61253

Environmental Impact Assessment Report

Cummeennabuddoge Wind Farm

Chapter 10: Soils, Geology & Hydrogeology

Cummeennabuddoge Wind (DAC)

September 2024

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Glossary of Terms

Term	Definition
The Applicant	Cummeennabuddoge Wind Designated Activity Company (DAC)
The Agent	Atmos Consulting Limited
Environmental Advisors and Planning Consultants	Atmos Consulting Limited
Environmental Impact Assessment	A means of carrying out, in a systematic way, an assessment of the likely significant environmental effects from a development
Environmental Impact Assessment Regulations	Schedule 6 of the Planning and Development Regulations 2001(as amended)
Environmental Impact Assessment Report	A document reporting the findings of the EIA and produced in accordance with the EIA Regulations
The Proposed Development	Cummeennabuddoge Wind Farm
The Proposed Development Site	The land enclosed by the red line shown on Figure 1-1a
The Planning Act	Directive 2011/92/EU (as amended by Directive 2014/52/EU, the EIA Directive).

List of Abbreviations

Abbreviation	Description
CEMP	Construction Environmental Management Plan
CGS	County Geological study
EPA	Environmental Protection Agency
ESB	Electricity Supply Board
GDG	Gavin & Doherty Geosolutions
GI	Ground Investigations
GSI	Geological Survey of Ireland
GWB	Groundwater Body
GWDTE	Ground Water Dependent Terrestrial Ecosystems
IGI	Institute of Geologists of Ireland
EPA	Environmental Protection Agency
IFI	Inland Fisheries Ireland
LI	Locally Important
NRA	National Roads Authority
ORS	Old Red Sandstone
PMP	Peat Management Plan
PSR	Peat stockpile restrictions
PSRA	Peat Stability Risk Assessment
WFD	Water Framework Directive
WMP	Waste Management Plan

10 Soils, Geology & Hydrogeology

10.1 Introduction

This chapter of the EIAR considers the potential effects on soils, geology & hydrogeology in relation to the construction, operation and decommissioning of 17 wind turbines and associated infrastructure (the Proposed Development). The Proposed Development is described in full in Chapter 4 of this EIAR.

The assessment has been undertaken in accordance with the Environmental Protection Agency's (EPA) Guidelines on the information to be contained in Environmental Impact Assessment Reports (2022). This includes presentation of information on the existing soil, geological and hydrogeological environment (i.e., the baseline for the site) to assess its importance or sensitivity.

The magnitude, probability and consequence of the potential direct and indirect effects caused by the construction, operation and decommissioning phases of the Proposed Development are used to determine the overall significance of the predicted effect.

Where a significant adverse effect is identified, mitigation measures are proposed, and any residual effects, once mitigation measures are implemented, are evaluated.

10.1.1 Statement of Authority

This chapter of the EIAR was prepared by Gavin & Doherty Geosolutions (GDG). GDG is a specialist engineering consultancy with a foundation in geoscience, environmental services and geotechnical engineering.

The company was founded in 2011 and is committed to supporting projects which contribute to the global sustainability agenda, such as enhancing infrastructure, supporting onshore and offshore wind farm developments and general civil infrastructure design.

The members of the GDG EIA team involved in this assessment include:

- Roy Harrison is the lead author on the Soils and Geology Chapter. Roy is a Chartered Geologist and Member of the Institution of Environmental Sciences with over 18 years' experience working in the sector, and has led the geoenvironmental EIA aspects of multiple large-scale developments in both wind farm projects (e.g. Middle Muir Wind Farm, Kype Muir Wind Farm, Kype Muir Extension Wind Farm) and large-scale transportation projects (e.g. Clyde Waterfront, Renfrew Riverside and Glasgow Airport Investment Area Infrastructure Development Projects, Cross Tay Link Road, A96 Hardmuir to Fochabers);
- Ruadh McIntosh is the project manager and has been involved in the design of the proposed development. Ruadh is Senior Engineering Geologist working in both the GDG Geo-Environmental team and the Onshore Renewables team. She is a Chartered Geologist with the Geological Society of London and has been working in consultancy for over 7 years. Ruadh has worked on a variety of renewables projects in a multidisciplinary capacity, with a focus on project management, geological assessment and borrow pit appraisal. She has been involved with projects such as; Chrathaich Wind Farm, Abhainn Dubh Wind Farm, Kellas Wind

Farm, Tomchrasky Wind Farm, Sandy Knowe Wind Farm Extension, Timahoe Wind Farm, and Clare 4N Wind Farm;

- Stephen Curtis is the primary author of this report. Stephen was involved throughout the development of the proposed design including several visits to the site and has carried out the stability analysis and interpretation of the ground model, reviewed peat stability and influence of peat handling practice at the site relating to the infrastructure design. Stephen is a senior engineering geologist on the onshore renewable team. He has over seven years of experience in both site investigation contracting and geotechnical consultancy environments. He is Chartered with the institute of Geologist of Ireland (IGI) and the European Association of Geographers. Stephen has worked on multiple renewable energy projects; primarily solar and wind farm projects in Ireland the UK for over four years. He has been involved in the feasibility study, planning, design and construction stages of wind and solar farm developments with a particular focus on geotechnical risk management, and mitigation for construction in upland peat areas and Irish glacial ground conditions;
- Alasdair Pilmer carried out the hydrogeological assessment as part of the Soils and Geology Chapter for Cummeennaboddoge Wind Farm. Alasdair is a Hydrogeologist on the Onshore Renewables team. He has five years of post-graduate experience in environmental and civil engineering consultancy (B.Sc. Geography, M.Sc. Hydrogeology). Alasdair has worked on multiple onshore and offshore wind fam projects in the UK and Ireland including Yellow River Wind Farm, Cushaling Wind Farm and Codling Wind Park. He was previously seconded to Geological Survey Ireland to assist with the Groundwater 3D Catchment Resource Assessments for the East of Ireland. Alasdair is a member of the International Association of Hydrogeologists (Irish Group);
- Tomás McGrath carried out several site visits for site assessment and site investigation studies across the site. Tomás is a Principal Engineer in GDG's Infrastructure team. He has over seven years of experience in geotechnical consultancy, design, and ground investigations. He is a Chartered Engineer with Engineers Ireland (IEI). Tomás has worked on multiple road schemes, flood defence schemes and renewable energy projects, including wind farm projects in Ireland and the UK for over four years. He has been involved in the feasibility study, design and construction stages of wind farm developments with a particular focus on geotechnical risk management, ground investigation specification and supervision, ground model interpretation and geotechnical design;
- Daniel Murphy carried out several site visits for site assessment and site investigation studies across the site. Daniel is a Graduate Engineer working in both the GDG Infrastructure team and the Structures team. He has a Masters degree in Civil Structural and Environmental Engineering from University College Cork and has been working with GDG since graduating in 2022. Daniel has worked on a variety of Temporary Works and Permanent Works design projects in Ireland and the UK and is experienced at peat probing;
- Brian McCarthy carried out several site visits for site assessment and site investigation studies across the site. Brian is a civil engineer within the infrastructure team in GDG with two years of post-graduate experience. Brian holds a Masters degree in Civil, Structural and Environmental Engineering from University College Cork and is a member of the Institution of Engineers of Ireland. Brian has worked on various renewable energy and infrastructural projects in Ireland and the UK and has carried out peat probing on a number of projects throughout Ireland;

- Irene Pascual carried out several site visits for site assessment and site investigation studies across the site. Irene is an engineering geologist with a Bachelors in Geology from Complutense University of Madrid (Spain). Irene has three years of professional experience within the Onshore Renewable and Geohazard Team at GDG. Her skillset is utilised for site identification for renewables projects, peat stability risk assessment, peat management plans, peat probing, borrow pit appraisals and geotechnical design for wind farms;
- Chris Engleman carried out several site visits for site assessment and site investigation studies across the site. Chris is a graduate geologist with four years of industry experience within the onshore renewables sector and the field of geological mapping; predominantly working on projects for peat stability and management in advance of wind farm construction, ground investigation, rock and soil logging, GIS mapping and geotechnical design. He has strong skills within peat stability, soil logging to BS5930, geological mapping, site investigation and GIS mapping. He has also gained experience in Holebase and SLOPE/W.

10.2 Methodology and Approach

The methodology used to produce this chapter included the following steps:

- A review of relevant legislation and guidance;
- A review of project scoping documents and consultation responses from relevant parties;
- A desk study of existing information available for the site information and mapping available publicly via online Geological Survey of Ireland (GSI) and Environmental Protection Agency (EPA) portals;
- A site walkover;
- Preliminary intrusive ground investigation to the level of detail recommended in BS5930 Code of Practice for Site Investigation (10.2.2);
- An assessment of the significance of potential effects;
- An identification of measures to avoid and mitigate likely significant adverse effects; and
- An evaluation of residual effects.

10.2.1 Legislative Context

This chapter has been prepared in accordance with the relevant parts of the following legislation and regulations:

- Groundwater Directive 2006/118/EC (Council of the European Union, 2006);
- Council Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment (as amended);
- Statutory Instrument (S.I.) No. 9 of 2010 European Communities Environmental Objectives (Groundwater) Regulations 2010 and amendments S.I. 389 of 2011, S.I. 149 of 2012, S.I. 149 of 2012 and S.I. 366 of 2016);
- Planning and Development Act 2000, as amended
- Planning and Development Regulations 2001, as amended;
- Wildlife Act 1976, as amended

- EC (Birds and Natural Habitats) Regulations 2011, as amended; and
- Heritage Act 1995, as amended.

10.2.2 Relevant Guidelines

This chapter has been prepared in accordance with the relevant parts of the following guideline documents:

- Revised Guidelines on the Information to be Contained in Environmental Impact Assessment Reports (EPA, 2022);
- Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements (Institute of Geologists of Ireland (IGI), 2013);
- Department of Housing, Planning and Local Government Wind Energy Development Guidelines (2006);
- British Standard Code of Practice for Ground Investigations, BS 5930:2015+A1:2020
- Guidance on the Authorisation of Discharges to Groundwater. Environmental Protection Agency, 2011;
- Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes (National Roads Authority (NRA), 2008);
- European Communities 2021. Assessment of plans and projects in relation to Natura 2000 sites – Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC;
- Peat Landslide Hazard and Risk Assessments, Best Practice Guide for Proposed Electricity Generation Developments - Second Edition (Natural Scotland and Scottish Executive, 2017); and
- Review of Wind Energy Development Guidelines "Preferred Draft Approach" (Department of Housing, Planning, Community and Local Government, 2019).

10.2.3 Study Area

The Proposed Development is located approximately 6km north of Ballymakeery town, in the Derrynasaggart Mountains, Co. Kerry. It encompasses the townlands of Cummeennabuddoge and Clydaghroe and is approximately 709 ha in size. The proposed access route passes through the townlands of Cummeenavrick and Glashacormick, Co. Kerry. The majority of the grid connection runs through Co. Cork, running eastwards towards the existing Ballyvouskill substation.

The extent of the study area and planning boundary for the proposed Cummeennabuddoge Wind Farm is illustrated in Figure 1-1a. The study area and the planning boundary are the same as the key hypothetical landslide origins and propagation locations remain within the planning boundary and analysis outside of this area is not required to define the peat stability risks of the Proposed Development.

10.2.4 Desk Study

A review of desk study information has been undertaken to ascertain baseline conditions for the Proposed Development. The findings are presented in Section 10.2.7, which comprised review of the following sources of information:

- Technical reports from the site and from nearby windfarm sites:
  - Environmental Impact Statement for Proposed Clydaghroe Wind Farm (MWP, 2010), Kerry Co. Co. Ref. 1075
    - Appendix 8-C: study area Investigations Database.
    - Appendix 8-I: Ground Investigation Holes and Von Post Results.
- GSI datasets:
  - Bedrock Geology 100k Ireland (ROI) ITM, last updated 16 Dec 2021;
  - Quaternary Geomorphology (Glacial Landforms), last updated 18 Nov 2021
  - Quaternary Sediments 50k Ireland (ROI) ITM, last updated 7 Jan 2022;
  - Groundwater Wells and Springs Ireland (ROI) ITM, last updated 17 Dec 2021;
  - IE GSI Karst Datasets 40k Ireland (ROI/NI) ITM, last updated 9 March 2023;
  - Groundwater Drinking Water Protection Areas Ireland (ROI) ITM, last updated 17 Dec 2021;
  - Group Water Scheme Abstraction Points (NFGWS) Ireland (ROI) ITM, last updated 17 Dec 2021;
  - IE GSI Groundwater Recharge 40K Ireland (ROI) ITM, last updated 10 Mar 2023;
  - IE GSI Groundwater Vulnerability 40k Ireland (ROI) ITM, last updated 10 Mar 2023;
  - IE GSI Subsoil Permeability 40k Ireland (ROI) ITM, last updated 10 Mar 2023;
  - IE GSI Aquifers Ireland (ROI) ITM, last updated 10 Mar 2023
  - Hydrostratigraphic Rock Unit Groups 1:100,000 Ireland (ROI) ITM, last updated 17 Dec 2021;
  - Aggregate Potential Mapping Crushed Rock Aggregate Potential Ireland (ROI) ITM, last updated 20 Oct 2021;
  - Geotechnical study area Investigations Ireland (ROI) ITM, last updated 10 Jan 2022;
  - Landslide locations and extents Ireland (ROI/NI) ITM, last updated 7Jan 2022;
  - Geological Heritage Audited study areas Ireland (ROI) ITM, last updated 28 Jun 2022;
  - Geological Heritage Unaudited study areas Ireland (ROI) ITM, last updated 28 Jun 2022;
- Environmental Protection Agency datasets (EPA, 2020):
  - Irish Soil Information System National Soils Map, dated 29 Sept 2015;
  - Corine Land cover, dated 2018;
  - Waste facilities (ongoing dataset), last accessed 23 January 2024; and
  - Water Flow Network, dated 2015.
- Historical Maps from the OSI – Irish Townland and Historical Map Viewer
  - 6 inch First Edition Black (1845 - 1846); and
  - 25 inch First Edition (Colour, 1894).

10.2.5 Site Walkover and Intrusive Investigation

GDG visited the site on several occasions between March 2021 and October 2022 to conduct site walkovers, peat probing and to supervise on a part time basis the ground investigation works being carried out by subcontractors. The purpose of these site visits and intrusive ground investigations were to inform the desk-based understanding of the baseline ground conditions and land uses at the Proposed Development.

The following intrusive investigation works have been undertaken by the specified GDG engineers to date in accordance with the best practice outlined in BS5930:2015, the primary objective of which was to understand better the depth and key physical characteristics of the peat. The engineers involved were:

- Tomas McGrath and Daniel Murphy, GDG (March 2021): walkover and 33 peat probes.
- Stephen Curtis and Daniel Murphy, GDG (June 2021): walkover and three peat probes at the substation location.
- Brian McCarthy, GDG (March 2022): walkover and 132 peat probes and 17 shear vanes.
- Ground Investigations Ireland (May 2022) with part time supervision by Stephen Curtis: 16 trial pits, 25 Russian core samples, geotechnical testing (including shear vanes, moisture contents, Atterberg limits and particle size distribution) and geo-environmental lab testing of samples for the assessment of phosphate levels in soils.
- Irene Pascual and Chris Engleman, GDG (June 2022): walkover and 48 peat probes.
- Brian McCarthy and Daniel Murphy, GDG (October 2022): walkover and 48 peat probes.

Previous to the Ground Investigations (GI) carried out specifically for the Proposed Development, there was some existing investigation works dated in 2011 available for a proportion of the Proposed Development site, which was received from the Kerry County Council archives and undertaken as part of a previous planning applicationt (Planning Reference Number PL08.236593).

This information has been used to supplement the GDG led investigations, and as the site has not been developed between 2011 to present the data is considered suitable for use in this assessment. This information consists of 91 nr. gouge auger samples carried out as part of a previous planning application and classifies the peat depths and peat characteristics at locations across the Proposed Development site.

In summary, a total of 415 intrusive ground investigation locations were used in the assessment of the site conditions.

The findings of these ground investigations are summarised and interpreted in the following GDG technical reports provided as appendices to this chapter:

- Cummeennabuddoge Geotechnical Interpretive Report (Appendix 10-1);
- Peat Stability Risk Assessment (Appendix 10-2); and
- Peat Management Plan (Appendix 10-3).

10.2.6 Evaluation Criteria for Potential Impacts

During each phase (construction, operation and decommissioning) of the proposed Cummeennabuddoge wind farm development, a number of activities will take place on site which will have the potential to cause impacts on the geological regime at the Proposed Development and the associated soils, geology and hydrogeology.

The methods used for assessment of effects is based on a combination of the '*Guidelines on the Information to be Contained in Environmental Impact Assessment Reports*' published by the EPA (2022), and the '*Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes*' published by the National Road Authority in 2008.

The importance or sensitivity of soil, geological or hydrogeological receptors in the study area will be determined using the criteria set out in Table 10-1**.**

The magnitude of the potential effect will be as described as per Table 10-2, which when combined with the sensitivity of the receptor will allow an assessment of the significance of the effect following the matrix presented in Image 10-1.

The potential impacts of the Proposed Development are discussed in Section **Error! Reference source not found.**. Mitigation measures, where required, are presented in Section 10.6, whilst Residual Impacts are considered in Section 10.7.

Table 10-1:Sensitivity Criteria (following EPA, 2022)

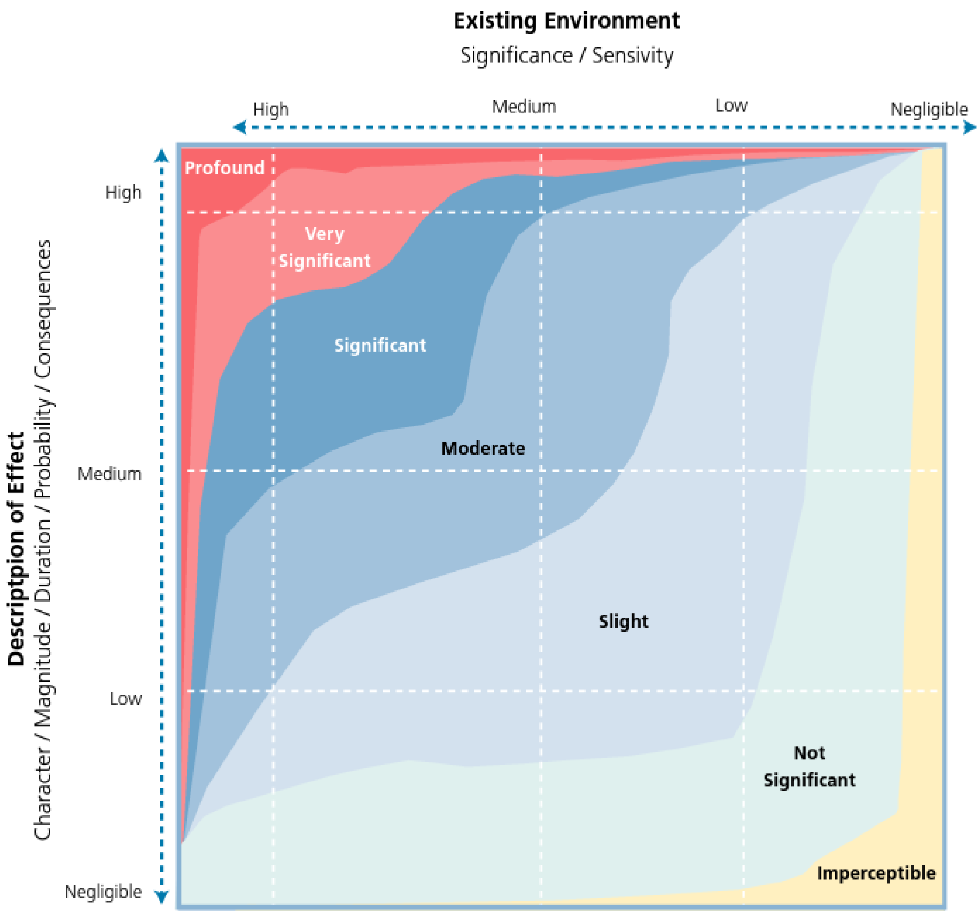
Importance (Sensitivity)	Definition and Examples
High Receptors with a high quality and/ or rarity, regional or national scale and limited potential for substitution/ replacement.	**Geology**: Geological resources (e.g. mineral reserves) within the study area are of very high value and importance (e.g. very rare or valuable minerals).
	Soils: Soils are of very high value and importance, e.g. peat, very highly productive agricultural soils, superficial soils of very high value or geological importance.
	Hydrogeology: Hydrogeological catchment area is of very high value and importance i.e. provides river baseflow and is used extensively for private and public water supplies, e.g. groundwater abstractions for public or private drinking within 0-250m of the Proposed Development site (greater than 1m depth excavations) or within 0-100m (excavations less than 1m depth), groundwater typically also has a vulnerability classification of Extreme.
Medium Receptors with a medium quality and/ or rarity, local scale and limited potential for substitution/ replacement or receptor with a low quality and rarity, regional or national scale and limited potential for substitution/ replacement.	**Geology**: Drift and solid geology underlying the Proposed Development is within a designated area and is of rare or of national importance. Geological resources (e.g. mineral reserves) within the study area are of high value and importance.
	Soils: Soils are of high value and importance, e.g. carbon rich soils, highly productive agricultural soils.
	Hydrogeology: Hydrogeological catchment area is of high value and importance i.e. provides baseflow to rivers, supports highly sensitive Ground Water Dependent Terrestrial Ecosystems (GWDTE) or used for local private water supplies, e.g. groundwater abstractions for private supply within 250m of the Proposed Development site (greater than 1m depth excavations) or 0-100m (excavations less than 1m depth). Groundwater typically also has a vulnerability classification of High.
Low Receptors with a low quality and/ or rarity, local scale and limited potential for	**Geology**: Drift and solid geology underlying the study area is not within a designated area and deposits are of medium value and importance. Geological resources (e.g. mineral reserves) within the study area are of medium value and importance.

Importance (Sensitivity)	Definition and Examples
substitution/ replacement or receptor with a negligible quality and rarity, regional or national scale and limited potential for substitution/ replacement.	**Soils**: Soils are of medium value, e.g. productive agricultural soils.
	Hydrogeology: Hydrogeological catchment area is of medium value and importance and is not generally used for public or private water supplies. Groundwater supports medium sensitivity GWDTE's. Groundwater typically also has a vulnerability classification of Moderate.
Negligible Receptors with a negligible quality and/ or rarity, local scale and potential for substitution/ replacement. Environmental equilibrium is stable and is resilient to changes that are greater than natural fluctuations, without detriment to its present character.	**Geology**: Drift and solid geology underlying the Proposed Development site is not within a designated area, and deposits are of low value and importance. Geological resources (e.g. mineral reserves) on the Proposed Development site are of low value and importance.
	Soils: Soils are of low value and importance, e.g. general superficial soils of low value or geological importance.
	Hydrogeology: Hydrogeological catchment area is of low value and importance and is not used for public or private water supplies. Groundwater typically also has a vulnerability classification of Low.

Table 10-2: Criteria for Rating Magnitude of Effects (following EPA, 2022)

Magnitude of Impacts	Criteria
High Adverse	Results in loss of attribute, i.e. long term, permanent change to receptors resulting from activities associated with the Proposed Development, e.g. major changes to the hydrogeological regime or complete loss of soil / carbon resource.
Medium Adverse	Impacts integrity of attribute or results in loss of part of attribute, i.e. short to medium term change to receptors resulting from activities associated with the Proposed Development, e.g. non-significant alteration to the hydrogeological regime or substantial loss of soil / carbon resource.
Low Adverse	Results in minor impact on attribute, i.e. detectable but non-material and transitory changes to receptors resulting from activities associated with the Proposed Development, e.g. minor alteration to the hydrogeological regime or minor loss of soil / carbon resource.
Negligible	Results in an impact on attribute but of insufficient magnitude to affect the use/integrity, i.e. negligible changes to receptors resulting from activities associated with the proposed development.

Image 10-1: Criteria for Determining Significance (taken from EPA, 2022)



10.2.7 Consultation

A programme of consultation was undertaken on an Environmental Impact Assessment Scoping Report prepared by Atmos Consulting Limited ('Atmos') in relation to the Proposed Development. See Chapter 2 EIA Approach and Methodology for further detail.

Comments relevant to this chapter are summarised in Table 10-3.

Table 10-3: Consultation Responses

Consultee	Consultee Comments during EIA Scoping	Addressed within the Chapter
Environmental Protection Agency (EPA)	No response was available at the time of reporting with regards to Soils, Geology and Hydrogeology	N/A

Consultee	Consultee Comments during EIA Scoping	Addressed within the Chapter
Inland Fisheries Ireland (IFI)	No physical interference with watercourses without consultation and no use of watercourses as mitigation measures Protection of water courses during construction Consultation on watercourse crossings	Refer to EIA Chapter 12 on hydrology. Section 10.3.4 presents a summary of baseline information on hydrogeology and subsequent potential effects on surface waters.
Kerry County Council (Kerry Co.Co.)	Concern over water quality impacts Discussion to be included at a pre-planning meeting	Refer to Section 10.3.4 for baseline information on hydrogeology. Potential effects on surface waters are assessed in Chapter 11: Hydrology.
Cork County Council (Cork Co.Co.)	Confirmed approach is acceptable	N/A
Geological Survey Ireland (GSI)	Use publicly available GSI datasets Consider potential impact on specific groundwater abstractions and on groundwater resources Identify areas of high to extreme groundwater vulnerability The Landslide Susceptibility map indicates areas of 'Moderately High' to 'High' landslide susceptibility Post consent instructions and guidance	Refer to Section10.3 for baseline information on hydrogeology, including resources and vulnerability, and regarding potential landslide risk (particularly in relation to peat) and Section 10.4 for consideration of potential effects.

10.3 Baseline Conditions

10.3.1 Topography, Setting and Land Use Study Area Description

The Proposed Development site, comprising the access track from the N22, the main site body, and the grid connection route, currently consists of coniferous plantation with existing forestry tracks traversing the Proposed Development site, and localised areas of cut forest. The access route is to extend from the N22 to the west and partially uses existing forestry tracks. The grid connection route follows an existing track before diverting through rough undeveloped hillside and into agricultural fields, alongside a rough farm track.

This assessment does not include consideration to the Turbine Delivery Route, as there are no earthworks proposed to facilitate delivery.

There are numerous watercourses flowing south to north across the Proposed Development site into the Clydagh River, which flows outside of and along the northern site boundary. The Clydagh River flows westwards into the River Flesk, which ultimately discharges into Lough Leane, approximately 25km to the west of the Proposed Development site.

There are no large waterbodies within the Proposed Development site, however Lough Carrignamork and Lough Gal are located approximately 20m and 150m respectively to the south (uphill) of the Development study area.

The topography of the study area typically slopes down from the southern boundary (maximum approximately 520m AOD) to the northern boundary (at approximately 300m AOD) with the Lackabaun and Mullaghanish mountain peaks located to the south of the site.

The majority of the central section of the study area is located between 300-400m AOD, and the watercourses cut largely south to north, creating a ridge and shallow valley system. Lower elevations are observed in the west of the site where the access track join from the N22, which is at approximately 270m AOD. The tracks within 1.5km of the N22 are steep, climbing from an elevation of 270m AOD to approximately 380m AOD.

Existing wind farms are present to the north, south and east of the Proposed Development. In addition, the study area is surrounded by other forestry sites and areas of historic and active peat cutting activities, with evidence of peat harvesting located adjacent to the south-west of the main Proposed Development site.

A map showing contours, watercourses and other key features is shown in Figures 10-1a to 1c.

10.3.2 Overburden Geology

Superficial Geology

GSI mapping of superficial geology within the Proposed Development boundary and surrounding area is shown in Figures 10-2a to 10-2c.

According to the GSI's quaternary sediments mapping (1:50k), the majority of the study area is predominantly underlain by blanket peat. Teagasc soil classification, obtained from the GSI's online map viewer, confirms that the majority of the Proposed Development is underlain by blanket peats.

The south of the study area contains some soils classified as podzols (peaty), lithosols, and peats. The depth and extent of peat deposits may vary over short distances as a function of local underlying geology, past and ongoing geomorphological progression and management history. Peat is discussed in further detail below.

Undifferentiated alluvium is mapped along some of the hillside streams within the Proposed Development, and along the River Clydagh adjacent to the north of the site. It is expected that some form of alluvium would be present adjacent to most of the watercourses that cross the site.

Two small areas of glacial till, derived from Devonian sandstones, are mapped along the northern boundary of the study area. Turbine 8 (T8) is underlain by till according to the maps, however probing in this area identified peat between 0.5m and 1.0m in depth, indicating that, if present, the till is beneath peat.

A significant thickness of peat (4.14m) was recorded 225m to the south-east of T8, indicating that there may be thicker bogs in the wider area.

Glacial till is shown on the mapping to be present along the final 500m of the proposed cable route to the east, and along the majority of the first 1.6km of the proposed site access track route. Glacial till typically comprises a heterogenous mix of sand, gravel, cobbles, and boulders, usually held in an over consolidated clay matrix.

An area where bedrock is at or near the site surface is shown in the south-east corner of the study area, with larger areas of bedrock shown in the upland areas to the south and southeast of the development boundary, and to the south of the majority of the eastern cable route. The thickness of superficial soil along the cable route is therefore predicted to be minimal.

Full results of ground investigations carried out at the study area as part of this project are outlined in the Geotechnical Interpretive Report prepared by GDG (Appendix 10-1).

Results generally show agreement with the GSI mapping data and indicate the ground model for the study area can be characterised as peat, overlying an orange to grey sandy gravely clay and silt, overlying dark brown slightly sandy clayey gravel with cobbles and occasional boulders. These materials are interpreted as glacial till, whilst in many cases the cobbles and boulders at depth are likely to be weathered bedrock.

Peat

Characteristics

Peat probing, shear vane testing, Russian coring, trial pitting and geomorphological mapping was carried out during intrusive GI (Appendix 10-1). Further information is provided in the Peat Management Plan (Appendix 10-3).

In summary, peat thickness encountered by intrusive investigations across the study area varies from 0m to a maximum of 5.4m (along the access road from the N22), often displaying sharp variation locally.

The depths encountered are considered to be moderate to deep in places: with approximately 57% of locations indicate a peat thickness of greater than 1m. Approximately 84% of locations were identified to have peat thickness less than 2m, and the remaining locations, 16%, identified deeper than 2m.

Peat depth was measured at 415 soil survey locations, which was used to create a peat depth map (included in Appendix 10-3), with the following trends observed regarding the main body of the Development site:

- South-west: Peat generally between 1.5m-2.0m, with localised instances of both thicker and thinner peat deposits. Maximum thickness 3.4m noted in an area of flatter topography.
- North-west: Majority of this area has peat deposits less than 1.5m thick, with peat less than 1m in the north-western-most corner. Localised instances of peat between 1.5m and 2.0m thickness.
- Central: Peat thickness generally less than 1.5m thickness, with a zone of thicker peat encountered moving eastwards. Peat generally remains less than 2.0m thick, with localised instances of thicker peat. Maximum thickness of 4.14m encountered, however no development is proposed in this area.
- North-east: Varied peat thickness, generally between 1.0m to 2.0m. Localised instances of both thinner and thicker peat, with a maximum of 3.6m measured.
- South-west: Peat thins towards the southern boundary from about 1.5m to less than 0.5m.

The composition of the peat is described in the trial pit logs (Appendix 10-1). These indicate a large level of variation in the peat body composition across the site, with no typical trend or succession in the peat layering. The peat is predominantly described as fibrous to pseudo fibrous with varying conditions between firm, spongy and plastic. The degree of humification (Von Post scale, a numerical rating outlining the level of decomposition in the peat) in the peat ranges between “insignificant” (H2) to “moderately strong” (H6), generally increasing in degree of humification with depth.

In the context of peat, humification involves the gradual transformation of plant material into peat through the activity of microorganisms in waterlogged and acidic environments. The process is typically slow due to the anaerobic (low-oxygen) conditions in waterlogged areas, which slow down the decomposition of organic matter.

Over time, the partially decomposed organic matter undergoes further chemical and microbial transformations, leading to the formation of humus. Humus is a stable, organic material that gives peat its characteristic dark colour and spongy texture. As more and more plant material undergoes humification, peat accumulates. Peat is essentially a result of the incomplete decomposition of plant material in waterlogged conditions.

During peat probing and Russian coring activities a firm layer of peat material was typically identified at the ground surface ranging in thickness up to 0.7m. This material is likely the ‘live peat’ which contains growing roots and grass material, which provide strength to the peat.

Shear vane tests were carried out at all the proposed turbine locations at 0.5m and 1m below ground level (bgl). The shear strength at 0.5m bgl ranged between 9kPa and 33kPa. The shear vane at 1.0m bgl ranged between 10kPa and 32kPa.

Considering the variation identified in the peat it is difficult to quantify the acrotelmic and catotelmic material of the peat body, but the Peat Management Plan concludes that all material at a depth of 0.6m and above is acrotelm (inclusive of ‘peaty soils’).

Stability

A Peat Stability Risk Assessment (GDG, 2023) is presented in Appendix 10-2, which assesses the risks posed by peat failures, based on the following steps:

- A desk study;
- Site walkover and field work;
- Stability analyses and a risk assessment; and
- Proposals for actions for the proposed development.

The methodology followed the principles in the guidance document Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (Scottish Executive, 2017).

The peat stability assessment was undertaken on the assumption that the peat strength across the entire site is 5kPa, which is conservative considering shear vanes at the turbines showed shear strength of the peat ranged up to 32kPa which is considerably higher with regards peat strength.

The PSRA provides an overview of historical peat landslides in Ireland, and their causes (where known). The closest landslide event identified is a set of three localised landslide events mapped as part of the GSI landslide inventory (GSI, 2022).

These landslide event occurred on occurring on steep ground on the opposite side of the Clydagh River, approximately 100m north of the Proposed Development red line boundary and 350m from the nearest Proposed turbine T13.

The geometry of the landslide event suggests that the slide is shallow likely less than 1m, potentially a debris slide more-so than a peat slide, disturbing the rock or mineral soils on the steep ground of the valley wall. The landslide is located at the maximum erosive face of the river (external side of the river's curvature).

Due to the elongated landslide morphology and its location relative to the river, the soil at the toe of the slope was likely eroded by the river, causing the instability of the slope and, hence, the landslide.

Further information on other notable slides in Ireland are provide in Table 10-4.

Table 10-4: Notable Historical Peat Landslide Events in Ireland

Event Location	Date	Failure Type	Slope (degrees)	Contributing Factors
Slieveanorra, Co. Antrim	25/08/2020	Slide	Unknown	**Intense rainfall** triggering an area of repeated historical slides.
Meenbog wind farm, Co. Donegal	13/09/2020	Slide	1-3.8	Over surcharging of deep area of peat during access track construction for a wind farm development, i.e. **inappropriate construction practice.** The surcharge triggered a preceding failure at the site.
Derrybrien wind farm, Co. Galway	16/10/2003	Slide	8 - 10	**Inappropriate construction practices** during wind farm construction leading to over surcharging of in-situ peat at a hardstand excavation for a wind farm development.
Shass Mountain, Co. Leitrim	28/06/2020	Slide	3-6	Period of dry weather followed by **heavy rainfall.**
Pollatomish, Co. Mayo	19/09/2003	Slide	30-60	A prolonged period of warm and dry weather following by an **intense rainfall** over short period of time. Highly impermeable rock enables sub-peat flow of water (i.e. a slip surface). Triggered over 40nr. peat slides.
Ballincollig, Co. Kerry	22/08/2008	Flow	3	Long period of **extended rainfall** triggered areas of intense peat harvesting.
Clare Island, Co. Mayo	14/12/2006	Unknown	Unknown	Extended period of very **heavy rainfall**.

Shear strength has been studied on various sites where peat failure has occurred around the country and where information is available. Two of the sites below are referenced in the table above (ie. Derrybrien and Ballincollig);

- Maghera Mountain (35,000m^3 bogflow) – range in the acrotelm (upper peat) 2.9kPa -7.6kPa
- Croaghan peat slide - <5kPa
- Garvagh Glebe wind farm peat failure – 2kPa to 4kPa
- Derrybrien wind farm peat slide – 2.5kPa
- Ballincollig Hill peat slide – 2.5kPa to 6kPa (catotelm) and 5kPa to 40kPa (acrotelm)

Generally, the peat strength at the turbine locations indicates that the peat is of higher strength than as observed at these other sites where peat failure has occurred.

On the basis of the table above, the most common trigger mechanisms for notable peat landslides in Ireland include one or more of the following:

- **Human interaction**: Poor/inappropriate/inconsiderate construction, industrial or agricultural practices influence on the environment triggering a peat slide event.
- **Weather**: prolonged or intense periods of rainfall, particularly after dry weather.
- **Terrain and slope**: Peat slides recorded occurring at slope angles of 3° up to 60° with steeper slopes being more susceptible to slippages.

Full details of the process and findings are presented in Appendix 10-2, however in summary it concluded that significant peat slides are unlikely on the site with diligent peat management and careful consideration of the peat conditions at the site at the design and construction stage. The results of the assessment can be summarised as follows;

- The Proposed Development was found to have acceptable factors of safety and levels of risk against peat instability, even whilst using the low-end 5kPa shear strength value. Therefore the peat stability risk with regards the proposed infrastructure ranges between negligible and low.
- The results of the factor of safety deterministic calculation and the site walkover allowed for the identification of:
  - 'Safety buffers' areas used during the development layout design for the avoidance of identified risks and spatially calculated risk potential (see Appendix L of the PSRA).
  - 'Peat stockpile restrictions' (PSR) areas have been highlighted as not suitable for side casting or stockpiling of peat or soils (see Appendix L in PRSA). These areas are considered to potentially have a landslide hazard when considered to have a material surcharge but are considered safe for construction in their natural state and without the addition of a vertical surcharge by addition of peat or spoil material. As a result no peat or spoil material shall be places or reinstated within these areas.
- While the study area is in a region of high rainfall and relatively steep topography, there is no record of past landslide events from the national landslide database or the desk study directly within the Proposed Development area. There was also no evidence of peat slides observed during the various walkovers. This is further summarised in the PSRA (Appendix 10-2).
- Overall, the PSRA concluded that outside of the scheduled restriction areas the areas, the Proposed Development is considered to have a low landslide risk and is safe for construction provided all works comply with the methodologies and mitigations outlined in the associated Peat Management Plan (PMP), and consequently the site is suitable for the proposed wind farm development.

Soil Contamination

There are no known areas of significant potential soil contamination within the study area based on current site activities and a review of historical mapping.

According to the EPA online mapping regarding licenced waste facilities and IPPC licenced facilities, there are no licenced waste facilities within the study area, or within 10km of the study area boundary.

No evidence of obvious soil contamination was noted during site walkovers or intrusive investigations conducted by GDG staff.

However, it is understood that phosphate fertilisers are commonly used in upland forestry operations. Consequently, as part of the intrusive investigation and interpretative report, a geoenvironmental testing suite was scheduled on samples to assess the phosphate levels of the shallow soils. All samples were of soils between 0.1m and 0.5m depth. Results of the testing are summarised as follows:

- Phosphorus levels ranged between 199mg/kg and 468mg/kg (6 samples);
- Orthophosphate levels range between <0.3mg/kg (i.e. less than the limit of detection) and 28.1mg/kg (6 samples); and
- Available phosphorus (index) in the soils tested range between 5.8mg/l and 21.4mg/l (6 samples).

These results are indicative of marginally elevated concentrations, but at the lower end of the typical range of concentrations compared to agricultural soils (Developing a National Phosphorus Balance for Agriculture in Ireland, EPA 2021). Therefore, there is considered to be a low risk of contamination associated with soils within the study area.

10.3.3 Bedrock Geology

Bedrock Units

The Geological Survey Ireland (GSI) 100k bedrock mapping identifies two main lithologies within the study area boundary.

The study area is underlain by the Glenflesk Chloritic Sandstone Formation which is an Upper Devonian (Frasnian) age sandstone & siltstone, which is part of the Old Red Sandstone sequence. The lithology is characterised by green, mostly medium-grained sandstone, conglomerate and pebbly sandstone, together with green and purple siltstone.

South of the southern boundary the Gun Point Formation is mapped, which is also Upper Devonian (Famennian) in age, but younger than the Glenflesk sandstone.

The Gun Point Formation consists of green-grey to purple, medium to fine-grained sandstones (locally pebbly), interbedded with green and red to purple siltstones and fine sandstones. This rock may be present on site however based on mapping it would not be expected to be extensive.

As noted in the GIR (Appendix 10-1), depth to bedrock ranges from at/near surface to greater than 5 m below ground level. As mentioned previously there is expected to be rock exposure along the south-eastern boundary and adjacent to the proposed cable route to the east of the main Development site body.

The key bedrock units and their structural features within the Proposed Development boundary and surrounding area is shown in Figures 10-3a to 3c.

Structural Geology

The geological structure of the rock that lies beneath the study area and surrounding landscape exhibits signatures of historical compression, with forces appearing to be roughly applied from the SSE and NNW, on the basis of synclines and anticlines, and thrust faulting noted on the 1:100k GSI mapping.

Anticlinal axes are present to the north of the study area on the northern side of the Clydagh River, with the main fold axis trending from WSW to ENE.

Secondary faulting is mapped within the site, with primary thrust faulting mapping to the north.

The secondary faults, associated with compression of the landscape, likely caused vertical movement of strata, however it is evident that movement was predominantly strike-slip in nature, based on the displacement observed adjacent to the faults of the overarching fold structures and boundary between the Glenflesk Chloritic Sandstone and the Gun Point Formation.

The Glenflesk Chloritic Sandstone Formation is mapped as dipping towards the south-east across the study area. Dip is recorded as approximately 46° in the western portion of the Proposed Development area. Dip is steeper in the eastern portion of the site area at 62°, whilst at the eastern edge of the Proposed Development where the proposed cable route begins the dip is shallower at 30°.

The Gun Point Formation dip also varies but is not pertinent to the study area, as although it will be present above the Glenflesk sandstone, the dip of the strata is expected to vary given that folding is prominent in the wider area.

Foliation of the Glenflesk sandstone strata is recorded as 53° in the west, and 74° in the eastern half of the study area.

10.3.4 Hydrogeology

Groundwater Bodies

According to GSI's groundwater map viewer, the majority of the Proposed Development Site overlies the Cahersiveen GWB (Groundwater Body), and the grid connection to the east crosses through the Ballinhassig West GWB. Groundwater bodies within the Proposed Development boundary and surrounding area are shown in Figures 10-4a to 4c.

Cahersiveen Groundwater Body

The Cahersiveen GWB comprises an area of 850km^2. It occupies uplands, slopes, sea cliffs and coastal sections on the Iveragh Peninsula. It is elongated east-west along the north side of the ridge formed by the Macgillycuddy's Reeks Mountains. The topography of this body is mountainous, with ground level continually rising from the coast to the highest elevations in the south and east of the body (GSI, 2004a).

The principal aquifer lithology in which the groundwater body resides is the Devonian Old Red Sandstone (ORS) (of which the Glenflesk sandstone is a part) which can be up to several kilometres thick in this region. These rocks typically have no intergranular permeability; groundwater flow occurs in fractures and faults.

The permeability in rock is generally highest in the upper few metres due to weathering, but generally decreases rapidly with depth as weathering decreases. In general, groundwater flow is concentrated in the upper 15m of the aquifer. The main discharges are to the rivers and streams via small springs and seeps.

The Cahersiveen GWB is currently designated as "Good" environmental status and is not considered an "At Risk" groundwater body under the Water Framework Directive (WFD) 3rd cycle assessment.

Ballinhassig West Groundwater Body

The greater Ballinhassig GWB (which comprises the Ballinhassig East and West GWBs) comprises an area of 1762km^2. The Ballinhassig West GWB occupies the uplands of the Lee catchment. Topography is very rugged in the west, encompassing the Sheehy, Derrynasaggart and Boggeragh mountains. Ground elevation rises to over 500m OD (GSI, 2004c).

The groundwater body primarily resides in the Devonian ORS and Dinantian Mudstones & Sandstones (Cork Group) which have low transmissivity and storativity, although localised zones of enhanced permeability occur along fault zones. The Glenflesk sandstone which lies beneath this area is therefore likely to contain the Ballinhassig West GWB, as part of the ORS sequence.

Flows in the aquifer are generally concentrated in a thin zone at the top of the rock (15 – 20m), although deeper groundwater flows along faults and major fractures (GSI, 2004c). None of these faults are located at the Proposed Development. The main discharges are to the gaining rivers and streams crossing the sandstones and mudstones (GSI, 2004c).

Flow path lengths are generally short, ranging from 30-300 m. Local groundwater flow directions are controlled by local topography (GSI, 2004c).

The Ballinhassig West GWB is currently designated as "Good" environmental status and is not considered an "At Risk" groundwater body under the Water Framework Directive (WFD) 3rd cycle assessment.

Bedrock Aquifers

The bedrock aquifer type within the Proposed Development boundary and surrounding area is shown in Figures 10-5a to 5c.

According to GSI's groundwater map viewer, the Proposed Development is underlain by a Locally Important (LI) aquifer. This is defined as 'Bedrock which is Moderately Productive only in Local Zones'. Locally important aquifers are generally capable of yielding enough water to supply single domestic wells only (10-20m^3/d), (GSI, 2017).

Bedrock is anticipated to consist of a limited and relatively poorly connected network of fractures, fissures and joints, giving a low fissure permeability which tends to decrease with depth (GSI, 2017).

It is noted by the GSI that the Cahersiveen GWB is "poorly productive", as are the neighbouring GWB's. It is typical that a shallow zone of higher permeability may lie within the top few metres, comprising more fractured/weathered rock, particularly where bedrock is outcropping on site. Hydraulic properties for the Glenflesk Chloritic Sandstone Formation are outlined in the table below.

Table 10-5: Bedrock Hydraulic Properties

Bedrock unit name	Rock Unit Group	Aquifer type	From Kelly et al, 2015			
			Best estimate transmissivity (m2/d)	Transmissivity range (5th—95th%ile) (m2/d)	Geometric mean of Storativity (-)	Geometric mean of Specific yield (-)
Glenflesk Chloritic Sandstone Formation	Devonian Old Red Sandstones	LI	5	0.7 - 75	2.6 x10-4 (0.00026)	1.7 x10-2 (0.017)

Subsoil Permeability

The majority of the Proposed Development is underlain by 'Moderate' subsoil permeability. Sections of the southern boundary and southeast are currently 'Not Assigned' due to assumed low depth to bedrock and sections of bedrock outcropping.

There are no sand and gravel aquifers within the Proposed Development boundary or in the vicinity, although it is possible that localised perched groundwater is present within granular layers and lenses within the glacial till and alluvial soils. Subsoil permeability within the Proposed Development boundary and surrounding area is shown in Figures 10-6a to 6c.

Groundwater Vulnerability

Groundwater vulnerability in Ireland, as defined in the Water Framework Directive – Recharge and Groundwater Vulnerability, is a function of the thickness and permeability of the subsoil that overlies bedrock. These factors strongly influence the attenuation processes and the time it takes for contamination to be released into the subsurface.

Groundwater vulnerability classifications within the Proposed Development boundary and surrounding area are presented in Figures 10-7a to 7c.

The majority of the Proposed Development exhibits 'Moderate' to 'High' degrees of groundwater vulnerability. Vulnerability transitions gradually from 'Moderate' to 'High' and eventually 'Extreme' and 'X-Extreme' (where rock is at or near the surface) from the centre to south of the Proposed Development.

This reflects the wider trend of higher expected groundwater vulnerability due to the anticipated reduction in depths-to-bedrock within the South Kerry Mountains geomorphic region (GSI, 2012).

Due to the localised variability on-site, pre-development vulnerability observed at individual WTGs and other infrastructure such as borrow pits, site compounds and peat storage areas will vary depending on location.

Based on the site walkover, ecological surveys and likely shallow groundwater regime, extensive sensitive GWDTE are considered unlikely across the site, although localised areas of groundwater dependant flora are possible associated with springs and flushes. Full review of the ecological baseline within the site, including the distribution of GWDTE, and an associated impact assessment are presented in Chapter 8 – Biodiversity.

Karst Risk Assessment

There are no bedrock karst features located within the Proposed Development boundary, as would be expected given the absence of bedrock comprising calcium carbonate beneath the site.

The closest karst feature is over five kilometres to the northeast of the Proposed Development. This is a groundwater spring located on the boundary between the Glenflesk Chloritic Sandstone Formation and Dinantian Limestones.

There is assessed to be low likelihood of bedrock karstification present on-site given the absence of carbonate rock.

10.3.5 Groundwater Wells and Abstractions

There are no listed Public Water Supplies, Group Water Schemes or Source Protection Zones located within the Proposed Development boundary.

There is one public abstraction noted approximately 8km to the southwest of the Proposed Development. It is a Group Water Scheme (Carraignadoura GWS) providing yields of approximately 182 m^3/day (EPA, 2010).

With reference to the GSI Groundwater Wells and Abstraction database, there are seventeen groundwater wells recorded within 5km of the Proposed Development boundary with the closest approximately 1km to the south of the access track, on the other side of a hill adjacent to the N22.

These wells are of poor yield at less than 50 m^3/day. No wells are recorded as providing a high yield. These are all separated from the site topographically or by large watercourses, and consequently none of the wells are likely to be in hydrogeological continuity with groundwater beneath the site.

There are unlikely to be unlisted wells within the study area, however if present, any yields would likely be low given the low permeability of the aquifer.

There are few properties in the vicinity of the site, with the nearest being one adjacent to the track at the western end of the site, and another on the other side of the Clydagh River, so in the unlikely event that these have unrecorded groundwater abstractions, potential impacts are unlikely due to hydrogeological connection to works that might impact them.

Accordingly groundwater abstractions as a specific receptor will not be considered further.

10.3.6 Geological Heritage

The GSI Geological Heritage database shows that there are currently no areas of geological heritage situated within, or within 5km of the Proposed Development boundary.

The closest (unaudited) Geological Heritage site is located approximately 5km to the east of the Proposed Development. This is known as “Killeen” and is a rhyolite complex, part of the Lough Guitane intrusions. It is designated within the County Geological study areas (CGS) for Kerry.

10.3.7 Economic Geology

According to the GSI online minerals data viewer, there are no active quarries or mineral occurrences within the Proposed Development boundary. One historical sand and gravel pit is located approximately 3km to the east at Carriganimmy.

Although not recorded in the GSI dataset, there is a historical pit present adjacent to the proposed T10 location. This was observed during the walkover in March 2021, with images from that visit provided in Figure 10-1 and Figure 10-2. It is evident from observing this area that granular Till, rather than rock, was present here. No works at this location are proposed as part of the Proposed Development.

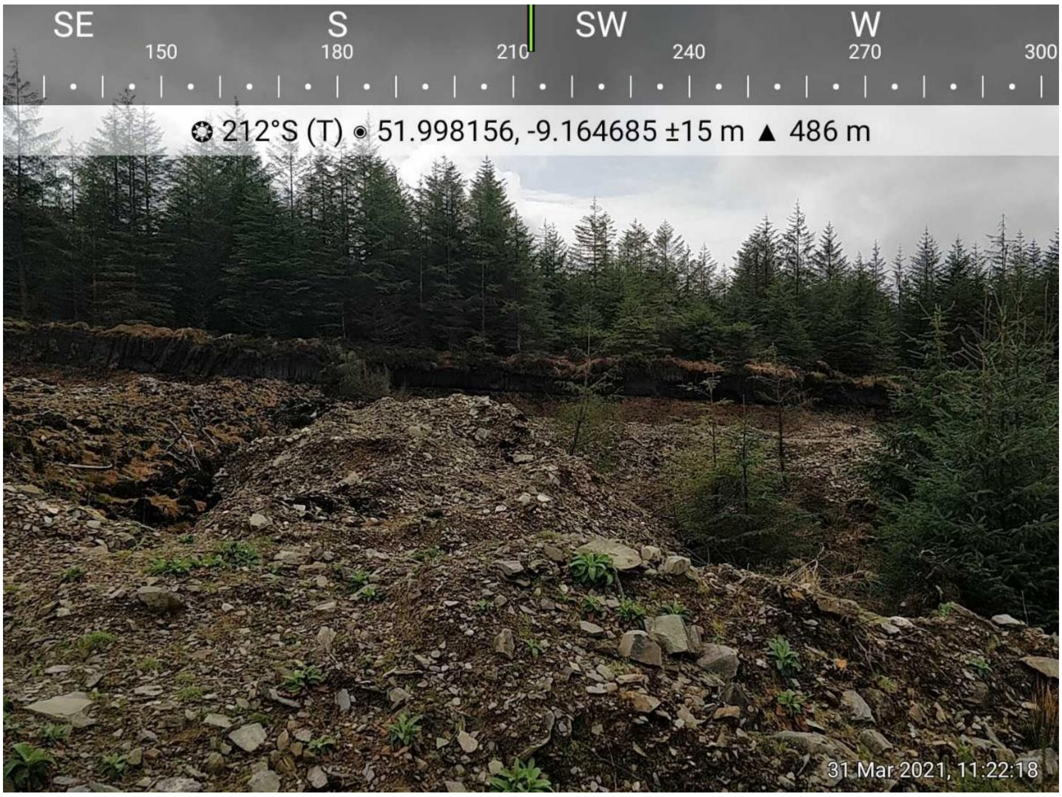


Figure 10-1 Overview of existing borrow pit adjacent to T10

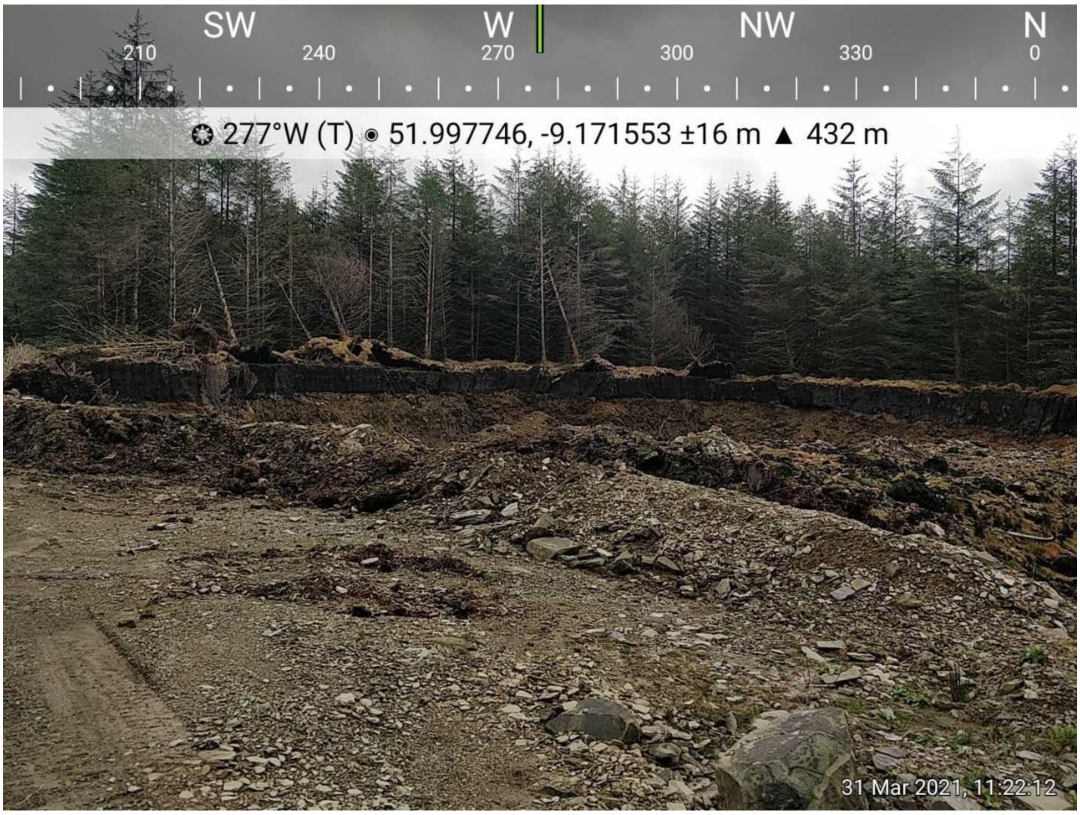


Figure 10-2 Overview of existing borrow pit adjacent to T10

Localised peat harvesting is evident adjacent to the south-western corner of the main body of the Proposed Development site on review of aerial imagery. Imagery does not show any peat harvesting within the study area.

The GSI aggregates database indicates very low to low potential for granular aggregate beneath the entirety of the Proposed Development boundary and surrounding area.

The GSI aggregates database indicated that the majority of the area has low potential for crushed rock aggregate. This transitions from low to moderate potential in the southern and south-eastern fringes of the Proposed Development boundary.

It should be noted that this is likely a reflection of the potentially moderate to high peat thicknesses prohibiting extraction, rather than a reflection of the rock quality for use as crushed aggregate.

There are localised areas of high potential crushed rock aggregate to the east and north-east of the development, crossed by the access route to the east and associated with the Glenflesk Chloritic Sandstone Formation therefore the use of borrow pits is deemed viable to provide aggregate to the Proposed Development.

10.3.8 Summary of Baseline Conditions

A review of desk study information on the Proposed Development indicates the majority of the Proposed Development is covered by glacial till overlain by blanket peat, and with localised alluvial soils associated with watercourses.

Peat is present across large parts of the site, generally between 1-2m thick, and up to 5.4m very locally (5.4m noted along the access track between the main turbine area and the N22). Peat landslide has been found to be a low risk in the study area, although areas where construction traffic and stockpiling should be prohibited have been identified (outside of the Proposed Development infrastructure footprint, but within the study area).

Bedrock comprises Upper Devonian sandstone & siltstones belonging to the Glenflesk Chloritic Sandstone, which is classified as a Locally Important aquifer, and holds the Cahersiveen and Ballinhassig groundwater bodies.

On the basis of moderate subsoil permeability of varied thickness, with bedrock at or near surface (particularly in the southern high points of the site), the majority of the groundwater on site is classified as highly vulnerable, although vertical groundwater migration is likely to be inhibited by the presence of glacial till and peat across the majority of the site.

It is considered unlikely that there are any extensive sensitive Groundwater Dependent Terrestrial Ecosystems (GWDTE) within the Proposed Development (see Chapter 8 – Biodiversity for further details).

There are no recorded geological heritage sites in the site, there is no karst present, and generally a very low to low potential for granular aggregate extraction on site, likely given the presence of peat on site which would limit extraction under normal circumstances.

There are no likely historical sources of significant contamination within the site, other than the possible use of phosphate fertilisers associated with the forestry use.

10.3.9 Sensitivity of Potential Receptors

A number of sensitive receptors in the geological and hydrogeological environment have been identified during assessment of baseline conditions. Receptor sensitivities are presented in Table 10-6, which have been assigned following the criteria detailed in Table 10-1.

Table 10-6: Receptor Sensitivity

Receptor	Sensitivity	Discussion
Soils (excluding peat)	Negligible	Peat soils across the site are generally expected to be underlain by glacial till, with localised alluvial soils associated with watercourses. Considering their low agricultural value and low geological importance, the sensitivity of the glacial till and alluvial soils is considered to be low.
Peat (resource)	High	Peat is present across large parts of the site at thicknesses of up to 5.4m, with more than half of the investigation locations recording thick peat (i.e. greater than 1.0m).
Peat (stability)	High	The peat stability risk with regards the proposed infrastructure locations ranges between negligible and low. However, the results of the risk assessment identified designated areas, referred to as 'safety buffers' that were used for avoidance of risk during the layout design of the Proposed Development . In addition to this, smaller peat stockpile restriction areas have been highlighted as not suitable for side casting or stockpiling of peat or soils and no peat and spoil will be placed or stored in these areas as part of the Proposed

		Development.
Geology	Low	Upper Devonian sandstone & siltstones of low geological value, no designated geological sites, economic geological resources or carbonate rock within the proposed development.
Hydrogeology	Medium	While the bedrock aquifer is only productive in local zones, it is considered to be of high value as it provides baseflow to rivers and there are substantial areas of the site where the groundwater vulnerability is High. It is considered unlikely that there are any sensitive Groundwater Dependent Terrestrial Ecosystems on or in the vicinity of the Proposed Development, and there are no public or private groundwater abstractions in hydrological continuity.
Contamination	Low*	There are no likely historical sources of significant contamination within the site, other than the possible use of phosphate fertilisers associated with the forestry use, and consequently the sensitivity associated with contamination in relation to soils, geology and hydrogeology is considered to be low.

*Risks to the surface water environment from phosphates are considered further in Chapter 11.

10.4 Predicted Effects

10.4.1 Do Nothing Scenario

Were the Proposed Development not constructed at the site, there would be no changes made to existing land-use, therein commercial forestry would continue undisturbed.

The land, soils and geology would remain generally unchanged as a result of the Do-Nothing scenario, with forestry continuing as it does today; felling of sub compartments once mature with re-planting with more coniferous trees thereafter. Soils will be cyclically exposed to Plantations may be reploughed and fertilised with phosphates where necessary to facilitate afforestation.

10.4.2 Proposed Development

The proposed development infrastructure is detailed in Chapter 4, but in short comprises the construction of 17 wind turbines and associated hardstand areas, an electrical substation, control building, electrical connections, met mast, upgraded tracks, peat repositories and borrow pits. Felling of existing forestry and additional temporary works will be required to enable development to commence.

During each phase of the wind farm development (construction, operation, and decommissioning), activities on-site may have the potential to impact the soils, geological and hydrogeological environment at the Proposed Development and surrounding area. Specific effects related to each phase of wind farm development are therefore outlined in the below section.

10.4.3 Construction and Operational Phase Effects

Activities

The construction phase is expected to take 24 months and the operational phase will be 35 years. As there is considerable overlap in the potential effects of the construction and operational phases of the development (for example effects associated with the temporary and permanent excavation and storage of peat), they are discussed together in the following subsections.

The activities associated with the proposed development which could give rise to potential effects are summarised as follows:

- Clearance, excavation and construction of 19.04km of new permanent access tracks (5m wide) and 3.6km of service track above the grid connection route (2.5m wide);
- Upgrade of 6.99km of existing access track;
- Clearance, excavation and construction of seventeen turbine foundations;
- Clearance, excavation and construction of seventeen permanent crane hard standings;
- Installation of eight permanent watercourse crossings;
- Cable laying within track verges;
- Cable laying along 3.6km grid connection route, the majority of the route located in an area of surface/near surface bedrock;
- Clearance and construction of three construction compounds;
- Storage and use of oils and fuels;
- Extraction of aggregate via four borrow pits;
- Backfilling of the four borrow pits with excavated peat
- Stockpiling of excavated soils and peat, including six permanent peat storage areas;
- Side casting of excavated peat along roadsides;
- Tree felling to create access track corridors and space for turbines and other structures;
- Installation of cut-off drains;
- Installation of drains, both temporary and permanent;
- Dewatering of excavations and trenches;
- Discharge of surface water and water from excavations;
- Concrete mixing and pouring;
- Clearance and construction of additional infrastructure (such as substation, met mast, etc.).

The estimated volumes of peat that will be excavated as part of the above works are calculated in the Peat Management Plan (Appendix 10-3) and summarised in Table 10-7.

Table 10-7: Summary of preliminary peat excavation volumes

Infrastructure Item	Excavated Peat Volume (m3)
Access roads (founded, including watercourse crossings and grid connection)	171,181.50
Turbine foundations	5,827
Crane hardstands	72,504.0
Borrow Pit 1	20,978.1
Borrow Pit 2	66,183.3
Borrow Pit 3	45,301.5
Borrow Pit 4	11,652.8
Substation	2,944.6
Met mast hardstand	1,375.0
Contractor compound	28,729.7
Total	426,677.00

The peat re-use/reinstatement volumes have been estimated in the PMP (Appendix 10-3) and are summarised Table 10-8. These volume represent volumes of excavated peat used for landscaping and reinstatement adjacent to indicated infrastructure, and capacity of peat repository areas and borrow pits for material deposition and reinstatement.

Comparison of the preliminary figures shows that the capacity for peat reinstatement/ storage exceeds the excavation volume, and with effective sequencing of earthworks there will not be a requirement for off-site disposal of peat in association with the development.

A construction stage peat management plan and construction methodology specifically related to peat management with inclusion of the findings of Appendix 10-3 Peat Management Plan will be required by the Contractor at the construction stage of the Proposed Development.

These reports will outline the construction stage activities and it will be in line with all the principles in the Peat management Plan (Technical Appendix 10-3) including maintaining peat restriction areas as well as all the details outlined in Section 10.3 above.

In the event planning consent is granted for the proposed development, this PMP will be updated prior to commencement of development to address the requirements of any relevant planning conditions, including any additional mitigation measures, which are conditioned and will be submitted to the planning authority for written approval.

Table 10-8: Summary of preliminary peat reinstatement volumes

Infrastructure Item	Reinstatement Peat Volume (m3)
Access roads	47,950
17 Turbine foundations	2,163
17 Crane hardstands	19,380
3 Compounds	2,100

Infrastructure Item	Reinstatement Peat Volume (m3)
4 Borrow pits	444,116
6 Peat repositories	115,225
1 Substation	750
1 Met mast hardstand	300
Total	**632,013**

Turbine Foundations

Excavations will be undertaken to reach a suitable bearing stratum, with all peat removed from the footprint of the turbine foundation. Peat shall be sloped into the excavation at no more than a 1 in 3 slope.

Based on understanding of the ground conditions from investigations and desk study to date, it is expected that foundations will comprise mass reinforced concrete bases, which will be backfilled upon completion with spoil and peat material and with peat at the surface to promote vegetating growth. The finished level will very gently tie in the existing ground level.

The diameter of the foundation is 22.5m, and it is expected that the foundations shall be 5m in depth. The calculated peat excavated from the turbine foundations (Table 10 7) constitutes only 1.4% of the wider project peat excavation volumes, i.e. this activity constitutes a very minor percentage of the wider development excavations.

The construction methodology will remain the same regardless of the turbine selection, and the footprint of the turbine foundation the same.

Dewatering of excavations may be required, depending on groundwater levels and flow, although based on the existing site investigation information, significant shallow groundwater is considered to be unlikely.

In summary, turbine foundations will generate potential direct impacts as follows:

- Temporary exposure of soils during construction leading to increased erosion and sediment run-off, and potentially causing instability;
- Permanent loss of soil, peat or solid geological resource;
- Temporary exposure of bedrock and increased groundwater vulnerability;
- Peat compaction / damage to the peat;
- Increased risk of peat slides caused by;
  - Cutting of peat at the toe of slopes creating an unloading of peat
  - Inappropriate side casting/ storage of excavated peat and soil
  - Loading of peat mass via heavy machinery, stockpiles, and structures
  - Changes in pore water pressures along slip surfaces due to an artificial drainage regime during construction and operation
- Potential localised alteration of the groundwater regime during construction of the turbine base structures and windfarm infrastructure; and
- Potential spillages of concrete or unset cement causing pollution of groundwater.

Additional Infrastructure

Additional excavations will be undertaken for infrastructure such as access tracks (including grid connection service track), compounds, grid connection cable trenches general areas of hardstanding, drainage, met mast and the substation compound.

Hardstand construction, including the new roads, shall involve excavation down to the till (or bedrock where till is absent), with gradation of the peat outwards, i.e. no vertical cuts of peat. The slope on the peat will not exceed 1 in 3. These will generate direct impacts:

- Exposure of soils leading to increased erosion and sediment run-off, and potentially cause instability;
- Loss of soil, peat or solid geological resource;
- Exposure of bedrock and increased groundwater vulnerability;
- Increased risk of peat slides caused by;
  - Cutting of peat at the toe of slopes creating an unloading of peat
  - Inappropriate side casting/ storage of excavated peat and soil
  - Loading of peat mass via heavy machinery, stockpiles, and structures
- Changes in pore water pressures along slip surfaces due to an artificial drainage regime during construction and operation
- Peat compaction; and
- Potential leakage or spill of fuels and oils from the grid transformer during the operational phase, which may result in pollution of soils and groundwater in the vicinity of the substation.

Existing Track Upgrades

In addition to new access tracks, upgrades will be made to the existing track network to accommodate turbine delivery. Direct impacts on geology, soils and hydrogeology are expected to be minimal, other than associated with vehicles and construction plant (Section Construction Plant and Equipment below), as upgrades are to be limited to placement of granular material within the existing track footprint.

Tree Felling

Felling of trees may cause enhanced erosion to soils from increased exposure to weathering and removal of root structures, and as a result increased sediment release as surface runoff.

Deforestation and removal of binding root structures (i.e. stump removal) to facilitate construction of the Proposed Development would reduce the upper layer of peat strength and make it more susceptible to peat slope failure.

There is the potential for enhanced mobilisation of phosphate fertilisers from the disturbed soils into groundwater, although this is unlikely to significantly affect groundwater as no shallow groundwater is understood to be present in the bedrock aquifer, and low permeability glacial till and peat covers the majority of the site.

Further consideration on potential effects from additional overland sediment release from construction (including felling) to surface waters is given in Chapter 11 of this EIAR.

Construction Plant and Equipment

Use of construction machinery, equipment and vehicle movement (including during the operational phase) may cause the accidental pollution of watercourses and groundwater due to fuel or chemical compound leakages, and compaction of the peat soils. Further leakages may also occur from oil, chemical or fuel storage and poor practices regarding other liquids on-site such as wastewater.

Use of the machinery in areas that have been identified as vulnerable to additional loading ("safety buffer" zones) increases the risk of a peat landslide (PSRA, Appendix 10-2) at these locations.

Excavation of Borrow Pits

There are four proposed borrow pit locations up to 5m in depth and between 1.7Ha and 4.5Ha in area, which will be excavated as required to provide aggregate material for works such as access roads, turbine hardstanding, upfill to foundations and temporary compounds.

Excavation and processing of materials in the borrow pit for use in construction will generate dust, and waste-water with high quantities of suspended solids, and potentially cause increased run-off to surface waters (discussed further in Chapter 12).

Dewatering of excavations will be required, associated with localised dewatering of minor volumes of perched water from the superficials, and the limited water expected to be present in the bedrock. Although considered unlikely because of the diggable nature of the rock, blasting may be required for the development of the borrow pit.

Activities in relation to excavating borrow pits may incur the following impacts:

- Exposure of soils leading to increased erosion and sediment run-off;
- Loss of soil, peat or solid geological resource;
- Exposure of bedrock and increased groundwater vulnerability;
- Potential localised alteration of the groundwater regime;
- Peat compaction and loss of resource;
- Mechanical vibrations or vibration from blasting causing an increase in shear stresses in peat; and
- Increased risk of peat slides caused by cutting of peat at the toe of slopes above the borrow pits, and causing an unloading of peat.

Peat Repositories and Materials Storage

Full details are available in the appended Peat Management Plan, however, in summary, temporary stockpiles of material will be required between excavation and transportation/reuse, and permanent peat storage areas will be required to enable the development. Six permanent peat storage areas have been included within the Proposed Development, however will only be utilised as needed.

The excess excavated peat and spoil material will be backfilled into the proposed borrow pits as part of the Proposed Development. The methodologies, construction details and arrangements of these borrow pit areas are specified in the Peat Management Plan (Appendix 10-3).

Temporary storage of peat/soil materials will be required occasionally during the works.

Implications of these activities include:

- Risk of collapse/peat slide if stockpiled peat is not stored correctly and/or is not stored in appropriate areas.
- Risk of increased sediment in runoff if appropriate peat storage design and drainage measures are not implemented.
- Risk of increased sediment in runoff from the storage of other materials (soils and gravel) if appropriate storage design and drainage measures are not implemented.
- Degradation of the peat if not stored appropriately, through drying out for example, as part of the temporary and permanent storage.

10.4.4 Decommissioning Phase Effects

Activities

The decommissioning phase is expected to take 12 months, and shall comprise;

- Reuse of the existing construction phase compounds;
- Vehicle use (no oversized, cranes, HGV and worker vehicles only);
- Storage and use of oils and fuels;
- Removal of all major equipment and structures (above ground only);
- The substation is to remain in place as it will be under Electricity Supply Board (ESB) ownership;
- On-site access tracks will be left in-situ for use by landowner;
- All underground cables will be removed; however ducting is to remain in place;
- All hardstands are to be left in place and allowed to naturally revegetate;
- Drainage is to be left in place;

Potential Effects

In general, potential impacts encountered during the decommissioning phase of the wind farm will be similar to those associated with the construction phase, but of a lesser magnitude. Potential impacts during the decommissioning phase relate to potential accidental release, leakage or spillage of hydrocarbons, fuel or oils from storage tanks/ plant during decommissioning causing pollution of groundwater.

10.5 Summary of Potential Effects

The potential effects of the construction, operation and decommissioning phases of the wind farm development on the receiving geological environment are discussed in this Section. Each effect has been assigned a ranking of Importance and Magnitude (based on the respective receptor sensitivity and criteria for assessing magnitude given in Table 10-1 and Table 10-2, further detailed in Table 10-6) and Significance has been assessed following the methodology outlined in Section 10.2, and prior to consideration of mitigation measures in Section 10.6. The Importance/Sensitivity of the Receptors are defined in Table 10-6.

Table 10-9: Summary of pre-mitigation effects on the receiving environment during the construction, operation and decommissioning phases

Receptor	Potential Effects	Importance (sensitivity)	Magnitude	Significance
Construction Phase				
Soils (excluding peat)	Potential loss of / adverse effects on the superficial geological resource (soils) due to temporary excavations for windfarm infrastructure.	Negligible	Low Adverse	Not Significant
Peat (resource)	Potential loss of / adverse effects on the peat soils due to temporary excavations for windfarm infrastructure. Peat compaction associated with construction traffic may reduce soil permeability and increase surface runoff. Potential increased erosion of superficial soils due to tree felling and loss of surface vegetation.	High	Medium Adverse	Significant Adverse
Peat (stability)	Potential landslide of peat caused by risk factors such as cutting, loading, unloading, vibration, alterations to surface water drainage, vegetation removal, or inappropriate storage of peat, leading to effects on surface water, infrastructure and people.	High	Medium Adverse	Significant Adverse
Geology	Potential loss of / adverse effects on the solid geological resource beneath temporary excavations for windfarm infrastructure and in association with the borrow pits (permanent bedrock loss).	Low	Negligible Adverse	Not Significant

Receptor	Potential Effects	Importance (sensitivity)	Magnitude	Significance
Hydrogeology	Potential localised increase in alkalinity from spillages of concrete or unset cement causing pollution of groundwater. Potential accidental release, leakage or spillage of hydrocarbons, fuel or oils from storage tanks/construction plant during construction causing pollution of groundwater. Potential localised alteration of the groundwater regime during construction of the turbine base structures and windfarm infrastructure. Potential localised alteration of the groundwater regime due open borrow pit excavations. Exposure of bedrock resulting in an increase in groundwater vulnerability.	Medium	Medium Adverse	Moderate Adverse
Contamination	Mobilisation of contamination in soils as a result of additional sediment loading or leaching.	Low*	Negligible Adverse*	Not Significant
Operational Phase				
Soils (excluding peat)	Potential loss of / adverse effects on the superficial geological resource (soils) due to permanent excavations for windfarm infrastructure.	Negligible	Low Adverse	Not Significant
Peat (resource)	Potential loss of / adverse effects on the peat soils due to permanent excavations for windfarm infrastructure. Ongoing erosion of superficial soils due to construction phase tree felling and loss of surface vegetation.	High	Medium Adverse	Significant Adverse
Peat (landslide)	Ongoing potential landslide of peat caused by risk factors during the construction phase such as cutting, loading, vibration, alterations to surface water drainage, vegetation removal, leading to effects on surface water, infrastructure and people.	High	Medium Adverse	Significant Adverse
Geology	Potential loss of / adverse effects on the solid geological resource beneath permanent excavations for windfarm infrastructure.	Low	Negligible Adverse	Not Significant
Hydrogeology	Potential accidental release, leakage or spillage of hydrocarbons, fuel or oils from storage tanks/plant during operation causing pollution of groundwater. Potential localised alteration of the groundwater regime due to turbine base	Medium	Medium Adverse	Moderate Adverse

Receptor	Potential Effects	Importance (sensitivity)	Magnitude	Significance
	structures and windfarm infrastructure. Potential localised alteration of the groundwater regime due backfilled borrow pit excavations. Potential pollution of groundwater by leachable contamination from imported fill materials. Reduction in infiltration caused by increased hardstanding cover or compaction of soils, resulting in impacts on groundwater.			
Contamination	Mobilisation of contamination in soils as a result of additional sediment loading or leaching.	Low*	Negligible Adverse*	Not Significant
Decommissioning Phase				
Soils (excluding peat)	None	Negligible	N/A	N/A
Peat (resource)	None	High	N/A	N/A
Peat (landslide)	None	High	N/A	N/A
Geology	None	Low	N/A	N/A
Groundwater bodies	Potential accidental release, leakage or spillage of hydrocarbons, fuel or oils from storage tanks/construction plant during decommissioning causing pollution of groundwater.	Medium	Medium Adverse	Moderate Adverse
Contamination	None	Low*	N/A	N/A

*Risks to the surface water environment from nutrient run-off are considered further in Chapter 11.

10.6 Mitigation Measures

10.6.1 Embedded Mitigation

With reference to the baseline study, the design of the Proposed Development has accounted for the sensitivity of key geological and hydrogeological receptors. Where possible, sensitive receptors have been avoided during infrastructure design in order to reduce the potential impacts which may arise from works associated with each phase of the Proposed Development.

Those activities which, after embedded mitigation in design, the developer has committed to implement in full, are outlined in the later mitigation measures sections below.

Specific embedded or designed-in measures which have dictated infrastructure design are detailed as follows:

General

- Infrastructure components are shared with neighbouring developments and where feasible, existing forest road has been incorporated to reduce the need for new track, to minimise potential impact on sensitive receptors;
- Infrastructure has been positioned to minimise cut and fill requirements and impact on peat by avoiding areas of deeper peat;
- Blade fingers have all been specified as temporary infrastructure, only required during the construction and decommissioning of the Proposed Development and will not involve founded construction and permanent excavation of peat;
- Infrastructure has been positioned to maintain a minimum distance from watercourses (see Chapter 11 for details); and
- A Surface Water Management Plan (Appendix 11-4) and drainage strategy has been developed to ensure that;
  - appropriate, robust and buildable SuDS techniques are incorporated for the prevention of erosion and the removal of silts and pollutants from construction runoff.
  - permanent drainage at the development is designed to a sufficient hydraulic capacity to contain a pre-determined return period rainfall event.
  - consideration is given to the control and monitoring proposals for the dewatering of excavations; and
  - surrounding agricultural lands, heath and peat lands are not negatively affected by surface water runoff from the site.

Turbines

- All WTGs are positioned to maintain a minimum buffer of 60m from watercourses;
- Turbine locations are located close to the access tracks to minimise lengths of track required and therefore minimise damage to the peat environment;
- Where possible, WTGs were strategically positioned to target shallow areas of peat and avoid deeper areas/areas noted to be unstable in Appendix 10-2; and

- Sizing of hardstanding areas associated with WTGs have been minimised and orientated so to reduce spatial area affected by works, i.e. reduce the level of excavation required.

Access tracks

- New proposed access roads were positioned to maintain a minimum buffer of 60m from watercourses, with the exception of watercourse crossing locations; and
- Track lengths between turbines have been minimised and follow shallower peat where possible to avoid causing instability and loss of peat resource following excavation of the roads.

Peat Repositories

- Peat repositories have been placed to maintain the minimum buffer of 60m from the watercourses;
- The peat repositories are on ground that does not exceed angles of 5°; and
- The areas have been shown as low risk with regards underlying peat stability when 1m of peat is placed on top (PSRA, Appendix 10-2).

10.6.2 Construction Mitigation

The following mitigation measures will be implemented in full to reduce or avoid the potential impacts, in relation to construction of the different elements of the Proposed Development.

Slope Stability

- Risk is outlined in Appendix 10-2 Peat Stability Risk Assessment (PSRA) and any identified risks will be minimised by applying the mitigation principles as outlined in the PSRA (Appendix 10-2) and Peat Management Plan (Appendix 10-3) and the Construction Environmental Management Plan (CEMP) provided in Appendix 4-1.;

  Particular restricted areas have been identified as part of the EIAR, Technical Appendix 10-2 Peat Stability Risk Assessment (PSRA). These consist of:
  - Safety buffer areas – areas used during the layout design of the Proposed Development for the voidance of potential hazards identified during site reconnaisance, desk strudt and PSRA assessments. These areas are restricted for construction activity and must not be used for storage or side casting of peat or any overburden materials
  - Peat stockpile restriction areas– areas that are not restricted for construction activity but must not be used for stockpiling of peat or any overburden materials
- A detailed method statement will be prepared prior to any element of work being carried out, as outlined in the CEMP (Appendix 4-1);
- A contractor with experience and excellent track record in wind farm development and management of peat shall be appointed for construction to ensure that the PMP is followed and poor construction practice is not a high risk on site (poor construction practice is one of the key contributing factors to peat slides, see Section 10.3.2);
- Proposed peat repositories areas are located in areas of low peat instability risk, in accordance with the PSRA (Appendix 10-2);

- There will be no vertical excavations into the peat, and the batter on the excavated peat slopes will not exceed a 1v:3h slope;
- Frequent monitoring of slopes associated with development will be undertaken during construction, and additional monitoring undertaken following heavy and/or prolonged rainfall events at the discretion of the supervising geotechnical engineer, as this is one of the key contributing factors to the occurrence of peat slides as discussed in Section 10.3.2;
- On the basis of the above point, when poor weather is forecast (e.g. heavy rainfall), new excavation of soils and peat shall be postponed until the weather improves, at the discretion of the supervising geotechnical engineer. Works shall continue on existing excavations (where safe to do so) to reduce the time of exposure of soils to the inclement weather;
- Excavated peat will be moved short distances from the point of extraction, i.e. side casting to begin with, followed by movement to the nearest storage space, i.e. borrow pit or peat storage area. Temporary stockpiling shall be avoided where feasible and heavily controlled if unavoidable. Controls shall include inspection by a qualified geotechnical engineer of designated areas, ensuring peat is not stored in the peat storage restriction areas (Appendix 10-2), slope monitoring around the temporary peat stockpiles, and a maximum peat stockpile height of 1m;
- Excavated surplus soils (non-peat) shall be reused on site as construction material wherever possible. If unsuitable, materials are to be placed in the excavated borrow pits to aid in reinstatement and rehabilitation of the excavated area;
- Peat related works will be subject to further detailed designed and checked by the relevant professionals, for example by a qualified geotechnical engineer, hydrologist, and/or drainage engineer;
- Excavation works will be monitored by a qualified geotechnical engineer; and
- Tree felling is only to be undertaken in areas of proposed infrastructure (see Figure 4-7), which has been designed to avoid areas of deeper peat and in areas of low peat instability risk. Felling buffers have been kept to a minimum, whilst balancing health and safety concerns with regards wind-blow. The retention of trees where possible will ensure that slope stability is not adversely impacted in these areas, and will reduce surface run off. Tree stumps are to be left in place wherever possible to reduce disturbance to the soils and retain stabilising root structures.

With regards risks assessment of major incidents, refer to Chapter 17 of this EIAR.

Borrow Pit Excavations

- Works will be undertaken in accordance with the CEMP;
- Temporary pumping of groundwater may be required to facilitate excavation and remove wastewater with high concentrations of suspended soils, however on the basis of the desk study information, groundwater in the bedrock is not expected to be significant / at high elevation (the GWB is found largely within a different type of rock, not present at shallow depth beneath the study area). In the event that conditions are significantly different to those predicted, the supervising geotechnical engineer will consider whether further detailed assessment or monitoring is required;
- Dust suppression techniques (misting/watering) during construction works will be implemented as necessary;

- Excavation works will be monitored by a qualified geotechnical engineer; and
- The earthworks will not be scheduled to take place during severe weather conditions if they present a risk to materials management or stability.

Peat Repositories

- Works will be undertaken in accordance with the PMP and the CEMP;
- A stone buttress shall be constructed to contain the peat at the Peat Repositories, which will help prevent the flow of peat material and prevent oversaturation of the soils (see Figures 4-9a to 4-9f and 4-8a to 4-8d for further details);
- Intermediate buttresses may be installed within the peat repositories to aid in the placement and stability of placed peat, these berms are to be shaped to align with the contours of the repository, as detailed in the PSRA and PMP.
- The surface of the placed peat will be shaped to allow efficient run-off of surface water from the peat storage areas into the Proposed Development drainage system;
- Upper acrotelm layers shall be placed on the surface right way up to promote vegetation growth. This growth will aid in stabilising the stored peat material and help in preventing it from becoming saturated following heavy period of rain;
- Drainage features, such as silt fencing, and settlement ponds have been incorporated into the design to capture any sediment/nutrient laden run-off from the Peat Repositories and reduce risk of oversaturation of the soils; and
- Movement monitoring posts shall be placed at all peat repositories, both upslope and downslope. Movement monitoring posts will be observed at least once a day with more frequent inspections when adjacent works are happening. Should movements be recorded the frequency of these inspections should be increased and at the discretion of the supervising geotechnical engineer works instructed to stabilise any potentially unstable slopes and/or cease adjacent works. Record should be kept of all monitor post inspections with reference to date, time and any relative movement between posts, if any. Any movement identified in the posts shall be recorded with reference to the post numbering system.

Turbine Foundations and Construction

- Works will be undertaken in accordance with the CEMP, as detailed particularly in Section 4.10.3 and peat and spoil management will be in accordance with the Peat Management Plan (Appendix 10-3)

Soil Erosion

- Excavations will be constructed and backfilled as quickly as possible to minimise risk of erosion;
- Excavations will pause during and immediately following periods of high rainfall if they present a risk to materials management or stability;
- Excavated soil and rock will be stored appropriately in accordance with the CEMP (particularly Section 4.7) to reduce sedimentation in run-off, with bunding and silt fences, for example, as required; and
- No stockpiles outside of the designated peat storage areas will be left on-site after the construction phase has ended.

Soil Compaction

- Prior to commencement of earthworks, the work corridor will be delineated and plant will be required to stay inside the designated boundary. This will limit damage to peat and soils outside of designated areas; and,
- Excavations will be conducted from access tracks wherever possible.

Contaminated Soils, Waste and Pollution

- A Waste Management Plan (WMP) is included as Annex B of the CEMP (Appendix 4-1) which provides detail on the control of all site-generated construction waste and the storage and disposal of the waste;
- Contaminated soils are not anticipated, but if encountered will be stored, removed, and treated/disposed of in accordance with waste management legislation;
- Material which is temporarily stored on-site will be stored appropriately, separate to clean materials, with covers and bunding as necessary;
- Classification and assessment of waste materials will be conducted as quickly as possible to ensure minimal exposure time to the receiving environment; and
- Concrete wash water handling areas will be suitably located and managed to prevent pollution of the environment.

Fuel and Waste Liquids

- All potentially polluting liquids will be stored in containers and/or fully bunded areas and using the necessary equipment in accordance with the CEMP (Appendix 4-1);
- Refuelling of plant machinery will be carried out at dedicated refuelling stations. Refuelling of immoveable cranes, for example, shall be undertaken with care; protective /bunding matting shall be placed beneath the refuelling point during this time to capture any accidental spillage;
- Construction plant will be checked regularly for leakages and will undergo maintenance on a regular basis (within the construction compounds wherever possible);
- Construction traffic will be limited to allocated areas of the Proposed Development;
- Emergency spill kits will be readily available across the Proposed Development area to enable quick and effective reaction if accidental release, leakage or spillage of potentially polluting substances occurs; and
- Wastewater will be contained within, and collected from the containerised welfare units and removed via a permitted waste contractor.

10.6.3 Operation Mitigation

The following mitigation measures will be implemented in full to reduce or avoid the potential impacts, in relation to the operation of elements of the Proposed Development.

Peat stability and soil erosion

- Visual inspections of areas of stored peat and peat slopes adjacent to wind farm components will be undertaken twice a year. Inspections will be undertaken by a qualified engineering geologist/geologist/geotechnical engineer/civil engineer, with photograph surveys;

- Monitoring of the monitoring posts installed at construction stage shall be carried out twice a year. Should movements be recorded the frequency of these inspections should be increased and, at the discretion of the appointed geotechnical engineer, works instructed to investigate the cause of the movement. Record should be kept of all monitor post inspections with reference to date, time and any relative movement between posts, if any. Any movement identified in the posts shall be recorded with reference to the post numbering system;
- Engineered solutions will be designed and implemented for areas of noticeable erosion or areas of suspected instability associated with the Proposed Development infrastructure, as and when required. Design will be undertaken by a qualified engineering geologist/geologist/geotechnical engineer/civil engineer;
- The monitoring results will ultimately be utilised to provide a final conclusive assessment of peat stability in areas where the peat is subject to ongoing monitoring. The production of this assessment shall be at the discretion of the designated site Geotechnical Engineer, and monitoring shall only cease when the conclusions have been accepted by the relevant stakeholders. It is likely that any minor settlement will have ceased well before the operation phase of the windfarm is complete, but in the unlikely event that any ongoing monitoring requirement is identified, then a mitigation plan will be developed and implemented following the principles outlined in this EIAR; and
- Areas no longer in use (i.e. the construction compounds and blade fingers) shall be allowed to naturally revegetate. The turbine zones cleared for felling shall also be allowed to naturally revegetate, although no tree planting shall occur in these areas. Presence of vegetation shall slow run-off and reduce potential for soil erosion in these areas.

Fuel and Waste Liquids

- All potentially polluting liquids will be stored in containers and/or fully bunded areas and using the necessary equipment in accordance with the CEMP;
- The substation shall be situated on hardstand which will prevent downward migration of any escaped pollutants into the subsoils/ groundwater; and
- Emergency spill kits will be readily available on study area to protect against accidental release, leakage or spillage of potentially polluting substances.

10.6.4 Decommissioning Mitigation

The decommissioning will occur as outlined in Chapter 4 – Project Description. As above, mitigation measures outlined in the construction phase will be followed as appropriate to the decommissioning of the wind farm.

Fuel and Waste Liquids

- During decommissioning all potentially polluting liquids will be stored in containers and/or fully bunded areas and using the necessary equipment in accordance with the CEMP;
- Refuelling of plant machinery will be carried out at dedicated refuelling stations. Refuelling of immoveable cranes, for example, shall be undertaken with care;

protective /bunding matting shall be placed beneath the refuelling point during this time to capture any accidental spillage;

- Plant will be checked regularly for leakages and will undergo maintenance on a regular basis (within the construction compounds wherever possible);
- Construction traffic will be limited to allocated areas of the Proposed Development;
- Emergency spill kits will be readily available across the Proposed Development area to enable quick and effective reaction if accidental release, leakage or spillage of potentially polluting substances occurs; and
- Wastewater will be contained within and collected from the containerised welfare units and removed via a permitted waste contractor.

10.7 Residual Impacts

10.7.1 Construction, Operation and Decommissioning

As indicated in Table 10-10, no significant residual impacts are considered likely following implementation of the mitigation measures, which predominantly comprises compliance with the Construction Environmental Management Plan, Peat Management Plan, and Peat Stability Risk Assessment.

10.8 Cumulative Residual Impacts

This assessment takes into consideration all of the projects detailed in Technical Appendix 2-3, including the grid routes from Gortyrahilly and Inchamore, which are both proposed to go through the Proposed Development site , largely along existing forestry tracks (i.e. minimal ground disturbance).

Any negative impacts arising from these developments in relation to soil, geology and hydrogeology will be localised and not significant, as stated in the respective EIARs. Furthermore, the combination effect is likely to be limited, and in the majority of cases will reduce the total overall potential effect, for example through shared excavations and an overall reduction in the consequent impacts.

It is acknowledged that there is a planning proposal submitted pending decision for an increase in tip height of the seven turbines that are already present at Knocknamork Wind Farm which borders south of the Proposed Development. The increase in tip height entails increasing the size of the foundations, resulting in a loss of 0.15Ha of land, with limited peat / subsoil excavation required.

The EIAR for this Knocknamork development notes that, with mitigation there are no significant residual effects on soils, geology and hydrogeology associated with that development, and considering the minor likely effects on these receptors, in combination with the proposed development there are not expected to be any cumulative significant effects.

The Proposed Development is not expected to contribute to any significant negative cumulative effects on the receiving environment in relation to soils, geology and hydrogeology.

This is because there are no predicted significant residual impacts associated with the Proposed Development, and the non-significant effects of this and nearby developments are localised and when combined are unlikely to be significant, considering the scale of the effects and the areas which would be impacted.

The shared grid routes noted above are likely to have the most significant cumulative effect, but this is expected to be overall positive, for example by sharing excavations and reducing overall impacts.

There may be minor cumulative effects on the groundwater flow regime due to excavations and hardstanding cover associated with other developments, although these are localised and not considered to be significant considering the size and scale of the catchment.

Considering the proposed mitigations for effects on soils, and the generally low sensitivity of the superficial geology resource, it is not predicted that there would be any significant construction or operational cumulative contamination effects.

10.9 Summary of Residual Effects

A summary of the potential effects of the construction, operation and decommissioning phases of the wind farm development on the receiving geological environment following mitigation measures is provided in the following table.

Table 10-10: Summary of post-mitigation effects on the receiving environment during the construction, operation and decommissioning phases

Receptor	Potential Effects	Importance (sensitivity)	Magnitude (pre-mitigation)	Significance (pre-mitigation)	Magnitude (post-mitigation)	Significance (post-mitigation)
Construction Phase						
Soils (excluding peat)	Potential loss of / adverse effects on the superficial geological resource (soils) due to temporary excavations for windfarm infrastructure.	Negligible	Low Adverse	Not Significant	Low Adverse	Not Significant
Peat (resource)	Potential loss of / adverse effects on the peat soils due to temporary excavations for windfarm infrastructure. Peat compaction associated with construction traffic and permanent storage of peat may reduce soil permeability and increase surface runoff. Potential increased erosion of superficial soils due to tree felling and loss of surface vegetation.	High	Medium Adverse	Significant Adverse	Low Adverse	Slight Adverse
Peat (stability)	Potential landslide of peat caused by risk factors such as cutting, loading, unloading, vibration, alterations to surface water drainage, vegetation removal, or inappropriate storage of peat, leading to effects on surface water, infrastructure and people.	High	Medium Adverse	Significant Adverse	Low Adverse	Slight Adverse
Geology	Potential loss of / adverse effects on the solid geological resource beneath temporary excavations for windfarm infrastructure and in association with the borrow pits (permanent bedrock loss).	Low	Negligible Adverse	Not Significant	Negligible Adverse	Not Significant
Hydrogeology	Potential localised increase in alkalinity from spillages of concrete or unset cement causing pollution of groundwater.	Medium	Medium Adverse	Moderate Adverse	Low Adverse	Slight Adverse

	Potential accidental release, leakage or spillage of hydrocarbons, fuel or oils from storage tanks/construction plant during construction causing pollution of groundwater. Potential localised alteration of the groundwater regime during construction of the turbine base structures and windfarm infrastructure. Potential localised alteration of the groundwater regime due open borrow pit excavations. Exposure of bedrock resulting in an increase in groundwater vulnerability.					
Contamination	Mobilisation of contamination in soils as a result of additional sediment loading or leaching.	Low*	Negligible Adverse*	Not Significant	Negligible Adverse*	Not Significant
Operational Phase						
Soils (excluding peat)	Potential loss of / adverse effects on the superficial geological resource (soils) due to permanent excavations for windfarm infrastructure.	Negligible	Low Adverse	Not Significant	Low Adverse	Not Significant
Peat (resource)	Potential loss of / adverse effects on the peat soils due to permanent excavations for windfarm infrastructure. Ongoing erosion of superficial soils due to construction phase tree felling and loss of surface vegetation.	High	Medium Adverse	Significant Adverse	Low Adverse	Slight Adverse
Peat (landslide)	Ongoing potential landslide of peat caused by risk factors during the construction phase such as cutting, loading, vibration, alterations to surface water drainage, vegetation removal, leading to effects on surface water, infrastructure and people.	High	Medium Adverse	Significant Adverse	Low Adverse	Slight Adverse
Geology	Potential loss of / adverse effects on the solid geological resource beneath permanent excavations for windfarm infrastructure.	Low	Negligible Adverse	Not Significant	Negligible Adverse	Not Significant
Hydrogeology	Potential accidental release, leakage or spillage of hydrocarbons, fuel or oils from storage tanks/plant during operation causing pollution of groundwater. Potential localised alteration of the groundwater regime due to	Medium	Medium Adverse	Moderate Adverse	Low Adverse	Slight Adverse

	turbine base structures and windfarm infrastructure. Potential localised alteration of the groundwater regime due backfilled borrow pit excavations. Potential contamination of groundwater by leachable contamination from imported fill materials. Reduction in infiltration caused by increased hardstanding cover or compaction of soils, resulting in impacts on groundwater.					
Contamination	Mobilisation of contamination in soils as a result of additional sediment loading or leaching.	Low*	Negligible Adverse*	Not Significant	Negligible Adverse*	Not Significant
Decommissioning Phase						
Soils (excluding peat)	None	Negligible	N/A	N/A	N/A	N/A
Peat (resource)	None	High	N/A	N/A	N/A	N/A
Peat (landslide)	None	High	N/A	N/A	N/A	N/A
Geology	None	Low	N/A	N/A	N/A	N/A
Groundwater bodies	Potential accidental release, leakage or spillage of hydrocarbons, fuel or oils from storage tanks/construction plant during decommissioning causing pollution of groundwater.	Medium	Medium Adverse	Moderate Adverse	Low Adverse	Slight Adverse
Contamination	None	Low*	N/A	N/A	N/A	N/A

*Risks to the surface water environment from nutrient run-off are considered further in Chapter 11.

10.10 Conclusion

A study has been undertaken to assess the key effects of the construction, operational and decommissioning phases of the proposed development on soils (including peat), geology and hydrogeology. No Significant Adverse residual impacts are predicted, following implementation of the mitigation measures.

Risks to the peat resource and associated with peat slide were identified as potentially significant prior to assessment and mitigation, however, detailed studies have demonstrated that neither of these are of significant risk following implementation of the mitigation measures.

A number of mitigation measures have been outlined in Section 10.6 that will be followed. The mitigations predominantly comprise compliance with the detailed measures set out in the following documents appended to this EIA:

- Peat Slide Risk Assessment (Technical Appendix 10-2);
- Peat Management Plan (Technical Appendix 10-3); and
- Construction Environmental Management Plan (Technical Appendix 4-1).

10.11 References

Construction Industry Research and Information Association (CIRIA) (2001). Control of water pollution from construction sites - Guidance for consultants and contractors.

Department of Environment, (2006), Wind Farm Planning Guidelines, DoEHLG.

Department of Housing, Planning, Community and Local Government (2017). Review of Wind Energy Development Guidelines "Preferred Draft Approach".

Dykes, A.P., (2022). Recent peat slide in Co. Antrim extends the known range of weak basal peat across Ireland.

Environmental Protected Agency, (2010). Establishment of Groundwater Source Protection Zones, Carraignadoura Group Water Supply Scheme, February 2010.

Environmental Protection Agency (2022). EPA Map Viewer. Available at: https://gis.epa.ie/EPAMaps/. Accessed: 20/09/22.

Environmental Protection Agency (2022). Guidelines on the Information to be contained in Environmental Impact Assessment Reports (EIAR), pp. 90.

European Commission (1979). Groundwater Directive 80/68/EEC.

European Commission (2006). Groundwater Directive 2006/118/EC.

Geological Survey Ireland, (2004a). 1st Draft Cahersiveen GWB Description – 2004. Available at: www.gsi.ie. Accessed: [03/10/2022].

Geological Survey Ireland, (2004b). 1st Draft Glenville GWB Description – 2004. Available at: www.gsi.ie. Accessed: [03/10/2022].

Geological Survey Ireland, (2004c). 1st Draft Ballinhassig GWB Description – 2004. Available at: www.gsi.ie. Accessed: [03/10/2022].

Geological Survey Ireland (2012). County Kerry Groundwater Protection Scheme, August 2012. Available at: www.gsi.ie

Geological Survey Ireland, (2017). A Description of Irish Aquifer Categories, Groundwater Programme, Geological Survey Ireland, Version 1.1, October 2017. Available at: www.gsi.ie.

Geological Survey of Ireland, (2022). Online Mapping. Available at: https://www.gsi.ie/Mapping.htm. Accessed: 20/09/22.

Institute of Geologists of Ireland, (2013). Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements.

Kelly, C., et al. (2015). Irish Aquifer Properties – A Reference Manual and Guide, Version 1, March 2015, Geological Survey Ireland & Environmental Protection Agency.

Long M., et al. (2014). Investigation of failures in Irish bogs

Malachy Walsh and Partners, (2010). Environmental Impact Statement for a Proposed Wind Farm at Clydaghroe, Co. Kerry. Volume 1 of 4. Non-Technical Summary, January 2010.

National Road Authority (2008). Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes.