12 MATERIAL ASSETS

12.1 INTRODUCTION

This chapter of the EIAR assesses the impacts of the Development on material assets. The Development refers to all elements of the application for the construction of Tullaghmore Wind Farm (**Chapter 2: Project Description**). The assessment will consider the potential effects during the following phases of the Development:

- Construction of the Development
- Operation of the Development
- Decommissioning of the Development

Common acronyms used throughout this EIAR can be found in **Appendix 1.2**. This chapter of the EIAR is supported by Figures provided in **Volume III** and by the following Appendix documents provided in **Volume IV** of this EIAR:

- **Appendix 12.1**: Shadow Flicker Assessment Output
- **Appendix 12.2**: Shadow Flicker Map

12.2 ASSESSMENT METHODOLOGY AND SIGNIFICANCE CRITERIA

Chapter 1: Introduction, Section 1.9.2 outlines in detail, the assessment methodology and significance criteria undertaken during assessments for the EIAR. Section 1.6.1 outlines the national legislation and requirements and approach of an EIA, while **Chapter 4: Planning Policy** outlines the planning and legislative context to the Application. Under the specification and guidance of these outlining chapters, assessments have been undertaken on material assets.

Following preliminary consultations with key consultees during the scoping process, field surveys and desk-based assessments were undertaken. In line with the EIA Directive 2011/92/EU as amended by EIA Directive 2014/52/EU and current (draft) EPA Guidelines, this EIAR aims to focus the assessment solely on those elements likely to have a significant effect on the environment. Where a topic / factor identified has been addressed over more than one chapter, findings are briefly summarised. Other topics deemed unlikely to have a significant effect are outlined very briefly and 'closed out' with a summary of reasoning. Where negative effects on other topics/factors are predicted, the chapter identifies appropriate mitigation strategies therein. Economic assets of natural heritage include non-renewable resources such as minerals or soils, and renewable resources such as wind and water. These assets are addressed in **Chapter 8: Soils and Geology**, **Chapter 9: Hydrology and Hydrogeology**, and **Chapter 10: Air and Climate**. Tourism and amenity resources are addressed in **Chapter 5: Population and Human Health**. The cultural assets of Archaeology and Cultural Heritage are addressed in **Chapter 14: Cultural Heritage**. The transport network assets are addressed in **Chapter 13: Traffic and Transport.**

The material assets considered include:

- Telecommunications and Electromagnetic Interference (EMI)
- Electrical Supply Board (ESB) Electricity Networks
- Air Navigation
- Air and Climate
- Waste
- Shadow flicker

12.3 LAND USE

12.3.1 Baseline Environment

12.3.1.1 Development Site

The Site, located c.9km west of Oughterard, is characterised as being generally upland bog landscape which is currently being used for grazing sheep and cattle. There are also a number of residential properties in a one-off settlement pattern and established wind farms in the region. The Development as a whole is characterised by elevations of between 47m and 257m AOD and a spatial area of approximately 161.88ha.

The total permanent land-take of the Site, including the access roads, hardstand, turbine foundation and sub-station is approximately 5.5ha. The Site is 161.88ha therefore the permanent land take is 3.4% of the Site. Areas not included as permanent land-take (approximately 4,502m^2) in the form of internal cabling and the Contractor's Temporary Compound are those that will be reinstated after the construction phase of the Development has been completed.

All rubbish and waste/excess materials will be removed from Site to an appropriate licenced facility from where it will be reused/recycled, where possible, or disposed of accordingly.

Peat and spoil materials excavated during construction of the infrastructure will be used to reinstate any areas of temporary infrastructure such as blade laydown areas and for landscaping around infrastructure such as Turbine Hardstands and Site Access Tracks. Peat turves will be removed in layers with the vegetated side up. The top vegetated turves will be placed on top of reinstated / restored areas so that the turves can 'knit' together effectively form areas of restored peatland habitat in accordance with the Draft HMP in **Appendix 6.2**.

The on-site installed drainage network will be left in place where it is considered beneficial to do so. This will be periodically monitored to see that it is operating to its stated design purpose. Water monitoring on nearby natural watercourses will be undertaken during and post construction to determine if any pollution has migrated off-site, and if so, implement measures to rectify the impact.

12.3.1.2 Grid Connection Route

A grid connection will be sought from the grid system operators by application to ESB Networks Limited, the Distribution System Operator (DSO). A full description of the works associated with the grid connection is outlined in **Chapter 2: Development Description, Section 2.5.10.** The Developer has indicated that the proposed grid connection point, which will be offered by ESB, will be Screebe 110kV ESB Substation (Screebe ESB Substation), located in the townland of Glencoh, Co. Galway. A new 38kV Substation will be constructed on-site as part of the Development which will connect into the Screebe ESB Substation via an underground cable duct. The grid connection will see the grid connection between Tullaghmore Windfarm and Screebe 110kV Substation as an underground cable (UGC), utilising sections of cabling in public roads, primarily regional public roads, as well as private third-party lands, comprising of peatland used for grazing sheep. The length of the grid connection is circa 18.65km.

12.3.1.3 Haul Route

It is proposed that the turbine nacelles, tower hubs and rotor blades will be landed in Galway Port. From there, they will be transported to the Site via the R336 through Spiddal, to Maam Cross and then the N59 east to the upgraded site entrance. There are four areas on the haul route that will require road-widening works in third party lands which comprise of roadside vegetation and degraded peat.

12.3.1.4 Forestry

The area surrounding the windfarm is covered in mixed commercial forestry, with large areas classed as low yield forestry. All forestry is outside the Site Boundary. There is no forestry located along the grid route which will be located in public roads. Additionally, there is very little vegetation and no forestry in the location of the four road widening locations along the haul route.

Given the nature of the Development, it is unlikely that it will result in significant indirect effects within its immediate footprint. Similarly, no indirect effects to forestry are expected as a result of the grid connection route, nor the haul route and its associated temporary road widening works. Therefore, overall effects on forestry associated with the Development are considered **imperceptible** and not considered any further.

12.3.1.5 Agriculture

The area surrounding the windfarm is covered in commercial forestry and therefore not used for intensive agriculture. The Site itself is an upland bog landscape which is currently used for non-intensive grazing of sheep and cattle. Upon completion of the construction phase of the Development, the land surrounding the turbines can still be used for grazing. Similarly, for the grid connection, the land use will not be altered significantly and can still be used for grazing. Therefore, the grid connection route is not envisaged to have significant effects on agriculture. Additionally, the lands in the vicinity of the proposed haul route and in the location of the four route upgrade works are deemed as having little agricultural value given that they comprise of degraded peat and are part of the existing road network.

Given the nature of the Development, it is unlikely that it will result in significant indirect effects within its immediate footprint. Similarly, no indirect effects are expected as a result of the grid connection route nor the haul route or its associated temporary road widening works, therefore effects on agriculture are considered **imperceptible** and not considered any further.

12.4 TELECOMMUNICATIONS AND ELECTROMAGNETIC INTERFERENCE

12.4.1 Introduction

During operation, wind turbines have the potential to interfere with electromagnetic signals passing above the ground due to the nature and size of the windfarm. During the construction phase, signals may be passed below ground via existing infrastructure. Impacts may include overground or underground communication cables, microwave links, telecommunication links, business radio and television reception.

Microwave links need an unobstructed line of sight from end to end because blocked links will perform inadequately. It is therefore necessary to see that tall wind turbines will not interrupt links. Impacts can include reflection, diffraction, blocking and radio frequency interference.

Ireland saw the roll out of Digital Terrestrial Television (DTT), locally known as Saorview TV, in October 2010, incorporating the switchover from analogue to digital television. According to Ofcom (a regulatory UK body) (2009), *digital television signals are much better at coping with signal reflections, and digital television pictures do not suffer from ghosting*[1]. Since digital switchover, there have been very few known cases of wind turbine interference with domestic analogue reception. Modern turbine blades are also typically made of synthetic materials which have a minimal impact on the transmission of electromagnetic radiation. Therefore, potential effects on television and radio signals from the Development will be negligible and are not considered further, given the advancements in technology, the consultee RTÉ (Ireland's national television and radio broadcaster) response (see **Table 12.1**), alongside the extended distance of 740m to the nearest dwelling.

12.4.2 Guidance

Potential effects generated by the Development have been assessed with reference to the following documents:

- Department of the Environment (2009), Planning Policy Statement 18 (PPS18): Renewable Energy[2]
- Ofcom (2009) Tall Structures and Their Impact on Broadcast and Other Wireless Services Information about Electric & Magnetic Fields and the Electricity Transmission System in Ireland, Eirgrid[3]
- Irish Wind Energy Association (2012) Best Practice Guidelines for the Irish Wind Energy Industry[4]
- Wind Energy Development Guidelines: Planning Guidelines, Department of Housing, Planning, Community and Local Government (DHPCLG) 2006[5]
- Department of Housing, Planning and Local Government (2017) Department Circular PL5/2017. Interim Guidelines for Planning Authorities on Statutory Plans, Renewable Energy and Climate[6]

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[1] Ofcom (2009) *Tall Structures and Their Impact on Broadcast and Other Wireless Services*, OFCOM, United Kingdom. Available online at: https://www.ofcom.org.uk/__data/assets/pdf_file/0026/63494/tall_structures.pdf [Accessed on 22 February 2022]

[2] Department of the Environment. Planning Policy Statement 18 'Renewable Energy'. Available online at: https://www.planningni.gov.uk/index/policy/planning_statements_and_supplementary_planning_guidance/planning_policy_statement_18__renewable_energy.pdf [Accessed on 22 February 2022]

[3] Eirgrid (2014) *Information on Electric and Magnetic Fields*. Available online at: http://www.eirgridgroup.com/site-files/library/EirGrid/Information%20on%20Electric%20and%20Magnetic%20Fields.pdf [Accessed on 22 February 2022]

[4] Irish Wind Energy Association (2012) Best Practice Guidelines for the Irish Wind Energy Industry, Available online at https://www.iwea.com/images/files/9660bdfb5a4f1d276f41ae9ab54e991bb600b7.pdf [Accessed on 22 February 2022

[5] Department of Housing, Planning, Community and Local Government (2006) *Planning Guidelines*. Available online at: https://www.housing.gov.ie/sites/default/files/migrated-files/en/Publications/DevelopmentandHousing/Planning/FileDownLoad%2C1633%2Cen.pdf [Accessed on 22 February 2022]

[6] Department of Housing, Planning, Community and Local Government (2017) Department Circular PL5/2017. Interim Guidelines for Planning Authorities on Statutory Plans, Renewable Energy and Climate https://www.housing.gov.ie/sites/default/files/publications/files/interim_guidelines-statutory_plans_renewable_energy_climate_change.pdf [Accessed on 22 February 2022]

- Wind Energy Development Guidelines: revised Draft (2019), Department of Housing, Planning and Local Government[7]
- Wind Energy Development Guidelines: revised Draft (2019), Department of Housing, Planning and Local Government[8]

12.4.3 Scoping and Consultation

Telecommunications providers were consulted on the Development. A summary of responses is outlined in **Table 12.1** and **Table 1.7** and full consultation responses are outlined in **Appendix 1.3**.

Table 12.1: Summary of Consultations

Consultee	Response Date	Response
RTÉ	01/10/2021	*'We don't have any fixed linking in the area. There is a risk of interference to our broadcasting services in the area and we would like to sign a protocol with the developer should the site go ahead.'*
Virgin Media Television	04/10/2021	*'Virgin Media does not have any record of underground services at these locations as indicated by your drawing.'*
Eir Ireland	03/09/2020	Highlighted links close to turbines. *'We have one transmission link near the proposed windfarm plot that is just outside the area of risk. for windfarm developments we would keep a buffer of 100meters radius away from this transmission path.'*
Vodafone Ireland	31/07/2020	*'Indication of any LOS microwave links that are affected by the proposed location of this proposed wind farm development – NONE.'*
Three Ireland	26/01/2021	Highlighted links close to turbines. *'We would require the distance of 75m for rotor plus the clearance for the Microwave Fresnel zone (10m) so a total of 85m.'*
Tetra Ireland	01/10/2021	*'We anticipate no impact from the development in the area proposed, can you ensure the proposal is also reviewed by eir as we have traffic carried on eir radio links in the area.'*

12.4.4 Assessment Methodology

Consultation with telecommunications operators was initiated during the scoping phase of this EIA to identify any potential microwave or telecommunication links that could be affected by the Development. Details of the Development were shared with link operators. Responses from Three and Eir indicated links in the vicinity of the Development. Both

[7] Department of Housing, Planning and Local Government (2019) Wind Energy Development Guidelines: revised Draft. Available online at: https://www.housing.gov.ie/sites/default/files/public-consultation/files/draft_revised_wind_energy_development_guidelines_december_2019.pdf [Accessed on 22 February 2022]
[8] Department of Housing, Planning and Local Government (2019) Wind Energy Development Guidelines: revised Draft. Available online at: https://www.housing.gov.ie/sites/default/files/public-consultation/files/draft_revised_wind_energy_development_guidelines_december_2019.pdf [Accessed on 22 February 2022]

consultees recommended buffer or clearance distances between turbines and their respective telecommunications links. These suggested buffers were considered and incorporated during the design phase of the Development.

RTÉ indicated a potential for impacts to the broadcasting service in the area and requested that they be notified should the Development progress. This is further detailed in **Appendix 1.3 - Scoping Opinion**.

12.4.5 Assessment of Potential Effects

All potential effects, which are associated with the operational phase of the Development, are classified as long-term effects. It is currently envisaged that there will be no effects to telecommunications infrastructure in the area as a result of the Development. In the unlikely event that effects do occur during the operational phase of the Development, appropriate mitigation measures can be implemented such that there will either be a negligible effect, or no effect, on infrastructure as a result of the Development.

12.4.5.1 Construction Phase

During the construction phase, there are likely to be several sources of temporary electromagnetic emissions. Chief among these will be the brief use of electrical power tools and the use of electrical generators which may be brought onsite before mains electricity is provided. These devices are required by Irish and European law to comply with the EMC Directive 2014/30/EU. Compliance with this Directive will mean that the electromagnetic emissions from these devices will not likely cause interference to other equipment.

The only other potential effects during the construction phase are likely to be as a result of tall cranes used for constructing the turbines. These cranes are likely to be in the vicinity of the proposed turbines, and as such any effects are likely to be similar to those identified during the operational phase of the Development.

12.4.5.2 Operational Phase

The turbine and sub-station control electronics will be typical of any circuits used by industry or a conventional generating station. In the operational phase, all electrical components, equipment, apparatus and systems will be required by Irish and European law to comply with the EMC Directive 2014/30/EU. Compliance with this Directive will mean that the electromagnetic emissions from these devices will not cause interference to other equipment and electromagnetic emissions from these devices will be well below those specified in the ICNIRP 1998 Guidelines and in the EU Council Recommendation 1999/519/EC.

Both electric and magnetic fields decrease with distance. Electric fields are also dissipated by objects such as building materials. On a daily basis, people are exposed to extremely low frequency ("ELF") EMF as a result of using electricity.

National and international health and scientific agencies have reviewed more than 35 years of research including thousands of studies. None of these agencies has concluded that exposure to ELF-EMF from power lines or other electrical sources is a cause of any long-term adverse effects on human, plant, or animal health. The International Commission on Non-Ionising Radiation Protection (ICNIRP) Guidelines give a limit of 100µT for sources of AC magnetic fields. This compares to 0.13µT that arises from a 110kV underground cable when directly above it; 1.29µT that arises from a 220kV underground cable when directly above it and 11.4µT that arises from a 400kV AC underground cable that is one metre deep and measured directly above it. This is detailed in information booklet published by ESB in 2017 called "EMF & You" which provides information about Electric & Magnetic Fields and the electricity network in Ireland[9].

In 2014 a study was undertaken in Canada[10], measuring electromagnetic fields around wind farms and the impact on human health. The study found that:

> *"there is nothing unique to wind farms with respect to EMF exposure; in fact, magnetic field levels in the vicinity of wind turbines were lower than those produced by many common household electrical devices and were well below any existing regulatory guidelines with respect to human health"*.

From the limit of 100µT for sources of AC magnetic fields given by the ICNIRP, a comparison of between 0.02µT and 0.41µT arises when turbines operate under "high wind" scenarios.

The likely sources of electromagnetic emissions from the Development will have low strength and will be located at such a distance from potential receptors that any likely effect will be imperceptible.

[9] EMF & You, ESB, 2017 - https://esb.ie/docs/default-source/default-document-library/emf-public-information_booklet_v9.pdf?sfvrsn=0, accessed 14/05/2021

[10] Lindsay C McCallum, *et al*. (2014) *Measuring electromagnetic fields (EMF) around wind turbines in Canada: is there a human health concern?*

The levels likely to be generated during the decommissioning and construction phases are well below those specified in the International Commission on Non-Ionising Radiation Protection (ICNIRP) 1998 Guidelines[11] on the limit of exposure to radio frequency electromagnetic fields and electronic and magnetic fields at 50/60Hz and in the EU Council Recommendation 1999/519/EC.

Consultation was carried out with telecommunications operators and all comments received in response were considered as part of constraints mapping, when determining site layout, and thus were considered and incorporated in the design phase of the Development.

12.4.5.3 Decommissioning Phase

When decommissioning of the Development will take place, effects associated with this phase will be broadly similar, but less than, those at the construction phase.

12.4.6 Mitigation Measures

Embedded measures were implemented in the design phase following consultation with telecommunications operators. As a result, the Development avoided interference with existing transmission links crossing the Site.

Compliance with the EMC Directive 2014/30/EU will mean that the electromagnetic emissions from devices use is unlikely to cause interference to other equipment.

If necessary, where effects to telecommunications and electromagnetics occur during the operational phase of the Development, additional mitigation options, such as technical solutions including re-alignment or replacement of TV antenna, re-tuning to alternative TV transmitters or provision of subscription free satellite television services can be implemented.

12.4.7 Cumulative Effects

Cumulative impacts could arise if dwellings are at risk from potential electromagnetic impacts from more than one windfarm. In this instance, the nearest operational windfarm is Galway Wind Park Phase 1 Wind Farm which is located approximately 8km to the southeast of the Site. There are six wind farms within 20km of the Site. The next nearest operational

[11] International Commission on Non-Ionising Radiation Protection (1998) ICNIRP *Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz)* Available online at: https://www.icnirp.org/cms/upload/publications/ICNIRPemfgdl.pdf [Accessed on 22 February 2022]

windfarm is Galway Wind Park Phase 2 Wind Farm which is located approximately 10km southeast of the Site. Given the distance of the Development from receptors and telecommunications links, it is highly unlikely that any significant cumulative effects will be experienced. However, in the unlikely event of interference with television or telecommunications reception, it will need to be ascertained which windfarm / turbine is responsible and mitigation measures, including re-alignment or replacement of TV antenna, re-tuning to alternative TV transmitters or provision of subscription free satellite television services can be implemented.

12.4.8 Statement of Significance

The implementation of mitigation measures will result in no interference with communication links. Therefore, no effects are predicted on telecommunications or radio reception as a result of the Development. The potential effects of the Development with regard to telecommunications and electromagnetic interference are therefore considered **not significant**.

12.5 GRID CONNECTION AND GRID NETWORK

12.5.1 Introduction

A connection between the Proposed Development site and the national electricity grid will be necessary to export electricity from the proposed windfarm. This section describes the Irish electrical transmission network in relation and the anticipated connection option. A description of the effects, if any, that would arise from the Development is provided along with mitigation measures designed to reduce or remove negative effects where applicable. A full description of the works associated with the grid connection is outlined in **Chapter 2: Development Description, Section 2.5.10.**

The nationwide electricity transmission system allows for the transport of large volumes of electricity from generation stations, including wind farms, to bulk supply points near the main population centres where it interconnects with the nationwide distribution system.

12.5.2 Methodology

TLI Group were engaged by Tullaghmore Windfarm Limited (the 'Developer') to identify and analyse potential grid connection options available for the Tullaghmore Wind Farm Project. The Developer indicated that the proposed grid connection point which will be offered by ESB will be Screebe 110kV ESB Substation (Screebe ESB Substation), located in the townland of Glencoh, Co. Galway, therefore grid connection route options were assessed by TLI Group.

The Screebe 110kV Substation is located approximately 10.5km southwest of the Development at its closest point. The TLI study identified 3 possible grid connection options. From these, one option has been chosen and is assessed in this EIAR. The grid connection between Tullaghmore Windfarm and Screebe 110kV Substation is proposed to be an underground cable (UGC), utilising sections of cabling in public roads, primarily regional public roads, as well as private third-party lands. The length of the connection is circa 18.65km. A new 38kV Substation will be constructed on-site to allow for the additional capacity and to meet the specification requirements of ESB Networks.

12.5.3 Mitigation Measures

There is no anticipated effect upon the grid network outside of the infrastructure for Tullaghmore Windfarm itself. The 38kV connection to Screebe will require the uprating of the existing 31.5MVA transformer to 63MVA. This is likely to involve the installation of a new transformer bay alongside the existing one and so there may be some requirement for a temporary outage while the works take place, expected to be a few hours. The effect can be predicted to be a minor negative and temporary effect. Predicted traffic volumes associated with the works are outlined in **Chapter 13: Traffic and Transport**.

12.5.4 Statement of Significance

No significant impacts on the grid connection or grid network are anticipated. However, depending on existing infrastructure at the Screebe ESB Substation, there may be a requirement for an update of the existing transformer from 31.5 to 63MVA in order to accommodate a new 38kV connection (i.e., replacing the existing transformer with a larger one).

12.6 AIR NAVIGATION

12.6.1 Introduction

Operating windfarms have the potential to cause a variety of adverse effects on aviation. Rotating wind turbine blades may have an impact on certain aviation operations, particularly those involving radar. The physical height of turbines can cause obstruction to aviation and the overall performance of communications, navigation and surveillance equipment. According to the IAA Guidance Material Annex 14, *Structures that extend to a height of 150m or more above ground elevation should be regarded as an obstacle*[12]. The Authority

[12] Irish Aviation Authority (2015) *Guidance Material on Aerodrome Annex 14 Surfaces*. Available online at: https://www.iaa.ie/docs/default-source/publications/advisory-memoranda/aeronautical-services-advisory-memoranda-(asam)/guidance-material-on-aerodrome-icao-annex-14-surfaces.pdf?sfvrsn=e2ae0df3_6 [Accessed on 24 February 2022]

requires that all structures over 150m in height require lighting of an obstacle[13] to warn aviation traffic. The proposed turbines at Tullaghmore Windfarm will have a maximum overall tip height of 185m above ground level, during operation.

The nearest operational airport to the Development is Connemara Regional Airport, also known as Spiddal Airport and Inverin Airport, located c. 24km south of the Development. The sole operator at this airport is Aer Arann Islands, established in 1970. Aer Arann Islands has been serving the Aran Islands communities for over 50 years, bringing Islanders, tourists and cargo to and from all three Arran Islands all year round. Flights operate daily with a frequency of up to 25 mainland departures per day during peak season and with a flight time of fewer than ten minutes. the airline provides a vital link for Islander and tourist alike.

Galway Airport located c. 38km southeast of the Site is closed to commercial traffic. Only the Galway Flying Club have use of Galway Airport. Cleggan Aerodrome is located approximately 40km west of the Site. There are two helipads located in the vicinity of University Hospital Galway, approximately 32km south-east of the Site. The closest internationally operating airport to the Development is Ireland West Airport Knock, located approximately 64km north-east of the Site.

12.6.2 Consultation

Consultation with the relevant aviation organisations was initiated during the scoping process, to identify any potential aviation issues that could be affected by the Development. The findings are summarised in **Table 12.2**.

Table 12.2: Summary of Consultation Response

Consultee	Type and Date	Consultee Response
Irish Aviation Authority (IAA)	Letter in Response to Scoping Report received 10/01/2022	*The Irish Aviation Authority (IAA) Air Navigation Services Division (ANSD) does not get involved in the planning process. The IAA ANSD is to be notified as detailed hereafter:* *According to S.I. 215 of 2005, Irish Aviation Authority (Obstacles to Aircraft in Flight), the IAA ANSD requires any person who seeks to erect a manmade object to notify the aerodrome operator of the*

[13] Irish Aviation Authority (2005) Statutory Instrument No. 215 of 2005, Obstacles to Aircraft in Flight Order, 2005. Available online at: https://www.iaa.ie/docs/default-source/publications/legislation/statutory-instruments-(orders)/irish-aviation-authority-(obstacles-to-aircraft-in-flight)-order.pdf?sfvrsn=fcb70df3_4 [Accessed on 24 February 2022]

Consultee	Type and Date	Consultee Response
		intended operation at least thirty days in advance if the structure is to be erected in the vicinity of the aerodrome…' *Additionally, any person who seeks to erect a manmade object in excess of 45 metres anywhere within the state above ground or water surface level must also notify the IAA ANSD of the intended crane erection at least thirty days in advance, as a crane operating at or above this height may constitute an obstacle to air navigation.*

12.6.3 Assessment of Potential Effects

Considering the proximity of the Development to surrounding aviation facilities, no potential effects to air navigation were identified.

12.6.4 Mitigation Measures

Although no potential effects were identified, the following mitigation measures are proposed to be implemented in accordance with ICAO Annex 15:

- any obstacle 100m or greater will be installed with a warning light system under direct specification and in accordance with ICAO Annex 15;
- An aeronautical lighting scheme for the Development will be agreed with the Irish Aviation Authority (IAA) and will be installed;
- As-constructed coordinates in WGS84 format together with ground and tip height elevations at each wind turbine location will be provided to the IAA;
- The IAA will be notified of intention to erect any infrastructure greater than 100m with at least 30 days prior notification of their erection;
- The IAA will be notified of intention to commence crane operations with at least 30 days prior notification of their erection.

12.6.5 Cumulative Effects

All existing and approved projects in **Appendix 1.2** have been considered. There are 9 No. proposed, permitted or operational wind farms within 20km of the Development. Each individual Developer is responsible for engaging with the aviation authority to ensure the proposals will not interfere with aviation radio signals by acting as a physical barrier. Therefore, as each project is designed and built to avoid impacts arising, a cumulative impact cannot arise. There will be no cumulative impacts relating to the Development and surrounding projects with regard to aviation, during the construction phase.

Potential negative cumulative effects on aviation are unlikely during the operational and decommissioning phases.

12.6.6 Statement of Significance

No significant impacts are predicted in terms of air navigation. In adherence with IAA Safety Regulations and ICAO Annex 15, aeronautical obstacle warning light schemes will be installed as requested by IAA. Co-ordinates along with ground and tip height elevations at each wind turbine location as constructed will be provided to the IAA. The IAA will be notified of the provision of the intention to commence crane operations within a minimum of 30 days prior to erection.

12.7 WASTE MANAGEMENT

12.7.1 Introduction

It is likely that waste will be generated onsite during the construction and decommissioning phases of the Development. All rubbish and waste/excess materials will be removed from Site to an appropriate licenced facility from where it will be reused/recycled, where possible, or disposed of accordingly.

12.7.2 Mitigation Measures

12.7.2.1 Staff Facilities

During the construction, operational and decommissioning phases of the Development, there will be the typical waste generated in an office such as left-over food and sandwich wrappers. This is a non-hazardous waste. All such waste will be stored appropriately and safely from wind, rain and wild animals that often tear apart rubbish bags. Provision for separation of waste streams will be provided so that e.g., paper and cardboard waste and bottles may be recycled. The effects of this waste will be not significant.

12.7.2.2 Sewage

The self-contained port-a-loo units which will be located in the temporary site compound during the construction/decommissioning phase, will be managed and serviced regularly (by removal of the contents by tanker to a designated sewage treatment plant such as Oughterard Wastewater Treatment Plant) and removed off site on completion of construction. Toilet waste is a non-hazardous waste and effects will be not significant.

It is proposed to install a rainwater harvesting system as the source of water for toilet facilities for the operational phase. Wastewater from the staff welfare facilities in the control building will be collected in a sealed storage tank, fitted with a high-level alarm. This is a device installed in a fuel storage tank that is capable of sounding an alarm, during a filling operation, when the liquid level nears the top of the tank. All wastewater will be tankered off-site by a licensed waste collector to a nearby wastewater treatment plant, likely Oughterard Wastewater Treatment Plant. There will be no on-site treatment of wastewater and effects will be not significant.

12.7.2.3 Concrete

During the construction phase:

- Precast concrete will be used wherever possible i.e., formed offsite. Where the use of precast concrete is not possible the following mitigation measures will apply.
- The acquisition, transport and use of any cement or concrete on site will be planned fully in advance and supervised at all times.
- Vehicles transporting such material will be relatively clean upon arrival on site, that is; vehicles will be washed/rinsed removing cementitious material leaving the source location of the material. There will be no excess cementitious material on the vehicle which could be deposited on trackways or anywhere else on site. To this end, vehicles will undergo a visual inspection prior to being permitted to drive onto the proposed site or progress beyond the contractor's yard. Vehicles will also be in good working order.
- Any shuttering installed to contain the concrete during pouring will be installed to a high standard with minimal potential for leaks. Additional measures will be taken to ensure this, for example the use of plastic sheeting or other sealing products at joints.
- Concrete will be poured during meteorologically dry periods/seasons. This will reduce the potential for surface water run off being significantly affected by freshly poured concrete. This will require limiting these works to dry meteorological conditions i.e. avoid foreseen sustained rainfall (any foreseen rainfall event longer than 4-hour duration) and/or any foreseen intense rainfall event (>3mm/hour, yellow on Met Éireann rain forecast maps), and do not proceed during any yellow (or worse) rainfall warning issued by Met Éireann. This also will avoid such conditions while concrete is curing, in so far as practical.
- Ground crew will have a spill kit readily available, and any spillages or deposits will be cleaned/removed as soon as possible and disposed of appropriately.
- Pouring of concrete into standing water within excavations will be avoided. Excavations will be prepared before pouring of concrete by pumping standing water out of excavations to the buffered surface water discharge systems in place.
- Temporary storage of cement bound sand (if required) will be on hardstand areas only where there is no direct drainage to surface waters and where the area has been

bunded e.g., using sand-bags and geotextile sheeting or silt fencing to contain any solids in run-off.

- No surplus concrete will be stored or deposited anywhere on site. Such material will be returned to the source location or disposed of off-site appropriately.

Upon implementation of the above mitigation measures, the effects of the construction of the Development are considered to be not significant.

There will be no need for the use of concrete during the operational phase therefore effects at this stage are not significant.

Concrete structures will be left in place during decommissioning and allowed to naturally revegetate over time. This is the least impactful process of decommissioning. As the Site will have already been altered, the impacts are negligible and permanent.

12.7.2.4 Chemicals, Fuels and Oils

All storage containers of over 200 litres will have a secondary containment of 110% capacity to ensure that any leakage is contained and does not enter the aquatic environment. Oil waste is classified as hazardous.

A Chemical and Waste Inventory will be kept. This inventory will include:

- List of all substances stored on-site (volume and description);
- Procedures and location details for storage of all materials listed; and
- Waste disposal records, including copies of all Waste Transfer Notes detailing disposal routes and waste carriers used.
- Any tap or valve permanently fixed to the mobile unit through which oil can be discharged to the open or when delivered through a flexible pipe which is fitted permanently to the mobile unit, will be fitted with a lock and locked shut when not in use.
- Sight gauges will be fitted with a valve or tap, which will be shut when not in use. Sight gauge tubes, if used will be well supported and fitted with a valve.
- Mobile units must have secondary containment when in use/out on site.
- Where mobile bowsers are used on site guidelines will be followed so that:
    - Any flexible pipe, tap or valve will be fitted with a lock where it leaves the container and be locked shut when not in use;

- Flexible delivery pipes will be fitted with manually operated pumps or a valve at the delivery end that closes automatically when not in use. Where possible, a nozzle designed to dispense oil is used; and
- The pump or valve will have a lock and be locked shut when not in use.

Diesel is classified as a dangerous substance. Under the EU Directive 95/55/EC all such dangerous substances will be conveyed in a container that complies with the ADR. As such, the manufacturer of each bowser will provide certification to contractors of the following:

- A leak-proof test certificate
- A copy of the IBC approval certificate
- An identification plate attached to the container

For loads in excess of 1,000 litres (220 gallons), the bowser vehicle driver will have undergone training and hold a special license.

Through the implementation of the above mitigation measures, the residual effects will not be significant in the construction/decommissioning phase. The storage/use of such liquids is not seen as necessary on site during the operational phase, thus the effects are negligible.

12.7.2.5 Refuelling

During construction/decommissioning, where possible all refuelling on site will be within the temporary compound within the re-fuelling area. Only essential refuelling (e.g., cranes) will be carried out, outside of this area, but not within 65m of any watercourse. In such cases a non-permeable High-density Polyethylene (HDPE) membrane will be provided beneath connection points to catch any residual oil during filling and disconnection. This membrane will be inspected and if there is any sign of oil contamination, it will be removed from site by a specialist licensed waste contractor. All vehicles will be well maintained and free from oil or hydraulic fuel leaks.

As this has been mitigated by design, the residual effects are not significant.

There will be no need for refuelling during the operational phase and effects are not significant.

12.7.2.6 Packaging

Packaging will be brought on site during the construction, operational and decommissioning phases and can include cardboard, wood and plastics used to package turbine components. In accordance with the waste hierarchy, packaging will be returned to the originator ahead of re-use or recycling. Where this is not possible, waste will be separated as appropriate and safely stored on site appropriately site in anticipation of recycling. This waste is non-hazardous, and the effects of this waste are not significant.

12.7.2.7 Metals

Waste metals from concrete reinforcing during construction and removal of metals during decommissioning etc. will have commercial value and will be re-used or recycled with the appropriate licensed waste contractor. This waste is non-hazardous, and effects will be not significant.

12.7.2.8 Excavated Materials

Spoil Quantities

The quantities of spoil likely to be generated at the Development have been calculated by Jennings O'Donovan & Partners. It is estimated that based on site surveys carried out by EcoQuest Environmental using peat probes that the amount of peat spoil predicted to be generated during construction of the wind farm is approximately 84,760m^3 of peat spoil.

The total amount of cut material below the peat layer estimated from the Development is approximately 218,635m^3 with the amount of fill being estimated at 174,526m^3. This leaves a surplus of 44,109m^3 that it is envisaged can be used as structural fill in Site Access Tracks, Turbine Hardstand and Turbine Foundation construction. More information can be found in **Chapter 8: Soils and Geology.**

Landscaping & Reinstatement

Due to the nature of the peatbog habitats on site, it is not envisaged that berms or large designated storage areas can be used for the storage of spoil will not be permitted. However, peat spoil will be used to reinstate exposed areas around infrastructure such as slopes/graded ground around Site Access Tracks and Turbine Hardstands and on the Turbine Foundations or where there is degraded bog that can be enhanced by depositing peat on it. Peat that cannot be used for reinstatement around the Site, will be taken off site to the designated spoil storage area to the east of Maam Cross, approximately 3.5km to the west of the wind farm site. The designated spoil area has an area of approximately 65,182m^2 (6.5ha) and a capacity of approximately 97,000m^3 assuming that the areas of cutover peat can be filled in and berm constructed in cells so that spoil can be stored up to a total height of approximately 1.5m. This will allow the total estimated amount of spoil to be stored taking into account a bulking factor of 10% (total of approximately 93,236m^3). These areas are shown on **Figure 1.2(b).**

Works at the spoil storage areas will involve the machinery similar to that used for peat excavation. A 40-60 tonne 360-degree long reach hydraulic excavator and tractors and trailers will be used to place the spoil in areas of cut away to create level surface. Where these areas are less than 1.5m deep (expected to be the majority), they will be filled with peat to the adjoining ground level and then a containment berm will be created to create cells. The cells will be bermed and will measure approximately 30m x 30m and have outfalls blocked and overflow management with the creation of drainage channels for excess water and sphagnum inoculation. Where the storage is on areas of non-cutover peat, then the cells will measure approximately 45m x 60m and have outfalls blocked and overflow management with the creation of drainage channels for excess water and sphagnum inoculation. More information can be found in **Chapter 7: Biodiversity**.

Non-Peat Spoil

Non peat spoil will consist of glacial till from granite bedrock / rock is present on site according to the PSRA report by EcoQuest Environmental Services contained in **Appendix 7.1**. It is envisaged in the design that all the non-peat material won on Site can be used as fill on site in the following places:

- Subsoil to be used around the blade laydown areas where load capacities required are less; and
- Rock won from excavations to be used within Site Access Track and Turbine Hardstand build up.

There will also be spoil generated from the grid connection works. This will be in the form of tarmacdam/asphalt, Clause 804 running layer material, compacted rock fill material and subsoils. The total amount of spoil material from the grid connection works is estimated to be 12,590m3. This material will need to be taken off site and recycled/disposed of at Carrowbrowne Recycling Centre which is an appropriate licenced facility to deal with inert waste.

12.7.3 Conclusion

There are no EPA-licensed or local authority-authorised waste facilities or activities located within the Site Boundary. The closest, authorised municipal waste facility is located approximately 34.9km southeast of the Development in Galway City, Co. Galway.

Considering the proposed management practises and mitigations, the residual effects of waste produced as a result of the construction, operational and decommissioning phases of the Development are considered to be not significant.

12.8 SHADOW FLICKER

12.8.1 Introduction

This section uses a shadow flicker computer model to assess the potential for the occurrence of shadow flicker on sensitive receptors in the vicinity of the Development. The model outputs are further detailed in **Appendix 12.1.**

Shadow flicker has the potential to cause disturbance and annoyance to local residents if it affects the occupied rooms of a house. Therefore, careful site selection, design and planning, can help reduce the possibility of shadow flicker. It should be noted that in modern wind turbines, an embedded shadow flicker mitigation is installed during manufacture, in the form of an automated shadow detection system which has the ability to measure sunlight levels and stop turbine rotation during conditions that are predicted to result in shadow flicker being experienced at any neighbouring property. Where residual negative effects are predicted, this section identifies appropriate mitigation strategies.

12.8.2 Background

Wind turbines, like other tall structures, can cast long shadows when the sun is low in the sky. The 2018 Review of the 2006 Guidelines confirms that:

"Shadow Flicker occurs when the sun is low in the sky and the rotating blades of a wind turbine casts a moving shadow which, if it passes over a window in a nearby house or other property results in a rapid change or flicker in the incoming sunlight. The time period in which a neighbouring property may be affected by shadow flicker is completely predictable."

"This effect lasts only for a short period and happens only in certain specific combined circumstances. The circumstances require that:

- *the sun is shining and is at a low angle (after dawn and before sunset), and*
- *the turbine is directly between the sun and the affected property, and*

- *there is enough wind energy to ensure that the turbine blades are moving".*

The 2019 Draft Revision of the Wind Energy Development Guidelines (WEDG) also added the circumstance where:

- *"there is sufficient direct sunlight to cause shadows (cloud, mist, fog or air pollution could limit solar energy levels)*" and note that
- "*Generally only properties within 130 degrees either side of north, relative to the turbines, can be affected at these latitudes in the UK and Ireland – turbines do not cast long shadows on their southern side"*.

The distance and direction between the turbine and property is of significance because:

- The duration of the shadow will be shorter the greater the distance (i.e. it will pass by quicker)
- The shadow flicker cast by rotating wind turbine blades will be reduced, the further a dwelling is from an operating turbine

The path of the sun varies over the seasons resulting in a changing potential for a shadow to be cast throughout the year. Similarly, the sun's position in the sky over the course of a day is changing such that the shadow cast by a turbine is constantly changing. Shadow flicker is more likely to occur on sunny winter days, when the sun is lower in the sky and shadows are cast a greater distance from the turbine. In general, shadow flicker is more likely to occur where turbines are sited to the east, south-east, west or south-west of properties. However, in some instances, no shadow flicker is experienced at the receptors (**Table 12.6**) due to the location of the receptor with respect to the proposed turbines.

Table 12.6: Dwellings with no predicted shadow flicker (see Figure 1.3).

H10	H14	H17	H27
H11	H15	H18	H28
H12	H16	H24	-

Persons with photosensitive epilepsy can be sensitive to flickering light between 3 and 60 Hertz (Hz)[14]. This is supported by research in recent years asserting that flicker from turbines must interrupt or reflect sunlight at frequencies greater than 3 Hz to pose a potential risk of inducing photosensitive seizures. The frequencies of flicker caused by modern wind

[14] Epilepsy Action (2012) *Other Possible Triggers of Photosensitive Epilepsy*. Available online at: http://www.epilepsy.org.uk/info/photosensitive-epilepsy [Accessed on 27 November 2019]

turbines are less than 1 Hz[15], and are well below the frequencies known to trigger effects in these individuals. Therefore, any potential shadow flicker effect from the Development is considered an effect on residential amenity, rather than having the potential to affect the health or well-being of residents.

12.8.3 Relevant Guidance

Although there is no legislative standard for shadow flicker impact in Ireland, the Department of Environment, Community and Local Government in its Wind Energy Development Guidelines (2006) (the 2006 Guidelines) considers that:

"*At distances greater than 10 rotor diameters from a turbine, the potential for shadow flicker is very low. Where shadow flicker could be a problem, developers should provide calculations to quantify the effect and where appropriate take measures to prevent or ameliorate the potential effect, such as by turning off a particular turbine at certain times*".

The 2006 Guidelines also state that:
"*It is recommended that shadow flicker at neighbouring offices and dwellings within 500m should not exceed 30 hours per year or 30 minutes per day*".

The revised draft of the Wind Energy Development Guidelines 2019 provides for zero shadow flicker:
"A condition should be attached to all planning permissions for wind energy development to ensure that there will be no shadow flicker at any existing nearby dwelling or other relevant existing affected sensitive property and that the necessary measures outlined in the shadow flicker assessment submitted with the application, such as turbine shut down during the associated time periods, should be taken by the wind energy developer or operator to eliminate the shadow flicker".

Therefore, the approach taken in this assessment is for the elimination of shadow flicker effects on sensitive receptors entirely by identifying specified turbines which are predicted to cause shadow flicker at specific times, and see that, with embedded mitigation measures integrated, no residual shadow flicker effects are predicted.

Taking the above into consideration, JOD examined maps to identify receptors (dwellings) in the local area within ten rotor diameters (1,620m, extended to 2km for completeness) of

[15] Harding, G., Harding, P., & Wilkins, A. (2008). *Wind turbines, flicker, and photosensitive epilepsy*. *Epilepsia* (49) 6, pp. 1095-1098.

the turbines used for the EIA assessments with a rotor diameter of 162m. The study area was extended to 2km for completeness, which resulted in the identification of 30 dwelling within this radius of the turbines, all of which are classed as sensitive receptors.

Figure 1.3 shows the 30 dwellings within a 2km radius of the proposed turbine locations.

12.8.4 Scoping Responses and Consultation

Consultation responses are outlined in **Table 12.7.**

Table 12.7: Summary of Consultation Responses on Shadow Flicker

Consultee	Type & Date	Summary of Response	Response to Consultee
Health Service Executive	Letter in Response to Scoping Request received on 5th November 2022	It is recommended that a shadow flicker assessment is undertaken to identify any dwellings and sensitive receptors which may be impacted by shadow flicker. The assessment must include all proposed mitigation measures. Dwellings should include all occupied properties and any existing or proposed properties for which planning consent has been granted for construction or refurbishment.	Addressed within this EIAR / Chapter.

12.8.5 Shadow Flicker Modelling

An industry standard windfarm assessment software package, WindPro from EMD International Software Version 3.5 was used to prepare a shadow flicker model for the Development. The programme facilitates the analysis of a wind farm for possible shadow flicker occurrence at nearby houses and identifies the turbines responsible. It allows for the production of maps and shadow flicker prediction reports from which turbine shutdown requirements can be deduced. The data output from the programme has been analysed and any receptors identified as potentially vulnerable to shadow flicker were identified and the significance of shadow flicker effects without mitigations were assessed.

Generic windows of $2m^2$ (2m width x 2m height), of which the centre is 0.5m from bottom line above ground are applied in the model to each side of the house. These windows represent an approximation of the existing windows on the house facing north, south, east and west and provide an estimate of potential shadow flicker to a window on each side of the house. The software determines the times of day/year when the sun will be in line with the rotational components of the turbine and the house/receptor, thereby having the potential to cause shadow flicker. The software outputs details of potential shadow flicker, in this case by mean and maximum duration of the shadow flicker events, days per year and times of occurrence and maximum hours per year and maximum minutes per day of shadow flicker.

The following data inputs were required and used to produce an estimate of the effect of shadow flicker from the windfarm:

- Ordnance Survey Ireland Raster base map
- Digital elevation model of the Development and areas around all properties within the model (3m resolution – OS X, Y, and Z data points)
- Turbine locations
- Turbine dimensions (rotor diameter and hub height)
- Receptor locations (i.e., property locations)
- Bottom line height above ground 'window' (0.5m above ground level)
- Wind speed and direction for the nearest weather monitoring station to the Site to determine the period that the wind turbines are estimated to be in operation from the different wind directions during the year

The software creates a mathematical model of the Development and its surroundings and uses this information to calculate specific theoretical times and durations of flicker effects for the identified properties. The following 'worst-case' assumptions were incorporated into the shadow flicker modelling:

- there are no clouds and sunlight is always bright and direct
- the turbines are always rotating whereas this might not be the case due to curtailment, maintenance works or break downs, or simply a lack of wind
- the turbine rotor will always be facing directly towards a given property and the property window will also always face each turbine, thus maximising the size of the shadow and duration of the effect
- there is no intervening structures or vegetation (other than topography) that may restrict the visibility of a turbine, preventing or reducing the effect
- a limit to human perception of shadow flicker is not considered by the model

The model operates by simulating the path of the sun during the year. The results of the model provide a calculation of theoretical specific times and durations of flicker effects for the identified properties. Given the aforementioned assumptions incorporated into the model, the calculations overestimate the duration of effects for the identified properties. Therefore, this is a worse-case scenario which is considered to be sufficient for the purposes of this assessment.

The model also outputs a more realistic scenario, or "real-case" scenario. In this scenario, the only change in assumptions is that the statistically likely monthly sunshine frequency and wind direction frequency data is assessed. This assessment only changes the annual operational hours per year metric and is not applied to the daily data. This is because it could be sunny, with the wind coming from the relevant direction, on any individual day. The data used in the real-case model was the:

- Long-term sunshine probability data from the Met Éireann synoptic station in Belmullet
- 12-month wind frequency data from 2006 for the Site, downloaded from the Sustainable Energy Authority of Ireland (SEAI) Wind Atlas[16].

12.8.6 Baseline Description

A preliminary assessment was carried out to record property locations identified as potentially affected by shadow flicker. The location of the property and distance from the closest turbine are listed in **Table 12.8** and shown on **Figure 1.3**.

The defined study area was based on the 2006 Guidelines which is for properties within 10 Rotor Diameters (1,620m), however, for completeness the study area was extended to 2km from each turbine, which resulted in 30 properties or sensitive receptors being included in the study. The properties were identified using a combination of *Ordnance Survey of Ireland (OSI) Maps, Google Maps/Street View, Google Earth and the Eircode Finder.* Once identified, a site visit was conducted to verify the status of the properties i.e., that they are in fact houses and that they are inhabited/habitable. This information was then used in the Shadow Flicker model to assess the potential for the occurrence of shadow flicker at each of the 30 sensitive receptors.

Table 12.8: Properties within 2km of Proposed Turbines

Property No.	Easting (ING)	Northing (ING)	Easting (ITM)	Northing (ITM)	Closest Turbine	Distance to Turbine (m)
1	101266	247092	501225	747115	T4	901.5
2	101311	247126	501270	747149	T4	848.0246
3	101365	247083	501323	747107	T4	813.1122
4	101381	247045	501340	747069	T4	813.7232
5	101425	247048	501384	747071	T4	773.3799
6	101495	246973	501454	746997	T4	750.9582
7	101630	246748	501588	746771	T4	811.2645
8	101738	246707	501696	746731	T4	787.4775
9	101835	246541	501794	746564	T4	902.2859

[16] Sustainable Energy Authority of Ireland. Wind Mapping System. Wind Data extract. Available online at http://maps.seai.ie/wind/

Property No.	Easting (ING)	Northing (ING)	Easting (ITM)	Northing (ITM)	Closest Turbine	Distance to Turbine (m)
10	102323	245839	502281	745862	T6	829.9967
11	102372	245830	502330	745853	T6	814.531
12	102399	245758	502357	745782	T6	867.9596
13	101996	246250	501955	746273	T6	803.1761
14	101901	245385	501860	745408	T6	1439.87
15	102052	245458	502010	745481	T6	1295.688
16	102228	245197	502186	745220	T6	1453.175
17	102526	244779	502485	744803	T6	1790.555
18	102546	244723	502504	744746	T6	1844.059
19	103256	248866	503214	748889	T3	1300.441
20	103303	248903	503262	748926	T3	1349.456
21	103321	248986	503280	749009	T3	1434.042
22	103298	248966	503257	748989	T3	1408.271
23	103384	249179	503343	749202	T3	1637.177
24	102483	249427	502442	749450	T3	1859.101
25	102217	249326	502176	749349	T3	1841.905
26	102096	249249	502054	749272	T3	1820.568
27	101684	249308	501642	749331	T4	1956.273
28	102020	245462	501979	745485	T6	1309.373
29	103452	249460	503411	749483	T3	1925.368
30	102257	249390	502215	749413	T3	1887.816

12.8.7 Cumulative Effects

There are no operational nor consented windfarms within 2km of the Proposed Development therefore the potential for cumulative effects involving shadow flicker sensitive receptors win the vicinity of the Proposed Development are considered negligible.

12.8.8 Assessment of Potential Effects (worst-case)

This assessment considers the potential worst-case shadow flicker impact of the Development on the 30 properties located within 2km of a turbine in terms of:

- Predicting and assessing the extent of shadow flicker experienced by all properties within the shadow flicker study area, without mitigations applied.
- Specifying mitigation measures where necessary.

Table 12.9 outlines the potential total hours of shadow flicker per year, the number of days per year that shadow flicker is possible, the maximum hours of shadow flicker per day and the predominant contributing turbine for each receptor, in the worst-case scenario. Full assessment outputs are outlined in **Appendix 12.1**. A predicted shadow flicker occurrences contour map is outlined in **Appendix 12.2**.

Table 12.9: Summary of Potential Annual and Daily Shadow Flicker for all receptor properties (worst-case scenario)

Property No.	Easting (ITM)	Northing (ITM)	Potential Total hours of Shadow Flicker per year (worst-case) (h:min)	Potential Shadow Days per year (worst - case) (d/y)	Potential maximum hours of Shadow Flicker per day (worst-case) (h:min)	Contributing Turbines					
						T1	T2	T3	T4	T5	T6
1	501225	747115	77:42:00	160	*00:44**			X	X	X	X
2	501270	747149	84:23:00	163	*00:47**			X	X	X	X
3	501323	747107	83:25:00	172	*00:49**	X	X	X	X	X	X
4	501340	747069	72:16:00	165	*00:50**	X	X	X	X	X	X
5	501384	747071	71:56:00	165	*00:52**	X	X	X	X	X	X
6	501454	746997	67:34:00	149	*00:53**	X	X	X		X	X
7	501588	746771	84:17:00	158	*00:54**	X	X			X	X
8	501696	746731	91:53:00	153	*00:59**	X	X			X	X
9	501794	746564	63:44:00	136	*00:56**	X	X				X
10	502281	745862	00:00	0	00:00						
11	502330	745853	00:00	0	00:00						
12	502357	745782	00:00	0	00:00						
13	501955	746273	72:57:00	114	*00:50**	X					X
14	501860	745408	00:00	0	00:00						
15	502010	745481	00:00	0	00:00						
16	502186	745220	00:00	0	00:00						
17	502485	744803	00:00	0	00:00						
18	502504	744746	00:00	0	00:00						
19	503214	748889	31:00:00	68	*00:31**			X			
20	503262	748926	27:44:00	64	00:30			X			
21	503280	749009	23:31	58	00:28			X			
22	503257	748989	24:45:00	60	00:29			X			
23	503343	749202	13:26	42	00:23			X			
24	502442	749450	00:00	0	00:00						
25	502176	749349	12:41	44	00:21			X			
26	502054	749272	19:15	58	00:23			X			
27	501642	749331	00:00	0	00:00						
28	501979	745485	00:00	0	00:00						
29	503411	749483	01:01	11	00:07			X			
30	502215	749413	06:53	30	00:17			X			

*Note: these predicted shadow flicker occurrences are based on the worst-case scenario without mitigations applied. In reality, curtailments measures will be implemented to see that no receptor receives more than the recommended maximum amount of shadow flicker exposure.

It can be demonstrated from **Table 12.9**, that there are 19 receptors predicted to experience some degree of shadow flicker and 11 receptors that are predicted to experience no shadow flicker, even in the worst-case scenario.

The calculated worst-case shadow flicker occurrences in **Table 12.9** assumes that the sun is always shining, there is never any cloud cover and the dwelling is always occupied. As previously stated, this calculation is based on topography alone and excludes vegetation, buildings and other man-made structures which, in real life, may act as a buffer between the turbines and receptors. The worst-case scenario models the information without considering embedded mitigations, such as an automatic shadow detection system, which will be incorporated into the design of the turbine during manufacture. As can be seen in the shadow flicker assessment attached as **Appendix 12.1** all of the proposed turbines are predicted to give rise to some degree of shadow flicker, if unmitigated. As previously stated, modern turbines are typically fitted with an automatic shadow detection system which will shut down the turbine if it calculates the possibility of shadow reception on any of the surrounding houses. The real-case, expected shadow flicker prior to applying mitigations is assessed below.

12.8.9 Assessment of Actual Effects (real-case)

12.8.9.1 Reduction of Shadow Flicker due to absence of Sunlight

In order to calculate more realistic and 'real world' occurrences of shadow flicker for the dwelling houses that are identified as potentially vulnerable to shadow flicker (**Table 12.8**), it is necessary to identify the likely meteorological conditions which are expected to be experienced at the Site. To estimate the likely duration of sunshine occurrence at the Site, historical meteorological data from Met Éireann is automatically uploaded by the software. Data from Belmullet Meteorological Observatory was used as this Met Éireann observatory is the closest to the Site that measures sunshine duration alongside a number of other environmental parameters. This data was utilised to consider the probability of sunshine occurrence, and thus allow the determination of 'projected' values for shadow flicker occurrence, prior to having mitigations applied.

In order to estimate the impact of sunshine occurrence, historical meteorological data is utilised to consider the likelihood of sunshine (the sunshine probability) at different times of the year, which then allows for the determination of 'expected' values for shadow flicker occurrence. This is achieved by applying a reductive factor to the worst-case total hours per year of shadow flicker. Occurrence in which 'long term average sunshine hours' refers to data collected by Met Éireann, 'Potential sunshine hours' refers to the intervening time period between modelled sunrise and sunset.

Table 12.10 shows real-case expected shadow flicker values per year which are likely to be experienced by each receptor without considering embedded mitigations, such as an automatic shadow detection system, which will be incorporated into the design of the turbine during manufacture. Although the projected duration of shadow flicker is reduced substantially for each of the 19 dwellings predicted to receive flicker, they are not eliminated entirely. The Draft Revised Wind Energy Development Guidelines, December 2019, recommend that shadow flicker should not impact any dwelling, therefore the relevant turbine or turbines creating the potential for shadow flicker occurrence must be shut down on a temporary basis, until the potential for shadow flicker ceases. Such is the role of the automatic shadow detection unit that will be installed on all wind turbines during their manufacture.

Table 12.10: Summary of Potential Annual Shadow Flicker Listing for All Properties (real-case)

Property No.	Easting (ITM)	Northing (ITM)	Potential Total hours of Shadow Flicker per year (worst case) (h:min)	Expected Shadow Values per year (real case) (h/y)
1	501225	747115	77:42:00	15:24
2	501270	747149	84:23:00	16:38
3	501323	747107	83:25:00	16:02
4	501340	747069	72:16:00	13:49
5	501384	747071	71:56:00	13:38
6	501454	746997	67:34:00	12:37
7	501588	746771	84:17:00	16:58
8	501696	746731	91:53:00	18:31
9	501794	746564	63:44:00	13:33
13	501955	746273	72:57:00	15:44
19	503214	748889	31:00:00	03:12
20	503262	748926	27:44:00	02:50
21	503280	749009	23:31	02:19
22	503257	748989	24:45:00	02:27
23	503343	749202	13:26	01:13
25	502176	749349	12:41	00:53
26	502054	749272	19:15	01:25
29	503411	749483	01:01	00:05
30	502215	749413	06:53	00:28

12.8.10 Residual Effects

As previously stated, in line with guidance, it is proposed that all wind turbines be fitted with an automatic shadow detection system at the manufacturing stage of the Development. This is an embedded mitigation measure that will provide that turbines with the potential to cause shadow flicker at any given time will shut down until the potential for occurrence ceases.

The control system will calculate, in real-time:

1. Whether shadow flicker has the potential to affect nearby properties, based on pre-programmed co-ordinates for the properties and turbines
2. Wind speed
3. Wind direction
4. The intensity of the sunlight
5. When the control system detects that the sunlight is strong enough to cast a shadow, and the shadow falls on a property or properties, then the turbine will automatically shut down
6. The turbine will restart when the potential for shadow flicker ceases at the affected properties.

It is intended that the measures outlined above will eliminate the potential for shadow flicker to affect any of the properties within the study area.

Given the embedded mitigation of having all turbines fitted with an automatic shadow detection system, there are no residual effects from shadow flicker predicted. However, in the unlikely event that complaints of shadow flicker are received by the Developer / Site Operator or by Galway County Council, an investigation will take place. The complaints frequency, duration and time of complaints will be considered, and specialist modelling software will be used to confirm the occurrence(s). A shadow flicker survey involving the collection of light data may also be carried out at the property in which the complaint was made. Further refinement of the shadow control system, will, if required, be conducted to eliminate the shadow flicker occurrence.

12.8.11 Cumulative Effects

Cumulative shadow flicker impacts could arise if dwellings are at risk from potential shadow flicker impacts as a result of more than one windfarm. While separate windfarms are not likely to cause effects simultaneously, they could increase the cumulative total hours where a receptor has the potential for impacts. There are no consented nor constructed wind farms within a 2km range of the Proposed Development, therefore there are no predicted cumulative shadow flicker impacts. Furthermore, should another windfarm be constructed within 2km of the proposed development in the future, the installation of the embedded mitigation of a shadow control system on all wind turbines will eliminate shadow flicker impacts from the Proposed Development, therefore, removing the potential for cumulative shadow flicker impacts.

12.8.12 Summary of Significant Effects

This assessment has identified the potential for shadow flicker to affect 19 houses in proximity to the proposed turbines when no mitigation measures are incorporated. However, it is proposed that a shadow control system be installed on each turbine during its manufacture to eliminate the potential for shadow flicker from the development. Such systems are common in many wind farm developments and the technology has been well established.

12.8.13 Statement of Significance

This assessment has identified no significant impacts nor residual impacts, providing that the proposed shadow control system is installed on all proposed turbines. Given that only effects of significant impact or greater are considered "significant" in terms of the EIA Regulations, the potential effects of the Development as a result of shadow flicker, when embedded mitigations are incorporated, are considered to be not significant.