Chapter 5:

Soil & Geology

5.1 Introduction

5.1.1 Background and Objectives

Hydro-Environmental Services (HES) was engaged by Pinewoods Wind Ltd. to carry out an assessment of the potential impacts of the proposed development on the soil and geological environment.

This report provides a baseline assessment of the proposed development in terms of soils and geology and discusses the potential impacts that the construction and operation of the proposed development will have on them. Where required, appropriate mitigation measures to limit any identified significant impacts to soils and geology are recommended.

5.1.2 Relevant Legislation

The EIS is carried out in accordance with the follow legislation:

- S.I. No. 349 of 1989: European Communities (Environmental Impact Assessment) regulations and subsequent amendments (S.I. No. 84 of 1995, S.I. No. 352 of 1998, S.I. No. 93 of 1999; S.I. No. 450 of 2000; S.I No. 538 of 2001); S.I. No. 30 of 2000 the Planning and Development Act, 2000;, and S.I 600 of 2001 Planning and Development Regulations and subsequent amendments, on the assessment of the effects of certain public and private projects on the environment; and,
- S.I. No. 4 of 1995: The Heritage Act, 1995.

5.1.3 Relevant Guidance

The soils and geology section of this EIS is carried out in accordance with guidance contained in the following documents:

- Environmental Protection Agency (2003): Advise Notes on Current Practice (in the Preparation on Environmental Impact Statements);
- Environmental Protection Agency (2002): Guidelines on the Information to be Contained in Environmental Impact Statements;
- Institute of Geologists Ireland (2013): Guidelines for Preparation of Soils, Geology & Hydrogeology Chapters in Environmental Impact Statements; and,
- National Roads Authority (2005): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes.

5.1.4 Methodology

5.1.4.1 Desk Study

A desk study of the wind farm site and the surrounding study area was largely completed in advance of undertaking the walkover survey and site investigations. The desk study involved collecting all the relevant geological data for the wind farm site and the study area. This included consultation with the following:

- Environmental Protection Agency database (www.epa.ie);
- Geological Survey of Ireland - National Draft Bedrock Aquifer map;
- Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 18 (Geology of Tipperary). Geological Survey of Ireland (GSI, 1999);
- Geological Survey of Ireland – 1:25,000 Field Mapping Sheets;

- General Soil Map of Ireland 2nd edition (www.epa.ie).

5.1.4.2 Geological Mapping and Site Investigations

A walkover survey and geological mapping of the site was undertaken by HES on 11th March 2015 and a comprehensive site investigation comprising trial pits and gouge cores was undertaken by HES on 30th and 31st March 2015.

In summary, site investigations to address the soil and geology section of the EIS included the following:

- Trial pits (13 no.) were undertaken at (or in the proximity of) the proposed turbine and access road locations to investigate overburden thickness and subsoil and bedrock lithology;
- Where a trial pit could not be undertaken at the exact proposed location of a turbine due to access issues, a gouge core was undertaken instead to investigate the subsoil lithology;
- Logging of bedrock outcrops and subsoil exposures;
- Mineral subsoils and peat were logged according to BS: 5930 and Von Post Scale respectively; and,
- A peat slide risk assessment for the proposed wind farm development was undertaken by Whiteford Geoservices Limited (May 2015).

5.1.4.3 Impact Assessment

Using information from the desk study and data from the site investigation, an estimation of the importance of the soil and geological environment within the study area is assessed using the significance criteria set out in **Table 5.1** (NRA, 2005).

Importance	Criteria	Typical Example
Very High	Attribute has a high quality, significance or value on a regional or national scale. Degree or extent of soil contamination is significant on a national or regional scale. Volume of peat and/or soft organic soil underlying route is significant on a national or regional scale.	Geological feature rare on a regional or national scale (NHA). Large existing quarry or pit. Proven economically extractable mineral resource
High	Attribute has a high quality, significance or value on a local scale. Degree or extent of soil contamination is significant on a local scale. Volume of peat and/or soft organic soil underlying site is significant on a local scale.	Contaminated soil on site with previous heavy industrial usage. Large recent landfill site for mixed wastes. Geological feature of high value on a local scale (County Geological Site). Well drained and/or high fertility soils. Moderately sized existing quarry or pit. Marginally economic extractable mineral resource.

Medium	Attribute has a medium quality, significance or value on a local scale. Degree or extent of soil contamination is moderate on a local scale. Volume of peat and/or soft organic soil underlying site is moderate on a local scale.	Contaminated soil on site with previous light industrial usage. Small recent landfill site for mixed Wastes. Moderately drained and/or moderate fertility soils. Small existing quarry or pit.
Low	Attribute has a low quality, significance or value on a local scale. Degree or extent of soil contamination is minor on a local scale. Volume of peat and/or soft organic soil underlying site is small on a local scale.	Large historical and/or recent site for construction and demolition wastes. Small historical and/or recent landfill site for construction and demolition wastes. Poorly drained and/or low fertility soils. Uneconomically extractable mineral Resource.

Table 5.1: Estimation of Importance of Soil and Geology Criteria (NRA, 2005)

The statutory criteria (EPA, 2002 and EPA, 2003) for the assessment of impacts require that likely impacts are described with respect to their extent, magnitude, type (*i.e.* negative, positive or neutral) probability, duration, frequency, reversibility, and transfrontier nature (if applicable). In addition the two impact characteristics of proximity and probability are described for each impact and these are defined in **Table 5.2**.

In order to provide an understanding of this descriptive system in terms of the geological/hydrological environment, elements of this system of description of impacts are related to examples of potential impacts on the geology and morphology of the existing environment, as listed in **Table 5.3**.

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

Table 5.2: Additional Impact Characteristics

Impact Characteristics		Potential Geological/Hydrological Impacts
Quality	Significance	
Negative only	Profound	Widespread permanent impact on: - The extent or morphology of a cSAC. - Regionally important aquifers. - Extents of floodplains. Mitigation measures are unlikely to remove such impacts.
Positive or Negative	Significant	Local or widespread time dependent impacts on: -The extent or morphology of a cSAC / ecologically important area. -A regionally important hydrogeological feature (or widespread effects to minor hydrogeological features). -Extent of floodplains. Widespread permanent impacts on the extent or morphology of a NHA/ecologically important area, Mitigation measures (to design) will reduce but not completely remove the impact – residual impacts will occur.
Positive or Negative	Moderate	Local time dependent impacts on: - The extent or morphology of a cSAC / NHA / ecologically important area. - A minor hydrogeological feature. - Extent of floodplains. Mitigation measures can mitigate the impact OR residual impacts occur, but these are consistent with existing or emerging trends
Positive, Negative or Neutral	Slight	Local perceptible time dependent impacts not requiring mitigation.
Neutral	Imperceptible	No impacts, or impacts which are beneath levels of perception, within normal bounds of variation, or within the bounds of measurement or forecasting error.

Table 5.3: Impact descriptors related to the receiving environment

5.2 Description of the Existing Environment

5.2.1 Site Description and Topography

The proposed development is located approximately 8km to the east of Abbeyleix in Co. Laois. The site lies within the townlands of Ironmills (Kilrush), Boleybawn, Knockardugar, Graiguenahown, Garrintaggart Co. Laois and Crutt Co. Kilkenny. This area is part of the Castlecomer Plateau, a broad upland area which straddles the boundaries between counties Laois, Carlow and Kilkenny. The site straddles the county border between Laois and Kilkenny, with the town of Castlecomer around 8km away. It is an upland area with elevations ranging from 250 – 300m OD (meters above Ordnance Datum). The site consists, in part, of lands owned and operated by Coillte and, as such, a series of forest tracks and third class roads cross the site. The remainder of the landholding comprises agricultural land. The current land use within the subject site is predominately forestry along with agricultural land for cattle grazing. The ground conditions at the site were noted to be relatively firm under foot apart from some localised blanket peat and boggy areas within the forestry areas.

5.2.2 Soils and Subsoils

The published soils map (www.epa.ie) for the area shows that poorly draining mineral soil (AminPD), deep well draining mineral soil (AminDW) and shallow mineral soil (AminSW) are the dominant soil types at the site (refer to **Figure 5.1**). The majority of the proposed turbines are located in areas mapped as AminDW or AminSW. Other soil types mapped in the site include shallow poorly draining soil (AminSP) and blanket peat. Blanket peat is mapped on an area of elevated ground east of turbine locations TL06 and TL08.

A map of the local subsoil cover is illustrated in **Figure 5.2** (www.gsi.ie). This indicates that the proposed site is predominately underlain by Namurian sandstone and shale tills. Bedrock is mapped close or at the surface on the more elevated areas of the site and along steep, lower-lying sections particularly on the western facing slopes of the site. A localised section of blanket peat is mapped on an area of elevated ground east of turbine locations TL06 and TL08.

A trial pit investigation was undertaken at the proposed development site on 30th and 31st March 2015. A total of 13 no. trial pits were carried out across the proposed development footprint. The locations of the trial pits and a summary of the investigation findings are shown in **Table 5.4** below. The locations of the trial pits are also illustrated in **Figure 5.3**. Trial pit logs are included as **Appendix 5.1.**

Gouge cores were also undertaken along proposed access roads between turbine locations (refer to **Table 5.5** below and **Figure 5.3**). Trial pits were not undertaken as the depth of subsoils along the access roads is expected to be similar to the closest turbine locations. Also, it should be noted that excavation of mineral subsoils along proposed access roads will not be undertaken as the access road will be constructed on the mineral subsoil layer. Therefore, determining the subsoil depth along access roads is not required for estimation of excavation volumes, except where peat is present. Gouge cores are sufficient to determine peat depths.

Sandstone or shale tills were encountered at all of the trial pit locations and the till subsoil typically comprised firm SILT/CLAY or CLAY. The regular occurrence of CLAY subsoils and the general absence of sand as a subcomponent (*i.e.* sandy SILT/CLAY) would suggest the parent material of the subsoils in this area is predominately shale bedrock. However, silty sand was encountered in trial pits TP08 and TP09 which is a sandstone till.

Peat with an approximate thickness of 0.5m was encountered in trial pits TP08, TP09 and TP13. TP08 and TP09 were carried out just off the forestry access road east of turbine locations TL09 and TL10. TP13 was undertaken 50m west of turbine location TL05. Peat with an approximate thickness of 1m and 1.7m was encountered at gouge core locations GC5 and GC9 respectively which were undertaken at respective turbine locations TL05 and TL06. Peat was also encountered on proposed sections of access road between TL05 – TL06 (GC8) and TL04 – TL05 (GC6). The peat overage is relatively consistent with the GSI mapping which shows blanket peat mapped in the central section of the landholding, albeit based on the site investigation data the peat does exist further south and west than shown by the GSI mapping. Outside of the localised blanket peat area, the till subsoils were typically overlain by mineral topsoil in areas of agricultural land and thin peaty/organic topsoil in forestry areas. Only turbine locations TL05 and TL06 were found to have blanket peat present.

Based on the trial pits undertaken, the overall subsoil thickness within the proposed development site varies between 0.3 and 2m. An undefined transition zone between the subsoils and bedrock was noted in some areas that existed over weathered shale bedrock. The transition zone between the subsoil and bedrock was generally more defined where sandstone bedrock was encountered and this was due to the less weathered state of the sandstone.

No ground stability issues were identified by the trial pit investigation and all subsoils were found to be firm and cohesive which is generally typical of tills. A separate peat stability assessment for the blanket bog was undertaken by Whitefords Geoservices Ltd and this is reviewed below in this chapter.

Trial Pit Name	Location	Primary Subsoil Lithology	Depth to Bedrock (m)
TP01 (TL02)	Turbine location 2	Firm CLAY – CLAY/SILT	1.2
TP02 (TL01)	Turbine location 1	Soft to firm SILT/CLAY	0.3
TP03	Access road north Of T1	Firm CLAY/SILT over very firm CLAY	0.75
TP04 (TL04)	Turbine location 4	Soft to firm SILT over firm sandy SILT/CLAY	0.8
TP05	Access road north Of T4	Soft to firm sandy SILT	2.0
TP06 (TL03)	Turbine location 3	Soft to firm CLAY	0.9
TP07 (TL08)	15m north of T8	Soft to firm SILT over firm CLAY	1.6
TP08 (TL09)	60m east of T9	PEAT over dense silty SAND	1.3
TP09 (TL10)	100 east of T10	PEAT over dense silty SAND	2.0
TP10 (TL07)	Turbine location 7	Firm, gravelly SILT/CLAY	1.2
TP11 (TL11)	Turbine location 11	Firm SILT/CLAY	1.1
TP12	Off forestry track	Soft to firm sandy SILT	1.2
TP13 (TL05)	50m west of T5	Soft to firm CLAY	1.9

Table 5.4: Summary of the Trial Pit Investigation

Location	Easting	Northing	Soil/subsoil Description
GC1	251,928	182,708	soil over SILT/CLAY
GC2	251,690	182,410	Organic soil over SILT
GC3	251,634	182,174	Organic soil over SILT
GC4	251,545	181,870	Mineral soil over SILT/CLAY
GC5	251,206	181,628	1m PEAT over CLAY
GC6	251,140	181,781	0.3m PEAT over SILT/CLAY
GC7	250,964	181,934	Mineral soil over SILT/CLAY
GC8	250,929	181,497	0.6m PEAT over SILT/CLAY

Location	Easting	Northing	Soil/subsoil Description
GC9	250,755	181,487	1.7m PEAT over SILT/CLAY
GC10	250,484	181,154	Organic soil over SILT/CLAY
GC11	250,742	180,675	Peaty topsoil over SILT/CLAY
GC12	250,826	180,372	Peaty topsoil over SILT/CLAY
GC13	250,595	180,409	Mineral soil over SILT/CLAY

Table 5.5: Summary of Soil/Subsoil Gouge Cores

5.2.3 Bedrock Geology

Based on the GSI bedrock map the bedrock units underlying the proposed development site comprises Namurian shales and sandstones and Westphalian shales and sandstones. Both shale and sandstone bedrock was encountered in the trial pits. Evidence of coal was noted within the shale bedrock at turbine location TL03. As stated above the depth to bedrock at the proposed development site is between 0.3 and 2m. The bedrock is poorly exposed within the proposed development site.

The upper profile of the shale bedrock was found to be generally weathered or very soft with excavation of the shale been possible with the excavator bucket. The sandstone bedrock was generally noted to be more competent with the exception of trial pit locations TP08 and TP09 where soft sandstone was proved down to a depth of 4.5m below ground level.

The Castlecomer Plateau, of which this area is a part, is a broad gentle syncline (V-shaped fold) in which the rock strata generally dip towards the centre. The Plateau is then subdivided into a series of compartments by NE-SW and NW-SE trending faults. There are no mapped faults in the area of the proposed development. A bedrock geology map of the area is illustrated in **Figure 5.4**.

5.2.4 Peat Stability Assessment

This section summarises the report on assessment of peat stability undertaken by Whitefords Geoservices Ltd (May, 2015). The peat stability risk assessment report is included as **Appendix 5.3** of this EIS.

The purpose of the peat stability investigation was to obtain sufficient information to allow an assessment of the potential risk of 'Peat Slide' occurrence during development works and to propose mitigation and management to ensure site stability during construction and during the lifetime of the wind energy scheme.

The mean peat/organic topsoil depth encountered in readings across the proposed development site was 0.40m. Peat thickness displayed a range from 0m to 1.90m within the potential development area surveyed by Whiteford Geoservices Ltd. The results of the peat probing are shown in **Table 5.6** below.

ID	Co-ordinates		Peat Depth (m)
	Easting	Northing	
T1	251604	182460	0.00 – 0.10*
T2	251693	182105	0.25 – 0.45*
T3	251676	181781	0.00 – 0.30*
T4	250937	181833	0.20 – 0.40#

ID		Co-ordinates	Peat Depth (m)
	Easting	Northing	
T5	251205	181628	0.80 – 1.00#
T6	250756	181489	0.50 – 1.90#
T7	250403	181186	0.00 – 0.10*
T8	250682	180984	0.00 – 0.10*
T9	250742	180675	0.00 – 0.10#
T10	250826	180372	0.00 – 0.10#
T11	250276	180413	0.00 – 0.10*

Table 5.6: Summary Peat Depths (Whitefords Geoservices Ltd)

* Topsoil/organic topsoil. # Blanket Peat

The appraisal of the Hazard Rankings for each proposed turbine and structure location indicates that the site (encompassing Turbines T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11 and the electrical substation and permanent met-mast) carry INSIGNIFICANT Hazard Rankings as determined in accordance with the guidelines outlined by The Scottish Executive & Halcrow Group Ltd in *"Peat Slide Hazard and Risk Assessment - Best Practice Guide for Proposed Electricity Generation Developments"*, December 2006.

Based on the assessment, the site is deemed suitable for the proposed development. Peat slide risk has indicated an INSIGNIFICANT risk of instability in relation to the structural aspects of the proposed development.

5.2.5 Geological Resource Importance

The sandstone and shale bedrock at the site could be classified as "Medium" importance. The bedrock could be used on a "sub-economic" local scale for construction purposes. The bedrock has not been used in the past at the site for this purpose.

The mineral subsoil deposits at the site could be classified as "High to Medium" in terms of agricultural and forestry usage respectively. Refer to **Table 5.1** for definition of these criteria.

5.2.6 Geological Heritage and Designated Sites

There are no GSI recorded Geological Heritage sites, mineral deposit sites or mining sites (current or historic) within the proposed development area. The proposed development is not located within any designated site. The closest geological heritage sites to the proposed development are located at The Swan which exists 4km to the east of the site. There will be no impact on this heritage site.

5.3 Description of Likely Impacts

The proposed development will typically involve removal of peat (where present), subsoils and bedrock for on-site access road, hardstandings and turbine foundations. Bedrock for construction will be sourced from local quarries as there are no proposals for an on-site borrow pit.

Estimated volumes of topsoil and peat to be removed are shown in **Table 5.7**.

Settlement ponds where constructed will be volume neutral, i.e. all material excavated will be used to form side bunds and landscaping around the ponds. There will be no excess material from settlement pond construction. The material will also be reinstated during decommissioning.

Development	Number	Length	Avg Width	Depth	M3	Allow 10% extra
Roads	1	7400	5	0.5	18500	20350
Turbine Hardstanding	11	50	20	1	11000	12100
Met Mast Hardstanding	1	22	15	1	330	363
Substation	1	94	21	2.25	4441.5	4886
Junction Upgrade	1	20	50	0.5	500	550
Compound Area	1	33	43	0.5	709.5	780

Table 5.7: Estimated Topsoil and Peat Excavation Volumes

5.3.1 "Do Nothing" Impacts

Surface water drainage excavations carried out in areas of existing access road, coniferous plantations and agricultural land will continue to function and may be extended in the case of all three. Coniferous forestry will be felled as forestry compartments reach maturity. Re-planting of these areas with more coniferous trees is likely to occur. Plantations will be re-ploughed where necessary to facilitate afforestation.

5.3.2 "Worst Case" Impacts

The impacts of a 'worst case' scenario are:-

- Localised contamination of soils and subsoils during the construction phase due to fuels/oils leaks and spillages.
- Localised soil stability issues due to the movement and storage of peat.

The "worst case" impacts are not deemed to be significant.

5.3.3 Potential Construction Phase Impacts

5.3.3.1 Peat, Subsoil Excavation and Bedrock Excavation

Excavation of peat, subsoil and bedrock will be required for site leveling, for the installation of foundations for the access roads and turbines etc. This will result in a permanent removal of peat, subsoil and bedrock at excavation locations. Estimated volumes of peat and subsoils to be relocated are shown in **Table 5.7** above.

The overall impact is determined not to be significant due to the following:

- A minimal volume of soil, subsoil and bedrock in comparison to the total volume present on the site will be removed to allow for infrastructural work to take place;
- The soil, subsoil and bedrock which will be removed during the construction phase will be localised to the turbine location and access roads;
- The bedrock at the site can be classified as "Medium" importance;
- The soils and subsoil at the site can be classified as "High to Moderate" importance with the former relating to agricultural land and the latter to forestry.

Mechanism: Extraction/excavation.

Receptor: *Peat, subsoil and bedrock*

Pre-mitigation Impact: Negative, slight/moderate, direct, high probability, permanent impact on peat, subsoil and bedrock.

5.3.3.2 Contamination of Soil by Leakages and Spillages and Alteration of Peat/Soil Geochemistry

Pathway: Peat, subsoil and bedrock pore space.

Receptor: Peat, subsoil and bedrock.

Pre-mitigation: Negative, direct, slight, short term, medium probability impact on peat, soils and bedrock.

5.3.3.3 Erosion of Exposed Subsoils During Tree Felling, Access Road and Turbine Base Construction Work

Mechanism: Vehicle movement, surface water and wind action.

Receptor: Peat, subsoil & weathered bedrock.

Pre-Mitigation Impact: Negative, direct, slight, high probability impact on peat, subsoils and bedrock.

5.3.3.4 Peat Instability and Failure

Peat instability or failure refers to a significant mass movement of a body of peat that would have an adverse impact on proposed wind farm development and the surrounding environment. Peat failure excludes localised movement of peat that could occur below an access road, creep movement or erosion type events. The consequence of peat failure at the study area may result in:

- Death or injury to site personnel;
- Damage to machinery;
- Damage or loss of access tracks;
- Drainage disrupted;
- Site works damaged or unstable;
- Contamination of watercourses, water supplies by particulates;
- Degradation of the peat environment.

Mechanism: Vehicle movement and excavations.

Receptor: Peat subsoils.

Pre-mitigation Impact: Direct, negative, significant, low probability impact on peat and subsoils.

5.4 Mitigation & Monitoring Measures

5.4.1 Construction Phase Mitigation Measures

5.4.1.1 Peat, Subsoil Excavation and Bedrock Excavation

- No turbines or directly related infrastructure will be constructed near or on any designated sites such as NHAs or SACs;
- Rock aggregate for construction purposes is to be sourced off-site to avoid large on-site borrow pits;
- The soil, subsoil and bedrock which will be removed during the construction phase will be localised to the turbine location and access roads.

Residual Impact:

Negative, Imperceptible, direct, short term, low probability impact.

Significance of Effects:

No significant impact on soils, subsoils or bedrock are anticipated.

5.4.1.2 Contamination of Soil by Leakages and Spillages and Alteration of Peat/Soil Geochemistry

Proposed Mitigation Measures:

- Minimal refuelling or maintenance of construction vehicles or plant will take place on site. Off-site refuelling will occur at a controlled fueling station;
- On site refuelling will be undertaken using a double skinned bowser with spill kits on the ready for accidental leakages or spillages;
- Fuels stored on site will be minimised. Storage areas, where required, will be bunded appropriately for the fuel storage volume for the time period, and fitted with a storm drainage system and an appropriate oil interceptor;
- The electrical control building will be bunded appropriately to the volume of oils likely to be stored; and to prevent leakage of any associated chemicals to groundwater or surface water. The bunded area will be fitted with a storm drainage system and an appropriate oil interceptor;
- The plant used during construction will be regularly inspected for leaks and fitness for purpose;
- An emergency plan for the construction phase to deal with accidental spillages will be contained within Environmental Management Plan. Spill kits will be available to deal with and accidental spillage in and outside the refuelling area.

Residual Impact:

Negative, Imperceptible, direct, short term, low probability impact.

Significance of Effects:

No significant impact on soils, subsoils or bedrock are anticipated.

5.4.1.3 Erosion of Exposed Subsoils During Tree Felling, Access Road and Turbine Base Construction Work

Proposed Mitigation Measures

- Peat and subsoils removed from turbine locations and access roads will be used for landscaping, cast aside and deposited on-site;
- Any excess temporary mounded subsoils in storage for long periods will be covered by a polyethylene sheets or seeded at the earliest opportunity. This will prevent erosion of soil. Silt fences will be installed around stockpiles to limit movement of entrained sediment in surface water runoff. The use of bunds around earthworks and mounds will prevent egress of water from the works;
- In order to minimise erosion of mineral subsoils stripping of topsoil will not take place during extremely wet periods (to prevent increased silt rich runoff). Temporary drainage systems will be required to limit runoff impacts during the construction phase;
- In forestry areas, brash mats will be used to support vehicles on soft ground, reducing topsoil and mineral soils erosion and avoiding the formation of rutted areas, in which surface water ponding can occur. Brash mat renewal will take place when they become heavily used and worn. Provision will be made for brash mats along all off-road routes, to protect the soil from compaction and rutting.

Residual Impact:

Negative, slight, direct, medium probability impact on peat, subsoils and weathered bedrock

Significance of Effects:

No significant impact on soils, subsoils or bedrock are anticipated.

5.4.1.4 Peat Instability and Failure

Impact Assessment / Mitigation Measures

Whitefords Geoservices Ltd appraisal of the Hazard Rankings, for each proposed turbine and structure location indicates that the site (encompassing turbines T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11 and the electrical switchroom and permanent met-mast) carry INSIGNIFICANT Hazard Rankings in relation to peat instability. Please refer to the peat stability assessment report for proposed measures to prevent peat slide and bog burst **(Appendix 5.2)**.

Residual Impact:

There are no residual impacts anticipated on the soils and geological environment.

Significance of Effects:

No significant impact on soils, subsoils or bedrock are anticipated.

Appendix 5.1: Trial Pit Logs

TRIAL PIT LOG

TRIAL PIT NUMBER: TP01-TL02

ENVIRONMENTAL ENGINEERING HYDROLOGY HYDROGEOLOGY

PROJECT NUMBER: P1264	**DATE STARTED:** 30/3/15	**EASTING:** 251693
SITE: Pinewoods WF, Co. Laois	**LOGGED BY:** DB	**NORTHING:** 182105
CLIENT: Pinewoods Wind Ltd.	**CONTRACTOR:** Shay Power	**ELEVATION:**

Comments	Sample Number	Sample Type	Water Strikes	Elevation	Meters Below Ground Surface	Lithology	Formation Description
				0.00			Ground Surface
				-0.20	0		Topsoil (Organic)
				-0.50			Dark brown, soft SILT/CLAY
				-1.20	1		Greyish blue, firm CLAY - SILT/CLAY with orange mottling
					2		SHALE (Flat slab of SHALE on base of hole) Bedrock Met Total Depth 1.2m
					3		
					4		
				-5.00	5		

REMARKS: Trial pit at turbine location TL02

PIT LENGTH:

PIT BREADTH:

FINAL DEPTH: 1.2m

EXCAVATOR:

LEGEND
∇ - Water strike
D - Disturbed sample
B - Bulk disturbed sample
W - Water sample
V - Vane test
T - No. of threads
R - Average length of ribbons
Dil - Dilatancy recorded
ND - No dilatancy recorded

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SCALE

HYDRO-ENVIRONMENTAL SERVICES 22 Lower Main Street Dungarvan Co. Waterford Tel: 058-44122 Fax: 058-44244 Email: info@hydroenvironmental.ie

ENVIRONMENTAL ENGINEERING
HYDROLOGY HYDROGEOLOGY

TRIAL PIT LOG

TRIAL PIT NUMBER: TP02-TL01

PROJECT NUMBER: P1264	**DATE STARTED:** 30/3/15	**EASTING:** 251604
SITE: Pinewoods WF, Co. Laois	**LOGGED BY:** DB	**NORTHING:** 182460
CLIENT: Pinewoods Wind Ltd.	**CONTRACTOR:** Shay Power	**ELEVATION:**

Comments	Sample Number	Sample Type	Water Strikes	Elevation	Meters Below Ground Surface	Lithology	Formation Description
				0.00	0		Ground Surface
							Topsoil
				-0.30			Reddish brown, soft to firm SILT/CLAY
				-0.70			Weathered, broken SHALE (flakey)
					1		Broken SHALE (getting more blocky) Bedrock Met
				-1.30			Total Depth 1.3m
					2		
					3		
					4		
				-5.00	5		

REMARKS: Trial pit at turbine location TL01

PIT LENGTH:
PIT BREADTH:
FINAL DEPTH: 1.3m
EXCAVATOR:

LEGEND
∇ - Water strike
D - Disturbed sample
B - Bulk disturbed sample
W - Water sample
V - Vane test
T - No. of threads
R - Average length of ribbons
Dil - Dilatancy recorded
ND - No dilatancy recorded

SCALE

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TRIAL PIT LOG

ENVIRONMENTAL ENGINEERING HYDROLOGY HYDROGEOLOGY

TRIAL PIT NUMBER: TP03-SSN

PROJECT NUMBER: P1264	**DATE STARTED:** 30/3/15	**EASTING:** 251780
SITE: Pinewoods WF, Co. Laois	**LOGGED BY:** DB	**NORTHING:** 182580
CLIENT: Pinewoods Wind Ltd.	**CONTRACTOR:** Shay Power	**ELEVATION:**

Comments	Sample Number	Sample Type	Water Strikes	Elevation	Meters Below Ground Surface	Lithology	Formation Description
				0.00			Ground Surface
				-0.20	0		Topsoil
				-0.50			Bluish grey, firm to very firm SILT/CLAY
				-0.75			Greyish blue, very firm CLAY with some orange mottling
				-1.10	1		Grey blue weathered SHALE
							Bedrock Met
							Total Depth 1.1m
					2		
					3		
					4		
				-5.00	5		

REMARKS: Trial pit at Substation North location

PIT LENGTH:

PIT BREADTH:

FINAL DEPTH: 1.1m

EXCAVATOR:

LEGEND
∇ - Water strike
D - Disturbed sample
B - Bulk disturbed sample
W - Water sample
V - Vane test
T - No. of threads
R - Average length of ribbons
Dil - Dilatancy recorded
ND - No dilatancy recorded

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SCALE

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ENVIRONMENTAL ENGINEERING HYDROLOGY HYDROGEOLOGY

TRIAL PIT LOG

TRIAL PIT NUMBER: TP04-TL04

PROJECT NUMBER: P1264
SITE: Pinewoods WF, Co. Laois
CLIENT: Pinewoods Wind Ltd.

DATE STARTED: 30/3/15
LOGGED BY: DB
CONTRACTOR: Shay Power

EASTING: 250937
NORTHING: 181833
ELEVATION:

Comments	Sample Number	Sample Type	Water Strikes	Elevation	Meters Below Ground Surface	Lithology	Formation Description
				0.00	0		Ground Surface
				-0.15			Topsoil (Organic)
				-0.30			Grey, soft to firm SILT
							Reddish brown, soft to firm, slightly sandy SILT/CLAY
				-0.80			Reddish brown, weathered SANDSTONE
					1		Bedrock Met
							Total Depth 0.9m
					2		
					3		
					4		
				-5.00	5		

REMARKS: Trial pit at turbine location TL04

PIT LENGTH:
PIT BREADTH:
FINAL DEPTH: 0.9m
EXCAVATOR:

LEGEND
∇ - Water strike
D - Disturbed sample
B - Bulk disturbed sample
W - Water sample
V - Vane test
T - No. of threads
R - Average length of ribbons
Dil - Dilatancy recorded
ND - No dilatancy recorded

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SCALE

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TRIAL PIT LOG

ENVIRONMENTAL ENGINEERING HYDROLOGY HYDROGEOLOGY

TRIAL PIT NUMBER: TP05-SSS

PROJECT NUMBER: P1264
SITE: Pinewoods WF, Co. Laois
CLIENT: Pinewoods Wind Ltd.

DATE STARTED: 30/3/15
LOGGED BY: DB
CONTRACTOR: Shay Power

EASTING: 251080
NORTHING: 181820
ELEVATION:

Comments	Sample Number	Sample Type	Water Strikes	Elevation	Meters Below Ground Surface	Lithology	Formation Description
				0.00	0		Ground Surface
				-0.15			Topsoil
							Greyish orange, firm, sandy SILT
				-1.00	1		Soft to firm, sandy SILT (with blue CLAY discontinuities and boulders and cobbles)
				-2.00	2		SANDSTONE Bedrock Met
							Total Depth 2.0m
					3		
					4		
				-5.00	5		

REMARKS: Trial pit at Substation South location

PIT LENGTH:
PIT BREADTH:
FINAL DEPTH: 2.0m
EXCAVATOR:

LEGEND
∇ - Water strike
D - Disturbed sample
B - Bulk disturbed sample
W - Water sample
V - Vane test
T - No. of threads
R - Average length of ribbons
Dil - Dilatancy recorded
ND - No dilatancy recorded

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SCALE

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ENVIRONMENTAL ENGINEERING HYDROLOGY HYDROGEOLOGY

TRIAL PIT LOG

TRIAL PIT NUMBER: TP06-TL03

PROJECT NUMBER: P1264
SITE: Pinewoods WF, Co. Laois
CLIENT: Pinewoods Wind Ltd.

DATE STARTED: 30/3/15
LOGGED BY: DB
CONTRACTOR: Shay Power

EASTING: 251677
NORTHING: 181752
ELEVATION:

Comments	Sample Number	Sample Type	Water Strikes	Elevation	Meters Below Ground Surface	Lithology	Formation Description
				0.00	0		Ground Surface
							Topsoil
				-0.40			Brown, soft SILT/CLAY
				-0.90			Grey, soft to firm CLAY (with evidence of coal)
				-1.70	1		Dark grey, soft SHALE Bedrock Met
					2		Total Depth 1.7m
					3		
					4		
				-5.00	5		

REMARKS: Trial pit at turbine location TL03

PIT LENGTH:
PIT BREADTH:
FINAL DEPTH: 1.7m
EXCAVATOR:

LEGEND
∇ - Water strike
D - Disturbed sample
B - Bulk disturbed sample
W - Water sample
V - Vane test
T - No. of threads
R - Average length of ribbons
Dil - Dilatancy recorded
ND - No dilatancy recorded

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SCALE

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ENVIRONMENTAL ENGINEERING HYDROLOGY HYDROGEOLOGY

TRIAL PIT LOG

TRIAL PIT NUMBER: TP07-TL08

PROJECT NUMBER: P1264	**DATE STARTED:** 30/3/15	**EASTING:** 250682
SITE: Pinewoods WF, Co. Laois	**LOGGED BY:** DB	**NORTHING:** 180995
CLIENT: Pinewoods Wind Ltd.	**CONTRACTOR:** Shay Power	**ELEVATION:**

Comments	Sample Number	Sample Type	Water Strikes	Elevation	Meters Below Ground Surface	Lithology	Formation Description
				0.00	0		Ground Surface
				-0.15			Topsoil
				-0.60			Greyish orange, soft to firm SILT
				-1.60	1		Bluish grey, firm CLAY
				-3.20	2, 3		Soft, broken SHALE Bedrock Met
					4, 5		Total Depth 3.2m

REMARKS: Trial pit 15m north of turbine location TL08

PIT LENGTH:
PIT BREADTH:
FINAL DEPTH: 3.2m
EXCAVATOR:

LEGEND
∇ - Water strike
D - Disturbed sample
B - Bulk disturbed sample
W - Water sample
V - Vane test
T - No. of threads
R - Average length of ribbons
Dil - Dilatancy recorded
ND - No dilatancy recorded

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ENVIRONMENTAL ENGINEERING HYDROLOGY HYDROGEOLOGY

TRIAL PIT LOG

TRIAL PIT NUMBER: TP08-TL09

PROJECT NUMBER: P1264	**DATE STARTED:** 31/3/15	**EASTING:** 250802
SITE: Pinewoods WF, Co. Laois	**LOGGED BY:** DB	**NORTHING:** 180673
CLIENT: Pinewoods Wind Ltd.	**CONTRACTOR:** Shay Power	**ELEVATION:**

Comments	Sample Number	Sample Type	Water Strikes	Elevation	Meters Below Ground Surface	Lithology	Formation Description
				0.00	0		Ground Surface
				-0.60			PEAT
				-1.30	1		Orange, dense, silty SAND (coarse)
				-2.90	2		Soft, weathered SANDSTONE Bedrock Met
					3		Total Depth 2.9m
					4		
				-5.00	5		

REMARKS: Trial pit 60m east of turbine location TL09

PIT LENGTH:

PIT BREADTH:

FINAL DEPTH: 2.9m

EXCAVATOR:

LEGEND
∇ - Water strike
D - Disturbed sample
B - Bulk disturbed sample
W - Water sample
V - Vane test
T - No. of threads
R - Average length of ribbons
Dil - Dilatancy recorded
ND - No dilatancy recorded

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ENVIRONMENTAL ENGINEERING
HYDROLOGY HYDROGEOLOGY

TRIAL PIT LOG

TRIAL PIT NUMBER: TP09-TL10

PROJECT NUMBER: P1264	**DATE STARTED:** 30/3/15	**EASTING:** 250928
SITE: Pinewoods WF, Co. Laois	**LOGGED BY:** DB	**NORTHING:** 180414
CLIENT: Pinewoods Wind Ltd.	**CONTRACTOR:** Shay Power	**ELEVATION:**

Comments	Sample Number	Sample Type	Water Strikes	Elevation	Meters Below Ground Surface	Lithology	Formation Description
				0.00			Ground Surface
					0		PEAT
				-0.50			Orange brown, dense, silty SAND
					1		
				-2.00	2		Orange brown, soft, weathered SANDSTONE Bedrock Met
					3		
					4		
				-4.50			Total Depth 4.5m
				-5.00	5		

REMARKS: Trial pit 100m east of turbine location TL10	**PIT LENGTH:** **PIT BREADTH:** **FINAL DEPTH:** 4.5m **EXCAVATOR:**

LEGEND
∇ - Water strike
D - Disturbed sample
B - Bulk disturbed sample
W - Water sample
V - Vane test
T - No. of threads
R - Average length of ribbons
Dil - Dilatancy recorded
ND - No dilatancy recorded

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SCALE

ENVIRONMENTAL ENGINEERING
HYDROLOGY HYDROGEOLOGY

TRIAL PIT LOG

TRIAL PIT NUMBER: TP10-TL07

PROJECT NUMBER: P1264	**DATE STARTED:** 31/3/15	**EASTING:** 250403
SITE: Pinewoods WF, Co. Laois	**LOGGED BY:** DB	**NORTHING:** 181186
CLIENT: Pinewoods Wind Ltd.	**CONTRACTOR:** Shay Power	**ELEVATION:**

Comments	Sample Number	Sample Type	Water Strikes	Elevation	Meters Below Ground Surface	Lithology	Formation Description
				0.00	0		Ground Surface
							Topsoil
				-0.50			Beige, firm, slightly gravelly SILT/CLAY
				-1.20	1		Grey, firm to very firm, very shaley SILT/CLAY
				-3.50	2, 3		Soft SHALE (very flakey) Bedrock Met
				-5.00	4, 5		Total Depth 3.5m

REMARKS: Trial pit at turbine location TL07

PIT LENGTH:
PIT BREADTH:
FINAL DEPTH: 3.5m
EXCAVATOR:

LEGEND
∇ - Water strike
D - Disturbed sample
B - Bulk disturbed sample
W - Water sample
V - Vane test
T - No. of threads
R - Average length of ribbons
Dil - Dilatancy recorded
ND - No dilatancy recorded

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SCALE

TRIAL PIT LOG

TRIAL PIT NUMBER: TP11-TL11

PROJECT NUMBER: P1264	**DATE STARTED:** 31/3/15	**EASTING:** 250276
SITE: Pinewoods WF, Co. Laois	**LOGGED BY:** DB	**NORTHING:** 180413
CLIENT: Pinewoods Wind Ltd.	**CONTRACTOR:** Shay Power	**ELEVATION:**

ENVIRONMENTAL ENGINEERING HYDROLOGY HYDROGEOLOGY

Comments	Sample Number	Sample Type	Water Strikes	Elevation	Meters Below Ground Surface	Lithology	Formation Description
				0.00	0		Ground Surface
				-0.15			Topsoil
				-1.10	1		Reddish brown, firm SILT/CLAY
				-1.50			Weathered SHALE with high SILT/CLAY content
				-3.80	2, 3		Soft SHALE Bedrock Met
				-5.00	4, 5		Total Depth 3.8m

REMARKS: Trial pit at turbine location TL11

PIT LENGTH:

PIT BREADTH:

FINAL DEPTH: 3.8m

EXCAVATOR:

LEGEND
∇ - Water strike
D - Disturbed sample
B - Bulk disturbed sample
W - Water sample
V - Vane test
T - No. of threads
R - Average length of ribbons
Dil - Dilatancy recorded
ND - No dilatancy recorded

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TRIAL PIT LOG

ENVIRONMENTAL ENGINEERING HYDROLOGY HYDROGEOLOGY

TRIAL PIT NUMBER: TP12

PROJECT NUMBER: P1264	**DATE STARTED:** 31/3/15	**EASTING:** 225112
SITE: Pinewoods WF, Co. Laois	**LOGGED BY:** DB	**NORTHING:** 181033
CLIENT: Pinewoods Wind Ltd.	**CONTRACTOR:** Shay Power	**ELEVATION:**

Comments	Sample Number	Sample Type	Water Strikes	Elevation	Meters Below Ground Surface	Lithology	Formation Description
				0.00	0		Ground Surface
				-0.30			Peaty Topsoil
				-1.20	1		Orange/grey, soft to firm, slightly sandy SILT
				-2.50	2		Weathered SHALE Bedrock Met
				-5.00	3, 4, 5		Total Depth 2.5m

REMARKS: Trial pit just off existing forestry track

PIT LENGTH:
PIT BREADTH:
FINAL DEPTH: 2.5m
EXCAVATOR:

LEGEND
∇ - Water strike
D - Disturbed sample
B - Bulk disturbed sample
W - Water sample
V - Vane test
T - No. of threads
R - Average length of ribbons
Dil - Dilatancy recorded
ND - No dilatancy recorded

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TRIAL PIT LOG

TRIAL PIT NUMBER: TP13-TL05

ENVIRONMENTAL ENGINEERING HYDROLOGY HYDROGEOLOGY

PROJECT NUMBER: P1264	**DATE STARTED:** 30/3/15	**EASTING:** 251155
SITE: Pinewoods WF, Co. Laois	**LOGGED BY:** DB	**NORTHING:** 181623
CLIENT: Pinewoods Wind Ltd.	**CONTRACTOR:** Shay Power	**ELEVATION:**

Comments	Sample Number	Sample Type	Water Strikes	Elevation	Meters Below Ground Surface	Lithology	Formation Description
				0.00	0		Ground Surface
				-0.50			PEAT
				-1.90	1		Bluish grey, soft to firm CLAY
					2		SANDSTONE Bedrock Met
					3		Total Depth 1.9m
					4		
				-5.00	5		

REMARKS: Trial pit 50m west of turbine location TL05

PIT LENGTH:

PIT BREADTH:

FINAL DEPTH: 1.9m

EXCAVATOR:

LEGEND
∇ - Water strike
D - Disturbed sample
B - Bulk disturbed sample
W - Water sample
V - Vane test
T - No. of threads
R - Average length of ribbons
Dil - Dilatancy recorded
ND - No dilatancy recorded

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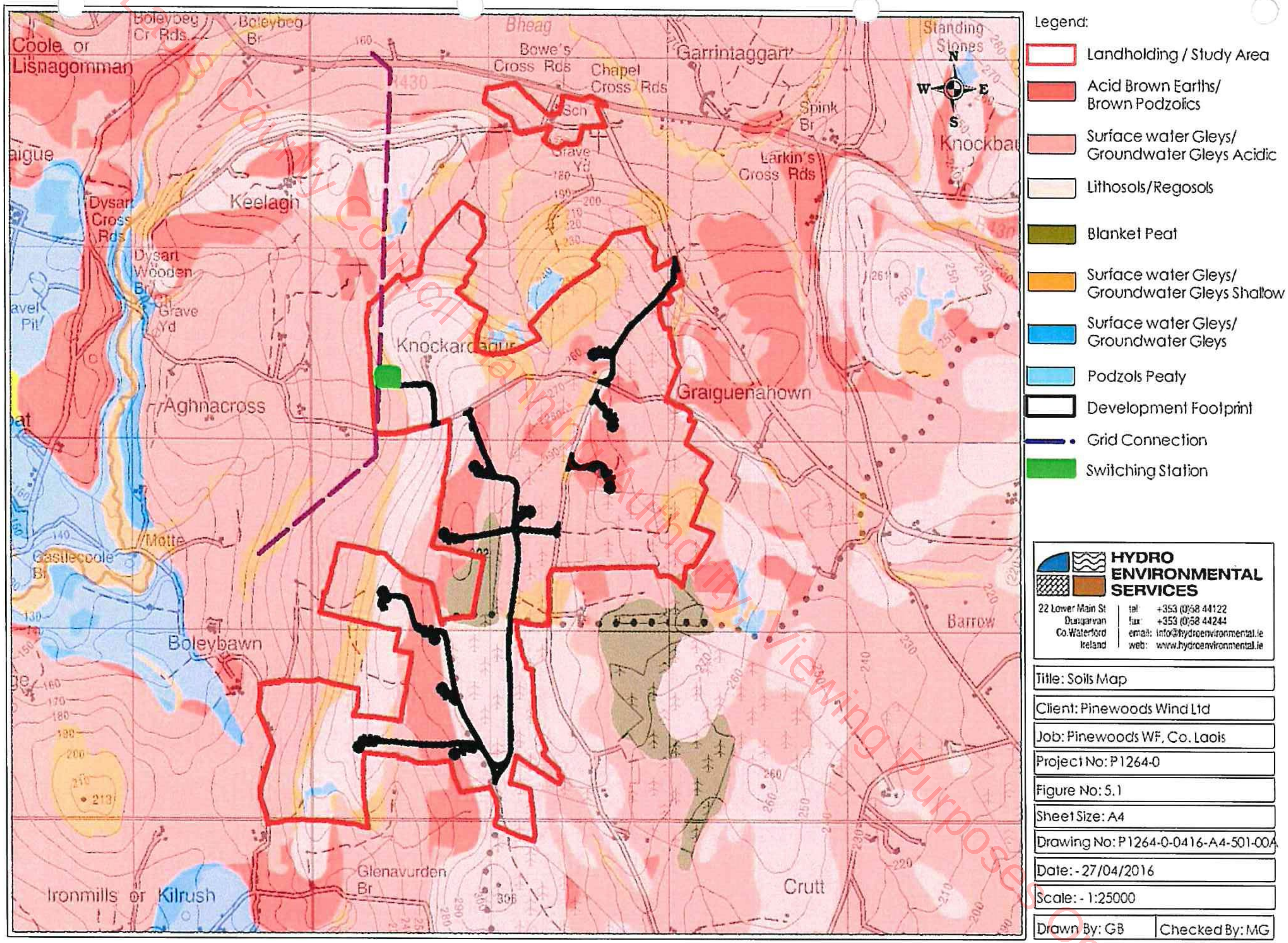
Appendix 5.2: Figures



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web: www.hydroenvironmental.ie

Title: Soils Map

Client: Pinewoods Wind Ltd

Job: Pinewoods WF, Co. Laois

Project No: P1264-0

Figure No: 5.1

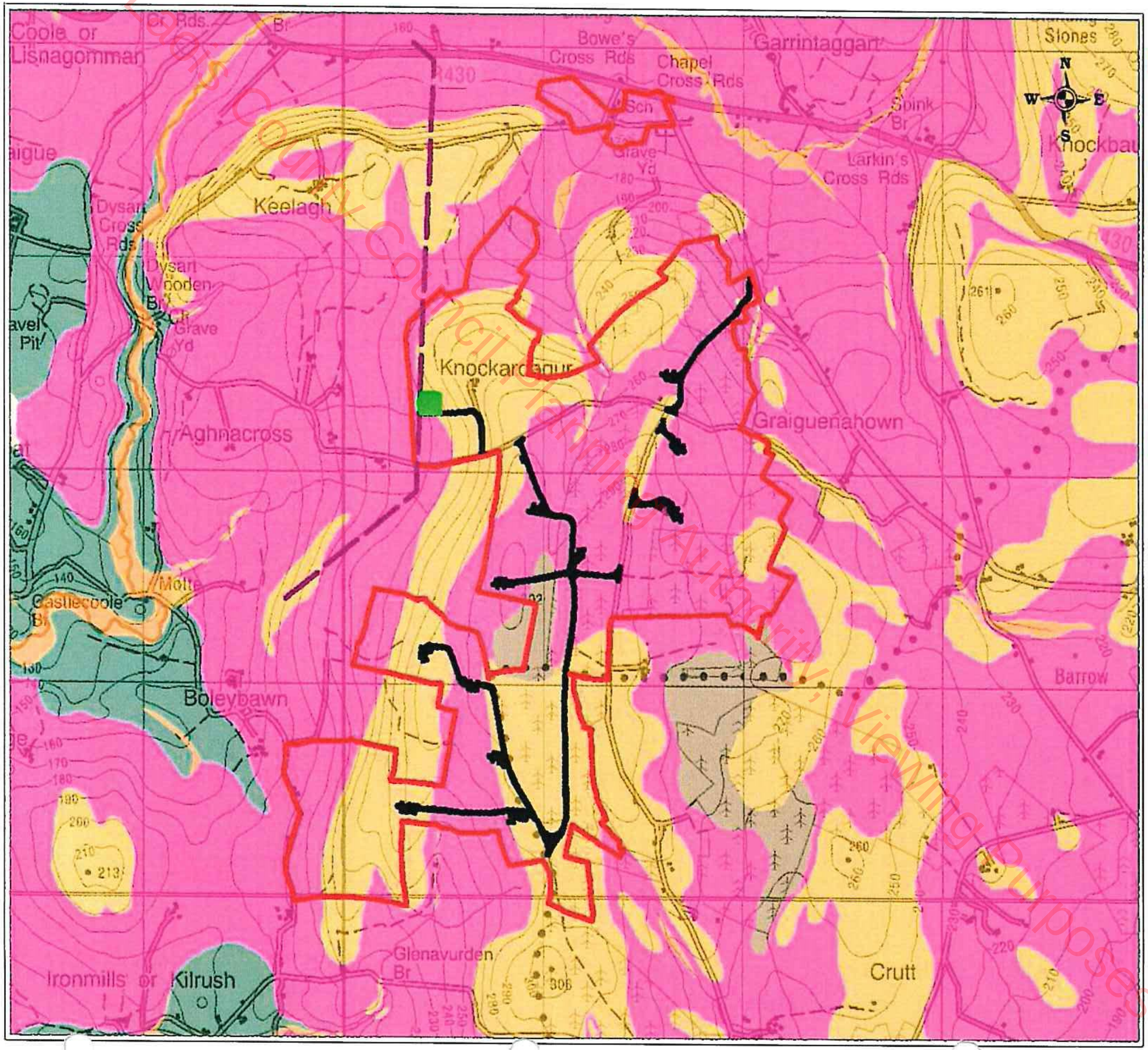
Sheet Size: A4

Drawing No: P1264-0-0416-A4-501-00A

Date: - 27/04/2016

Scale: - 1:25000

Drawn By: GB | Checked By: MG



Legend:

- Landholding / Study Area
- Namurian Shales & Sandstones
- Bedrock at or close to Surface
- Undifferentiated Alluvium - Gravelly
- Blanket Peat
- Limestone Sand and Gravels
- Development Footprint
- Grid Connection
- Switching Station

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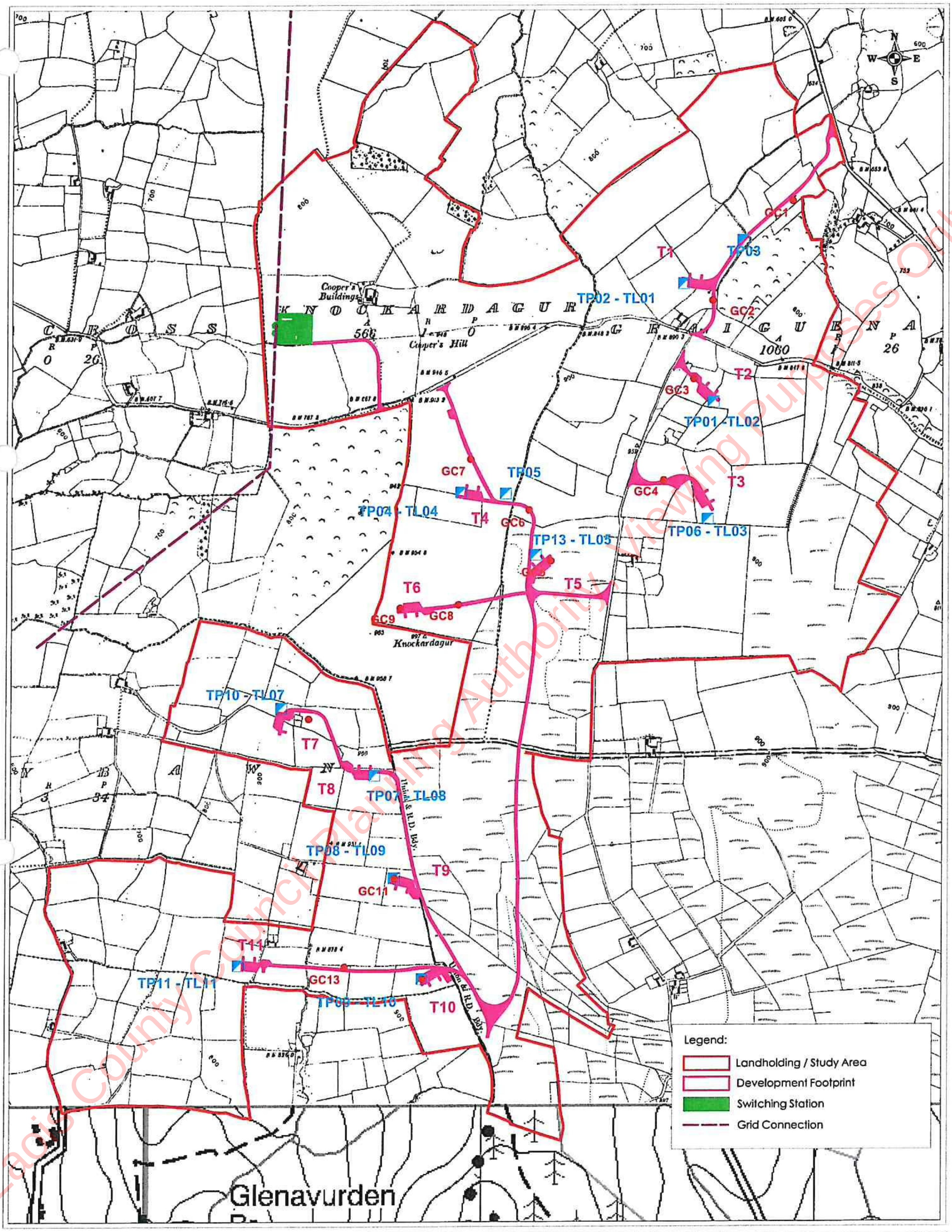
Title: Subsoils Map	
Client: Pinewoods Wind Ltd	
Job: Pinewoods WF, Co. Laois	
Project No: P1264-0	
Figure No: 5.2	
Sheet Size: A4	
Drawing No: P1264-0-0416-A4-502-00A	
Date: - 27/04/2016	
Scale: - 1:25000	
Drawn By: GB	Checked By: MG



Client: Pinewoods Wind Ltd	Drawing No: P1264-0-0416-A3-503-00A	
Job: Pinewoods WF Co. Laois / Kilkenny	Sheet Size: A3	Project No: P1264
Title: Site Investigation Map	Scale: - 1:10000	Drawn By: DB
Figure No: 5.3	Date: - 27/04/2016	Checked By: MG

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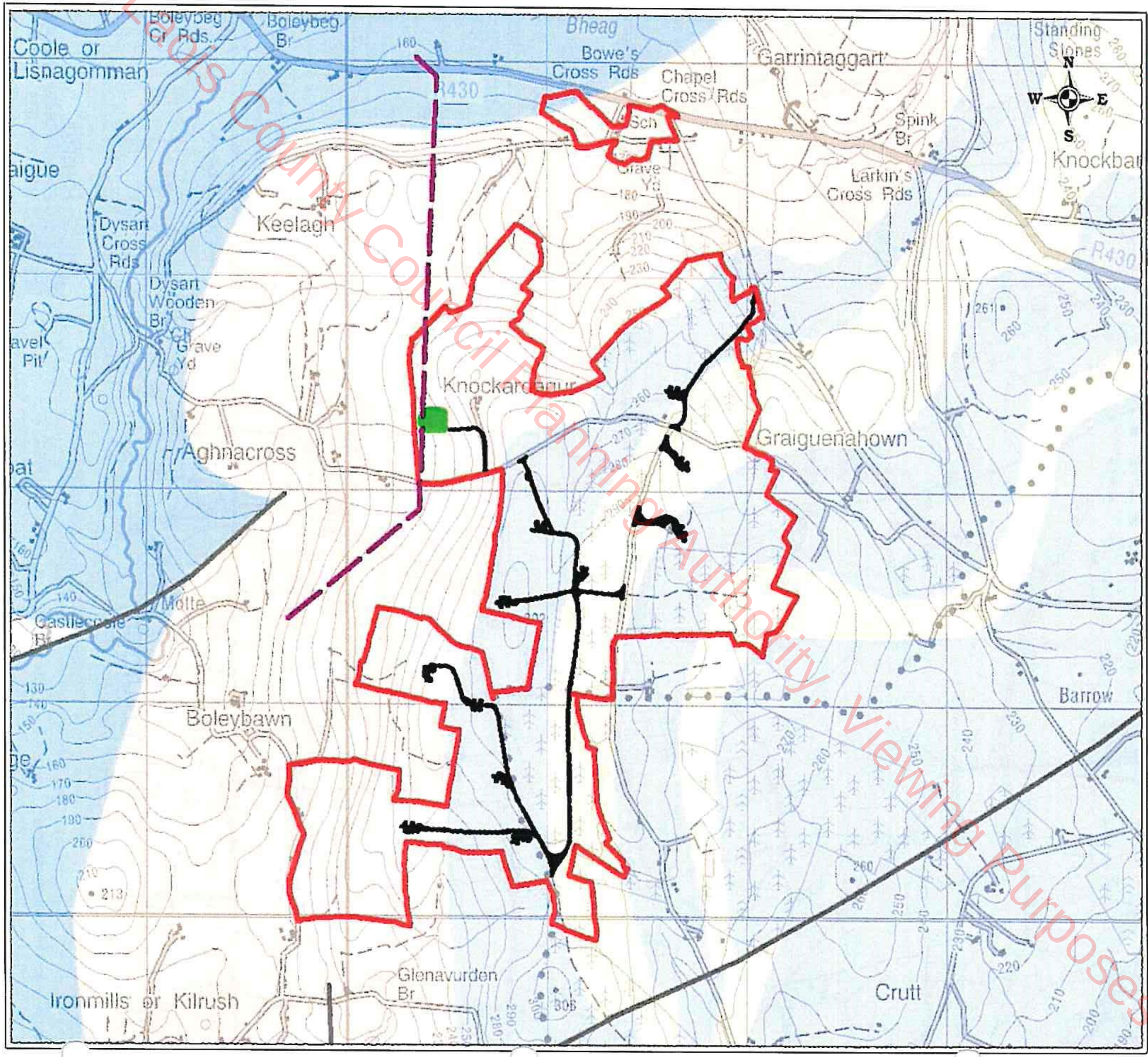

Legend:

- Landholding / Study Area
- Namurian Shales
- Namurian Sandstones
- Westphalian Shales
- Westphalian Sandstones
- Mapped Faults
- Development Footprint
- Grid Connection
- Switching Station

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Title: Bedrock (Unit) Map	
Client: Pinewoods Wind Ltd	
Job: Pinewoods WF, Co. Laois	
Project No: P1264-0	
Figure No: 5.4	
Sheet Size: A4	
Drawing No: P1264-0-0416-504-A4-0A	
Date: - 27/04/2016	
Scale: - 1:25000	
Drawn By: GB	Checked By: MG

Appendix 5.3: Peat Slide Risk Assessment

whiteford
explore the possibilities

Pinewoods Wind Farm
Peat Slide Risk Assessment

Report No: 1502-14 Rev 3

12th May 2016

This document has been prepared by Whiteford Geoservices Ltd on behalf of

Pinewoods Wind Ltd

Galetech Energy Developments Ltd

UVDB empowered by Achilles

Constructionline

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Peat Slide Risk Assessment at Pinewoods Wind Farm, Co. Laois and Co. Kilkenny

Client: Galetech Energy Developments Ltd c/o Pinewoods Wind Ltd

Date: 12th May 2016

Report No. 1502-14 Rev 3 PWL

Statement of Authority

John Whiteford BSc (Hons) Geol MIOSH MEAGE has more than 15 years of experience in the field of earth sciences, geotechnical engineering and management. His academic qualifications are a BSc with Honours in Geophysics from Edinburgh University, with memberships of The European Association of Geoscientists and Engineers and The Institute of Safety and Health.

Commencing work with Kirk McClure Morton (Consulting Engineers) in Belfast in 1993 he has been engaged in full-time consultancy for the past 15 years and since 1996 trading as Whiteford Geoservices Ltd. The company has a staff of more than 10 professional and technical personnel and has completed in excess 700 contracts for clients within the construction and mineral exploration sectors where they have built up a recognised level of specialist experience, particularly in the field of Wind Energy. Working at home, in Europe and worldwide the company has been involved in more than 80 wind power projects where our services have been sought in relation to foundation design, peat slide risk assessment, geophysics, electrical earthing design and thermal resistivity analysis.

The following report is based upon the guidance contained within the Scottish Executive's "*Peat Slide Hazard and Risk Assessment – Best Practice Guide for Proposed Electricity Generation Developments*", published as a final version in December 2006 (referred to as "the Scottish Guidance"). Unless otherwise stated, all assessments and conclusions contained within this report are made with reference to this publication. However, there are a significant number of variations from the guidance and where this occurs the reason for the divergence is provided, either within the text or as a footnote.

This report details the works undertaken by Whiteford Geoservices Ltd on the site of the proposed Pinewoods Wind Farm, Co. Laois and Co. Kilkenny.

1.0 INTRODUCTION

1.1.1 Background and Purpose

At the request of Galetech Energy Developments Ltd, on behalf of Pinewoods Wind Ltd, Whiteford Geoservices Ltd has undertaken a walk over survey and peat slide risk assessment at the site of the proposed Pinewoods Wind Farm, Co. Laois and Co. Kilkenny.

The purpose of this investigation was to obtain sufficient information to allow an assessment of the potential risk of 'Peat Slide' occurrence during development works and to propose mitigation and management to ensure site stability during construction and during the lifetime of the wind energy scheme.

The following report details the fieldwork undertaken to gather data required to determine the risk from peat instability to the surrounding environment. It also details the analytical process undertaken to apportion risk to the various construction elements; namely construction of turbine bases and associated infrastructure.

Background desk study information was obtained for the site, prior to initiating fieldwork (as per the requirements of the Scottish Guidance).

Whiteford Geoservices Ltd personnel visited the site on 1st August and 22nd November 2014 to undertake a walkover survey for the assessment of topography, superficial geology, drainage and ground stability conditions.

1.1.2 The Site

The site of the proposed Pinewoods Wind Farm is located within the townland of Knockardagur, approximately 7.5km east of Abbeyleix in County Laois. The site lies south of the R430 carriageway.

The site is relatively flat and is serviced with an extensive network of drains associated with forestry on-site. The terrain consists mainly of good to rough pasture with rushes prevalent. Shrubs and small trees, along with moderately large areas of dense juvenile forestry, are present throughout the proposed site.

Turbines T1, T3, T4, T7, T11, the Met Mast and Substation are situated within agricultural pastureland.

Turbines T5 and T6 are positioned within existing juvenile forestry.

Turbines T8, T9 and T10 are located within forestry.

Turbine T2 is located within an area of rough "boggy" land adjacent to agricultural pastureland.

1.2 Methodology

The survey at the proposed Pinewoods Wind Farm was carried out as follows:

Stage 1

Selected depth probing was undertaken at proposed turbine locations by the low impact method of plunging a series of rigid rods (commonly known as "depthing rods" provided in 1.00m long screw-together sections) through the peat / organic topsoil to determine at what level refusal was encountered on the underlying till or bedrock.

Although this method of investigation is not covered in the Scottish Guidance it remains the optimal technique for rapidly mapping the thickness of peat. This technique is commonly employed by consultants for the purpose of Peat Slide Risk Assessment undertaken prior to construction works and is documented in the Scottish Government publication "Guidance: Developments on Peatland: Site Surveys" Scottish Natural Heritage, Scottish Environment Protection Agency and The James Hutton Institute.

For further reference to the use of "depthing rods" and peat quality assessment by gouge core / auger, shear vane and Von Post assessment please refer to the following two sources:-

1. *Soil Survey of Scotland. 1984. "Organisation and Methods. Handbook 8". MacAulay Institute for Soil Research.*
2. *Soil Survey of Scotland "Scottish Peat Surveys, 1964 Volume 1 HMSO, Edinburgh.*

A Thales DGPS system was employed to record the location of each depth probed. Waypoints were entered into the DGPS to establish each survey line, which allowed the operator to navigate between individual probe locations and fix their positions.

Probing was undertaken manually by driving a series of rods into the ground until a significant change in resistance was registered within the sub-soil. The depth of peat / organic topsoil observed was then measured and recorded along with the relevant co-ordinates into a hand-held PDA Logger.

2.1 EXISTING ENVIRONMENT

2.2 Geology

Published geological maps of the area and Geological Survey of Ireland (GSI), show the site to be underlain by Fluvio-deltaic and basinal marine (Turbiditic) Shale, sandstone, siltstone and coal, which is shown to be overlain by glacial till and fluvio-glacial deposits. These are in turn mantled by geologically recent materials, composed mainly of negligible peat cover.

The mean peat / organic topsoil depth encountered in readings across the potential Pinewoods development area was 0.40m. Peat / organic topsoil thickness displayed a range from 0.00m to 1.90m within the potential development area surveyed by Whiteford Geoservices Ltd.

ID	Co-ordinates		Peat / Organic Topsoil Depth (m)
	Easting	Northing	
T1	251604	182460	0.00 – 0.10*
T2	251693	182105	0.25 – 0.45*
T3	251676	181781	0.00 – 0.30*
T4	250937	181833	0.20 – 0.40#
T5	251205	181628	0.80 – 1.00#
T6	250756	181489	0.50 – 1.90#
T7	250403	181186	0.00 – 0.10*
T8	250682	180984	0.00 – 0.30*
T9	250742	180675	0.00 – 0.50#
T10	250826	180372	0.00 – 0.50#
T11	250276	180413	0.00 – 0.20*
Substation	250435	182335	0.10 – 0.30*
Met Mast	250890	182093	0.00 – 0.10*

Table 1 – Peat / Organic Topsoil Depth at proposed Structure Locations

N.B. Obstructions within the peat layer can cause an increase in resistance or refusal, which may result in inaccurate depth measurement during the probing survey. Results of probing are therefore indicative only.

 # Blanket peat present
** Organic topsoil / No peat present*

2.3 Potential for Bog Failure

An analysis was made of available topographic survey data and collected peat / organic topsoil depth thickness at each turbine to determine the potential for movement. From this information the following table of potential risks was produced.

Reference is made, in this section, to "*Peat Slide Hazard and Risk Assessment Best Practice Guide for Proposed Electricity General Developments*", produced by The Scottish Executive & Halcrow Group Ltd (Dec 2006).

Stability Issue	New Access Route	Turbine Base Location and Other Infrastructure
Existing Slopes	The slopes encountered at the proposed site are generally low to moderate and vary between approximately 0 – 10 degrees to the horizontal.	Slopes encountered at the proposed turbine locations are low to moderate and display magnitudes of 0 – 10 degrees to the horizontal.
Landslip / Peat Slide	***<u>Excavations</u>*** The favoured method of construction for new access roads will be to found, where possible, directly on top of the natural soils present immediately underlying the peat / topsoil. Where this is carried out and slopes are of low to moderate magnitude (0 – 10 degrees) the potential for peat slide, at a time post-dating the completion of the site works, is classified to be at INSIGNIFICANT RISK (where peat is < 1.50m). 1. This is anticipated to **apply to all** proposed access tracks at the Pinewoods Wind Farm site. ***<u>"Floated" Road Construction</u>*** Where the peat thickness is in excess of 1.50m, "floated road" construction is considered to be more effective than excavation. This method of construction **is not anticipated to be applicable** for any proposed access roads at Pinewoods Wind Farm.	Analysis of available topographic information and peat depth data gives the following assessment at each proposed turbine location. ***<u>Excavations</u>*** At turbine locations T1, T2, T3, T4, T5, T6, T7, T8, T9, T10 and T11, the substation and the permanent meteorological mast, the combination of negligible to shallow peat thickness and low to moderate slope gradient is not considered to give cause for concern. Consequently, these proposed locations can be classified to have INSIGNIFICANT RISK. The designation INSIGNIFICANT RISK does not however mean that the risks of constructing within environments where PEAT is present can be ignored. These designations all make the assumption that the general procedures outlined in the ***Mitigation*** section will be adopted and implemented fully during the construction period.

Table 2 – Summary of Peat Slide Analysis for Pinewoods Wind Farm

These potential risks have been used to calculate a risk ranking, based upon the following:-

Hazard: *Likelihood of the peat slide event occurring*

(This relates to the potential for a peat slide to be triggered. Factors considered include the topographic slope, peat thickness, strength of peat, type of peat present and method of construction proposed.)

The table below gives a general view of some of the factors used to establish HAZARD:-

Scale of Risk	*Hazard*
0	*Peat not present and average slopes < 5 degrees to the horizontal*
1	*Peat less than 2.50m thick and slopes < 5 degrees to the horizontal*
2	*Peat less than 2.50m thick and slopes 5 – 10 degrees to the horizontal* *Peat 2.50m to 4.00m and slope < 5 degrees to the horizontal* *Where peat cover is greater than 1.50m, the construction of "floated" roads is recommended*
3	*Peat 2.50m to 4.00m thick and slopes > 5 and < 10 degrees to the horizontal*
4	*Peat 2.50m to 4.00m thick and slopes > 10 and < 22.5 degrees to the horizontal* *Peat > 4.00m thick and slopes > 5 and < 10 degrees to the horizontal*

Table 3
Qualitative assessment of Peat Slide Hazard

Exposure: *Impact that such an event might have at this particular location*

(This relates to the receptor in the event of a peat slide. This can range from adjacent areas of blanket bog, to farmland, watercourses, water abstraction sites, roads, un-occupied structures and occupied structures.)

The Scottish Guidance assesses exposure in terms of impact, e.g. Very Low Impact to Extremely High Impact, but does not state directly what receptors are of concern. In fact the guidance leaves this determination very much up to the consultant / engineer. The two receptors identified by the Scottish Guidance are potential for "Financial Impact" and / or "Environmental Impact".

The nature of these EXPOSURE receptors is often debated by consultants. The chosen rationale promoted in this report is as follows:-

1. The main purpose of this report is to determine the risk to 3rd parties. That is infrastructure, structures and environmentally sensitive receptors, such as watercourses and protected zones.

That being the case, the individual EXPOSURES employed and their relative weighting are summarised in Table 4, below.

The table below gives a general view of some examples of the factors used to establish EXPOSURE:-

Scale of Exposure	*Examples of Determining Factors*	*Impact upon total project*
1	*Flat agricultural land or blanket bog within 100m of structure or 50m for roads* *(i.e. Structure >100m or site tracks >50m from an unspecified environmental receptor, such as an undesignated stream,*	*Very low Impact (< 1%)*
2	*Structure <100m from minor water course or other sensitive landform or <50m for site tracks*	*Low Impact (1% - 4%)*
3	*Structure or site tracks <100m from receptor of high environmental sensitivity – e.g. major designated water course, or uninhabited buildings, minor roads, public utilities*	*High Impact (4% - 10%)*
4	*Structure <100m from major public road, area of special scientific interest, sensitive buildings, water abstraction etc.*	*Very High Impact (10% - 100%)*
5	*Structure <100m proximity to temporary or permanently inhabited buildings, important commercial property, areas of public congregation*	*Extremely High Impact (> 100%)*

Table 4

Qualitative assessment of Peat Slide Exposure

The precise classification of each EXPOSURE is determined by the consultant in consultation with other members of the development team.

By assessing each peat slide event against the scales given above, it is possible to assess the hazard ranking by multiplying the hazard and exposure of each event.

This results in a Hazard Ranking value as follows;

HAZARD RANKING = HAZARD x EXPOSURE

The following table outlines the suggested action for the different levels of hazard ranking. The rationale employed to determine the relative severity of Hazard Rankings is based upon the Scottish Guidance.

Hazard Ranking	***Hazard Ranking Level***	***Action Suggested***
≥17	**Serious**	Avoid project development at these locations
11 – 16	**Substantial**	Project should not proceed unless hazard can be avoided or mitigated at these locations, without significant environmental impact, in order to reduce hazard ranking to significant or less.
5 – 10	**Significant**	Project may proceed pending further investigation to refine assessment and mitigate hazard through relocation or re-design at these locations
0 – 4	**Insignificant**	Project should proceed with monitoring and mitigation of peat landslide hazards at these locations as appropriate

Table 5

Hazard Ranking and Suggested Actions (Refer to "*Peat Slide Hazard and Risk Assessment – Best Practice Guide for Proposed Electricity Generation Developments*", December 2006)

The following table summarises the relative Hazard Ranking of each Turbine and structural location to be constructed at Pinewoods Wind Farm.

ID	Co-ordinates		Peat Slide Hazard Ranking
	Easting	Northing	
T1	251604	182460	1
T2	251693	182105	1
T3	251676	181781	0
T4	250937	181833	0
T5	251205	181628	1
T6	250756	181489	1
T7	250403	181186	1
T8	250682	180984	0
T9	250742	180675	1
T10	250826	180372	1
T11	250276	180413	0
Substation	250435	182335	0
Met Mast	250890	182093	1

Table 6
Hazard Ranking for each proposed structural location at Pinewoods Wind Farm

2.4 Site Features

The site is relatively flat and is serviced with an extensive network of drains. The terrain consists mainly of good to rough pasture with rushes prevalent. Shrubs and small trees, along with moderately large areas of dense juvenile forestry, are present throughout the proposed site.

Turbines T1, T3, T4, T7, T11, the Met Mast and Substation are situated within agricultural pastureland.

Turbines T5 and T6 are positioned within existing juvenile forestry.

Turbines T8, T9 and T10 are located within forestry.

Turbine T2 is located within an area of rough "boggy" land adjacent to agricultural pastureland.

2.5 Peatland Disturbance, Soil Removal and Drainage

Ecological mapping was undertaken at the Pinewoods site previously by other consultants. Low slope gradients are to the advantage of the proposed development in terms of ground stability and reduced potential for pollution run off into surface water systems.

A relatively extensive network of existing man-made surface drainage channels currently services the site.

3.1 CHARACTERISTICS OF THE DEVELOPMENT

The proposed Pinewoods Wind Farm development includes the following aspects:

- Excavation and construction of 11 Nr. turbine base foundations, each approximately 324m^2, with a minimum excavation depth of 2.65m below existing ground level.
- Construction of 11 Nr. hardstanding areas of approximately 1,000m^2.
- Erection of 11 Nr. wind generating turbines of hub height 82m, rotor diameter 103m and a maximum overall height not exceeding 136.50m.
- An electrical substation of 8000m^2 in area.
- Construction compound of 1,400m^2 in area.
- 1 Nr. permanent meteorological mast.
- Construction of approx. 7,400m of 5.00m wide site access tracks.
- Upgrade of existing site access tracks.
- Installation of underground electrical cabling.
- Overall development site area of approximately 18.42 hectares.

These development changes will consist of the following earthworks excavations and movement:

- Excavation for turbine foundations / bases and hardstanding areas.
- Excavation for substation building and compound.
- Site tracks will be installed to facilitate the transport of turbine components and turbine maintenance.
- No site access tracks are proposed to be constructed using "Floated road" techniques.

4.1 Potential Impacts as a Result of the Proposed Development

4.2 Construction Phase without mitigation

4.2.1 Earthworks Activities

Implementation of the proposed development will result in the removal of peat in parts of the subject site to facilitate construction of site access tracks and foundations for the wind turbines to a competent bedrock or substrate foundation.

Analysis of peat depths recorded along proposed site tracks and turbine locations indicates a range of 0.00m to 1.90m across the Pinewoods development area with an average peat / organic topsoil depth of 0.40m within the construction zone.

Assuming average peat / organic topsoil depths prevail across the construction footprint, the volume of peat to be extracted is estimated to be approximately 22,110m^3.

Assuming an average depth to competent bearing stratum of 0.50m for tracks, 1.00m for hardstandings and 2.50m for turbine foundations, the volume of drift / glacial soil to be extracted is estimated to be approximately 21,780m^3.

Ground conditions vary across the site with a fluctuating peat cover due to the site's exposure and underlying bedrock topography. At the turbine bases, excavations deeper than 3.00m may be required to achieve a suitable, stable foundation. Where rock is ultimately present at shallow depth (i.e. < 2.00m below existing ground level), rock excavation may be required.

4.2.2 Potential for Bog Failure

Site investigations did not reveal any evidence of peat failure or bog bursts within the proposed development area.

Consideration has been given to the potential for bog failure at the Pinewoods Wind Farm site.

These mass movements of peat can take the form of either bog burst or bog slide. Historical evidence suggests that raised bogs are more prone to bog bursts while bog slides are more common on blanket bogs. Because of their peculiar topography, geology and hydrology, certain upland areas are especially prone to bog failure[1].

These peat failures generally occur either during or immediately after periods of heavy rainfall. Failures are especially likely to occur where there is a break of slope at the edge of an upland plateau of peat. Records indicate that bog bursts naturally occur on shallow slope angles varying between 3 and 6 degrees while bog slides generally occur on slopes that are greater than 6 degrees.

Following well documented bogslides on the slopes of Dooncarton and Barnachuille mountains, Co. Mayo in September 2003 and more significantly at Derrybrien, Co. Galway in October 2003, the potential for bog failure has come to the fore in consideration of planning for a wind farm development. The following potential causal factors for bog failure are identified following research and assessment of recent slides and from historical evidence over the last 200 years in Ireland.

1. Research into the history of bog slide occurrence indicates that the majority of bog slides have occurred on the blanket bogs of the west where rainfall is highest. Here, bog slides tend to be more frequent during **the autumn and winter months.**

[1] Feehan, J. and O' Donovan, G. (1996) *The Bogs of Ireland - An Introduction to the natural, Cultural and Industrial Heritage of Irish Peatlands*. University College Dublin, The Environmental Institute

2. The following criteria are considered to be the causal or contributory factors to bog slide occurrence:

(a) **Slope** is the single most important factor for blanket bogs. Bog slides are especially likely to occur where there is a break in slope at the edge of an upland plateau of blanket peat, providing a line of weakness. While initial failure is likely to be slippage (translational or rotational faults) semi-fluid to fully fluid behaviour is the main movement mechanism down slope. Slope gradient imparts kinetic energy to the sliding material.

(b) The **depth of peat** and its relationship to humification (the degree to which the fibre structure of the peat has decayed), pore water pressure, shear vane strength and other parameters generally indicates that the deeper the peat profile the more unstable it is, if external controls such as slope, drainage, removal of adjoining earth materials are changed. Exact depth threshold of stability are not applicable due to the variability of peat environments (raised bog, blanket bog or fen habitats) and their site specific conditions. However, as a rule of thumb peat of depths greater than 2.00m are significantly more vulnerable to instability than shallower peat at < 1.00m depth, and in particular the top-layer of acrotelm (living) peat at < 0.30m.

(c) The pattern of **recent precipitation** such as intense localised rainfall (or melting snow) is an important trigger mechanism.

(d) **Antecedent weather conditions** such as drought conditions are identified as a contributing factor. In the case of the recent landslides at Dooncarton and Barnachuille in September 2003 and at Derrybrien October 2003, short intense periods of heavy rainfall followed an exceptionally dry late summer. Historically, the Owenmore bog slide in Erris, Co. Mayo (1819) was also preceded by two months of drought. Sustained dry conditions leads to high soil moisture deficit (SMD). This dries the blanket peat, causing shrinkage and desiccation cracks.

(e) Some bog slides are caused by **excessive interference** – e.g. opening of turf banks, opening deep drains on blanket bog. All drains should be perpendicular to slope contour not parallel to it.

Finally the following items are noted:

1. Geological structural features generally play no part in bog slide occurrence.
2. Bogslides are prone in certain upland locations due to their peculiar topography, ground composition and hydrology. When a slide occurs, it acts as a safety valve to restore equilibrium.
3. The most destructive bogslides involve the combination of slide materials with floodwaters, diluting the peat and mud in waterways and accelerating the velocity of the debris flow.

The possibility of peat slide occurring is considered to be an unlikely event at the proposed Pinewoods Wind Farm site. There are no published records of bog failures at the subject site.

4.2.3 *Water Quality*

The following impacts both likely and potential are identified:

(a) Suspended solids release during excavations

In a wind farm development, it is the construction phase that poses the highest risk to the site's hydrology, in particular to the quality of surface water due to generally poor aquifer conditions on high elevation terrain. The Pinewoods site does have this high terrain topography. It is likely that during excavation works, storage and re-use of materials, suspended solids will be entrained by sustained rainfall and surface water runoff.

The most vulnerable areas to surface water quality deterioration are (a) access road crossings of man made drains and (b) turbine hardstand and infrastructure development at moderate gradient slopes proximal to existing waterways, which this site should not be threatened by as it has relatively low gradients and no natural waterways near turbine locations.

Some of the man made drains may have steep gradients cut out, which should be taken into account if constructing new access tracks. This is considered to be short-term and temporary but could have significant negative impact. With appropriate environmental engineering controls and measures, this impact can be negated and mitigated against.

4.3 Operational Phase

4.3.1 *Change to Hydrological Regime*

The rate and amount of surface water run-off from the site will increase as a function of the replacement of vegetation, peat and sub-soils cover (which absorb rainfall) in parts of the site with a concrete/aggregate hardstand at turbine locations, and aggregate mix for proposed access tracks.

4.3.2 *Water Quality*

A potential impact on water aspects of the environment may arise during the operational phase of the development if regular maintenance, monitoring and auditing of mitigation structures and procedures are not undertaken during the lifetime of the project.

4.4 "Worst Case" Scenario without mitigations

The worst-case scenario without the implementation of mitigation measures which may arise from the proposed development could include:

(a) Sudden slope failure, by shearing, giving rise to a debris flow. Where this debris flow occurs on a slope all elements down slope are potentially at risk.

Such ground movements have the ability to cause disruption to construction works; loss of plant and machinery; structural damage; loss of life and ultimately major financial loss.

(b) Pollution of waters may occur due to suspended solids, which will be temporary and short term, hydrocarbons (medium term), nutrients and waste (medium-term).

Overall the groundwater is unlikely to be affected due to the natural attenuation processes by overlying substrates. The net results would be temporary pollution and deterioration of surface waters.

Long-term changes to the hydrological regime are likely to occur. These effects will include local drying out of some areas of the site by introduced drainage and wetting of other areas by soakaways or buffered outfalls.

5.1 MITIGATION MEASURES

Ecological and peat depth investigations at this site have indicated low to moderate slopes and negligible to shallow peat areas. These areas have been taken into consideration as part of the design of the development.

Avoidance of construction within the proposed buffer zones will be adhered to, reducing potential for adverse impacts.

5.2 Construction Phase with mitigation

5.2.1 Earthworks Activities

The removal of bedrock will be unavoidable in places, but every effort will be made to ensure that the amount of overburden / sub-soils removed is kept to a minimum, in order to limit the impact on the geotechnical and hydrological balance of the site.

It is noted that the "natural hydrology" of parts of the site have been previously altered by man-made land drainage. That notwithstanding, measures will be put in place to minimise any additional impact to the existing site hydrology, that would otherwise result from the construction of the wind farm.

During the construction works, the excavation, storage and re-use of the excavated materials have the potential to directly or indirectly negatively impact on water quality. Appropriate engineering controls, such as the installation of the drainage system with settlement / stilling ponds, soak-aways, and interceptor drains, will be carried out in tandem with, and where possible, prior to, any excavation work to mitigate potential impacts. In relation to construction works, the most important aspects of these recommendations involve mitigation.

These recommendations will be included in the contractor's contract of works for the site. In addition, a construction phase management plan will be in operation to check equipment, materials storage and transfer areas, drainage structures and their attenuation ability on a regular basis. The purpose of this management control is to ensure that the measures in place are operating effectively, prevent accidental leakages, and identify potential breaches in the protective retention and attenuation network during earthworks operations.

5.2.2 Potential for Bog Failure

Construction Mitigation of Risk

<u>General Constraints and Anecdotal Evidence</u>

Analysis of the historic conditions following peat slides indicates that the following main factors generally trigger slope failures:

1. Excessive quantities of spoil loaded onto sensitive peat covered sloping ground. (In such cases the gradient of the slope should be no more than an average of 5 degrees to the horizontal). Where peat is not of a sensitive nature, as is the case at the Pinewoods site, it will be possible to load spoil onto slopes up to a maximum of 10 degrees to the horizontal.
2. The angle of repose of the cut face of excavations is all too often found to be too high, sometimes 70 – 80 degrees to the horizontal. Battering back the sides of an excavation to approx. 45 degrees helps to reduce the potential for slippage, which will significantly reduce the potential for movement.
3. The consequences of peat slide can be identified as Damage to Machinery, Damage or Loss of Site track, Damage to Site Drainage, Site Works Damaged, Death or Injury to Personnel or Degradation to the Environment.

4. A contingency plan is to be compiled and will be enacted should peat movement occur.

Prevention of Peat Slide and Bog Burst

Application of the following procedures will have the effect of reducing the Hazard Ranking associated with Peat Instability:-

1. Excavated spoil will not be deposited on the down slope or up slope edges of the adjacent peat. This spoil will instead be deposited on the two flanks either side of the excavation where gradient is least.
2. Bog Burst is recognised to be a difficult condition to mitigate against. Bog Burst tends to occur within deep peat (> 3.00m thickness) after very heavy or prolonged precipitation. To ward against this possibility the design of turbine bases should be engineered to ensure that excavations do not cut into deep peat (> 2.50m). This does not apply to the proposed Pinewoods Wind Farm site.
3. The hardstandings surrounding the turbine bases should be designed in a manner such that crane loadings can be transferred directly onto the competent strata underlying the peat soils. In order to facilitate these works it will be necessary to undertake limited excavations.
4. Movement can often occur during or following severe rainstorm events, particularly when following a prolonged dry spell. Extra vigilance will be maintained at such times, during construction.
5. All slopes will be regularly checked for development of tension cracks.
6. Extra care will be taken where the peat has previously been tilled. Note; during site visits there was evidence of peat harvesting at the proposed site.
7. Method statements will be followed at all times.
8. Slopes will not be undercut or excavations left unsupported for periods in excess of 24 hours. Excavations are to be backfilled as soon as practicable. Excavation and filling operations shall be coordinated to minimise the time an excavation remains opened.
9. Pore water pressure within excavations should be kept low at all times by draining deliberate or intentional sumps at regular intervals. This is to prevent ponding of water within excavations which can in turn increase hydraulic heads locally and potentially lead to instability.
10. The potential for Peat Slide will be monitored regularly during the construction works, by means of regular site visits and assessments, by a suitably qualified and experienced professional.
11. Site staff will also undergo induction training to learn about the risks associated with working on "upland environments" and procedures aimed at reducing Peat Slide risk.

Storage of Surplus Excavated Material

Surplus excavated material will invariably be generated during excavations for foundations at turbines and along new site tracks.

Minimisation of the production of this excess excavated material will be treated as a high priority, but it is nevertheless expected that there will be in the region of 22,110m^3 of peat / organic topsoil and 21,780m^3 of glacial spoil excavated during site works.

The above figures have been derived from calculations assuming the following:

- Average peat depth of 0.40m across the site, an excavated depth of approx. 2.50m to rock / suitable bearing strata at turbine base locations and an average excavated depth of 1.00m of glacial soils at hardstandings and met-mast location, 2.25m at the substation and 0.50m at the compound.
- Excavated areas at turbines and hardstandings of 324m^2 and 1,000m^2 respectively.
- Excavated area at substation and compound of 8000m^2 and 1,400m^2 respectively.
- Excavated area at met mast location of 330m^2.
- Excavated access track area estimated to be approximately 37,000m^2, with an average excavated depth of 0.50m.

The two spoil types will be treated separately. Glacial soils and peat will be separated during excavation and these two types of spoil will be disposed of generally as follows:-

A Glacial soils will be deposited directly on top of other glacial soils. This will require the removal of peat where present to facilitate the process.

B Peat can be disposed of either on top of glacial soils, on top of inactive peat or on top of the "Acrotelm" where the "Top Mat" has been removed.

This is described further as follows:

<u>Glacial soil:</u>

1. Surplus excavated glacial soil should be permanently stored at a pre-designated site, preferably close to the temporary compound and / or turbines and other infrastructure.
2. Each storage area will be clearly defined on a site drawing and clearly identified on site.
3. Glacial soil will be deposited, in layers of 0.50m and will not exceed a total thickness of 2.00m.
4. Glacial soil will only be deposited on slopes of < 10 degrees to the horizontal and greater than 10m from the top of a cutting. The exact location of such areas will be determined in consultation with the geotechnical specialist.
5. All storage areas shall be located outside of the watercourse / environmental buffers.
6. A Glacial Soils Stability Register will record the location of each storage site used and regular weekly assessment will be made by the construction manager or other suitably qualified individual.
7. Once construction is complete the storage site should be landscaped (including landscaping of the temporary compound area) and re-vegetated with either the "Top Mat" removed at the commencement of storage operations or re-seeded as directed by the Ecologist.

<u>Surplus excavated peat:</u>

1. Surplus excavated peat / organic topsoil will be stored in a designated area adjacent to each individual structure or the temporary construction compound, on slopes of < 10 degrees to the horizontal and outside areas of environmental constraints (i.e. within watercourse buffers as delineated in the Hydrology and Hydrogeology Report).
2. Surplus peat will only be deposited on slopes of < 10 degrees to the horizontal and greater than 10m from the top of a cutting. The exact location of such areas will be determined in consultation with the geotechnical specialist.
3. In the vicinity of site tracks which are constructed using an excavated technique, surplus excavated peat shall be temporarily stored immediately adjacent to the site track and following the completion of sections of site track construction shall be

carefully placed along track side verges.

4. The "Top Mat" of the peat will be transplanted to a pre-designated area and maintained for re-use during restoration operations.
5. Surplus peat will be deposited, in layers of 0.50m and will not exceed a total thickness of 2.00m. This surplus peat will be used to reinstate trackside verges and any areas used for temporary deposition of material during construction.
6. Surplus peat storage should be avoided in areas where underlying peat is thicker than 2.00m.
7. A Peat Stability Register will record the location of each storage area used and regular weekly assessment will be made by the construction manager or other suitably qualified individual.

Once construction works are complete the storage sites will be re-vegetated with either the "Top Mat" removed at the commencement of storage operations or through re-seeding.

6.0 CONCLUSION

Appraisal of the Hazard Rankings for each proposed turbine and structure location indicates that the site (encompassing turbines T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11 and the electrical substation and permanent met-mast) carry **INSIGNIFICANT** Hazard Rankings as determined in accordance with the guidelines outlined by The Scottish Executive & Halcrow Group Ltd in "*Peat Slide Hazard and Risk Assessment - Best Practice Guide for Proposed Electricity Generation Developments*", December 2006.

Excavation of peat / topsoil so that road bases can be founded directly onto the underlying glacial soils remains the optimal approach. There is normally a higher degree of risk associated with this method in areas where peat is greater than 1.50m depth and in such cases "floating" road construction is the preferred method of access road emplacement.

In the case of the proposed Pinewoods Wind Farm the thickness of sensitive peat appears to be <2.00m, although thicker sequences of peat may be present in certain areas.

Regardless of the above the Hazard Ranking attributable to the access roads is anticipated to remain **INSIGNIFICANT**, according the Scottish Executive guidance.

The Pinewoods Wind Farm site is suitable for development as proposed. Peat slide risk assessment has indicated an INSIGNIFICANT risk of instability in relation to the structural aspects of the proposed development.

This report has been prepared on behalf of Galetech Energy Developments Ltd and Pinewoods Wind Ltd

by

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12th May 2016

Chapter 6:

Water

6.1 Introduction

6.1.1 Background & Objectives

Hydro-Environmental Services (HES) was engaged by Pinewoods Wind Ltd to undertake an assessment of the potential impacts of the proposed development on water aspects (hydrology and hydrogeology) of the receiving environment:

The objectives of the assessment are:

- Produce a baseline study of the existing water environment (surface water and groundwater) in the area of the proposed wind farm development;
- Identify likely negative impacts of the proposed development on surface water and groundwater during construction and operational phases of the development;
- Identify mitigation measures to avoid, remediate or reduce significant negative impacts:
- Assess significant residual impacts and cumulative impacts of the proposed development.

6.1.2 Scoping Responses

A number of scoping letters were issued to relevant agencies in relation to the EIS for the proposed development. Details of responses received can be found in Chapter 1 of this EIS.

6.1.3 Relevant Legislation

The EIS chapter is carried out in accordance with the follow Irish legislation:

- S.I. No. 349 of 1989: European Communities (Environmental Impact Assessment) Regulations, and subsequent Amendments (S.I. No. 84 of 1995, S.I. No. 352 of 1998, S.I. No. 93 of 1999, S.I. No. 450 of 2000 and S.I. No. 538 of 2001), S.I. No. 30 of 2000, the Planning and Development Act, and S.I. 600 of 2001 Planning and Development Regulations and subsequent Amendments. These instruments implement EU Directive 85/373/EEC and subsequent amendments, on the assessment of the effects of certain public and private projects on the environment;
- S.I. No. 600 of 2001: Planning and Development Regulations, 2001;
- S.I. No. 94 of 1997: European Communities (Natural Habitats) Regulations, resulting from EU Directives 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (the Habitats Directive) and 79/409/EEC on the conservation of wild birds (the Birds Directive);
- S.I. No. 293 of 1988: Quality of Salmon Water Regulations, resulting from EU Directive 78/659/EEC on the Quality of Fresh Waters Needing Protection or Improvement in order to Support Fish Life;
- S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 and S.I. No. 722 of 2003 European Communities (Water Policy) Regulations which implement EU Water Framework Directive (2000/60/EC) and provide for implementation of 'daughter' Groundwater Directive (2006/118/EC). Since 2000 water management in the EU has been directed by the Water Framework Directive (WFD). The key objectives of the WFD are that all water bodies in member states achieve (or retain) at least 'good' status by 2015. Water bodies comprise both surface and groundwater bodies, and the achievement of 'Good' status for these depends also on the achievement of 'good' status by dependent ecosystems. Phases of characterisation, risk assessment, monitoring and the design of programmes of measures to achieve the objectives of the WFD have either been

completed or are ongoing. In 2015 it will fully replace a number of existing water related directives, which are successively being repealed, while implementation of other Directives (such as the Habitats Directive 92/43/EEC) will form part of the achievement of implementation of the objectives of the WFD;

- S.I. No. 41 of 1999: Protection of Groundwater Regulations, resulting from EU Directive 80/68/EEC on the protection of groundwater against pollution caused by certain dangerous substances (the Groundwater Directive);
- S.I. No. 249 of 1989: Quality of Surface Water Intended for Abstraction (Drinking Water), resulting from EU Directive 75/440/EEC concerning the quality required of surface water intended for the abstraction of drinking water in the Member States (repealed by 2000/60/EC in 2007);
- S.I. No. 439 of 2000: Quality of Water intended for Human Consumption Regulations and S.I. No. 278 of 2007 European Communities (Drinking Water No. 2) Regulations, arising from EU Directive 98/83/EC on the quality of water intended for human consumption (the Drinking Water Directive) and WFD 2000/60/EC (the Water Framework Directive);
- S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009;
- S.I. No. 9 of 2010: European Communities Environmental Objectives (Groundwater) Regulations 2010;
- S.I. No. 296 of 2009: European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009.

6.1.4 Relevant Guidance

The following guidance was reviewed in the preparation of this chapter:

- Environmental Protection Agency (2003): Advice Notes on Current Practice (in the preparation on Environmental Impact Statements);
- Environmental Protection Agency (2002): Guidelines on the Information to be Contained in Environmental Impact Statements;
- Institute of Geologists Ireland (2013): Guidelines for Preparation of Soils, Geology & Hydrogeology Chapters in Environmental Impact Statements;
- National Roads Authority (2005): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;
- Wind Farm Development Guidelines for Planning Authorities (2006);
- Forestry Commission (2004): Forests and Water Guidelines, Fourth Edition. Publ. Forestry Commission, Edinburgh;
- Coillte (2009): Forest Operations & Water Protection Guidelines;
- Forest Services (Draft) Forestry and Freshwater Pearl Mussel Requirements – Site Assessment and Mitigation Measures;
- Forest Service (2000): Forestry and Water Quality Guidelines. Forest Service, DAF, Johnstown Castle Estate, Co. Wexford;
- COFORD (2004): Forest Road Manual – Guidelines for the Design, Construction and Management of Forest Roads;

- Eastern Regional Fisheries Board (not dated): Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites;
- Good Practice During Wind farm Construction (Scottish Natural Heritage, 2010);
- PPG1 – General Guide to Prevention of Pollution (UK Guidance Note);
- PPG5 – Works in, near or over Watercourses (UK Guidance Note);
- CIRIA (Construction Industry Research and Information Association) 2006: Guidance on 'Control of Water Pollution from Linear Construction Projects' (CIRIA Report No. C648, 2006);
- CIRIA 2006: Control of Water Pollution from Construction Sites - Guidance for Consultants and Contractors. CIRIA C532. London, 2006.

6.1.5 Methodology

6.1.5.1 Desk Study

A desk study of the proposed development site and surrounding area was largely completed prior to the undertaking of field mapping and walkover assessments. The desk study involved collecting all relevant geological, hydrological, hydrogeological and meteorological data for the area. This included consultation with the following:

- Environmental Protection Agency database (www.epa.ie);
- Geological Survey of Ireland - National Draft Bedrock Aquifer map;
- Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Met Éireann Meteorological Databases (www.met.ie);
- National Parks & Wildlife Services Public Map Viewer (www.npws.ie);
- Water Framework Directive "WaterMaps" Map Viewer (www.wfdireland.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 18 (Geology of Tipperary). Geological Survey of Ireland (GSI, 1999);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 15 (Geology of Galway - Offaly). Geological Survey of Ireland (GSI, 1999);
- Geological Survey of Ireland - Groundwater Body Characterisation Reports;
- OPW Indicative Flood Maps (www.floodmaps.ie);
- Environmental Protection Agency – "Hydrotool" Map Viewer (www.epa.ie);
- CFRAM Preliminary Flood Risk Assessment (PFRA) maps (www.cfram.ie);
- Department of Environment, Community and Local Government on-line mapping viewer (www.myplan.ie).

6.1.5.2 Site Investigations

A hydrological walkover survey, including detailed drainage mapping and baseline monitoring/sampling, was undertaken by HES on 11th, 30th and 31st March 2015. The hydrological walkover survey involved:

- Walkover surveys and hydrological mapping of the proposed site and the surrounding area were undertaken whereby water flow directions and drainage patterns were recorded;

- A preliminary flood risk assessment for the proposed development footprint area;
- Field hydrochemistry measurements (electrical conductivity, pH and temperature) were taken to determine the origin and nature of surface water flows;
- A total of 3 no. surface water samples were undertaken to determine the baseline water quality of the primary surface waters originating from the proposed site.

6.1.5.3 Impact Assessment Methodology

The sensitivity of the water environment receptors was assessed on completion of the desk study and baseline study. Levels of sensitivity which are defined in **Table 6.1** are then used to assess the potential effect that the proposed development may have on them.

Sensitivity of Receptor	
Not sensitive	Receptor is of low environmental importance (*e.g.* surface water quality classified by EPA as A3 waters or seriously polluted), fish sporadically present or restricted). Heavily engineered or artificially modified and may dry up during summer months. Environmental equilibrium is stable and is resilient to changes which are considerably greater than natural fluctuations, without detriment to its present character. No abstractions for public or private water supplies. GSI groundwater vulnerability "Low" – "Medium" classification and "Poor" aquifer importance.
Sensitive	Receptor is of medium environmental importance or of regional value. Surface water quality classified by EPA as A2. Salmonid species may be present and may be locally important for fisheries. Abstractions for private water supplies. Environmental equilibrium copes well with all natural fluctuations but cannot absorb some changes greater than this without altering part of its present character. GSI groundwater vulnerability "High" classification and "Locally" important aquifer.
Very sensitive	Receptor is of high environmental importance or of national or international value *i.e.* NHA or SAC. Surface water quality classified by EPA as A1 and salmonid spawning grounds present. Abstractions for public drinking water supply. GSI groundwater vulnerability "Extreme" classification and "Regionally" important aquifer

Table 6.1: Receptor Sensitivity Criteria (Adapted from www.sepa.org.uk)

6.2 Description of the Existing Environment

6.2.1 Site Description & Topography

The proposed wind farm site is located approximately 8km to the east of Abbeyleix, Co. Laois. The site lies within the townlands of Boleybawn, Knockardugar, Graiguenahown, Ironmills (Kilrush) and Garrintaggart, in Co. Laois and the townland of Crutt in Co. Kilkenny. This area is part of the Castlecomer Plateau, a broad upland area which straddles the boundaries between counties Laois, Carlow and Kilkenny. The site lies on the county boundary between Laois and neighbouring Kilkenny to the south, with the town of Castlecomer around 8km away. It is an upland area with elevations ranging from 250 – 300m AOD (meters above Ordnance Datum). The site consists, in part, of lands owned and operated by Coillte and as such a series of forest tracks and third class roads cross the site. The current land use at the site is predominately agricultural grazing and forestry. The site is drained by several streams which are tributaries of the Owenbeg River.

6.2.2 Water Balance

Long term rainfall and evaporation data was sourced from Met Éireann. The 30 year annual average rainfall (1981 - 2010) recorded at Abbeyleix, 6.5km northwest of the site, are presented in **Table 6.2.**

Station		X-Coord		Y-Coord		Ht (MAOD)		Opened		Closed		
Abbeyleix		248,200		186,900		164		1874		N/A		
Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
94	67	72	63	63	67	70	87	74	105	91	90	943

Table 6.2: Local Average long-term Rainfall Data (mm)

The closest synoptic station where the average potential evapotranspiration (PE) is recorded is at Kilkenny, approximately 26km south of the site. The long term average PE for this station is 459mm/yr. This value is used as a best estimate of the site PE. Actual Evaporation (AE) at the site is estimated as 436mm/yr (which is 0.95 × PE).

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

Effective rainfall (ER) = AAR – AE

= 943mm/yr – 436mm/yr

ER = 507mm/yr

Based on groundwater recharge coefficient estimates from the GSI (www.gsi.ie) an estimate 100 - 130mm/year average annual recharge cap is given for the local aquifers. This means that the hydrology of the study area is characterised by relatively high surface water runoff rates and low groundwater recharge rates. Based on a conservative recharge cap of 100mm/year, the annual runoff rate for the site is estimated to be 407mm/yr. The large coverage of poorly draining soil means recharge rates are likely to be towards the lower end of the GSI range and therefore the more conservative recharge cap of 100mm/year is used.

6.2.3 Regional & Local Hydrology

Regionally, the proposed development site itself is located in the Nore River surface water catchment within Hydrometric Area 15 of the South Eastern River Basin District (SERBD). A regional hydrology map is shown as **Figure 6.1.**

In terms of local hydrology the proposed development site is situated within the Owenbeg River and the Dinin River surface water catchments. The Owenbeg River flows in southerly direction approximately 2km west of the site while the Dinin River flows in a southerly direction approximately 6km southeast of the site. A local hydrology map is shown as **Figure 6.2**.

In terms of proposed development, all of the proposed 11 no. turbines are located in the Owenbeg River catchment. A section of access road is located within the Dinin River catchment. Refer to **Table 6.3** below for a summary of proposed infrastructure in relation to local and regional surface water catchments.

6.2.4 Forestry Drainage Background

Within the proposed development site there are numerous manmade drains that are in place predominately to drain the existing forestry plantations. The current internal forestry drainage pattern is influenced by the topography, peat subsoils, layout of the forest plantation and by the existing road network. The forestry plantations, which cover a significant proportion of the site are generally drained by a network of mound drains which typically run perpendicular to the topographic contours of the site and feed into collector drains, which discharge to interceptor drains down-gradient of the plantation (refer to **Plate 6.1** below for existing forestry drainage layout schematic).

Mound drains and ploughed ribbon drains are generally spaced approximately every 15-20m and 2m respectively. Interceptor drains are generally located up-gradient (cut-off drains) and down-gradient of forestry plantations. Interceptor drains are also located up-gradient of existing forestry access roads. Culverts are located on existing access roads at stream and drain crossings and at low points under access roads which drain runoff onto down-gradient forest plantations.

The site drainage surveys, which were undertaken on 11th, 30th and 31st March 2015, were carried out after significant amounts of rainfall and therefore the drains and streams at the site were observed during wet conditions. Every effort was made during the surveys to map the main important drains in the vicinity of the proposed development footprint but due to the dense forestry coverage in some areas it was not feasible to map every single drain. However, it is not necessary to map or have knowledge of every single forestry drain, as the typical standard forestry drainage layout (as shown in **Plate 6.1**) can be applied when designing the wind farm drainage and runoff control measures for the protection of surface water quality. The integration of the existing forestry drains with the proposed wind farm drainage is a key component of the drainage design and the same integration approach (which is outlined further below) will be applied to all forestry drainage and field drainage during the construction and operation of the proposed development.

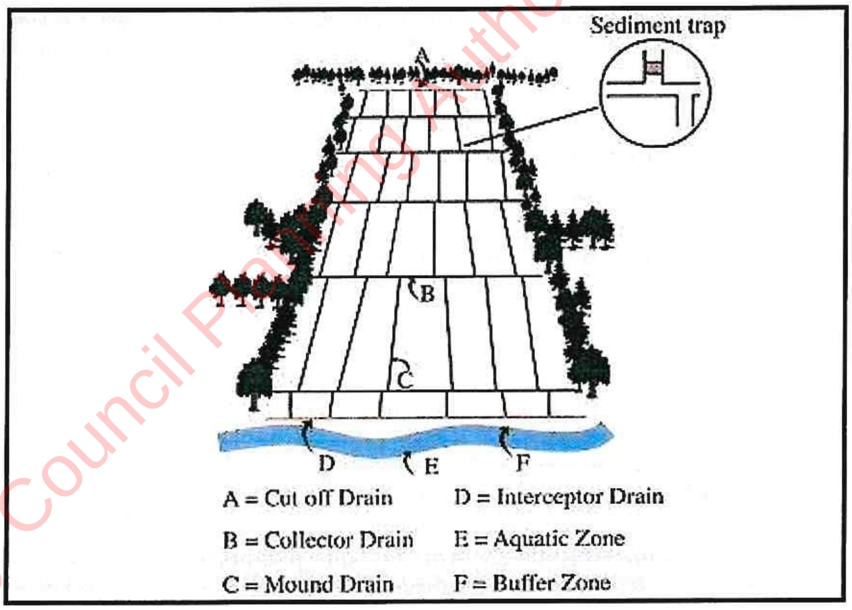


Plate 6.1: Standard Forestry Drainage (Forestry Schemes Manual, Forest Service, August 2004)

6.2.5 Site Drainage

Based on the local topography and the current drainage regime the landholding area can be divided into five sub-catchments. A site drainage map is shown as **Figure 6.3** and a site sub-catchment map is shown **Figure 6.4**.

Sub-catchment 1 includes the north-eastern section of the landholding. The catchment is drained by two unnamed streams; referred to in this report as S2 and S3. Stream S2 rises in a field approximately 200m west/northwest of turbine location T1. Stream S2 then flows in a north-easterly direction for approximately 0.9km prior to merging with stream S3. Stream S3 then flows in a northerly direction along the eastern section of the landholding prior to merging with stream S2. The Owenbeg River exists approximately 500m downstream of the confluence point of the two streams.

Sub-catchment 2 includes the central area of the northern section of the landholding and is drained by one primary stream. Stream S1 emerges in the central area of the site and flows in a northerly direction towards the Owenbeg River. Two new stream crossings over stream S1 will be required to facilitate the development.

Sub-catchment 3 comprises the western slopes of the landholding. This section of landholding drains to several small streams that merge away to the west of the landholding boundary. All these streams flow directly into the Owenbeg River. No streams emerge in the landholding area itself within Sub-catchment 3 and drainage ditches are the primary drainage routes.

Sub-catchment 4 comprises the majority of the southern section of the landholding area. Sub-catchment 4 is drained by one primary stream (S4) which is a tributary of the Ironmills River. The Ironmills River flows in a westerly towards the Owenbeg River.

Sub-catchment 5 comprises a small section on the south-eastern corner of the landholding area. No streams emerge in the landholding area itself within Sub-catchment 5 and drainage ditches are the primary drainage routes towards downstream watercourses that flow into the Dinin River.

A summary of the site sub-catchments and proposed infrastructure is shown in **Table 6.3** below.

Sub-catchment	Proposed Infrastructure	Primary On-site Drainage Features	River Catchment
SC1	Turbines T1, T2, T3 and substation/compound	Streams S2 & S3	Owenbeg
SC2	Turbines T4 & T5	Stream S1	Owenbeg
SC3	Turbine T6, T7, met mast & switching station	Various forestry drains/agricultural land drains	Owenbeg
SC4	Turbines T8, T9, T10 & T11	Stream S4 (i.e. Ironmills River)	Owenbeg
SC5	Existing forestry road for upgrade	Various forestry drains/agricultural land drains	Dinin

Table 6.3: Summary of Site Sub-Catchments & Proposed Infrastructure

6.2.6 Flood Risk Identification

To identify those areas as being at risk of flooding, OPW's indicative river and coastal flood map (www.floodmaps.ie), CFRAM Preliminary Flood Risk Assessment (PFRA) maps (www.cfram.ie) and historical mapping (*i.e.* 6" and 25" base maps) were consulted.

No recurring flood incidents within the site or surrounding area were identified from OPW's indicative river and coastal flood map. In addition, no flooding incidences are mapped along the Owenbeg River or the Dinin River immediately downstream of the site.

The PFRA map no. 168 (www.cfram.ie) shows the extents of the indicative 1 in 100-year flood zone which relates to fluvial (*i.e.* river) and pluvial (*i.e.* rainfall) flood events. The 1 in 100 year fluvial flood zone incorporates notable land area surrounding the Owenbeg River to the north of the site and the Ironmills River to the southwest of the site. There was no 1 in 100 year fluvial flood zones mapped within the site or surrounding area.

There is no identifiable map text on local available historical 6" or 25" mapping for the study area that identify lands that are "prone to flooding".

There are no areas within the site or downstream of it mapped as "Benefiting Lands". Benefiting lands are defined as a dataset prepared by the Office of Public Works identifying land that might benefit from the implementation of Arterial (Major) Drainage Schemes (under the Arterial Drainage Act 1945) and indicating areas of land subject to flooding or poor drainage.

A key mitigation measure of the proposed development to ensure all surface water runoff is treated (water quality control) and attenuated (water quantity/flood management control), prior to diffuse discharge at pre-existing Greenfield rates. As such, the mechanism by which downstream flooding is prevented and controlled is through avoidance by design. These proposed drainage attenuation measures are outlined in the impact assessment section below.

6.2.7 Surface Water Hydrochemistry

Q-rating status data for EPA monitoring points on the Dinin River are shown on **Table 6.4** below. No Q-rating data was available for Owenbeg River catchment.

The Q-rating for the Dinin River is Good Status with the exception of the station at Doonane Bridge where a Moderate Status is reported.

Water body	*EPA Location Description*	*Easting*	*Northing*	*EPA Q-Rating Status*
Dinin	Br North of Crettyard House	258,820	177,480	Good
Dinin	Doonane Bridge	257,900	177,740	Moderate
Dinin	2km d/s of Massford Bridge	254,260	175,800	Good

Table 6.4: EPA Water Quality Monitoring Q-Rating Values

Field hydrochemistry measurements of electrical conductivity (µS/cm), pH (pH units) and temperature (°C) were taken within surface watercourses across the study area on 11th March 2015. The monitoring was undertaken during a period of wet weather and as a result streams and drains were observed in high flow conditions. The results are listed (along with the surface water feature type) in **Table 6.5** below

Electrical conductivity (EC) values for streams at the site area ranged between 86 and 100µS/cm. This indicates that surface water flow was derived predominantly from rainfall input/runoff during the monitoring period. Measurement in lower-flow conditions (lower water levels in late summer time) may indicate a higher groundwater flow component (i.e. baseflow - typically signified by 'higher' EC values) contributing to discharge in the primary streams. The pH values were generally slightly acidic with some values just exceeding neutral in the larger streams. Slightly acidic pH values of surface waters would be typical of upland areas where acidic gley soils dominate. In addition, the sandstone and shale bedrock (and related till subsoils) which underlie the study area would have slightly acidic groundwater characteristics which would have some effect on surface water chemistry especially during dry periods, when baseflow is likely to be more prevalent.

Location ID	Easting	Northing	EC (µS/cm)	H	p ℃	Drainage Feature
SW1	250,190	179,600	100	0.1	0.0	Stream S4
SW2	251,290	182,340	95	6.9	8.5	Stream S1
SW3	252,110	182,800	86	0.9	0.5	Stream S3
FP1	251,700	181,740	90	2.0	0.5	Stream S2
FP2	251,700	181,740	90	0.2	0.5	Stream S2

Table 6.5: Summary of Surface Water Chemistry Measurements

Surface water samples were taken from watercourses draining the proposed development study area on 11th March 2015. Refer to **Figure 6.3** for sampling locations. Results of the laboratory analysis are shown alongside relevant water quality regulations in **Table 6.6**. In addition, Environmental Objectives Surface Water Regulations (S.I. 272 of 2009) are shown in **Table 6.7**. Original laboratory reports are attached as **Appendix 6.1**.

Parameter	EC DIRECTIVES			Sample ID		
	2006/44/EC		EC DW Regs 2007	SW1	SW2	SW3
	Salmonid	Cyprinid				
Total Suspended Solids (mg/L)	≤ 25 (O)	≤ 25 (O)	-	28	39	14
Ammonia N (mg/L)	≤0.04	≤0.02	0.3	0.036	0.023	0.072
Nitrite NO2 (mg/L)	≤ 0.01	≤ 0.03	0.5	<0.043	0.066	0.046
Ortho-Phosphate – P (mg/L)	-	-	-	0.015	0.031	0.023
Nitrate - NO3 (mg/L)	-	-	50	1.46	1.82	3.19
Phosphorus (mg/L)	-	-		0.063	0.023	0.06
Chloride (mg/L)	-	-	250	12	12.9	13.8
BOD	≤ 3	≤ 6	-	2	<1	2

Table 6.6: Analytical Results of Surface Water Samples (SW1-SW3)

Total suspended solids ranged between 14 and 39 mg/L for samples SW1 to SW3. There was an exceedance of the Freshwater Fish Directive (2006/44/EC) in samples SW1 and SW2 for the Salmonid/Cyprinid limits. As stated above the drainage mapping and sampling was undertaken on a very wet day and the elevated suspended solids are likely due to high turbid flows in the local streams and rivers.

Ammonia N ranged between 0.023 and 0.072 mg/L for samples SW1 to SW3. All samples exceeded the Freshwater Fish Directive (2006/44/EC) in relation to the Cyprinid limit. In relation to the Salmonid limit, there was only one exceedance and that was sample SW3. The exceedances in Ammonia N are not significant (refer to WFD status below) and additional sampling would be required to establish trends. The streams sampled drain both agricultural and forestry lands and these activities will influence local water quality.

Nitrite (NO2) ranged between 0.043 and 0.066 mg/L for samples SW1 to SW3 which exceeded the Freshwater Fish Directive (2006/44/EC) for both Salmonid and Cyprinid limits. Again, additional sampling would be required to establish trends. Agricultural and forestry activities within the catchment will influence local water quality.

In comparison to the Environmental Objectives Surface Water Regulations (S.I. 272 of 2009), Ammonia N in samples SW1 and SW2 were within the High Status threshold while SW3 exceeded both the Good Status and High Status threshold values.

Ortho-phosphate was within the High Status threshold in samples SW1 and SW3 while SW2 was within the Good Status threshold.

BOD exceeded both the High Status and Good Status threshold in samples SW1 and SW3 while SW2 was within the High Status threshold.

Parameter	Threshold Values (mg/L)
BOD	High status ≤ 1.3 (mean)
	Good status ≤ 1.5 mean
Ammonia-N	High status ≤ 0.04 (mean)
	Good status ≤0.065 (mean)
Ortho-phosphate	High status ≤0.025 (mean)
	Good status >0.035 (mean)

Table 6.7: Chemical Conditions Supporting Biological Elements*

** Environmental Objectives Surface Water Regulations (S.I. 272 of 2009)*

6.2.8 Hydrogeology

The Westphalian sandstones which are mapped to underlie the central section of the subject site are classified by the GSI (www.gsi.ie) as a Locally Important Aquifer, bedrock which is generally moderately productive (Lm).

The Westphalian shales and Namurian sandstones, which underlie the remainder of the subject site, are classified as a Poor Aquifer, having bedrock which is generally unproductive except for local zones (Pl / Pu).

The shales and sandstones that underlie the site generally have an absence of inter-granular permeability, and most groundwater flow is expected to be in the uppermost part of the aquifer comprising a broken and weathered zone typically less than 3m thick, a zone of interconnected fissuring 10m thick, and a zone of isolated poorly connected fissuring typically less than 150m.

Groundwater levels in this bedrock type elsewhere have been measured mainly 0-5m below ground level. Groundwater flowpaths are likely to be short (30-300m), with groundwater discharging to nearby streams and small springs. Water strikes deeper than the estimated interconnected fissure zone suggest a component of deep groundwater flow, however shallow groundwater flow is thought to be dominant. Groundwater flow directions are expected to follow topography and therefore groundwater directions within the site are expected to be towards the primary streams within the valleys of the site (GSI, 2004).

Baseflow contribution to streams tends to be low, particularly in summer as the groundwater regime cannot sustain summer baseflows due to low storativity within the aquifer. In winter, low permeabilities will lead to a high water table and potential water logging of soils. Local groundwater flow directions will mimic topography, whereby flowpaths will be from topographic high points to lower elevated discharge areas at local streams (GSI, 2004).

6.2.9 Groundwater Vulnerability

The vulnerability rating of the aquifer within the overall landholding ranges between Extreme (E) to Extreme (X) and this reflects the varying depth of local subsoils. An Extreme (X) vulnerability rating is given where bedrock is at or close to the surface. An Extreme (E) vulnerability rating is given where subsoils are present with a maximum thickness of 3 metres. All of the proposed turbines are located in areas mapped as Extreme (E) as determined by the trial pit investigation (refer to Chapter 5).

However, due to the relatively low permeability nature of the shales and sandstones underlying the site, groundwater flowpaths are likely to be short (30 – 300m), with recharge emerging close by at seeps and surface streams. This means there is a low potential for groundwater dispersion and movement within the aquifer, therefore surface water bodies such as drains and streams are more vulnerable than groundwater at this site.

6.2.10 Groundwater Hydrochemistry

There are no groundwater quality data for the proposed development site and groundwater sampling would generally not be undertaken for this type of development in terms of EIS reporting, as groundwater quality impacts would not be anticipated.

Based on data from GSI publication Calcareous/Non calcareous classification of bedrock in the Republic of Ireland (WFD,2004), alkalinity for these non-calcareous bedrock type generally ranges from 14 – 400mg/L while electrical conductivity and hardness are reported to have mean values of 446µS/cm and 200mg/L respectively.

6.2.11 Water Framework Directive Water Body Status & Objectives

The South Eastern River Basin District (SERBD) Management Plan was adopted by all local authorities in the SERBD prior to 30th of April 2010, as stipulated in the European Communities (Water Policy) Regulations 2003 (S.I. 722 of 2003 as amended). The SERBD Management Plan (2009 – 2015) objectives, which will be integrated into the design of the proposed wind farm development, include the following:

- Prevent deterioration and maintain a high status where it already exists;
- Protect, enhance and restore all waters with aim to achieve at least good status by 2015;
- Ensure waters in protected areas meet requirements;
- Progressively reduce chemical pollution.

Our understanding of these objectives is that surface waters, regardless of whether they have 'Poor' or 'High' status, should be treated the same in terms of the level of protection and mitigation measures employed, *i.e.* there should be no negative change in status at all.

Strict mitigation measures in relation to maintaining a high quality of surface water runoff from the development and groundwater protection will ensure that the status of both surface water and groundwater bodies in the vicinity of the site will be at least maintained (see below for WFD water body status and objectives) regardless of their existing status.

6.2.12 Groundwater Body Status

Local Groundwater Body (GWB) and Surface water Body (SWB) status reports are available for download from www.wfdireland.ie.

The Ballingarry GWB (IE_SE_G_009) underlies the western section of the proposed development site and the Castlecomer GWB (IE_SE_G_034) underlies the eastern section of the proposed development site.

All the above mentioned GWBs are assigned 'Good Status', which is defined based on the quantitative status and chemical status of the GWB.

6.2.13 Surface Water Body Status

A summary of the WFD status and risk result of Surface Water Bodies (SWBs) in which development is proposed (or immediately upstream of) are shown in **Table 6.8** below. The locations of the SWBs are shown on **Figure 6.2**.

The northern/north-eastern section of the proposed development site is located within the Owenbeg Upper SWB and this water body has been assigned "Moderate" status.

The western/northwestern section of the proposed development site is located within the Owenbeg Mid SWB and this water body has also been assigned "Moderate" status.

The southeastern corner of the proposed development site is located within the Dinin Mid SWB and this water body has been assigned "Moderate" status.

The southern section of the proposed development site is located within the Ironmills SWB and this water body has been assigned "High" status.

Surface Water Bodies (in which development is proposed or downstream of) reported to be either At Risk (1a) or Probably At Risk (1b) from forestry related suspended solid input and eutrophication include the Ironmills SWB and the Owenbeg Upper SWB.

Poor construction and water management practices during the construction phase have the potential to impact on local surface water quality in ways similar to forestry activities as outlined above. Mitigation measures (as detailed below) will ensure that surface runoff from the developed areas of the site will be of a high quality and will therefore not impact on the status of downstream surface water bodies.

Water Body	*General Physico-Chemical Status*	*Overall Ecological Status*	*Overall Status*	*Overall Risk Result*	*Overall Objective*
Dinin Mid	Good	Moderate	Moderate	1a	Restore 2021
Owenbeg Mid	Good	Moderate	Moderate	a	Restore 2021
Ironmills	n/a	High	High	a	Restore 2021
Owenbeg Upper	High	Moderate	Moderate	a	Restore 2021

Table 6.8: Summary WFD Information for Surface Water Bodies

6.2.14 Designated Sites & Habitats

Designated sites include National Heritage Areas (NHAs), Proposed National Heritage Areas (pNHAs), Special Areas of Conservation (SACs), candidate Special Areas of Conservation (cSAC) and Special Protection Areas (SPAs).The proposed development site is not located within any designated conservation site. Designated sites in proximity to the proposed development study area are show in **Figure 6.5.**

The proposed development site drains to the Owenbeg River and the Dinin River which forms part of the River Barrow and River Nore SAC. The River Nore downstream of the site is also a designated pNHA (*i.e.* River Nore and Abbeyleix Woods Complex).

Designated sites that are not hydrologically connected to the development site but are located in the vicinity include Lisbigney Bog SAC and pNHA (5.5km to the southwest of the site). These designated sites are not hydrologically connected to the proposed wind farm site and therefore there is no potential for impact (*i.e.* there is no surface water runoff or groundwater flow).

6.2.15 Water Resources

There are no groundwater protection zones mapped within the proposed development site or study area. A search of private well locations (wells with an accuracy of 1 – 50m were only considered) in the GSI well database (www.gsi.ie) was also undertaken. No private wells with a mapped accuracy of 1 – 50m are present within 1km of the site.

Due to the fact that the GSI well database is not exhaustive in terms of every well location it is assumed that every private dwelling in the area has a well supply and this impact assessment approach is described further below. This is a very conservative approach as it is unlikely that every private dwelling will have its own supply well.

The private well assessment undertaken below also assumes the groundwater flow direction in the aquifer underlying the site mimics topography, whereby flowpaths will be from topographic high points to lower elevated discharge areas at streams and rivers. Using this conceptual model of groundwater flow, dwellings that are potentially located down-gradient of the proposed development footprint are identified and an impact assessment for these potential well locations is undertaken in the impact assessment section below.

Shown on **Figure 6.6** are the locations of private dwellings in the vicinity of the development study area. Private dwellings are only potentially located down-gradient of turbine location Turbine 11. The potential impact on these wells (if present) is assessed further below. The remainder of the proposed development is not up-gradient of a private dwelling location (refer to footnote below **Table 6.9** further for details relating to the impact assessment approach).

Development Location	*Distance from Closest Private Dwelling (m)*	*Elevation Difference (m)*
Turbine 11	522	65

Table 6.9: Potential Private Wells Down-gradient of the Development Footprint

Note: Distance from closest turbine, compound, borrow pit or substation (i.e. bedrock excavation). Access roads and the grid connection cable trench are not considered a potential risk due to the shallow nature of the works. The distances listed above are from the nearest wind farm infrastructure within the same surface water catchment as the dwelling. Each dwelling is assumed to have an on-site private water well.

6.2.16 Receptor Sensitivity

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

Based on criteria set out in **Table 6.1** above, the Poor Aquifers (*i.e.* Westphalian shales and Namurian sandstones) at the site can be classed as Not Sensitive to pollution while the Locally Important

Aquifers (*i.e.* Westphalian sandstones) can be classed as Sensitive to pollution. The majority of the site is also covered in poorly draining soil which acts as a protective cover to the underlying aquifer. Any contaminants which may be accidently released on-site are more likely to travel to nearby streams within surface runoff.

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

The nearest River Nore Freshwater Pearl Mussel population to the proposed site development is 21.2km downstream via the Owenbeg River. FPM was not recorded in the Owenbeg River during the current assessment. The southern boundary of the site is 14km from the River Nore Freshwater Pearl Mussel population via the Boleybawn Stream/Moneycleare River, where Site 1 was found to be dry during survey work. Freshwater Pearl Mussel can be considered very sensitive to potential impact.

A hydrological constraints map for the development site is shown as **Figure 6.7**. A self-imposed 50m buffer from streams and lakes was applied during the constraints mapping and will be maintained during the construction phase. Apart from the two proposed stream crossings over stream S1 and the proposed stream crossing over stream S4, the proposed development areas are generally away from areas on the site that have been determined to be hydrologically sensitive. Where the development footprint exists within the 50m buffer zone additional mitigation measures will be employed to protect surface water quality. These measures are outlined further below in the chapter.

The large setback distance from sensitive hydrological features means they will not be impacted on by excavations/drains or any general construction works. It also allows adequate room for the proposed drainage mitigation measures (discussed below) to be properly installed up-gradient of primary drainage features within sub-catchments. This will allow attenuation of surface runoff to be more effective.

6.2.17 Assessment of Changes in Site Runoff Volumes

The water balance undertaken in this section is for baseline characterisation purposes along with an assessment of potential runoff changes as a result of the proposed development footprint. The rainfall depths presented in this section, which are long term averages, are not used in the design of the sustainable drainage system for the wind farm. As outlined further below a 1 in 100 year 6 hour return period will be used for design purposes.

The water balance calculations are carried out for the month with the highest average recorded rainfall minus evapotranspiration, for the current baseline site conditions (**Table 6.10**). It represents therefore, the long term average wettest monthly scenario in terms of volumes of surface water runoff from the study area pre-development. The surface water runoff co-efficient for the area is estimated to be 80% based on the GSI recharge estimates.

The highest long term average monthly rainfall recorded at Abbeyleix over the period 1981 - 2010 occurred in October, at 105mm. The average monthly evapotranspiration for the synoptic station at Kilkenny over the same period was 16.8mm. The water balance indicates that a conservative estimate of surface water runoff for the site during the highest rainfall month is 270,560m3/month as outlined in **Table 6.11** below.

Water Balance Component	Depth (m)
Average October Rainfall (R)	0.105
Average October Potential Evapotranspiration (PE)	0.0168
Average October Actual Evapotranspiration (AE = PE x 0.95)	0.016
Effective Rainfall October (ER = R - AE)	0.09
Recharge co-efficient (20% of ER)	0.018
Runoff (80% of ER)	0.072

Table 6.10: Water Balance and Baseline Runoff Estimates for Wettest Month

Approx. Area (ha)	Baseline Runoff per month (m3)	Baseline Runoff per day (m3)
380	270,560	8,728

Table 6.11: Baseline Runoff for the Study Area

Site Baseline Runoff/month (m3)	Baseline Runoff/day (m3)	Permanent Development Area (m2)	Permanent Development Area 100% Runoff (m3)	Permanent Development Area 80% Runoff (m3)	Net Increase/month (m3)	Net Increase/day (m3)	% Increase from Baseline Conditions (m3)
270,560	8,728	65,000	5,785	4,628	1,157	37	0.43

Table 6.12: Water Balance and Estimated Development Runoff Volumes

The emplacement of the proposed permanent development footprint, as described in Chapter 2 of the EIS, (assuming emplacement of impermeable materials as a worst case scenario) could result in an average total site increase in surface water runoff of 1,157m3/month from the landholding (**Table 6.12**). This represents a potential increase of 0.43% in the average daily/monthly volume of runoff from the study area in comparison to the baseline pre-development site runoff conditions. This is a very small increase in average runoff and results from a relatively small area of the landholding area being developed, the proposed total permanent development footprint being approximately 6.5ha, representing 1.7% of the total landholding area of 380ha. The additional volume in all sub-catchments is relatively low due to the fact that the runoff potential from the site is naturally relatively high (80%). Also, the calculation assumes that all hardstanding areas will be impermeable which will not be the case as access tracks will be constructed of permeable stone aggregate). The increase in runoff from the landholding will therefore be negligible. This is even before mitigation measures will be put in place. Therefore, there will be no risk of exacerbated flooding down-gradient of the site.

6.2.18 Development Interaction with the Existing Forestry Drainage Network

In relation to hydrological constraints, a self-imposed buffer zone of 50m has been put in place for on-site streams. Manmade forestry drains or other land drains at the site are not considered a hydrological constraint and therefore no buffering of forestry drains has been undertaken.

The general design approach to wind farm layouts in existing forestry is to utilise and integrate with the existing forestry infrastructure where possible, whether it is existing access roads or the existing forestry drainage network. Utilising the existing infrastructure means that there will be less of a requirement for new construction/excavations which have the potential to impact on downstream watercourses in terms of suspended solid input in runoff (unless managed appropriately). The existing forestry drains have no major ecological or hydrological value, and can be readily integrated into the proposed wind farm drainage scheme using the methods outlined below.

6.2.19 Proposed Drainage Management

Runoff control and drainage management are key elements in terms of mitigation against impacts on surface water bodies. Two distinct methods will be employed to manage drainage water within the proposed development. The first method involves 'keeping clean water clean' by avoiding disturbance to natural drainage features, minimising any works in or around artificial drainage features, and diverting clean surface water flow around excavations, construction areas and temporary storage areas. The second method involves collecting any drainage waters from works areas within the site that might carry silt or sediment, and nutrients, to route them towards settlement ponds (or stilling ponds) prior to controlled diffuse release over vegetated surfaces. There will be no direct discharges to surface waters. During the construction phase all runoff from works areas will be attenuated and treated to a high quality prior to being released. A schematic of the proposed site drainage management is shown as **Plate 6.2** below.

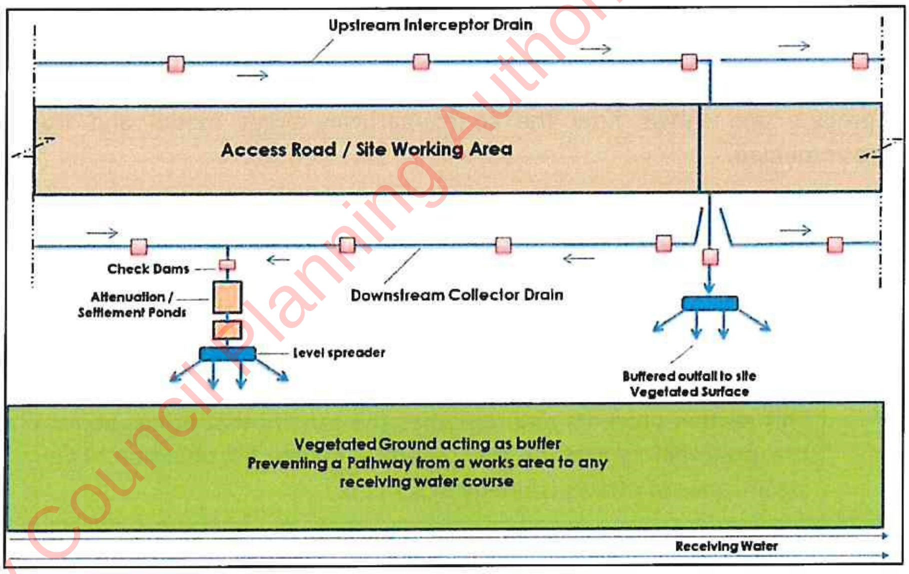
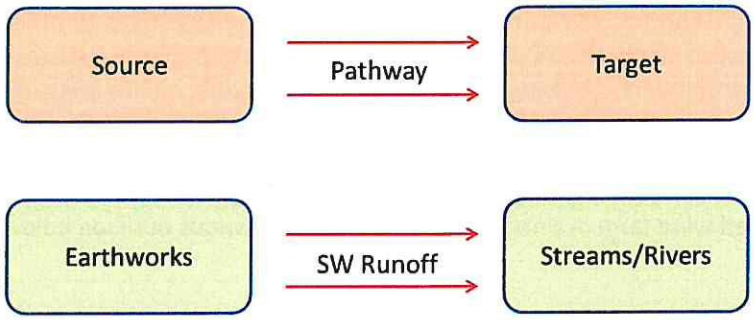


Plate 6.2: Schematic of Proposed Site Drainage Management

6.3 Description of Likely Impacts

6.3.1 Overview

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



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

- Advice Notes on Current Practice in the Preparation of Environmental Impact Statements (EPA, 2003); and,
- Guidelines on the Information to be contained in Environmental Impact Statements (EPA, 2002).

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

In order to provide an understanding of the stepwise impact assessment process applied below, we have firstly presented below a summary guide that defines the steps (1 to 7) taken in each element of the impact assessment process. The guide also provides definitions and descriptions of the assessment process and shows how the source-pathway-target model and the EPA impact descriptors are combined.

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

Step 1	Identification and Description of Potential Impact Source This section presents and describes the activity that brings about the potential impact or the potential source of pollution. The significance of effects is briefly described.	
Step 2	Pathway/ Mechanism:	The route by which a potential source of impact can transfer or migrate to an identified receptor. In terms of wind farm developments, surface water and groundwater flows are the primary pathways, or for example, excavation or soil erosion are physical mechanisms by which a potential impact is generated.
Step 3	Receptor:	A receptor is a part of the natural environment which could potentially be impacted upon, *e.g.* human health, plant/animal species, aquatic habitats, soils/geology, water resources, water sources. The potential impact can only arise as a

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

6.3.2 Construction Phase Potential Impacts

6.3.2.1 Clear Felling of Coniferous Plantation

It is estimated that approximately 6 hectares in total of existing plantation forestry will be felled to allow for development of the proposed wind farm infrastructure. All proposed felling will be undertaken Owenbeg River catchment.

Potential impacts during tree felling occur mainly from:

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

Pathways: Drainage and surface water discharge routes.

Receptors: Surface waters and associated dependant ecosystems.

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

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

Construction phase activities including access road construction, turbine base/hardstanding construction and grid cable trench excavation will require earthworks resulting in removal of vegetation cover and excavation of peat and mineral subsoil where present. Potential sources of sediment laden water include:

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

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

Pathways: Drainage and surface water discharge routes.

Receptors: Down-gradient rivers and dependant ecosystems.

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

6.3.2.3 Potential Release of Hydrocarbons during Construction and Storage

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

Pathway: Groundwater flow paths and site drainage network.

Receptor: Groundwater and surface water.

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

6.3.2.4 Groundwater and Surface Water Contamination from Wastewater Disposal

Release of effluent from wastewater treatment has the potential to impact on groundwater and surface waters.

Pathway: Groundwater flow paths and site drainage network.

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

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

6.3.2.5 Release of Cement-Based Products

Concrete and other cement-based products are highly alkaline and corrosive and can have significant negative impacts on water quality. They generate very fine, highly alkaline silt (pH 11.5) that can physically damage fish by burning their skin and blocking their gills. A pH range of ≥ 6 ≤ 9 is set in S.I. No. 293 of 1988 Quality of Salmonid Water Regulations, with artificial variations not in excess of ± 0.5 of a pH unit. Entry of cement based products into the site drainage system, into surface water runoff, and hence to surface watercourses or directly into watercourses represents a risk to the aquatic environment. Peat ecosystems are dependent on low pH hydrochemistry. They are extremely sensitive to introduction of high pH alkaline waters into the system. Batching of wet concrete on site and washing out of transport and placement machinery are the activities most likely to generate a risk of cement based pollution.

Pathway: Site drainage network.

Receptor: Surface water and peat water hydrochemistry.

Pre-Mitigation Impact: Indirect, negative, moderate, short term, medium probability impact to surface water.

6.3.2.6 Morphological Changes to Surface Watercourses & Drainage Patterns

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

It is proposed that 3 no. new stream crossings will be required to facilitate the wind farm access road. This includes two crossings over stream S1 and one crossing over stream S4.

Pathway: Site drainage network.

Receptor: Surface water flows and stream morphology.

Pre-mitigation Impact: Negative, direct, slight, long term, high probability impact.

6.3.2.7 Potential Impacts on Hydrologically Connected Designated Sites

The proposed development site drains to the Owenbeg River and the Dinin River which forms part of the River Barrow and River Nore SAC. The River Nore downstream of the site is also a designated pNHA (*i.e.* River Nore and Abbeyleix Woods Complex).

Possible effects include water quality impacts which could be significant if mitigation is not put in place.

Pathway: Surface water flow paths.

Receptor: Down-gradient water quality and designated sites.

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

6.3.2.8 Potential Impacts on Local Groundwater Well Supplies

Release of contaminants and alterations of groundwater levels within excavations has the potential to impact on groundwater supplies down-gradient of the site. As assessed above no significant impacts on site groundwater levels are anticipated and therefore, no impacts on local groundwater supplies can occur from this impact. Water quality impacts on local wells supplies could potentially occur from contaminants such as hydrocarbons/chemicals etc.

As stated above, private dwellings are potentially located down-gradient of a proposed turbine location Turbine 11. It is assumed that these houses have a private well; however this has not being confirmed. The remainder of the dwelling houses are remote (*i.e.* not located down-gradient of a proposed development area). Details regarding these down-gradient dwellings and their location in relation to proposed wind farm development areas are shown in **Table 6.10** above and on **Figure 6.6**.

Pathway: Groundwater flow paths.

Receptor: Groundwater Supplies.

Pre-Mitigation Impact: Indirect, negative, slight, short term, low probability impact.

Impact Assessment: Private dwelings are potentially down-gradient of a proposed turbine T11. Proposed turbine T11 is approximately 522m up-gadient of the private dwelling and potential well.

However, the risk to this potential well source (and the remaining dwellings which are further away) from potential contaminant release within any excavation at this distance is negligible. Due to the relatively low permeability of this aquifer type and low recharge characteristics, flowpaths are generally short. Maximum flowpaths are estimated to be 30–300m for aquifers in this bedrock type. The flowpath is the distance and direction from the aquifer recharge area to where groundwater is discharged as surface water in rivers, seeps or springs. Therefore, it is unlikely that groundwater flow volumes and direction will be impacted by any activity that is at a distance of greater than 30-300m from a given point in the aquifer. If a flowpath between turbine T11 and the dwelling house did exist, the relatively low permeability would mean that a pollutant would take months to travel this distance as demonstrated below by means of the Darcy mean velocity equation.

$$q = k.i$$

$$v = q/ ne$$

$$T = L / v$$

where:

q	= specific discharge (m/day)
k	= permeability m/day (a value of 0.5m/day for low permeability bedrock is used).
ne	= porosity (a value of 0.025 is used for this bedrock type).
i	=slope of the water table in low permeability rock can be estimated from on topography (a value of 0.12 is used down-gradient of T11 (265mOD - 200mOD)/522m = 0.12).
v	= Darcy velocity (m/day).
L	= Distance (metres).
T	= Time of travel (days)

Based on a groundwater flow velocity of 2.4m/day, the time of travel (ToT) for a potential pollutant to flow from the T11 location to the dwelling house would be in the order of 217 days. During this time any discharge would be assimilated and attenuated by natural groundwater flow, and diluted by rainfall recharge. Also any entrained sediment would be filtered within the low permeability bedrock aquifer. Therefore the risk posed to potential well sources at this distance from potential spills and leaks from excavations is negligible to none.

6.3.2.9 Potential Impacts on Freshwater Pearl Mussel in the River Nore Catchment

The nearest River Nore Freshwater Pearl Mussel population to the proposed site development is 21.2km downstream via the Owenbeg River. FPM were not recorded in the Owenbeg River during the current assessment. The southern boundary of the site is 14km from the River Nore FPM population via the Boleybawn Stream/Moneycleare River, where Site 1 was found to be dry during survey work.

Possible effects relating to poor quality surface water runoff could be significant if mitigation is not put in place.

Pathway: Surface water flow paths.

Receptor: Down-gradient water quality and fresh water pearl mussel sites.

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

6.3.3 Operational Phase

6.3.3.1 Progressive Replacement of Natural Surface with Lower Permeability Surfaces

Progressive replacement of the vegetated surface with impermeable surfaces could potentially result in an increase in the proportion of surface water runoff reaching the surface water drainage network. The footprint comprises turbine hardstandings, upgraded access roads, substation and compound. During storm rainfall events, additional runoff coupled with increased velocity of flow could increase hydraulic loading, resulting in erosion of watercourses and impact on aquatic ecosystems.

Pathway: Site drainage network.

Receptor: Surface waters and dependant ecosystems.

Pre-Mitigation Impact: Direct, negative, moderate, permanent, moderate probability impact.

Impact Assessment: As determined above there could be a potential increase of 0.43% in the average daily/monthly volume of runoff from the study area in comparison to the baseline pre-development site runoff conditions. This is a very small increase in average runoff and results from a relatively small area of the study area being developed, the proposed total permanent development footprint being approximately 6.5ha, representing 1.7% of the total study area of 380ha.

The increase in runoff from the most development will therefore be negligible. This is even before mitigation measures will be put in place. Therefore, there will be no risk of exacerbated flooding down-gradient of the site.

6.3.4 Decommissioning Phase

The potential hydrological impacts during the decommissioning phase are expected to be similar to the construction phase and therefore mitigation will be the same as the construction phase which is outlined below.

6.4 Mitigation & Monitoring

6.4.1 Construction Phase

6.4.1.1 Clear Felling of Coniferous Plantation

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

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

Mitigation by Avoidance: There is a requirement in the Forest Service Code of Practice and in the FSC Certification Standard for the installation of buffer zones adjacent to aquatic zones at planting stage. Minimum buffer zone widths recommended in the Forest Service (2000) guidance document "*Forestry and Water Quality Guidelines*" are shown in **Table 6.13**.

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

Table 6.13: Minimum Buffer Zone Widths (Forest Service, 2000)

During the wind farm construction phase a self-imposed buffer zone of 50m will be maintained for all streams where possible. These buffer zones are shown on **Figure 6.7**.

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

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

- Machine combinations will be chosen which are most suitable for ground conditions at the time of felling, and which will minimise soils disturbance;
- Checking and maintenance of roads and culverts will be on-going through any felling operation. No tracking of vehicle through watercourses will occur, as vehicles will use road infrastructure and existing watercourse crossing points. Where possible, existing drains will not be disturbed during felling works;
- Ditches which drain from the proposed area to be felled towards existing surface watercourses will be blocked, and temporary silt traps will be constructed. No direct discharge of such ditches to watercourses will occur. Drains and sediment traps will be installed during ground preparation. Collector drains will be excavated at an acute angle to the contour (~0.3%-3% gradient), to minimise flow velocities. Main drains to take the discharge from collector drains will include water drops and rock armour, as required, where there are steep gradients, and should avoid being placed at right angles to the contour;
- Sediment traps will be sited in drains downstream of felling areas. Machine access will be maintained to enable the accumulated sediment to be excavated. Sediment will be carefully disposed of in the peat disposal areas. Where possible, all new silt traps will be constructed on even ground and not on sloping ground;
- In areas particularly sensitive to erosion, it may be necessary to install double or triple sediment traps. This measure will be reviewed on site during construction;
- All drainage channels will taper out before entering the aquatic buffer zone. This ensures that discharged water gently fans out over the buffer zone before entering the aquatic zone, with sediment filtered out from the flow by ground vegetation within the zone. On erodible soils, silt traps will be installed at the end of the drainage channels, to the outside of the buffer zone;
- Drains and silt traps will be maintained throughout all felling works, ensuring that they are clear of sediment build-up and are not severely eroded. Correct drain alignment, spacing and depth will ensure that erosion and sediment build-up are minimized and controlled;

- Brash mats will be used to support vehicles on soft ground, reducing peat and mineral soils erosion and avoiding the formation of rutted areas, in which surface water ponding can occur. Brash mat renewal should take place when they become heavily used and worn. Provision should be made for brash mats along all off-road routes, to protect the soil from compaction and rutting. Where there is risk of severe erosion occurring, extraction should be suspended during periods of high rainfall;
- Timber will be stacked in dry areas, and outside a local 50m watercourse buffer. Straw bales and check dams to be emplaced on the down gradient side of timber storage/processing sites;
- Works will be carried out during periods of no, or low rainfall, in order to minimise entrainment of exposed sediment in surface water run-off;
- Checking and maintenance of roads and culverts will be on-going through the felling operation;
- Refuelling of vehicles will normally take place off-site, however, should refuelling or maintenance of machinery be necessary on-site, it will not occur within 100m of a watercourse. Mobile bowser, drip kits, qualified personnel will be used where refuelling is required;
- Branches, logs or debris will not be allowed to build up in aquatic zones. All such material will be removed when harvesting operations have been completed, but care will be taken to avoid removing natural debris deflectors.

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

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

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

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

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

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

Residual Impact: Indirect, negative, slight, temporary, low probability impact.

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

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

The key mitigation measure during the construction phase is the avoidance of sensitive aquatic areas where possible. From **Figure 6.7** it can be seen that all of the key proposed development areas are actually significantly away from the delineated buffer zones with the exception of the proposed stream crossings. Additional control measures, which are outlined further on in this section, will be undertaken at these locations).

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

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

Mitigation by Design:

Source controls: Interceptor drains, vee-drains, diversion drains, flume pipes, erosion and velocity control measures such as use of sand bags, oyster bags filled with gravel, filter fabrics, and other similar/equivalent or appropriate systems.

Small working areas, covering stockpiles, weathering off stockpiles, cessation of works in certain areas or other similar/equivalent or appropriate measures.

In-Line controls: Interceptor drains, vee-drains, oversized swales, erosion and velocity control measures such as check dams, sand bags, oyster bags, straw bales, flow limiters, weirs, baffles, silt bags, silt fences, sedimats, filter fabrics, and collection sumps, temporary sumps/attenuation lagoons, sediment traps, pumping systems, settlement ponds, temporary pumping chambers, or other similar/equivalent or appropriates systems.

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

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

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

- Apart from interceptor drains, which will convey clean runoff water to the downstream drainage system there will be no direct discharge (without treatment for sediment reduction, and attenuation for flow management) of runoff from the proposed wind farm drainage into the existing site drainage network where possible. This will reduce the potential for any increased risk of downstream flooding or sediment transport/erosion;
- Silt traps will be placed in the existing drains upstream of any streams where construction works/tree felling is taking place, and these will be diverted into proposed interceptor drains, or culverted under/across the works area;
- During the operational phase of the wind farm runoff from individual turbine hardstanding areas will be not discharged into the existing drain network but discharged locally at each turbine location through settlement ponds and buffered outfalls onto vegetated surfaces;
- Buffered outfalls which will be numerous over the site will promote percolation of drainage waters across vegetation and close to the point at which the additional runoff is generated, rather than direct discharge to the existing drains of the site;
- Drains running parallel to the existing roads requiring widening will be upgraded. Velocity and silt control measures such as check dams, sand bags, oyster bags, straw bales, flow limiters, weirs, baffles, silt fences will be used during the upgrade construction works. Regular buffered outfalls will also be added to these drains to protect downstream surface waters.

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

Silt Fences: Silt fences will be emplaced within drains down-gradient of all construction areas. Silt fences are effective at removing heavy settleable solids. This will act to prevent entry to watercourses of sand and gravel sized sediment, released from excavation of mineral sub-soils of glacial and glacio-fluvial origin, and entrained in surface water runoff. Inspection and maintenance of these structures during construction phase is critical to their functioning to stated purpose. They will remain in place throughout the entire construction phase. Double silt fences will be emplaced within drains down-gradient of all construction areas inside the 50m hydrological buffer zone.

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

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

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

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

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

Works should be suspended if forecasting suggests any of the following is likely to occur:

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

Management of Runoff from Peat and Subsoil Storage Areas: It is proposed that excavated soil will be permanently stored at a pre-designated site close to the temporary compound. Peat will be stored in designated areas based on geotechnical assessment.

During the initial placement of peat and subsoil, silt fences, straw bales and biodegradable geogrids will be used to control surface water runoff from the storage areas. 'Siltbuster' treatment trains will be employed if previous treatment is not to a high quality.

Drainage from peat storage areas will ultimately be routed to an oversized swale and a number of settlement ponds and a 'Siltbuster' with appropriate storage and settlement designed for a 1 in 100 year 6 hour return period before being discharged to the on-site drains.

Peat/subsoil storage areas will be sealed with a digger bucket and vegetated as soon possible, to reduce sediment entrainment in runoff. Once re-vegetated and stabilised, peat/subsoil storage areas will no longer be a potential source of silt laden runoff. All storage areas will be kept outside of the 50m buffer zone.

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

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

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

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

Residual Impact: Negative, indirect, imperceptible, temporary, low probability impact.

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

6.4.1.3 Potential Release of Hydrocarbons during Construction and Storage

Mitigation by Design:

- On site refuelling of machinery will be carried out using a mobile double skinned fuel bowser. The fuel bowser, a double-axel custom-built refuelling trailer will be re-filled off site, and will be towed around the site by a 4x4 jeep to where machinery is located. The 4x4 jeep will also carry fuel absorbent material and pads in the event of any accidental spillages. The fuel bowser will be parked on a level area in the construction compound when not in use and only designated trained and competent operatives will be authorised to refuel plant on site. Mobile measures such as drip trays and fuel absorbent mats will be used during all refuelling operations;
- Fuels stored on site will be minimised. Any storage areas will be bunded appropriately for the fuel storage volume for the time period of the construction;
- The electrical control building shall be bunded appropriately to the volume of oils likely to be stored, and to prevent leakage of any associated chemicals and to groundwater or surface water. The bunded area will be fitted with a storm drainage system and an appropriate oil interceptor;
- The plant used shall be regularly inspected for leaks and fitness for purpose; and,
- An emergency plan for the construction phase to deal with accidental spillages will be contained within Environmental Management Plan. Spill kits will be available to deal with accidental spillages.

Residual Impact: Indirect, negative, imperceptible, temporary, low probability impact on groundwater and surface water.

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

6.4.1.4 Groundwater and Surface Water Contamination from Wastewater Disposal

Mitigation by Avoidance:

- Self-contained port-a-loos with integrated waste holding tank will be used at the site compound, maintained by the providing licensed contractor, and removed from site on completion of the construction works;
- Water supply for the site office and other sanitation will be brought to site and removed after use from the site to be discharged at a suitable off-site treatment location;
- No water will be sourced on the site, or discharged to the site.

Residual Impact: No impact

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

6.4.1.5 Release of Cement-Based Products

Mitigation by Avoidance:

- No batching of wet-cement products will occur on site. Ready-mixed supply of wet concrete products and where possible, emplacement of pre-cast elements, will take place;
- Where possible, pre-cast elements for culverts and concrete works will be used;
- No washing out of any plant used in concrete transport or concreting operations will be allowed on-site;
- Where concrete is delivered on site, only the chute need be cleaned, using the smallest volume of water possible. No discharge of cement contaminated waters to the construction phase drainage system or directly to any artificial drain or watercourse will be allowed. Chute cleaning water is to be tanked and removed from the site to a suitable, non-polluting, discharge location;
- Use weather forecasting to plan dry days for pouring concrete;
- Ensure pour site is free of standing water, and plastic covers will be ready in case of sudden rainfall event.

Residual Impact: Negative, Indirect, imperceptible, short term, low probability impact.

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

6.4.1.6 Morphological Changes to Surface Watercourses & Drainage Patterns

Mitigation by Design:

- Where possible all proposed new stream crossings will be bottomless culverts and the existing banks will remain undisturbed. No in-stream excavation works are proposed and therefore there will be no impact on the stream at the proposed crossing location;
- Where the proposed grid connection cable route runs adjacent to a proposed access road or road proposed for upgrade, the cable will pass over the culvert within the access road;
- Any guidance/mitigation measures proposed by the OPW or the Inland Fisheries Ireland will be incorporated into the design of the proposed crossings;
- As a further precaution near stream construction work will only be carried out during the period permitted by Inland Fisheries Ireland for in-stream works according to the Eastern Regional Fisheries Board (2004) guidance document *"Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites"*, that is, May to

September inclusive. This time period coincides with the period of lowest expected rainfall, and therefore minimum runoff rates. This will minimise the risk of entrainment of suspended sediment in surface water runoff, and transport via this pathway to surface watercourses;

- During the near stream construction work double row silt fences will be emplaced immediately down-gradient of the construction area for the duration of the construction phase. There will be no batching or storage of cement allowed in the vicinity of the crossing construction areas;
- All access road river/stream crossings will require a Section 50 application (Arterial Drainage Act, 1945). The river/stream crossings will be designed in accordance with OPW guidelines/requirements on applying for a Section 50 consent.

Residual Impact: Neutral, direct, negligible, short term, high probability impact.

Significance of Effects: No significant effects on stream morphology or stream water quality are anticipated at crossing locations.

6.4.1.7 Potential Impacts on Hydrologically Connected Designated Sites

The proposed mitigation measures for protection of surface water quality which will include buffer zones and drainage control measures (*i.e.* interceptor drains, swales, settlement ponds) will ensure that the quality of runoff from proposed development areas will remain unchanged.

As stated above, there could potentially be an *"imperceptible, temporary, low probability impact"* on local streams and rivers but this would be very localised and over a very short time period (*i.e.* hours). Therefore, there is reasonable scientific certainty that there will be no significant direct, or indirect impacts on the River Nore SAC/pNHA.

Residual Impact: Reasonable scientific certainty as to the absence of impacts.

Significance of Effects: Reasonable scientific certainty of no significant impacts.

6.4.1.8 Potential Impacts on Local Groundwater Well Supplies

In addition, there are proposed mitigation measures (outlined above) that will minimise and prevent potential groundwater contamination from hydrocarbons and other chemicals.

Residual Impacts

No residual impacts on groundwater supplies are anticipated either in terms of quality or quantity.

Significance of Effects

No significant impacts on potential groundwater supplies are anticipated.

6.4.1.9 Potential Impacts on Freshwater Pearl Mussel in the River Nore Catchment

Best guidance in relation to protection of freshwater pear mussel (FPM) sites can be obtained from guidance document *Forestry and Freshwater Pearl Mussel Requirements – Site Assessment and Mitigation Measures (Draft).*

Within catchments that contain FPM and especially populations that are designated (*i.e.* cSAC) particular emphasis is placed upon forestry sites (*i.e.* or proposed wind farm development sites) that lie less than 6km upstream of an identified FPM population. **Table 6.14** shows the screening criteria taken from the FPM requirements guidance document.

Distance from nearest downstream FPM population (Note 1)		*Soil (Note 2)*	*Requirements (see * below)*
PART A within 6km from a FPM site	Site Adjoins Population	Erodible	FPM Requirements
		Peaty	FPM Requirements
		Mineral	FPM Requirements
	Site contains or adjoins an aquatic zone	Erodible	FPM Requirements
		Peaty	FPM Requirements
		Mineral	FPM Requirements
	Site does not contain or adjoin an aquatic zone	Erodible	FPM Requirements
		Peaty	FPM Requirements
		Mineral	FS Guidelines*
PART B greater than 6km from a FPM site		Erodible	FS Guidelines*
		Peaty	FS Guidelines*

Table: 6.14: Forest Operations Screening Table (FPM Requirements)

**Note 1: Forestry Services Guidelines apply except in the following situations where the Forestry and FPM Requirements apply.*

- >10% of catchment (Note 3)
- Afforestation >50ha (Note 4)
- Clear felling >25ha (Note 4)

Notes:

1. Distance is measured along the shortest hydrological distance from the nearest point of the site of application to the nearest known FPM population downstream.
2. Soil: Soil types are those as defined in the guidance document.
3. Cumulative Effect: If the application increases the total cumulative area of an operation in a three year period to more than 10% of the FMP catchment, then FPM *Requirements* apply.
4. Area of Individual Operation refers to the area of an individual site (e.g. felling coupe, afforestation site).

The proposed wind farm development is more than 6km upstream of the nearest mapped FPM site and therefore the Forestry Services Guidelines apply as outlined below.

Mitigation measures from best practice Forestry Service Guidelines along with the proposed drainage design (as outlined above in this chapter) will reduce the risk of entrainment of suspended solids and nutrient release in surface watercourses.

Best Practice Mitigation Measures as follows:

- Machine combinations will be chosen which are most suitable for ground conditions at the time of felling, and which will minimise soils disturbance;
- Use of buffer zones for aquatic zones (see **Table 6.14** above);
- Checking and maintenance of roads and culverts will be on-going through any felling operation. No tracking of vehicle through watercourses will occur, as vehicles will use road

infrastructure and watercourse crossing points. Where possible, existing drains will not be disturbed during felling works;

- Drains which drain from the area to be felled towards surface watercourses will be blocked, and temporary silt traps will be constructed. No direct discharge of such drains to watercourses will occur. Drains and sediment traps should be installed during ground preparation. Collector drains will be excavated at an acute angle to the contour (0.3%-3% gradient), to minimise flow velocities. Main drains to take the discharge from collector drains must be provided with water drops and rock armour where there are steep gradients, and should avoid being placed at right angles to the contour;
- Sediment traps will be sited outside of buffer zones and will have no direct outflow into the aquatic zone. Machine access will be maintained to enable the accumulated sediment to be excavated. Sediment will be carefully disposed of away from all aquatic zones. Where possible, all new silt traps will be constructed on even ground and not on sloping ground;
- In areas particularly sensitive to erosion, it may be necessary to install double or triple sediment traps;
- All drainage channels will taper out before entering the aquatic buffer zone. This ensures that discharged water gently fans out over the buffer zone before entering the aquatic zone, with sediment filtered out from the flow by ground vegetation within the zone. On erodible soils silt traps will be installed at the end of the drainage channels to the outside of the buffer zone;
- Drains and silt traps will be maintained throughout all felling works, ensuring that they are clear of sediment build-up and are not severely eroded. Correct drain alignment, spacing and depth will ensure that erosion and sediment build-up are minimised and controlled;
- Brash mats will be used to support vehicles on soft ground, reducing peat and mineral soils erosion and avoiding the formation of rutted areas, in which surface water ponding can occur. Brash mat renewal should take place when they become heavily used and worn. Provision should be made for brash mats along all off-road routes, to protect the soil from compaction and rutting. Where there is risk of severe erosion occurring, extraction should be suspended during periods of high rainfall;
- Timber will be stacked in dry areas, and outside a local 50m stream buffer zone. Straw bales and check dams to be emplaced on the down gradient side of timber storage/processing sites;
- Works should be carried out during periods of no, or low rainfall, in order to minimise entrainment of exposed sediment in surface water run-off;
- Checking and maintenance of roads and culverts will be on-going through the felling operation;
- Do not refuel or maintain machinery within 50m of an aquatic zone. Dedicated refuelling areas will be used during the felling works; and,
- Do not allow branches, logs or debris to build up in aquatic zones. All such material will be removed when harvesting operations have been completed, but avoid removing natural debris deflectors.

In addition to the Forestry Service Guidelines the protection of surface watercourses during the construction, operational and decommissioning phases of the wind farm will be achieved by a combination of mitigation by avoidance and mitigation by design.

The avoidance of sensitive hydrological features within the site and the proposed drainage system will ensure that the existing quality of surface waters will be maintained and protected. The high level of protection provided to surface water bodies within the catchments of the proposed development will ensure that there will be no impact on freshwater pearl mussel sites, if present, downstream of the proposed development site.

6.4.1.10 Surface Water Quality Monitoring

Sampling will be done before, during (if the operation is conducted over a protracted time) and after the construction works. The 'before' sampling should be conducted within 4 weeks prior to the construction work beginning, preferably in medium to high water flow conditions. The "during" sampling will be undertaken once a week or after rainfall events. The 'after' sampling should comprise as many samplings as necessary to demonstrate that water quality has returned to pre-activity status (*i.e.* where an impact has been shown).

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

- Avoid man-made drains and watercourses without all-year flow;
- Select sampling points upstream and downstream of the works;
- It is advantageous if the upstream location is outside/above the site in order to evaluate the impact of land-uses other than the development works; and,
- Where possible, three downstream locations should be selected: one immediately below the working area, the second at exit from the site boundary, and the third some distance from the second (this allows demonstration of no impact through dilution effect or contamination by other land-uses where impact increases at third downstream location relative to second downstream location).

Residual Impact

No residual impact.

Significance of Effects

No significant residual impacts on the aquatic environment are anticipated.

6.4.2 Operational Phase

6.4.2.1 Progressive Replacement of Natural Surface with Lower Permeability Surfaces

Progressive replacement of the vegetated surface with impermeable surfaces could potentially result in an increase in the proportion of surface water runoff reaching the surface water drainage network. The footprint comprises turbine hardstandings, upgraded access roads, substation and compound. During storm rainfall events, additional runoff coupled with increased velocity of flow could increase hydraulic loading, resulting in erosion of watercourses and impact on aquatic ecosystems.

Pathway: Site drainage network.

Receptor: Surface waters and dependant ecosystems.

Pre-Mitigation Impact

Direct, negative, moderate, permanent, moderate probability impact.

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

- Interceptor drains will be installed up-gradient of all proposed infrastructure to collect clean surface runoff, in order to minimise the amount of runoff reaching areas where suspended sediment could become entrained. It will then be directed to areas where it can be re-distributed over the ground by means of a level spreader;
- Swales/road side drains will be used to collect runoff from access roads and turbine hardstanding areas of the site, likely to have entrained suspended sediment, and channel it to settlement ponds for sediment settling;

- On steep sections of access road transverse drains ('grips') will be constructed where appropriate in the surface layer of the road to divert any runoff off the road into swales/road side drains;
- Check dams will be used along sections of access road drains to intercept silts at source. Check dams will be constructed from a 4/40mm non-friable crushed rock;
- Settlement ponds, emplaced downstream of road swale sections and at turbine locations, will buffer volumes of runoff discharging from the drainage system during periods of high rainfall, by retaining water until the storm hydrograph has receded, thus reducing the hydraulic loading to watercourses; and,
- Settlement ponds will be designed in consideration of the Greenfield runoff rate.

Residual Impact: Negative, direct, negligible, long term, moderate probability impact.

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

6.4.3 Decommissioning Phase

As assessed above for the construction phase, no significant impacts on the hydrological environment are anticipated during the decommissioning phase.

6.4.4 "Do Nothing" Scenario

Current land use practices such as forestry and agriculture will continue. In particular commercial deforestation and reforestation will continue at the site. Surface water drainage carried out in areas of forestry will continue to function and may be extended in some areas.

6.4.5 "Worst Case" Scenario

Contamination of surface water streams during the construction and operational phases, which in turn could affect the ecology and quality of the downstream water bodies such as the Owenbeg River, Dinin River and Ironmills River. Also, potentially localised groundwater contamination may occur. However, measures will be put in place to prevent this from happening.

6.4.6 Hydrological Cumulative Impacts

A hydrological cumulative impact assessment was undertaken for other wind farm developments and non wind farm projects and plans located within the Owenbeg River catchment. There are no turbines proposed within the Dinin River catchment and the overall access road construction within the catchment is small and therefore no cumulative impacts on the Dinin River catchment was undertaken

The wind farm developments assessed are listed in **Table 6.15** below and are shown on **Figure 6.8**.

In terms of the potential impacts of wind farm developments on downstream surface water bodies, the biggest risk is during the construction phase of the development as this is the phase when earthworks and excavations will be undertaken at the sites.

Catchment Area	Wind Farm Name	Total Turbine No.	Potential No. of Turbines in Owenbeg Catchment
Owenbeg	Cullenagh WF	18	8

Table 6.15: Other Wind Farms in the Owenbeg River Catchment

The total number of turbines that could potentially be operating within the Owenbeg River catchment is 19 (11 from the proposed development and 8 from other wind farms as shown in **Table 6.15** above). The total catchment area of the Owenbeg River is ~94km^2 and therefore this currently equates to one turbine for approximately every ~11.7km^2, which is considered imperceptible in terms of potential cumulative hydrological impacts. When the proposed development is assessed cumulatively with the Cullenagh WF, it equates to one turbine per ~4.95km^2. The potential for impact remains negligible, given the relatively small footprint area of one turbine. Therefore, no significant cumulative hydrological impacts are anticipated from the construction of the proposed wind farm and other wind energy developments in the region.

The proposed grid connection for the proposed development will tie into the permitted 110kV Laois–Kilkenny Grid Reinforcement Project which runs through the north-western section of the site within the Owenbeg River catchment. No hydrological cumulative impacts are expected in-combination with the Laois–Kilkenny Grid Reinforcement Project line and the proposed development, as the former development comprises predominately overhead lines in the vicinity of the development and therefore no significant hydrological impacts are anticipated.

6.5 Conclusion

The hydrological and hydrogeological assessment has shown that the site will be minimally impacted by the proposed development. The residual effects associated with the proposed development will be minimal and hydrological and hydrogeological effects are considered to be of slight significance.

The construction activities and any routine operational activities will be undertaken with full regard to current best practice and guidance. This will reduce the likelihood of abnormal or accidental occurrences, as well as to ensure there are response measures in place throughout the project.

It is anticipated that the proposed mitigation measures will ensure that impacts on the hydrological and hydrogeological regime will be of slight significance. The construction activities and any routine operational activities will be undertaken with full regard for current best practice and guidance. This will reduce the likelihood of abnormal and accidental occurrences, as well as ensure there are response measures in place throughout the project. It is anticipated that the proposed mitigation measures will ensure that impacts on the hydrological and hydrogeological regime will be of slight significance.

Appendix 6.1: Laboratory Reports

ENVIRONMENTAL
LABORATORY SERVICES
Acorn Business Campus
Mahon Industrial Park,
Blackrock,
Cork
Ireland
Tel: +353 21 453 6141
Fax: +353 21 453 6149
Web: www.irishwatertesting.com
email: info@elsltd.com

ISO 17025 INAB ACCREDITED TESTING DETAILED IN SCOPE REG NO.111T

Contact Name	David Broderick	Report Number	83766 - 1
Address	Hydro-Environmental Services 22 Lower Main Street, Dungarvan,	Sample Number	83766/001
		Date of Receipt	12/03/2015
		Date Started	13/03/2015
Tel No	058 44122	Received or Collected	Hand
Fax No	058 44244	Condition on Receipt	Good
Customer PO	P1264	Date of Report	31/03/2015
Quotation No	QN004036	Sample Type	Surface Waters
Customer Ref	Sw1		

CERTIFICATE OF ANALYSIS

TEST	ANALYTE	SUB	METHOD	LOQ	SPEC	RESULT	UNITS	ACCRED.	OOS
Ammonia									
	Ammonia (as N)		EW154M-1	0.0070		0.036	mg/l N	INAB	
AQ2-UP1									
	Nitrate (as N)		EW154M-1	0.12		0.33	mg/l N	INAB	
	Nitrate (as NO3)(Calc)		EW154M-1	0.53		1.46	mg/l NO3	INAB	
	Nitrite (as N)		EW154M-1	0.013		<0.013	mg/l N	INAB	
	Nitrite (as NO2)(Calc)		EW154M-1	0.043		<0.043	mg/l NO2	INAB	
	Phosphate-Ortho(as P)		EW154M-1	0.009		0.015	mg/l P	INAB	
AQ2-UP2									
	Chloride		EW154M-1	2.6		12.0	mg/L	INAB	
BOD									
	BOD		EW001	1		2	mg/L	INAB	
Suspended Solids									
	Suspended Solids		EW013	5		28	mg/L	INAB	
Total Phosphorus-TP									
	Total Phosphorus-TP		EW146	0.010		0.063	mg/l P	INAB	

Signed : 31/03/2015

Brendan Murray-Deputy Technical Manager

NOTES
1.This Report shall not be Reproduced except in full, without the permission of the laboratory and only relates to the items tested.
2.SPEC= Allowable limit or parametric value
3.OOS=Result which is outside specification highlighted as OOS-A
4.LOQ=Limit of Quantification or lowest value that can be reported
5.ACCRED=Indicates matrix accreditation for the test,a blank field indicates not accredited
6."*" Indicates sub-contract test

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email: info@elsltd.com

ISO 17025 INAB ACCREDITED TESTING DETAILED IN SCOPE REG NO. 111T

Contact Name	David Broderick	**Report Number**	**83766 - 1**
Address	Hydro-Environmental Services 22 Lower Main Street, Dungarvan,	**Sample Number**	83766/002
		Date of Receipt	12/03/2015
		Date Started	13/03/2015
Tel No	058 44122	**Received or Collected**	Hand
Fax No	058 44244	**Condition on Receipt**	Good
Customer PO	P1264	**Date of Report**	31/03/2015
Quotation No	QN004036	**Sample Type**	Surface Waters
Customer Ref	Sw2		

CERTIFICATE OF ANALYSIS

TEST	ANALYTE	SUB	METHOD	LOQ	SPEC	RESULT	UNITS	ACCRED.	OOS
Ammonia									
	Ammonia (as N)		EW154M-1	0.0070		0.023	mg/l N	INAB	
AQ2-UP1									
	Nitrate (as N)		EW154M-1	0.12		0.41	mg/l N	INAB	
	Nitrate (as NO3)(Calc)		EW154M-1	0.53		1.82	mg/l NO3	INAB	
	Nitrite (as N)		EW154M-1	0.013		0.020	mg/l N	INAB	
	Nitrite (as NO2)(Calc)		EW154M-1	0.043		0.066	mg/l NO2	INAB	
	Phosphate-Ortho(as P)		EW154M-1	0.009		0.031	mg/l P	INAB	
AQ2-UP2									
	Chloride		EW154M-1	2.6		12.9	mg/L	INAB	
BOD									
	BOD		EW001	1		<1	mg/L	INAB	
Suspended Solids									
	Suspended Solids		EW013	5		39	mg/L	INAB	
Total Phosphorus-TP									
	Total Phosphorus-TP		EW146	0.010		0.023	mg/l P	INAB	

Signed : ______________________ 31/03/2015

Brendan Murray-Deputy Technical Manager

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3.OOS=Result which is outside specification highlighted as OOS-A
4.LOQ=Limit of Quantification or lowest value that can be reported
5.ACCRED=Indicates matrix accreditation for the test,a blank field indicates not accredited
6."*" Indicates sub-contract test

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Tel: +353 21 453 6141
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Web: www.irishwatertesting.com
email: info@elsltd.com

DETAILED IN SCOPE REG NO.111T

Contact Name	David Broderick	Report Number	83766 - 1
Address	Hydro-Environmental Services 22 Lower Main Street, Dungarvan,	Sample Number	83766/003
		Date of Receipt	12/03/2015
		Date Started	13/03/2015
Tel No	058 44122	Received or Collected	Hand
Fax No	058 44244	Condition on Receipt	Good
Customer PO	P1264	Date of Report	31/03/2015
Quotation No	QN004036	Sample Type	Surface Waters
Customer Ref	Sw3		

CERTIFICATE OF ANALYSIS

TEST	ANALYTE	SUB	METHOD	LOQ	SPEC	RESULT	UNITS	ACCRED.	OOS
Ammonia									
	Ammonia (as N)		EW154M-1	0.0070		0.072	mg/l N	INAB	
AQ2-UP1									
	Nitrate (as N)		EW154M-1	0.12		0.72	mg/l N	INAB	
	Nitrate (as NO3)(Calc)		EW154M-1	0.53		3.19	mg/l NO3	INAB	
	Nitrite (as N)		EW154M-1	0.013		0.014	mg/l N	INAB	
	Nitrite (as NO2)(Calc)		EW154M-1	0.043		0.046	mg/l NO2	INAB	
	Phosphate-Ortho(as P)		EW154M-1	0.009		0.023	mg/l P	INAB	
AQ2-UP2									
	Chloride		EW154M-1	2.6		13.8	mg/L	INAB	
BOD									
	BOD		EW001	1		2	mg/L	INAB	
Suspended Solids									
	Suspended Solids		EW013	5		14	mg/L	INAB	
Total Phosphorus-TP									
	Total Phosphorus-TP		EW146	0.010		0.060	mg/l P	INAB	

Signed : ______________________ 31/03/2015

Brendan Murray-Deputy Technical Manager

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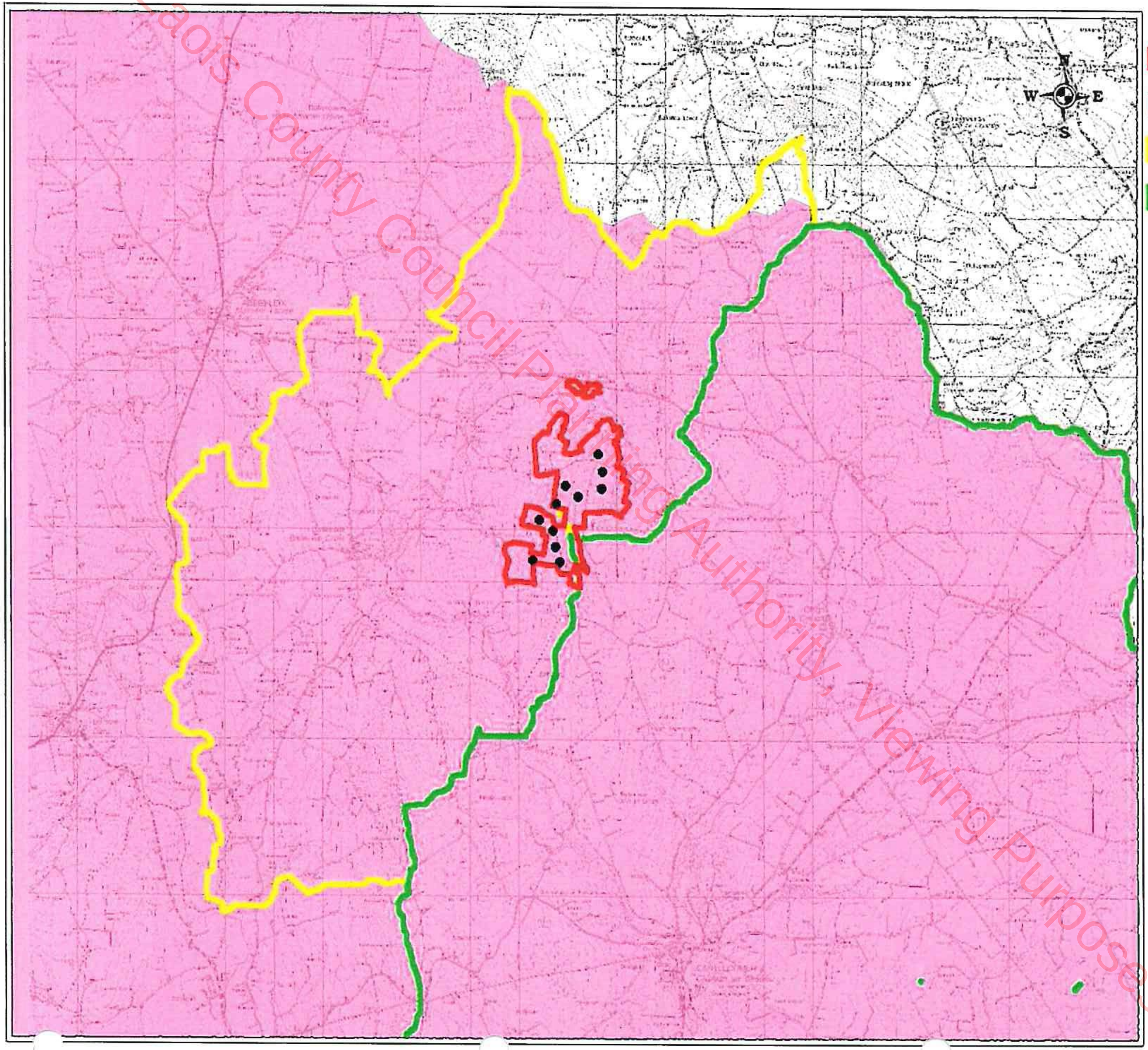
6."*" Indicates sub-contract test

Appendix 6.2: Figures



Legend:

- Landholding / Study Area
- Nore River Regional Catchment
- Owenbeg River Catchment
- Dinin River Catchment
- Proposed Turbine location

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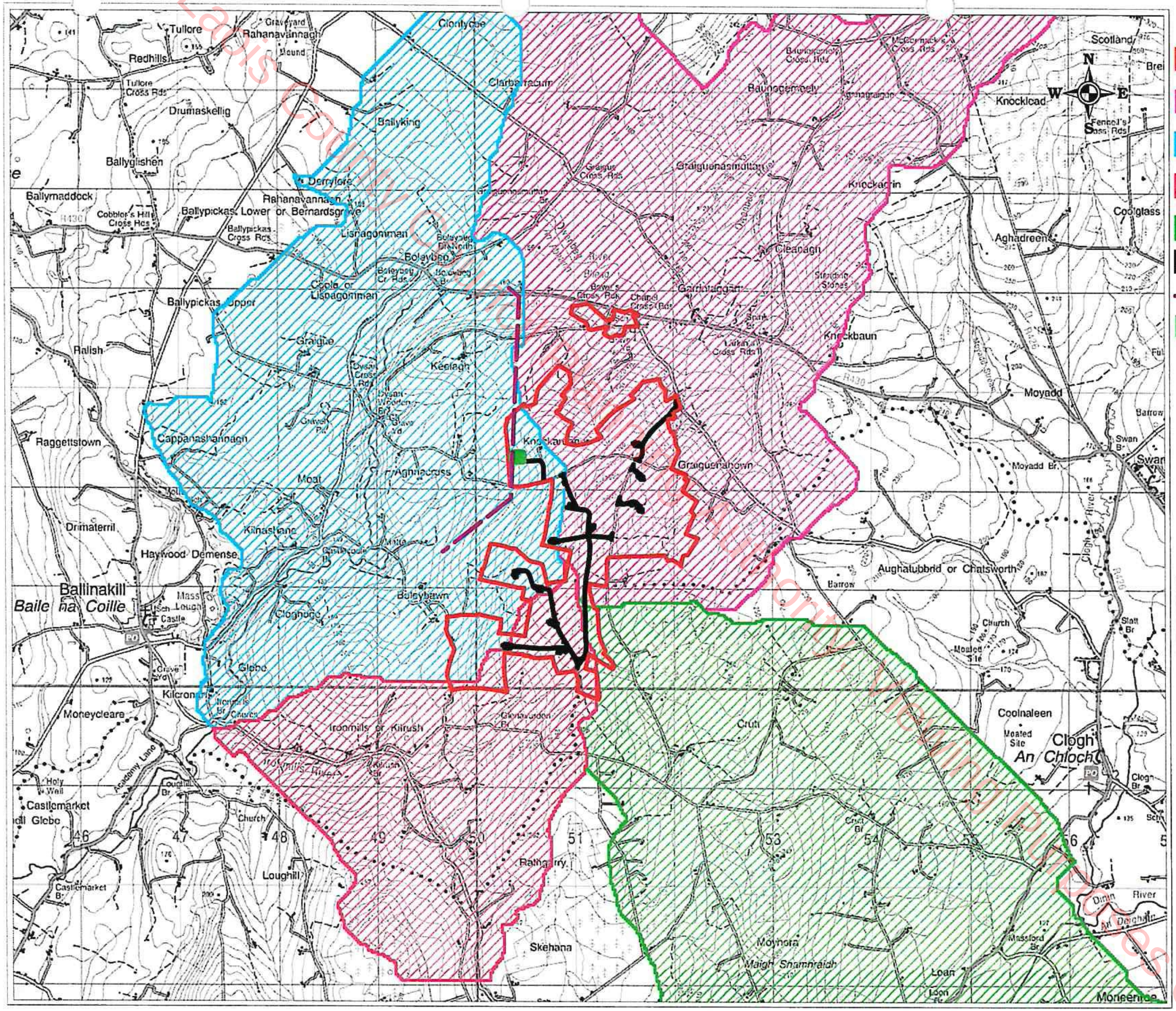
web: www.hydroenvironmental.ie

Title: Regional Hydrology Map	
Client: Pinewoods Wind Ltd	
Job: Pinewoods WF, Co. Laois	
Project No: P1264-0	
Figure No: 6.1	
Sheet Size: A4	
Drawing No: P1264-0-0416-A4-601-00A	
Date: - 27/04/2016	
Scale: - 1:100,000	
Drawn By: GB	Checked By: MG



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Title: Local Hydrology Map

Client: Pinewoods Wind Ltd

Job: Pinewoods WF, Co. Laois

Project No: P1264-0

Figure No: 6.2

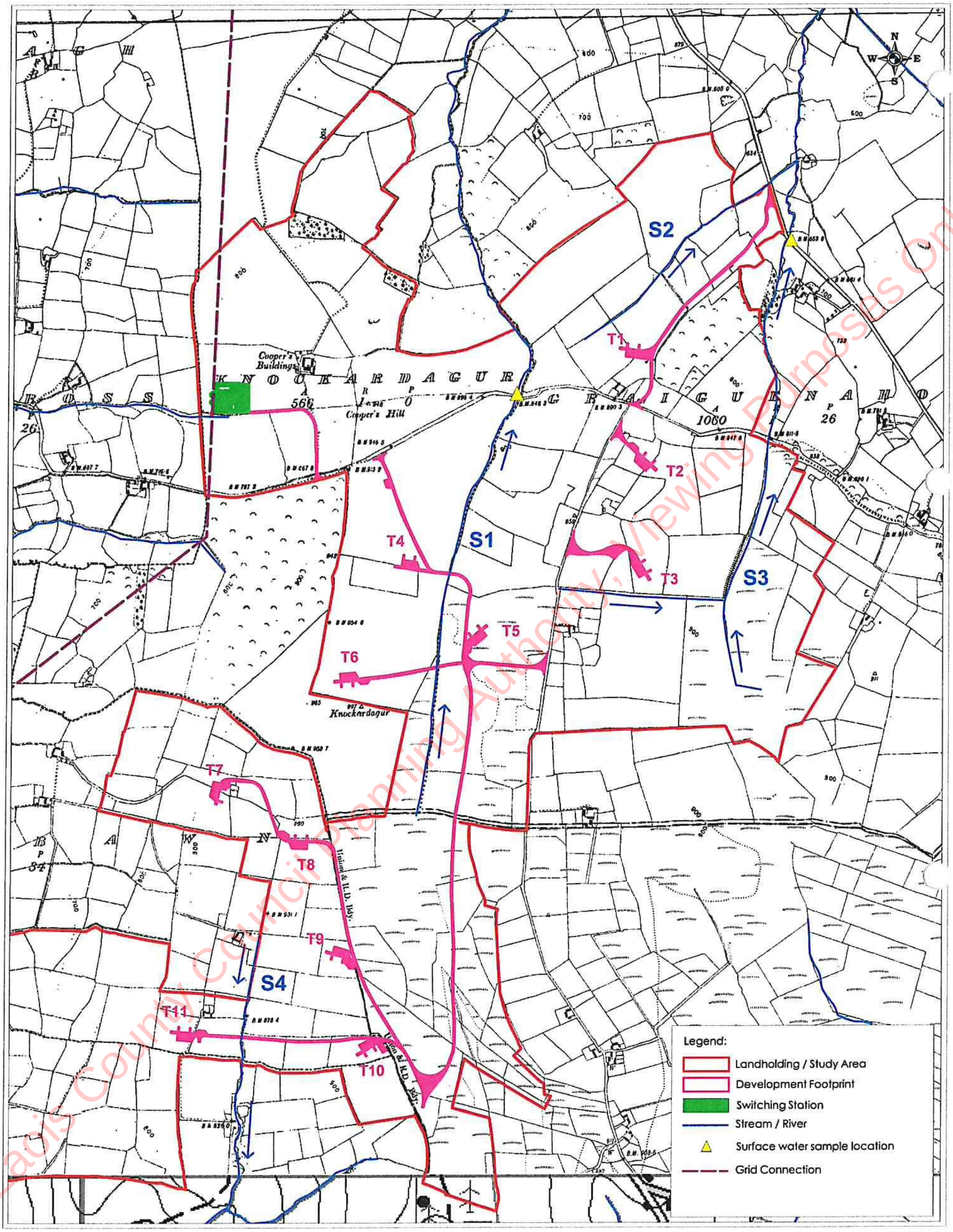
Sheet Size: A4

Drawing No: P1264-0-0416-A4-602-00A

Date: - 27/04/2016

Scale: - 1:50,000

Drawn By: GB | Checked By: MG



Client: Pinewoods Wind Ltd	Drawing No: P1264-0-0416-A3-603-00A		
Job: Pinewoods WF Co. Laois / Kilkenny	Sheet Size: A3	Project No: P1264	
Title: Site Drainage Map	Scale: - 1:10000	Drawn By: DB	
Figure No: 6.3	Date: - 27/04/2016	Checked By: MG	

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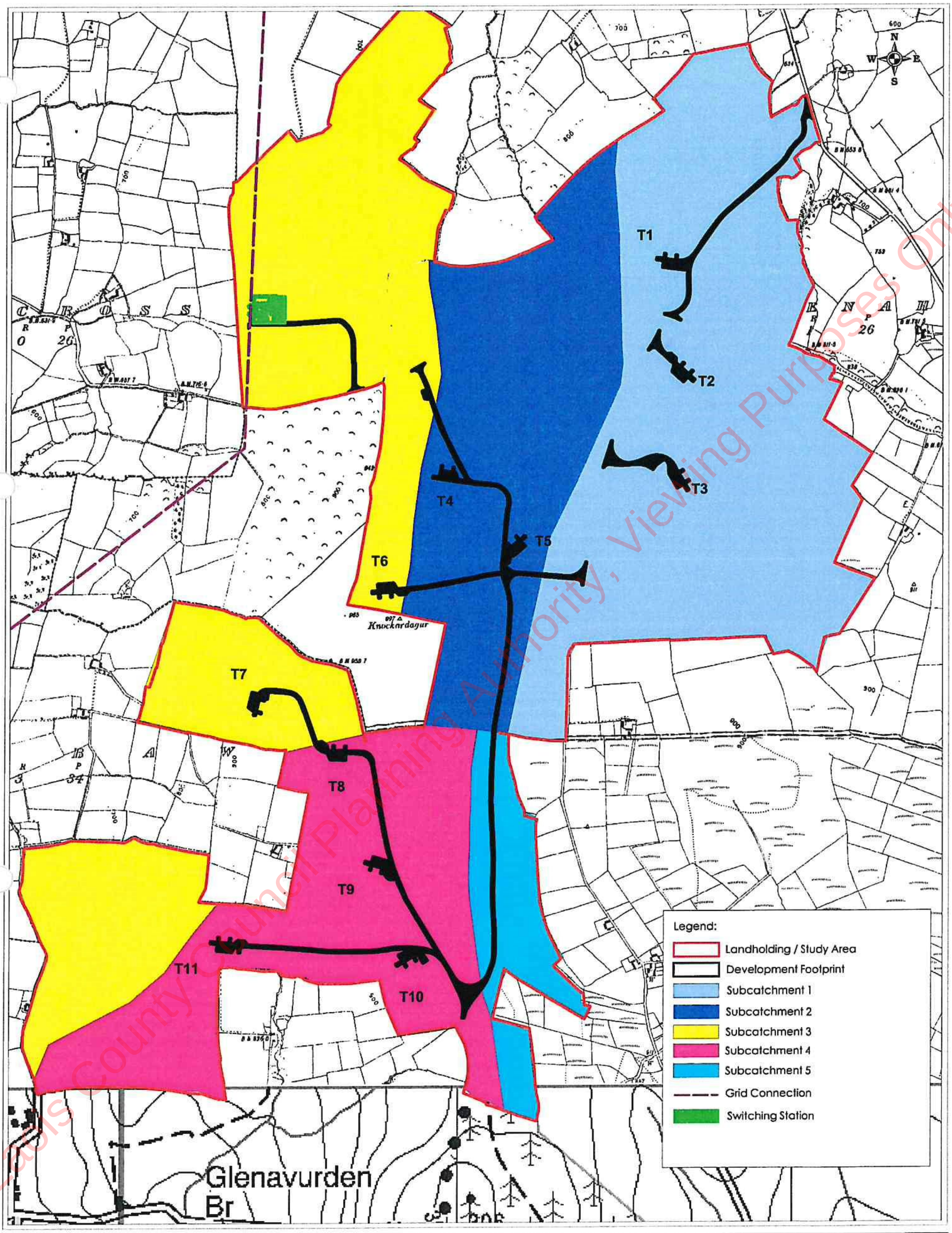

Client: Pinewoods Wind Ltd	Drawing No: P1264-0-0416-A3-604-00A	
Job: Pinewoods WF Co. Laois / Kilkenny	Sheet Size: A3	Project No: P1264-0
Title: Site Subcatchment Map	Scale: - 1:10000	Drawn By: DB
Figure No: 6.4	Date: - 27/04/2016	Checked By: MG

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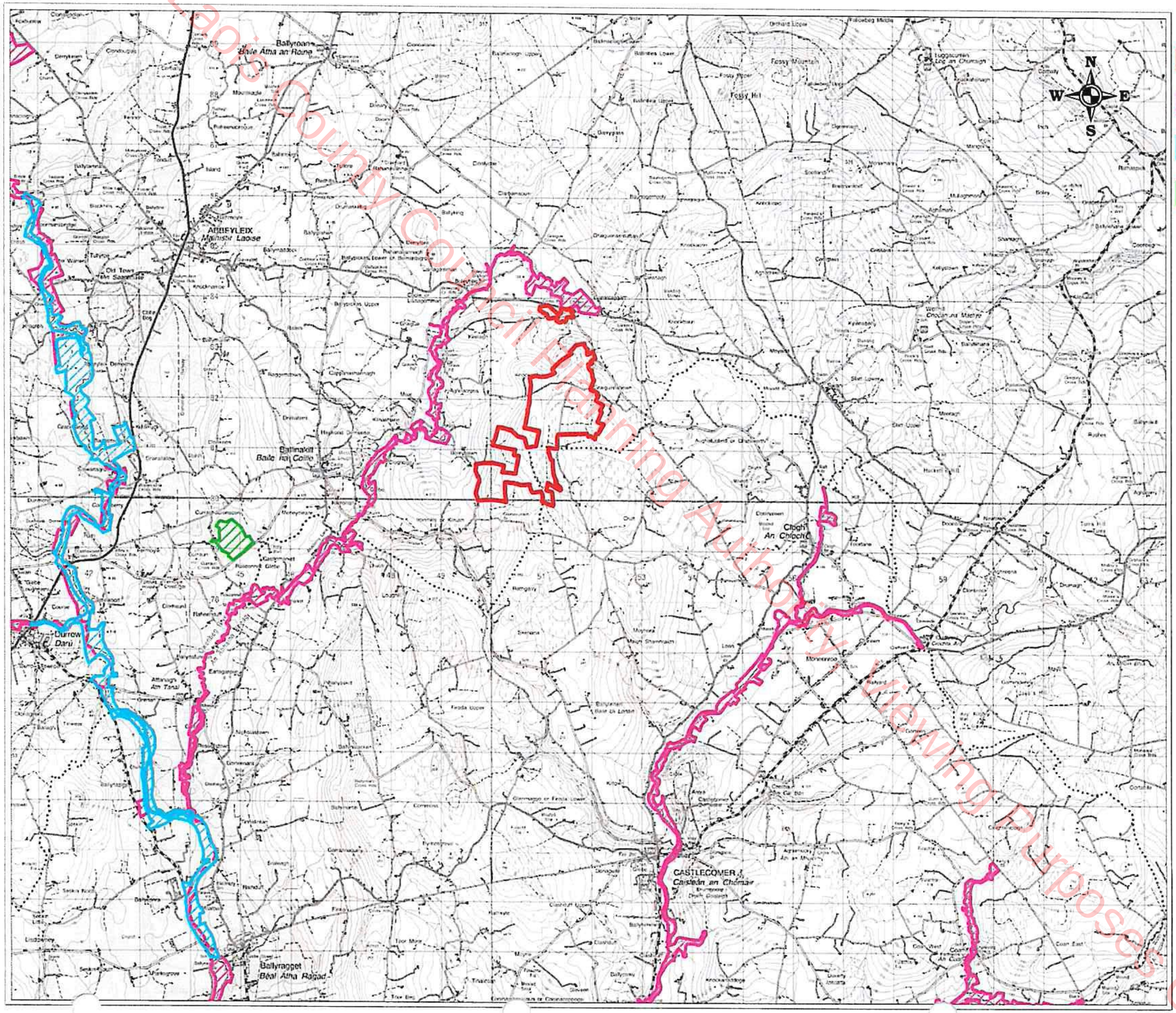

Legend:

- Landholding / Study Area
- River Barrow & River Nore SAC
- River Nore & Abbeyleix Woods Complex pNHA
- Lisbigney Bog SAC & pNHA

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Title: Designated Sites Map

Client: Pinewoods Wind Ltd

Job: Pinewoods WF, Co. Laois

Project No:P1264

Figure No: 6.5

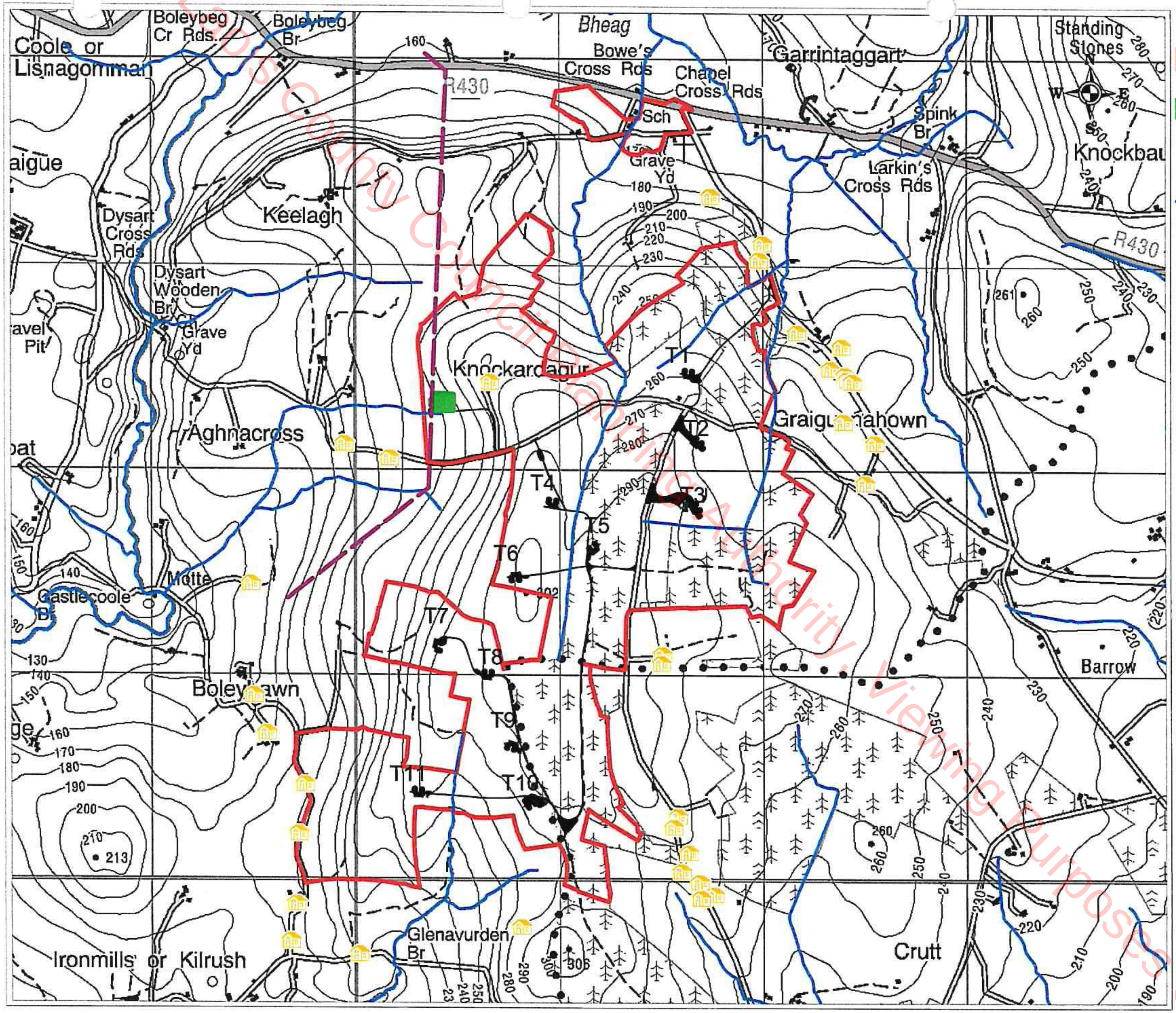
Sheet Size: A4

Drawing No:P1264-0-0416-A4-605-00A

Date: - 27/04/2016

Scale: - 1:100,000

Drawn By: GB | Checked By: MG



Legend:

Landholding / Study Area

Switching Station

Private Dwelling Location

Rivers/Streams

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Title: Water Supply Assessment

Client: Pinewoods Wind Ltd

Job: Pinewoods WF, Co. Laois

Project No: P1264-0

Figure No: 6.6

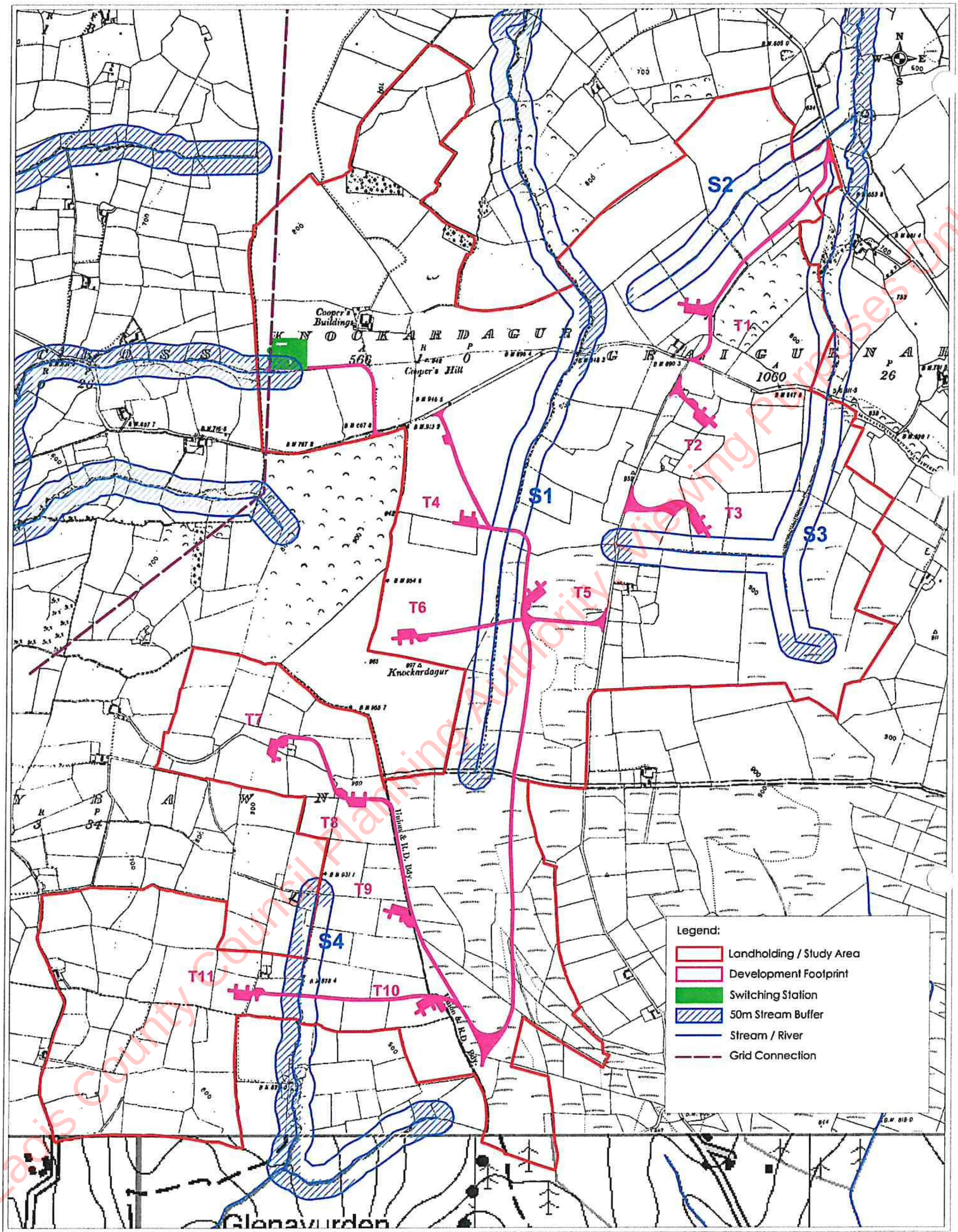
Sheet Size: A4

Drawing No:P1264-0-0416-A4-606-00A

Date: - 27/04/2016

Scale: - 1:25,000

Drawn By: GB | Checked By: MG



Client: Pinewoods Wind Ltd	Drawing No: P1264-0-0416-A3-607-00A	
Job: Pinewoods WF Co. Laois / Kilkenny	Sheet Size: A3	Project No: P1264-0
Title: Hydrological Constraints Map	Scale: - 1:10000	Drawn By: DB
Figure No: 6.7	Date: - 27/04/2016	Checked By: MG

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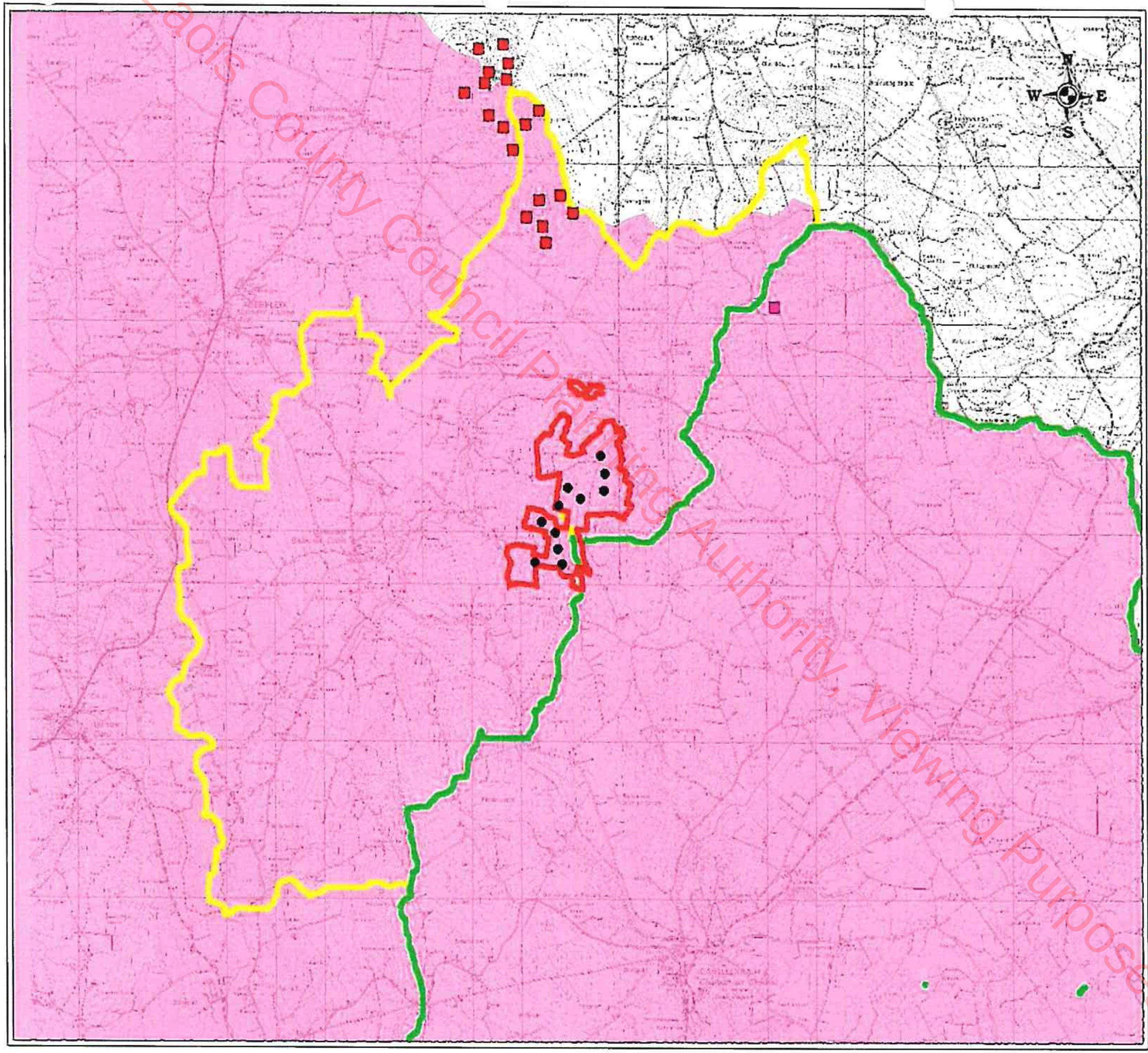

Legend:
- Landholding / Study Area
- Nore River Regional Catchment
- Owenbeg River Catchment
- Dinin River Catchment
- Cullenagh WF
- Knocklead 1 Turbine

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Title: Other Wind Farm Developments
Client: Pinewoods Wind Ltd
Job: Pinewoods WF, Co. Laois
Project No: P1264-0
Figure No: 6.8
Sheet Size: A4
Drawing No: P1264-0-0416-A4-608-00A
Date: - 27/04/2016
Scale: - 1:100,000
Drawn By: GB / Checked By: MG

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Date: 15th December, 2016
Our Ref: P1264-1-0020

Galetech Energy Services
Clondargan
Stradone,
Co. Cavan
H12 NV06

Attn: Mr. Simon Carleton

Dear Simon,

Re: Response to a Further Information Request in relation to Pinewoods Wind Farm, Co. Laois/Kilkenny – (Laois Co. Co. Planning Ref: 16/260)

1.0 INTRODUCTION

Hydro-Environmental Services (HES) were requested by Galetech Energy Services to respond to a further information request issued by Laois County Council in relation to the proposed Pinewoods Wind Farm, Co. Laois / Co. Kilkenny.

This letter report is a response to Item 9 (*Group Water Schemes in the area*) of the information request which was issued by Laois County Council on 21st July 2016. Item 9 is written as follows:

> *"The Councils Water Services section has requested that the following details be submitted in relation to Chapter 6 "Water" in the EIS:"*
>
> (a) *Confirmation that the proposed development will not impact negatively upon the water source and zone of contribution of Ironmills Group Water Scheme (GWS), Graiguenahoun Group Water Scheme, Garrintaggert No. 1 and No. 3 Group Water Scheme and Moyadd No. 1 Group Water Scheme; and,*
>
> (b) *Evidence supporting the evaluation of the proposed impact upon these Group Water Schemes.*

2.0 EIS - GROUNDWATER SUPPLY IMPACT ASSESSMENT

Potential impacts on local groundwater supplies were extensively assessed in the EIS. As stated in Section 6.2.16 of the EIS (Chapter 6 – Water Chapter), due to the nature of wind farm developments, being near surface construction activities, impacts on groundwater are generally negligible and surface water is generally the main sensitive receptor assessed during impact assessments. The primary risk to groundwater at the site would be from cementitious materials, hydrocarbon spillage and leakages. These are common potential impacts on all construction sites (such as road works and industrial sites). As normal best practice, all these potential contamination sources are to be carefully managed at the site during the construction and operational phases of the development and comprehensive mitigation measures are proposed in the EIS to deal with these potential minor impacts.

An impact assessment on local groundwater supplies was also undertaken in Chapter 6 of the EIS (Section 6.2.15). The assessment assumed that every private dwelling within 1km of the proposed wind farm has a well supply. The assessment determined that the risk posed to local groundwater supplies was negligible to none and this was due to the local hydrogeological regime (*i.e.* low permeability bedrock aquifer) and the significant setback distance from the proposed wind turbines (>500m).

The group scheme wells that were identified in the further information request are located at significantly greater distances from the proposed wind farm than the private dwelling locations assessed in the EIS. Nevertheless an impact assessment in relation to the group scheme well sources is carried out below in response to the FI request.

3.0 DETAILS OF THE GROUP WATER SCHEMES

Mrs. Mary Donohue (RWLO/Administrative Officer) of Laois County Council was contacted in relation to the schemes in question and a map showing the scheme locations along with details of the schemes were provided to HES. The map provided by Laois County Council is attached as Appendix I of this report, and the details of the relevant schemes are shown in **Table A**. The locations of the group scheme source wells in relation to the proposed Pinewoods Wind Farm are illustrated on **Figure 1**.

The mapping and information provided by Laois County Council indicate that the Garrintaggert GWS source wells are named No. 2 and No. 3 and not No. 1 and No. 3 as stated in the further information request letter. It was confirmed by Laois County Council that well No. 1 is no longer in use.

The National Federation of Group Water Schemes (NFGWS) was also contacted by HES in order to determine if a groundwater source protection study was completed as part of Rural Water Programme which was undertaken in conjunction with the Geological Survey of Ireland. The NFGWS confirmed that they are not involved with these group schemes and have no information regarding any of the identified source wells. It is our understanding that no groundwater zone of contribution has been established for the group schemes in question.

Table A: Details of Group Water Schemes.

GWS Name	Source	Distance from Wind Farm (km)	GWS Water Usage Details
Ironmills	Borehole	2.4	3 no. domestic connections
Graiguenahoun	Borehole	0.8	4 - 5 no. domestic connections
Garrintaggert No. 3	Borehole	0.95	1.2m³/day
Garrintaggert No. 2	Borehole	0.75	3 no. domestic connections
Moyadd No. 1	Borehole	4	526m³/day

4.0 DESK STUDY REVIEW

In order to assess the potential impact of the proposed Pinewoods Wind Farm on the group schemes, a desk study review of each of the group scheme well locations was undertaken and this information is summarised in **Table B** below. This information was used to delineate a likely conservative zone of contribution (ZOC) for each of the group scheme sources.

Table B: Summary of the GWS Geological / Hydrogeological Setting.

GWS Name	Bedrock Type	Aquifer Classification	GSI Recharge (mm/year)	Groundwater Vulnerability Rating
Ironmills	Shales	Poor (Pl)	51 - 100	High – Extreme
Graiguenahoun	Sandstone / Shales	Local (Lm)	101 - 150	Extreme
Garrintaggert No. 3	Sandstone	Poor (Pl)	51 - 100	Extreme
Garrintaggert No. 2	Sandstone	Poor (Pl)	51 - 100	Extreme
Moyadd No. 1	Shales	Poor (Pu)	51 - 100	Extreme

5.0 GROUNDWATER ZONE OF CONTRIBUTION DELINEATION

The zone of contribution (ZOC) to a well is the area required to support abstraction from long term groundwater recharge. The area required to support abstraction (ZOC) is calculated using groundwater recharge and the long term abstraction rate:

$$ZOC\ Area = \frac{m^3/day \times 365}{Recharge\ (m/year)}$$

An abstraction rate for only two of the schemes was confirmed by Laois County Council (refer to **Table A** above). The number of connections within each scheme was only provided for the rest of the sources.

In order to estimate the water demand of the schemes where only connection numbers were provided, a typical daily water usage of 150 L/person/day was used (EPA, 2009). Therefore assume a 5 person household, the water demand per domestic connection is estimated to be 0.75m³/day. The number of domestic connections for each scheme is shown in **Table A** above.

The ZOC area is delineated for a 50% higher than actual abstraction rate to allow for a potential future increase in demand and also for zone of contribution expansion during dry weather periods. Using the increased demand and the conservative GSI recharge value for the location of the source, the area of the ZOC is calculated for each of the sources as shown in **Table C** below.

Table C: Zone of Contribution Delineation.

GWS Name	Demand + 50% (m3/d)	Effective Rainfall (mm/yr)	Assumed Recharge (mm/year)	Zone of Contribution Area (km²)
Ironmills	3.4	566	51	0.023
Graiguenahoun	5.6	580	101	0.02
Garrintaggert No. 3	1.8	580	51	0.012
Garrintaggert No. 2	3.4	580	51	0.023
Moyadd No. 1	789	583	51	5.6

The delineated zone of contribution for each of the schemes, which is based on the area required to support abstraction (as described above) and the local topography is shown on **Figure 2**.

6.0 POTENTIAL IMPACT OF THE PROPOSED DEVELOPMENT

None of the zones of contribution delineated for the group scheme sources intercept the proposed development footprint or even the proposed site area itself. Therefore, there can be no impacts on any of the sources or their ZOCs as a result of the proposed wind farm development.

7.0 CONCLUSION

The assessment/evaluation is based on the delineation of a likely conservative zone of contribution for each of the identified group water schemes. It has been demonstrated through this assessment process that no part of the estimated ZOCs for any of the group schemes intersect with the development footprint or site area.

Therefore it can be confirmed that no impacts are expected on the local group water schemes as a result of the proposed wind farm development.

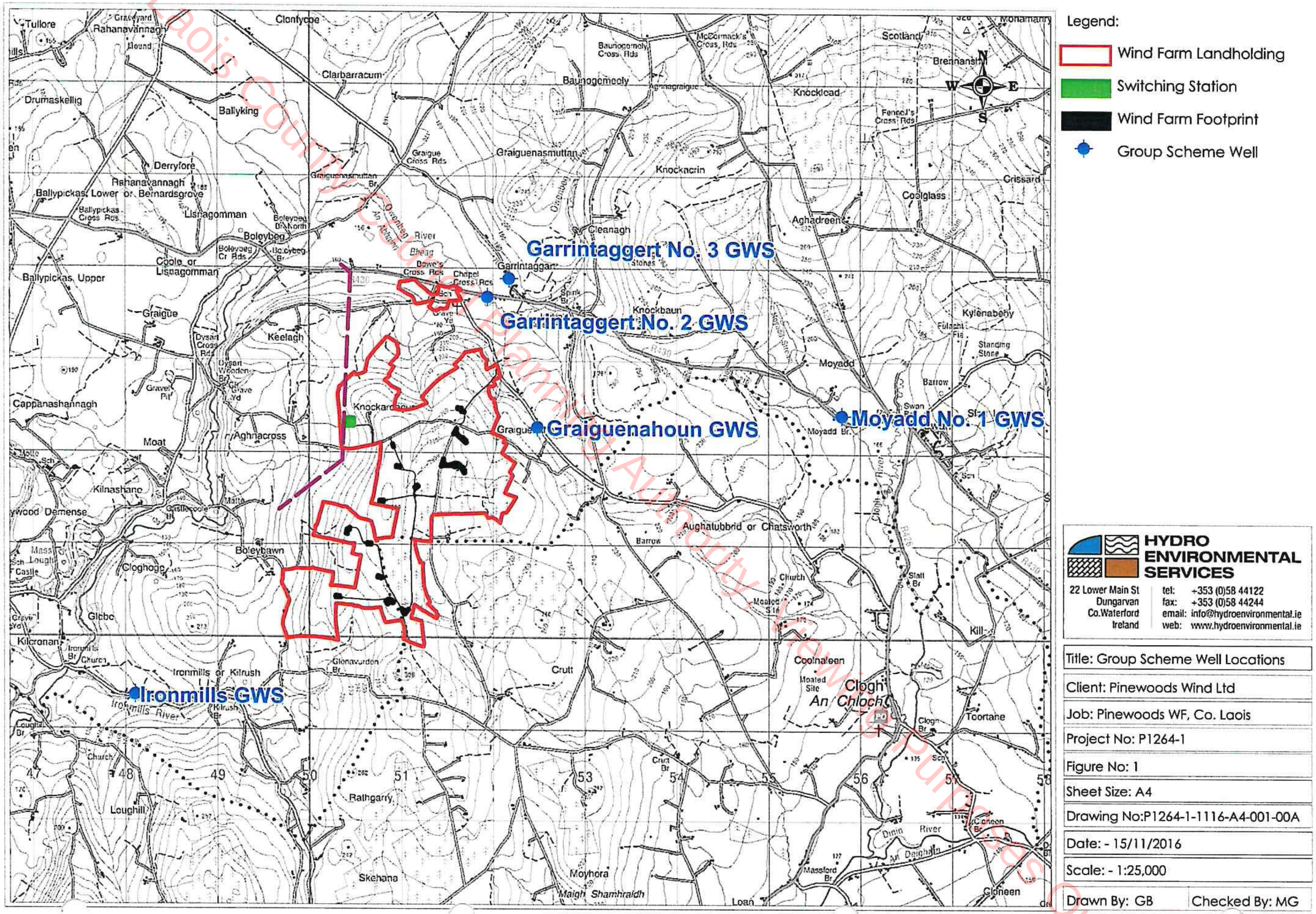
8.0 Closure

We trust the above response meets your requirements. Please contact the undersigned if you have any questions regarding the above.

Yours sincerely,

David Broderick
Hydrogeologist
(BSc, H. Dip Env Eng, MSc)

FIGURES



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web: www.hydroenvironmental.ie

Title: Group Scheme Well Locations

Client: Pinewoods Wind Ltd

Job: Pinewoods WF, Co. Laois

Project No: P1264-1

Figure No: 1

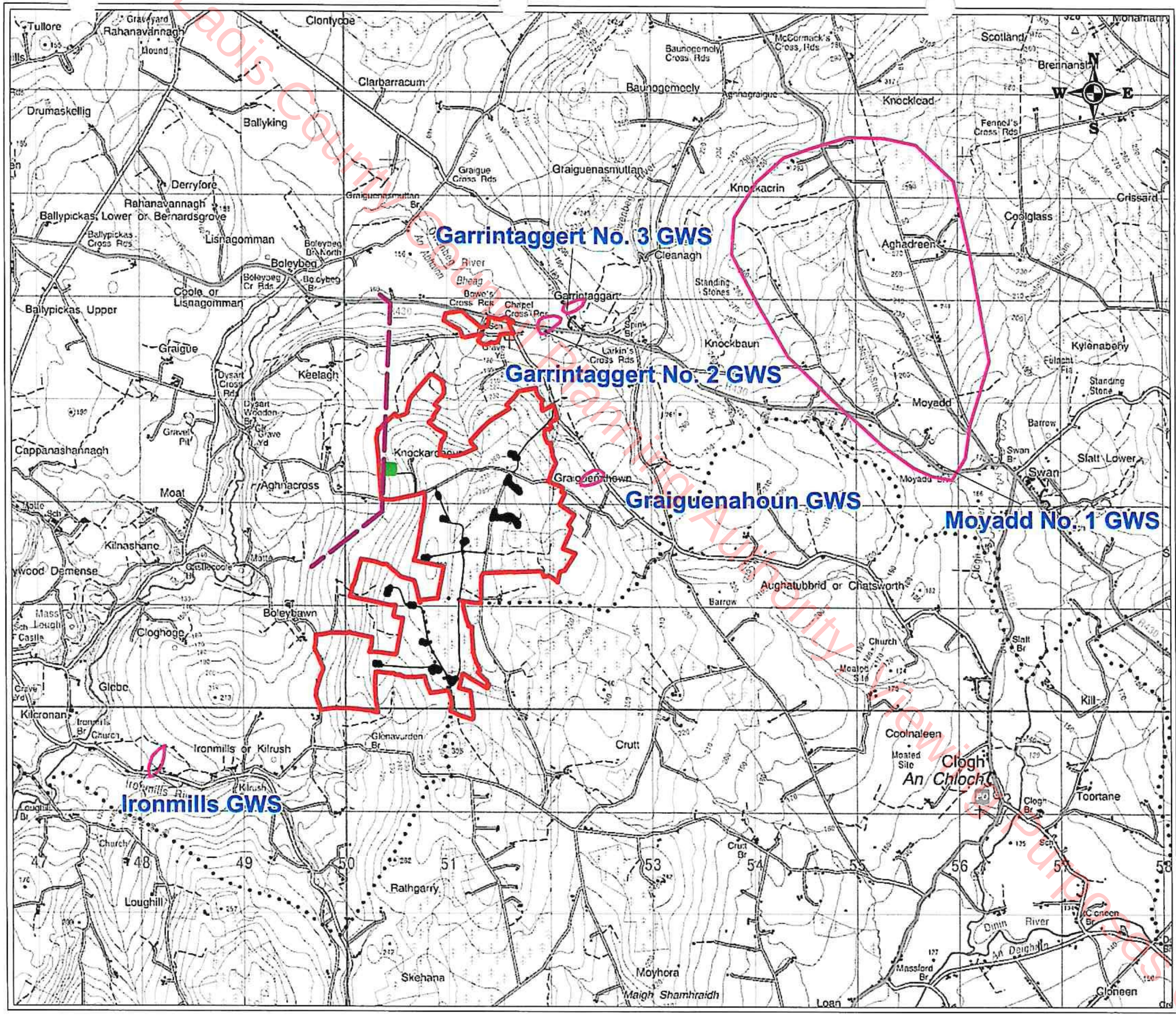
Sheet Size: A4

Drawing No:P1264-1-1116-A4-001-00A

Date: - 15/11/2016

Scale: - 1:25,000

Drawn By: GB | Checked By: MG



Legend:

Wind Farm Landholding

Switching Station

Wind Farm Footprint

Groundwater Zone of Contribution (ZOC)

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fax: +353 (0)58 44244
email: info@hydroenvironmental.ie
web: www.hydroenvironmental.ie

Title: Local Group Scheme Well ZOC
Client: Pinewoods Wind Ltd
Job: Pinewoods WF, Co. Laois
Project No: P1264-1
Figure No: 2
Sheet Size: A4
Drawing No:P1264-1-1116-A4-002-00A
Date: - 15/11/2016
Scale: - 1:50,000
Drawn By: GB / Checked By: MG

APPENDIX I
LOCATIONS OF GWS AS PROVIDED BY LAOIS CO. CO.

BALLYPICKAS GWS groundwater borehole
DBO Scheme
GARRINTAGGART 3 GWS groundwater borehole
GARRINTAGGART 2 GWS groundwater borehole
GRAIGUENAHOWN GWS groundwater borehole
MOYADD 1 GWS groundwater borehole
IRONMILLS GWS ground water borehole
BALLYPICKAS
THE SWAN
MAYO DOONANE
Clogh
An Chloch
Ballinakill
na Coille
KILKENNY RD BALLINAKILL
BALLINAKILL
RYGLASS
Laois County Council Planning Authority Viewing Purposes Only!

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www.hydroenvironmental.ie

Chapter 7:

Air & Climate

7.1 Introduction

7.1.1 Overview

The purpose of this chapter is to assess the air quality and climate impacts of the proposed development. The following key issues are addressed:

- Impacts of the construction phase on air quality and climate e.g. the construction activities may generate quantities of dust, pollutants, emissions etc;
- Impacts of the operation phase on air quality and climate e.g. traffic emissions resulting from the proposed development etc.

7.1.2 Assessment Methodology

7.1.2.1 Ambient Air Quality Standards

In order to reduce the risk to health from poor air quality, national and European statutory bodies have set limit values in ambient air for a range of air pollutants. These limit values or 'Air Quality Standards' are health or environmental-based levels for which additional factors may be considered. For example, natural background levels, environmental conditions and socio-economic factors may all play a part in the limit value which is set. Air quality significance criteria are assessed on the basis of compliance with the appropriate standards or limit values. The applicable standards in Ireland include the Air Quality Standards Regulations 2011, which incorporate European Commission Directive 2008/50/EC which has set limit values for the pollutants SO2, NO2, PM10, benzene and CO. Council Directive 2008/50/EC combines the previous Air Quality Framework Directive (96/62/EC) and its subsequent daughter directives (including 1999/30/EC and 2000/69/EC) (see **Table 7.1**).

7.1.2.2 Climate Agreements

Ireland is a party to the United Nations Framework Convention on Climate Change (UNFCC) and currently has a binding EU target to reduce greenhouse gas emissions by 20% over 2005 levels by 2020 (Directive 2003/87/EC). This is likely to increase by up to 40% by 2030 in accordance with the current EU 2030 Climate and Energy Policy Framework. The most recent reports from the EPA and the EU indicates that Ireland is unlikely to achieve 2020 EU greenhouse gas reduction targets[1]. Ireland is also a signatory to the Paris COP21 Climate Agreement. This agreement sets out a global action plan to put the world on track to avoid dangerous climate change by limiting global warming to well below 2°C.

7.1.2.3 Gothenburg Protocol

Ireland is a signatory to the Gothenburg Protocol to the 1979 UN Convention on Long Range Transboundary Air Pollution. The objective of the Protocol is to control and reduce emissions of Sulphur Dioxide (SO2), Nitrogen Oxides (NOX), Volatile Organic Compounds (VOCs) and Ammonia (NH3). In order to achieve the targets, Ireland was required, by 2010, to have met national emission ceilings of 42kt for SO2 (67% below 2001 levels), 65kt for NOX (52% reduction), 55kt for VOCs (37% reduction) and 116kt for NH3 (6% reduction). European Commission Directive 2001/81/EC, the National Emissions Ceiling Directive, prescribes the same emission limits. Emissions of SO2 and NH3 from the road traffic sector are insignificant accounting for less than 2% of total emissions in Ireland in 2011. Road traffic emissions of Nitrogen Oxides (NOX) and Volatile Organic Compounds (VOCs) are important accounting for 37% and 38% respectively of total emissions of these pollutants in Ireland in 2001 (EPA, 2013A). A National Programme for the progressive reduction of emissions of the four transboundary pollutants is in place since April 2005. A review of the National Programme in 2011 showed that Ireland complied with the emissions ceilings for SO2, VOCs and NH3, but failed to comply

[1] EPA, 2015, Ireland's Greenhouse Gas Emission Projections 2014-2035

with the emission ceiling for NOX. Although emissions from road traffic decreased by 47% over the period 1990 – 2011, NOX levels in 2011 were 2.6 kt above the emission ceiling of 65kt.

Pollutant	Regulation note 1	Limit Type	Margin of Tolerance	Value
Nitrogen Dioxide	2008/50/EC	Hourly limit for protection of human health - not to be exceeded more than 18 times/year	40% until 2003 reducing linearly to 0% by 2010	200 µg/m^3 NO_2
		Annual limit for protection of human health	40% until 2003 reducing linearly to 0% by 2010	40 µg/m^3 NO_2
		Annual limit for protection of vegetation	None	30 µg/m^3 NO + NO_2
Lead	2008/50/EC	Annual limit for protection of human health	100%	0.5 µg/m^3
Sulphur dioxide	2008/50/EC	Hourly limit for protection of human health - not to be exceeded more than 24 times/year	150 µg/m^3	350 µg/m^3
		Daily limit for protection of human health - not to be exceeded more than 3 times/year	None	125 µg/m^3
		Annual & Winter limit for the protection of ecosystems	None	20 µg/m^3
Particulate Matter (as PM_{10})	2008/50/EC	24-hour limit for protection of human health - not to be exceeded more than 35 times/year	50%	50 µg/m^3 PM_{10}
		Annual limit for protection of human health	20%	40 µg/m^3 PM_{10}
$PM_{2.5}$ (Stage 1)	2008/50/EC	Annual limit for protection of human health	20% from June 2008. Decreasing linearly to 0% by 2015	25 µg/m^3 $PM_{2.5}$
$PM_{2.5}$ (Stage 2) Note 2	-	Annual limit for protection of human health	None	20 µg/m^3 $PM_{2.5}$
Benzene	2008/50/EC	Annual limit for protection of human health	100% until 2006 reducing linearly to 0% by 2010	5 µg/m^3
Carbon Monoxide	2008/50/EC	8-hour limit (on a rolling basis) for protection of human health	60%	10 mg/m^3 (8.6 ppm)

Table 7.1: European Union Ambient Air Quality Standard (Based on Directive 2008/50/EC)

**Note 1: EU 2008/50/EC – Clean Air For Europe (CAFÉ) Directive replaces the previous Air Framework Directive (1996/30/EC) and daughter directives 1999/30/EC and 2000/69/EC*

**Note 2: EU 2008/50/EC states - 'Stage 2 — indicative limit value to be reviewed by the Commission in 2013 in the light of further information on health and environmental effects, technical feasibility and experience of the target value in Member States'*

7.1.2.4 Methodological Approach

The assessment of air quality has been carried out using a phased approach as recommended by the EPA and UK DEFRA[2]. The phased approach recommends that the complexity of an air quality assessment be consistent with the risk of failing to achieve the air quality standards. In the current assessment, an initial scoping of possible key pollutants was carried out. An examination of recent EPA and Local Authority data in Ireland has indicated that SO_2, smoke and CO are unlikely to be exceeded at locations such as the subject site and thus these pollutants do not require detailed monitoring or assessment to be carried out. However, the analysis did indicate potential issues in regards to Nitrogen Dioxide (NO_2) and PM_{10} at busy junctions in urban centres. Benzene, although previously reported at quite high levels in urban centres, has recently been measured at several city centre locations to be well below the EU limit value.

The scoping assessment has indicated that the pollutants NO_2, CO, PM_{10}, $PM_{2.5}$ and benzene are unlikely to be exceeded in rural areas. Nevertheless, the current assessment has identified the existing baseline levels of these pollutants in the region of the proposed development by analysis of suitable EPA monitoring data. Thereafter, a qualitative assessment on air quality and climate was carried out based on the nature, size and location of the proposed development.

7.1.2.5 Significance Criteria

The impact of the proposed development is assessed in terms of the relative additional contribution of the development, expressed as a percentage of the limit value. Although no relative impact, as a percentage of the limit value, is enshrined in EU or Irish Legislation, the National Roads Authority document *"Guidelines for the Treatment of Air Quality During the Planning and Construction of National Road Schemes"* details a methodology for determining air quality impact significance criteria for road schemes. The degree of impact is determined based on both the absolute and relative impact of the development. The NRA significance criteria have been adopted for the purposes of this current assessment and are detailed in **Tables 7.2 and 7.3.**

Magnitude of Change	*Annual Mean NO_2 / PM_{10}*	*Days PM_{10} > 50 µg/m^3*
Very Large	Increase / decrease >25%	Increase / decrease >25 days
Large	Increase / decrease 15-25%	Increase / decrease 15-25 days
Medium	Increase / decrease 10-15%	Increase / decrease 10-15 days
Small	Increase / decrease 5-10%	Increase / decrease 5-10 days
Very Small	Increase / decrease 1-5%	Increase / decrease 1-5 days
Extremely Small	Increase / decrease <1%	Increase / decrease <1 days

Table 7.2: Definition of Impact Magnitude for Changes in Ambient Pollutant Concentrations

[2] UK DEFRA (2009) Part IV of the Environment Act 1995: Local Air Quality Management, LAQM. TG(09); UK DETR (1998) Preparation of Environmental Statements for Planning Projects That Require Environmental Assessment - A Good Practice Guide, Appendix 8 - Air & Climate

Absolute Concentration in Relation to Standard[Note 1]	Change in Concentration					
	Extremely Small	Very Small	Small	Moderate	Large	Very Large
Decrease with Scheme						
Above Standard with Scheme	slight beneficial	slight beneficial	substantial beneficial	substantial beneficial	very substantial beneficial	very substantial beneficial
Above Standard in Do-min, Below with Scheme	slight beneficial	moderate beneficial	substantial beneficial	substantial beneficial	very substantial beneficial	very substantial beneficial
Below Standard in Do-min, but not Well Below	negligible	slight beneficial	slight beneficial	moderate beneficial	moderate beneficial	substantial beneficial
Well Below Standard in Do-min	negligible	negligible	slight beneficial	slight beneficial	slight beneficial	moderate beneficial
Increase with Scheme						
Above Standard in Do-min	slight adverse	slight adverse	substantial adverse	substantial adverse	very substantial adverse	very substantial adverse
Below Standard in Do-min, Above with Scheme	slight adverse	moderate adverse	substantial adverse	substantial adverse	very substantial adverse	very substantial adverse
Below Standard with Scheme, but not Well Below	negligible	slight adverse	slight adverse	moderate adverse	moderate adverse	substantial adverse
Well Below Standard with Scheme	negligible	negligible	slight adverse	slight adverse	slight adverse	moderate adverse

Table 7.6: Air Quality Impact Significance Criteria

*Note 1: Well Below Standard = <75% of limit value.

7.2 Description of the Existing Environment

7.2.1 Meteorological Conditions

A key factor in assessing temporal and spatial variations in air quality is the prevailing meteorological conditions. Depending on wind speed and direction, individual receptors may experience significant variations in pollutant levels under the same source strength (i.e. traffic levels)[3]. Wind is of key importance in dispersing air pollutants and for ground level sources, such as traffic emissions, pollutant concentrations are generally inversely related to wind speed. Thus, concentrations of pollutants derived from traffic sources will generally be greatest under very calm conditions and low wind speeds when the movement of air is restricted. In relation to PM_{10}, the situation is more complex due to the range of sources of this pollutant. Smaller particles (less than $PM_{2.5}$) from traffic sources will be dispersed more rapidly at higher wind speeds. However, fugitive emissions of coarse particles ($PM_{2.5}$ - PM_{10}) will actually increase at higher wind speeds. Thus, measured levels of PM_{10} will be a non-linear function of wind speed.

The nearest representative weather station collating detailed weather records is Oak Park Automatic Weather Station (AWS) which is situated in the grounds of Teagasc, Oakpark Co. Carlow, approximately 23km east of the site. Meteorological data from Oak Park AWS has been examined to identify the prevailing wind direction and average wind speeds over a three-year period. From data collated, the predominant wind direction is south-westerly with an average wind speed of approximately 5m/s.

7.2.2 Trends in Air Quality

Air quality is variable and subject to both significant spatial and temporal variation. In relation to spatial variations in air quality, concentrations generally fall significantly with distance from major road sources. Thus, residential exposure is determined by the location of sensitive receptors relative to major roads sources in the area. Temporally, air quality can vary significantly by orders of magnitude due to changes in traffic volumes, meteorological conditions and wind direction

7.2.3 Baseline Air Quality

Air quality monitoring programs have been undertaken in recent years by the EPA and Local Authorities. The most recent annual report on air quality is the EPA's *Air Quality Monitoring Report 2014* which details the range and scope of monitoring undertaken throughout Ireland.

As part of the implementation of the Framework Directive on Air Quality (1996/62/EC), four air quality zones have been defined in Ireland. Dublin is defined as Zone A and Cork City as Zone B. Zone C is composed of 21 towns with a population of greater than 15,000. The remainder of the country, which represents rural Ireland but also includes all towns with a population of less than 15,000, is defined as Zone D. In terms of air monitoring, the area in which the proposed development site is located is categorised as Zone D.

NO_2 monitoring was carried out at four rural Zone D locations at Emo, Co. Laois; Enniscorthy, Co. Wexford; Castlebar, County Mayo and Killikitt, Co. Monaghan. The NO_2 annual mean for the four sites were 3, 13, 8 and 3 $\mu g/m^3$ respectively. Hence long-term average concentrations measured at all locations were significantly lower than the annual average limit value of 40 $\mu g/m^3$. Based on the above information, a conservative estimate of the background NO_2 concentration for the subject site in 2016 is 7 $\mu g/m^3$. The annual mean for hourly SO_2 concentrations at three rural monitoring stations as 4, 2 and 3 $\mu g/m^3$ respectively.

Long-term PM_{10} measurements were carried out at five Zone D locations, with average levels ranging from 9 $\mu g/m^3$ in Kilkitt to 22 $\mu g/m^3$ at Enniscorthy. For $PM_{2.5}$ the values are 13 and 5 $\mu g/m^3$ at Longford and Claremorris respectively. Based on this information, a conservative estimate of the background PM_{10} and $PM_{2.5}$ concentration at the subject site of 13 $\mu g/m^3$ and 9 13 $\mu g/m^3$ in 2016 has been used. Again, these are significantly below the required limit.

The EPA has produced provisional estimates of greenhouse gas emissions for the time period 1990 - 2014. For 2014, total national greenhouse gas emissions are estimated to be 58.21 million tonnes carbon dioxide equivalent (Mt CO2eq). Emissions from Energy (principally electricity generation)

[3] World Health Organization (2000) *Air Quality Guidelines For Europe*

decreased by 1.9% (0.22 Mt CO2 eq) in 2014. This reflects a 2.9% decrease in coal used in conventional fossil fuel fired power stations for electricity generation, and also a decrease in natural gas use of 6.0% in 2014. Electricity generated from renewables increased by 12.6% between 2013 and 2014.

7.3 Description of Likely Impacts

7.3.1 Construction Phase

7.3.1.1 Air Quality

The greatest potential impact on air quality during the construction phase of the proposed development is from construction dust emissions and the potential for nuisance dust. Construction vehicles, generators etc., will also give rise to some exhaust emissions but this shall be temporary and minor in significance.

7.3.1.2 Climate

There is the potential of greenhouse gas emissions to atmosphere during the construction of the development. Construction vehicles, generators etc., may give rise to CO_2 and NO_2 emissions. Again these will be temporary and minor in significance.

7.3.2 Operational Phase

7.3.2.1 Air Quality

The assessment of baseline air quality in the region of the proposed development has shown that current levels of key pollutants are significantly lower than their required limit values. As set out in **Chapter 13**, the proposed development will give rise to insignificant traffic movements during the operational phase. Due to the size, nature and remote location of the proposed development, road traffic emissions resulting from the proposed development will therefore have a negligible impact on air quality. However, at a strategic level, the generation of c.110 GWh of renewable electricity will lead to significant positive impacts in terms of air quality.

7.3.2.2 Climate

The generation of c.110 GWh of electricity to the national grid will lead to a net reduction in terms of greenhouse gas emissions by displacing fossil fuels. The greenhouse gas reduction benefits from the proposed development is estimated to be 50,000 tonnes of CO_2 Equivalent per annum.

7.3.2.3 Modification of Atmospheric Conditions

The proposed development has the potential to affect wind speed and turbulence in the immediate area of the wind farm with the turbines slowing winds in their path. However, this micro-climate impact will be minor and limited in extent to the immediate area of the wind farm.

7.4 Mitigation & Monitoring Measures

7.4.1 Air Quality

7.4.1.1 Construction Phase

As with all projects, construction activities are likely to generate some dust emissions. A Dust Minimisation Plan will be formulated as part of the Construction Management Plan for the construction phase of the project, (see **Appendix 7.1**).

7.4.1.2 Operational Phase

By displacing fossil fuels, the proposed development will result in a positive impact on regional air quality and Ireland's obligation under EU and national air quality legislation. Thus, no mitigation measures are necessary. Residual impacts will be negligible.

7.4.1.3 Decommissioning Phase

There is the potential for a number of emissions to the atmosphere during the decommissioning of the development. In particular, activities may generate quantities of dust. Required vehicles and machinery will also give rise to some exhaust emissions. With implementation of dust mitigation measures (**Appendix 7.1**) the impact on air quality and climate is likely to be negligible.

Appendix 7.1: Dust Minimisation Plan

A dust minimisation plan will be formulated for the construction phase of the project, as construction activities are likely to generate some dust emissions. The potential for dust to be emitted depends on the type of construction activity being carried out in conjunction with environmental factors including levels of rainfall, wind speeds and wind direction. The potential for impact from dust depends on the distance to potentially sensitive locations and whether the wind can carry the dust to these locations. The majority of any dust produced will be deposited close to the potential source and any impacts from dust deposition will typically be within several hundred metres of the construction area.

In order to ensure that no dust nuisance occurs, a series of measures will be implemented. Site roads shall be regularly cleaned and maintained as appropriate. Hard surface roads shall be swept to remove mud and aggregate materials from their surface while any un-surfaced roads shall be restricted to essential site traffic only. Furthermore, any road that has the potential to give rise to fugitive dust must be regularly watered, as appropriate, during dry and/or windy conditions.

Vehicles using site roads shall have their speed restricted, and this speed restriction must be enforced rigidly. Indeed, on any un-surfaced site road, this shall be 20km per hour, and on hard surfaced roads as site management dictates. Vehicles delivering material with dust potential shall be enclosed or covered with tarpaulin at all times to restrict the escape of dust. Public roads outside the site shall be regularly inspected for cleanliness, and cleaned as necessary.

Material handling systems and site stockpiling of materials shall be designed and laid out to minimise exposure to wind. Water misting or sprays shall be used as required if particularly dusty activities are necessary during dry or windy periods.

Furthermore, during movement of the soil both on and off-site, trucks will be covered with tarpaulin where necessary. Before entrance onto public roads, trucks will be adequately inspected to ensure no potential for dust emissions.

At all times, the procedures put in place will be strictly monitored and assessed. In the event of dust nuisance occurring outside the site boundary, movement of these soils will be immediately terminated and satisfactory procedures implemented to rectify the problem before the resumption of the operations.

The dust minimisation plan shall be reviewed at regular intervals during the construction phase to ensure the effectiveness of the procedures in place and to maintain the goal of minimisation of dust through the use of best practise and procedures.