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# 12 SHADOW FLICKER

## 12.1 Introduction

This chapter assesses the potential effects that may arise from shadow flicker resulting from the construction, operation and decommissioning of the proposed Project. The objectives of the chapter are to describe:

- The background of the assessment and relevant guidance considered;
- The assessment methodology used;
- The potential for shadow flicker effects, including direct, indirect and cumulative effects;
- The need for and operation of any shadow flicker mitigation measures; and
- Potential remaining effects following the implementation of such mitigation measures.

The Wind Energy Development Guidelines (2006)[1] from the Department of the Environment, Heritage and Local Government (DoEHLG) provide a definition of shadow flicker, stating that:

"*The effect known as shadow flicker occurs where the blades of a wind turbine cast a shadow over a window in a nearby house and the rotation of the blades causes the shadow to flick on and off. This effect lasts only for a short period and happens only in certain specific combined circumstances, such as when:*

- *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.*"

If any of the above conditions are not present, shadow flicker cannot occur. The guidelines further note that at distances greater than 10 rotor diameters from the turbine, the potential for shadow flicker is very low.

### 12.1.1 The Proposed Development

The proposed development includes the construction, operation and decommissioning of a wind energy development consisting of 11 wind turbines and associated infrastructure as described in **Chapter 5 Project Description**. For the purpose of this assessment, the proposed wind turbine structures are the only infrastructure that have the potential to cause shadow flicker, so other elements of the proposed project are not considered in this chapter. The locations of these turbines at the site are shown in **Figure 5.1** (EIAR **Volume IV**) and all coordinates referred to in this chapter are to Irish Transverse Mercator (ITM). This chapter comprehensively assesses all scenarios within the turbine dimension range which is described in **Chapter 5 Project Description**.

[1] Department of Environment, Heritage and Local Government, 2006. Wind Energy Development Guidelines.

## 12.2 Statement of Authority

This assessment has been undertaken by Dr Thomas Burke and reviewed by Ben Hockridge, both of RSK ADAS Ltd. Thomas Burke is a GIS (Geographic Information Systems) Consultant with expertise in the evaluation, analysis, and visualisation of geospatial data to investigate and solve environmental management issues. Thomas uses these skills and experience to manage and deliver projects for a range of clients, particularly in the area of onshore renewables development. Thomas joined RSK ADAS in 2022, prior to which he spent four years as a graduate researcher in geography and GIS following completion of his MSc in Earth and Environmental Science.

Ben Hockridge is principal GIS and Remote Sensing Consultant at RSK ADAS. He has over 10 years' experience in providing GIS and Remote Sensing expertise in a range of projects and services. Ben first joined RSK ADAS in 2012 following his studies in Physical Geography (BSc) and Environmental Monitoring, Modelling and Management (MSc). Ben returned to work for RSK ADAS in 2017 after spending a year providing GIS solutions for the Ministry for Primary Industries in New Zealand. This range of experience has provided him with an in depth understanding on the use of GIS and Remote Sensing and their application in environmental management.

## 12.3 Policy and Guidance

The following documents were taken into consideration during development of the assessment methodology and scope:

- Wind Energy Development Guidelines (2006)
- Clare County Development Plan 2023 – 2029 (2023)[2]
- IWEA Best Practice Guidelines for the Irish Wind Energy Industry (2012)[3]

In addition to these, further legislation and guidance documents, as detailed in **Chapter 2 EIA Methodology** were considered and applied in the preparation of this chapter.

The Wind Energy Development Guidelines (2006) provided by the DoEHLG are the current guidance, and state that:

*"Careful site selection, design and planning, and good use of relevant software, can help avoid the possibility of shadow flicker in the first instance. 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."*

*"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 Clare Wind Energy Strategy is detailed in Volume 6 of the Clare County Development Plan 2023 – 2029. The strategy has developed four area classifications for wind farm development in the county: 'Strategic Areas', 'Acceptable in Principle', 'Open to

[2] Clare County Council, 2023. Clare County Development Plan 2023 – 2029.

[3] Irish Wind Energy Association, 2012. Best Practice Guidelines for the Irish Wind Energy Industry.

Consideration' and 'Not Normally Permissible'. The site of the proposed Project is located within land designated as a 'Strategic Area' and 'Acceptable in Principle'. For Strategic Areas, the strategy notes that projects within these must:

*"Be designed and developed in line with the Wind Energy Development Guidelines, Guidelines for Planning Authorities (DoEHLG, 2006) in terms of siting, layout and environmental studies."*

For areas Acceptable in Principle, it notes that projects must be:

*"Designed and developed in line with the Planning Guidelines in terms of siting, layout and environmental studies."*

Regarding shadow flicker specifically, Annex A: Best Practice and General Considerations for wind energy developments in County Clare, section 6.7 (Population and Human Health) states that:

*"Applications must have regard to the thresholds, limits and buffer zone in the Planning Guidelines for Wind Energy Development for Planning Authorities 2006 in order to mitigate against potential impacts on human health in terms of shadow flicker, visual impact and noise."*

With regards to the calculation of shadow flicker, the Irish Wind Energy Association (IWEA, now Wind Energy Ireland) Best Practice Guidelines for the Irish Wind Energy Industry[3] (2012) state that:

*"Calculations for shadow flicker modelling generally assume 100 % sunshine conditions. It is reasonable in Ireland's climate to modify these figures. Some attention can also be given to the wind rose which indicates the percentage of winds from each direction. If winds rarely come from the sectors which would give rise to the greatest shadow flicker effects on a dwelling, this can be taken into account."*

*"The assessment of potentially sensitive locations or receptors within a distance of ten rotor diameters from proposed turbine locations will normally be suitable for EIA purposes. The DoEHLG's Wind Energy Development Guidelines set recommended limits for shadow flicker which are 30 hours per year or 30 minutes per day for receptors within 500 m."*

*"It is important to determine if there are other existing and/or permitted but not constructed wind farms in the vicinity of the proposed development which could contribute towards a cumulative shadow flicker impact on any receptors. Any such wind farm developments within 2 km of the proposed development should be considered in a separate cumulative shadow flicker assessment."*

## 12.4 Methodology

Considering the policy and guidance outlined above, this section describes the methodology for assessment of shadow flicker for the Proposed Development.

### 12.4.1 Turbine Dimensions

Planning permission is being sought for an envelope with turbines of the following dimensions:

- Candidate turbine 1: Hub height 105 m; rotor diameter 150 m; tip height 180 m.
- Candidate turbine 2: Hub height 105 m; rotor diameter 149 m; tip height 179.5 m.
- Candidate turbine 3: Hub height 110 m; rotor diameter 133 m; tip height 176.5 m.

Full shadow flicker assessments have been conducted for each candidate turbine model.

### 12.4.2 Study Area

Given the recommendations in the above Guidance documents, it is considered that an assessment of potential shadow flicker at properties within ten rotor diameters of the turbine locations is appropriate to provide a robust assessment of shadow flicker from the proposed project. This is a distance of 1,500m, for candidate turbine 1; 1,490m for candidate turbine 2; and 1,330m for candidate turbine 3.

### 12.4.3 Identification of Sensitive Receptors

The assessment considers all identified shadow flicker sensitive receptors within the study area. Refer to EIAR **Chapter 2 EIA Methodology** which describes the methodology applied in compiling the database of sensitive receptors.

### 12.4.4 Assessment of Effects

This chapter presents predicted shadow flicker effects at all identified sensitive receptors. These results quantify the theoretical maximum number of hours per year and per day during which shadow flicker effects may occur.

Significance of effects has been determined with reference to EPA Guidelines on the information to be contained in Environmental Impact Assessment Reports (2022)[4], and policy and guidance detailed in Section 12.3. The EPA's EIA Guidelines present the approach to describing environmental effects as applied to this EIAR. In determining significance of effects, magnitude of change is considered in relation to the sensitivity of the receiving environment. Further information is provided in Chapter 2 EIA Methodology. The Wind Energy Development Guidelines (2006) recommend that shadow flicker at neighbouring offices and dwellings within 500m of a turbine should not exceed 30 hours per year or 30 minutes per day. For this assessment, it is considered that exceedance of this threshold at any sensitive receptor within the 10 rotor diameter study area, unmitigated, constitutes a significant, and adverse effect.

The modelling results presented are a 'worst-case' scenario, where the conditions required for shadow flicker to occur are present for all daylight hours through the year. The potential annual hours of shadow flicker are also presented for a 'likely' scenario, taking into account average annual sunshine hours, following guidance in the IWEA Best Practice Guidelines for the Irish Wind Energy Industry[3]. Full details of these scenarios are provided in Section 12.4.6.

[4] Environmental Protection Agency, 2022. Guidelines on the information to be contained in Environmental Impact Assessment Reports.

### 12.4.5 Identification of Measures to Avoid and Mitigate Effects

Where predicted shadow flicker at a sensitive receptor is shown to exceed the current Wind Energy Development Guidelines (2006) thresholds of 30 hours per year or 30 minutes per day, measures will be applied to mitigate shadow flicker effects. This will be achieved through the use of a shadow flicker control module, which is used to curtail the operation of particular turbines when conditions in which shadow flicker are predicted to occur are detected. The assessment therefore follows the Wind Energy Development Planning Guidelines (2006), the Clare County Development Plan 2023 – 2029 (2023), and best practice as described in Section 12.3.

Draft Revised Wind Energy Development Guidelines were published by the DoEHLF in December 2019[5], with public consultation closing in February 2020. Following this, revised or updated guidelines have not been released. Should final revised guidelines with further limitations on shadow flicker be adopted during the planning application process for this Project, the technical solutions described above can be adapted and applied to adhere to these. Full details of this are provided in Section 12.7.

### 12.4.6 Shadow Flicker Assessment

Shadow flicker calculations have been undertaken using the Shadow Flicker module of ReSoft WindFarm, a specific wind farm design tool package that is commonly used throughout the industry. Following the described turbine envelope (Section 12.4.1), each turbine was modelled in the WindFarm software and assigned the relevant hub height and rotor diameter, A study area and maximum distance of shadow influence of 10 times the rotor diameter was defined around each turbine.

- Candidate turbine 1: 10x 150 m = 1,500 m study area
- Candidate turbine 2: 10x 149 m = 1,490 m study area
- Candidate turbine 3: 10x 133 m = 1,330 m study area

Shadow flicker calculations were carried out for each identified sensitive receptor, represented by a point located at the centre of the building. In the absence of specific information on windows at receptors within the assessment study area, each receptor was assigned a North, South, East and West facing window placed at the centroid of the property, 1m x 1m in dimension, and with a height of 2m above the ground. This allows for shadow flicker from all directions to be assessed. A full list of input sensitive receptors is provided in **Appendix 12.1**, **Appendix 12.2** and **Appendix 12.3** (EIAR **Volume III**) for candidate turbines 1, 2 and 3 respectively. Study areas and sensitive receptors within these are mapped in **Figure 12.1, Figure 12.2** and **Figure 12.3** (EIAR **Volume IV**) for candidate turbines 1, 2 and 3 respectively.

The ReSoft WindFarm model used assumes that:

- The sun is shining from sunrise to sunset (cloudless sky);
- The turbine blades are turning 100% of the time;
- The turbine rotor is oriented directly between the sun and the sensitive receptor; and

[5] Department of Housing, Local Government and Heritage, 2020. Draft Revised Wind Energy Development Guidelines December 2019.

- There is no screening between the turbine and the receptor (excluding topography).

The inclusion of the above factors results in a 'worst-case' scenario being reported in this assessment. In real life conditions, therefore, the actual shadow flicker durations will be less than the theoretical predicted levels from the model.

#### *12.4.6.1 Sunshine hours*

Shadow flicker can only occur when the sun is shining. Historical weather data was therefore used to provide a more realistic prediction of potential annual shadow flicker duration when taking into account the frequency of clear skies when shadows may be cast. This is reported in this assessment as the 'likely' theoretical hours of shadow flicker per year.

Average monthly sunshine data was obtained from the Met Éireann Shannon Airport station[6], the closest long-term weather station, located approximately 19 km from the proposed Project. Data for 1991 – 2020, the most recent 30-year time period available was used. Daylight hours were then obtained for Shannon[7]. These are presented in **Table 12.1.**

**Table 12.1: Average hours of sunshine (Shannon Airport Meteorological Station, 1991 - 2020) and average hours of daylight (Shannon) for the proposed Project.**

| | Mean Daily Sunshine Hrs (Shannon Airport) | Mean Daily Daylight Hrs (Shannon) | % Sunshine |
|---|---|---|---|
| Jan | 1.7 | 8.2 | 20.7 |
| Feb | 2.4 | 9.9 | 24.4 |
| Mar | 3.6 | 11.8 | 30.4 |
| Apr | 5.4 | 13.9 | 38.8 |
| May | 5.9 | 15.7 | 37.5 |
| Jun | 5.5 | 16.7 | 32.9 |
| Jul | 4.4 | 16.2 | 27.1 |
| Aug | 4.6 | 14.6 | 31.5 |
| Sep | 3.9 | 12.6 | 30.9 |
| Oct | 3.0 | 10.6 | 28.4 |
| Nov | 2.1 | 8.7 | 24.1 |
| Dec | 1.5 | 7.7 | 19.5 |
| **Avg** | **3.7** | **12.2** | **30.0** |

[6] Shannon Airport 1991–2020 averages. Available at: https://www.met.ie/cms/assets/uploads/2023/09/www_met_ie_shannon_airport_9120.htm.

[7] Sunrise and sunset Shannon 2023. Available at: https://www.sunrise-and-sunset.com/en/sun/ireland/shannon/2023.

This monthly data was used to calculate the average daily sunshine hours (3.7) and daylight hours (12.2) over the course of a year, which were then used to calculate an average annual sunshine hours percentage of 30%. Based on this, a correction factor of 30% can be applied to the annual total theoretical predicted levels of shadow flicker to provide an estimate of the amount of time when the sun is shining and shadows can be cast. These shadow flicker durations, however, are still likely to be conservative as no account is taken of when turbine blades are not turning, orientation of the turbine rotor or the presence of screening between the receptor and turbine (excluding topography).

## 12.5 Receiving Environment

The database of sensitive receptors as identified by the RSK project team was used in the shadow flicker model. This includes planning permission sites validated and granted up to 4th of December 2023. **Chapter 2 EIA Methodology** describes the methodology applied in compiling the database of sensitive receptors.

### 12.5.1 Candidate Turbine 1

There are no sensitive receptors within 500m of the proposed turbines. There are 101 sensitive receptors within the 10 rotor diameter (1,500 m) study area for candidate turbine 1. These consist of:

- 82 residential dwellings;
- 5 associated dwellings[8];
- 1 place of worship;
- 3 sites with planning permission; and
- 10 dilapidated dwellings / potential replacement opportunities.

Of these, the facades of three receptors (IDs 85, 86, 87) were found to lie partially within the study area. In a conservative approach, the points representing these receptors in the modelling software were moved from the centre of the buildings to a location on the building within the study area, such that they were included in the assessment.

**Figure 12.1** (EIAR **Volume IV**) presents the study area (1,500 m buffer around the proposed 11 turbines, based on the turbine rotor diameter of 150 m) for candidate turbine 1, and the receptors identified within this area.

[8] Associated dwellings include financially involved land and property owners.

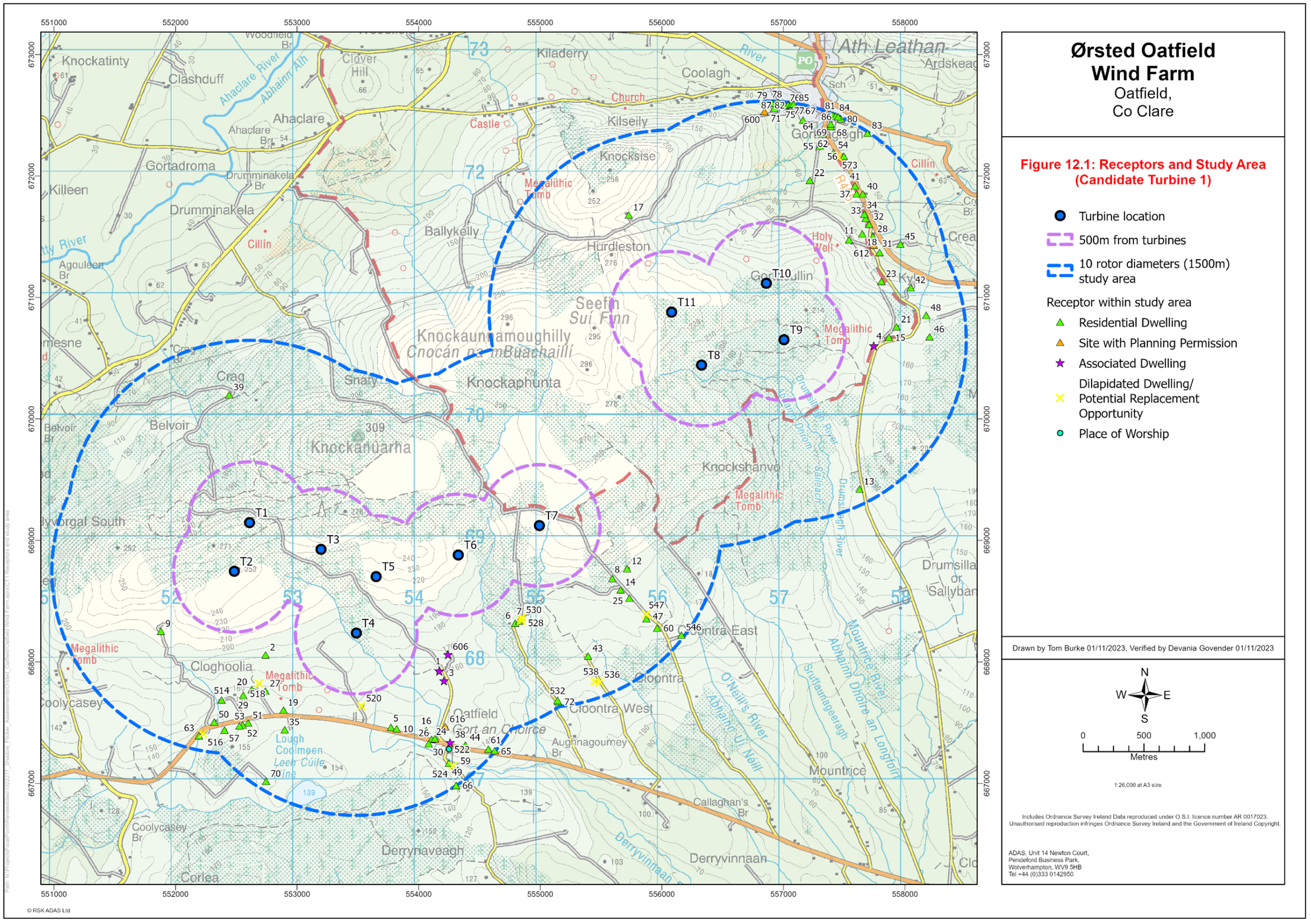


**Figure 12.1 Receptors and study area (candidate turbine 1)**

### 12.5.2 Candidate Turbine 2

There are no sensitive receptors within 500m of the proposed turbines. There are 98 sensitive receptors within the 10 rotor diameter (1,490 m) study area for candidate turbine 2. These consist of:

- 79 residential dwellings;
- 5 associated dwellings;
- 1 place of worship;
- 3 sites with planning permission; and
- 10 dilapidated dwellings / potential replacement opportunities.

Of these, the facades of eight receptors (IDs 65, 66, 79, 80, 81, 82, 83, 84) were found to lie partially within the study area. In a conservative approach, the points representing these receptors in the modelling software were moved from the centre of the buildings to a location on the building within the study area, such that they were included in the assessment.

**Figure 12.2** (EIAR **Volume IV**) presents the study area (1,490m buffer around the proposed 11 turbines, based on the turbine rotor diameter of 149m) for candidate turbine 2, and the receptors identified within this area.

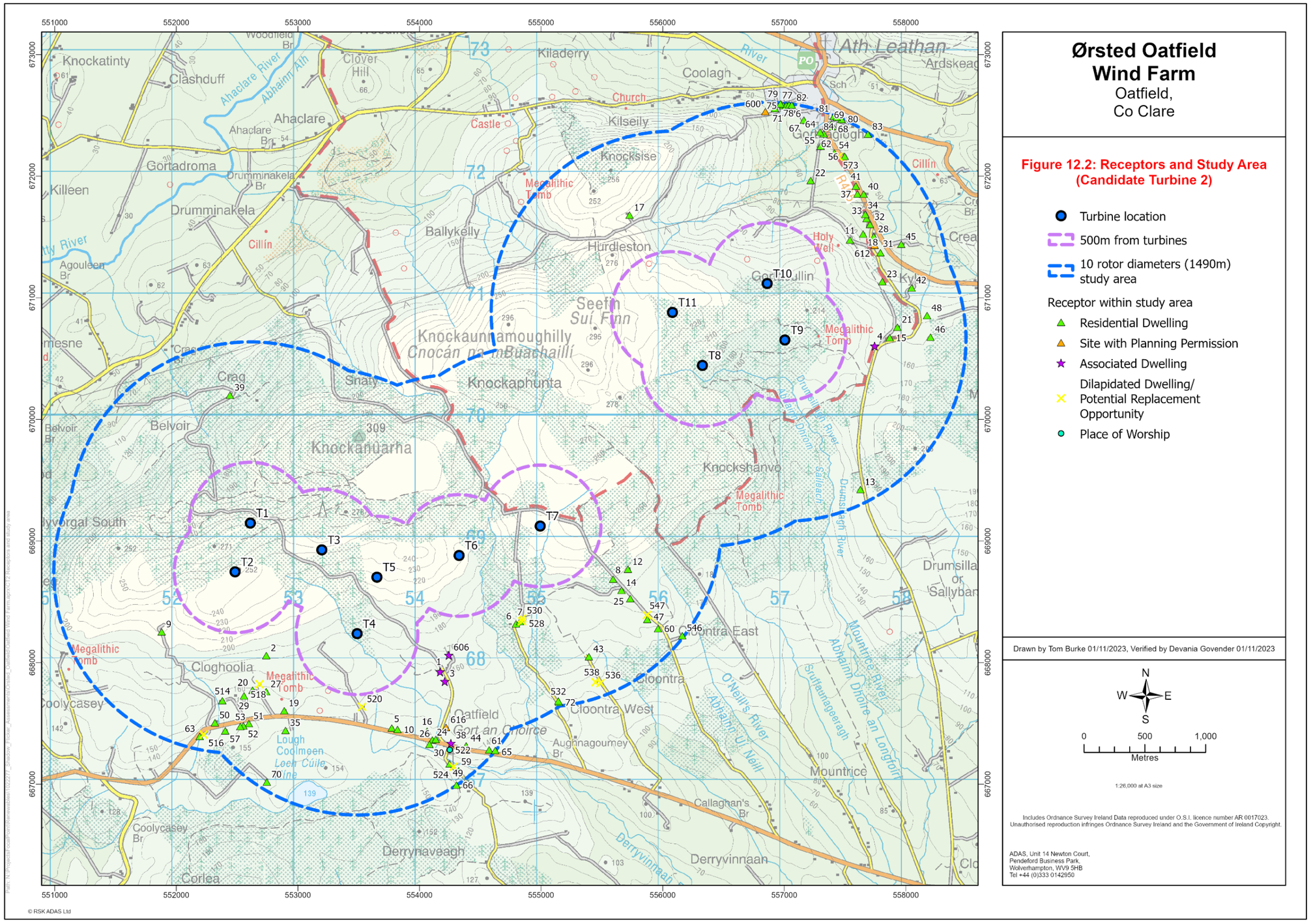


**Figure 12.2 Receptors and study area (candidate turbine 2)**

### 12.5.3 Candidate Turbine 3

There are no sensitive receptors within 500m of the proposed turbines. There are 69 sensitive receptors within the 10 rotor diameter (1,330 m) study area for candidate turbine 3. These consist of:

- 55 residential dwellings;
- 5 associated dwellings;
- 1 place of worship;
- 2 sites with planning permission; and
- 6 dilapidated dwellings / potential replacement opportunities.

**Figure 12.3** (EIAR **Volume IV**) presents the study area (1,330m buffer around the proposed 11 turbines, based on the turbine rotor diameter of 133m) for candidate turbine 3, and the receptors identified within this area.

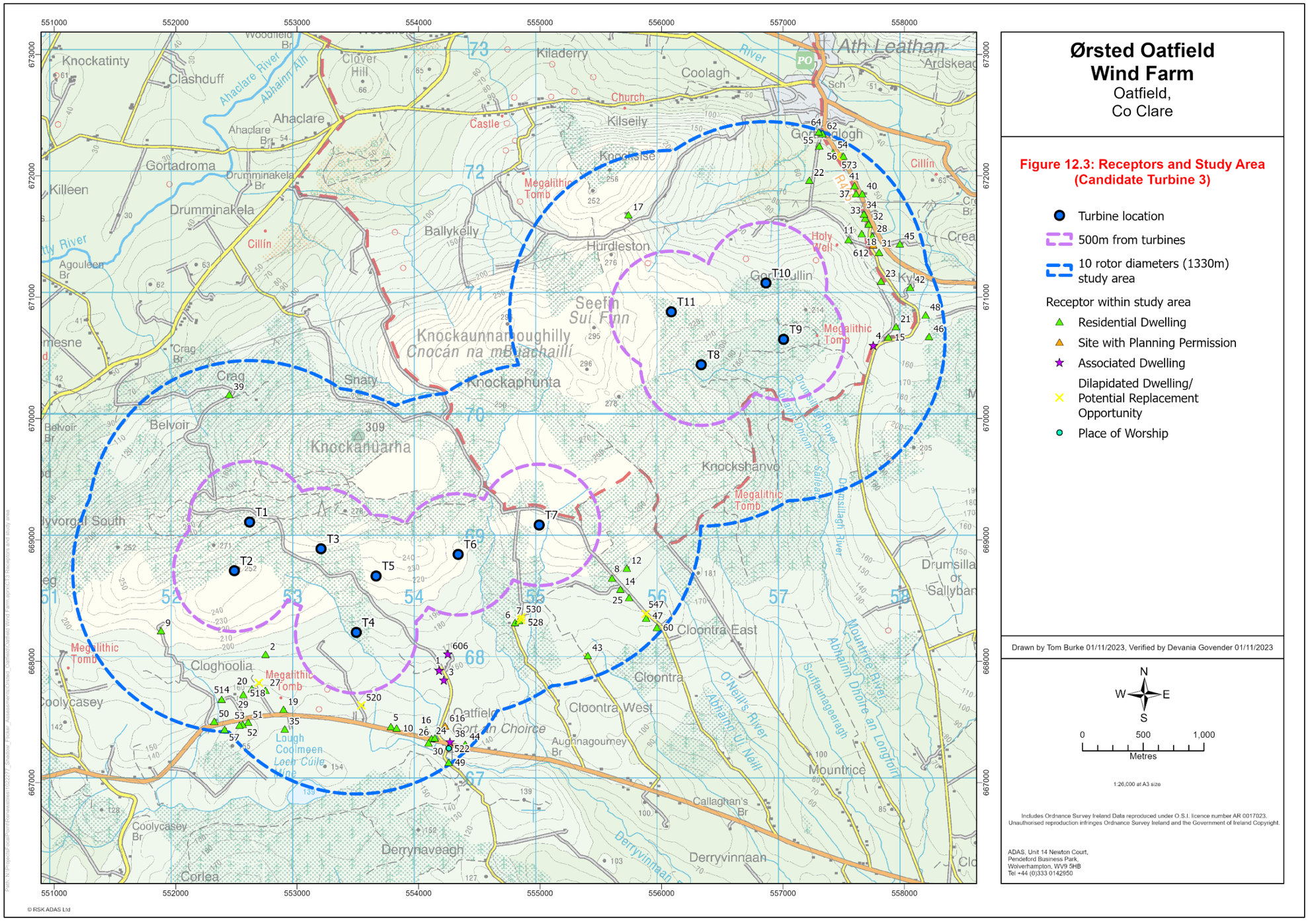


**Figure 12.3 Receptors and study area (candidate turbine 3)**

## 12.6 Potential Effects of the Proposed Development

### 12.6.1 Do-Nothing Scenario

In the ‘do-nothing’ scenario, the Proposed Development would not be consented and no turbines would be constructed. Therefore, there would be no shadow flicker.

### 12.6.2 Construction Phase

As outlined in Section 12.1, shadow flicker can only occur when the turbine blades are moving. This requires the turbine to be operational. As such, there will be no shadow flicker effects during the construction phase of the Project.

### 12.6.3 Operational Phase

**Table 12.2, Table 12.3** and **Table 12.4** present the modelled ‘worst-case’ scenario shadow flicker durations at the identified receptors for candidate turbines 1, 2 and 3, respectively. The tables also present the ‘likely’ scenario shadow flicker durations when taking into account estimated sunshine probability (30%). Shaded cells indicate exceedances of Wind Energy Development Guidelines (2006) thresholds of 30 hours per year or 30 minutes per day. The locations of each receptor and their corresponding Receptor ID are shown in:

- **Figure 12.1** (EIAR **Volume IV**) (candidate turbine 1);
- **Figure 12.2** (EIAR **Volume IV**) (candidate turbine 2); and
- **Figure 12.3** (EIAR **Volume IV**) (candidate turbine 3).

The modelled areas over which shadows may be cast (and therefore there is potential for shadow flicker to occur) are shown in:

- **Figure 12.4** (EIAR **Volume IV**) (candidate turbine 1);
- **Figure 12.5** (EIAR **Volume IV**) (candidate turbine 2); and
- **Figure 12.6** (EIAR **Volume IV**) (candidate turbine 3).

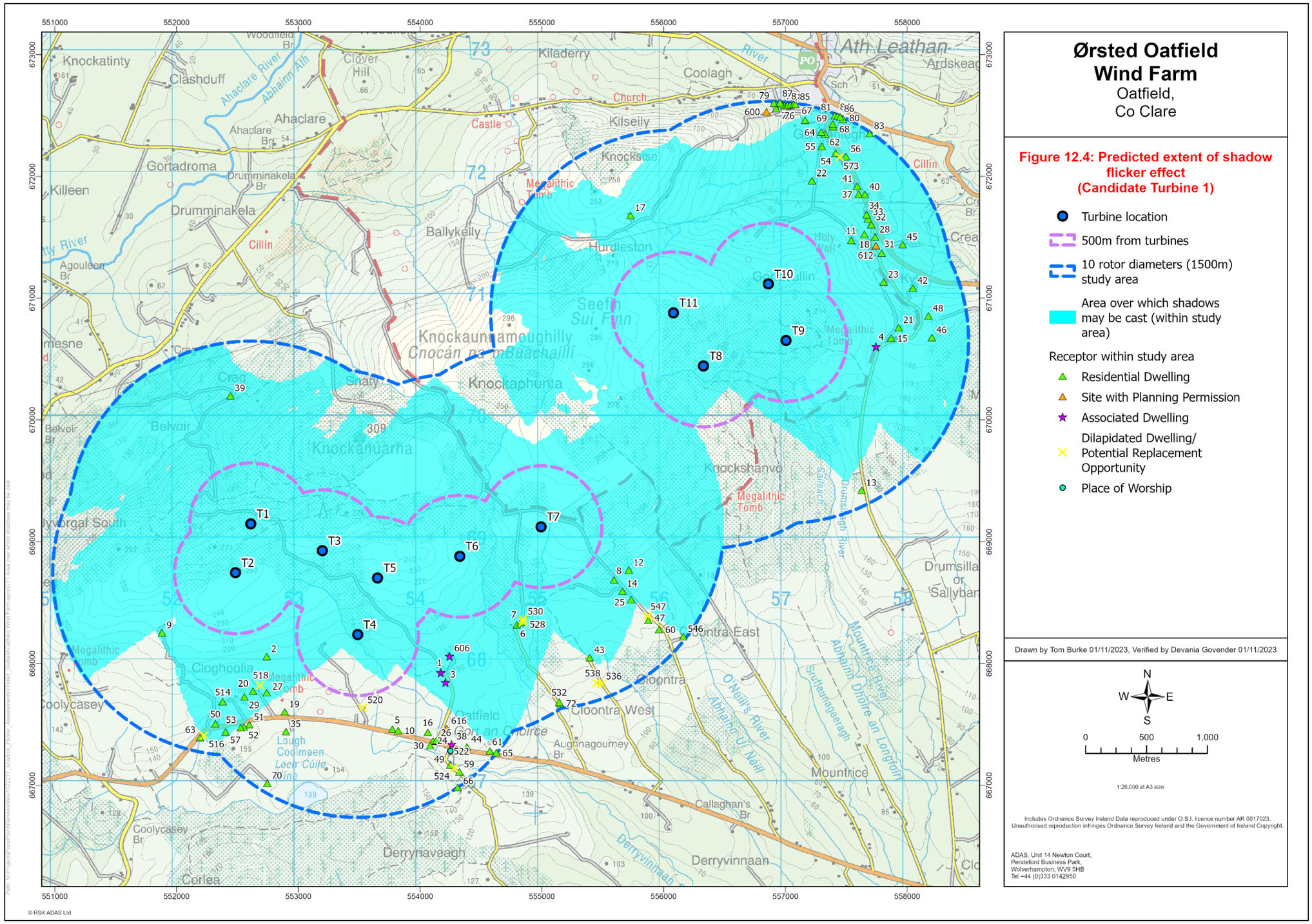


**Figure 12.4 Predicted extent of shadow flicker effect (candidate turbine 1)**

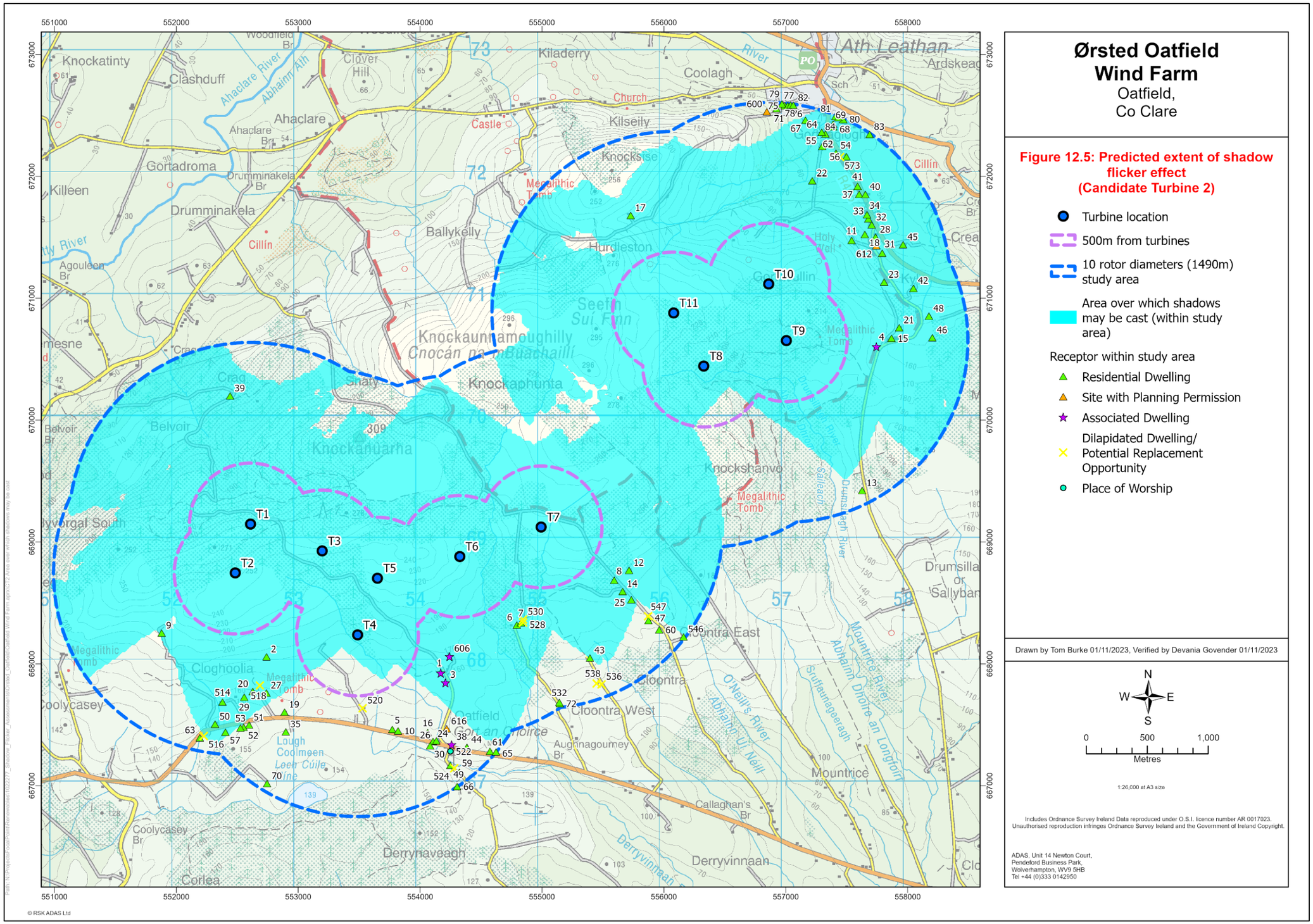


**Figure 12.5 Predicted extent of shadow flicker effect (candidate turbine 2)**

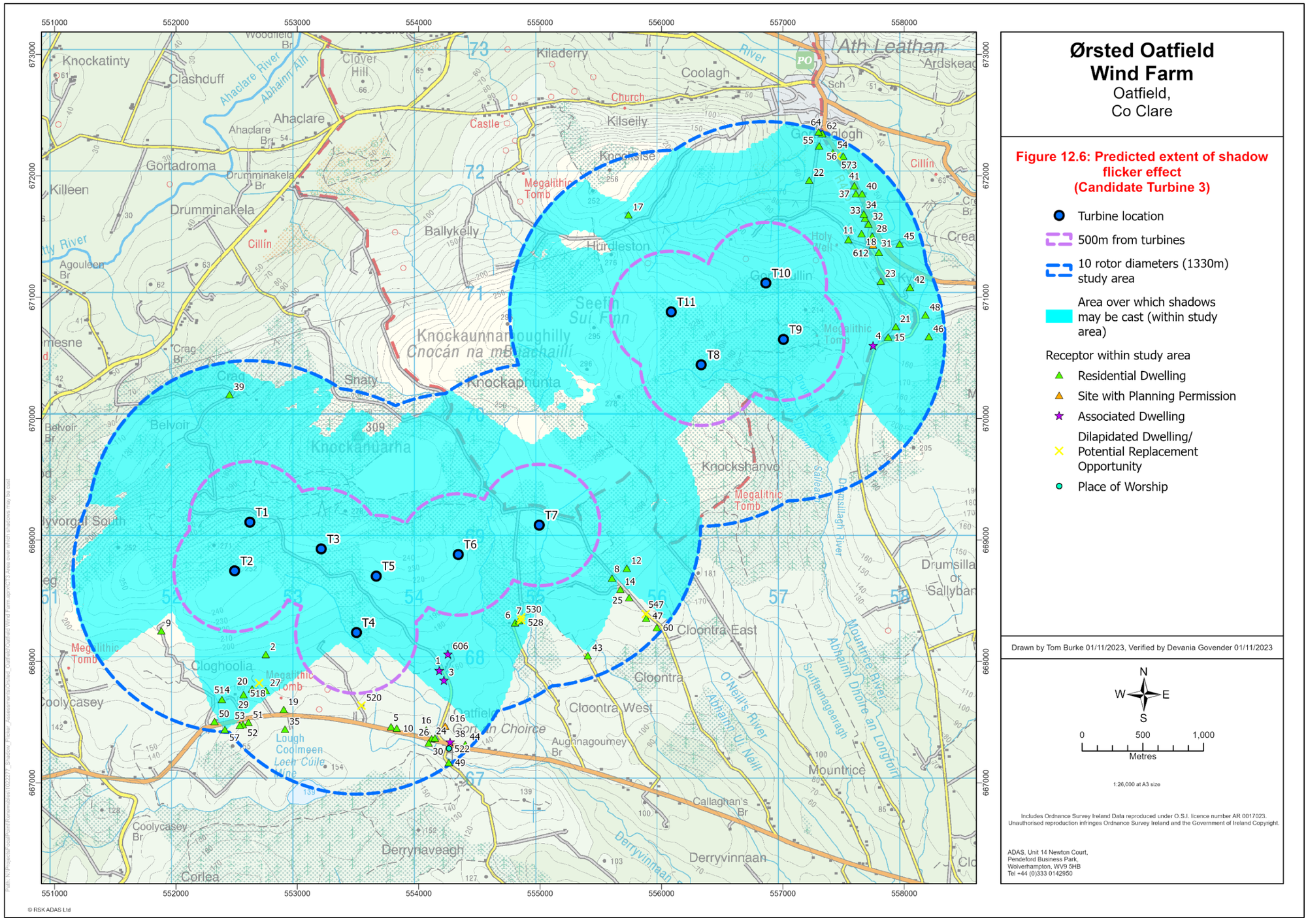


**Figure 12.6 Predicted extent of shadow flicker effect (candidate turbine 3)**

**Table 12.2: Shadow flicker assessment results by receptor (candidate turbine 1). Shaded cells indicate exceedances of Wind Energy Development Guidelines (2006) thresholds of 30 hours per year or 30 minutes per day.**

| Receptor ID | Description | Max hours per day | Total hours per year | 'Likely' hours per year (30% sunshine hrs) | Contributing turbines |
|---|---|---|---|---|---|
| 1 | Associated Dwelling | 0.85 | 70.8 | 21.24 | 4 |
| 2 | Residential Dwelling | 0.81 | 58.6 | 17.58 | 4, 5 |
| 3 | Associated Dwelling | 0.79 | 54.6 | 16.38 | 4 |
| 4 | Associated Dwelling | 0.81 | 70.2 | 21.06 | 8, 9, 10 |
| 5 | Residential Dwelling | 0 | 0 | 0 | |
| 6 | Residential Dwelling | 0.53 | 37.3 | 11.19 | 4, 5 |
| 7 | Residential Dwelling | 0.52 | 34.3 | 10.29 | 4, 5 |
| 8 | Residential Dwelling | 0.49 | 17.5 | 5.25 | 6, 7 |
| 9 | Residential Dwelling | 0.45 | 24.1 | 7.23 | 3 |
| 10 | Residential Dwelling | 0 | 0 | 0 | |
| 11 | Residential Dwelling | 0.76 | 23.3 | 6.99 | 9, 10 |
| 12 | Residential Dwelling | 0.8 | 70 | 21 | 6, 7 |
| 13 | Residential Dwelling | 0 | 0 | 0 | |
| 14 | Residential Dwelling | 0.46 | 14.5 | 4.35 | 6 |
| 15 | Residential Dwelling | 0.7 | 63.7 | 19.11 | 9, 10 |
| 16 | Residential Dwelling | 0 | 0 | 0 | |
| 17 | Residential Dwelling | 0.61 | 44.8 | 13.44 | 10, 11 |
| 18 | Residential Dwelling | 0.67 | 24.4 | 7.32 | 9, 10 |
| 19 | Residential Dwelling | 0 | 0 | 0 | |

| | | | | | |
|---|---|---|---|---|---|
| 20 | Residential Dwelling | 0.68 | 47.6 | 14.28 | 4 |
| 21 | Residential Dwelling | 0.65 | 48.4 | 14.52 | 9, 10 |
| 22 | Residential Dwelling | 0.7 | 53.1 | 15.93 | 9, 10 |
| 23 | Residential Dwelling | 0.64 | 37.8 | 11.34 | 9, 10 |
| 24 | Residential Dwelling | 0 | 0 | 0 | |
| 25 | Residential Dwelling | 0.44 | 13.5 | 4.05 | 6 |
| 26 | Residential Dwelling | 0 | 0 | 0 | |
| 27 | Residential Dwelling | 0.64 | 24.8 | 7.44 | 4 |
| 28 | Residential Dwelling | 0.62 | 26.1 | 7.83 | 9, 10 |
| 29 | Residential Dwelling | 0.63 | 42.3 | 12.69 | 4 |
| 30 | Residential Dwelling | 0 | 0 | 0 | |
| 31 | Residential Dwelling | 0.62 | 32.1 | 9.63 | 9, 10 |
| 32 | Residential Dwelling | 0.62 | 29.5 | 8.85 | 9, 10 |
| 33 | Residential Dwelling | 0.62 | 28 | 8.4 | 9, 10 |
| 34 | Residential Dwelling | 0.61 | 27.9 | 8.37 | 9, 10 |
| 35 | Residential Dwelling | 0 | 0 | 0 | |
| 37 | Residential Dwelling | 0.59 | 49.3 | 14.79 | 9, 10 |
| 38 | Associated Dwelling | 0 | 0 | 0 | |
| 39 | Residential Dwelling | 0.58 | 26.1 | 7.83 | 1 |
| 40 | Residential Dwelling | 0.57 | 44.1 | 13.23 | 9, 10 |
| 41 | Residential Dwelling | 0.58 | 46.1 | 13.83 | 9, 10 |
| 42 | Residential Dwelling | 0.54 | 31.5 | 9.45 | 9, 10 |
| 43 | Residential Dwelling | 0 | 0 | 0 | |
| 44 | Residential Dwelling | 0 | 0 | 0 | |
| 45 | Residential Dwelling | 0.53 | 28.8 | 8.64 | 9, 10 |

| | | | | | |
|---|---|---|---|---|---|
| 46 | Residential Dwelling | 0.51 | 31.9 | 9.57 | 9, 10 |
| 47 | Residential Dwelling | 0 | 0 | 0 | |
| 48 | Residential Dwelling | 0.52 | 31 | 9.3 | 9, 10 |
| 49 | Residential Dwelling | 0 | 0 | 0 | |
| 50 | Residential Dwelling | 0.49 | 24.1 | 7.23 | 4 |
| 51 | Residential Dwelling | 0 | 0 | 0 | |
| 52 | Residential Dwelling | 0 | 0 | 0 | |
| 53 | Residential Dwelling | 0 | 0 | 0 | |
| 54 | Residential Dwelling | 0.54 | 34 | 10.2 | 10 |
| 55 | Residential Dwelling | 0.54 | 27.1 | 8.13 | 10 |
| 56 | Residential Dwelling | 0.53 | 37 | 11.1 | 10 |
| 57 | Residential Dwelling | 0.29 | 6.3 | 1.89 | 4 |
| 59 | Residential Dwelling | 0 | 0 | 0 | |
| 60 | Residential Dwelling | 0 | 0 | 0 | |
| 61 | Residential Dwelling | 0 | 0 | 0 | |
| 62 | Residential Dwelling | 0.48 | 19.5 | 5.85 | 10 |
| 63 | Residential Dwelling | 0 | 0 | 0 | |
| 64 | Residential Dwelling | 0.46 | 17.3 | 5.19 | 10 |
| 65 | Residential Dwelling | 0 | 0 | 0 | |
| 66 | Residential Dwelling | 0 | 0 | 0 | |
| 67 | Residential Dwelling | 0.19 | 2.5 | 0.75 | 10 |
| 68 | Residential Dwelling | 0.45 | 17 | 5.1 | 10 |
| 69 | Residential Dwelling | 0.42 | 15 | 4.5 | 10 |
| 70 | Residential Dwelling | 0 | 0 | 0 | |
| 71 | Residential Dwelling | 0 | 0 | 0 | |

| | | | | | |
|---|---|---|---|---|---|
| 72 | Residential Dwelling | 0 | 0 | 0 | |
| 75 | Residential Dwelling | 0 | 0 | 0 | |
| 76 | Residential Dwelling | 0 | 0 | 0 | |
| 77 | Residential Dwelling | 0 | 0 | 0 | |
| 78 | Residential Dwelling | 0 | 0 | 0 | |
| 79 | Residential Dwelling | 0 | 0 | 0 | |
| 80 | Residential Dwelling | 0.41 | 14.8 | 4.44 | 10 |
| 81 | Residential Dwelling | 0.36 | 10.1 | 3.03 | 10 |
| 82 | Residential Dwelling | 0 | 0 | 0 | |
| 83 | Residential Dwelling | 0.45 | 27.9 | 8.37 | 10 |
| 84 | Residential Dwelling | 0.38 | 11.5 | 3.45 | 10 |
| 85 | Residential Dwelling | 0 | 0 | 0 | |
| 86 | Residential Dwelling | 0.39 | 12.6 | 3.78 | 10 |
| 87 | Residential Dwelling | 0 | 0 | 0 | |
| 514 | Residential Dwelling | 0.54 | 39.9 | 11.97 | 4 |
| 516 | Dilapidated Dwelling/Potential Replacement Opportunity | 0 | 0 | 0 | |
| 518 | Dilapidated Dwelling/Potential Replacement Opportunity | 0.73 | 48.4 | 14.52 | 4 |
| 520 | Dilapidated Dwelling/Potential Replacement Opportunity | 0 | 0 | 0 | |
| 522 | Place of Worship | 0 | 0 | 0 | |
| 524 | Dilapidated Dwelling/Potential Replacement Opportunity | 0 | 0 | 0 | |
| 528 | Dilapidated Dwelling/Potential Replacement Opportunity | 0.51 | 33.1 | 9.93 | 4, 5 |
| 530 | Dilapidated Dwelling/Potential Replacement Opportunity | 0.51 | 32.4 | 9.72 | 4, 5 |
| 532 | Residential Dwelling | 0 | 0 | 0 | |
| 536 | Dilapidated Dwelling/Potential Replacement Opportunity | 0 | 0 | 0 | |
| 538 | Dilapidated Dwelling/Potential Replacement Opportunity | 0 | 0 | 0 | |

| | | | | | |
|---|---|---|---|---|---|
| 546 | Residential Dwelling | 0 | 0 | 0 | |
| 547 | Dilapidated Dwelling/Potential Replacement Opportunity | 0 | 0 | 0 | |
| 573 | Dilapidated Dwelling/Potential Replacement Opportunity | 0.55 | 37.8 | 11.34 | 10 |
| 600 | Site with Planning Permission | 0 | 0 | 0 | |
| 606 | Associated Dwelling | 0.79 | 48.2 | 14.46 | 4 |
| 612 | Site with Planning Permission | 0.63 | 27.7 | 8.31 | 9, 10 |
| 616 | Site with Planning Permission | 0 | 0 | 0 | |

**Table 12.3: Shadow flicker assessment results by receptor (candidate turbine 2). Shaded cells indicate exceedances of Wind Energy Development Guidelines (2006) thresholds of 30 hours per year or 30 minutes per day.**

| Receptor ID | Description | Max hours per day | Total hours per year | 'Likely' hours per year (30% sunshine hrs) | Contributing turbines |
|---|---|---|---|---|---|
| 1 | Associated Dwelling | 0.85 | 70.3 | 21.09 | 4 |
| 2 | Residential Dwelling | 0.8 | 57.6 | 17.28 | 4, 5 |
| 3 | Associated Dwelling | 0.79 | 54 | 16.2 | 4 |
| 4 | Associated Dwelling | 0.81 | 69.5 | 20.85 | 8, 9, 10 |
| 5 | Residential Dwelling | 0 | 0 | 0 | |
| 6 | Residential Dwelling | 0.53 | 36.8 | 11.04 | 4, 5 |
| 7 | Residential Dwelling | 0.52 | 33.9 | 10.17 | 4, 5 |
| 8 | Residential Dwelling | 0.49 | 16.8 | 5.04 | 6, 7 |
| 9 | Residential Dwelling | 0.45 | 23.8 | 7.14 | 3 |
| 10 | Residential Dwelling | 0 | 0 | 0 | |
| 11 | Residential Dwelling | 0.76 | 23 | 6.9 | 9, 10 |
| 12 | Residential Dwelling | 0.8 | 69.3 | 20.79 | 6, 7 |
| 13 | Residential Dwelling | 0 | 0 | 0 | |
| 14 | Residential Dwelling | 0.46 | 14.4 | 4.32 | 6 |
| 15 | Residential Dwelling | 0.69 | 62.8 | 18.84 | 9, 10 |
| 16 | Residential Dwelling | 0 | 0 | 0 | |
| 17 | Residential Dwelling | 0.6 | 44.1 | 13.23 | 10, 11 |
| 18 | Residential Dwelling | 0.67 | 24.1 | 7.23 | 9, 10 |
| 19 | Residential Dwelling | 0 | 0 | 0 | |
| 20 | Residential Dwelling | 0.67 | 47.1 | 14.13 | 4 |

| | | | | | |
|---|---|---|---|---|---|
| 21 | Residential Dwelling | 0.64 | 47.9 | 14.37 | 9, 10 |
| 22 | Residential Dwelling | 0.69 | 52.5 | 15.75 | 9, 10 |
| 23 | Residential Dwelling | 0.64 | 37.5 | 11.25 | 9, 10 |
| 24 | Residential Dwelling | 0 | 0 | 0 | |
| 25 | Residential Dwelling | 0.44 | 13.3 | 3.99 | 6 |
| 26 | Residential Dwelling | 0 | 0 | 0 | |
| 27 | Residential Dwelling | 0.64 | 24.6 | 7.38 | 4 |
| 28 | Residential Dwelling | 0.62 | 25.7 | 7.71 | 9, 10 |
| 29 | Residential Dwelling | 0.62 | 42 | 12.6 | 4 |
| 30 | Residential Dwelling | 0 | 0 | 0 | |
| 31 | Residential Dwelling | 0.61 | 31.8 | 9.54 | 9, 10 |
| 32 | Residential Dwelling | 0.61 | 29.2 | 8.76 | 9, 10 |
| 33 | Residential Dwelling | 0.61 | 27.7 | 8.31 | 9, 10 |
| 34 | Residential Dwelling | 0.61 | 27.6 | 8.28 | 9, 10 |
| 35 | Residential Dwelling | 0 | 0 | 0 | |
| 37 | Residential Dwelling | 0.59 | 48.8 | 14.64 | 9, 10 |
| 38 | Associated Dwelling | 0 | 0 | 0 | |
| 39 | Residential Dwelling | 0.58 | 25.8 | 7.74 | 1 |
| 40 | Residential Dwelling | 0.57 | 43.6 | 13.08 | 9, 10 |
| 41 | Residential Dwelling | 0.57 | 45.6 | 13.68 | 9, 10 |
| 42 | Residential Dwelling | 0.54 | 31.2 | 9.36 | 9, 10 |
| 43 | Residential Dwelling | 0 | 0 | 0 | |
| 44 | Residential Dwelling | 0 | 0 | 0 | |
| 45 | Residential Dwelling | 0.52 | 28.5 | 8.55 | 9, 10 |
| 46 | Residential Dwelling | 0.51 | 31.6 | 9.48 | 9, 10 |

| | | | | | |
|---|---|---|---|---|---|
| 47 | Residential Dwelling | 0 | 0 | 0 | |
| 48 | Residential Dwelling | 0.51 | 30.7 | 9.21 | 9, 10 |
| 49 | Residential Dwelling | 0 | 0 | 0 | |
| 50 | Residential Dwelling | 0.49 | 23.9 | 7.17 | 4 |
| 51 | Residential Dwelling | 0 | 0 | 0 | |
| 52 | Residential Dwelling | 0 | 0 | 0 | |
| 53 | Residential Dwelling | 0 | 0 | 0 | |
| 54 | Residential Dwelling | 0.54 | 35.1 | 10.53 | 10 |
| 55 | Residential Dwelling | 0.54 | 27 | 8.1 | 10 |
| 56 | Residential Dwelling | 0.53 | 36.6 | 10.98 | 10 |
| 57 | Residential Dwelling | 0.29 | 6 | 1.8 | 4 |
| 59 | Residential Dwelling | 0 | 0 | 0 | |
| 60 | Residential Dwelling | 0 | 0 | 0 | |
| 61 | Residential Dwelling | 0 | 0 | 0 | |
| 62 | Residential Dwelling | 0.47 | 19.2 | 5.76 | 10 |
| 63 | Residential Dwelling | 0 | 0 | 0 | |
| 64 | Residential Dwelling | 0.46 | 17.1 | 5.13 | 10 |
| 65 | Residential Dwelling | 0 | 0 | 0 | |
| 66 | Residential Dwelling | 0 | 0 | 0 | |
| 67 | Residential Dwelling | 0.18 | 2.3 | 0.69 | 10 |
| 68 | Residential Dwelling | 0.44 | 16.8 | 5.04 | 10 |
| 69 | Residential Dwelling | 0.42 | 14.8 | 4.44 | 10 |
| 70 | Residential Dwelling | 0 | 0 | 0 | |
| 71 | Residential Dwelling | 0 | 0 | 0 | |
| 72 | Residential Dwelling | 0 | 0 | 0 | |

| | | | | | |
|---|---|---|---|---|---|
| 75 | Residential Dwelling | 0 | 0 | 0 | |
| 76 | Residential Dwelling | 0 | 0 | 0 | |
| 77 | Residential Dwelling | 0 | 0 | 0 | |
| 78 | Residential Dwelling | 0 | 0 | 0 | |
| 79 | Residential Dwelling | 0 | 0 | 0 | |
| 80 | Residential Dwelling | 0.41 | 14.8 | 4.44 | 10 |
| 81 | Residential Dwelling | 0.36 | 10.6 | 3.18 | 10 |
| 82 | Residential Dwelling | 0 | 0 | 0 | |
| 83 | Residential Dwelling | 0.45 | 27.9 | 8.37 | 10 |
| 84 | Residential Dwelling | 0.39 | 12.2 | 3.66 | 10 |
| 514 | Residential Dwelling | 0.53 | 39.6 | 11.88 | 4 |
| 516 | Dilapidated Dwelling/Potential Replacement Opportunity | 0 | 0 | 0 | |
| 518 | Dilapidated Dwelling/Potential Replacement Opportunity | 0.72 | 48 | 14.4 | 4 |
| 520 | Dilapidated Dwelling/Potential Replacement Opportunity | 0 | 0 | 0 | |
| 522 | Place of Worship | 0 | 0 | 0 | |
| 524 | Dilapidated Dwelling/Potential Replacement Opportunity | 0 | 0 | 0 | |
| 528 | Dilapidated Dwelling/Potential Replacement Opportunity | 0.51 | 32.7 | 9.81 | 4, 5 |
| 530 | Dilapidated Dwelling/Potential Replacement Opportunity | 0.51 | 32 | 9.6 | 4, 5 |
| 532 | Residential Dwelling | 0 | 0 | 0 | |
| 536 | Dilapidated Dwelling/Potential Replacement Opportunity | 0 | 0 | 0 | |
| 538 | Dilapidated Dwelling/Potential Replacement Opportunity | 0 | 0 | 0 | |
| 546 | Residential Dwelling | 0 | 0 | 0 | |
| 547 | Dilapidated Dwelling/Potential Replacement Opportunity | 0 | 0 | 0 | |
| 573 | Dilapidated Dwelling/Potential Replacement Opportunity | 0.54 | 37.5 | 11.25 | 10 |
| 600 | Site with Planning Permission | 0 | 0 | 0 | |

| | | | | | |
|---|---|---|---|---|---|
| 606 | Associated Dwelling | 0.79 | 47.6 | 14.28 | 4 |
| 612 | Site with Planning Permission | 0.63 | 27.4 | 8.22 | 9, 10 |
| 616 | Site with Planning Permission | 0 | 0 | 0 | |

**Table 12.4: Shadow flicker assessment results by receptor (candidate turbine 3). Shaded cells indicate exceedances of Wind Energy Development Guidelines (2006) thresholds of 30 hours per year or 30 minutes per day.**

| Receptor ID | Description | Max hours per day | Total hours per year | 'Likely' hours per year (30% sunshine hrs) | Contributing turbines |
|---|---|---|---|---|---|
| 1 | Associated Dwelling | 0.76 | 59.4 | 17.82 | 4 |
| 2 | Residential Dwelling | 0.72 | 41.7 | 12.51 | 4, 5 |
| 3 | Associated Dwelling | 0.7 | 43.8 | 13.14 | 4 |
| 4 | Associated Dwelling | 0.72 | 59.9 | 17.97 | 9, 10 |
| 5 | Residential Dwelling | 0 | 0 | 0 | |
| 6 | Residential Dwelling | 0.48 | 29.9 | 8.97 | 4, 5 |
| 7 | Residential Dwelling | 0.47 | 17.1 | 5.13 | 5 |
| 8 | Residential Dwelling | 0.44 | 12.5 | 3.75 | 6 |
| 9 | Residential Dwelling | 0 | 0 | 0 | |
| 10 | Residential Dwelling | 0 | 0 | 0 | |
| 11 | Residential Dwelling | 0.68 | 19.9 | 5.97 | 9, 10 |
| 12 | Residential Dwelling | 0.72 | 49.6 | 14.88 | 7 |
| 14 | Residential Dwelling | 0 | 0 | 0 | |
| 15 | Residential Dwelling | 0.62 | 53.4 | 16.02 | 9, 10 |
| 16 | Residential Dwelling | 0 | 0 | 0 | |
| 17 | Residential Dwelling | 0.54 | 37.5 | 11.25 | 10, 11 |
| 18 | Residential Dwelling | 0.6 | 21.1 | 6.33 | 9, 10 |
| 19 | Residential Dwelling | 0 | 0 | 0 | |
| 20 | Residential Dwelling | 0.61 | 39.1 | 11.73 | 4 |
| 21 | Residential Dwelling | 0.58 | 40.9 | 12.27 | 9, 10 |

| | | | | | |
|---|---|---|---|---|---|
| 22 | Residential Dwelling | 0.61 | 46.1 | 13.83 | 10 |
| 23 | Residential Dwelling | 0.57 | 32.5 | 9.75 | 9, 10 |
| 24 | Residential Dwelling | 0 | 0 | 0 | |
| 25 | Residential Dwelling | 0 | 0 | 0 | |
| 26 | Residential Dwelling | 0 | 0 | 0 | |
| 27 | Residential Dwelling | 0.54 | 19.7 | 5.91 | 4 |
| 28 | Residential Dwelling | 0.56 | 22.7 | 6.81 | 9, 10 |
| 29 | Residential Dwelling | 0.56 | 34.9 | 10.47 | 4 |
| 30 | Residential Dwelling | 0 | 0 | 0 | |
| 31 | Residential Dwelling | 0.55 | 28 | 8.4 | 9, 10 |
| 32 | Residential Dwelling | 0.55 | 25.7 | 7.71 | 9, 10 |
| 33 | Residential Dwelling | 0.55 | 24.3 | 7.29 | 9, 10 |
| 34 | Residential Dwelling | 0.55 | 24.3 | 7.29 | 9, 10 |
| 35 | Residential Dwelling | 0 | 0 | 0 | |
| 37 | Residential Dwelling | 0.53 | 20.3 | 6.09 | 10 |
| 38 | Associated Dwelling | 0 | 0 | 0 | |
| 39 | Residential Dwelling | 0.52 | 22.7 | 6.81 | 1 |
| 40 | Residential Dwelling | 0.51 | 18.5 | 5.55 | 10 |
| 41 | Residential Dwelling | 0.52 | 20.7 | 6.21 | 10 |
| 42 | Residential Dwelling | 0.48 | 26.9 | 8.07 | 9, 10 |
| 43 | Residential Dwelling | 0 | 0 | 0 | |
| 44 | Residential Dwelling | 0 | 0 | 0 | |
| 45 | Residential Dwelling | 0.47 | 24.8 | 7.44 | 9, 10 |
| 46 | Residential Dwelling | 0.46 | 13.1 | 3.93 | 9 |
| 47 | Residential Dwelling | 0 | 0 | 0 | |

| | | | | | |
|---|---|---|---|---|---|
| 48 | Residential Dwelling | 0.46 | 12.9 | 3.87 | 9 |
| 49 | Residential Dwelling | 0 | 0 | 0 | |
| 50 | Residential Dwelling | 0 | 0 | 0 | |
| 51 | Residential Dwelling | 0 | 0 | 0 | |
| 52 | Residential Dwelling | 0 | 0 | 0 | |
| 53 | Residential Dwelling | 0 | 0 | 0 | |
| 54 | Residential Dwelling | 0.48 | 30.9 | 9.27 | 10 |
| 55 | Residential Dwelling | 0.49 | 24.1 | 7.23 | 10 |
| 56 | Residential Dwelling | 0.47 | 31.1 | 9.33 | 10 |
| 57 | Residential Dwelling | 0 | 0 | 0 | |
| 60 | Residential Dwelling | 0 | 0 | 0 | |
| 62 | Residential Dwelling | 0.43 | 17 | 5.1 | 10 |
| 64 | Residential Dwelling | 0.41 | 15 | 4.5 | 10 |
| 514 | Residential Dwelling | 0.48 | 33.8 | 10.14 | 4 |
| 518 | Dilapidated Dwelling/Potential Replacement Opportunity | 0.65 | 42.3 | 12.69 | 4 |
| 520 | Dilapidated Dwelling/Potential Replacement Opportunity | 0 | 0 | 0 | |
| 522 | Place of Worship | 0 | 0 | 0 | |
| 528 | Dilapidated Dwelling/Potential Replacement Opportunity | 0.46 | 16.6 | 4.98 | 5 |
| 530 | Dilapidated Dwelling/Potential Replacement Opportunity | 0.46 | 16.2 | 4.86 | 5 |
| 547 | Dilapidated Dwelling/Potential Replacement Opportunity | 0 | 0 | 0 | |
| 573 | Dilapidated Dwelling/Potential Replacement Opportunity | 0.49 | 32.4 | 9.72 | 10 |
| 606 | Associated Dwelling | 0.71 | 38.7 | 11.61 | 4 |
| 612 | Site with Planning Permission | 0.57 | 24.3 | 7.29 | 9, 10 |
| 616 | Site with Planning Permission | 0 | 0 | 0 | |

### 12.6.4 Candidate Turbine 1

The results of the analysis for the 'worst-case' scenario for candidate turbine 1 show that of the 101 receptors within the (1,500m) study area, 45 are predicted to experience no shadow flicker, while it is predicted that 56 may experience some shadow flicker. Of these, 40 may potentially exceed the Wind Energy Development Guidelines (2006) thresholds of 30 hours per year or 30 minutes per day.

These consist of:

- 4 associated dwellings;
- 4 dilapidated dwellings / potential replacement opportunities;
- 31 residential dwellings; and
- 1 site with planning permission.

With the incorporation of average annual sunshine data to identify the more 'likely' hours per year, no receptors are predicted to exceed the guideline of 30 hours per year. This correction has not been applied to the daily totals, as historical monthly sunshine averages cannot be used to predict daily sunshine hours with sufficient accuracy.

**Appendix 12.4** (EIAR **Volume III**) lists theoretical shadow times per turbine and **Appendix 12.7** (EIAR **Volume III**) theoretical shadow times per sensitive receptor for candidate turbine 1.

### 12.6.5 Candidate Turbine 2

The results of the analysis for the 'worst-case' scenario for candidate turbine 2 show that of the 98 receptors within the (1,490m) study area, 43 are predicted to experience no shadow flicker, while it is predicted that 55 may experience some shadow flicker. Of these, 40 may potentially exceed the Wind Energy Development Guidelines (2006) thresholds of 30 hours per year or 30 minutes per day.

These consist of:

- 4 associated dwellings;
- 4 dilapidated dwellings / potential replacement opportunities;
- 31 residential dwellings; and
- 1 site with planning permission.

With the incorporation of average annual sunshine data to identify the more 'likely' hours per year, no receptors are predicted to exceed the guideline of 30 hours per year. This correction has not been applied to the daily totals, as historical monthly sunshine averages cannot be used to predict daily sunshine hours with sufficient accuracy.

**Appendix 12.5** (EIAR **Volume III**) lists theoretical shadow times per turbine and **Appendix 12.8** (EIAR **Volume III**) theoretical shadow times per sensitive receptor for candidate turbine 2.

### 12.6.6 Candidate Turbine 3

The results of the analysis for the 'worst-case' scenario for candidate turbine 3 show that of the 69 receptors within the (1330m) study area, 26 are predicted to experience no shadow flicker, while it is predicted that 43 may experience some shadow flicker. Of these, 31 may potentially exceed the Wind Energy Development Guidelines (2006) thresholds of 30 hours per year or 30 minutes per day.

These consist of:

- 4 associated dwellings;
- 2 dilapidated dwellings / potential replacement opportunities;
- 24 residential dwellings; and
- 1 site with planning permission.

With the incorporation of average annual sunshine data to identify the more 'likely' hours per year, no receptors are predicted to exceed the guideline of 30 hours per year. This correction has not been applied to the daily totals, as historical monthly sunshine averages cannot be used to predict daily sunshine hours with sufficient accuracy.

**Appendix 12.6** (EIAR **Volume III**) lists theoretical shadow times per turbine and **Appendix 12.9** (EIAR **Volume III**) theoretical shadow times per sensitive receptor for candidate turbine 3.

### 12.6.7 Potential effects

IWEA Best Practice Guidelines for the Irish Wind Energy Industry (2012) note that shadow flicker "*would not generally have any effect on health or safety, but could on limited occasions present a brief nuisance effect for some neighbours*".

Criteria for significance is outlined in Section 12.4.4. Due to predicted 'worst-case' scenario shadow flicker effects at 40 sensitive receptors (candidate turbines 1 and 2) or 31 receptors (candidate turbine 3) exceeding 30 minutes per day or 30 hours per year, it is considered that in the absence of mitigation, the shadow flicker that would be experienced at these receptors is significant and adverse.

As noted previously, results from the modelling do not take into consideration that there will be times in the year when the turbine blades are not turning due to low wind speeds or during scheduled and unscheduled maintenance activities, and that the turbine rotor will not always be facing the receptor. The modelling results also do not account for the fact that the walls facing the turbine may not all have windows, or that some windows may be screened by vegetation or other structures in the intervening landscape, thereby preventing a line of sight between the window and turbines. The 'worst-case' scenario also assumes that the sun is shining from sunrise to sunset (cloudless sky).

### 12.6.8 Decommissioning Phase

As outlined in Section 12.1, shadow flicker can only occur when the turbine blades are moving. This requires the turbine to be operational. As such, there will be no shadow flicker effects during the decommissioning phase of the Proposed Development.

## 12.7 Mitigation Measures

### 12.7.1 Operational Phase

A shadow flicker control system will be installed and operated as part of the Proposed Development. In this system, specialist software calculates the position of the sun and uses one or more light sensors to measure the intensity of sunlight. When the conditions for shadow flicker to occur at a sensitive receptor within the study area are detected, responsible turbine(s) can be curtailed, and will come to a stop. When these conditions are no longer present, the turbine(s) can be released. It is recognised that there will be a short period (approximately 1 – 2 minutes) where shadow flicker may occur before the turbine(s) shut down, once pause criteria are met.

Through implementation and operation of this system, the Project will adhere to currently adopted Wind Energy Development Guidelines (2006) thresholds of 30 minutes per day, or 30 hours per year. The control system described can be used to detect and mitigate instances of shadow flicker at any sensitive receptor if required. Should guidelines with revised limitations on shadow flicker be adopted during the planning application process for this Development, the technical solutions described above can be adapted and applied to adhere to these (allowing for a short period for shadow conditions to be confirmed and for the turbines to come to a stop).

## 12.8 Residual Effects

### 12.8.1 Operational Phase

With the application of mitigation as detailed in Section 12.7.1 to curtail turbines where there is potential to exceed Wind Energy Development Guidelines (2006) thresholds of 30 hours per year or 30 minutes per day, it is considered that there would be no significant effects related to shadow flicker from the Proposed Development.

## 12.9 Cumulative Effects

### 12.9.1 Operational Phase

Annex IV, point 5 (e) of the EU EIA Directive requires that the cumulation of effects with other existing and/or approved projects are described in the EIAR.

Wind Energy Development Guidelines (2006) note that at distances greater than 10 rotor diameters from a turbine, the potential for shadow flicker is very low. For the purposes of this assessment, it is therefore considered that if the 10-rotor diameter study area of the Proposed Development overlaps with the 10-rotor diameter study area of any other existing or approved project, there is the potential for cumulative shadow flicker effects.

A review was undertaken by the RSK project team to identify existing and proposed wind farms within a 20 km+ radius of the Proposed Development. Further details are provided in **Section 2.4.3.3** in **Chapter 2 EIA Methodology**. The following operational and granted wind farms were identified within 20 km, and were considered further:

- Carrownagowan WF (granted) 6.8km to the northeast, comprising 19 turbines with a maximum rotor diameter of 136m. As the 10-rotor diameter study area of

this project does not overlap with that of the Proposed Development, there is no potential for cumulative effects.

- Parteen Turbine (operational) 8.2km to the south, comprising 1 turbine with a maximum rotor diameter of 53m. As the 10-rotor diameter study area of this project does not overlap with that of the Proposed Development , there is no potential for cumulative effects.
- Vision Care Turbine (operational) 12km to the southeast, comprising 1 turbine with a maximum rotor diameter of 80m. As the 10-rotor diameter study area of this project does not overlap with that of the Proposed Development , there is no potential for cumulative effects.

It is therefore considered that there is no potential for the cumulation of effects with other existing and/or approved projects.

In addition to these, the following planning and pre-planning wind farms were identified within 20 km, and were considered further:

- Ballyclar WF (pre-planning) 4.9km to the south, comprising 12 turbines with a currently unspecified rotor diameter. As the locations and rotor diameters of the proposed turbines are not currently available, it is not currently possible to determine if the 10-rotor diameter study area of the Proposed Development would overlap with the 10-rotor diameter study area of Ballyclar WF.
- Fahybeg Onshore Wind Farm (at appeal) 5.1km to the east, comprising 8 turbines with a maximum rotor diameter of 138m. As the 10-rotor diameter study area of this project does not overlap with that of the Proposed Development , there is no potential for cumulative effects.
- Knockshanvo (pre-planning), adjacent, comprising 9 turbines with a maximum rotor diameter of 163m. The 10-rotor diameter study area of this project overlaps with that of the Proposed Development, such that there is potential for cumulative effects.
- Lackareagh WF (pre-planning) 6.5km to the northeast, comprising 7 turbines with a currently unspecified rotor diameter. As the locations and rotor diameters of the proposed turbines are not currently available, it is not currently possible to determine if the 10-rotor diameter study area of the Proposed Development would overlap with the 10-rotor diameter study area of Lackareagh WF.

There is therefore a possibility for cumulative shadow flicker effects from the potential Knockshanvo development. A cumulative shadow flicker assessment was undertaken, following the methodology detailed in Section 12.4.

This cumulative assessment considered all turbines for both the proposed Oatfield and Knockshanvo developments. The Knockshanvo development has not yet been submitted for planning, and such is subject to change. The latest known project details (including turbine locations and dimensions) have therefore been used in the cumulative assessment. At this time, the proposed turbine envelope for the Knockshanvo development is:

- Rotor diameter: 149m – 163m;
- Hub height: 102.5m – 110.5m;

- Tip height: 179.5m – 185m.

Specific combinations of hub height and rotor diameter have not been made available. To consider a potential range of cumulative shadow flicker effects, two scenarios were therefore assessed:

- Cumulative scenario 1: Assumes the hub height (110.5m) and rotor diameter (163m) of the Knockshanvo turbines are the largest of the ranges provided. This results in a tip height of 192m, slightly larger than the provided turbine envelope. Candidate turbine 1 (largest rotor diameter and tip height) is assumed for the Oatfield turbines;
- Cumulative scenario 2: Assumes the hub height (102.5m) and rotor diameter (149m) of the Knockshanvo turbines are the smallest of the ranges provided. This results in a tip height of 177m, slightly smaller than the provided turbine envelope. Candidate turbine 3 (smallest rotor diameter and tip height) is assumed for the Oatfield turbines.

As detailed in Section 12.4.2, it is considered that an assessment of potential shadow flicker at properties within ten rotor diameters of the turbine locations is appropriate to provide a robust assessment of shadow flicker. For the cumulative assessment, it is therefore considered that properties within 10 rotor diameters of both the Oatfield and Knockshanvo turbines have the potential to experience cumulative shadow flicker effects. These have therefore been included in the cumulative assessment.

#### *12.9.1.1 Cumulative Scenario 1*

**Figure 12.7** (EIAR **Volume IV**) presents the Oatfield and Knockshanvo turbines and assumed 10-rotor diameter buffers for cumulative scenario 1. Sensitive receptors within both 10-rotor diameter buffers are displayed. **Table 12.5** presents the modelled 'worst-case' scenario shadow flicker durations these receptors. The table also presents the 'likely' shadow flicker durations when taking into account estimated sunshine probability (30%). Shaded cells indicate exceedances of Wind Energy Development Guidelines (2006) thresholds of 30 hours per year or 30 minutes per day.

21 receptors are within 10 rotor diameters of both the Oatfield and Knockshanvo turbines, and therefore have the potential to experience cumulative shadow flicker effects. Of these, 3 are predicted to experience no shadow flicker, while 18 may experience some shadow flicker. Of these, 2 would experience effects from Oatfield turbines only, 3 from Knockshanvo turbines only, and 13 from both Oatfield and Knockshanvo turbines.

In cumulative scenario 1, 16 sensitive receptors may potentially exceed the Wind Energy Development Guidelines (2006) thresholds of 30 hours per year or 30 minutes per day. Of these, 2 would experience effects from Oatfield turbines only, 1 from Knockshanvo turbines only, and 13 from both Oatfield and Knockshanvo turbines. With the incorporation of average annual sunshine data in the cumulative assessment to identify the more 'likely' hours per year, 6 receptors are predicted to exceed the guideline of 30 hours per year. Of these, 5 would experience effects from both Oatfield turbines and Knockshanvo turbines, and 1 from Knockshanvo turbines only.

The modelled cumulative area over which shadows may be cast (and therefore there is potential for shadow flicker to occur) for cumulative scenario 1 is shown in **Figure 12.8** (EIAR **Volume IV**).

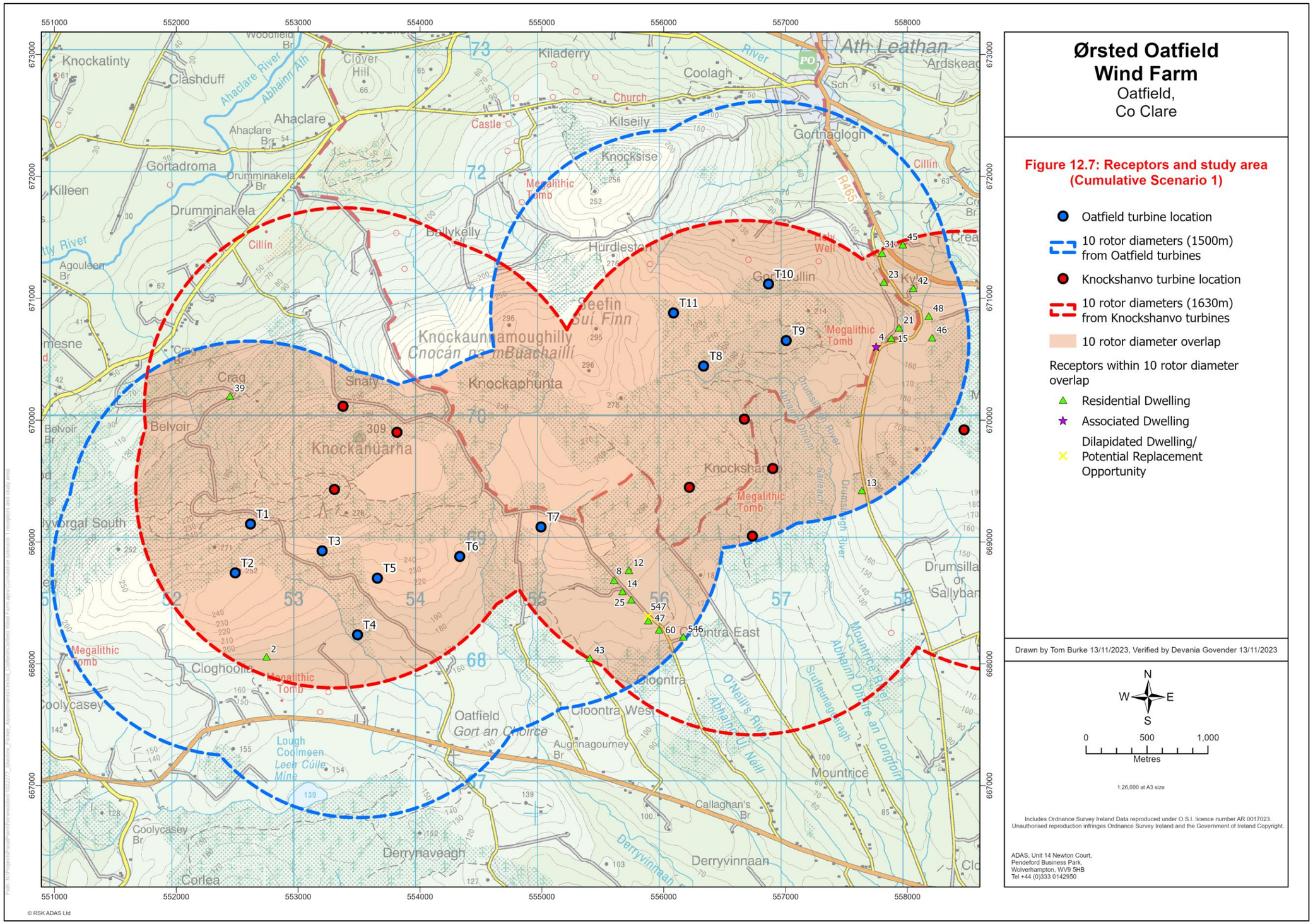


**Figure 12.7 Receptors and study area (cumulative scenario 1)**

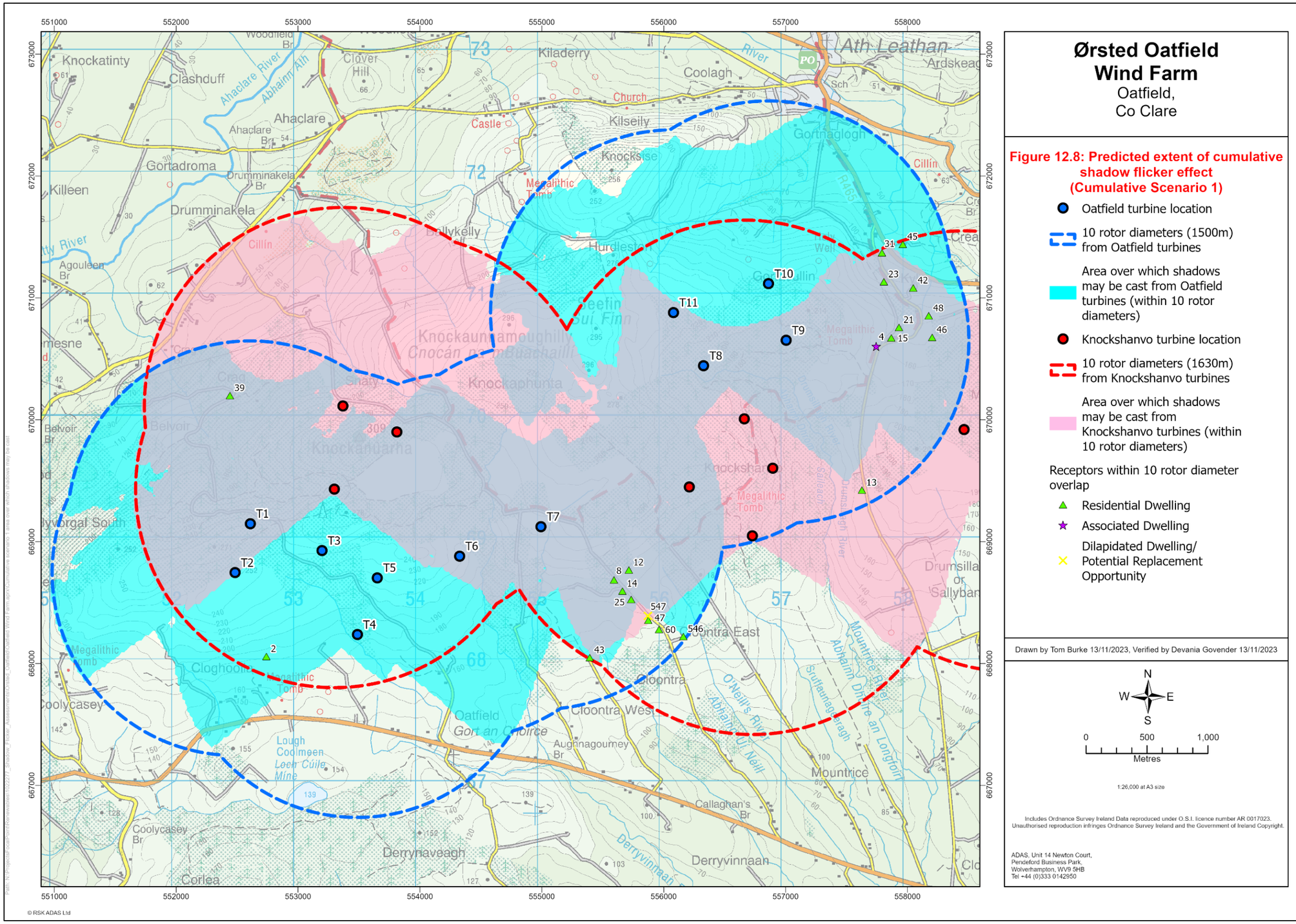


**Figure 12.8 Predicted extent of cumulative shadow flicker effect (cumulative scenario**

#### *12.9.1.2 Cumulative Scenario 2*

**Figure 12.9** (EIAR **Volume IV**) presents the Oatfield and Knockshanvo turbines and assumed 10-rotor diameter buffers for cumulative scenario 2. Sensitive receptors within both 10-rotor diameter buffers are displayed. **Table 12.6** presents the modelled 'worst-case' scenario shadow flicker durations these receptors. The table also presents the 'likely' shadow flicker durations when taking into account estimated sunshine probability (30%). Shaded cells indicate exceedances of Wind Energy Development Guidelines (2006) thresholds of 30 hours per year or 30 minutes per day.

16 receptors are within 10 rotor diameters of both the Oatfield and Knockshanvo turbines, and therefore have the potential to experience cumulative shadow flicker effects. Of these, 1 is predicted to experience no shadow flicker, while 15 may experience some shadow flicker. Of these, 1 would experience effects from Oatfield turbines only, 4 from Knockshanvo turbines only, and 10 from both Oatfield and Knockshanvo turbines.

In cumulative scenario 2, 13 sensitive receptors may potentially exceed the Wind Energy Development Guidelines (2006) thresholds of 30 hours per year or 30 minutes per day. Of these, 1 would experience effects from Oatfield turbines only, 2 from Knockshanvo turbines only, and 10 from both Oatfield and Knockshanvo turbines. With the incorporation of average annual sunshine data in the cumulative assessment to identify the more 'likely' hours per year, 3 receptors are predicted to exceed the guideline of 30 hours per year. Of these, all would experience effects from both Oatfield turbines and Knockshanvo turbines.

The modelled cumulative area over which shadows may be cast (and therefore there is potential for shadow flicker to occur) for cumulative scenario 2 is shown in **Figure 12.10** (EIAR **Volume IV**)

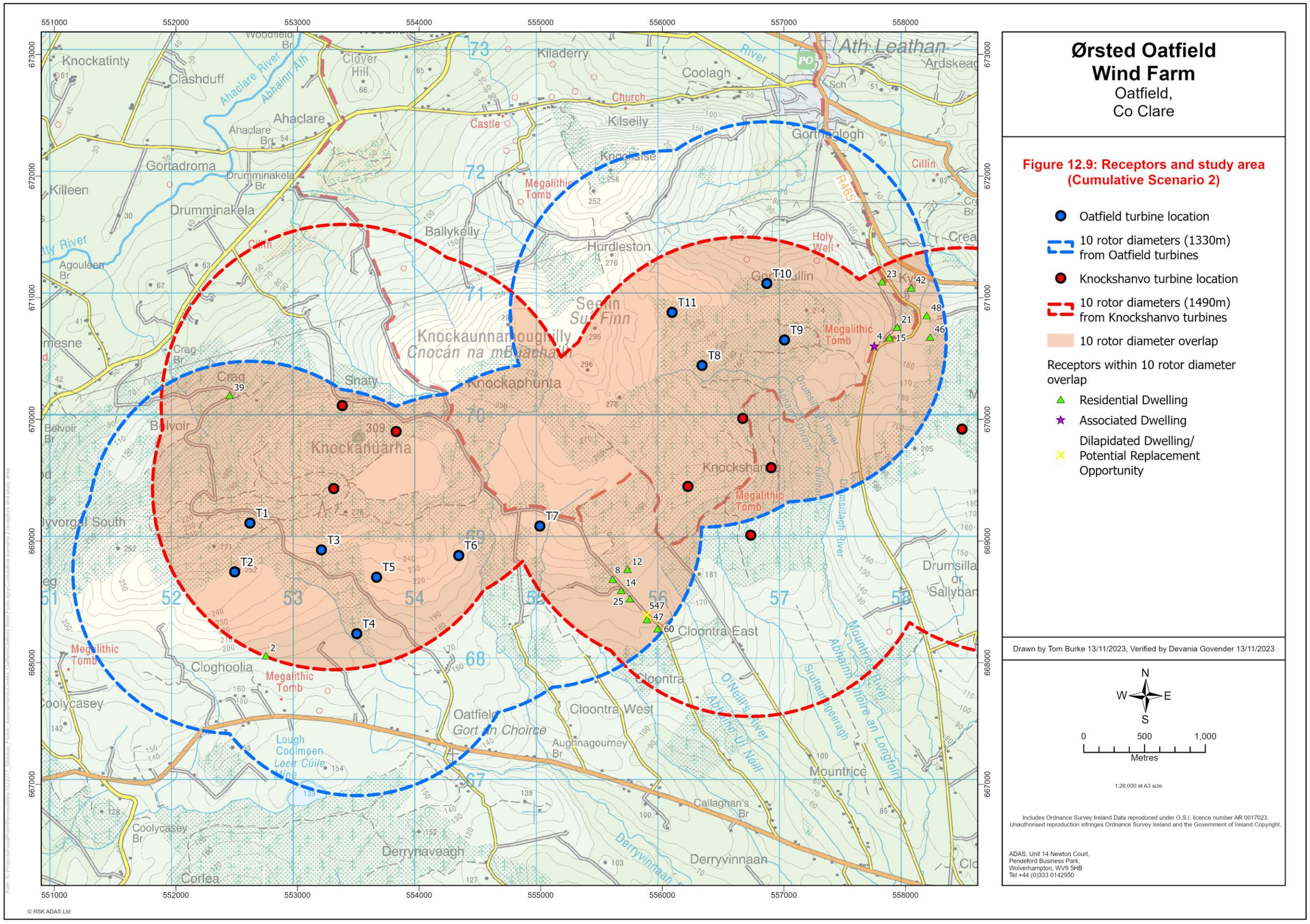


**Figure 12.9 Receptors and study area (cumulative scenario 2)**

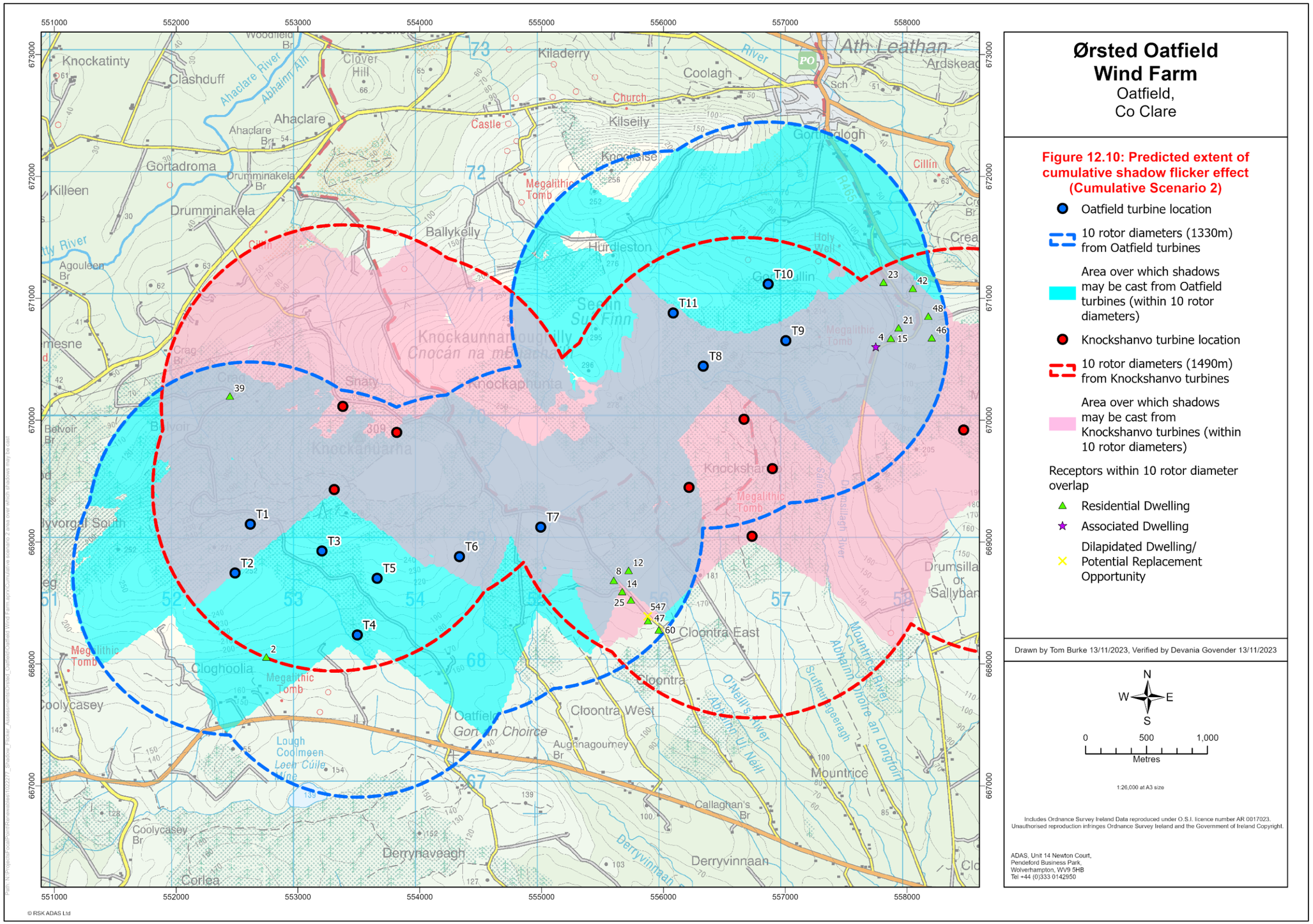


**Figure 12.10 Predicted extent of cumulative shadow flicker effect (cumulative scenario 2)**

#### *12.9.1.3 Mitigation Measures*

Criteria for significance is outlined in Section 12.4.4. Due to predicted 'worst-case' scenario shadow flicker effects from the combination of Oatfield and Knockshanvo turbines exceeding 30 minutes per day or 30 hours per year at 13 (cumulative scenario 1) or 10 (cumulative scenario 2) receptors, it is considered that in the absence of mitigation, the cumulative shadow flicker that would be experienced at these receptors is significant and adverse.

Section 12.7.1 details mitigation measures that will be employed at the Proposed Development. Should the Knockshanvo project be developed, the described shadow flicker control system will also be operated to curtail Oatfield turbines should they, in combination with Knockshanvo turbines, result in exceedances of adopted Wind Energy Development Guidelines (2006) thresholds of 30 minutes per day, or 30 hours per year. The control system described can be used to detect and mitigate instances of shadow flicker at any sensitive receptor if required. Should guidelines with revised limitations on shadow flicker be adopted during the planning application process for this Development, the technical solutions described above can be adapted and applied to adhere to these (allowing for a short period for shadow conditions to be confirmed and for the turbines to come to a stop).

#### *12.9.1.4 Residual Cumulative Effects*

With the application of this mitigation, it is considered that were would be no significant cumulative effects relating to shadow flicker from the Proposed Development.

**Table 12.5: Cumulative scenario 1 shadow flicker assessment results by receptor. Shaded cells indicate exceedances of Wind Energy Development Guidelines (2006) thresholds of 30 hours per year or 30 minutes per day.**

| Receptor ID | Description | Max hours per day | Total hours per year | 'Likely' hours per year (30% sunshine hrs) | Contributing turbines (O = Oatfield, K = Knockshanvo) |
|---|---|---|---|---|---|
| 2 | Residential Dwelling | 0.81 | 58.6 | 17.58 | O |
| 4 | Associated Dwelling | 1.06 | 154.1 | 46.23 | O, K |
| 8 | Residential Dwelling | 0.83 | 68.5 | 20.55 | O, K |
| 12 | Residential Dwelling | 1.3 | 128.3 | 38.49 | O, K |
| 13 | Residential Dwelling | 1.19 | 173.9 | 52.17 | K |
| 14 | Residential Dwelling | 0.6 | 57.2 | 17.16 | O, K |
| 15 | Residential Dwelling | 1.33 | 174.5 | 52.35 | O, K |
| 21 | Residential Dwelling | 1.44 | 150.7 | 45.21 | O, K |
| 23 | Residential Dwelling | 0.64 | 56.7 | 17.01 | O, K |
| 25 | Residential Dwelling | 0.63 | 65.1 | 19.53 | O, K |
| 31 | Residential Dwelling | 0.62 | 37.1 | 11.13 | O, K |
| 39 | Residential Dwelling | 0.75 | 76.6 | 22.98 | O, K |
| 42 | Residential Dwelling | 0.54 | 43.6 | 13.08 | O, K |
| 43 | Residential Dwelling | 0 | 0 | 0 | |
| 45 | Residential Dwelling | 0.53 | 28.8 | 8.64 | O |
| 46 | Residential Dwelling | 1.27 | 102.9 | 30.87 | O, K |
| 47 | Residential Dwelling | 0.18 | 3.3 | 0.99 | K |
| 48 | Residential Dwelling | 0.9 | 63 | 18.9 | O, K |
| 60 | Residential Dwelling | 0 | 0 | 0 | |

| | | | | | |
|---|---|---|---|---|---|
| 546 | Residential Dwelling | 0 | 0 | 0 | |
| 547 | Dilapidated Dwelling/Potential Replacement Opportunity | 0.47 | 14.1 | 4.23 | K |

**Table 12.6: Cumulative scenario 2 shadow flicker assessment results by receptor. Shaded cells indicate exceedances of Wind Energy Development Guidelines (2006) thresholds of 30 hours per year or 30 minutes per day.**

| Receptor ID | Description | Max hours per day | Total hours per year | 'Likely' hours per year (30% sunshine hrs) | Contributing turbines (O = Oatfield, K = Knockshanvo) |
|---|---|---|---|---|---|
| 2 | Residential Dwelling | 0.72 | 41.7 | 12.51 | O |
| 4 | Associated Dwelling | 0.9 | 129.9 | 38.97 | O, K |
| 8 | Residential Dwelling | 0.76 | 32.9 | 9.87 | O, K |
| 12 | Residential Dwelling | 1.19 | 100.9 | 30.27 | O, K |
| 14 | Residential Dwelling | 0.56 | 26.9 | 8.07 | K |
| 15 | Residential Dwelling | 1.05 | 137.5 | 41.25 | O, K |
| 21 | Residential Dwelling | 0.59 | 88.3 | 26.49 | O, K |
| 23 | Residential Dwelling | 0.57 | 46 | 13.8 | O, K |
| 25 | Residential Dwelling | 0.58 | 44.9 | 13.47 | K |
| 39 | Residential Dwelling | 0.7 | 64.5 | 19.35 | O, K |
| 42 | Residential Dwelling | 0.48 | 32.4 | 9.72 | O, K |
| 46 | Residential Dwelling | 1.17 | 69.1 | 20.73 | O, K |
| 47 | Residential Dwelling | 0.16 | 2.6 | 0.78 | K |
| 48 | Residential Dwelling | 0.73 | 31.8 | 9.54 | O, K |

| | | | | | |
|---|---|---|---|---|---|
| 60 | Residential Dwelling | 0 | 0 | 0 | |
| 547 | Dilapidated Dwelling/Potential Replacement Opportunity | 0.43 | 12.8 | 3.84 | K |

**Table 12.7: Summary of Assessment of Effects – Shadow flicker**

| Potential Effect | Beneficial / Adverse / Neutral | Extent (Site / Local / National / Transboundary) | Short term/ Long term | Direct / Indirect | Permanent / Temporary | Reversible / Irreversible | Significance of Effects (according to defined criteria) | Proposed Mitigation | Residual Effects (according to defined criteria) |
|---|---|---|---|---|---|---|---|---|---|
| **Construction Phase** | | | | | | | | | |
| None | | | | | | | | | |
| **Operational Phase** | | | | | | | | | |
| Shadow flicker at sensitive receptors | Adverse | Local (Up to 1.5km from proposed turbines) | Long term (Will occur for lifetime of project) | Direct | Temporary (Will occur for lifetime of project) | Reversible (Will occur for lifetime of project) | Significant | Installation and use of shadow flicker control module | Not significant |
| **Decommissioning Phase** | | | | | | | | | |
| None | | | | | | | | | |

## 12.10 References


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