10.0 HYDROGEOLOGY

10.1 INTRODUCTION

This chapter assesses the potential impact the proposed development of Oweninny Wind Farm Phase 3 and associated works may have on the hydrogeology in the area. The proposed development site is located on Bord na Móna lands at Bellacorick, in North County Mayo, just north of the N59 national road. Details of the existing site conditions are presented, potential effects are assessed, and mitigation measures that will be implemented.

10.1.1 Statement of authority

This chapter has been completed by TOBIN Consulting Engineers. TOBIN Hydrologists and Hydrogeologists are intimately familiar with the site characteristics for the Oweninny Wind Farm, having worked on wind farms at Lisheen, Derryadd, Ummeras and Bruckana set in similar ground conditions and water environment.

This chapter has been completed by Mr. John Dillon (BSc, MSc, MCIWM, PGeo), TOBIN Consulting Engineers. John has 18 years of experience in hydrogeological/hydrological assessment for EIA. John has 18 years of experience in hydrogeological/hydrological assessment for EIA. John also has experience in the hydrogeological/hydrological assessment and supervision of powerline projects including Curragh wind farm, Castlebanny wind farm, Lisheen Phase III wind farm , Derryadd wind farm, Ummeras wind farm, Cloon – Lanesboro 110kv uprate, Moy Bellacorrick 110kV uprate, Moneypoint substation and Laois Kilkenny 400/110 kV substation.

10.2 METHODOLOGY

The methodology used to produce this chapter included a review of relevant legislation and guidance, a desktop study, a site walkover, an intrusive investigation, an evaluation of potential effects, an evaluation of significance of the effects, and an identification of measures to avoid and mitigate effects.

The desktop assessment of the soils and geology included the following resources:

- Publicly available data from the Department of Communications, Energy and Natural Resources; (accessed July 2022 and January 2023);
- 1992 Bellacorick wind farm application (Bord na Mona) – Planning references P90/1077 P92/355;
- 2013 Oweninny Wind Farm Application (Oweninny Power Ltd) Planning reference PA0029;

- EPA Environmental Data Maps (https://gis.epa.ie/EPAMaps/)(accessed July 2022 and January 2023);
- GeoHive online data maps (http://map.geohive.ie/)(accessed July 2022 and January 2023);
- The Geological Survey of Ireland (GSI) website (www.gsi.ie) (accessed July 2022 and January 2023);
- The GSI 1:100,000 Sheet No. 6 Geology of North Mayo;
- Irish Water – Water Supply Zone mapviewer (www.water.ie) (accessed July 2022 and January 2023);
- EPA/WFD Water Environment Maps (www.catchments.ie/maps) (accessed July 2022 and January 2023);
- Waste and IPPC licensed facility data from EPA Geoportal(accessed July 2022 and January 2023); and
- Aerial Photography from ESRI (ArcGIS) (accessed July 2022 and January 2023).

Guidelines and legislation used in the preparation of the report include the following:

- EPA document 'Guidelines on Information to be contained in Environmental Impact Statements' (2022)[1];
- DECLG (2018) Guidelines for Planning Authorities and An Bord Pleanála on Carrying out Environmental Impact Assessment', published by the Department of the Environment, Community and Local Government (DECLG)
- Institute of Geologists of Ireland (IGI) publication 'Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements' (2013)[2];
- Department of Housing, Planning and Local Government Wind Energy Development Guidelines (2006);
- Groundwater Directives (80/68/EEC) and (2006/118/EC);
- Peat Landslide Hazard and Risk Assessments, Best Practice Guide for Proposed Electricity Generation Developments - Second Edition (Natural Scotland Scottish Executive, 2017); and
- Review of Wind Energy Development Guidelines "Preferred Draft Approach" (Department of Housing, Planning, Community and Local Government, 2017).
- SEPA (2016) Life Extension And Decommissioning Of Onshore Windfarms

Mitigation measures are proposed, where required, to ensure that any proposed activities at the site will not adversely impact upon the geological and water environment outside of the site boundary.

The assessment examined the likely significant effects of the Proposed Project on the different elements of the hydrogeological environment.

- Water supply wells and natural springs. - Quality and Yield;
- Groundwater dependant terrestrial ecosystems - SAC / NHA wetland sites; and
- The dominant hydrogeological characteristics (aquifer classification) of the underlying strata.

[1])
[2] http://www.igi.ie/news/updated-eis-guidelines.htm

The significance of the effect is a consideration of the importance of the receptor (attribute) being effected and the degree or level of the effect. Both direct and indirect impacts are assessed.

Criteria for evaluating impact level are shown in Table 10-1. Terminology for impact significance and duration follows those set out in the EPA's Guidelines (2022).

Table 10-1: Significance of Effects

Significance/Sensitivity	Examples
Very High	Geological feature rare on a regional or national scale (NHA) Large existing quarry or pit Proven economically extractable mineral resource Groundwater which supports river, wetland or surface water body ecosystem protected by EU legislation e.g., SAC or SPA status
High	Contaminated soil on-site with previous heavy industrial usage Large recent landfill site for mixed wastes Geological feature of high value on a local scale (County Geological Site) Moderately sized existing quarry or pit Regionally Important Aquifer with multiple wellfields Groundwater which supports river, wetland or surface water body ecosystem protected by national legislation – NHA status Regionally important potable water source supplying >2,500 homes Inner source protection area for regionally important water source
Moderate	Contaminated soil on-site with previous light industrial usage Small recent landfill site for mixed wastes Small existing quarry or pit sub-economic extractable mineral resource Regionally Important Aquifer Groundwater which 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 Locally Important Aquifer Potable water source supplying >50 homes Outer source protection area for locally important water source
Low	Large historical and / or recent site for construction and demolition wastes Small historical and / or recent landfill site for construction and demolition wastes

The magnitude of any effects considers the likely scale of the predicted change to the baseline conditions resulting from the predicted effect and takes into account the duration of the effect, i.e., temporary or permanent. Definitions of the magnitude of any effects are provided in Table 10-2.

Table 10-2: Magnitude of Effects

Magnitude	Criteria	Examples
Very High / High adverse	An impact, which obliterates sensitive characteristics of the soil or geology environment	Loss of high proportion of future quarry or pit reserves Removal of entirety of geological heritage feature Requirement to excavate / remediate entire waste site Removal of large proportion of aquifer Changes to aquifer or unsaturated zone resulting in extensive change to existing water supply springs and wells, river baseflow or ecosystems Potential high risk of pollution to groundwater from

Magnitude	Criteria	Examples
		routine run-off Calculated risk of serious pollution incident >2% annually
Moderate adverse	Fundamental change to ground conditions, groundwater quality or flow regime	Loss of moderate proportion of future quarry or pit reserves Removal of part of geological heritage feature Requirement to excavate / remediate significant proportion of waste site Removal of moderate proportion of aquifer Changes to aquifer or unsaturated zone resulting in moderate change to existing water supply springs and wells, river baseflow or ecosystems Potential medium risk of pollution to groundwater from routine run-off Calculated risk of serious pollution incident >1% annually
Low adverse	Measurable change to ground conditions, groundwater quality or flow regime	Loss of small proportion of future quarry or pit reserves Removal of small part of geological heritage feature Removal of small proportion of aquifer Changes to aquifer or unsaturated zone resulting in slight change to water supply springs and wells, river baseflow or ecosystems Potential low risk of pollution to groundwater from routine run-off Calculated risk of serious pollution incident >0.5% annually
Negligible	No measurable effects on ground conditions, groundwater quality or flow	No measurable changes in attributes
Low Beneficial	Minor change to ground conditions, groundwater quality or flow regime	Slight enhancement of geological heritage feature.
Moderate Beneficial	Measurable change to ground conditions, groundwater quality or flow regime	Moderate enhancement of geological heritage feature
High Beneficial	Fundamental change to ground conditions, groundwater quality or flow regime	Major enhancement of geological heritage feature

Source: Examples based on NRAs Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes

Effect ratings may have negative, neutral, or positive application where:

- Positive impact – A change which improves the quality of the environment;
- Neutral impact – A change which does not affect the quality of the environment; and
- Negative impact – A change which reduces the quality of the environment.

Terms relating to the duration of effects are as described in the EPA's Guidelines on the Information to be contained in Environmental Impact Statements (2022) as:

- Momentary Effects – Effects lasting from seconds to minutes;
- Brief Effects – Effects lasting less than a day;
- Temporary Effects - lasting one year or less;
- Short term Effects - lasting one to seven years;
- Medium term Effects - lasting seven to fifteen years;
- Long term Effects - lasting fifteen to sixty years;

- Permanent Effects - lasting over sixty years; and
- Reversible Effects – Effects than can be undone, for example through remediation or restoration.

A degree of confidence is assigned to assess the likelihood of an impact occurring (integration of impact characteristics). The following likelihood scale (as defined within the NRA Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes (2009)) is referred to:

- Certain/Near Certain: >95% chance of occurring as predicted;
- Probable: 50-95% chance as occurring as predicted;
- Unlikely: 5-50% chance as occurring as predicted; and
- Extremely Unlikely: <5% chance as occurring as predicted.

Indirect – Indirect effects on the environment were assessed. Indirect effects which are not a direct result of the project, often produced away from the project site or because of a complex pathway. If the proposed development, existing or proposed projects or plans effect hydrogeology, there is potential to lead to cumulative impacts which could be of a higher level of significance.

Reversibility: An irreversible effect is one from which recovery is not possible within a reasonable timescale or there is no reasonable chance of action being taken to reverse it. A reversible effect is one from which spontaneous recovery is possible or which may be counteracted by mitigation.

A qualitative approach was used in the evaluation generally, following the significance classification in **Error! Reference source not found.** and through professional judgement. The significance of a predicted effect is based on a combination of the sensitivity or importance of the attribute and the predicted magnitude of any effect. Effects are identified as beneficial, adverse or negligible, temporary or permanent and their significance as major, moderate, slight or not significant (negligible) as shown in Table 10-3.

Table 10-3: Effects Matrix

Sensitivity	Magnitude			
	Very High	**High**	**Medium**	**Low**
Very High	Profound	Profound	Moderate	Low
High	Profound	Moderate	Moderate / Low	Moderate / Slight
Medium	Moderate	Moderate / Low	Moderate / Slight	Slight
Low	Moderate/Low	Slight	Slight	Negligible
Negligible	Slight	Slight	Negligible	Negligible

In order for a potential effect to be realised, three factors must be present. There must be a source or a potential effect, a receptor which can be adversely affected and a pathway or connection which allows the source to effect the receptor. Only when all three factors are present can an effect be realised.

10.2.1 Consultation

Consultation with various state agencies and environmental Non-Governmental Organisations (NGO's) was undertaken to inform the EIA. All project consultation is detailed in Chapter 1 of the EIAR and all responses received are summarised in Chapter 1 (Introduction) of this EIAR. Consultees were informed of updates to the site layout, as appropriate. Consultation letters were sent (as described in Chapter 1 (Introduction)) to the following key parties relevant to this chapter (see Table 10-4):

- Geological Survey Ireland; and
- Environmental Protection Agency.

Table 10-4: Response to Consultation specific to Hydrogeology

Department	Comments and Recommendations	EIAR Chapter/Section
Geological Survey Ireland	• Groundwater • Geotechnical Database Resources	• Ch15 Cultural Heritage • Ch9 Land, Soils & Geology • Ch10 Hydrogeology • Ch11 Hydrology
Environmental Protection Agency	No Response to date	No Response to date

10.3 RECEIVING ENVIRONMENT

The existing environment is discussed in terms of geomorphology (landscape and topography), superficial and solid geology, and hydrogeological conditions. The regional review of geological and hydrogeological conditions covers a zone of 2 km from the proposed development site, as suggested in the IGI guidelines.

10.3.1 Site Description

The proposed development site is located in North Mayo, west of Crossmolina and east of Bangor Erris, just north of the N59 road. Figure 10.1 below shows the site location with respect to the nearby towns and roads. The Phase 3 development will comprise a wind farm consisting of 18 wind turbines with an overall tip height of 200m , within an overall site area of 2282ha.

The installed turbines will have an individual installed capacity that will range from 4.5MW to 6.5MW. The proposed Oweninny Wind Farm Phase 3 ('the Project') will have a maximum export capacity of approximately 90MW wind energy (81MW to 117MW). Planning permission is sought for a period of 10 years, with an operational life of 30 years from the date of commissioning.

Phase 3 of the development will involve the construction of a 110 kV substation located approximately 0.5km north of Lough Dahybaun within the site bounds. The substation compound will occupy an area of 0.85ha. Two borrow pits are proposed at the site, Borrow Area 1 and Area 2.

Existing access tracks will be upgraded and new access tracks will also be constructed within the proposed site for Phase 3 of the development. Approximately 30km of access tracks are to be constructed/upgraded. These will provide access to necessary locations within the site e.g., wind turbines and substation. A full description of the Proposed Development is detailed in Chapter 3 Description of the development.

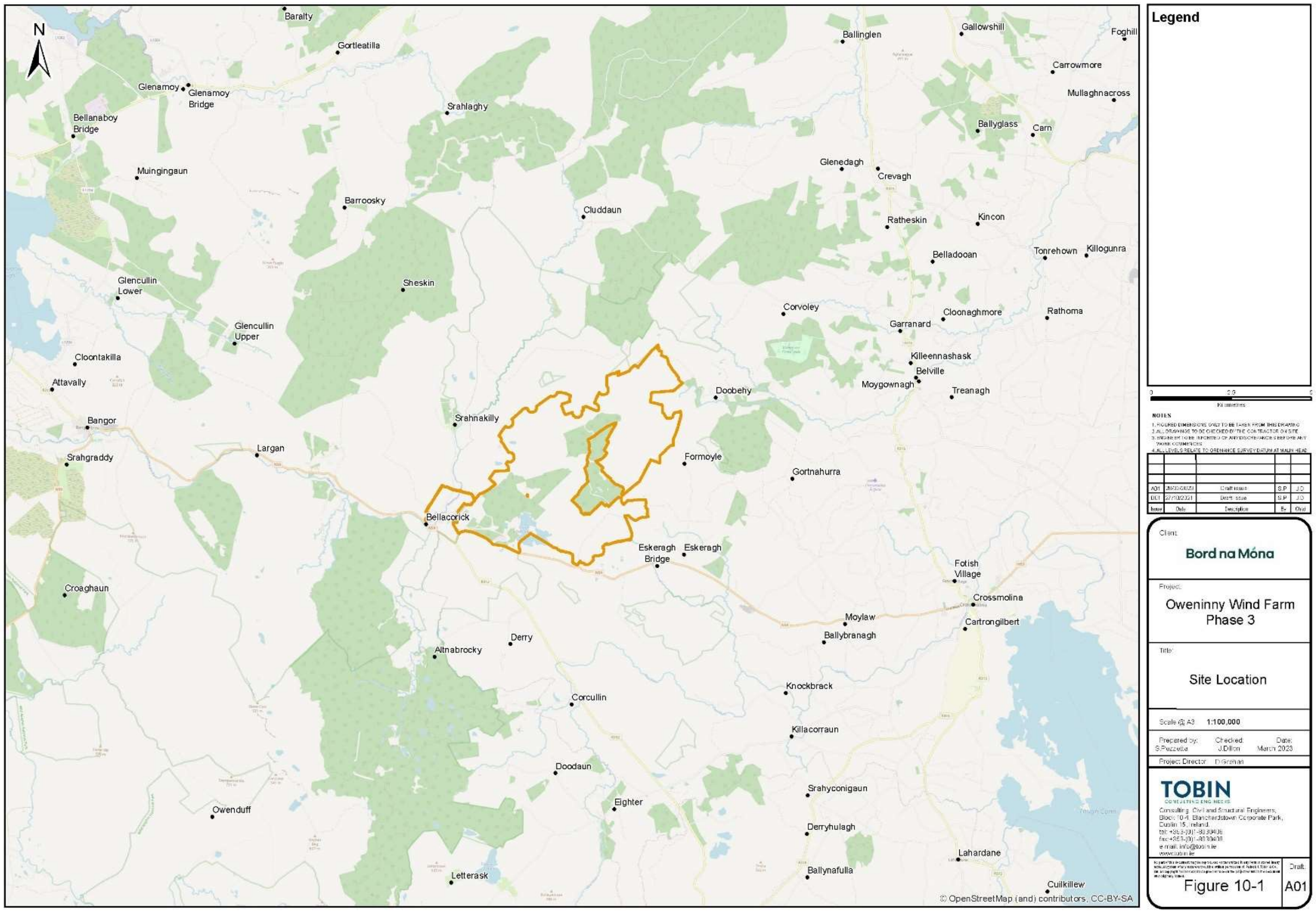

Figure 10.1 Site Location Map

10.3.2 Topography and Geomorphology

Information on the topography and geomorphology of the area has been obtained from publicly available data on the GeoHive, GSI and EPA websites. The area of the proposed development is defined by Quaternary features. A number of glacial depositions known as drumlins are identified across the site resulting in local variations in topography. The glacial deposits are in places associated with topographical elevation, but in general terms represent the haphazard deposition of soils in glacial and post-glacial environments.

The topographical elevations range from c.80 to 130 mAOD, with the majority of the site located on the lower and relatively flat-lying areas, currently overlain by blanket peat bog (see Figure 10.2).

Localised anthropogenic changes to the topography in the form areas of shallow excavation are also present due to the historic peat cutting in the area.

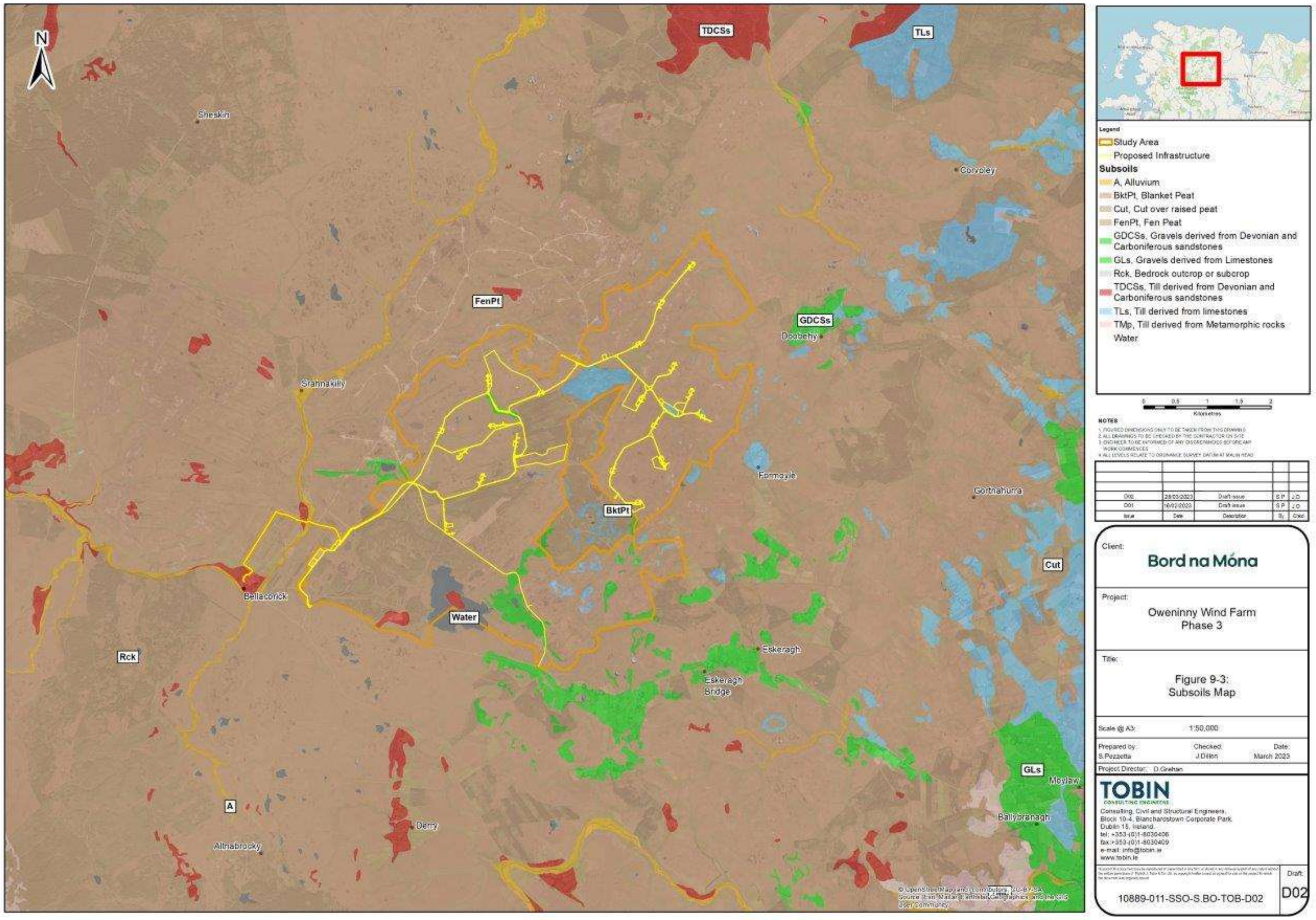

Figure 10.2 Subsoil Map

10.3.3 Land Use

The Bellacorick area occupies an important place in the development of Ireland's renewable energy industry. In 1992, Bord na Móna Energy Limited established Ireland's first commercial wind farm on the cutover blanket bog at Bellacorick. In the past, the main activity in the surrounding area was the harvesting of peat to supply the nearby power station at Bellacorick. The peat-burning power station at Bellacorick burned milled peat from the surrounding bogland from 1962 until it was decommissioned in 2004 (the cooling tower was demolished in 2007). A Peatland rehabilitation plan was completed between 2003 and 2007. An application for Leave for substitute consent for the historical peat extraction activity was submitted to An Bord Pleanala (ABP Ref -311862) on the 04/11/2021. No decision has been made on this application to date.

10.3.4 Bedrock Geology

Information on the bedrock geology was obtained from the Geology of North Mayo, Sheet No. 6 (1:100,000) and accompanying booklet published by the Geological Survey of Ireland (GSI).

The proposed site is underlain by the Downpatrick Formation which is comprised of Carboniferous cross-bedded sandstone and siltstone. The underlying bedrock geology is composed of a sequence of interbedded rock types comprising near shore marine mudstones and siltstones; alluvial and deltaic sandstones and siltstones; and fully marine bioclastic limestones interbedded with calcareous shales. Figure 10.3 below shows the underlying bedrock geology of the proposed site.

The geological mapping of the area does not show any faults beneath the sites, but faults are present to the east and west and these faults typically have a northeast southwest orientation.

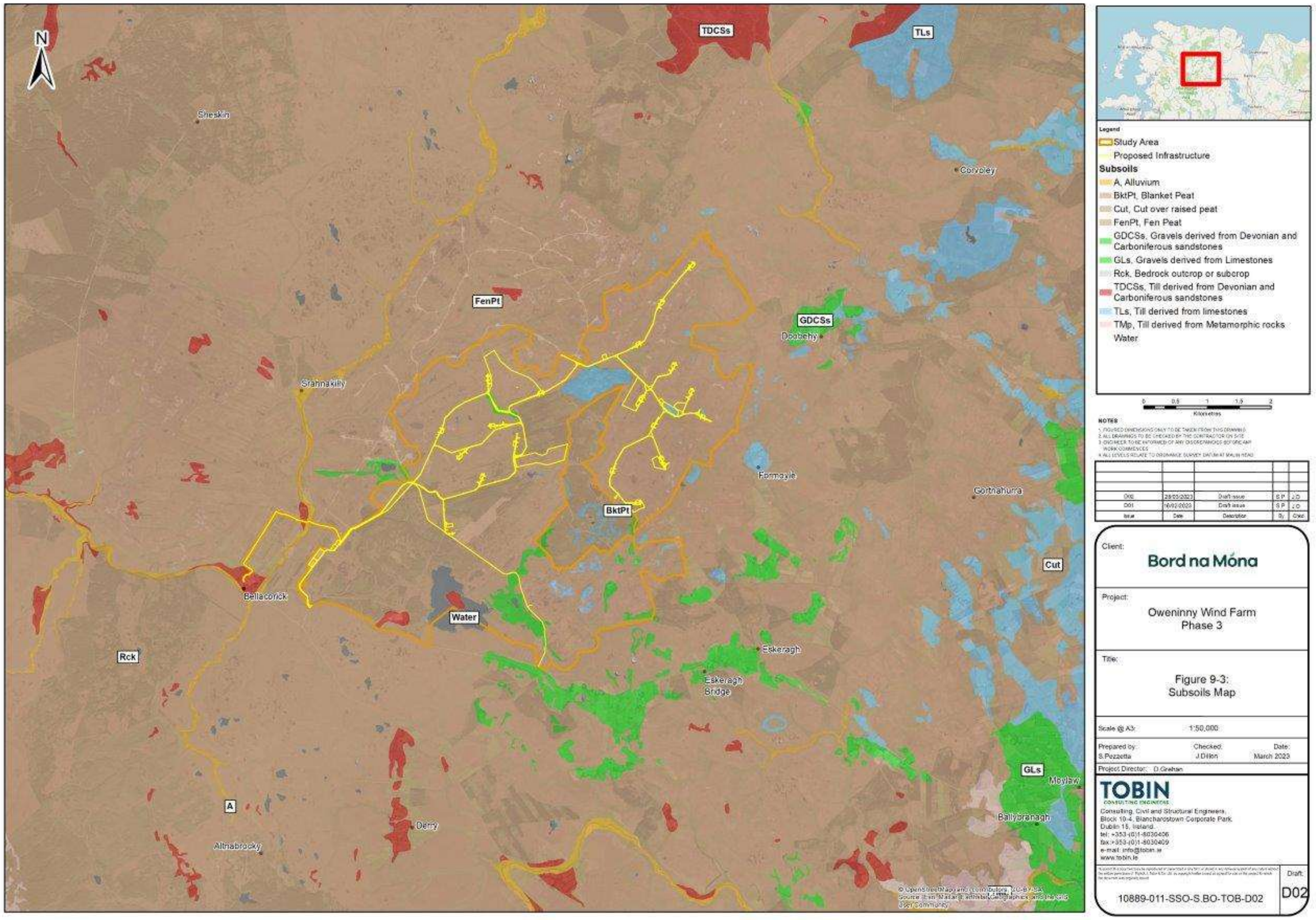

Figure 10.3: Underlying Bedrock Geology Map

The GSI database contain records of ground investigations carried out approximately 1 km west of the proposed site boundary, consisting of 16 no. boreholes at the site of the former Bellacorick Power Station.

Previous site investigation work in the area includes 3 no. boreholes within the boundaries of the proposed Phase 3 site. Relevant information extracted from these borehole logs is summarised in Table 10-5 below.

Table 10-5: Depth to bedrock from boreholes located within Phase 3 site boundary

Borehole ID	Depth to Bedrock
BH5 (NE of Site)	8.30 (Obstruction – Rock or boulder)
BH7	15.15m (Moderately strong SANDSTONE)
BH8 (SW of Site)	23.10m (Strong SANDSTONE w/ thin MUDSTONE)

The GSI Karst database was consulted for records of locations and types of reported karst features. There are no karst features located at the proposed wind farm site. No karst features were identified during the site visit.

10.3.5 Contaminated Land and Waste Facilities

An evaluation was undertaken to determine the presence and extent of potentially contaminated land in the study area. This evaluation is based on the identification of potential source pathways and receptors. As the site is predominently peatland, the potential for contamination is very low.

A review of the EPA website for existing and historic licensed and illegal waste activities, mines and industries was carried out to identify any potential contamination sources present in the area and to identify any potential contaminating activities near the proposed development.

The EPA/WFD online water maps contain a points dataset of the location of current Waste facilities (including licensed, applied, surrendered, rejected etc.). In 1996 the EPA began licensing certain activities in the waste sector. These include landfills, transfer stations, hazardous waste disposal and other significant waste disposal and recovery activities.

No waste facility licences or contaminated lands are recorded within the proposed site boundary.

10.3.1 EPA/GSI Source Protection Zones

As reported by the EPA and the GSI, groundwater sources, particularly public, group scheme and industrial supplies, are of critical importance in many regions. Consequently, the objective of Source Protection Zones is to provide protection by placing tighter controls on activities within all or part of the zone of contribution (ZOC) of the source.

According to the GSI/EPA Source Protection Zone Map (www.gsi.ie), there are no Source Protection Zones within the study area or in the surrounding region. Crossmolina Eskeragh Group Scheme source protection zone is c. 7 km south-east of the proposed site at Ballinlabaun (IE_WE_34A350930).

10.3.2 Groundwater Wells

The GSI maintain a groundwater database of wells drilled throughout Ireland. There are no groundwater wells within the footprint of the proposed development.

Five no. boreholes for water abstraction were identified within 1km of the proposed development. These are associated with the former Bellacorick Power Station, with 3 no. wells drilled in 1989 and 2 no. drilled in 1998. Only 1 no. well appears to have generated a 'Good' yield and was drilled to a depth of 160 m (GSI Well ID 0831SEW005). This well is identified as being for industrial use, with the use for the 4 no. unproductive wells being described as 'Other'.

10.3.3 Existing Groundwater Quality

The Water Framework Directive (WFD) (www.wfdireland.ie) describes the groundwater quality status of the proposed development in the area. A WFD assessment is included in Appendix 11.1.

The Muing River and Cloonaghmore River are of '*Good*' status. The Owenmore River has '*High*' status and the Shanvolahan River is at 'moderate' status in the 2016-2021 River Waterbody WFD Status . The River Waterbody Status results are recorded in accordance with European Communities (Water Policy) Regulations 2003 (SI no. 722/2003).The WFD status is based on an assessment of the point and diffuse sources in the area that may affect the groundwater quality. These classifications arise from an evaluation of the ecological health of Ireland's groundwaters against the standards and objectives set out in the EU Water Framework Directive The groundwater in this area was found to have been particularly at risk from Diffuse source pollution (DIF). Overall, the quality of the groundwater in the area can be described as being good.

10.3.4 Groundwater Bodies

The groundwater body (GWB) is the groundwater management unit under the WFD. Groundwater bodies are subdivisions of large geographical areas of aquifers so that they can be effectively managed in order to protect the groundwater and linked surface waters3. The GWB is defined as a distinct volume of groundwater, including recharge and discharge areas with little flow across the boundaries. The proposed development is underlain by the Belmullet GWB and the Bellacorrick-Killala GWB. The groundwater body descriptions are available from the GSI website4 and the 'status' is obtained from the WFD website5 and the EPA website6. The GWBs underlying the site are classified as being at 'Good' status as shown on Table 10-6. The Belmullet and Bellacorrick-Killala GWB is comprised of low transmissivity and storativity rocks, described as Poorly Productive bedrock as detailed in Table 10-6.

Table 10-6: Summary of groundwater bodies

EU_CD Code	Name	Description	GWB status (2016-2021)
IE_WE_G_0057	Belmullet	Poorly productive bedrock	Good
IE_WE_G_0041	Bellacorick-Killala	Poorly productive bedrock	Good

10.3.5 Aquifer Potential and Characteristics

The aquifer potential of a bedrock unit is determined by the groundwater productivity. The productivity is determined based on hydraulic characteristics compiled from borehole data throughout the county.

Reference to the GSI National Aquifer Map (www.gsi.ie) for the study area indicates that the underlying bedrock unit (Downpatrick Formation of Dinantian sandstones, shales and limestones) is classified as a 'Poor Aquifer – Bedrock which is Generally Unproductive except for Local Zones (PI)'. The underlying bedrock aquifer map for the development site is shown in Figure 10.4.

The subsoil deposits overlying the bedrock are not considered to be of sufficient lateral extent or depth to represent an aquifer body. However, the soils are comprised of high permeability sands and gravels. Summarised below in Table 10-7, are the aquifer characteristics of the underlying aquifer and surrounding aquifers.

[3] https://www.gsi.ie/en-ie/programmes-and-projects/groundwater/activities/understanding-ireland-groundwater/Pages/Groundwater-bodies.aspx
[4] www.gsi.ie
[5] www.wfdireland.ie
[6] www.epa.ie

Table 10-7: Underlying Bedrock Aquifer and Characteristics

Aquifer Classification	Permeability/Flow Mechanism	Bedrock	Karst Features
Poor Aquifer (PI)	Unproductive except for local zones	Underlies entire site of sandstone and siltstone bedrock	None

Given the poorly productive nature of the aquifer, groundwater flow is expected to be dominated by shallow flowpath (see Figure 10.5), As such, groundwater is expected to flow towards via the upper portion of the aquifer towards the most convenient receptor, the local surface water courses. s. Adjacent to the rivers, water levels will be closer to ground level.

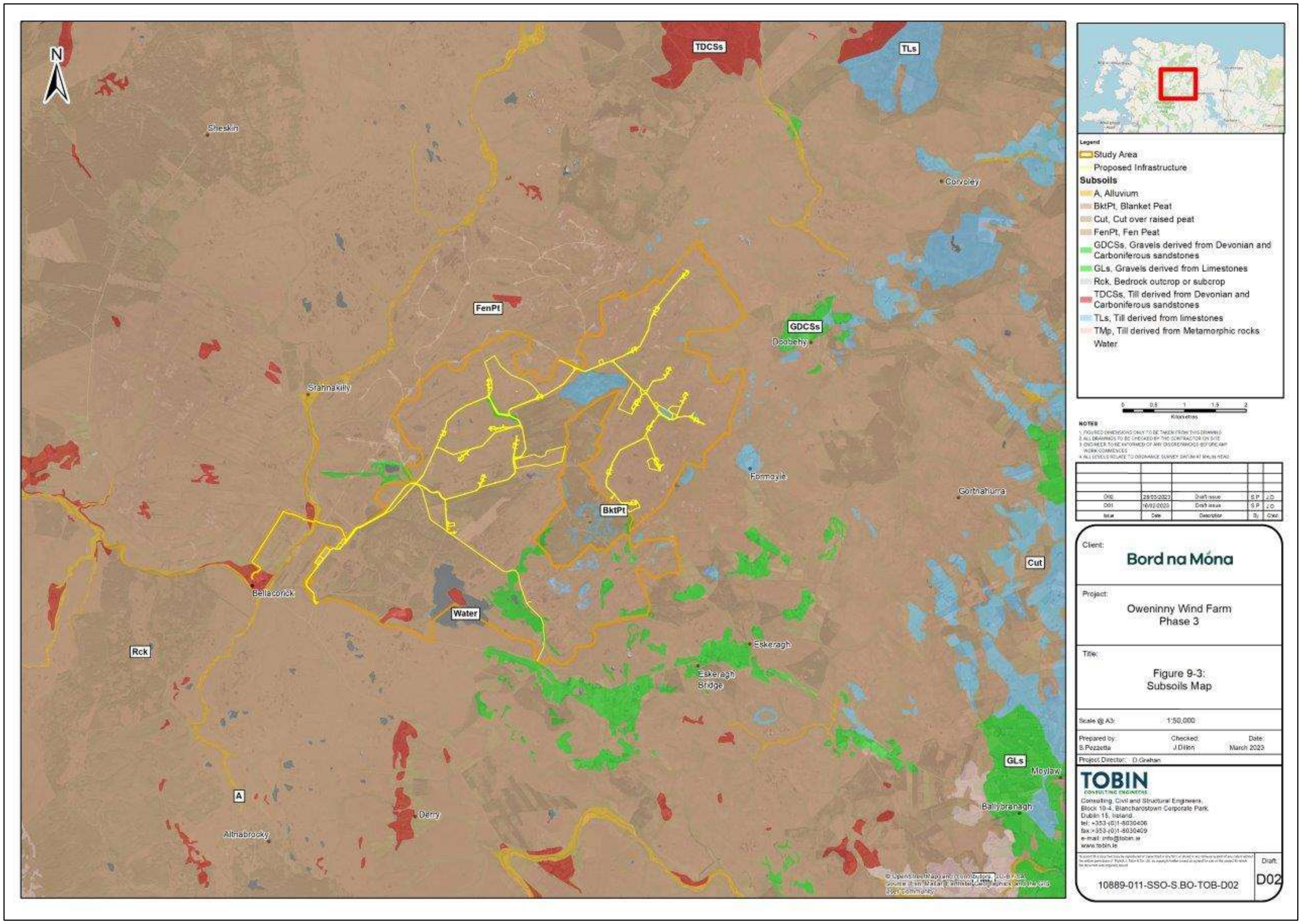

Figure 10.4: Aquifer Map

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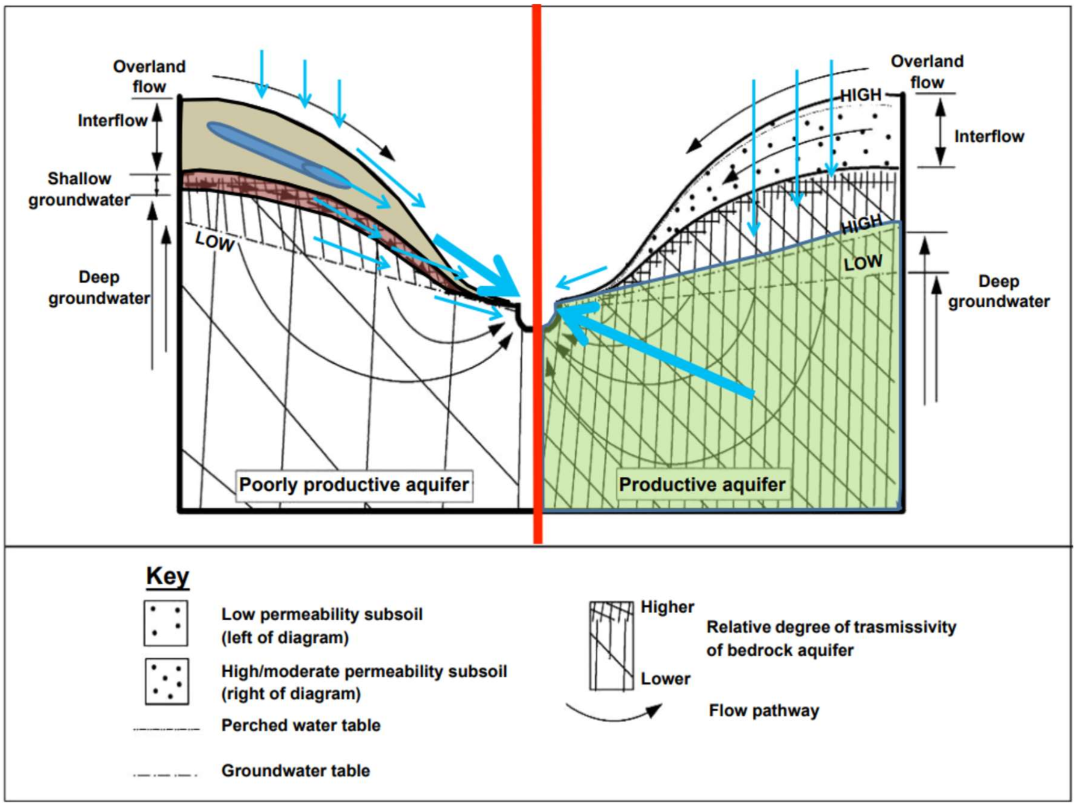

Figure 10.5 Dominant groundwater pathways in contrasting aquifer settings (original figure and concept by D. Daly and N. Hunter Williams, 2007, in RPS 2008)[7]

10.3.6 Groundwater Vulnerability

Groundwater vulnerability is dictated by the nature and thickness of the material overlying the uppermost groundwater 'target'. This means that vulnerability relates to the thickness of the unsaturated zone in the sand/gravel aquifer, and the permeability and thickness of the subsoil in areas where the sand/gravel aquifer is absent. A detailed description of the vulnerability categories can be found in the Groundwater Protection Schemes document (DELG/EPA/GSI, 1999[8]) and in the GSI Guidelines for Assessment and Mapping of Groundwater Vulnerability to Contamination (Fitzsimons *et al*, 2003[9]).

Groundwater vulnerability represents the intrinsic geological and hydrogeological characteristics that determine how easily groundwater may be contaminated by activities at the surface. Vulnerability depends on the quantity of contaminants that can reach the groundwater,

[7] RPS Consultants 2008 (Glasgow, G., Jennings, S.). Further Characterisation Study. An integrated approach to quantifying groundwater and surface water contributions of stream flow. RPS Report for Southwestern River Basin District for Further Characterisation

[8] DELG, EPA and GSI, 1999. Groundwater Protection Schemes. Department of Environment and Local Government, Environmental Protection Agency and Geological Survey of Ireland, Dublin, Ireland

[9] Fitzsimons, V., Daly, D. and Deakin, J., 2003. GSI Guidelines for Assessment and Mapping of Groundwater Vulnerability to Contamination. The Geological Survey of Ireland, Dublin, Ireland.

the time taken by water to infiltrate to the water table and the attenuating capacity of the geological deposits through which the water travels.

These factors are controlled by the types of subsoils that overlie the groundwater, the way in which the contaminants recharge the geological deposits (whether point or diffuse) and the unsaturated thickness of geological deposits from the point of contaminant discharge.

The groundwater vulnerability throughout the proposed site ranges from moderate vulnerability to high vulnerability. The groundwater vulnerability categories are listed in Table 10-8. The majority of the site consists of blanket peat subsoil which contributes to moderate groundwater vulnerability. Some areas within the site e.g., east of Lough Dahybaun are characterised by highly permeable glaciofluvial sand and gravels making up the subsoil which are overlain by poorly drained soil/ peat. These areas where peat overlays highly permeable sand and gravels results in high groundwater vulnerability.

The groundwater vulnerability map for the region is (Figure 10.6) dominated by 'Moderate' vulnerability in the study area, correlating with areas of blanket peat cover. However, areas where alluvial deposits are found along the Bellacorick River and areas where gravels derived from sandstones and limestone are located are described as having 'High' vulnerability. In addition, there are some lesser areas along the site boundaries that are described as having 'Low' groundwater vulnerability.

Based on previous permeability tests undertaken on the Oweninny site in 2013, the mineral subsoils in the area of the cSAC were found to have a moderate permeability (i.e., k value of between 10-6 to 10-7 m/s).

The variation in groundwater vulnerability throughout the Oweninny Phase 3 development site can be seen in Figure 10.6.

Table 10-8: Groundwater Vulnerability Categories

Sensitivity	Hydrogeological Conditions				
	Subsoil Permeability (Type) and Thickness			Unsaturated Zone	Karst Features
	High Permeability (Sand and Gravel)	Medium Permeability (Sandy Subsoil)	Low Permeability (Clayey Subsoil/ Peat)	Sand and Gravel aquifers only	<30 radius
Extreme (E)	0 – 3.0m	0 – 3.0m	0 – 3.0m	0 – 3.0m	-
High (H)	>3.0m	3.0 -10.0m	3.0 – 5.0m	> 3.0m	N/A
Moderate (M)	N/A	>10.0m	5.0-10.0m	N/A	N/A
Low (L)	N/A	N/A	>10m	N/A	N/A

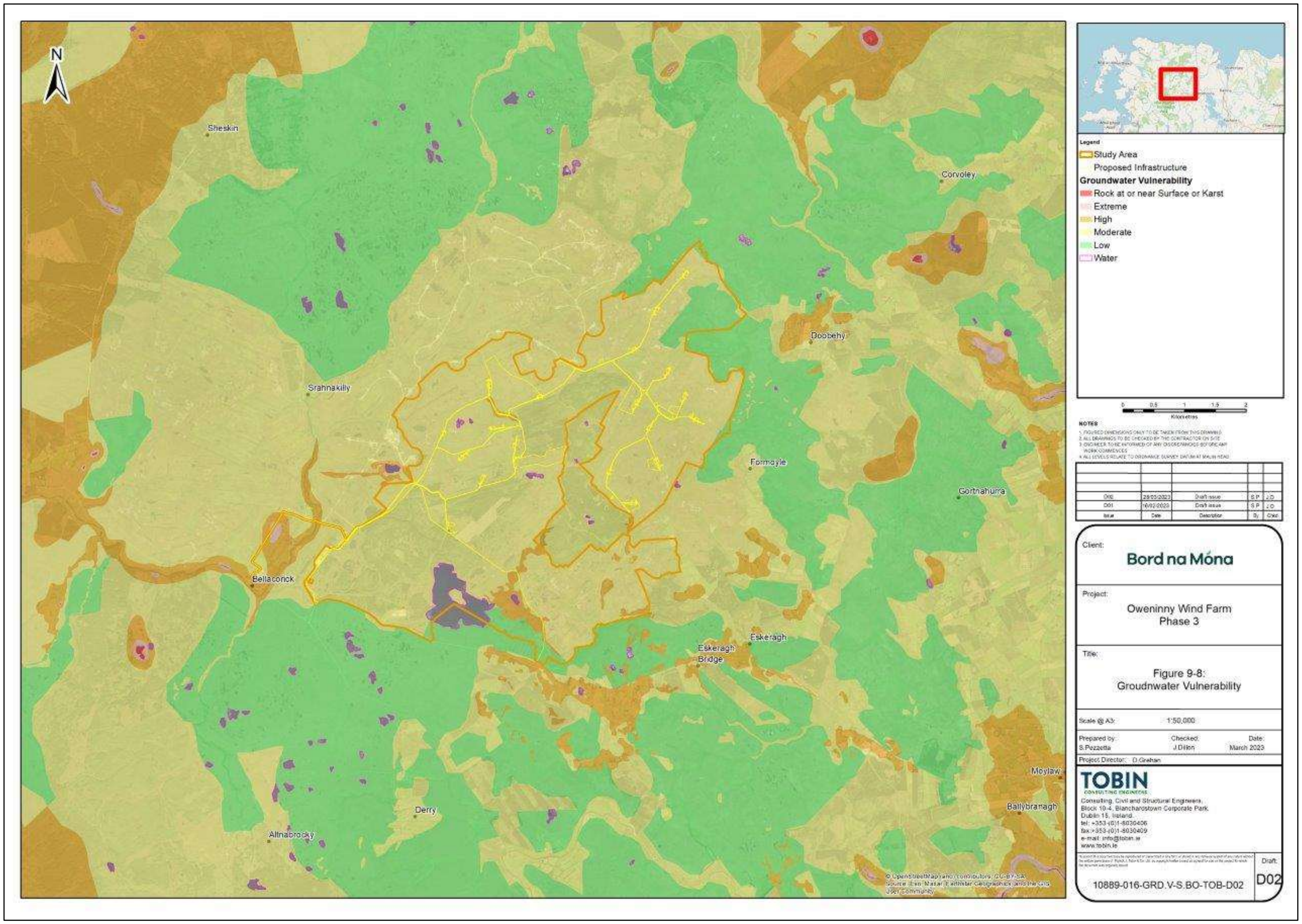

Figure 10.6: Groundwater Vulnerability Map

10.3.7 Groundwater Recharge

The hydrogeological setting for the majority of the site consists mainly of 'Moderately' vulnerable blanket peat. The average annual recharge for the site is limited and typically ranges from 41mm/yr to 48mm/yr. Certain areas within the proposed site that have higher vulnerability are the areas where highly permeable subsoils like sand and gravels are overlain by peat. An example of such an area is immediately east of Lough Dahybaun to the south of the site. This results in higher annual recharge rates in the region of 468mm/yr. With the exception of the amenity track, Lough Dahybaun and the associated gravels are located outside of the proposed development area. The proposed substation is located 500m from Lough Dahybaun however there is no hydrological connection to the lake.

The proposed development footprint for Oweninny Windfarm Phase 3 lies across the border of two hydrometric areas. To the west is the Blacksod-Broadhaven hydrometric area and the Moy and Killala Bay hydrometric area is located to the east. The proposed development is sited across two catchment areas, which correspond to the hydrometric areas mentioned above.

More locally, three sub catchments are located across the proposed development site. These are the Cloonaghmore_SC_010 sub catchment located to the northeast of the site. This sub catchment is in the area of the Moy and Killala Bay catchment. The west of the site lies within the Owenmore [Mayo]_SC_020 sub catchment which falls under the Blacksod-Broadhaven catchment. The southeast of the site is within the Deel [Crossmolina]_SC_010 sub catchment which is a part of the Moy and Killala Bay hydrometric area.

The WFD catchments and subcatchments are shown in Figure 10.7.

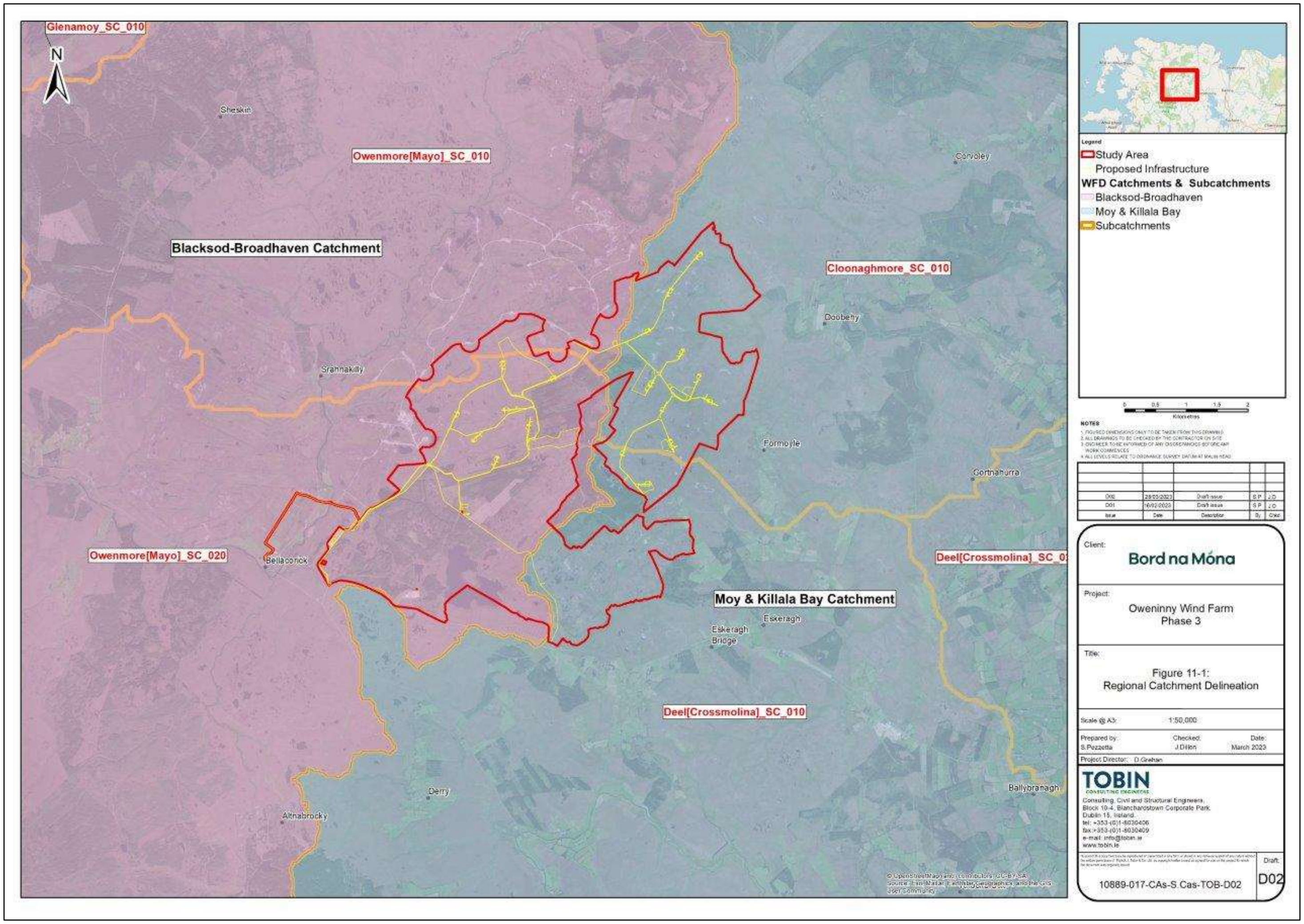

Figure 10.7 WFD Catchments and Subcatchments

10.3.8 Groundwater Usage

According to Mayo County Council and Irish Water data, no public water schemes (PWS) are present within a 2km radius of the site. Using the GSI database, there are no recorded wells within the proposed development study area. There are 5 no. recorded historic wells to the southwest of the site, associated with the Bellacorrick Power Station. For the purposes of the assessment, on a worst-case basis, all dwellings have been assumed to have a groundwater well 50m from the dwelling in the direction of the proposed development. According to the GSI, there are no domestic wells within 0.8 km of the turbines or borrow pits.

10.3.9 Groundwater Flow

It is assumed that groundwater flow would mirror topography, and local flows are likely to be varied reflecting the local drainage patterns. Across the majority of the site, it is assumed that the groundwater flow is towards local drains and streams, reflecting the general flow direction of the various catchments. Limited recharge and discharge are likely to occur due to the extensive peat deposits and deep subsoils.

Local groundwater flow discharges to the local streams and drainage ditches in the area.

10.3.9.1 Peatland groundwater levels

Groundwater within the site flows downgradient with discharge to local drainage as well as possibly through an open joint network in the underlying transition zone bedrock. Water table levels are a reliable measure of the hydrologic condition of peat soils. Water storage opportunity increases as the bog water table recedes from the surface and decreases as the water table rises. Model 601 Solonist Standpipe Piezometers were used to monitor groundwater levels on the site and cable route from August 2020 to Feb 2022. Piezometers were composed of a 3/4" diameter PVC body, which is perforated to expose the preformed Vyon (porous plastic) filter inside. The PVC tip connects to plain end 3/4" Sch. 40 PVC riser pipe with push-fit couplings. The pointed tip is pushed into the peat soils and recorded on a monthly basis. Groundwater levels were monitored at the proposed Borrow Pit Area 1, proposed substation location and at a remnant peatland to the south east of Temporary Construction Compound 3. Groundwater levels for the site are included in Table 10-9 below *and piezometer locations are shown on*

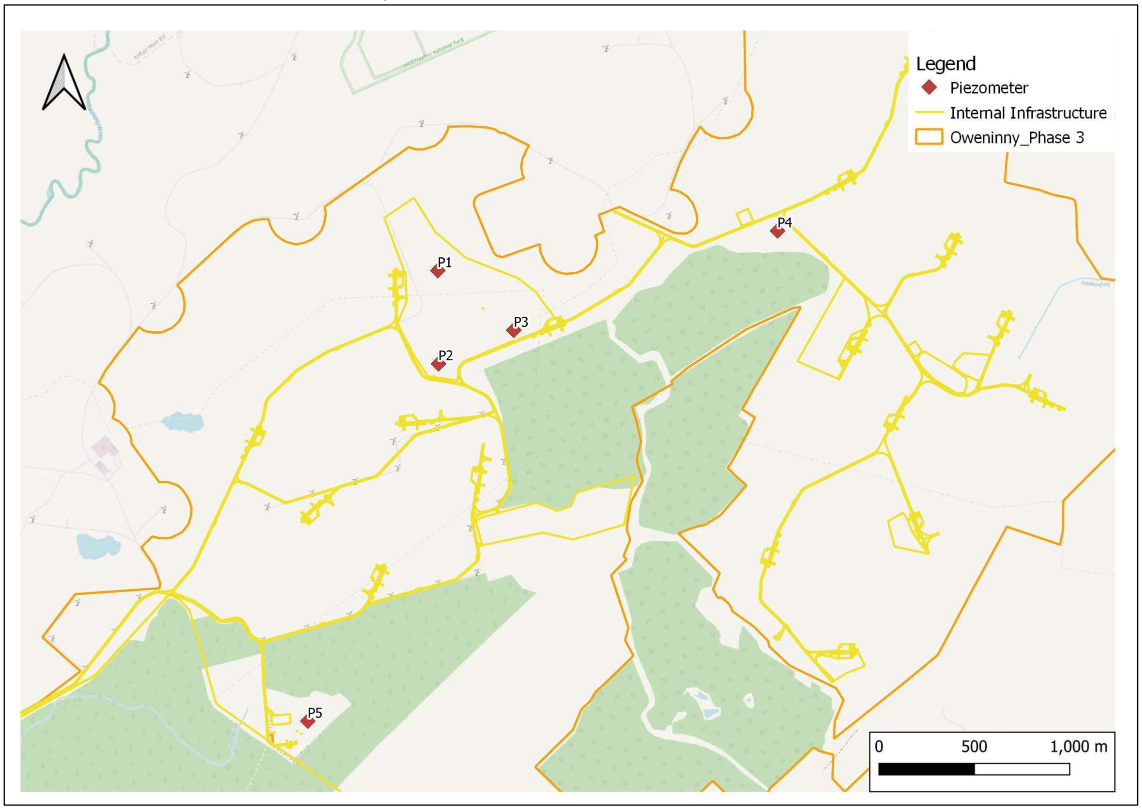

Figure 10.8.

Table 10-9: Shallow Groundwater levels

Piezometer	Ground level mOD	Nov '20 m bgl	August '21 m bgl	Feb 2023 m bgl
P1	94.6	0.19	0.41	0.2
P2	91.1	0.23	0.27	0.12
P3	94.5	0.31	0.55	0.13
P4	112.5	0.01	0.23	0.05
P5	94	0.1	0.29	0.1

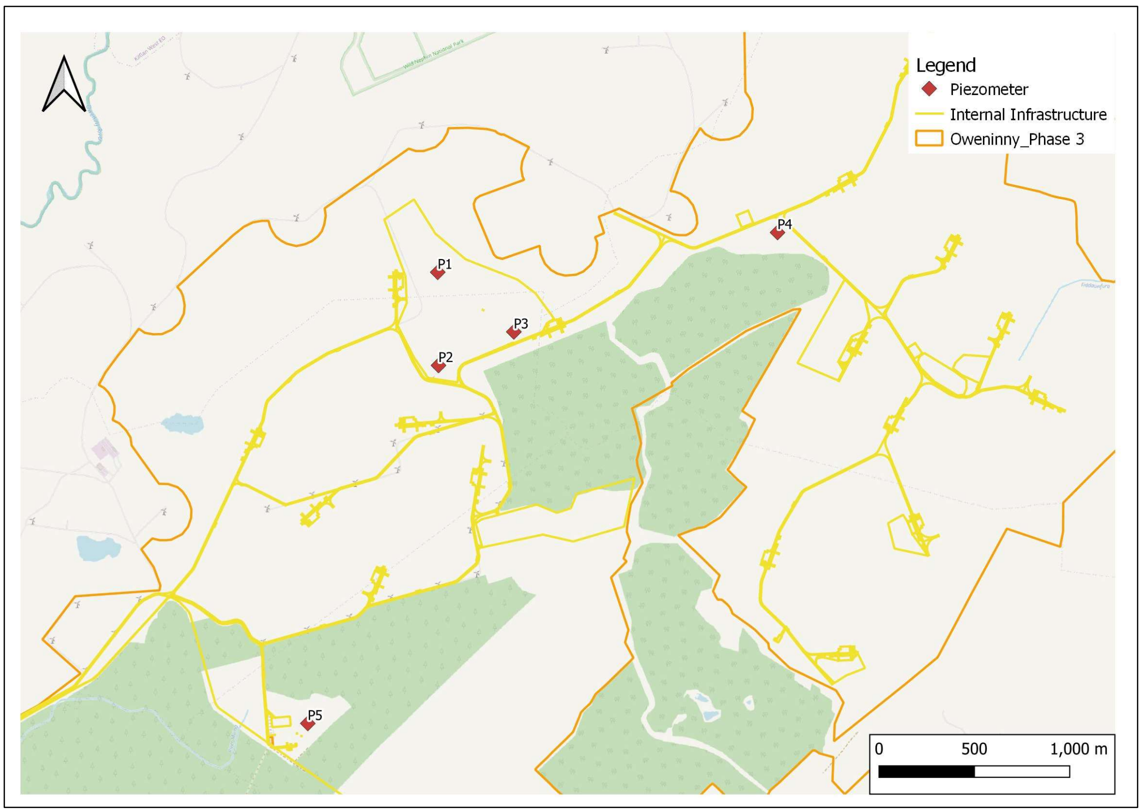

Figure 10.8 Piezometer locations

10.3.9.2 Hydrochemistry

Electrical conductivity values for surface water were between 50 and 100µS/cm. These values show that the source of water within the majority of the man-made drains and on the vegetated surface of the blanket peat is meteoric in origin (i.e., from precipitation). The exception to this is drain D4 which receives runoff from the flush area of the Bellacorick SAC and therefore showed an average electrical conductivity value of approximately 128µS/cm during the monitoring period (refer to Table 10-10).

Higher conductivity values (270 μS/cm) occur on the streams which discharge to Lough Dahybaun which reflect shallow water in contact with the mineral subsoils and discharges from the sand and gravel deposits.

The pH range was between 6.3 and 7.2 with the higher pH being recorded within the flush. The electrical conductivity of the water in the bog pools within the SAC was approximately 58μS/cm and therefore the source of water to these pools is also meteoric in origin and not groundwater.

10.3.10 Groundwater Dependent Terrestrial Ecosystems

10.3.10.1 Bellacorick Iron Flush

The Bellacorick Iron Flush Special Area of Conservation (SAC) is surrounded by Phase 1 of the operational Oweninny Windfarm and is 0.65km to the northwest of the proposed development footprint. The area is shown in Figure 10.9. The flush area is owned by An Taisce with an additional buffer area around the flush owned by the Department of Arts, Heritage and the Gaeltacht (National Parks and Wildlife Service). The iron flush is an area of intact blanket bog that receives mineral-rich groundwater in what is otherwise an ombrotrophic (peat water) setting. This flush area supports rare and protected species including Marsh Saxifrage. The iron flush area ecology is dependent on the rate of groundwater flow through it and also its hydrochemistry. The Formoyle Flush is located approximately 1km to the east of the Oweninny site. This also supports rare plant species dependent on groundwater flow and hydrochemistry.

Within the SAC and especially on the lower lying western side of the site the blanket bog remains relatively intact. The flush has an approximate area of 2.3ha which only accounts for 13% of the SAC. The SAC site is characterised by an isolated east – west orientated hillock on the east of the site. The western, lower lying side of the site, where the iron flush exists, slopes to the west / northwest in the direction of the Sruffaunnamuingabatia Stream which is located near the western boundary of the SAC. Iron oxide precipitates leaves an ochre (rust) colour in the discharge from the flush.

The hydrological and hydrogeological characterisation of the Bellacorick iron flush is based on the data acquired from the desk study, review of previous investigations, site investigation and monitoring from the previous windfarm applications. The hydrogeological conceptual model was developed for the iron flush and summarised below and Figure 10.9.

The superficial geology in the vicinity of the iron flush comprises blanket peat overlying 20 to 30m of sandstone till (mineral subsoil). The underlying parent material (i.e., bedrock) is mapped to be bedded sandstone. Areas where peat is absent are located on the elevated ground 100m to the east of the iron flush. The zone of contribution to the Iron Flush was delineated as part of the 2013 application. The zone of contribution to the flush does not extend into the Phase 3 development. No impact occurred on the Iron Flush during the construction and operation of Phase 1.

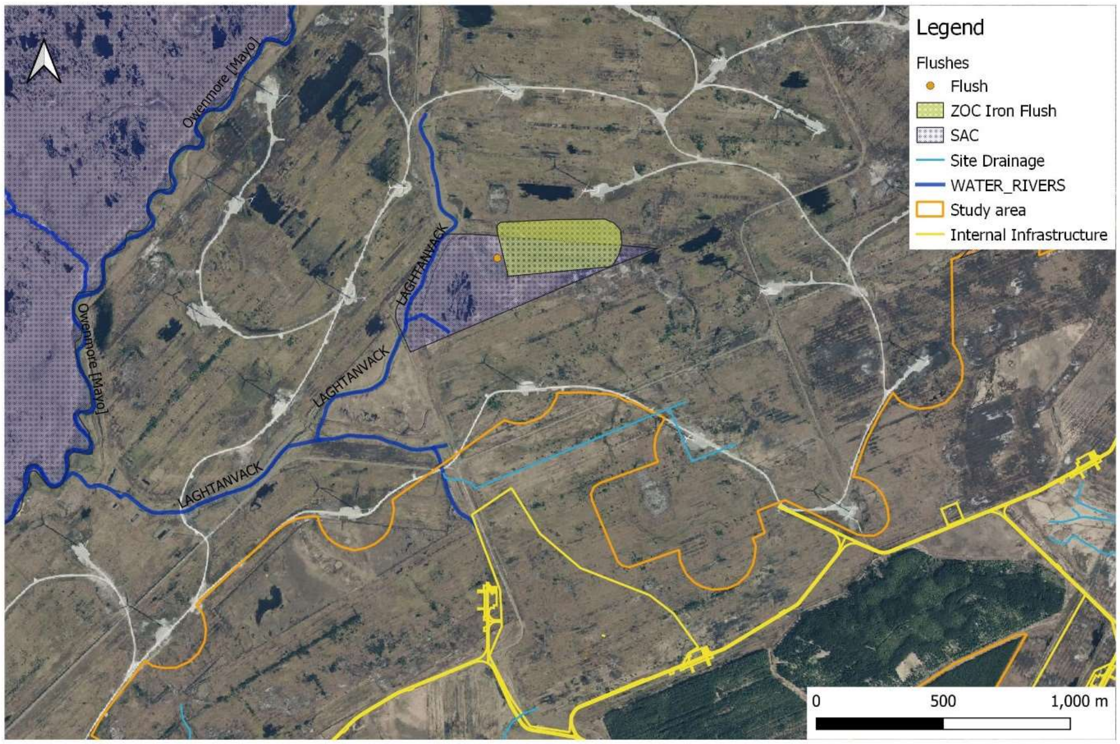

Figure 10.9: Bellacorrick Flush and ZOC

Oweninny phase 3, is located to the south and south west of Iron Flush. The nearest proposed excavations comprise a shallow borrow pit. It has an area of approximately 40Ha. The borrow pit area has some areas of shallow residual peat remains overlying variable glacial tills, with a coarse sandy gravel horizon extending from approximately 0.2mbgl to 3mbgl. The proposed borrow pit is located approximately 650m to the southeast of the SAC at its nearest point and approximately 2km at its furthest.

The borrow pit area drains predominantly to the southwest, with surface water evident to the west of the borrow pit. It is proposed that the gravels in the borrow pit will be excavated to approximately 2.5m below ground level. Where the borrow pit requires excavation of gravels below the water table, it will operate as a wet pit, thereby avoiding the need for dewatering. The existing cutaway ground level in Area 1 lies in the ranges from 99 mOD to the northeast, approximately 91mOD to the southeast and 93 to 94mOD to the east of the borrow pit. The borrow pit will drain to south west. Trial pits indicate the presence of discontinuous sand and gravel deposits with an increase in fines to the north and north west of Area 1. Based on the available site investigation data there is a degree of variability within the deposits at the proposed borrow pit, ranging from coarse sandy GRAVELS and slightly silty gravelly SANDS to clayey GRAVELS. With the evident variability in composition of the tills, there will also be an associative variability in permeability. While all locations have high water table, the coarse gravels have recorded high seepage rates and indicate high localised permeability, while where clay is noted seepage rates are recorded as minor. The material excavated from the borrow pit will be used for the construction of subbase material for the access roads and turbine base/hardstanding areas. The roads will be capped with crushed rock material.

Given the topography almost all of the borrow pit area is below the level of the discharge line within the flush at approximately 96mOD and the variable nature of the till deposits, this area and the area of the borrow pit, there is no potential groundwater flow paths towards the iron flush.

Based on topography and groundwater levels, groundwater flow from the borrow pit is to the west-southwest, with discharge to the Croaghaun West Stream. Therefore, based on the assessment above the groundwater flow around the borrow pit area is occurring independently of the flow regimes supporting the iron flush.

There are no proposed turbines, access roads or borrow pits located within the delineated areas that recharge to the Bellacorrick iron flush. Therefore, there can be no direct impact on groundwater flow paths towards the flush within the recharge area.

All of the proposed development areas in the vicinity of the iron flush are significantly outside the groundwater recharge area and surface water catchment area to the flush. As a result, there is no potential to impact on groundwater flows or surface water to the flush area.

10.3.10.2 Lough Dahybaun SAC

Limited construction works are proposed in the catchment area to Lough Dahybaun. A proposed amenity access is proposed to provide walking access to the site (see Figure 10.10). The existing track is in general good repair with only limited surface maintenance required.

Figure 10.10 Access track of north L Dahybaun

Electrical conductivity values for surface water were generally between 50 and 100µS/cm. These values show that the source of water within the majority of the man-made drains and on the vegetated surface of the blanket peat is meteoric in origin (i.e., from precipitation).

Higher conductivity values (270 µS/cm) occur on the streams which discharge to Lough Dahybaun which reflect shallow water in contact with the mineral subsoils and discharges from the sand and gravel deposits to the east and north of Lough Dahybaun – see Table 10-10.

Turbidity values were monitoring on Lough Dahybaun and on the streams which flow to the lake. Turbidity was generally low in the streams and in the Lake. All turbidity values were less than 5 FNU. Visibility at the lake is greater than 1.5m. The surface water monitoring points are shown on Figure 10.11.

Table 10-10: Water quality Monitoring - L. Dahybaun

Sample location	Ph	mV ORP	Cond (A)	FNU	Temp	
78	5.2	130	54	1	18	Surface runoff from gravels - away from lake
79	6.97	156	91	1.6	17.8	NE drain

Sample location	Ph	mV ORP	Cond (A)	FNU	Temp	
80	7.18	138	94	1.4	17.8	NE drain
81	7.96	104	248	0	20.2	NW drain
82	8.14	101	166	2.3	18.12	Lake North
83	8.05	114	163	4.6	18.4	Lake North East
84	8.05	114	163	4.6	18.4	Lake
85	7.7	121	132	1.4	19	Stream entering lake NE
88	7.3	110	89	1.7	19	Stream entering lake SW

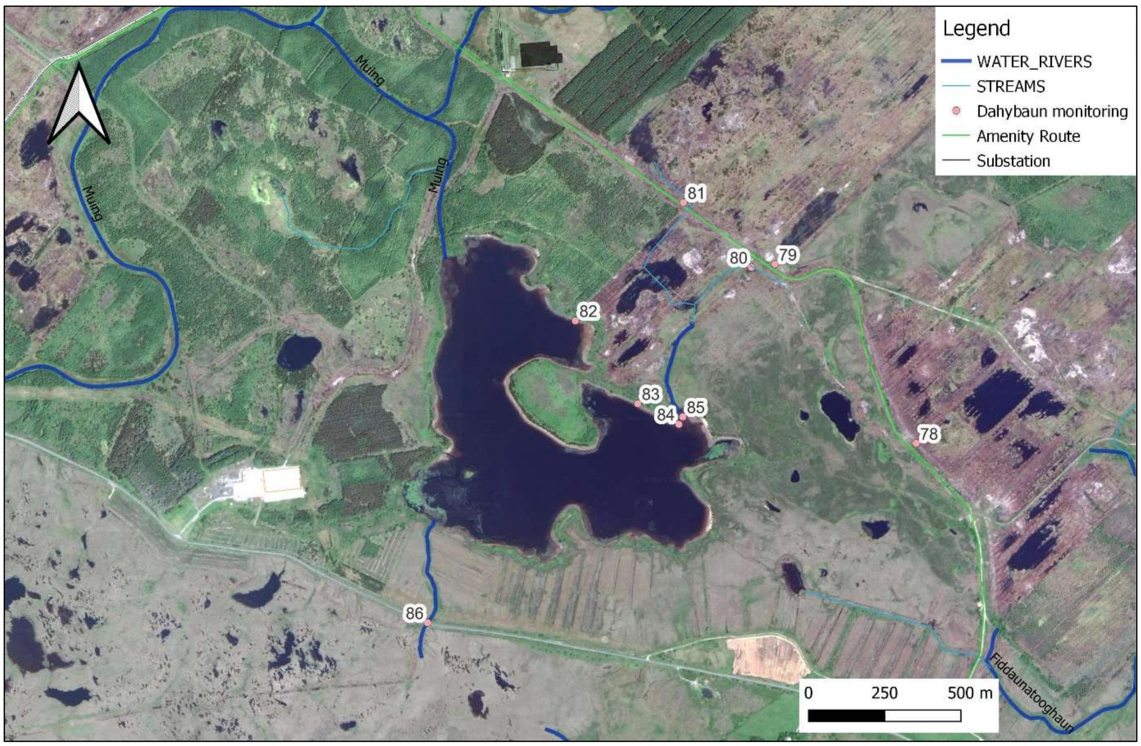

Figure 10.11: Surface water monitoring - Lough Dahybaun

10.3.10.3 Poor Flushes and other groundwater discharges

A number of small poor flush and wetland areas are located on the site. A map showing the location of the flushes and wetlands is shown on Figure 10.12. A number of the wetlands/flush areas correspond to former lake areas on the 6inch OSi maps. The poor flush areas have a low conductivity and neutral pH. Conductivity measurements in August 2021 indicated conductivity of <90uS/cm and pH 6.8 to 7.2. It is not proposed to alter these areas as part of the Oweninny Phase 3.

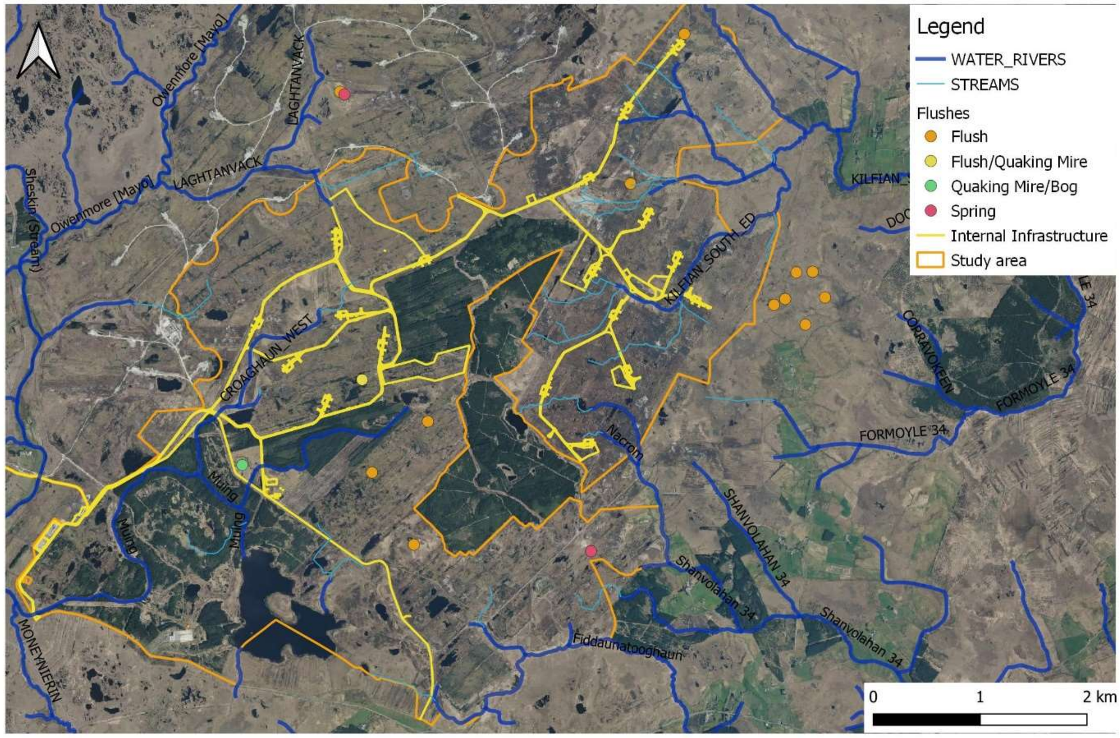

Figure 10.12: Springs, Flushes and Wetlands at Oweninny

10.3.10.4 Peatlands

A number of remnant peat areas and rehabilitated peatlands occur on the site. See Chapter 8 Biodiversity for further details. It is not proposed to alter these areas as part of the proposed development.

10.3.10.5 Formoyle Flush

Formoyle Flush is located to the east of the Oweninny site, within the Bellacorick Bog Complex (SAC Site Code: 001922). This also supports rare plant species dependent on groundwater flow and hydrochemistry. The Formoyle flush, is located to the east of the site boundary and approximately 1km from the nearest turbine. The flush area occurs near subsoil exposures and drains eastwards to the Corovokeen/Formoyle River which is a sub-catchment of the regional Cloonaghmore River catchment (HA 34). A series of minor seepage points occur within the SAC. Field hydrochemistry measurements show a pH 6.8 to 7 and an electrical conductivity of between 180 and 250μS/cm which indicates mineral rich water .

10.4 POTENTIAL EFFECTS

This section addresses the potential effects on the hydrogeological environment of the proposed wind farm.

The description of the likely significant effects covers direct effects and any indirect, secondary, cumulative, transboundary, short-term, medium-term and long-term, permanent and temporary, positive and negative effects of the project. The criteria (EPA, 2022) for the assessment of impacts require that likely significant effects are described with respect to their magnitude, frequency, extent, complexity, probability, duration, reversibility etc.

A qualitative approach was used in the evaluation, following the significance classification in Table 10-11 and through professional judgement. The significance of the effect has been determined through the consideration of the importance/sensitivity of the receptor (attribute) likely to be impacted and the magnitude (the degree or level) of that impact. Effects have been identified as beneficial, adverse or negligible, temporary or permanent and their significance as major, moderate, slight or not significant (negligible) as shown Table 10-12, both the adverse and beneficial effects are considered.

Table 10-11 Effects Matrix

Sensitivity	Magnitude			
	Very High	**High**	**Moderate**	**Low**
Very High	Profound	Profound	Moderate	Low
High	Profound	Moderate	Moderate / Low	Moderate / Slight
Medium	Moderate	Moderate / Low	Moderate / Slight	Slight
Low	Moderate/Low	Slight	Slight	Negligible
Negligible	Slight	Slight	Negligible	Negligible

In order for a potential effect to be realised, three factors must be present. There must be a source or a potential effect, a receptor which can be adversely affected and a pathway or connection which allows the source to effect the receptor. Only when all three factors are present can an effect be realised.

The hydrogeological assessment identified water sensitive waterbodies downstream from the proposed infrastructure works.

The current proposals for all construction activities, operational infrastructure and decommissioning were reviewed to identify activities likely to impact upon identified water bodies including water courses within and remote from the site. Following the identification of sensitive waterbodies, the extent and severity of potential construction, operational and decommissioning impacts were evaluated considering all proposed control measures included in the project design.

10.4.1 Do-Nothing Scenario

If the Oweninny Windfarm Phase 3 development does not proceed, the proposed development site will remain as peatland/bogland. Pressures on the local water quality will continue without separate intervention. There are no significant effects to the hydrogeological environment in a do-nothing scenario.

10.4.2 Potential Effects – Construction Phase

The proposed works will represent Phase 3 of the Oweninny Wind Farm project. In its entirety the project will require the construction of an extensive road network, turbine foundations, hard stands, borrow pits, peat disposition areas, substation and ancillary infrastructure, maintenance areas, and underground cables. These activities may have potential effects on groundwater conditions. Potential effects are direct, short term, unlikely and not significant.

Construction Activities

The construction of the temporary site compound areas, site access tracks, turbine foundations, turbine hardstands, laying of underground electrical cabling, borrow pits, drainage channels will involve the removal of vegetation and the excavation of peat, marl, and mineral subsoil. Exposed and disturbed ground may increase the risk of erosion and subsequent sediment laden surface water runoff. The release of suspended solids is primarily a consequence of the physical disturbance of the ground during the construction phase, if not correctly compacted. Incorrect site management of earthworks and excavations could, therefore, lead to loss of suspended solids to surface waters as a consequence of the following activities:

- Soil stripping, if necessary, to construct the access roads, passing/turning bays, site compounds, turbine foundations, hardstands, borrow pits, turbines/hardstanding/roads and substation
- Run-off and erosion from soil stockpiles (prior to reinstatement/profiling/side casting);
- Dewatering of excavations for turbine foundations, and borrow pits (where necessary). The result of increased sediment loading to watercourses is to degrade water quality of the receiving waters and change the substrate character

Potential effects are negative, direct, short term, likely and slight.

Concrete and similar other products may give rise to alkali effluents that may impact on receiving waters. Potential effects are negative, direct, short term, unlikely and slight.

A Horizontal Directional Drill (HDD) beneath the local road is used then this will have its own potential risks, primarily arising from the break-out of bentonite clay used during drilling and cable installation. The risk of bentonite clay to groundwater is not considered significant as no significant groundwater resource is present within the deep overburden and given the geology present any breakout will only impact on a limited volume of groundwater local to the bore. Potential effects are negative, direct, temporary, unlikely and slight to negligible.

Hydrogeological Effects

Approximately 3.9% of the Muing river catchment and less than 2% of the other river sub-catchments will be affected by the development. Additionally, settling ponds constructed as part of the erosion and sediment control plan for the site will provide a further degree of flow attenuation. No significant impact from changes to hydrology arising from development on the site is predicted, see Chapter 11 (Water). Potential effects are negative, direct, temporary, unlikely and slight.

Development could potentially reduce the infiltration capacity of the soils in areas where earthworks are undertaken and increase the rate and volume of direct surface runoff. However, infiltration to groundwater on the site is low based on the peat soils and deep low permeability soils. Surface water control measures are incorporated into the design of the proposed development. A slight reduction in peak rainfall is anticipated where areas of peat are replaced with gravel trackways and gravel hardstand areas. The potential for an increase in runoff to streams is limited as surface water runoff is already controlled and managed in accordance with the IPC licence and site management procedures. Pre-mitigation, the potential construction effect varies from a slight, negative to slight beneficial short-term impact.

There is a potential impact as a result of dewatering borrow pits and turbine bases on site. Borrow pit areas for example, are up to 3m deep. Pre-mitigation, the potential construction effect varies from a slight, negative, direct, likely and short-term impact.

During construction of the wind farm, there is a risk of accidental pollution incidences from the following sources:

- Spillage or leakage of oils and fuels stored on site;
- Spillage or leakage of oils and fuels from construction machinery/vehicles;
- Spillage or leakage of wastewater from temporary site facilities;

- Spillage of oil or fuel from refuelling machinery on site; and
- Spillages arising during the use of concrete and cement for turbine foundations and hardstanding areas.

There will be a risk of pollution from site traffic through the accidental release of oils, fuels and other contaminants from vehicles. Concrete (specifically, the cement component) is highly alkaline and any spillage to a local watercourse would be detrimental to water quality and fauna and flora. Pre-mitigation, the potential construction effect is slight negative, direct, likely and short-term impact.

The proposed development layout is orientated to avoid impacts on Bellacorick Iron Flush SAC, iron flushes and sensitive ecological sites such as remnant blanket bog. Remnant peatlands were avoided and will not be impacted by the proposed development. Pre-mitigation, the potential construction effect varies from neutral to slight, negative, direct, likely and long-term impact.

In relation to the Habitats Directive, based on this assessment there will be no adverse impact on the integrity of the Bellacorick Iron Flush, and the Conservation Objectives as a result of the proposed wind farm development The site topography does not indicate any potential connection or impact on the flush area.

10.4.3 Operational Phase

Maintenance activities will be ongoing at the site, but the intensity of such works will vary with the type and extent of maintenance required.

Operational wind farms include components that require oil for lubrication and cooling and substations will require transformers that utilise oil for insulation and cooling. Where oil is stored there is a risk of vessel failure and spillage that can impact on water and soil quality.

Effluent will be generated from permanent welfare facilities which will be required at the site substation; if uncontrolled discharge of such effluents occur it may impact on water quality. Mitigation measures are outlined in section 10.5. Pre-mitigation, the potential effects varies from neutral to slight, negative, direct, unlikely and short-term impact.

With regard to water quality impacts, there will be no direct discharges to the surface water environment during the operational phase. Due to the nature of the development, there will be vehicles periodically on the site at any given time which may lead to potential effects as a result of, occasional/accidental emissions, in the form of oil, petrol or diesel leaks, which could cause slight/negligible temporary and localised contamination of site drainage channels.

10.4.4 Magnitude and Significance of Impact – Construction and Operation

The magnitude of an impact includes the timing, scale, size and duration of the potential impact (pre-mitigation). The magnitude criteria for hydrology/hydrogeology are defined as set out in Table 10-12 and Table 10-13 below.

Table 10-12: Magnitude and Significance of Hydrological Criteria - Construction Phase (Pre-mitigation)

Criteria	Description	Duration and Frequency of Effects	Significance of potential effect
Groundwater Levels	No significant change in groundwater is expected. Slight localised drawdown predicted at the borrow pit locations however no sensitive receptors located near borrow pits. No ZOCs or wells within 250m of borrow pits or turbines.	Temporary and occasional	Negligible
Groundwater Quality	No change in groundwater quality is expected	Not applicable	Negligible
Groundwater dependant terrestrial ecosystems	No potential for impacts on SACs/SPAs/NHAs	No potential for impacts on SACs/SPAs/NHAs	Negligible

Table 10-13 : Magnitude and Significance of Hydrogeological Criteria - Operational Phase (Pre-mitigation)

Criteria	Description	Duration and Frequency of Effects	Significance of potential effect
Groundwater Levels	No significant change in groundwater is expected.	Not applicable	Negligible
Groundwater Quality	No change in groundwater quality is expected. No ZOCs or wells within 250m of turbines. Rare potential fuel spills may occur within the proposed development.	Short-term and rarely	Negligible

Potential effects are of slight/ negligible significance.

10.4.5 Decommissioning Phase

Once the wind farm reaches the end of its operational life the turbines and all above ground structures that do not have an alternative use will be dismantled to ground slab level. Roads will be left in place and below ground structures will be remain in place. The site substation will also remain in place to continue to function as part of the national grid infrastructure.

In general, the potential effects associated with decommissioning will be similar to those associated with construction but of reduced magnitude because extensive excavation, and wet concrete handling will not be required. The potential environmental effect of soil storage and stockpiling and contamination by fuel leaks will remain during decommissioning. The potential for impact as a result is slight to not significant.

The grid connection infrastructure will remain in place underground and would be covered with earth and allowed to revegetate or reseed as appropriate. The site access tracks will be in use for additional purposes to the operation of the wind farm (e.g., for recreational use) by the time the decommissioning of the project is to be considered, and therefore will remain in-situ for future use.

In most cases, and certainly for granular based tracks (but also concrete and asphalt) these materials are mostly inert and stable over the long-term, so will not pose a contamination risk if left in-situ.

10.5 MITIGATION MEASURES

Mitigation measures for the construction, operation and decommissioning of the proposed development site to avoid or reduce the potential effect of the proposed development are presented below. As outlined in Chapter 3, Description of the Proposed Development, the design of the proposed development has considered a range of construction measures which ensure avoidance of impacts throughout the construction and operational phases. Additional measures have been developed to mitigate the impacts identified in the preceding section.

10.5.1 Mitigation by Avoidance

Incorporation of measures to mitigate environmental impacts is inherent in the planning and design of wind farms such as the proposed Oweninny Wind Farm Phase 3 development. This extends to all phases of the wind farm project from site selection and the concept phase, including consideration of alternatives, through development, pre-planning and design phases to construction, operation and decommissioning.

The hierarchy in mitigating environmental impacts in the Oweninny Wind Farm Phase 3 project has been avoidance, reduction and remedy. The objective of the development has been to maximise the sustainable wind energy capture of what is a very suitable site for wind energy development without causing significant adverse environmental impacts. The design of Oweninny Wind Farm Phase 3 meets the primary objective of avoidance of impacts on environmental resources. For instance all of the proposed development areas in the vicinity of the Bellacorick Iron Flush SAC are significantly outside the groundwater recharge area and surface water catchment area to the flush. As a result, there is no potential to impact on groundwater flows or surface water to the flush area.

A consideration in all projects is to manage the scope of project activity necessary to achieve the project objectives in a manner that is environmentally responsible. At Oweninny impacts on all aspects of the environment have been minimised by selection of the proposed scheme over the multiplicity of possible alternatives.

An example of mitigation by avoidance is the siting and design of construction of turbines to avoid potential impact on the designated areas including Lough Dahybaun SAC.

10.5.2 Mitigation by Prevention and Reduction

A number of mitigation measures are outlined below and are considered as in-built to the design of the project. These mitigation measures are a combination of measures to comply with legislation and construction methods to be implemented in order to prevent water (surface and groundwater) pollution.

10.5.3 Mitigation Measures - Construction Phase

Prior to commencement of construction work the Construction Environment Management Plan (CEMP) will be finalized to reflect any relevant planning consent conditions or further input from the local authority. The CEMP included in Appendix 3.1 details the procedures to prevent, control and mitigate potential environmental impacts from the construction of the development.

It will be a requirement that all permits, and licences are obtained from the regulatory authorities as required by environmental law or regulation and will discharge the relevant conditions of the planning permission to commence site works, or as otherwise appropriate in advance of specific site activities.

Compliance with good construction practice, will be a key requirement for all contractors and it is proposed that the general guidance provided by the CIRIA *Environmental good practice on site guide (fourth edition)* (C741). Specific guidance published by Irish regulatory agencies will be used where applicable.

10.5.4 Materials and Fuels

Concrete and similar other products may give rise to alkali effluents that may impact on receiving waters. Therefore, waste concrete and wash waters need to be disposed of in dedicated areas where the waste material can be neutralised and collected for appropriate disposal or reuse. Any use of crushed concrete aggregates must consider the potential for generation of alkali run off, and such reuse must not be located in proximity to sensitive receiving waters or where conduits to such waters exist.

Fuel storage and fuelling facilities will be required at several fixed locations and at mobile locations around the site, given the size of the project site it is impractical to track large plant to a single fixed facility. Fuel storage and any oil storage will be carried out in accordance with the CIRIA *Containment systems for the prevention of pollution* (CIRIA 736F).

Fuel and oil storage at fixed locations will be in a fixed tank, undercover and within a steel or concrete bund. A dedicated impermeable bunded refuelling area will be constructed adjacent to the fixed fuel storage areas. Double skinned plastic tanks will not be acceptable at the site for any purpose unless they are placed within fixed concrete or steel external bunds. Each fixed fuel and oil storage bunds shall be sized to hold 110 % of the oil volume of the largest tank therein.

In the event of a spill, the liquid contained in the bund shall be removed by a liquid waste tanker, as will be the contents of the surface water drainage system and oil interceptor. Where refuelling is required on site away from fixed storage locations this will only be carried out utilising steel intrinsically bunded mobile fuel bowsers. At site refuelling locations, refuelling will take place within mobile bunds, but at a minimum fuel line from the bowser to the plant being fuelled will be contained by drip trays.

Generators and associated fuel tanks to be used at the site shall either be placed within bunds as per fuel storage tanks or shall be integrated units (i.e., fuel tank and generator in one unit) that are intrinsically bunded. No external tanks and associated fuel lines shall be permitted on site unless these are housed within a fixed bund with the generator.

The contractor's yard/maintenance yard shall incorporate a bund for the storage of small vehicles and oil filled equipment, such as hand portable generators, pumps, etc. Storage of small volume oils or chemicals, in barrels, IBCs, etc, will be stored in a covered bunded area. Where barrels or other containers are required at work locations these shall be stored in enclosed bunded cabinets, and drip trays shall be used where distribution of the material is required.

The main storage areas for oil filled equipment, vehicles, plant, etc, shall be impermeably surface and the discharge of surface water from these areas will be via oil interceptors. An oil spill response plan will be developed for the construction works and appropriate containment equipment will be available at work locations in the event of a spillage. Oil spill response will form part of site personnel induction and training at the site.

All wastes generated on site will be segregated so that appropriate materials are re-used on site. Residual materials will be collected by licensed waste haulier for appropriate sorting, recycling and disposal.

10.5.5 Water and Effluents

It is expected that groundwater will be encountered in some excavations at the site. Groundwater arising from excavations may have high levels of suspended solids. The waters from excavations will be discharged through settlement pond and silt control device (silt bag/check dams) to the recolonising cutover peat land.

Settlement ponds will be located downstream to manage/buffer volumes of water thereby reducing the loading to watercourses.

The following shall apply to construction of settlement ponds at the site:

- Pond depths generally to be excavated to less than 2m;
- Side slopes to be shallow, nominally at a 1 in 3 side slope (maximum);

Discharge of settlement pond will be via a silt bag/check dam which will filter sediment from the pumped water. Material excavated from the settlement pond should be compacted around the edge of the pond. Site personnel will be trained in pollution incident control response prior to commencement of works. Emergency silt control & spillage response procedures contained within the CEMP will ensure that appropriate information will be available on site outlining the spillage response procedures and a contingency plan to contain silt during an incident.

Temporary welfare facilities will be located on site these will discharge to sealed sumps that will be emptied as needed by appropriately licensed contractors.

Permanent welfare facilities at the substation will discharge to a holding tank prior to removal to an appropriate licenced facility.

Surface water arising at the contractors' compounds, and fixed fuel storage locations will be discharged in an appropriate manner via necessary controls that will include alarmed oil interceptors.

It is not anticipated that the creation of the structures and infrastructure required for the project have a significant potential to influence the general quality or quantity of groundwater available across the area. It is expected that dewatering will be required for some turbine bases and other excavations in parts of the site. It is not expected that the temporary and localised nature of the necessary dewatering works would impact on the groundwater table, except locally to the works, and therefore would not significantly impact groundwater flow regime within or beyond the site.

10.5.6 Borrow Pits

All of the proposed development areas are significantly outside the groundwater recharge area and surface water catchment area to the Bellacorick Iron Flush SAC. As a result, there is no potential to impact on groundwater flows or surface water to the flush area. In relation to the Habitats Directive, based on this assessment there will be no adverse impact on the integrity of the Bellacorick Iron Flush, and the Conservation Objectives as a result of the proposed wind farm development.

Standard practice mitigation measures in relation to hydrocarbons spill management are set out in Section 10.5.4 included the provision of spill kits etc will be applied to all borrow pit areas.

10.5.7 Underground Cables and HDD

Construction of internal electricity transmission lines and cables will present similar, but lower-level risks, to the construction risks outlined above, and the same mitigation measures will be adopted as above. No significant hydrogeological effects are anticipated from the construction of the grid connection underground cabling trench due to the shallow nature of the excavation (i.e. ~1.2m), the excavation of the trench adjacent or within the road/trackway carriageway and the nature of the subsoil to be excavated.

All works must follow the guidance set out in the Guidance document entitled: Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites (IFI, 2016), and the CIRIA Control of water pollution from linear construction projects

(C648). Storage locations for excavated materials, equipment, hydrocarbons (including fuels for machinery) will not be stored within 20m of any watercourses or wetland areas.

Directional Drilling Mitigation Measures:

If a Horizontal Directional Drill (HDD) beneath the local road is used then this will have its own potential risks, primarily arising from the break-out of bentonite (clay)used during drilling and cable installation. The risk of bentonite to groundwater is not considered significant as no significant groundwater resource is present within the deep overburden and given the geology present any breakout will only impact on a limited volume of groundwater local to the bore.

A number of measures to mitigate potential effects associated with the directional drilling are listed below:

- Before any ground works are undertaken, double silt fencing will be placed downgradient of the works;
- The area around the bentonite batching, pumping and recycling plant will be bunded using terram (as it will clog) and sandbags in order to contain any spillages;
- Drilling fluid returns will be contained within a sealed tank / sump to prevent migration from the works area;
- Any sediment laden water from the works area will not be discharged directly to a watercourse or drain;
- Daily monitoring of the compound works area, the water treatment and pumping system and the percolation area will be completed by a suitably qualified person during the construction phase.
- On completion of the works, the ground surface disturbed during the site preparation works and at the entry and exit pits will be carefully reinstated and re-seeded at the earliest opportunity to prevent soil erosion;
- The drilling fluid/bentonite will be non-toxic and naturally biodegradable (i.e. Clear Bore Drilling Fluid or similar will be used);
- Any frac-out material will be contained and removed off-site; and
- The drilling location will be reviewed, before re-commencing with a higher viscosity drilling fluid mix.

10.5.8 Mitigation Measures - Operational Phase

The operational team will carry out maintenance works such as servicing of wind turbine and transmission infrastructure, upkeep of access tracks and any hardstand areas, ensuring drainage system remains functional throughout the operation of the windfarm.

Mitigation for the operational maintenance works include regular scheduled maintenance works, regular inspections of all project elements with any unscheduled repairs or maintenance arising to be undertaken.

The potential impact of hydrocarbon or oil spills during the operational phase of the windfarm are limited by the size of the fuel tank of vehicles used on the site. Mitigation measures for the potential release of hydrocarbons or oil spills include:

- The plant and vehicles to attend site should be regularly inspected or at least prior to the scheduled site visit to be free from leaks and is fit for purpose;
- Fuels stored on site will be minimised, any storage areas will be bunded appropriately for the fuel storage volume for the time period of the operation;
- Operational team to be competent and trained in an emergency plan for the operation phase to deal with accidental spillages; and
- Spill kits will be available to deal with accidental spillages.

10.5.8.1 Substation

All fuel will be stored in bunded areas. The bund capacity will be sufficient to accommodate 110% of the largest tank's maximum capacity or 25% of the total maximum capacities of all tanks, whichever is the greater. The exception to this being double walled tanks equipped with leak detection, which do not require additional retention.

A hydrocarbon interceptor will be installed at the proposed substation site with regular inspection and maintenance, to ensure optimal performance.

Given the requirement for sanitary facilities during occasional operation and maintenance works, wastewater effluent will be directed to an onsite holding tank, from where it will be tankered off site to a suitably licensed wastewater treatment plant. An automatic alert system will be used to monitor the holding tank to alert the operator if the tank is nearing full capacity. A water supply will be collected using a rainwater harvesting facility on the control building.

The majority of the proposed development site will be accessed from the project's permanent road network, however some low maintenance project elements, will require access and egress across cutaway peat bog should maintenance be required. In such event the access and egress will be undertaken using the approach outlined for construction.

10.5.9 Mitigation Measures - Decommissioning Phase

Decommissioning will comprise the removal of non-reusable power generation devices and infrastructure to ground level, it is assumed that below ground cabling, etc, would be abandoned in-situ.

The proposed decommissioning will be undertaken after 30 years of operation. The SEPA (2016)[10] guidance details the following recommendations.

- Remove infrastructure unless the potential environmental risks posed by removal (e.g. carbon loss, impacts on the water environment) would outweigh the benefits.
- Maximise recovery of materials from removed infrastructure and treat as high up the waste hierarchy as possible

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[10] SEPA (2016) Life Extension And Decommissioning Of Onshore Windfarms

- Optimise habitat restoration of areas affected by infrastructure removal
- Long term aftercare programme established to monitor/manage any potential long term environmental risks

Foundations can be dismantled using an excavator. Reinforcing steel and concrete will be transported separately to special plants for further recovery or recycling.

Internal access roads could be removed there may be benefits to leaving them in place for access and continued amenity use. Furthermore, in the context that almost all of the internal roads will have a dual function of providing access to the turbines and amenity trackways it is intended that all of the roadways will be retained.

Concrete bases will be left in the ground, covered with topsoil and allowed to naturally re-seed in line with IWEA best practises (IWEA, 2012). The area around the bases will be rehabilitated by covering it with locally sourced soil in order to regenerate the vegetation. This will also reduce run-off and sedimentation effects.

A fuel management plan to avoid contamination by fuel leakage during decommissioning works will be implemented as per the construction phase mitigation measures.

The risks arising from the decommissioning of the site would be less than those for construction, but mitigation measures for decommissioning would conform to those given for construction and would be anticipated to be fully protective of the environment.

10.6 CUMULATIVE IMPACT

Cumulative effects of this project with other developments in the region, as discussed in Chapter 5 - Policy, Planning and Development Context. Efficient design along with material management will ensure optimisation of the volume of materials required to be imported to site. This will mitigate any cumulative effects relating to importing of material and use of public roads as haul roads.

Cumulative effects of this project with other developments in the region, relate to the effects on Hydrology. These developments include other existing or planned developments in the environs of Oweninny Bog and/or developments with the potential to interface with the bog in terms of environmental effects. Key developments in the area include:

- Sheskin Wind Farm Phase 1 and 2;
- Doonleg Wind Turbine;
- Oweninny Wind Farm Phase 1 and 2; and
- Green Hydrogen Plant (Planning Phase).

Sheskin Wind Farm

Sheskin Wind Farm (Mayo Co. Co. Planning reference: 15825) is comprised of 8 wind turbines and associated works, is located approximately 150 metres from the proposed development site. Each turbine will have a maximum overall height of 150 metres. It was granted conditional planning permission 2016 and construction commenced in 2022. An NIS and EIAR for this development concluded the implementation of appropriate mitigation measures, the proposed wind farm at Sheskin will have no potential for cumulative impacts with other known projects.

Sheskin South Wind Farm

Sheskin South Wind Farm (ABP Planning reference: ABP-315933-23) is comprised of 21 wind turbines and associated works, is located approximately 2km from the proposed development site. An NIS and EIAR for this development concluded the implementation of appropriate mitigation measures, the proposed wind farm at Sheskin will have no potential for cumulative impacts with other known projects.

Dooleeg Wind Turbine

Permission for a single wind turbine generator (Mayo Co. Co. Planning Reference: 20467), with an overall max height of 180 metres and 20kV grid connection to Bellacorick 110kV substation. It is located approximately 300m from the proposed development site and was granted conditional permission in 2021. An EIAR and NIS have been produced for this proposed development. The NIS concluded that this project alone or in-combination with other plans or projects, will not result in significant adverse effects to any European sites.

Oweninny Wind Farm Phase 1 and 2

Oweninny Phase 1 and Phase 2 are operational wind farm developments. Construction of Oweninny Wind Farm Phase 1 has been completed and the project is in the operational phase. Oweninny Wind Farm Phase 2 is currently finishing construction works.

The bog remnant and bog rehabilitation areas will not be significantly affected by the wind farm development and the overall site development will be carried out in a manner that integrates with the bog rehabilitation programme. The criteria defining successful rehabilitation are the same with or without the windfarm; Stabilisation of peat through revegetation, mitigation of silt run-off and establishment of wetland communities where possible.

The bog is relatively flat lying, with cutover blanket peat overlying glacial till that in turn overly sedimentary bedrock of mixed lithology. No significant groundwater resources are present at the site, although localised perched groundwater may be associated with areas of granular overburden.

The principal risks associated with hydrogeology at the site was the generation of silty waters due to runoff from construction areas, and the loss of construction and operational materials (concrete, fuel and oil, etc) to water. No significant impacts occurred on the Bellacorrick Iron Flush SAC.

As mentioned, these risks can be mitigated through the adoption of the operational phase mitigation measures and hence, it is highly unlikely that the development will give rise to any significant cumulative impacts with regards to hydrogeology and water quality.

Oweninny Bog Substitute Consent

TOBIN have been commissioned to submit a substitute consent application on behalf of Bord na Mona for the historic peat extraction at Oweninny Bog. Within this application an assessment was carried out on of any likely significant effects on biodiversity as a result of this peat extraction. The proposed development site is located within Oweninny Bog.

A remedial EIAR has been developed (unpublished TOBIN reports) for the Oweninny Bog, which included an assessment on any likely significant effects from the historic peat extraction within the receiving groundwater environment. It is expected that there will be no likely residual impacts in relation to groundwater.

Mayo Green Hydrogen Production Plant

The development of a hydrogen plant (Mayo Co. Co. Planning Reference: 22502) that will produce hydrogen by the electrolysis of water, is proposed at a site approx. 1km from the Oweninny Phase 3 site boundary. The hydrogen produced will be stored on site and available for Injection into the transmission gas network or the removal off site by trucks with tube trailers. Water will be abstracted from the adjacent Oweninny river, ground water or a combination of both. The oxygen produced from electrolysis will be vented to atmosphere.

In terms of the potential effects of the Mayo Green Hydrogen Plant development on downstream surface water bodies, the biggest risk is during the construction phase of the development as this is the phase when earthworks and excavations will be undertaken at the sites. The proposed development has potential hydrological connectivity at downstream sites and therefore there can be potential cumulative effects or interactions with both the construction, operation, and decommissioning phases of other developments.

However, the implementation of the proposed mitigation measures will ensure there will be no cumulative significant adverse effects on the groundwater environment from the proposed hydrogen plant in combination with other relevant developments within a 10km radius in the Blacksod-Broadhaven catchment, as well as with the proposed grid and gas connection works associated with the project.

Other Smaller Developments

A review of the Mayo County Council planning portals revealed a number of small scale residential and rural developments (e.g., residential one-off housing and agriculturally based developments) proposed in areas between Crossmolina, Bellacorick and Bangor-Erris in proximity to the proposed development site. Considering the small scale residential and rural developments, there is no potential for significant adverse effects on hydrology. A full list of planning applications within the wider area of the site are provided in Chapter 5 (Policy, Planning & Development Context) Appendix 5-1 of this EIAR.

10.6.1 Cumulative Assessment

No significant residual effects on any ecological receptor have been identified from the sections above.

No significant residual effects were reported for any receptors within any of the nearby wind farm/other assessment reviewed. Taking into consideration other plans or projects no residual cumulative effects are anticipated.

Due to the localised nature of the proposed works within the site boundary, there is no potential for significant, negative cumulative effects in-combination with other local developments on the groundwater environment.

10.7 RESIDUAL IMPACT

The project site is relatively flat lying, with cutover blanket peat overlying deep glacial sandy tills The site overlies a poor aquifer that is unproductive except for local zones. The residual impacts on the surrounding groundwater quality, hydrology and existing drainage regime at the site are considered to be negligible and short term in nature. The existing on-site drainage system will remain active during construction and operation of the proposed wind farm and will be enhanced by a proposed drainage plan that has been designed for this development.

The construction timescale of activities within the site will be phased and short-term in duration and, thereafter, the only activities within the site that will be associated with maintaining existing drains, ongoing maintenance and monitoring during the operational phase. There are no significant long-term impacts.

10.8 SUMMARY

The project site is relatively flat lying, with cutover blanket peat overlying glacial till that in turn overly sedimentary bedrock of mixed lithology. No significant resources are present at the site, although localised perched groundwater may be associated with areas of granular overburden.

There are no significant potential effects on Natura sites or groundwater dependant ecosystems. It is not expected that the project will give rise to any significant residual impacts with regard to hydrogeology.

Hence, it is not expected that the project will give rise to any significant residual impacts with regard to hydrogeology.