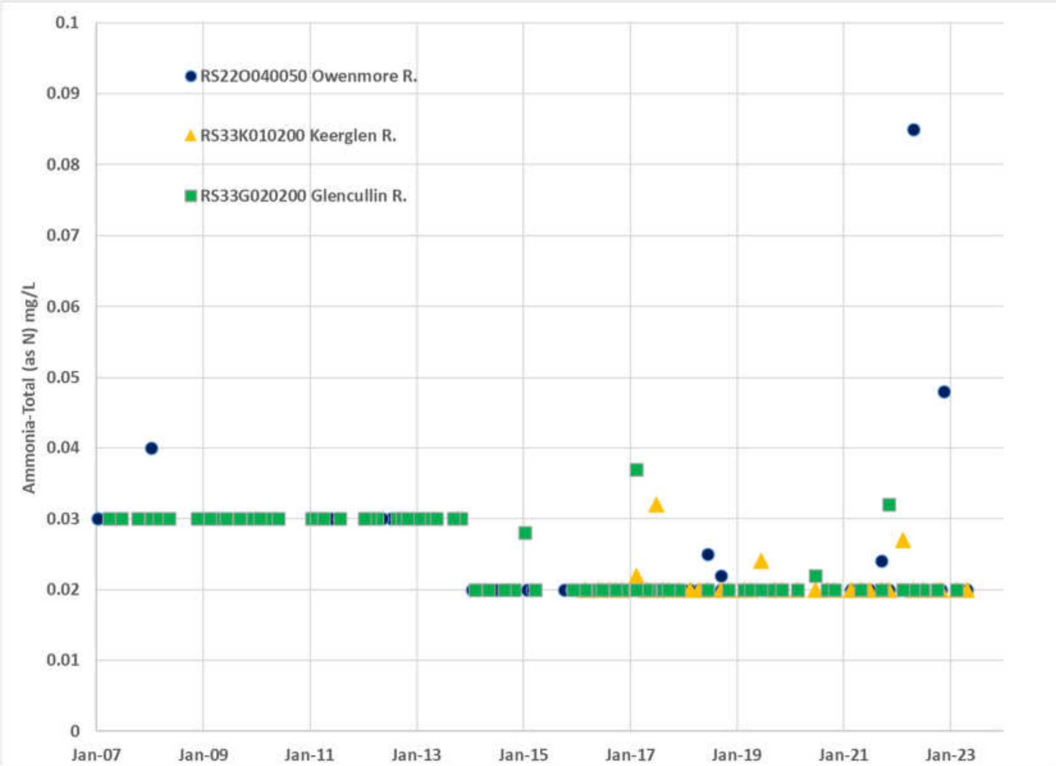

Figure 9-11 Total Ammonia, 2007-2023, EPA Data

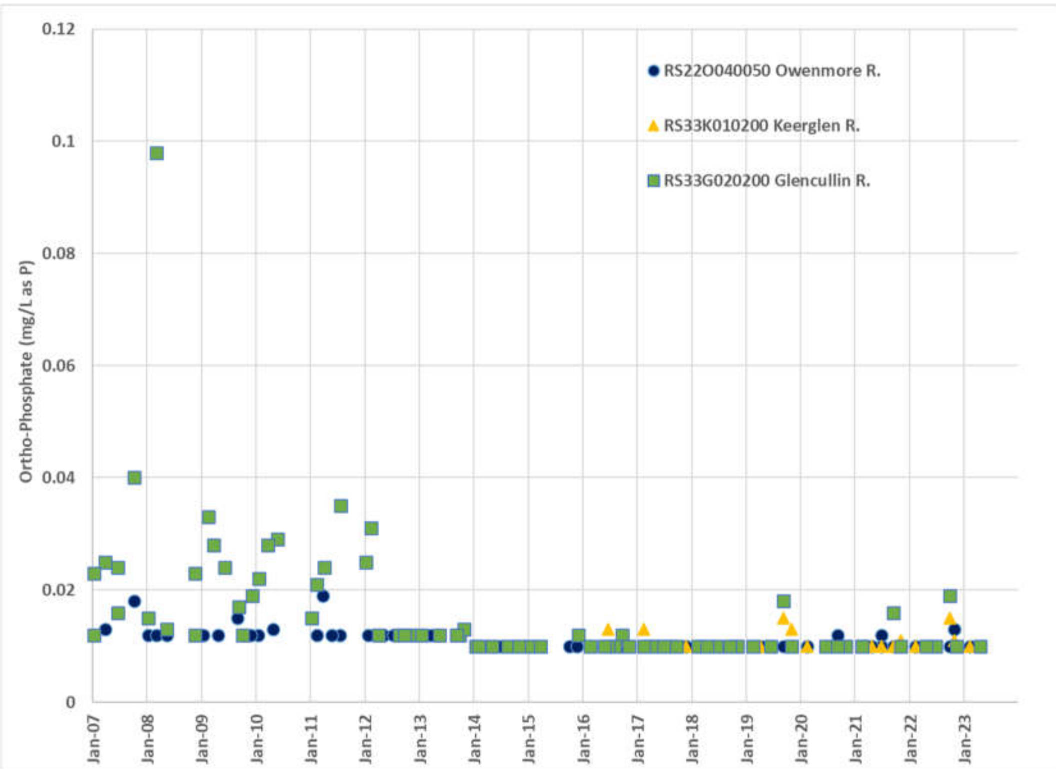

Figure 9-12 Orthophosphate, 2007-2022, EPA Data

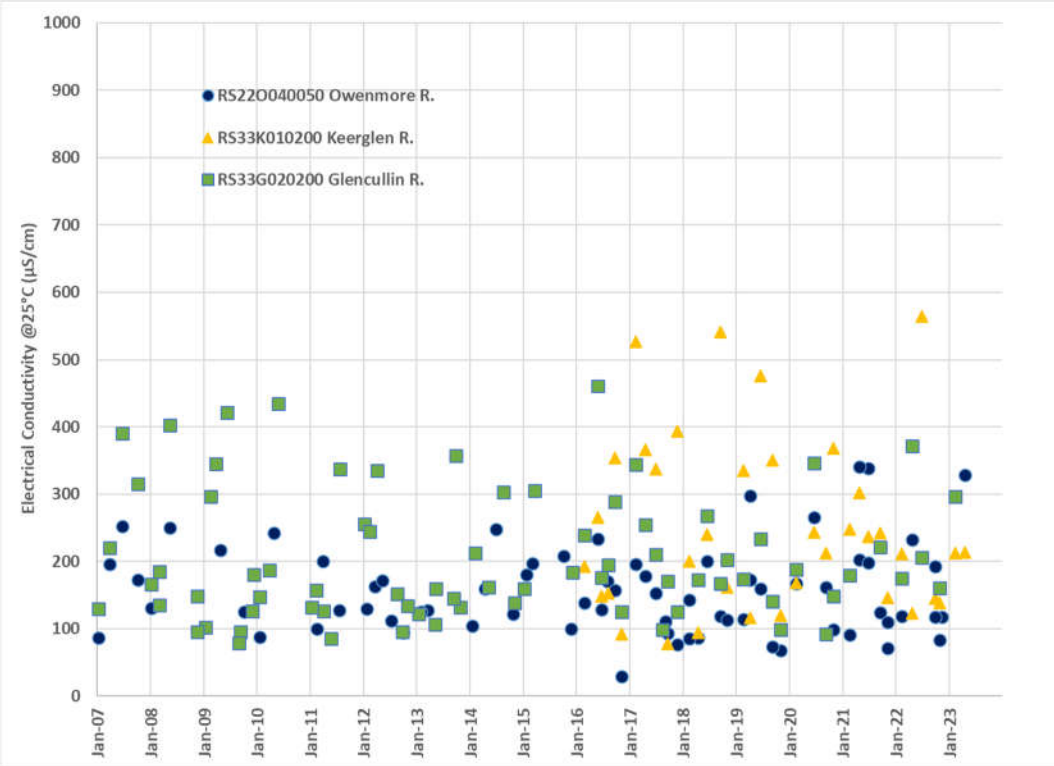

Figure 9-13 Electrical Conductivity, 2007-2023, EPA Data

9.3.7.4 Total Alkalinity

Total alkalinity concentrations are shown in **Figure 9-14**. Concentrations show seasonal changes, generally with summer maxima. Average concentrations are <100 mg/L (as $CaCO_3$) at each station, but concentrations are noticeably lower at the Owenmore River station compared to the other two stations, for the same reasons described above.

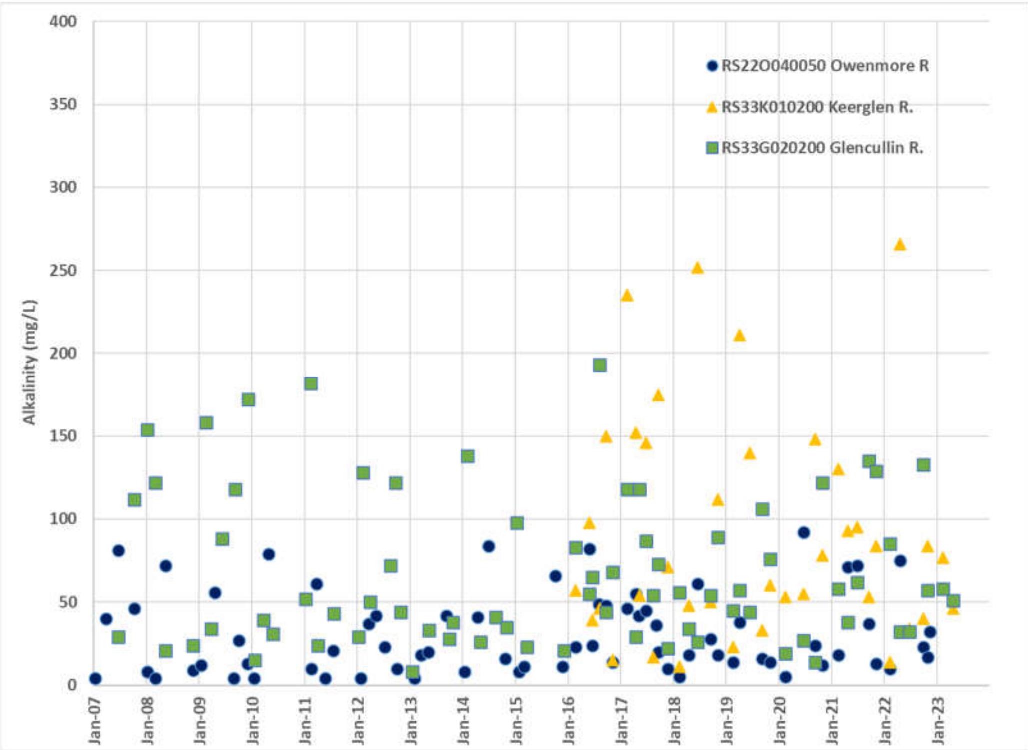

Figure 9-14 Total Alkalinity, 2007-2023, EPA Data

9.3.7.5 pH

As shown in **Figure 9-15**, pH values range from 6 to 8.5, generally with summer maxima. pH values are also generally lower at the Owenmore River station.

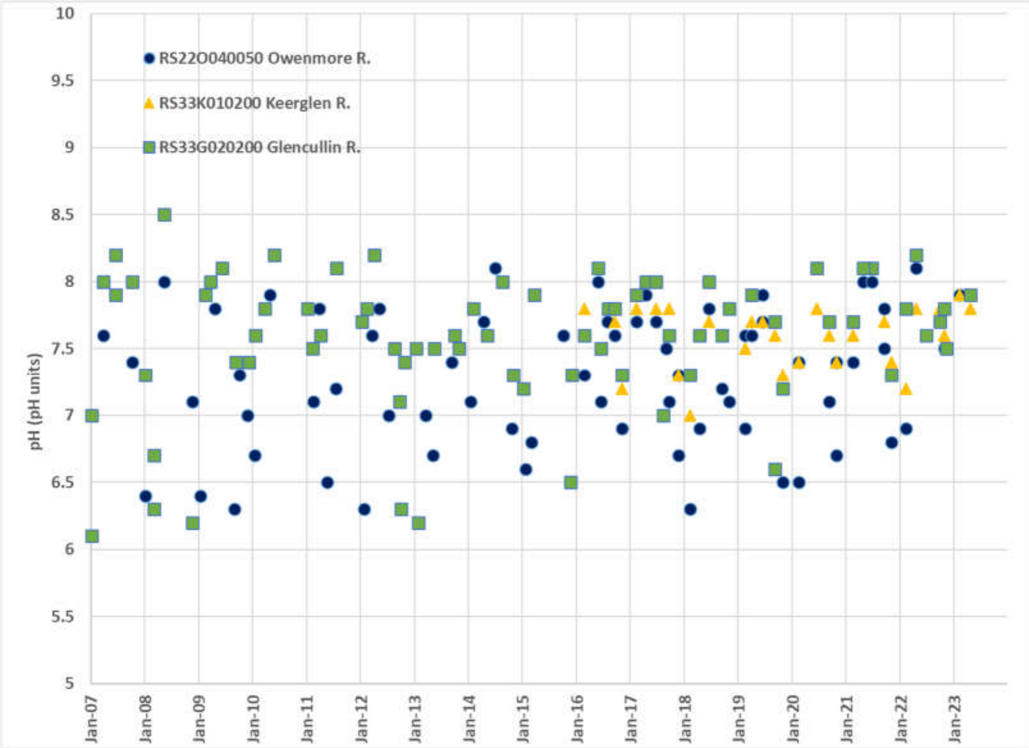

Figure 9-15 pH, 2007-2022, EPA Data

9.3.7.6 True Colour

As shown in **Figure 9-16**, true colour concentrations ranged between 12 and 402 mg/l in the three rivers over the period of record. Water leaving bogs has natural colour, principally from dissolved organic (humic) matter in the peat (**Photo 8**). The recorded variations reflect runoff and drainage of peat during storm events. The higher true colour values result from the mobilisation and export of organic matter during rainstorm events.

9.3.7.7 Suspended Solids

Based on **Table 9-10**, concentrations of suspended solids in the five locations sampled within Glenora Forest were low at the time of sampling (generally <2 mg/L, max 5 mg/L). This is supported by low turbidity values in the same samples. Unfortunately, the longer-term EPA datasets do not contain suspended solids or turbidity data.

Likely, the sampling events did not capture conditions during significant storm events. During site walkover surveys conducted on 17 and 18 June 2023, observations were made of sediment mobilisation to drainage ditches as depicted in **Photo 9**, taken on 18 June 2023. On this day, several short (<15 min) duration and intense rain showers occurred across the Wind Farm Site within a short time period (estimated c. 2 hours). Although far away, the nature of the rainfall is exemplified by the available hourly rainfall data from the Belmullet synoptic weather station (**Figure 9-17**), where 5.8 mm of rainfall was recorded over a 4-hour period.

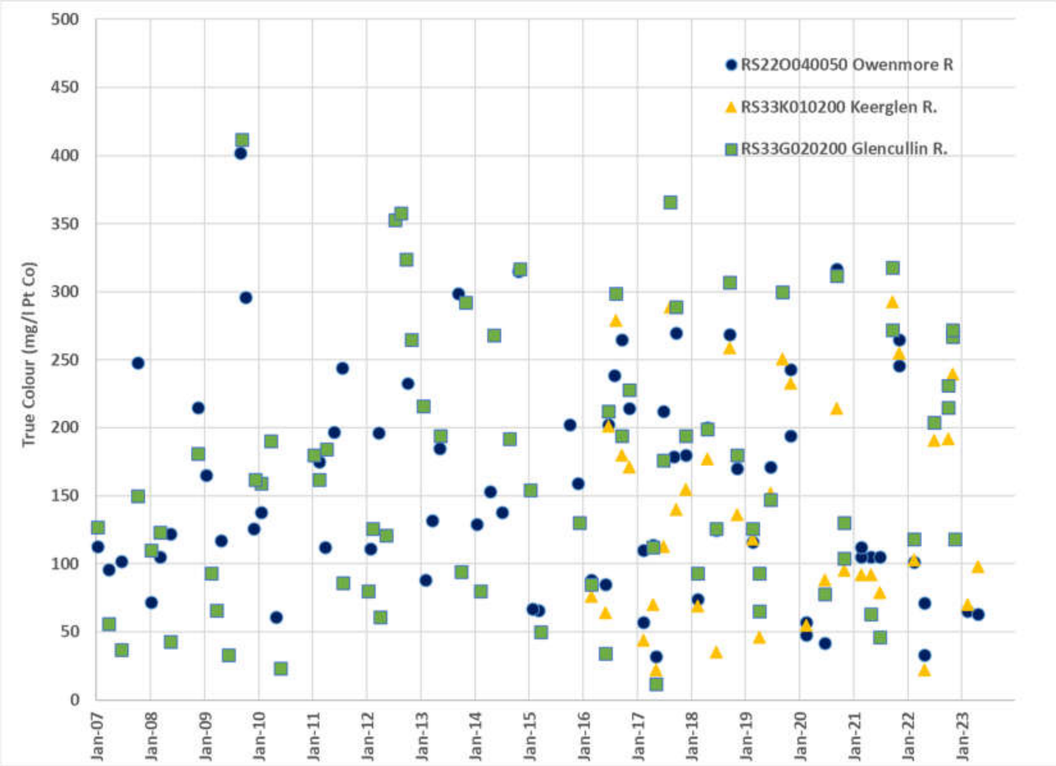

Figure 9-16 True Colour, EPA Data, 2007-2022

Photo 8: Natural Orange/Brown (Humic) Water Colour in Drainage Ditches

Photo 9: Suspended Sediments in Drainage Water, 18 June 2023

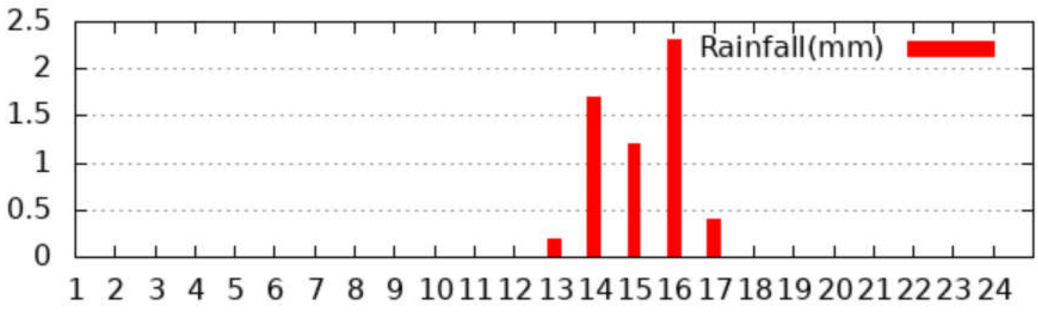

Figure 9-17 Hourly Rainfall (mm), Belmullet, 18 June 2023 (Source: Met Éireann)

9.3.7.8 EPA Q Values

In addition to the WFD water quality monitoring, EPA conducts biological monitoring through macroinvertebrate 'kick-sampling' at the same fixed water quality sampling locations on the same named rivers. Most recent data from EPA[5] shows that resulting 'Q rating' values are:

- For station ID RS33O040050 on the Owenmore River, 4 to 5 in 2021, indicating High Q status (invertebrate) conditions.
- For station ID RS33K010200 on the Keerglen River, 4 to 5 in 2020, indicating High Q status (invertebrate) conditions.
- For station ID RS33G020200 on the Glencullin River, 4 to 5 in 2021, indicating High Q status (invertebrate) conditions. A second station on the Glencullin River closer to Glenora Forest, station ID RS33G020100, indicated a Q value of 4 (Good Q status) in 2011 (latest available value at that location).

9.3.8 Hydrogeology

9.3.8.1 Bedrock Aquifer Classification

Based on GSI's 1:100,000 scale bedrock mapping (**Figure 9-18**), the Wind Farm Site in Glenora Forest is principally underlain by sandstones, siltstones and mudstones of the Downpatrick, Minnaun Sandstone Formations. The southwestern extent comprises the Glencullin River Formation and the northwesternmost corner of the Wind Farm Site is underlain by the Pollacappul Formation which incorporates metamorphic rock types, notably quartzite, schist and marble.

In the northwestern part of the Wind Farm Site, rock formations are faulted, and mapped faults trend northeast-southwest and north-south (see **Figure 9-18**). Drainage may be influenced by such structures, noting that the Altderg and Ballinglen Rivers tend to align with mapped faults.

The grid connection route is mainly underlain by the Downpatrick Formation (including the Moyny Point Limestone Member along the Ballinglen River) and the Ballina Limestone Formation (Lower)[6] further east.

From a hydrogeological perspective, the geological formations named above are classified by GSI as:

- 'Pl' bedrock aquifers: Downpatrick Formation, Pollacappul Formation.
- 'Ll' bedrock aquifer: Glencullin River Formation
- 'Lm' bedrock aquifer: Minnaun Sandstone Formation
- 'Lk' bedrock aquifer: Moyny Point Limestone Member of the Downpatrick Formation, present along the Ballinglen River

[5] As presented on the EPA Water web viewer at https://gis-stg.epa.ie/EPAMaps/Water
[6] As described by MacDermot *et al* (1996).

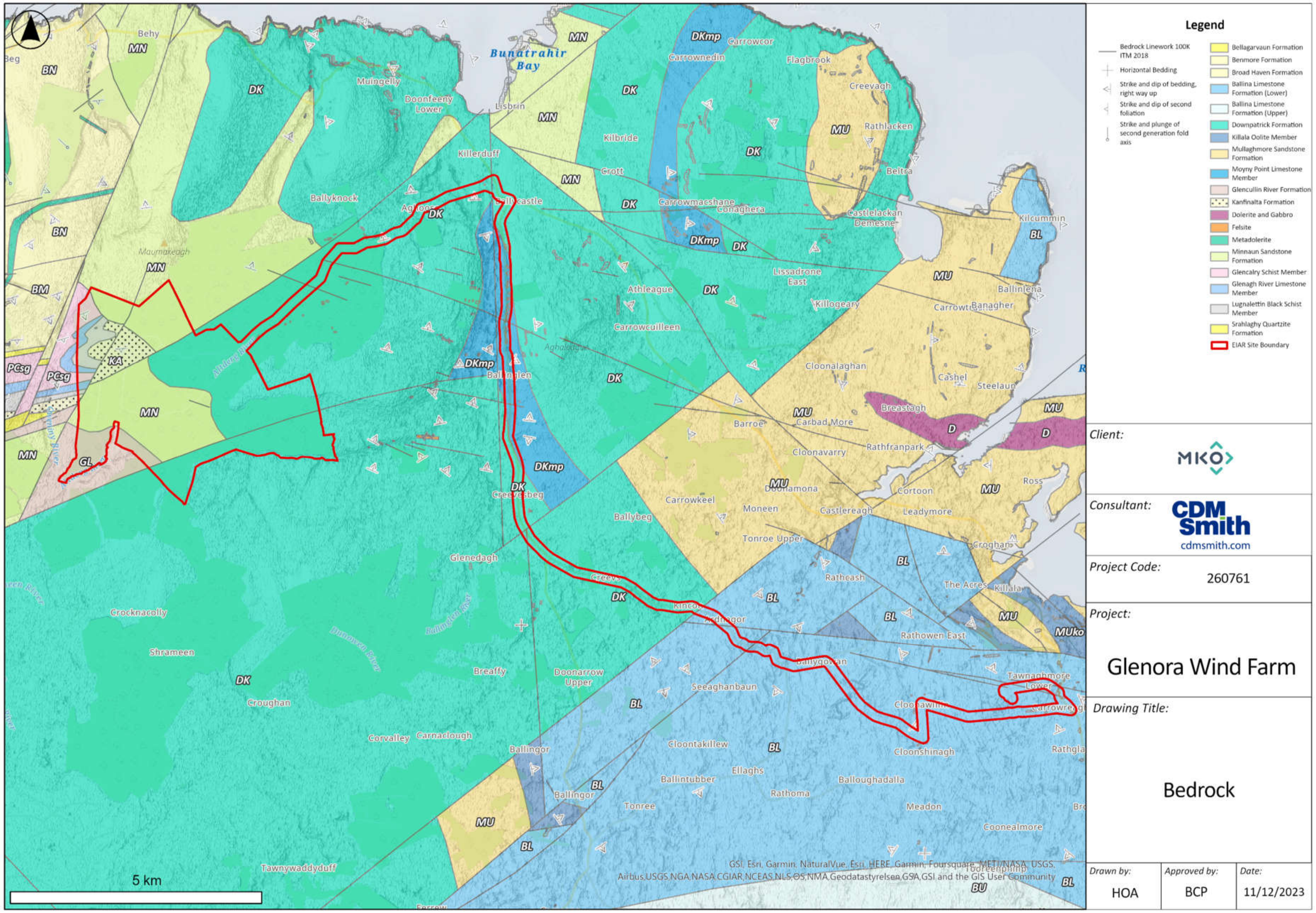

Figure 9-18 Bedrock Map, 1:100,000 Scale (Source: GSI)

GSI's bedrock aquifer classification map is presented in **Figure 9-19**. GSI' classification scheme (DELG/EPA/GSI 1999) considers the relative importance of bedrock as a groundwater resource, whereby:

- 'Pl' and 'Ll' bedrock aquifers are defined as "*poorly productive bedrock aquifers which are generally unproductive except for local zones*", where the term 'local zones' usually refers to geological faults.
- 'Lm' bedrock aquifers are "*locally important*" and "*generally moderately productive*". 'Lk' bedrock aquifers are "*locally important*" and "*karstified*". The latter term means that bedrock is prone to dissolution processes, whereby groundwater can move preferentially through solutionally enlarged conduits. It is noted that GSI's database of karst features (which is available from GSI's website) does not contain any karst features in the mapped area of the Moyny Point Limestone Member. This does not, however, mean that karst features are necessarily absent, as GSI's karst database reflects the current status of GSI's national mapping and is regularly updated (based on GSI's field work).

The predominance of 'Pl' and 'Ll' (poorly productive) and 'Lm' bedrock aquifers in the areas of interest means that groundwater will, conceptually, provide limited baseflow to streams/rivers, but may yet be important in providing the environmental supporting conditions for blanket bog.

9.3.8.2 Peat and Subsoil Characteristics

The bedrock is overlain by subsoils and peat. Based on 550 no. peat probes conducted along roadways and at infrastructure locations, recorded peat depths range from 0.1 to 4.6 m, with an average peat depth of 1.8 m (FT, 2023). Sixty-three percent (%) of the probes recorded peat depths of less than 2.0 m, and 99% of probes recorded peat depths of less than 3.0 m. a small number of recorded peat depths ranged from 3.0 to 4.6m (FT, 2023).

The subsoils beneath the peat consist of glacial till. Based on trial pit excavations, the till comprises soft to stiff, sandy, gravelly, SILT and CLAY with variable pebble and cobble content (FT, 2022). Grey to orange and brown, silty, SAND and GRAVEL deposits are also recorded locally (FT, 2022). Based on particle size distribution curves of 9 no. till samples (FT, 2022), the sediments can be described as poorly sorted, with percentages passing SILT grade ranging from 25 to 98%.

The glacial till is exposed on steep slopes and along streams that cut through the peat. Small areas of alluvial sediments have also been mapped by GSI along the lower section of the Altderg and Keerglen Rivers (**Figure 9-20**).

The grid connection route is underlain by glacial till of different types which are derived from the underlying bedrock.

In the hydrogeological context, the GSI has mapped and considers the subsoils across the Wind Farm Site to have 'Moderate' and 'Low' permeability characteristics (**Figure 9-21**). In such scenarios, groundwater fluxes through subsoils will be limited.

9.3.8.3 Groundwater Vulnerability

Groundwater vulnerability within the Wind Farm Site is mapped by GSI as 'Extreme' to 'Low' (**Figure 9-22**). GSI's vulnerability mapping is based on the combination of estimates of depths to bedrock and subsoil permeability (DELG/EPA/GSI, 1999). GSI's 'Extreme' vulnerability areas have been mapped on higher ground where subsoils are thinner and/or bedrock is exposed. Areas of 'Low' vulnerability coincide with lower elevation grounds along the Altderg River. The site specific data presented in FT's site investigations report (FT, 2022) broadly confirm GSI's mapped interpretation of vulnerability, even if localised differences apply. Peat is thinner on higher ground and generally thicker and deeper on lower ground.

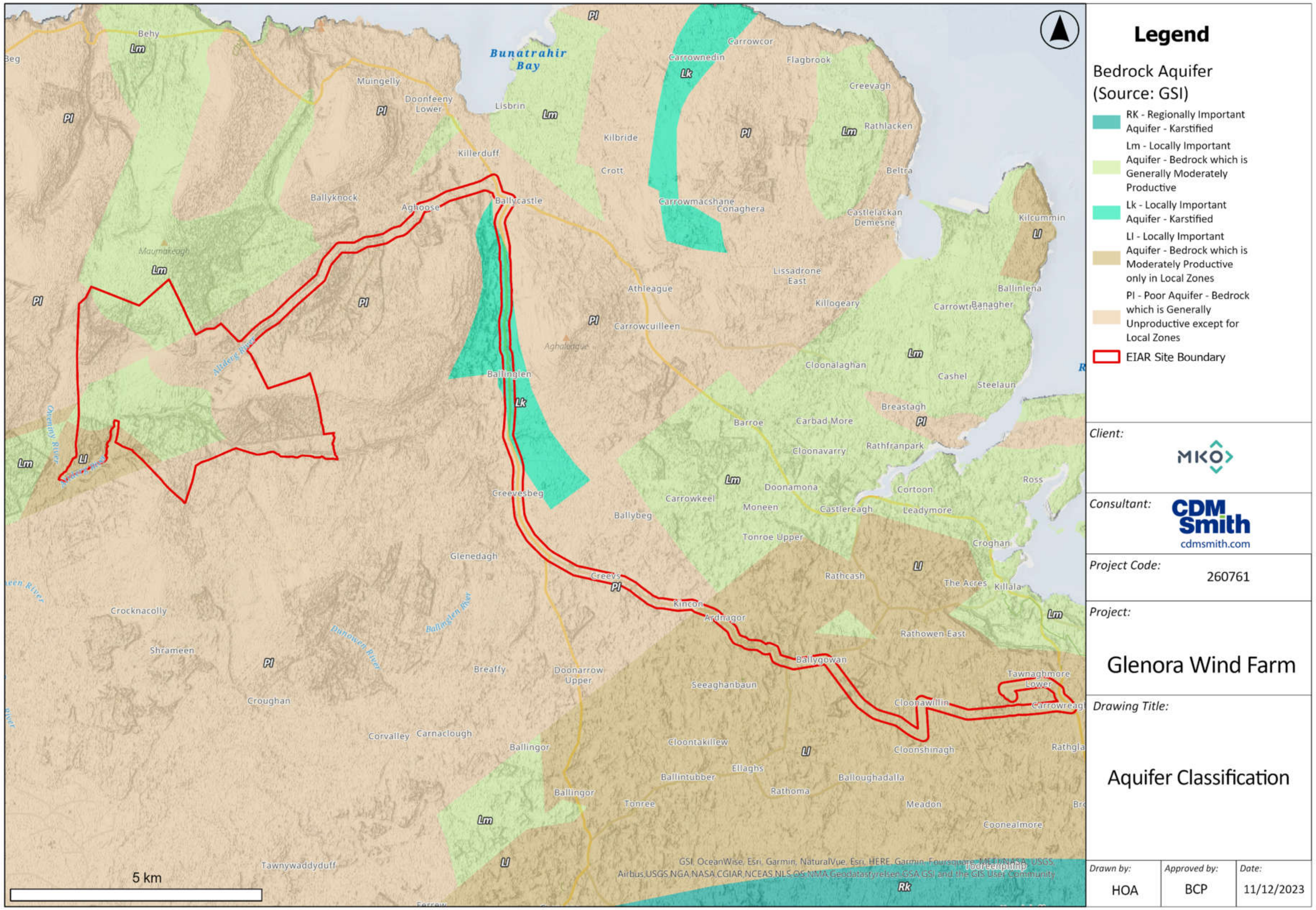

Figure 9-19 Bedrock Aquifer Classification (Source: GSI)

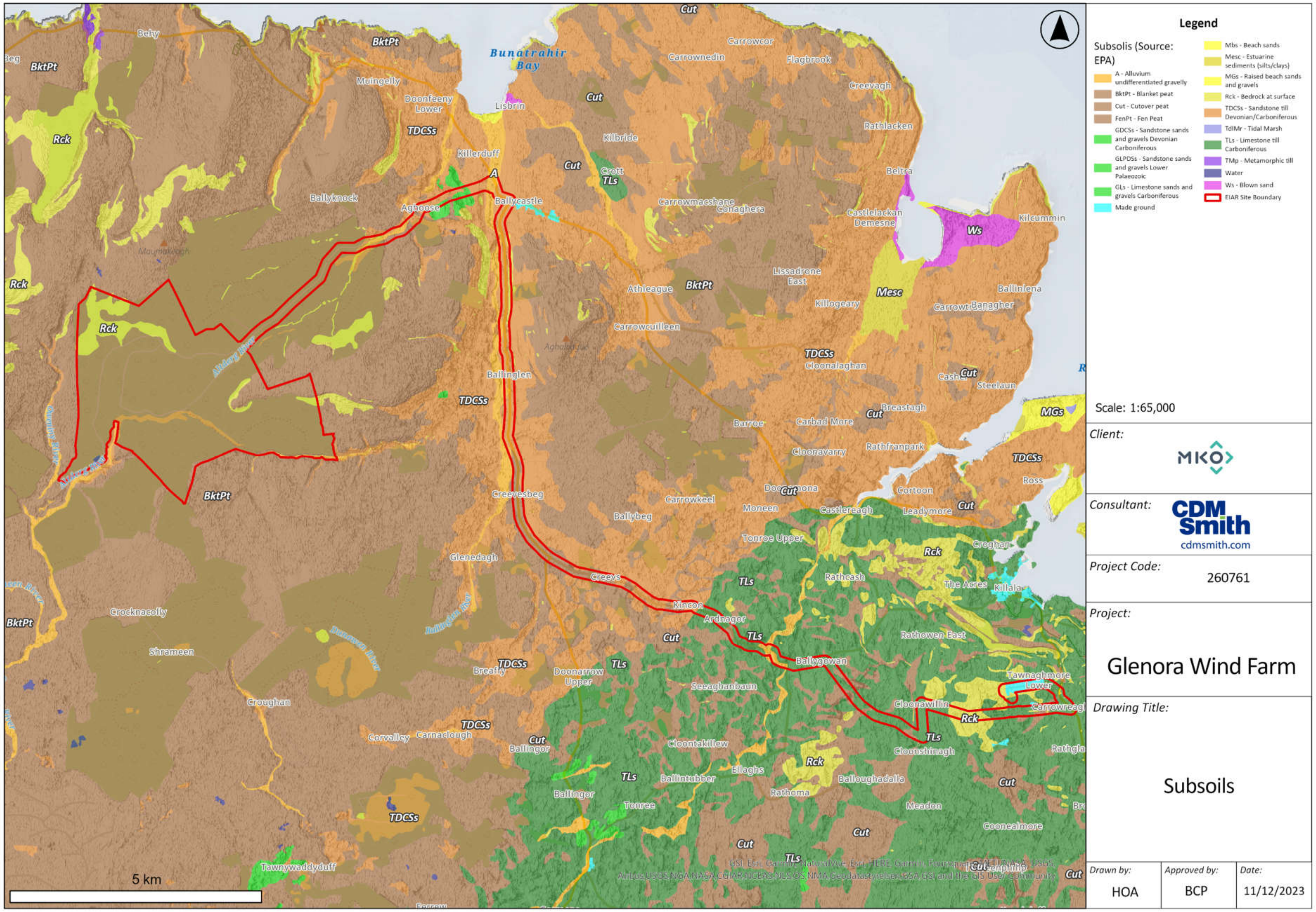

Figure 9-20 Subsoil Map (Source: GSI)

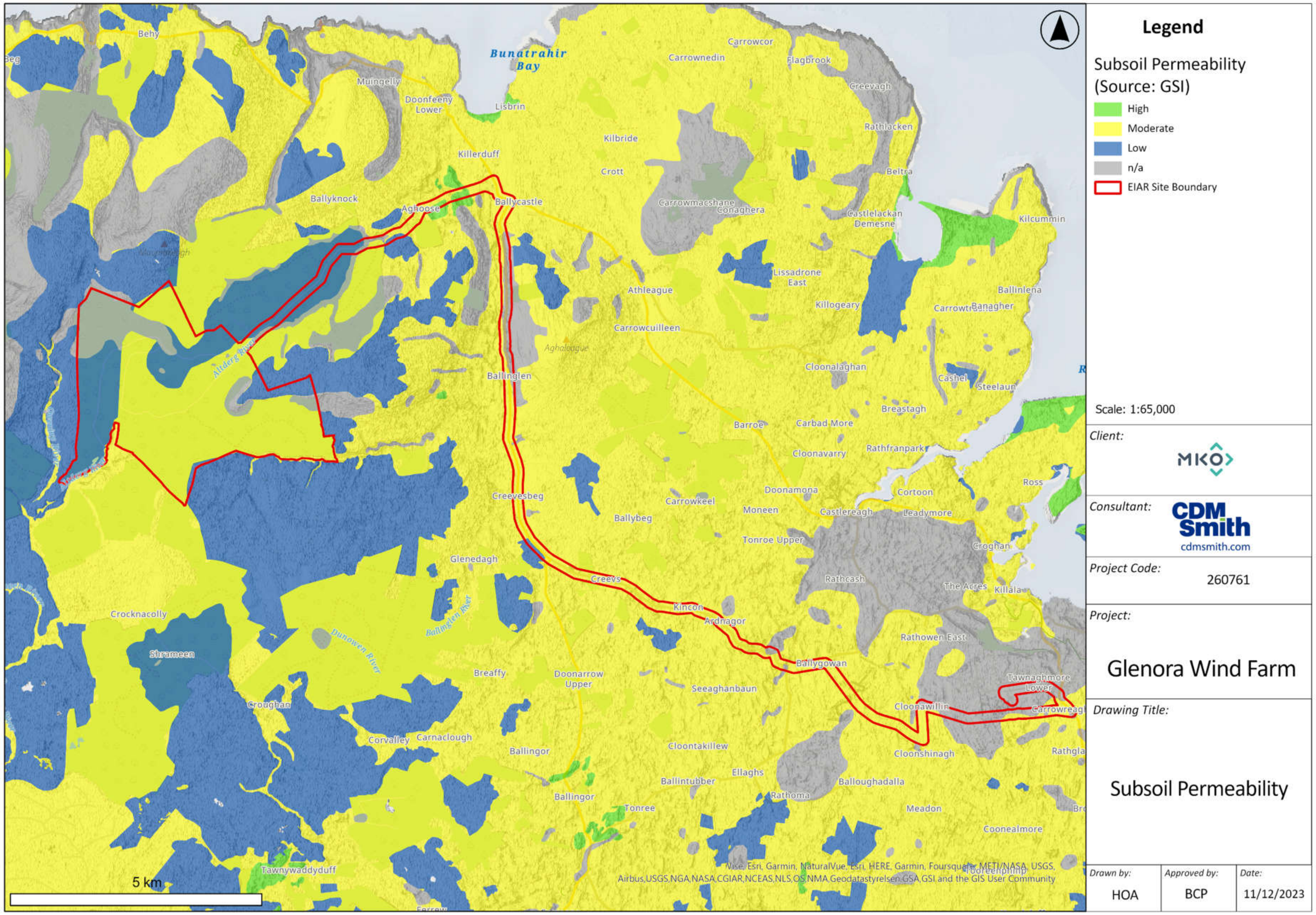

Figure 9-21 Subsoil Permeability (Source: GSI)

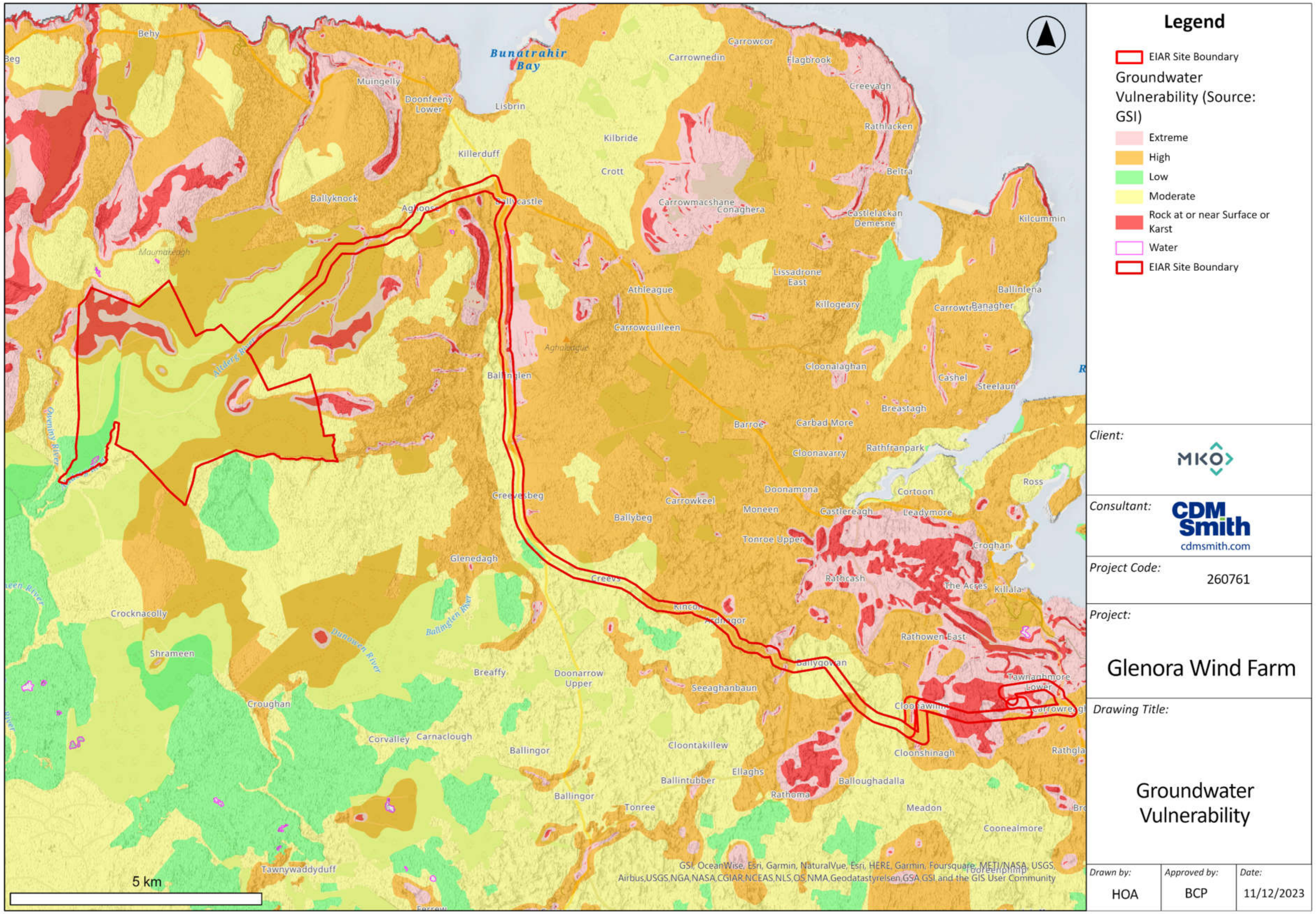

Figure 9-22 Groundwater Vulnerability (Source: GSI)

Along tributaries of the Glencullin River and along a section of the Keerglen River, groundwater vulnerability is mapped as 'Extreme' where peat and till have been cut through by the rivers and bedrock is close to surface or exposed along the streambed.

9.3.8.4 Groundwater Levels and Flow

During the excavation of 13 no. trial pits (to max. depths of 4.5 m) across the Wind Farm Site, groundwater seepages were recorded in most trial pits at depths between 1.0 and 3.2 mbgl (FT, 2022). Some trial pits were also reported as being dry (*i.e.,* seepages were not observed).

A total of 24 no. piezometers were installed across the Wind Farm Site for groundwater level monitoring purposes (FT, 2022). The piezometers were mainly installed to monitor water levels in peat but some of the piezometers also extend into subsoils. The piezometer locations are shown in **Figure 9-23**.

Water level measurements were taken manually in each piezometer at monthly intervals across one year, from May 2020 to May 2021 (FT, 2022). Automatic data loggers were also installed in Piezometers 6, 15 and 23 for continuous recording of water levels in the period September 2020 through May 2021.

Monthly measurements of depth to groundwater in the piezometers are shown in **Figure 9-24,** reproduced from FT, 2022. Automatically recorded water levels (mOD) in Piezometer 6 are shown in **Figure 9-25,** also reproduced from FT, 2022. Piezometer 6 was selected for presentation as the piezometer is far removed from any stream and, therefore, depicts the seasonal change in water level within the bog at this location, and which is free of any influence of streams on water levels in the bog. In both **Figure 9-24** and **Figure 9-25**, water levels are plotted along daily rainfall for rainfall measurement stations in Co. Mayo.

Key observations from the available data can be summarised as follows:

- Water levels in the peat fluctuated by less than 0.5 m over the period of record.
- The observed water level responses across the Wind Farm Site are consistent for the period of record.
- The seasonally high water levels generally occurred in January 2021 (with few exceptions) and the seasonally low water levels occurred in July/August 2020).
- Water levels in certain piezometres may be affected by drainage already, noting that several piezometers (e.g. Piezo 10) record water tables deeper than 50 cm.
- Water levels respond quickly to individual rainfall events.

As documented by FT (2022), groundwater flow directions in the peat/subsoils tend to mimic topography, flowing towards the local streams/rivers. As such, it is inferred that shallow groundwater in the peat and subsoil provides *some* baseflow to local streams/rivers.

Within the bedrock, groundwater flows through fissures and fractures. Like peat and subsoils, groundwater flow directions will be influenced by topography and shallow groundwater in bedrock is expected to discharge towards the Altderg and Keerglen Rivers. Groundwater flow patterns may also be locally influenced by faults, whereby enhanced fracture permeability along faults can act as groundwater drains. In poorly productive bedrock settings, groundwater flow cells tend to be localised, with flow paths that are on a scale of a few hundred metres only. Conceptually, the shallow groundwater in bedrock may also be hydraulically connected with groundwater in subsoils, potentially via a 'transition zone' at the top of rock (Moe *et al.*, 2010).

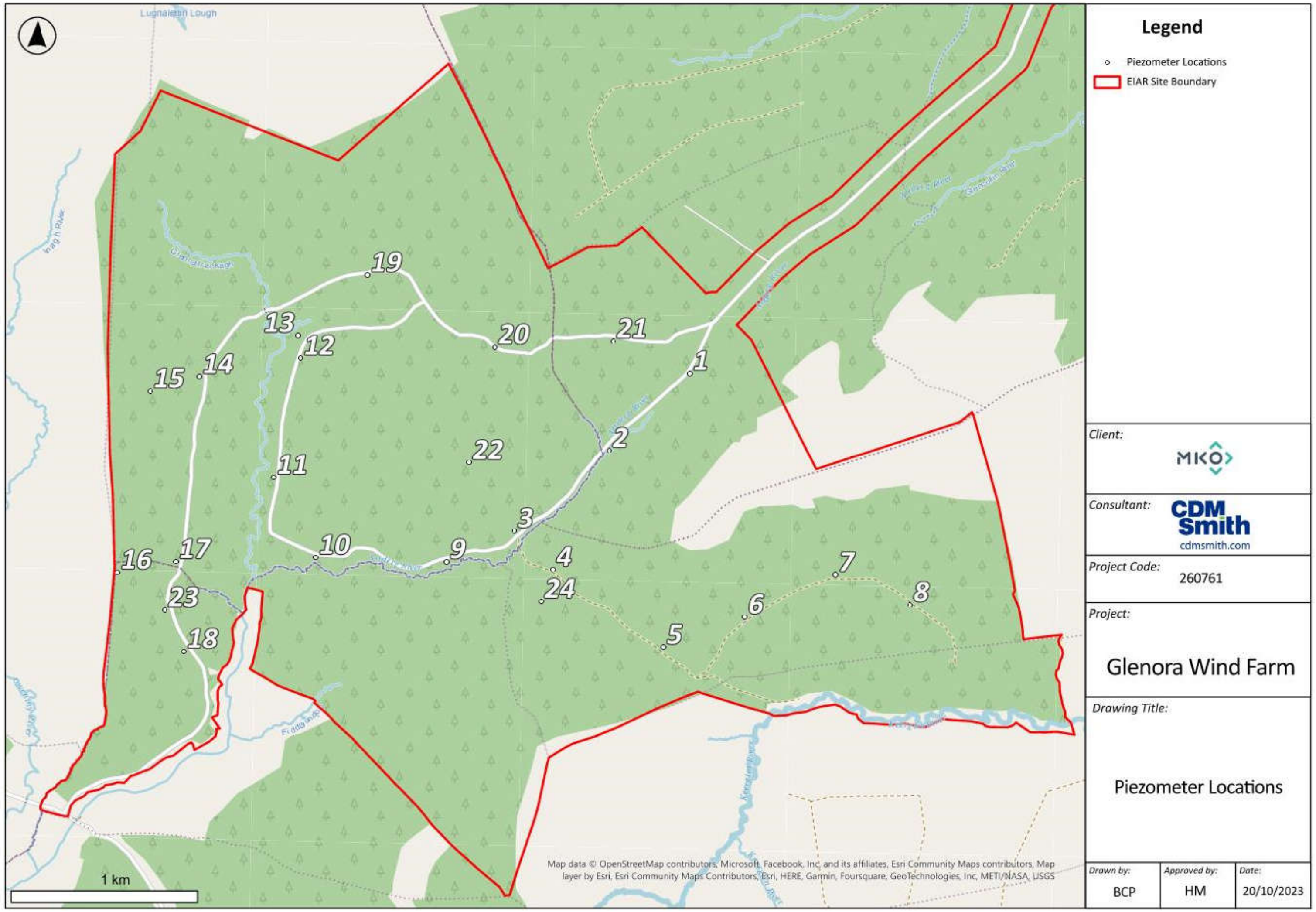

Figure 9-23 Piezometer Locations (Source of Coordinates: FT, 20

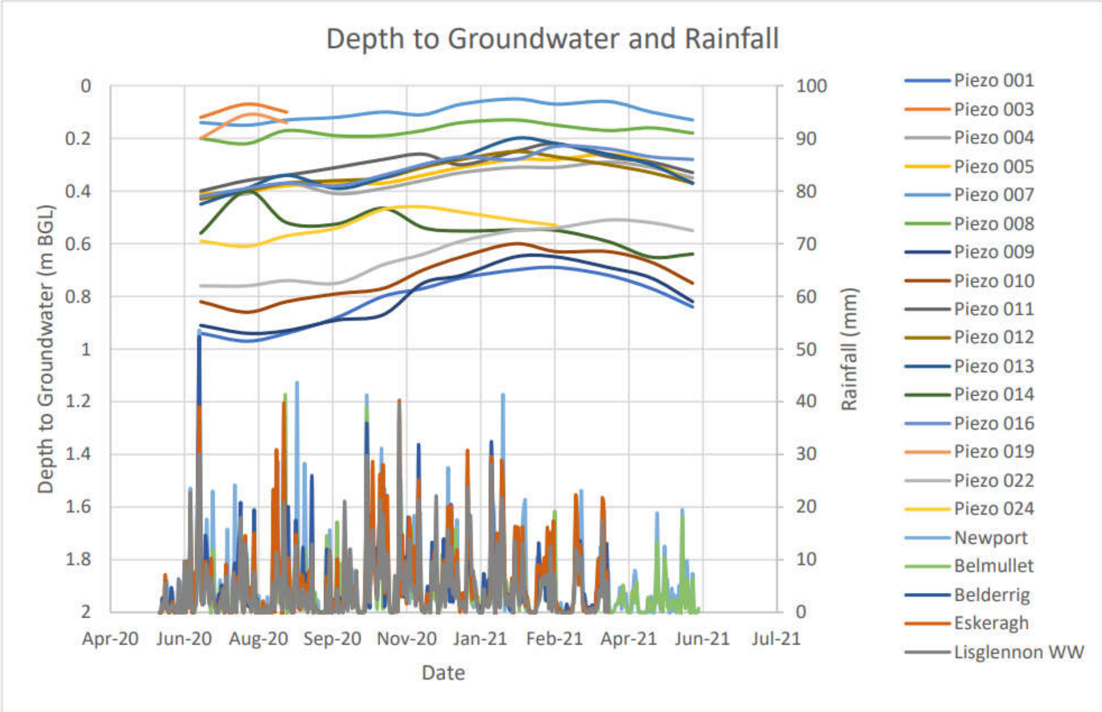

Figure 9-24 Groundwater Levels, All Piezometers, May 2020 - May 2021 (Source: FT, 2022)

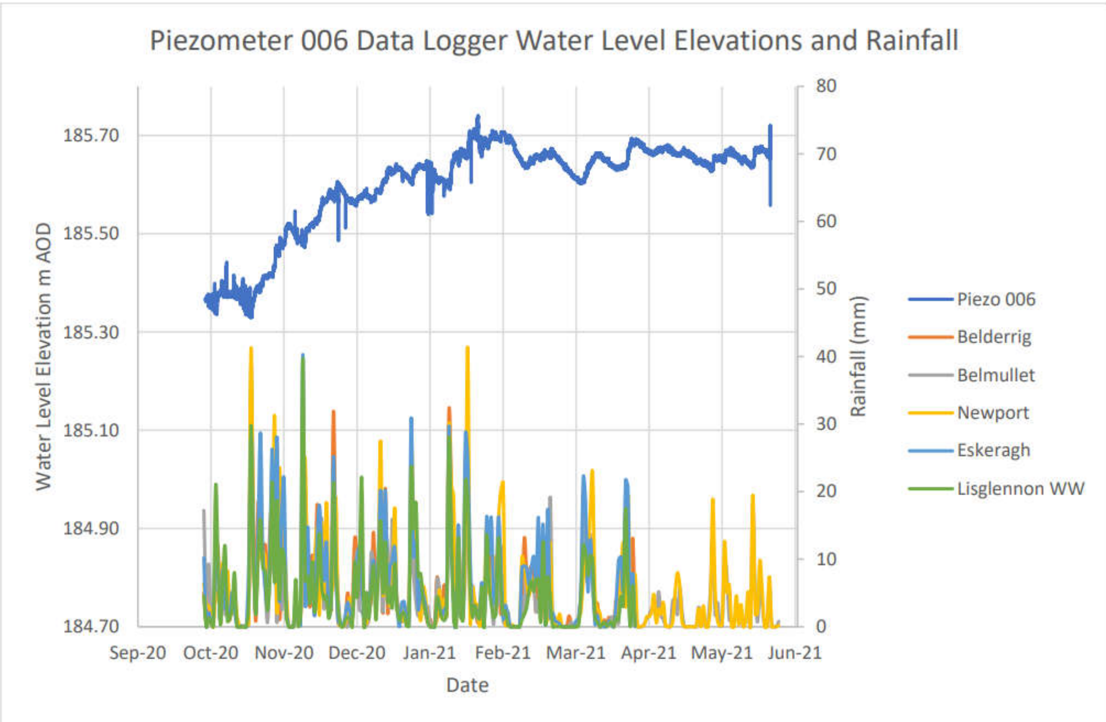

Figure 9-25 Groundwater Level Fluctuations in Piezometer 6, Sept. 2020 – May 2021 (Source: FT, 2022)

As indicated in Section 9.3.5, groundwater discharges to streams for a small component of the water balance across the Wind Farm Site. Surface runoff and water flow through the peat are expected to be the dominant pathways to surface watercourses. This is consistent with existing descriptions of the Belmullet and Bangor groundwater bodies by the GSI.[7]

9.3.9 Public and Private Water Supply

There are no surface water or groundwater abstractions used for public water supply purposes within or downslope/downgradient of the Wind Farm Site. The nearest source of public water supply is at Belderrig, c. 6 km to the northwest of Glenora Forest, outside subcatchments that are linked with the Proposed Development. It is noted that the nearest town, Ballycastle, receives water supply from the Ballina distribution network which is sourced from Lough Conn.

With regard to private water supplies, the nearest dwellings and/or farms that may abstract groundwater from private wells are located in the townland of Gurrankill to the east of the Wind Farm Site. Although the area is served by public water, it is conservatively assumed, but not confirmed, that dwellings/farms in this area use private wells. The townland of Gurrankill is sidegradient of groundwater flow directions within the Wind Farm Site and private wells are, therefore, not at risk of potential pollution from the Proposed Development activity.

9.3.10 WFD Water Body Status and Risk Assessment

A WFD compliance assessment is presented in **Appendix 9-3**. A summary of the latest WFD status classification (period 2016-2021) and WFD risk assessment for the third cycle of WFD implementation in Ireland (2022-2027) is presented in **Table 9-12**. In short:

- The Keerglen River, specifically the Keerglen_010 river water body, has been assigned a WFD 'High' ecological status objective by the EPA. Protection of 'High' ecological status water bodies is a priority in the latest available river basin management plan for Ireland (DEHLG, 2022).
- The Keerglen River did not meet its WFD 'High' status objective in the period 2016-2021. Based on information available from EPA's website www.catchments.ie, the water body is classified at 'Moderate' ecological status, due to "*Moderate biological conditions*", specifically "*Moderate fish status or potential*". The specific cause of this is not given, and it is noted that EPA's water quality test criteria were met (hence, the classification is not caused by water quality).
- The downstream Ballinglen_010 and Ballinglen_020 river water bodies also do not meet their WFD 'Good' status objectives. EPA cites unsatisfactory fish and invertebrate status, respectively. For Ballinglen_010, EPA (2021) notes "*a decline in both salmon and trout number. The pressure is unknown, but siltation is expected to be an issue.*" The Ballinglen_010 river water body is also flagged by EPA as having a water quality issue with chromium. Both of the Ballinglen river water bodies are 'Areas for Action', and both rivers are presently subjects of investigative assessments by the Local Authorities Waters Programme (EPA, 2021).
- The Moyne_010 river water body is of 'Moderate' status, which is based on modelling, noting that a) EPA has assigned 'low confidence' to this case; and b) there are no monitoring data available for the Moyne River.

[7] Available from: https://www.gsi.ie/en-ie/programmes-and-projects/groundwater/activities/understanding-ireland-groundwater/Pages/Groundwater-bodies.aspx

Table 9-12 Summary of WFD Status (2016-2021) and Risk (2022-2027)

WFD River Water Body	WFD Status Objective	WFD Ecological Status Classification 2016-2021	WFD 3rd Cycle Risk Assessment	Comments
Wind Farm Site				
Owenmore(Mayo)_010 (IE_WE_33O040050)	At Least Good	High	Not at Risk	WFD status exceeds its WFD status objective
Owenmore(Mayo)_020 (IE_WE_33O040200)	At Least Good	High	Not at Risk	WFD status exceeds its WFD status objective
Keerglen_010 (IE_WE_33K010200)	High	Moderate	Not at Risk	Failed to meet its WFD High status objective based on 'moderate biological status or potential' (specifically, 'moderate fish status or potential'. Water quality conditions passed EPA's test criteria. Details at https://stg.catchments.ie/data/#/waterbody/IE_WE_33K010200?_k=rc11va
Ballinglen_010 (IE_WE_33B010100	At Least Good	Poor	At Risk	Failed to meet its Good status objective based on 'poor biological status or potential' (specifically, 'poor fish status or potential'. Water quality conditions are 'moderate', based on chromium exceedances. Details at https://stg.catchments.ie/data/#/waterbody/IE_WE_33B010100?_k=65940q
Ballinglen_020 (IE_WE_33B010200)	At Least Good	Poor	Under 'Review'	Failed to meet its WFD Good status objective based on 'moderate biological status or potential' (specifically, 'moderate invertebrate status or potential'. Water quality conditions passed EPA's test criteria. Details at https://stg.catchments.ie/data/#/waterbody/IE_WE_33B010200?_k=hbtcwc
Grid Connection Route				
Glencullin (North Mayo)_010 (IE_WE_33G020200)	At Least Good	Good	Not at Risk	WFD status objective is met.
Ballinglen_010 (IE_WE_33B010100	At Least Good	Poor	At Risk	See above. Risks are related anthropogenic pressures which are yet to be determined by EPA.
Ballinglen_020 (IE_WE_33B010200)	At Least Good	Moderate	Under 'Review'	See above. EPA is currently undertaking investigate assessments in the subcatchment.
Breaghwy_010 (IE_WE_34B060600)	At Least Good	Good	Not at Risk	WFD status objective is met.

WFD River Water Body	WFD Status Objective	WFD Ecological Status Classification 2016-2021	WFD 3rd Cycle Risk Assessment	Comments
Cloonaghmore_040 (IE_WE_34C030200)	At Least Good	Good	Not at Risk	WFD status objective is met.
Cloonaghmore_050 (IE_WE_34C030270	At Least Good	Good	Not at Risk	WFD status objective is met.
Moyne_010	At Least Good	Moderate	Under 'Review'	The water body is subject to investigative assessment work by LAWPRO/EPA.

All other water bodies linked with the Proposed Development met or exceeded their WFD ecological status objective. From the information above, it is apparent that current practices within Glenora Forest are presently not identified or confirmed as a cause of water quality deterioration to the extent that it negatively influences WFD ecological status in the period 2016-2021.

With regard to the WFD risk assessment, only the Ballinglen river water bodies are classified as being at risk of failing to achieve WFD objectives in year 2027. As stated previously, The Ballinglen river water bodies are subjects of ongoing investigative assessments by the Local Authority Waters Programme (LAWPRO), owing to anthropogenic pressures to be determined. An earlier catchment assessment report prepared by EPA (2019) for the second cycle of WFD implementation in Ireland (to year 2021, lists environmental pressures in respective subcatchments as hydromorphology (channelisation), urban wastewater discharges (Ballycastle agglomeration), and agriculture.

With regard to the three groundwater bodies that underlie the Proposed Development, these were all at 'Good' status in the period 2016-2021 and classified as 'Not at Risk' of failing to achieve 'Good' status objectives in year 2027.

9.3.11 Designated Sites and Protected Areas

The potential for the Proposed Development to impact on designated sites and protected areas considered the mapping and listing by NPWS of:

- Special Areas of Conservation (SACs) and Special Protection Areas for Birds (SPAs), which are designated under the EU Habitats Directive and EU Birds Directive, respectively. SACs and SPAs are collectively referred to as 'Natura 2000' or 'European Sites'.
- Natural Heritage Areas (NHAs), which are designated under Section 18 the Wildlife (Amendment) Act 2000.
- Proposed Natural Heritage Areas (pNHAs), which are designated on a non-statutory basis in 1995 but have not since been statutorily proposed or designated.
- Candidate SACs and SPAs listed (but not designated) under the terms of the EU Habitats Directive.

The source-pathway-receptor model of environmental risk assessment served to guide the determination about which sites might be affected. Mainly, the designated sites have to be potentially hydrologically or hydrogeologically connected with the Proposed Development via surface water or groundwater pathways. As well, the designated sites and protected areas must have qualifying interest (designation features) which are water-dependent. The latter was checked from 'site synopsis' reports and web-based resources made publicly available by the National Parks and Wildlife Service (NPWS), as presented on their website (www.npws.ie).

With reference to the presentation of designated sites and protected areas in Chapter 6 of this EIAR, those that are potentially connected with the Proposed Development (i.e., within the 'Likely Zone of Influence' of the Proposed Development) are listed in **Table 9-13.**

None of the rivers or designated sites named previously are designated bathing waters, drinking water protected areas, or designated freshwater pearl, salmonid or nutrient sensitive waters. However, EPA notes that the Ballinglen River is an "*important non-designated salmonid area*". As described in Chapter 6 of this EIAR, salmonid species were recorded in the Owenmore, Keerglen and Ballinglen Rivers. Sites on the Owenmore River and Keerglen River provided the best overall salmonid nursery habitat.

Table 9-13 Designated Sites and Protected Areas – Assessment of Likely Zone of Influence

Designated Site/Protected Area	Nearest Distance From Proposed Development	Assessment of Likely Zone of Influence
Special Areas of Conservation (SAC)		
Glenamoy Bog Complex SAC [000500]	0.2 km from Site (upslope)	The SAC boundary is approximately 200 m from the EIAR redline boundary, but 750 m away from the nearest proposed works, in the upslope direction. Hence, there will be no direct effects as the development footprint is outside the designated site and there are no pathways or surface water linkages in a downstream direction. From a hydrogeological perspectives, indirect effects of peat drainage could translate to the SAC. However, the 750 m distance to the SAC boundary the likelihood of effects occurring is low to negligible. Hence, **further assessment is not required.**
Bellacorick Bog Complex SAC [001922]	c. 2.5 km from Site (downslope)	The SAC boundary, which is marked by the Oweninny River, is approximately 2.5 km from the Wind Farm Site boundary in the downslope direction. There will be no direct effects as the development footprint is located entirely outside the SAC. Although there is potential for water pollution of the Oweninny River, there are no pathways or connectivity to the habitats within the SAC, and there will be no effects of the Proposed Development on the SAC. There are other wind farms in existence near the SAC. For these reasons, **further assessment is required** as part of the potential cumulative effects.
Broadhaven Bay SAC [000472]	>30 km flow distance from Site (downslope)	The SAC is more than 30 km downstream of the Wind Farm Site. There will be no direct effects as the footprint of the Proposed Development is outside the designated site. There is only indirect and remote hydrological connectivity Wind Farm Site via the Owenmore River and Tullaghan Bay (an estuary), thus potential effects are considered negligible. Hence, **further assessment is not required.**
Killala Bay/Moy Estuary SAC [000458]	1.1 km from grid connection	There will be no direct effects as the development footprint is located outside the designated site. Downstream surface connectivity with the SAC has been identified via the watercourses that cross the proposed grid connection route. Hence, there is (remote) potential for deterioration of water quality during the construction phase of the grid connection, and **further assessment is required.**
Owenduff/Nephin Complex SAC [000534]	13.3 km from Site (downslope)	The SAC boundary is approximately 13.3 km downslope of the Wind Farm Site boundary. The SAC boundary runs along the bank of the Owenmore River. There will be no direct effects as the development footprint is located entirely outside the SAC. Although there is potential for water pollution of the Owenmore River, there are no pathways or connectivity to the habitats within this SAC, and there will be no effects of the Proposed Development on the SAC. Hence, **further assessment is not required.**
Special Protection Area (SPA)		
Blacksod Bay/ Broadhaven SPA [004037]	>30 km flow distance from Site (downslope)	There will be no direct effects as the footprint of the Proposed Development is outside the designated site. The designated site is indirectly hydrologically linked in the downstream direction, but because of the distance involved (more than 30 km), there is an unlikely potential for effects to occur. Any pollutants will be diluted to such an extent that impact will not be perceptible. For this reason, **further assessment is not required.**
Killala Bay/Moy Estuary SPA [004036]	1.9 km from grid connection	There will be no direct effects as the grid connection footprint is located outside the designated site. Downstream hydrological connectivity with the SAC is identified via the watercourses that cross the proposed grid connection route. There is (remote) potential for deterioration of water quality during the construction phase of the grid connection and for this reason **further assessment is required.**

Designated Site/Protected Area	Nearest Distance From Proposed Development	Assessment of Likely Zone of Influence
Owenduff/Nephin Complex SPA [004098]	13.3km from Site (downslope	There will be no direct effects as the development footprint is located entirely outside the designated site. The SPA boundary is approximately 20 km (flow distance) of the Wind Farm Site boundary in the downslope direction, and the SPA boundary runs along the bank of the Owenmore River. Although there is potential for water pollution of the Owenmore River, there are no pathways or connectivity to the habitats of this SPA and there will be no effects of the Proposed Development on the SPA. Hence, **further assessment is not required.**
National Heritage Area (NHA)		
Inagh Bog NHA [002391	0 km. Adjacent.	Works will be conducted close to the boundary of this NHA, which borders the Wind Farm Site. There will be no direct effects but there can be indirect effects, e.g. dust transmission, hydrological changes from peat/subsoil drainage. The Wind Farm Site adjoins the NHA, in a sidegradient and downgradient direction. As stated in the site synopsis report for the NHA (NPWS, 2004), the site is of "*considerable conservation value*" and "*The main threats are from grazing, burning, drainage, further afforestation and potentially renewable energy development, in particular wind power installations and associated infrastructure*". For this reason, **further assessment is required.**
Ummerantarry Bog NHA [00157]	<0.1 km, opposite Keerglen River	There will be no direct effects as the NHA is south of, and on the opposite side of, Keerglen River, from the Proposed Development Site. Although there is potential for water pollution of the Keerglen River, there are no pathways or connectivity to the habitats of this NHA, and there will be no effects of the Proposed Development on the NHA. For this reason, **further assessment is not required.**
Proposed National Heritage Area (pNHA)		
Glenamoy Bog Complex [000500]	0.2 km from Site (upslope)	See SAC description above. **Further assessment is not required.**
Bellacorick Bog Complex [001922]	c. 2.5 km from Site (downslope)	See SAC description above. **Further assessment is required.**
Killala Bay/Moy Estuary [000458]	1.1 km from grid connection	See SAC description above. **Further assessment is required.**
Owenduff/Nephin Complex [000534]	13.3 km from Site (downslope)m Site (downslope)	See SAC description above. **Further assessment is required.**

9.3.12 Receptor Importance/ Sensitivity

Based on the baseline characterisation, the principal environmental receptors associated with the Wind Farm Site are the surface watercourses (streams) that drain to the Altderg and Keerglen Rivers, plus those two named rivers. The many watercourses that are crossed by the grid connection route are also potential receptors.

None of the referenced watercourses are designated salmonid rivers, nutrient sensitive water bodies, or within a freshwater pearl mussel catchment. They are also not used for drinking water supply and are not upstream of a designated drinking water protected area.

The Keerglen River and its tributaries within the Wind Farm Site are, however, designated WFD 'High Status' objective water bodies, and are Quality Class A water bodies (with Biotic Index Q4, Q5). Based on **Table 9-2**, the importance and sensitivity of this receptor surface water environment is considered to be "Very High" (from **Table 9-2**).

The Altderg River and its tributaries within the Wind Farm Site are not designated WFD 'High' status objective water bodies. However, the Altderg River adjoins two bog NHAs and includes Quality Class A water bodies (with Biotic Index Q4, Q5). The Western Way which passes through the Wind Farm Site, and the Altderg River subcatchment specifically, is also an important amenity site. For these reasons, and based on **Table 9-2**, the importance and sensitivity of the related watercourses are considered to be "Very High".

For the grid connection route, related watercourses incorporate important amenity sites, including the Western Way, and Quality Class A water bodies (with Biotic Index Q4, Q5). As such, the related watercourses are also assigned a "Very High" significance and importance as a receptor surface water environment.

Groundwater provides minor baseflow to streams and is a minor water balance component overall. However, groundwater is part of the environmental supporting conditions of the peat within the Wind Farm Site. For this reason, the importance of the groundwater receiving environment is considered to be "Medium" (from **Table 9-3**).

9.3.13 Drainage Planning

Modification of surface runoff patterns will occur within the Wind Farm Site as a result of the construction of new infrastructure. Mainly, drainage management will influence how runoff moves through the Wind Farm Site to local streams. If roads and associated drainage is poorly designed, constructed or maintained, then runoff could travel through a subcatchment much faster than if it were to travel as diffuse overland flow. This could result in an increase in peak flows and influence response times during storm events.

To accommodate the Wind Farm Site, the integration of existing drains into the drainage planning reduces the magnitude of changes to the existing drainage regime. To serve as a basis for the assessment of likely significant effects, the drainage system that will need to be constructed within the Wind Farm Site was planned as presented below, described in **Appendix 4-1,** and shown in **Appendix A of Appendix 4-4**. In short:

- Existing and new interceptor drains will capture greenfield runoff from areas that are upslope of new and existing infrastructure. This greenfield runoff will be discharged in a controlled manner from multiple locations at greenfield runoff rates to flow diffusely across ground before entering streams. Buffered outfalls will promote percolation of discharge waters across vegetation. The interceptor drains will be integrated with existing drains that currently exist

as part of forestry operations. In-line check dams in interceptor dams will be used to break the energy of drain water during high flow, storm events.
- Swales will be established downslope of proposed infrastructure components and access roads to capture 'dirty water' during construction activity. The swale water will be directed to settlement ponds before being discharged diffusively across ground before entering streams to the maximum extent possible. The swales will remain in place during all subsequent phases of the Proposed Development and will capture runoff from access roads and hardstanding.

The proposed drainage system layout is presented in **Appendix A of Appendix 4-4**. Calculations of runoff rates and pond area requirements are presented in **Appendix 9-2**. Layout and locations of drains, swales, and ponds are dictated by the combined consideration of:

- Topography, making sure the drainage network always transmits water in the downslope direction, even across shallow gradient areas.
- Physical space, between existing or planned features.
- Avoidance of situations where discharges from one drain or pond is entrained by another in the downslope direction. It is noted that there will be certain situations where this occurs, specifically where access roads are constructed parallel to one another, at different elevations within the Wind Farm Site.

Topography in some areas is also subtle, and it is anticipated that some engineering judgement of final placement/alignment of culverts, swales and settlement ponds will be necessary during construction based on detailed surveying. The proposed drainage layout will require the:

- Construction of 2 no. new watercourse crossings.
- Potential upgrade of 4 no. existing culverted watercourse crossings.
- Provision of an estimated 66 no. culverts, which includes upgrades to existing piped culverts and which are not related to natural watercourse crossings.
- Construction of interceptor drains upstream and swales with settlement ponds downslope of proposed infrastructure elements.

Along the grid connection route, drainage management will not be needed as cables will be housed in trenches along existing roadways, span existing bridges and only in a few cases cross streams with drilled, horizontal boreholes.

To estimate greenfield runoff rates, the Wind Farm Site was divided into subcatchments that drain to roads and infrastructure components. Subcatchments were drawn from development layouts and detailed Lidar survey data (0.5-m contour intervals). Roads were divided into logical segments guided by their orientations relative to topographic contours and natural streams. The delineated subcatchments are presented in **Figure 9-26**. Calculations are presented in **Appendix 9-2**.

The proposed drainage management approach is detailed in **Appendix 4-4**. Infrastructure, including swales, drains and settlement ponds, will be constructed at least 50 m away from streams, where possible, in order to minimize the potential for effects (e.g., sedimentation and morphological changes) to streams. The layout of the planned infrastructure (swales, drains, settling ponds, etc.), watercourses and 50 m buffer are shown on the planning-level drawings in **Appendix A of Appendix 4-4**. One of the borrow pits will by design need to extend into the 50 m buffer of a local watercourse. A swale will be built between the borrow pit and an access road which parallels the water course in question as a protective measure. The captured swale water will subsequently be directed to a settlement pond.

In no circumstance will direct discharges to watercourses take place. There are, however, locations constrained by physical space where some discharges will have to be within a few metres of watercourses. In such instances, additional attenuation ponds and double or triple silt fencing will be applied as additional measures, the details of which will be judged practically in the field. Where existing drains are utilised, there will be no direct discharge to streams. During construction, new drains will be integrated with existing drains as much as possible to reduce the scale of earthworks and maintain current runoff patterns in Glenora Forest.

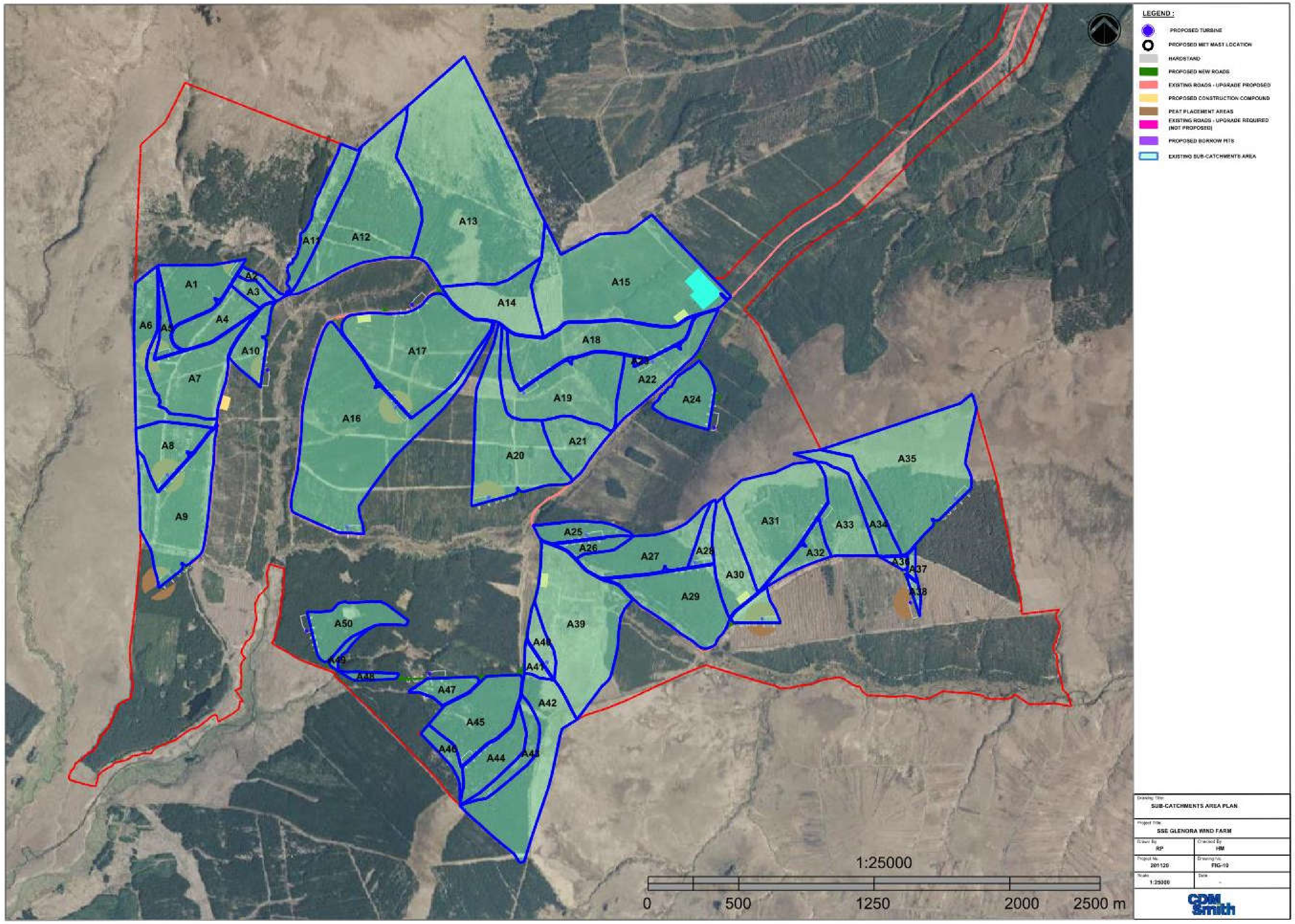

Figure 9-26 Subcatchments Used To Calculate Greenfield Runoff

Check dams will be incorporated along interceptor drains and swales to attenuate the flow and energy associated with storm events, thereby reducing scour and erosion and promoting the settling of sediments. Depending on slope, check dams will be incorporated every 50 m or less.

The proposed Construction and Environmental Management Plan (CEMP) in **Appendix 4-3** incorporates all measures related to drainage management. Runoff management is furthermore detailed in the Surface Water Management Plan in **Appendix 4-4**.

9.3.14 Proposed Monitoring

During the construction phase, a field monitoring campaign will be undertaken in related streams. Stream monitoring involves a) visual checks of drains, swales, settlement ponds and streams, and b) measurements of field parameters temperature, pH, specific electrical conductivity (SEC), alkalinity and turbidity. The field measurements will be taken at locations upstream and downstream of the construction activity. Frequency of measurement will be judged in the field by the resident/supervising engineer, but will be done at least on a weekly basis (potentially more frequently during storm events).

The field measurement campaign will begin two weeks prior to the proposed commencement of works, and will cease up to four weeks after the proposed works are completed, unless observations dictate that measurements should continue. Regular inspections of all installed drainage components 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.

If visible impact occurs, works will be suspended at the discretion of the resident/supervising engineer, in which case the problem will be identified and corrective action taken before recommencing works.

Surface water samples will also be collected to monitor for effects and any shifts in baseline conditions. The following sampling locations are proposed:

- On the Altderg River (by the existing single-span bridge) just downstream from Glenora Forest.
- On the Keerglen River at a location immediately downstream from the forest, at the first accessible sampling point near an existing farm to the east of the forest.

The samples will be collected on a monthly schedule during construction and decommissioning, and on a quarterly schedule during the first three years of the operational phase. Periodic review will determine the need for, or recommended amendments to, the monitoring programme in line with principles of adaptive monitoring (guided by the data review and findings).

The monthly samples will be analysed for general physico-chemical parameters, nutrients, dissolved organic carbon, true colour, and suspended solids. The quarterly samples will cover the same, but dissolved metals will be added to the list every six months. Adaptive monitoring will be practiced, whereby analytes and frequency of monitoring may change based on periodic review of results. All sampling events will be accompanied by field measurements of water temperature, pH, SEC, alkalinity and turbidity.

The broader purpose of the proposed monitoring is to track baseline conditions and how these might evolve under prevailing conditions. The baseline monitoring will begin three months prior to commencement of the construction phase. The data will be periodically reviewed to assess whether changes (trends) to water quality are occurring.

9.4 Likely Significant Effects and Associated Mitigation Measures

9.4.1 'Do-Nothing Scenario'

If the Proposed Development were not to proceed, the commercial forestry operations will continue, involving coniferous plantation and tree-felling operations.

In this scenario, the existing surface water drainage will continue to function in the manner currently observed and experienced. Because there will be no changes to forestry operations or drainage, there will be no further or additional effects from current operations.

If there are new coniferous plantations, or re-ploughing to facilitate afforestation is planned, then reviews of the existing drainage systems will be required before activity commences in order to protect watercourses from chemical and sediment loads, and from potential physical damage to watercourses. The same applies before tree-felling operations commence, to assure that adequate protective measures are in place for the planned activity.

9.4.2 Construction Phase – Likely Significant Effects and Mitigation Measures

The likely significant effects of the Proposed Development and mitigation measures that were considered during the approximate 2-year construction phase (see Chapter 4 of this EIAR) relate to:

- Clearfelling of coniferous plantations
- Earthworks
- Culvert installations
- Cable works installations
- Hydraulic effects of drainage
- Water quality effects of drainage
- Pumping from open pits
- Accidental spills or leaks
- Release of cement-based products
- Wastewater management
- Turbine delivery route
- Public and private water supplies
- WFD water body status
- Designated sites

Mitigation measures consider specific actions which are designed to avoid, prevent or lessen potential effects – *i.e.,* mitigation by avoidance and mitigation by design.

9.4.2.1 Clear-Felling of Coniferous Plantation

As described in Chapter 4 of this EIAR, a total of 116 ha of forest will be felled to accommodate the Proposed Development. The felling activity will occur intermittently through the first year of the 2-year total construction period. Tree felling is subject to a Felling Licence application to the Forest Service, in accordance with the Forestry Act 2014 and the Forestry Regulations 2017 (SI No. 191/2017) and as per the Forest Service's policy on granting felling licenses for wind farm developments.

Clear-felling involves the use of machinery. The activity results in physical disturbance of residual peat and subsoil. The disturbance is from vehicle tracking and skidding, forwarding extraction methods, and damage to existing tracks and timber/brush in stacking areas.

The related activity can release sediments, organic matter (including dissolved organic carbon) and nutrients into drains.

Pathways: Runoff, drains.

Receptors: Local streams and the Altderg, Oweninny and Keerglen Rivers downstream.

Pre-Mitigation Potential Effects: Without mitigation, potential effects will be indirect, negative, moderate, temporary, reversible, and of high probability.

Proposed Mitigation Measures: Best practice methods will be incorporated into the forestry management. These are set out below and will be in accordance with:

- DAFM (2019): Standards for Felling and Reforestation.
- Coillte (2009): Forest Operations and Water Protection Guidelines.
- Coillte (2009): Methodology for Clear Felling Harvesting Operations; Forest Service (Draft).
- Forest Service of the Department of Agriculture, Food & the Marine (2008): 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.

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. Minimum buffer zone widths recommended in the Forest Service (2000) guidance document "Forestry and Water Quality Guidelines" are shown in **Table 9-14**.

Table 9-14 Recommended Buffer Zone Widths Adjacent to Aquatic Zones

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

Mitigation by Design: Mitigation measures will be implemented wherever clear-felling is planned. The objective will be to mitigate the risk of mobilising suspended solids and nutrients into drains and surface watercourses, as follows:

- Small felling areas (<25ha), sequencing of felling to avoid intense felling in one subcatchment
- Limiting felling areas and sequencing the felling to avoid intense felling in one subcatchment.
- Machine combinations (*i.e.* handheld or mechanical) will be chosen which are most suitable for ground conditions and which will minimise soils disturbance.
- Sediment/Silt traps will be strategically placed downslope within forestry drains near streams before ground preparation. The purpose is to slow water flow, increase residence time, and allow settling of silt. No direct discharge of such ditches to watercourses will occur.
- Crossing of streams away from bridges and culverts will not be permitted. Checking and maintenance of roads and culverts will be on-going throughout felling activity. No tracking of vehicles through watercourses will occur. Existing interceptor drains will also not be disturbed.
- Clay, soil and silts will be removed from roads during wet periods and dust will be suppressed during dry spells.
- Main drains that accommodate the discharge from collector drains will include rock armour, as required, where there are steep gradients.
- On steep slopes and where felling inside the 50 metre buffer is required, double or triple sediment traps will be installed. All drainage channels will taper out before entering the buffer zone. This ensures that discharged water fans out over the buffer zone before entering the aquatic zone, with sediment filtered out by ground vegetation within the 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. Machine access will be maintained

to enable the accumulated sediment to be excavated. Sediment will be carefully disposed of in dedicated disposal areas.
- Correct drain alignment, spacing and depth will ensure that erosion and sediment build-up are minimized and controlled.
- Brash management/removal.
- Brash mats will be used to support vehicles on soft ground, reducing soil erosion and avoiding the formation of rutted areas. 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, extraction will be suspended during periods of high rainfall.
- Timber will be stacked in dry areas and outside a 50 metre buffer. Straw bales and check dams will be emplaced on the downgradient side of timber storage/processing sites.
- Works will not be conducted during significant rainfall events (see Section 9.4.2.2) in order to minimise entrainment of exposed sediment in surface water run-off.
- Branches, logs or debris will not be allowed to build up in aquatic zones. All such material will be removed when tree-felling operations have been completed.

Drain Inspection and Maintenance: The following items will be conducted 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 (*i.e.,* hot spot areas).
- Inspections of plant and machinery will be conducted prior to any works to assure all are in good condition.
- Inspection of drainage ditches and outfalls. During pre-felling inspections, the main drainage ditches will be identified. The pre-felling inspection will be conducted during rainfall events.
- Following tree felling, all main drains will be inspected to ensure that they are functioning.
- Extraction tracks nears drains will be broken up and diversion channels created to ensure that water in the tracks spreads out over the adjoining ground; Culverts on drains exiting the site will be unblocked.
- 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: Surface water monitoring will be conducted as presented in Section 9.3.14. Field measurements will be conducted upstream and downstream of the felling activity. Visual observation will be relied on to shut down activity if necessary, in order to fix or upgrade any components of mitigation which may be failing or underperform. Surface water monitoring forms will be kept onsite for record and inspection.

Residual Effects: The proven forestry best practice measures proposed above will break the pathway between sources and receptors. Residual effects will be indirect, negative, slight, temporary, and of low probability.

Significance of Effects: With implementation of the proposed mitigation measures, likely significant effects on surface water receptors will not occur.

9.4.2.2 Earthworks

The construction phase involves earthworks in the form of excavation, movement, staging, and reinstatement of excavated materials. The scale of earthworks and the means and methods of conducting earthworks were presented in Chapter 4 of this EIAR. Within the Wind Farm Site, which encompasses 1,290 hectares (12.9 km^2), the proposed permanent development footprint is approximately 49 ha or 3.25 % of the total area.

The main risks associated with earthworks are direct releases/discharges of sediment load to surface watercourses. Releases of sediments to surface watercourses increases suspended sediment and organic matter loads. In a blanket bog environment, such releases can affect water quality, water clarity, morphology, and aquatic habitats in the downstream direction. Clogging of streambed substrate is a morphological effect.

Compared to tree-felling, the scale of earthworks during the construction phase are considerably greater. This means that the potential magnitude of likely effects are also greater.

Pathways: Drainage, runoff, surface water discharge routes.

Receptors: Local streams and the Altderg, Keerglen Rivers and linked rivers further downstream.

Pre-Mitigation Potential Effects: Without mitigation, potential effects will be indirect, negative, significant, short-term, reversible, and of high probability.

Mitigation by Avoidance: Works areas will be kept at least 50 m from watercourses to the extent possible. The proposed setback distance/buffer will serve to avoid:

- Direct physical damage to watercourses and associated releases of sediment.
- Direct entry of suspended sediments from earthworks into watercourses.
- Direct entry of suspended sediments from the drainage system into watercourses, which is achieved in part by ending drain discharges outside the buffer and allowing percolation across the vegetation within the buffer.

Risks and effects of earthworks are made greater during storm events. Hence, earthworks will not be conducted during significant storm events. The works programme for the entire construction stage of the Proposed Development will take account of weather forecasts, notably predicted rainfall. Large excavations and movements of soil/subsoil or vegetation stripping will be scaled back or suspended if heavy rain is forecast. Decisions to suspend works will be made from review of weather forecasts and visual observations, as judged and decided upon by the project hydrologist and/or environmental clerk of works.

The checking and communication of weather forecasts are part of the CEMP. Prior to suspending works for climatic reasons, the following control measures will be completed:

- Open excavations will be secured.
- Temporary or emergency drainage will be provided to prevent back-up of surface runoff in work areas.
- Working for up to 12 hours after heavy rainfall events will be avoided to ensure drainage systems are not overloaded. Decisions are subject to visual inspection and judgement by the resident (supervising) engineer. The intent and objective is to control erosion, avoid collapses of embankments, and limit the mobilisation and transport of sediments.

Mitigation by Design: Key mitigation by design measures that will be implemented comprise source controls, in-line controls and treatment systems, as follows:

- Source control measures cover working areas, staging areas and stockpiles. Methods that will be employed are diversion drains, flume pipes, sand bags, oyster bags filled with gravel, and filter fabrics. Flexibility to adapt methods will be required based on location-specific conditions, as judged by supervising engineers from visual inspection.
- In-Line controls involve settling of suspended sediments and particulate organic matter with the use of silt fences, straw bales, sand or oyster bags, weirs, baffles, and check dams. Flow limiters and sump pumping systems may be employed where needs arise in order to maintain the hydraulic functioning of the existing drain system.
- Treatment systems involve sediment traps and temporary sumps/attenuation ponds.

Moreover, soil accumulations will be removed from access roads during wet periods and dust will be suppressed during dry spells.

If discharge water fails to be of a high quality during regular inspection, then a filtration treatment system such as a “Siltbuster” or equivalent will be used to filter discharge water before release to watercourses. This applies for the entire construction phase.

For discharges near watercourses, within the 50 m buffer, and including discharges of greenfield runoff, double silt fences will be employed. These will be inspected and maintained, and remain in place throughout the entire construction phase.

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 outfall from the silt bag. Sedimats will be secured to the ground surface using stakes/pegs. Sedimats will extend the full width of the outfall to ensure all water passes through this additional treatment measure. Level spreaders will be designed for each outfall.

Management of Runoff from Peat and Spoil Placement Areas: Excavated peat and spoil will be used for landscaping, spread within the proposed peat placement areas around certain turbines and used to reinstate the 3 no. borrow pits. A Peat and Spoil Management Plan which describes details of the excavations is presented in **Appendix 4-2**.

During the initial placement of peat and spoil, silt fences, straw bales and biodegradable matting will be used to control runoff from reinstatement areas. ‘Siltbuster’ treatment trains will be employed if previous treatment is not to a high quality, as stated above.

Drainage from peat placement areas will ultimately be routed to swales and settlement ponds with storage and settlement designed for a 6-hour duration, 1 in 10 year storm event. Peat and spoil placement areas will be vegetated to reduce sediment entrainment in runoff, which will further help to reduce risks of sediment mobilisation.

Field Inspection: An inspection and maintenance plan for the construction drainage system will be prepared in advance of commencement of works. Regular inspections of installed drainage systems will be undertaken, especially after heavy rainfall, to check for damage and blockages, and ensure there is no escape or 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 conducted on a daily basis.

Surface Water Quality Monitoring: Monitoring will be performed as described in Section 9.3.14.

Residual Effects: Proven and effective measures to mitigate the risk of releases of sediment have been proposed which will break the pathway between potential sources and receptors. Hence, residual effects will be indirect, negative, not significant, short-term, and of low probability.

Moreover, residual effects will be monitored for and corrective action can be taken. Slight changes in current baseline conditions are expected during the construction phase but these are not sufficient to change the character or sensitivity of the receiving waters, and not sufficient to affect the WFD status classification of the watercourses within Glenora Forest that drain to the Altderg, Oweninny and Keerglen Rivers (**Appendix 9-3**).

Significance of Effects: For the reason outlined above, likely significant effects on surface water quality will not occur.

9.4.2.3 Culverts

Culverts are necessary where access roads cross watercourses and where runoff waters captured by interceptor drains and swales need to be led across roads. Based on the planned layout (**Appendix A of Appendix 4-4**), the planned works will require:

- Construction of 2 no. new watercourse crossings.
- Potential upgrade of 4 no. existing culverted watercourse crossings.
- Provision of an estimated 66 no. culverts, which includes upgrades to existing piped culverts and which are not related to natural watercourse crossings.

The works require use and movement of machinery and equipment which can result in physical disturbance of streambanks and streambeds, hence sediment mobilisation and both water quality and morphological effects.

Pathway: Runoff and streams.

Receptor: Local streams and the Altderg, Oweninny and Keerglen Rivers downstream.

Pre-Mitigation Potential Effects: Without mitigation, potential effects will be direct, negative, moderate, short-term, reversible, and of high probability.

Mitigation Measures by Avoidance: Machinery and personnel are kept out of the river directly. Direct in-stream works will be avoided.

Mitigation Measures by Design: All works will be conducted in accordance with the CEMP which incorporates the best practice IFI "Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters" (IFI, 2016). Related activity incorporates many of the same measures that are presented in Section 9.4.2.2 (earthworks). Moreover:

- All stream crossings will be bottomless-box or clear span culverts. Existing banks will remain undisturbed.
- Based on IFI (2016), the relevant work period is July to September inclusive, *i.e.,* the relatively drier summer period. Any deviation that may be temporarily necessary will be done in discussion with the IFI.
- During near-stream construction works, double-row silt fences will be emplaced immediately downgradient of work areas for the duration of activity.
- All new 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.

Underground cabling routes within the Wind Farm Site (e.g. from turbines) will follow access roads and cables will pass within the structure of the road and associated culverts.

Residual Effects: With the proposed mitigation measures, residual effects will be direct, negative, not significant, short-term, and of low probability.

Significance of Effects: For the reasons outlined above, likely significant effects on surface watercourses will not occur.

9.4.2.4 Grid Connection Installation

As described in Chapter 4 of this EIAR, the grid connection route follows existing roadways from the Wind Farm Site to the Tawnaghmore 110kV Electricity Substation near Killala in the east. Cables will be installed below ground in trenches except for 10 no. bridge crossings where horizontal directional drilling (HDD) will accommodate the crossing. HDD involves the use of a drill rig and ancillary plant. This requires secure and safe footing for operations, hence also preparatory earthworks, including use of basecourse or mats for protection purposes. The risks of effects are the same as those described in Sections 9.4.2.2, 9.4.2.3, and 9.4.2.8.

In-stream works will be avoided in all cases. With regard to HDD, mitigation measures relating to the use of a mixture of a natural, inert and fully biodegradable drilling fluid such as Clear Bore™ and water for directional drilling will be implemented in full, as follows:

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

Pathways: Runoff.

Receptors: All local streams and rivers along the grid connection route.

Pre-Mitigation Potential Effects: Without mitigation, potential effects will be direct, negative, slight, temporary, reversible and of medium probability.

Mitigation by Design: Applicable mitigation measures for dug trenches (involving earthworks) are those described in Section 9.4.2.2 and 9.4.2.3. Where trenches are dug with excavators, spoil will be kept adjacent to the trenches and filled in immediately upon of installation of cables. Cable works will proceed in sections or segments to avoid trenches remaining open over protracted periods of time. Where cables will cross streams in horizontally drilled boreholes, mitigation measures for earthworks and culverting also apply, per Sections 9.4.2.2 and 9.4.2.3.

Residual Effects: With mitigation measures, the residual effects are direct, negative, not significant, temporary, and unlikely.

Significance of Effects: For the reasons outlined above, likely significant effects on surface water quality will not occur.

9.4.2.5 Hydraulic Effects of Drainage

The shallow interceptor drains that are planned upslope of infrastructure components will capture greenfield runoff. While drainage within Glenora Forest will be managed, the water balance of the natural drainage system is maintained.

The main risks associated with the construction of interceptor drains are a) sediment mobilisation to watercourses, and b) the potential for draining peat. The latter involves hydraulic effects (see below) and can contribute to water quality effects (addressed in Section 9.4.2.6).

Draining of peat lowers water levels in the peat. This can result in subsidence/slumping of the peat surface and loss or changes to vegetation types/communities in the hydraulically affected area(s). As presented in Section 9.3.8.4, the peat is already drained in parts of the Wind Farm Site with depths to water in several piezometers exceeding 0.5 m.

Hydraulic effects of drainage propagate away from drains, in the upslope directions especially. There is no simple rule of thumb that can be applied to estimate how far the effect may extend, as bog hydrology is location-specific and both dynamic and transient, responding to event-based, seasonal, and longer-term climatic conditions. Researchers like Rezanezhad *et. al.* (2016), Holden (2009), and Ramchunder *et al.* (2009) highlight the combined influences of drain depths, peat depths, relative slopes, the potential interference with other nearby drains, as well as peat stratigraphy, permeability, and structure.

In the UK and Irish scientific literature, there are empirically-based examples of drainage effects, as follows:

- Based on monitoring data from Derrycolumb, Co. Longford, Gill (2020) reported that "*water levels on the high bog adjacent to a 1.5m high facebank (with drain along production side) are not significantly influenced by the facebank and associated drainage beyond c. 40m distance*". Gill (2020) concluded that a "*zone of influence distance of 60 m would be a conservative buffer*". For deep perimeter bog drains at the same site, Gill (2020) reported that a "*conservative buffer*" of 100 m would apply.
- Price *et al.* (2003) examined evidence for the "*efficacy of drainage*" and referred to studies where water tables in peat were lowered to distances "*up to 50m from the ditch in fibrous peat*".
- Based on monitoring at Clara Bog in Co. Offaly, Regan *et al.* (2019) estimated that the hydraulic influence of bog margin drainage extended up to 900 m into the bog, as indicated by subsidence of land surface. It was cautioned that the sensitivity of a bog system to environmental change (such as drainage) will vary depending on the connectivity of the bog to the regional hydrological regime. A similar observation was made by Siegel and Glaser, (2006). In the case of Clara Bog, the bog is underlain by thick and highly permeable glacial deposits.

In contrast to Clara Bog, the upland blanket bogs within the Wind Farm Site are:

- Underlain by glacial till (mainly silt/clay) and poorly productive bedrock, which limits rainfall-recharge and groundwater flow.
- Characterised by high and frequent rainfall.

From this, it is considered that the peat in Glenora Forest is rainfall-dependent more so than groundwater-dependent, even though hydrogeology is part of the mechanism that helps to maintain saturation of peat.

To advance the discussion pragmatically for the purposes of this EIAR, a distance of 100 m was used to guide the further discussion of potential effects, which would primarily occur during the operational phase (Section 9.4.3.2). As bog hydrology is both dynamic and transient, it will take time for potential effects at distance to become established - likely much longer than the 2-year construction phase. For this reason, the discussion of hydraulic effects has greater relevance during the operational phase of the Proposed Development.

In contrast to potential effects of linear interception drains, the smaller excavations that will serve the construction of other infrastructure components (e.g. foundations of turbines) will involve temporary sump pumping, which is addressed in Section 9.4.2.7.

Pathways: Peat, drains.

Receptors: Peat.

Pre-Mitigation Potential Effects: For drainage effects of 100 m, some drying out of saturated peat may occur, but effects will be countered by naturally high and frequent rainfall across Glenora Forest, and thus areas involved are small. Potential effects are considered to be direct, negative, not significant, long-term (extending beyond the construction phase, see Section 9.4.3.2) and likely.

Mitigation Measures by Design: Development footprints have been reduced to a minimum and interceptor drains will be shallow (<1.5 m) which serves to reduce the relative risk of drainage effects. The drainage system will be integrated with the existing drainage network in the forest to the maximum extent possible. All construction works will be supervised.

Residual Effects: Given the time span of construction (2 years), residual effects from the construction phase will occur in the operational phase (see Section 9.4.3.2).

Significance of Effects: For the reasons outlined above, likely significant hydrological or hydrogeological effects, beyond those already experienced in Glenora Forest, are not expected to occur. See Section 9.4.3.2 for further detail.

9.4.2.6 Water Quality Effects of Drainage

Drainage water can carry suspended matter, dissolved organic matter, and nutrients. If peat is excessively drained, drainage water can also affect the pH of surface water. Hence, local streams in Glenora forest can experience shifts in baseline conditions even if this is unlikely to affect the much larger rivers downstream.

Specific, potential water quality issues would relate to water clarity, colour, pH and nutrient concentrations. Sedimentation of suspended matter can also affect streambed substrate, which is also a stream morphological issue. All water quality items can affect aquatic habitats and biota.

Water quality deterioration has the potential to affect the WFD status classification of related surface water bodies, not in the construction phase but in the operational phase. This is described in Section 9.4.2.13 and in **Appendix 9-3**.

Pathway: Drains.

Receptor: Local streams and the Altderg, Oweninny, and Keerglen Rivers downstream.

Pre-Mitigation Potential Effects: Without mitigation, potential effects will be indirect, negative, slight, temporary, and of medium probability.

Mitigation by Design: Potential effects from construction works will be mitigated by drainage controls (e.g. Sections 9.4.2.1 through 9.4.2.3) which are established as part of drainage management. Further descriptions are presented in drainage-related **Appendices 4-1** and **4-4**, as well as Section 9.3.13.

Monitoring: Streams will be monitored as described in Section 9.3.14.

Residual Effects: With the planned drainage system, residual effects will be indirect, negative, not significant, temporary, and of low probability.

Significance of Effects: For the reasons outlined above, changes to current baseline conditions may be measurable but likely significant effects will not occur.

9.4.2.7 Pumping from Open Pits

It is expected that open excavations for foundation works (e.g. for turbines) and the Borrow Pits will have to be temporarily pumped to keep the excavations free of seepage water. As described in the Peat and Spoil Management Plan (**Appendix 4-2**), excavation depths will range from 1.2 mbgl at the electrical substation to 4 mbgl at turbine locations, and to approximately 22, 35, 9 mbgl maximum for Borrow Pits 1, 2 and 3, respectively. The maximum depth of peat to be excavated is up to 3 mbgl at turbine locations.

Water will enter directly from rainfall and via subsurface seepage when the groundwater table is intersected. In bedrock, groundwater may ingress from fractures and a 'transition zone' that may be present at the contact between subsoils and bedrock. The quantities to be pumped will be small given the generally low-permeability characteristics of both the till and bedrock groundwater flow system.

The pumping from excavations will only be needed for short periods of time. For most components, the time frame is measured in days to weeks. However, the Borrow Pits will be excavated in stages over an extended period of more than one year, requiring intermittent pumping.

The pumped water, which is expected to contain suspended solids, will be pumped to the nearest swale and led to the associated settlement pond which has been established in the first stage of construction, prior to diffuse discharge across open ground.

The excavation-related water will be discharged periodically, on an as-needed basis. It is not a continuous process, and the volumes pumped will vary from location to location.

Given the geology of the Wind Farm Site and poorly permeable nature of the bedrock aquifer, the volumes that will be pumped and managed are expected to be less than 10 m^3/hr (0.0026 m^3/s, or 2.6 l/s).

Discharges from sump pumping can affect the water quality of watercourses, especially with regard to suspended sediments.

Pre-Mitigation Potential Effects: Without mitigation, potential effects will be indirect, negative, not significant, temporary, reversible, and medium probability. Hydrogeologically, from a quantitative perspective, pumping effects are direct, neutral, imperceptible, temporary and unlikely.

Mitigation by Avoidance: An upslope interceptor drain will be established upslope of the excavation area to prevent greenfield runoff into the excavations. Berms will also be used, as necessary.

Mitigation by Design: The water pumped by sump pumps will pass through silt bags before being discharged into the swale. As the water pass through the silt bags, the majority of sediment and organic matter is retained by geotextile fabric. The silt bags will be used with natural vegetation filters or sedimats. The sedimats will be secured to the ground surface using stakes/pegs. They will extend to the full width of the outfall to ensure that all water passes through this treatment measure. Level spreaders will be installed for each outfall.

The footprints of excavations for infrastructure foundation works and hardstanding have been planned to be as small as practicable. Excavations will be backfilled after completion of installations, which will serve to restore water levels and drainage patterns, hence reduce the temporary drainage effects.

Residual Effects: As outlined in the CEMP, the methods above are standard practice methods which serve to reduce suspended matter loads from pumped discharges. In this manner, the sediment load is managed and residual effects will be indirect, negative, not significant, temporary, and of low probability. Hydrogeologically, from a quantitative perspective, residual pumping effects are direct, neutral, imperceptible, temporary and unlikely.

Significance of Effects: For the reasons outlined above, likely significant effects will not occur.

9.4.2.8 Accidental Spills, Leaks or Other Releases

Accidental spillage of fuels or chemicals represent a pollution risk to both groundwater and surface water, as well as aquatic habitats and biota.

Pathways: Runoff, drains, streams, groundwater.

Receptors: Groundwater, local streams and Altderg, Oweninny and Keerglen Rivers downstream.

Pre-Mitigation Potential Effects: Without mitigation, potential effects are direct and indirect, negative, imperceptible to profound, brief to long-term, reversible and of low probability.

Small spills and leaks may cause effects that are imperceptible. Large or continuous spills and leaks can potentially damage the habitats and living organisms in the receiving water.

Hence, effects can be brief to long-term, depending on the nature and scale of the spills or leaks. Potential effects can be mitigated.

Mitigation Measures by Design: The prevention of, and responses to, accidental spills and leaks of fuel and other chemicals are covered by the CEMP and SWMP. The following mitigation measures will be implemented:

- Trained personnel will conduct onsite refuelling only.
- Onsite refuelling of machinery will be done by mobile double-skinned fuel bowsers.
- Drip trays and fuel absorbent mats will be available and used during all refuelling operations
- A permit for the fuel system will be put in place.
- Fuels stored onsite will be minimised. Fuel storage areas will be bunded to contain 110%v of the fuel storage volume for the time period of the construction. Rainwater will not be allowed to accumulate within the bund, and will thus be fitted with a storm drainage system and appropriate oil interceptor.
- The plant used during construction will be regularly inspected for leaks and fitness for purpose.
- Spill kits will be available to deal with and accidental spillage in and outside the re-fuelling area.

Residual Effects: With mitigation, residual effects will be indirect, negative, imperceptible, short-term, and unlikely.

Proven, routine, and effective measures to mitigate the risk of releases of fuels and chemicals are proposed which will break the link between potential sources and receptors.

Significance of Effects: For the reasons outlined above, likely significant effects on surface water or groundwater quality will not occur.

9.4.2.9 Release of Cement-based Products

Entry of cement-based products into drains or surface water within the Wind Farm Site represents a risk to the aquatic environment at and downstream of the release.

Concrete and other cement-based products are alkaline and can be corrosive. They generate fine, highly alkaline silt (pH 11.5) that can physically damage fish. 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.

Batching of wet concrete onsite is not proposed. Washing out of transport and placement machinery are the activities most likely to generate a risk of cement-based pollution.

Releases of cement-based products are obvious when they happen and can be stopped. They also involve small volumes (individually). Risks are increased with repeated poor practice.

Pathways: Drains, streams.

Receptors: Peat and local streams.

Pre-Mitigation Effects: Pre-mitigation effects on peat are covered in Chapter 8 of this EIAR. Pre-mitigation effects on surface waters can be direct and indirect (depending on how and where releases occur), and are negative, slight, temporary to short term, and of low probability.

Mitigation Measures by Avoidance:

- Concrete will be delivered in sealed concrete delivery trucks. Batching of wet-cement products will not occur on site.
- Ready-mixed supply of wet concrete products and emplacement of pre-cast elements will take place.
- Pre-cast elements for culverts and concrete works will be used.
- Concrete trucks will not be washed out on site but will be directed back to their batching plant for washout.

Mitigation Measures by Design:

- 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 washout ponds.
- Where temporary lined impermeable containment areas are used, such containment areas are built using straw bales and lined with an impermeable membrane. These are covered when not in use to prevent rainwater collecting.
- Pour sites of cement will be kept free of standing water, and plastic covers will be ready in case of sudden rainfall events.

Concrete deliveries are often conducted outside of normal working hours in order to limit traffic effects on roads. Concrete pouring for turbine foundations is normally completed in a single day per turbine. The placed concrete begins curing straight away after placement and vibrations, it is solid in 24-48 hours, and it reaches its full strength after 28 days. As such, leakage from the formwork to the surrounding ground is not possible.

Risks of pollution will be further reduced as follows:

- Concrete will not be transported around the site in open trailers or dumpers so as to avoid spillage while in transport.
- All concrete used in the construction of turbine bases will be pumped directly into the shuttered formwork from the delivery truck. If this is not practical, the concrete will be pumped from the delivery truck into a hydraulic concrete pump or into the bucket of an excavator, which will transfer the concrete locally to the location where it is needed.
- Arrangements for concrete deliveries to the site will be discussed with suppliers before work starts, confirming routes, prohibiting on-site washout and discussing emergency procedures.
- Clearly visible signage will be placed in prominent locations close to concrete pour areas specifically stating washout of concrete lorries is not permitted on the site.
- Weather forecasting will be used to assist in planning large concrete pours and large pours will be avoided where prolonged periods of heavy rain is forecast.
- Concrete pumps and machine buckets from slewing over watercourses will be restricted while placing concrete.

- Excavations will be sufficiently dewatered before concreting begins and dewatering will continue while concrete sets.
- Covers will be available for freshly placed concrete to avoid the surface washing away in heavy rain.
- Any potential, small surplus of concrete will be disposed of after completion of a pour in suitable locations away from any watercourse or sensitive habitats.

Residual Effects: Residual effects on peat are covered in Chapter 8 of this EIAR. With mitigation, residual effects on surface water quality will be indirect, negative, imperceptible, short-term, and unlikely.

Proven, routine, and effective measures to mitigate the risk of releases of cement-based products are in place which will break the link between potential sources and receptors.

Significance of Effects: For the reasons outlined above, likely significant effects on surface water or groundwater quality will not occur.

9.4.2.10 Wastewater Management

During the construction phase of the Proposed Development, staff welfare facilities will be provided at each of 5 no. construction compounds. Port-a-loos will be used. These will be collected regularly and brought offsite in fully enclosed tanks for disposal by authorised means (permitted wastewater collector) to a wastewater treatment plant.

Pathways: Runoff, drains.

Receptors: Local streams and Altderg, Oweninny and Keerglen Rivers downstream, and groundwater.

Pre-mitigation Potential Effects: Potential effects are direct and indirect, negative, not significant, short-term, reversible, and of low probability.

Mitigation Measures by Avoidance: Wastewater will not be treated or disposed of onsite.

Residual Effects: Use of sealed storage tanks and offsite disposal breaks the link between the source and potential receptors. With the planned management measures, residual effects will be indirect, neutral, imperceptible, short-term, and unlikely.

Significance of Effects: For the reasons outlined above, likely significant effects on surface water or groundwater quality from wastewater will not occur.

9.4.2.11 Turbine Delivery Route Accommodation Works

As described in Chapter 4 of this EIAR, accommodation works will be required: a) for an area of approximately 1,500 m^2 at the proposed link road off the R314 (access road between Ballycastle and Glenora Forest); and b) the intersection of the N17 and N5, comprising construction of widened junctions to facilitate the delivery of turbine components and other abnormal loads.

The activity involves earthworks, which was described in Section 9.4.2.2, and carries risk of accidental spills and leaks, which was described in Section 9.4.2.8.

Pathways: Runoff

Receptors: Local streams and the Altderg, Oweninny and Keerglen Rivers.

Pre-mitigation Potential Effects: Without mitigation, potential effects are direct, negative, moderate, temporary and of medium probability.

Mitigation Measures by Design: Mitigation measures in relation to earthworks are presented in Section 9.4.2.2. Mitigation measures in relation to accidental spills, leaks or other releases are described in Section 9.4.2.8.

Residual Effects: With planned mitigation, residual effects are indirect, negative, not significant, temporary and of low probability.

Significance of Effects: For the reasons outlined above, likely significant effects on nearby watercourses will not occur.

9.4.2.12 Public or Private Water Supply

The Wind Farm Site is not hydrologically linked to any sources of public water supply. Hence, the risk of affecting public water supplies are absent. The only risk is posed by private wells, at single dwellings and farms downgradient of the Wind Farm Site. The nearest dwellings/farms are approximately 2 km east of the nearest proposed turbine location. Groundwater flow in the poorly productive bedrock aquifer is localized, with short flow paths (hundreds of metres) to local streams. The nearest dwellings/farms are hydraulically sidegradient of the Proposed Development.

Pathway: Groundwater.

Receptor: Groundwater and private wells downgradient of the Site.

Pre-Mitigation Potential Effects: Indirect, negative, imperceptible, permanent, unlikely (high probability).

Proposed Mitigation Measures: By following the best practice measures outlined for other potential effects (e.g. accidental spills and leaks, wastewater management) risks to private wells are eliminated.

Residual Effects: With mitigation, residual effects are indirect, neutral, imperceptible, permanent, and unlikely (high probability).

Significance of Effects: For the reasons outlined above, likely significant effects on public or private water supplies will not occur.

9.4.2.13 WFD Water Body Status

WFD water body status was presented in Section 9.3.10 and a further WFD compliance assessment is presented in **Appendix 9-3.** The Proposed Development has the potential to affect surface water quality.

The duration of the construction phase is approximately 2 years, whereas WFD status is classified by EPA every 6 years. This means that risks of affecting (causing a deterioration of) WFD status in respective river water bodies become more relevant for the longer-term operational phase (Section 9.4.3.7).

Pathways: Runoff, drains, other discharges (e.g. spills and leaks).

Receptors: Streams/rivers, and groundwater.

Pre-Mitigation Potential Effects: During construction, and without mitigation, potential effects on the WFD status of named river water bodies within and downstream of the Wind Farm Site are both direct and indirect, negative, moderate, short-term, but unlikely. Effects are deemed unlikely due to the short duration of construction in relation to the WFD 6-year status classification and reporting cycle.

Along the grid connection route, potential effects are indirect, negative, imperceptible, short-term, and unlikely.

For groundwater, potential pre-mitigation effects are also indirect, negative, not significant, short-term, and unlikely.

Mitigation by Design: Mitigation measures are necessary and proposed to break potential source-receptor linkages and allow for sediment settling and attenuation. The means and methods of achieving the necessary levels of protection are understood and proposed, largely based on existing guidance (Section 9.1.4) and practical experiences from other comparable sites.

Relevant mitigation measures are all of those described in preceding sections for the construction phase. The Contractor will be legally required to adhere to the **CEMP** which encompasses the proposed mitigation measured. All works will be supervised and monitoring will be undertaken as described in Section 9.3.14 in order to be able to identify potential effects and take corrective action, as necessary.

Residual Effects: With mitigation, residual effects are indirect, negative, not significant, short-term, and unlikely (with high probability). The same applies for the underlying groundwater bodies.

Significance of Effects: For the reasons outlined above, likely significant effects on WFD status of the named river subbasins and groundwater bodies will not occur in the construction period.

9.4.2.14 Designated Sites/Protected Areas

As presented in Section 9.3.11, the following designated sites/protected areas that are considered to be within the "Likely Zone of Influence" of the Wind Farm Site are:

- Bellacorick Bog Complex SAC
- Bellacorick Bog Complex pNHA
- Killala Bay/Moy Estuary SAC
- Killala Bay/Moy Estuary SPA
- Killala Bay/Moy Estuary pNHA
- Inagh Bog NHA

Potential effects of the Wind Farm Site on each designated site and protected area that is hydrologically or hydrogeologically linked to the Proposed Development during construction are presented in **Table 9-15**.

The mitigation measures presented in Section 9.4.2 and SMWP will serve to protect and mitigate against the identified, potential effects. For the reasons described in **Table 9-15**, likely significant effects on the designated sites/protected areas will not occur during the construction phase.

Table 9-15 Assessment of Likely Significant Effects on Designates Sites and Protected Areas During Construction

Designated Site/Protected Area	Direct/Indirect Connection to Proposed Development	Description	Assessment of Likely Significant Effects
Bellacorick Bog Complex SAC	Indirect – Proposed Development is located upstream of, and entirely outside, the SAC.	There is potential for water pollution of the Oweninny River downslope from the Wind Farm Site. The Oweninny River marks the SAC boundary which coincides with the convergence of the Altderg and Inagh Rivers to form the Oweninny River. Although the SAC is downslope from the Wind Farm Site, there are no pathways that link the Proposed Development with habitats <u>within</u> the SAC. The habitats within the SAC boundaries are dependent on the hydrological and hydrogeological conditions <u>within</u> the SAC. Water within the SAC drains towards the Oweninny River. Hence, there will be no effects of the Proposed Development on the qualifying interests of SAC, neither during construction or any other subsequent phase. Mitigation measures described in Sections 9.4.2.1 through 9.4.2.10 will serve to protect the SAC further from any potential quality or quantity effects. The Altderg River which flows south from Wind Farm Site is a headwater subcatchment of the Oweninny River (and the Owenmore River further downstream). Other proposed and existing wind farms are situated within other subcatchments of the Oweninny River. Potential cumulative effects are presented in Section 9.4.5.	Without Mitigation: indirect, negative, not significant, short-term, and low probability. With Mitigation: indirect, negative, imperceptible, short-term, and unlikely.
Killala Bay/Moy Estuary SAC	Indirect – grid connection route and grid connection point at Tawnaghmore are upstream of the SAC.	The grid connection route crosses the Cloonaghmore River. The grid connection point at Tawnaghmore is part of the Moyne River subcatchment. Both rivers are hydrologically linked with and discharge into the estuary SAC. Hence, there is potential for water pollution of the estuary. Any pollution that discharges into the estuary will be significantly attenuated by dilution/mixing. The grid connection route crosses streams at approximately 30 locations. Crossings will occur through/across culverts and bridges but will also include horizontal directional drilling technology at 10 no. locations. There will be no earthworks at or immediately adjacent to stream crossings.	Without Mitigation: indirect, negative, not significant, short-term, and low probability. With Mitigation: indirect, negative, imperceptible, short-term, and unlikely.

Designated Site/Protected Area	Direct/Indirect Connection to Proposed Development	Description	Assessment of Likely Significant Effects
		Managed earthworks for the grid connection at Tawnaghmore will take place approximately 1.5 km from the nearest stream. There will be no direct discharges of stormwater or swale water to any local watercourses. Mitigation measures described in Sections 9.4.2.1 through 9.4.2.10 will serve to protect the SAC further from any potential effects.	
Special Protected Area (SPA)			
Killala Bay/Moy Estuary SPA	Indirect – grid connection route and grid connection point at Tawnaghmore are upstream of the SAC.	See SAC description above.	Without Mitigation: indirect, negative, not significant, short-term, and low probability. With Mitigation: indirect, negative, imperceptible, short-term, and unlikely.
National Heritage Area (NHA)			
Inagh Bog NHA	Indirect – Wind Farm Site is located sidegradient and downgradient of the NHA	The NHA is an area of upland blanket bog which borders the Wind Farm Site to the west. Construction works will take place more than 100 m from the NHA boundary. According to the site synopsis report by NPWS (2004), "*The blanket bog within the site can be divided into two basic types: wet, deep blanket bog on flat to gently sloping ground and shallower, drier blanket bog on the steeper slopes and mountain ridges. Below an altitude of approximately 200 m, most of the bog occurs as relatively deep and sometimes quaking peat on flat to gently sloping ground*". As an upland blanket bog, the NHA is water-dependent. Although the NHA borders the Wind Farm Site, the NHA is upgradient and sidegradient of the Proposed Development. For this reason, the NHA cannot be directly affected by the Proposed Development. Indirect effects are related to potential dust transmission and potential hydrological effects from the drainage of peat/subsoil within c. 100 m of the NHA boundary.	Without Mitigation: indirect, negative, not significant, short-term, and low probability. With Mitigation: indirect, negative, imperceptible, short-term, and unlikely.

Designated Site/Protected Area	Direct/Indirect Connection to Proposed Development	Description	Assessment of Likely Significant Effects
Proposed National Heritage Area (pNHA)			
Bellacorick Bog Complex	See SAC description above.		
Killala Bay/Moy	See SAC description above.		

9.4.3 Operational Phase - Likely Significant Effects and Mitigation Measures

The likely significant effects of the Proposed Development and mitigation measures that were considered during the 35-year operational phase (see Chapter 4 of this EIAR) relate to:

- Maintenance works.
- Hydraulic effects of drainage.
- Water quality effects of drainage – general.
- Water quality effects of drainage – designated sites.
- Compaction of access roads and hardstanding.
- Water well installation and pumping.
- Wastewater management.
- WFD water body status.
- Designated sites and protected areas.

Mitigation measures consider specific actions which are designed to avoid, prevent or lessen potential effects – *i.e.,* mitigation by avoidance and mitigation by design.

9.4.3.1 Maintenance Works

During the operational phase, impediments to drainage can generally occur as a result of blockages to watercourse crossings, ditches and watercourses resulting from vegetation and erosion debris. Maintenance works of access roads, structures, and drainage system components (e.g. settlement ponds) will be undertaken regularly per the CEMP. Maintenance is a repeated activity which includes cleaning and removal of accumulated sediments and debris.

For the drainage system, potential effects are related to sedimentation and damage to watercourses. However, risks are much reduced compared to the construction activity as the scale of works are significantly less.

Accidental spills and leaks can also occur. Oil used in transformers at the substation and within each turbine, and storage of oils in tanks at the substation, could leak during the operational phase and impact on streams and groundwater. Risk can be managed by following the mitigation measures presented in Section 9.4.2.8. The substation transformer and oil storage tanks will be in a concrete bund capable of holding 110% of the stored oil volume. Turbine transformers are located within the turbines, so any leaks would be contained within the turbine structure.

Pathway: Runoff and drains, surface water, and groundwater (for accidental spills and leaks).

Receptor: Local streams and Altderg, Oweninny and Keerglen Rivers downstream, and groundwater (for accidental spills and leaks).

Pre-Mitigation Potential Effects: Potential effects will be those that would occur without the SWMP, in which case the potential effects will be indirect, negative, slight, long-term, and of medium probability.

Mitigation by Design: Maintenance works will be subject to control measures contained in Section 3.2.3 of the SWMP (**Appendix 4-4**).

Monitoring: Monitoring will be performed as described in Section 9.3.14.

Residual Effects: With mitigation measures, residual effects will be indirect, negative, not significant, long-term, and of low probability.

Significance of Effects: For the reasons outlined above, likely significant effects from maintenance works will not occur.

9.4.3.2 Hydraulic Effects of Drainage

The planned interceptor drains will collect greenfield runoff. Where planned new drains, beyond those already in existence as part of forestry operations, intersect peat and subsoils, the new drains will contribute to some lowering of water levels in vicinity of the drains, notably in upslope directions, and as a function of the many variables that were identified in Section 9.4.2.5. Such water level lowering is a longer-term issue as the drains will be functional in all phases of the Proposed Development. The extent of water level lowering will be constrained by the depth of the drains.

The only sensitive habitat that could be affected by water level lowering is the Inagh Bog NHA. This is mostly sidegradient and only marginally upslope from the Wind Farm Site in Glenora Forest. As such, it was considered further below, on the assumption that the hydraulic influence of drainage within the Wind Farm Site will extend to the NHA.

Given the layout of the Proposed Development (Chapter 4), it is principally the planned interceptor drains at wind turbines T2, T3 and T4 at the western end of Glenora Forest that could influence the Inagh Bog NHA. Distance from wind turbines T2, T3, and T4 to the NHA boundary marginally exceed the 100 m threshold that was proposed in Section 9.4.2.5. The north to south oriented road which runs parallel to the NHA boundary is more than 200 m from the boundary, and thus poses a lower risk to the hydrology of the NHA.

To be conservative, a worst case scenario was considered which assumes that the hydraulic influence of planned, new drains at T2, T3, and T4 will extend 100 m into the NHA. The total area affected by lowering of water levels in the peat would thus be:

> 100 m × 100 m (width of turbine interceptor drains, perpendicular to drainage direction) × 3 turbines = 30,000 m^2, or 3 ha.

This equates to 0.5 % of the approximate total NHA area of 600 ha (6 km^2).

Pathways: Peat and shallow groundwater (subsoils).

Receptors: Peat/blanket bog.

Pre-Mitigation Potential Effects: Indirect, negative, not significant, long-term, and unlikely.

Mitigation Measures by Design: Development footprints have been reduced to a minimum and current drainage conditions are maintained to the maximum extent possible. Maintaining shallow drains as proposed also reduces the scope for and likelihood of drainage effects.

Residual Effects: Indirect, negative, not significant, long-term, and unlikely.

Significance of Effects: For the reasons outlined above, likely significant hydrological or hydrogeological effects on the Inagh Bog NHA will not occur.

9.4.3.3 Water Quality Effects - General

Water quality risks during the operational phase are much reduced compared to the construction phase. Maintenance activity is the main item that can affect water quality. Runoff waters may contain suspended and dissolved organic matter, and both drains and settlement ponds will require periodic cleaning.

Specific water quality issues relate to sedimentation, water clarity, pH and nutrient concentrations. Sedimentation is a stream morphology issue. All items can affect aquatic habitat and biota.

Drains and ponds will be visually assessed on an annual basis to determine the need for maintenance.

Pathway: Runoff, drains.

Receptor: Local streams and the Altderg, Oweninny and Keerglen Rivers downstream.

Pre-Mitigation Potential Effects: Without mitigation (e.g., maintenance), potential effects will be indirect, negative, slight, long-term, and of low probability.

Mitigation Measures by Design: During the operational phase, potential effects will be mitigated by measures contained in Section 3.2.3 of the SWMP (**Appendix 4-4**).

Monitoring: Streams will be monitored as described in Section 9.3.14.

Residual Effects: With mitigation, residual effects are expected to be indirect, negative, not significant, long-term, and of low probability.

Significance of Effects: For the reasons outlined above, and with the extensive mitigation and monitoring measures that are proposed, likely significant effects on the surface water receptor environment are not expected to occur.

9.4.3.4 Compaction of Access Track and Hardstanding

Access roads and hardstanding (e.g., turbine spaces) will reduce the permeability of the ground across respective areas. Over time, these may become compacted further, which in theory can increase runoff from such areas.

The total footprint of access roads and hardstanding for turbines is 288,195m^2. In **Appendix 9-2**, the runoff from these areas was calculated to be 0.404 m^3/s for a 1 in 10 year storm event, using a runoff coefficient of 0.7. Accounting for compaction in the future (which reduces ground permeability), by adjusting the runoff coefficient to 0.8, runoff volumes will increase by 0.057 m^3/s to 0.46 m^3/s. To settle out particles of 10 µm (**Appendix 9-2**), this increases the associated settlement pond area requirements by 247 m^2 in total, which does not pose a practical challenge across the Wind Farm Site.

Pathways: Drainage.

Receptors: Local streams and the Altderg, Oweninny and Keerglen Rivers downstream.

Pre-Mitigation Potential Effects: Without maintenance, potential effects will be indirect, negative, slight, long-term, and of medium probability.

Proposed Mitigation by Design: The operational phase drainage system (**Appendix 4-4**) will be functioning and maintained (Section 9.4.3.1).

Residual Effects: With maintenance, residual effects will be indirect, negative, imperceptible, long-term, and of low probability.

Significance of Effects: For the reasons outlined above, likely significant effects from surface compaction will not occur.

9.4.3.5 Water Well Installation and Abstraction

As described in Chapter 4 of this EIAR, staff welfare facilities will be provided at the control buildings and the operation and maintenance building during the operational phase. There will be a small water requirement for these facilities, albeit not for potable use. It is proposed to install a well adjacent to the electrical substation and to the operation and maintenance building in accordance with the Institute of Geologists Ireland (IGI) "*Guide for Drilling Wells for Private Water Supplies*" (IGI, 2007).

The wells will be flush to the ground and covered with a standard manhole. A pump house is not required as an in-well pump will direct water to a water tank within the roof spaces of the buildings. Bottled water will be supplied for drinking.

The volumes of groundwater that will be pumped are small, <5 m^3/d. The pumping will be intermittent. The hydraulic influence of pumping would be localised and will not result in any significant reduction in groundwater levels, peat water levels, or natural groundwater baseflow to streams.

Pathways: Groundwater.

Receptors: Groundwater, peat, and local streams.

Pre-Mitigation Potential Effects: Direct, negative, imperceptible, long-term, and of low probability.

Mitigation Measures: None is required.

Residual Effects: Direct, neutral, imperceptible, long-term, and unlikely.

Significance of Effects: For the reasons outlined above, likely significant effects will not occur from low-volume well pumping.

9.4.3.6 Wastewater Management

Toilet facilities will be installed with a low-flush cistern and low-flow wash basin. It is not proposed to treat wastewater on site. Wastewater from the staff welfare facilities in the control building and operation and maintenance building will be managed by means of sealed storage tanks, with all wastewaters being transported offsite by permitted waste collector to wastewater treatment plants.

Pathways: Runoff, drains.

Receptors: Local streams and the Altderg, Oweninny and Keerglen Rivers downstream, and groundwater.

Pre-mitigation Potential Effects: Indirect, negative, imperceptible, long-term, reversible, and unlikely.

Mitigation Measures by Avoidance: Wastewater will not be treated or disposed of onsite.

Mitigation Measures by Design: The proposed wastewater storage tanks will be fitted with an automated alarm system that will provide sufficient notice that the tanks require emptying. Full details of the proposed tank alarm system will be submitted to the Planning Authority in advance of any works commencing on-site. Only waste collectors holding valid waste collection permits under the Waste Management (Collection Permit) Regulations, 2007 (as amended), will be employed to transport wastewater away from the site.

Residual Effects: Use of sealed storage tanks and offsite disposal breaks the link between the source and potential receptors. Hence, residual effects will be indirect, neutral, imperceptible, long-term, and unlikely.

Significance of Effects: For the reasons outlined above, likely significant effects on surface water or groundwater quality from wastewater management will not occur.

9.4.3.7 WFD Water Body Status

During the operational phase, maintenance works can affect water quality but risks of effects are much reduced compared to the construction phase.

During the operational phase, the functional drainage management system and all necessary mitigation measures are in place to limit the entry of potential pollutants to streams, especially sediment and suspended and dissolved organic matter.

In the context of WFD status, all of the water quality parameters which can affect the biological quality elements of streams are addressed by the proposed mitigation measures. Maintenance works will be subject to strict maintenance protocols and procedures to avoid sediment mobilisation and potential siltation of streams. Other parameters like pH and ammonia, which can be influenced by drainage from peat, will undergo attenuation in the downstream direction by a) mixing/dilution with the greenfield runoff, b) further mixing/dilution in the streams, and c) in-stream transformation mechanisms (e.g. nitrification) that will take place in the downstream direction.

It is worth noting that 'High' and/or 'Good' status have been maintained in streams that exit Glenora Forest over three successive river basin management cycles. This means that existing forestry operations and land uses in and around Glenora Forest have not affected WFD status objectives to date. A possible exception is the Keerglen River, which was at 'High status from 2007 through 2015, but deteriorated to 'Moderate' in the period 2016-2021. The water quality of the Keerglen River is currently meeting the status classification thresholds used by EPA for at least Good status, but 'Fish' status is 'Moderate'. The precise cause for this is, as yet not known.

A monitoring programme will be implemented as described in Section 9.3.14.

Pathway: Runoff, drains

Receptor: Local streams and the Altderg, Oweninny and Keerglen Rivers downstream

Pre-Mitigation Potential Effects: Without mitigation potential effects are indirect, negative, slight, long-term, and of low probability.

Mitigation Measures by Design: During the operational phase, potential effects will be mitigated by implementation of measures specified in the CEMP which overs visual checks, de-silting of settling ponds with proposed offsite disposal and maintaining the physical integrity and functioning of the drainage system.

Monitoring: Streams will be monitored as described in Section 9.3.13.

Residual Effects: Mitigation measures are in place to address identified risks, and residual effects will be indirect, negative, not significant, long-term, and unlikely.

Significance of Effects: For the reasons outlined above, and with the extensive mitigation and monitoring measures that are proposed, no likely significant effects on WFD status of surface water and groundwater bodies are expected to occur during the operational phase.

9.4.3.8 Designated Sites/Protected Areas

Operational activities of the Proposed Development can affect the water quality and morphology of hydrologically linked streams and rivers. Risks are mainly associated with maintenance works, including drainage management and accidental spills of fuel.

Potential effects of the Proposed Development on each designated site and protected area that was considered further and assessed in **Table 9-16** for the operational phase. The mitigation measures presented in Section 9.4.3 will serve to protect and mitigate against the identified potential effects. For the reasons described in **Table 9-16**, likely significant effects on the named designated sites/protected areas will not occur during the operational phase.

Table 9-16 Assessment of Likely Significant Effects on Designates Sites and Protected Areas During Operations

Designated Site/Protected Area	Direct/Indirect Connection to Proposed Development	Description	Assessment of Likely Significant Effects
Bellacorick Bog Complex SAC	Indirect – Proposed Development is located upstream of, and entirely outside, the SAC.	There is potential for water pollution of the Oweninny River downslope from the Wind Farm Site during maintenance works of roads, drains and settlement ponds. This is a periodic activity and is always temporary in nature. Importantly, there are no pathways that link the Proposed Development with any habitats within the SAC. The habitats within the SAC boundaries are dependent on the hydrological and hydrogeological conditions within the SAC. Hence, there will be no effects of the Proposed Development on the qualifying interests of SAC. Mitigation measures described in Sections 9.4.3.1 and 9.4.3.3 through 9.4.3.6 will serve to mitigate potential effects. The Altderg River is a headwater subcatchment of the Oweninny River, Other proposed and existing wind farms are situated within other subcatchments of the Oweninny River. Potential cumulative effects are presented in Section 9.4.5.	Without Mitigation: Indirect, negative, not significant, long-term, and unlikely (high probability). With Mitigation: Indirect, negative, imperceptible, long-term, and unlikely (high probability).
Killala Bay/Moy Estuary SAC	Indirect – grid connection route and grid connection point at Tawnaghmore are upstream of the SAC.	There is potential for water pollution and sediment mobilisation during maintenance works, mainly related to trenching and backfilling activity. This is not regular and is always temporary in nature. Mitigation measures described in Sections 9.4.3.1 and 9.4.3.3 through 9.4.3.6 will serve to mitigate potential effects.	Without Mitigation: Indirect, negative, not significant, long-term, and unlikely (high probability). With Mitigation: Indirect, negative, imperceptible, long-term, and unlikely (high probability).
Special Protected Area (SPA)			
Killala Bay/Moy Estuary SPA	Indirect – grid connection route and grid connection point at Tawnaghmore	See above (SAC description).	Without Mitigation: Indirect, negative, not significant, long-term, and unlikely (high probability). With Mitigation: Indirect, negative, imperceptible, long-term, and unlikely (high probability).

Designated Site/Protected Area	Direct/Indirect Connection to Proposed Development	Description	Assessment of Likely Significant Effects
	are upstream of the SAC.		
National Heritage Area (NHA)			
Inagh Bog NHA	Indirect – Proposed Development is located sidegradient and downgradient of the NHA	Dust effects will not occur. Drainage effects are not expected to extend into the NHA as the NHA is situated across a topographic divide and the Wind Farm Site is characterised by high and frequent rainfall conditions. Mitigation measures described in Sections 9.4.3.1 through 9.4.3.6 will be relied on to mitigate potential effects.	Without Mitigation: Indirect, negative, not significant, long-term, and unlikely. With Mitigation: Indirect, negative, imperceptible, long-term, and unlikely.
Proposed National Heritage Area (pNHA)			
Bellacorick Bog Complex	See above (SAC description).		
Killala Bay/Moy	See above (SAC description).		

9.4.4 Decommissioning Phase - Likely Significant Effects and Mitigation Measures

The potential effects associated with decommissioning of the Proposed Development will be similar to those associated with construction but of a reduced magnitude.

Decommissioning works are described in Chapter 4 of this EIAR. During decommissioning, it will be possible to reverse or reduce any of the potential effects caused during construction, and to a lesser extent operations, by rehabilitating constructed areas such as turbine bases and hardstanding. This will be done by re-establishing vegetation, thereby reducing runoff and sediment loads.

Roadways will be kept and maintained following decommissioning of the proposed infrastructure, as these will be used by ongoing forestry works and for recreational purposes.

The electrical cabling connecting the proposed wind turbines to the intended on-site substation will be removed, while ducting will remain in-situ rather than excavating and removing it, as this is considered to have less of a potential environmental effect, in terms of soil disturbance, and thus on the possibility of the generation of suspended sediment.

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 offsite along their original delivery route. The disassembly and removal of the turbines will not have an effect on the hydrological/hydrogeological environment at the Wind Farm Site.

Other effects 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 effects will be avoided by leaving elements of the Proposed Development in place where appropriate. 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. With these measures, no significant effects on the hydrological and hydrogeological environment will occur during the decommissioning stage of the Proposed Development.

Table 9-17 Assessment of Likely Significant Effects on Designates Sites and Protected Areas During Decommissioning

Designated Site/Protected Area	Direct/Indirect Connection to Proposed Development	Description	Assessment of Likely Significant Effects
Bellacorick Bog Complex SAC	Indirect – Proposed Development is located upstream of, and entirely outside, the SAC.	There is potential for water pollution of the Oweninny River downslope from the Wind Farm Site during decommissioning works which is a short-term activity. Importantly, there are no pathways that link the Proposed Development with any habitats within the SAC. The habitats within the SAC boundaries are dependent on the hydrological and hydrogeological conditions within the SAC. Hence, there will be no effects of the Proposed Development on the qualifying interests of SAC. Mitigation measures described in Sections 9.4.2.1 through 9.4.2.10 will serve to mitigate potential effects. The Altderg River is a headwater subcatchment of the Oweninny River, Other proposed and existing wind farms are situated within other subcatchments of the Oweninny River. Potential cumulative effects are presented in Section 9.4.5.	Without Mitigation: Indirect, negative, not significant, short-term, and unlikely (high probability). With Mitigation: Indirect, negative, imperceptible, short-term, and unlikely (high probability).
Killala Bay/Moy Estuary SAC	Indirect – grid connection route and grid connection point at Tawnaghmore are upstream of the SAC.	There is potential for water pollution and sediment mobilisation during decommissioning works which is a short-term activity. Ducting will be left in ground rather than digging up, which reduces the scale of earthworks. Mitigation measures described in Sections 9.4.2.1 through 9.4.2.10 will serve to mitigate potential effects.	Without Mitigation: Indirect, negative, not significant, short-term, and unlikely (high probability). With Mitigation: Indirect, negative, imperceptible, short-term, and unlikely (high probability).
Special Protected Area (SPA)			
Killala Bay/Moy Estuary SPA	Indirect – grid connection route and grid connection point at Tawnaghmore are upstream of the SAC.	See above (SAC description).	Without Mitigation: Indirect, negative, not significant, short-term, and unlikely (high probability). With Mitigation: indirect, negative, imperceptible, short-term, and unlikely (high probability).

Designated Site/Protected Area	Direct/Indirect Connection to Proposed Development	Description	Assessment of Likely Significant Effects
National Heritage Area (NHA)			
Inagh Bog NHA	Indirect – Proposed Development is located sidegradient and downgradient of the NHA	Dust effects will not occur.	Without Mitigation: Indirect, negative, not significant, short-term, and unlikely. With Mitigation: indirect, negative, imperceptible, short-term, and unlikely.
Proposed National Heritage Area (pNHA)			
Bellacorick Bog Complex	See above (SAC description).		
Killala Bay/Moy	See above (SAC description).		

9.4.5 Cumulative Effects

The Proposed Development was considered in combination with other plans and projects in the area that could result in cumulative impacts on the identified receptor water bodies and designated sites/ protected areas. The plans and projects considered were those listed in Chapter 2 of this EIAR, which include existing forestry operations within the Wind Farm Site and wind farm developments within 20 km of the Wind Farm Site, as presented in **Figure 2-3** (see Chapter 2). The latter incorporates:

- Bellacorick wind farm (21 no. turbines) – existing wind farm.
- Oweninny Phase 1 (29 no. turbines) – existing wind farm.
- Oweninny Phase 2 (32 no. turbines) – existing wind farm.
- Oweninny Phase 3 (18 no. turbines) – proposed wind farm.
- Killala Community wind farm (6 no. turbines) – existing wind farm.
- Dooleg More wind farm (1 no turbine) – consented wind farm.
- Kilsallagh wind farm (13 no. turbines) – proposed wind farm.
- Sheskin South (21 no. turbines) – proposed wind farm.
- ABO Sheskin (8 no. turbines) – consented wind farm.

There is, additionally, a plan for the establishment of a hydrogen plant just northeast of the Bellacorick substation.

With the exception of the Killala Community wind farm, the listed wind farms are either in separate subcatchments from the Proposed Development or are downslope of the Proposed Development. As such, they will not interact with or influence the hydrological or hydrogeological conditions within the redline boundaries of the Proposed Development. The same is true for the proposed hydrogen plant near Bellacorick, which adjoins the Owenmore River and is approximately 15 km south and downslope of the Wind Farm Site.

The Proposed Development has, in combination with the other wind farm developments in the subcatchments of the Oweninny and Owenmore Rivers, the potential to affect the water quality (and biological conditions) of said rivers. To date, there has been no discernible or identified effects from the existing wind farms, as evidenced by the 'High' ecological status classification referred to in Section 9.3.10. With mitigation measures, the likely significant residual cumulative effects on the same rivers are considered indirect, negative, not significant, long-term, and unlikely.

With regard to the existing Killala Community wind farm, this is situated within the same subcatchment of the Moyne River ('Moyne_010' river water body) that encompasses the Tawnaghmore grid connection point. The trenching associated with the Proposed Development will pass approximately 300 m south of Killala Community wind farm. There are no expected cumulative effects of the Proposed Development in combination with the Killala Community wind farm. For the grid connection, mitigation measures will be implemented as outlined in Sections 9.4.2.2 and 9.4.3.1. Construction of the Tawnaghmore grid connection will be planned and coordinated such as not to interfere with the Killala Community wind farm operations.

With regard to existing forestry operations, these are subject to best management practices and licence conditions. Future forestry operations have the potential to influence water quality and biological conditions of local streams, as a result of sediment mobilisation and transport, and re-sedimentation, and from fertiliser and pesticide applications. Effects can be both direct and indirect. The integration of the drainage management systems and the addition of both check dams and settlement ponds, along with diffuse discharges at greenfield runoff rates, will serve to reduce or mitigate risks of water quality effects.

With the implementation of mitigation measures and best practice methods on the part of both the Proposed Development and forestry operators, risks of effects are reduced and potential cumulative effects can be monitored, managed and mitigated. As such, the likely significant residual cumulative effects are considered both direct and indirect, negative, not significant, long-term, and unlikely.