17 SHADOW FLICKER

17.1 INTRODUCTION

This chapter assesses the effects of the Proposed Development in terms of shadow flicker. The Proposed Development refers to all elements of the application for the construction of Kellystown Wind Farm as detailed in **Chapter 2: Description of the Proposed Development**. Where negative effects are predicted, the chapter identifies appropriate mitigation strategies therein. The assessment considers the potential effects during the operational phase of the Proposed Development.

Shadow flicker will not occur during the construction or Decommissioning phase of the Proposed Development. Shadow flicker is an effect caused by the sun shining behind the rotating blades of a turbine relative to a nearby sensitive receptor which causes a momentary shadow on a window of that sensitive receptor. This shadow can appear as a flickering of sun light due to the rotating blades. Therefore, shadow flicker will only occur during the operational phase of the Proposed Development.

Common acronyms used throughout this EIAR can be found in **Appendix 1.3.** 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 17.1** Shadow Flicker Analyses

17.1.1 Statement of Authority

This chapter has been prepared by Ms. Aileen Byrne of Jennings O'Donovan & Partners Limited. Aileen Byrne is an Environmental Scientist, who holds a Bachelor (Hons) Degree in Geography and Information Technology from the National University of Ireland, Galway, and a Higher Diploma in Environmental Science from the University of Limerick. She forms part of the Environmental team responsible for preparing the EIAR Chapters. Aileen has experience writing EIARs, Feasibility Studies and Shadow Flicker analysis.

This chapter was reviewed by Ms. Sarah Moore. Sarah Moore is an Environmental Scientist in JOD with over 17 years of environmental consultancy experience. She has obtained a MSc in Environmental Engineering from Queens University, Belfast, and a BSc in Environmental Science from University of Limerick. Since joining JOD, Sarah has been involved as a Project Environmental Scientist on a range of renewable energy, wastewater, structures and commercial projects. She has experience in the preparation of Appropriate Assessments, Ecological Impact Assessments, Environmental Impact Assessments, Shadow Flicker analysis and Geographic Information Systems.

The chapter has also been reviewed by Mr. David Kiely of Jennings O'Donovan & Partners Ltd. Mr. Kiely has 41 years' experience in the civil engineering and environmental sector. He has obtained a Bachelor's Degree in Civil Engineering and a Masters in Environmental Protection, has overseen the construction of over 60 wind farms and has carried out numerous soils and geology assessments for EIA's. He has been responsible in the overall preparation of in excess of 60 EIARs.

17.1.2 Assessment Structure

In line with the relevant legislation and guidelines identified in **Chapter 1: Introduction**, **Section 1.6** and the topic-specific guidance described below. The structure of this shadow flicker chapter is as follows:

- Assessment methodology and significance criteria
- Description of baseline conditions at the Wind Farm Site including the likely evolution of the Baseline
- Limitations of the assessment
- Identification and assessment of effects of shadow flicker associated with the Proposed Development, during the construction, operational and Decommissioning phases of the Proposed Development
- Mitigation measures to avoid or reduce the effects identified
- Identification and assessment of residual impact of the Proposed Development considering mitigation measures
- Identification and assessment of cumulative effects if and where applicable

The information presented in this chapter and the appendices is considered appropriate to allow Louth County Council to carry out an adequate assessment of the Proposed Development.

17.2 SHADOW FLICKER

This chapter comprehensively assesses the potential shadow flicker effects of the operational stage of the Proposed Development. No shadow flicker will occur during the construction or Decommissioning phases. The Grid Connection and Turbine Delivery Route are not included in this assessment as shadow flicker relates to the turbines only.

17.2.1 Assessment Methodology

This assessment of shadow flicker involved the following:

- Evaluation of potential effects (see **Section 17.2.6**) includes predicting the shadow flicker effects on the sensitive receptors within the Study Area across the three scenarios, minimum, median and maximum scenarios, and comparing them against the 2006 Guidelines

- Evaluation of the significance of effects using the methodology set out in **Chapter 1: Introduction**, **Section 1.11.3**
- Identification of measures to avoid and mitigate potential effects

The Study Area is defined as 10 times the widest possible potential rotor diameter within the range (10 x 163m = 1,630m). This was increased to 2000m for completeness which captures all possible scenarios in the turbine range. A shadow flicker computer model (WindPRO 4.0) was used to calculate the occurrence of shadow flicker at relevant receptors to the Proposed Development. The sensitive receptors were identified using a combination of Ordnance Survey of Ireland (OSI) Maps, AutoCAD drawings and from internet mapping resources including *Eircode Finder, Google Street View*, *Google Earth*, *Bing Maps,* a planning permission search using the Louth County Council web resource and from a visit in February 2022 to the Study Area. The desktop sensitive receptor search was originally completed in November 2022 with regular rechecks completed to ensure no new receptors are identified within the Study Area. The output from the calculations is analysed to identify and assess potential shadow flicker effects. Wind turbines, like other tall structures, can cast long shadows when the sun is low in the sky. A minimum separation distance from all sensitive receptors of 500m has been used with the Project design. There are 375 No. receptors within 2km of any proposed wind turbine location.

The 2019 Draft Revised Wind Energy 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*."
While there is no one candidate turbine, a turbine range has been established to capture all possible turbine models within the proposed range. This parameters for assessment are:

- Turbine tip height range of 179.5m – 180m
- Rotor diameter range of 149m – 163m
- Hub height range of 98m – 105m

In order to ensure the full extent of the moving shadow which would be created by the turning turbines within the range is considered in the assessment, the following example scenarios were modelled based on a maximum, minimum and median rotor diameter:

- Maximum Scenario: 98m hub, 163m rotor diameter, 179.5m tip height

- Median Scenario: 102.5m hub, 155m rotor diameter, 180m tip height
- Minimum Scenario:105m hub, 149m rotor diameter, 179.5m tip height

Any references to the turbine dimensions in this shadow flicker assessment should be considered in the context of the above and should not be construed as pre-determining the dimensions of the wind turbine to be used on the Wind Farm Site.

These scenarios were included in the assessment. Cumulative effects were also assessed in **Section 17.2.8**.

Where negative effects are predicted, this section identifies appropriate mitigation strategies. The assessment considers the potential effects during the operational phase of the Proposed Development.

A shadow flicker computer model was used to calculate the occurrence of shadow flicker at relevant receptors to the Proposed Development. The output from the calculations is analysed to identify and assess potential shadow flicker effects. This is further detailed in **Appendix 17.1**.

Shadow flicker lasts only for a short period and happens only in certain specific combined circumstances. The circumstances required for shadow flicker to occur are:

- the sun is shining and at a low angle in the sky; and
- the turbine is directly between the sun and the affected sensitive receptor; and
- there is enough wind energy to ensure that the turbine blades are moving; and
- the turbine blades are positioned so as to cast a shadow on the receptor.

If any one of these conditions is absent, shadow flicker cannot occur.

The 2019 Draft Revised the Wind Energy Development Guidelines (WEDG)[1] 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".

[1] Department of Housing, Planning and Local Government, 2019. *Draft Revised Wind Energy Development Guidelines*, Dublin. Government of Ireland. [Available Online: https://assets.gov.ie/46097/6e68ea81b8084ac5b7f9343d04f0b0ef.pdf]

Shadow flicker may have the potential to cause disturbance and annoyance to residents if it affects occupied rooms of a house. Persons with photosensitive epilepsy can be sensitive to flickering light between 3 and 60 Hertz (Hz). This is supported by research in recent years asserting that flicker from turbines must interrupt or reflect sunlight at frequencies greater than 3Hz to pose a potential risk of inducing photosensitive seizures. The frequencies of flicker caused by modern wind turbines are less than 1Hz and are well below the frequencies known to trigger effects in these individuals. Therefore, any potential shadow flicker effect from the Proposed Development is considered an effect on residential amenity, rather than having the potential to affect the health of residents.

Careful site selection, design and planning, and good use of relevant software to control the turbine operation can help reduce the possibility of shadow flicker. Modern wind turbines have the facility to measure sunlight levels and to reduce or stop turbine rotation if the conditions exist that would lead to any shadow flicker at neighbouring sensitive receptors. The distance and direction between the turbine and sensitive receptor 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 sensitive receptor 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 cast a greater distance from the turbine. Shadow flicker is more likely to occur to the east or west of the Wind Farm Site. This can be seen in **Appendix 17.1**.

17.2.2 Relevant Guidance

The relevant Irish guidance for shadow flicker is derived from the '*Wind Energy Development Guidelines*' (Department of the Environment, Heritage and Local Government (DoEHLG), 2006) the '*Best Practice Guidelines for the Irish Wind Energy Industry*' (Irish Wind Energy Association, 2012), and the Draft Revised Wind Energy Development Guidelines (Department of Housing, Local Government and Heritage, 2019).

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 2006 Guidelines state that shadow flicker lasts only for a short period of time and occurs only during certain specific combined circumstances, as follows:

- the sun is shining and is at a low angle in the sky, i.e., just after dawn and before sunset;
- the turbine is located directly between the sun and the affected sensitive receptor;
- there is enough wind energy to ensure that the turbine blades are moving; and
- the turbine blades are positioned so as to cast a shadow on the receptor.

Although the DoEHLG thresholds apply to dwellings located within 500 metres of a proposed turbine location, for the purposes of this assessment, the guideline thresholds of 30 hours per year or 30 minutes per day have been applied to all sensitive receptors located within ten rotor diameters (i.e., 1,630 metres (163m)) of the proposed turbines within the Site (as per IWEA guidelines, 2012[2]). This was increased to 2km (2000m) for completeness, which encompasses all proposed turbine rotor diameter ranges. The 2006 Guidelines state that at distances greater than 10 rotor diameters from a turbine, the potential for shadow flicker is very low.

The adopted 2006 DoEHLG guidelines are currently under review. The Department of Housing, Local Government and Heritage released the 'Draft Revised Wind Energy Development Guidelines' in December 2019. The Draft Revised Wind Energy Development Guidelines (2019) provides for zero shadow flicker:

"Computational models can be used to accurately predict the strength and duration of potential shadow flicker during daylight hours for every day of the year. A Shadow Flicker Study detailing the outcome of computational modelling for the potential for shadow flicker

[2] Irish Wind Energy Association, 2012. *Best Practice Guidelines for the Irish Wind Energy Industry*, Cork: Wind Skillnet. [Available online: https://windenergyireland.com/images/files/9660bdfb5a4f1d276f41ae9ab54e991bb600b7.pdf]

from the development should accompany all planning applications for wind energy development.

If a suitable shadow flicker prediction model indicates that there is potential for shadow flicker to occur at any particular dwelling or other potentially affected property, then a review of site design involving the possible relocation of one or more turbines to explore the possibility of eliminating the occurrence of potential flicker is required. Following such a review, if shadow flicker is not eliminated for any dwelling or other potentially affected property then clearly specified measures which provide for automated turbine shut down to eliminate shadow flicker should be required as a condition of a grant of permission."

The Draft 2019 Guidelines are based on the recommendations set out in the 'Proposed Revisions to Wind Energy Development Guidelines 2006 – Targeted Review in relation to Noise, Proximity and Shadow Flicker' (December 2013) and the 'Review of the Wind Energy Development Guidelines 2006 – Preferred Draft Approach' (June 2017).

The assessment herein is based on compliance with the current DoEHLG Guidelines limit (30 hours per year or 30 minutes per day). However, it should also be noted the Development will be brought in line with the requirements of the 2019 draft guidelines, which allows for no shadow flicker to impact an existing sensitive receptor, through implementation of the mitigation measures outlined herein.

17.2.3 Shadow Flicker Modelling

An industry standard wind farm assessment software package, WindPRO from EMD International Version 4.0 was used to prepare a model of the Proposed Development. The programme facilitates the analysis of a wind farm for possible shadow flicker occurrence at nearby houses. It allows for the production of maps, and shadow flicker prediction. The data output from the programme has been analysed and the receptors potentially vulnerable to shadow flicker were identified. The significance of shadow flicker effects was assessed.

Generic windows of 2m width, 2m height and 0.5m from bottom line above ground are applied in the model to each side of the house. The model assumes the receptor will not face any particular direction, but instead will face all directions. These windows represent an approximation of the existing windows on the houses 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 wind farm:

- Digital elevation model of the Proposed Development and areas around all sensitive receptors within the model (10m resolution – OS X, Y, and Z data points)
- Turbine locations
- Turbine dimensions (rotor diameter and hub height)
- Receptor locations
- Bottom line height above ground 'window' (0.5m above ground level)
- Wind speed and direction for the Wind Farm Site to determine the period that the wind turbines will be in operation from the different wind directions during the year

The software creates a mathematical model of the Proposed Development and its surroundings and uses this information to calculate specific theoretical times and durations of flicker effects for the identified sensitive receptors. The following 'worst-case' assumptions were initially 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 maintenance works, break downs, wind speeds below the turbine threshold or curtailment
- 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 sensitive receptors. As previously stated, given the assumptions incorporated into the model, the calculations overestimate the duration of effects. The worst-case assumption is considered to be sufficient for the purposes of this assessment as it assumes the sky is always clear, the turbines are always aligned face-on to each window and that there is a clear and undisturbed line of sight between the windows of the receptors and the turbines (except where this is prevented due to topography). In reality, this will not occur; the turbines will not always be orientated as described, clouds will obscure the sun and line of sight may also be obscured (for example, from leaves on trees). The flicker effects will be substantially less than this and will not meet the results of the worst-case assumption.

The model also outputs a more realistic scenario, or "expected values". 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 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 model was the:

- Long-term sunshine probability data from the Met Éireann synoptic station in Dublin Airport
- Long-term wind rose data from the SEAI Wind Mapping System (ITM co-ordinates 709000E, 783000N)

17.2.4 Baseline Description & Likely Evolution of the Baseline

The Wind Farm Site is located in a densely populated rural area, typically ribbon development with sporadic cul-de-sacs. Should the Proposed Development not proceed, the surrounding areas will remain the same. Shadow flicker is directly associated with the operation of turbines.

Taking the above into consideration, JOD examined maps to identify sensitive receptors in the local area within a Study Area, a distance ten times the proposed rotor diameter of the proposed turbines (10 x 163m = 1630m). This was increased to 2000m for completeness. There are 375 receptors within the shadow flicker Study Area radius. The coordinates of each sensitive receptor and its distance to the closest proposed turbine are listed in **Table 17.1** and are shown in **Figure 2.5.**

Table 17.1: Sensitive receptors within the shadow flicker study area

House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H1	709505	784550	T02	1131
H2	709367	784550	T02	1003
H3	707206	782871	T03	1093
H4	707318	782870	T05	1002
H5	707444	781961	T05	1236
H6	707513	781507	T05	1552
H7	707383	781906	T05	1318
H8	705584	783319	T01	1895

House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H9	705744	783414	T01	1712
H10	705902	783048	T01	1743
H11	708134	781146	T05	1698
H12	706829	782648	T01	1478
H13	709591	783271	T04	921
H14	709625	783428	T04	939
H15	709647	783479	T04	962
H16	709657	783517	T04	973
H17	709551	783895	T04	974
H18	709459	783967	T04	931
H19	709386	784693	T02	1082
H20	709354	784771	T02	1096
H21	709398	784820	T02	1159
H22	709114	784973	T02	1052
H23	709077	784968	T02	1025
H24	708564	785327	T02	1169
H25	709371	785841	T02	1918
H26	709336	785853	T02	1911
H27	709496	782453	T05	1238
H28	709526	782458	T05	1265
H29	709557	782461	T05	1293
H30	709649	782293	T05	1436
H31	707754	784932	T01	988
H32	707338	785150	T01	1114
H33	707139	784828	T01	816
H34	710397	782450	T04	1980
H35	705824	784510	T01	1587
H36	705550	783314	T01	1929
H37	705812	785050	T01	1833
H38	707240	781305	T05	1872
H39	707528	781402	T05	1636
H40	707291	781712	T05	1522

House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H41	707540	782027	T05	1121
H42	707674	782146	T05	942
H43	708690	781931	T05	976
H44	709175	781337	T05	1725
H45	707126	782653	T05	1206
H46	707344	782894	T03	973
H47	706698	782663	T01	1515
H48	706639	782666	T01	1538
H49	709674	783593	T04	999
H50	708565	784842	T02	689
H51	707289	785222	T01	1187
H52	707364	785326	T01	1291
H53	706194	785494	T01	1854
H54	706039	784628	T01	1428
H55	707042	784741	T01	765
H56	707077	784751	T01	762
H57	705927	784462	T01	1474
H58	705705	784510	T01	1700
H59	705521	784573	T01	1895
H60	705656	784393	T01	1719
H61	705616	784300	T01	1743
H62	706612	783934	T01	734
H63	705816	783140	T01	1766
H64	706071	785473	T01	1916
H65	706123	785479	T01	1886
H66	706349	783922	T01	996
H67	705540	784312	T01	1820
H68	705596	784822	T01	1912
H69	708136	785009	T02	899
H70	708483	784848	T02	686
H71	708669	784739	T02	618
H72	709294	784805	T02	1066

House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H73	709311	784893	T02	1134
H74	709363	785756	T02	1839
H75	709335	785767	T02	1835
H76	709291	785868	T02	1904
H77	707293	785144	T01	1109
H78	707340	784844	T01	808
H79	707301	784792	T01	757
H80	707252	784779	T01	748
H81	709390	784492	T02	1003
H82	709503	783935	T04	951
H83	709610	783743	T04	970
H84	709573	783753	T04	938
H85	709535	783765	T04	906
H86	709484	783778	T04	863
H87	708177	781136	T05	1704
H88	707792	781047	T05	1863
H89	707456	781117	T05	1921
H90	707203	781303	T05	1894
H91	707245	781206	T05	1950
H92	707415	781706	T05	1445
H93	709577	781624	T05	1745
H94	709574	781659	T05	1719
H95	709571	781704	T05	1687
H96	709565	781730	T05	1665
H97	709652	781734	T05	1728
H98	710271	782572	T04	1810
H99	710392	782695	T04	1864
H100	710154	782410	T04	1797
H101	710096	782415	T04	1747
H102	709782	782400	T04	1516
H103	709653	782327	T05	1427
H104	709486	782375	T05	1254

House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H105	709265	782119	T05	1185
H106	709201	781889	T05	1293
H107	709196	781773	T05	1377
H108	709275	782875	T04	821
H109	709266	782972	T04	749
H110	709289	783047	T03	723
H111	710003	783760	T04	1353
H112	709324	783893	T04	778
H113	709411	783875	T04	841
H114	709463	783861	T04	880
H115	709255	783893	T04	722
H116	709467	784495	T02	1077
H117	709282	784741	T02	1019
H118	707145	784976	T01	960
H119	708308	786067	T02	1908
H120	705922	783376	T01	1563
H121	705963	783037	T01	1700
H122	709536	781439	T05	1851
H123	706804	782632	T01	1502
H124	706066	782611	T01	1910
H125	706111	785544	T01	1945
H126	707126	785263	T01	1246
H127	709426	784111	T02	985
H128	709392	785462	T02	1609
H129	708305	782018	T05	816
H130	708330	782064	T05	770
H131	708379	782060	T05	776
H132	708418	782035	T05	804
H133	708356	782014	T05	821
H134	708578	782087	T05	790
H135	709648	781687	T05	1756
H136	709004	781720	T05	1307

House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H137	709126	781613	T05	1463
H138	707259	782476	T05	1118
H139	709611	781494	T05	1862
H140	707668	782062	T05	1009
H141	707304	781411	T05	1748
H142	706657	781789	T05	1963
H143	707054	782762	T05	1267
H144	709238	784049	T02	804
H145	709146	784894	T02	1015
H146	709081	784786	T02	892
H147	707624	782023	T05	1068
H148	708458	786104	T02	1940
H149	709179	781738	T05	1393
H150	708515	785357	T02	1196
H151	709357	784502	T02	975
H152	709311	785254	T02	1394
H153	708444	781087	T05	1752
H154	705947	782729	T01	1909
H155	705470	784531	T01	1933
H156	707342	784881	T01	845
H157	707342	784908	T01	872
H158	707196	784755	T01	733
H159	709256	785879	T02	1899
H160	708205	782041	T05	801
H161	708510	781960	T05	894
H162	707719	782168	T05	896
H163	707234	784825	T01	796
H164	709237	781637	T05	1508
H165	709111	781063	T05	1940
H166	709367	784069	T04	922
H167	709307	784515	T02	934
H168	709352	785081	T02	1292

House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H169	707979	784969	T05	929
H170	709169	784987	T02	1099
H171	709496	785693	T02	1857
H172	709460	785707	T02	1849
H173	709467	785745	T02	1885
H174	709433	785761	T02	1880
H175	709934	784019	T04	1372
H176	709387	784150	T02	945
H177	709340	784163	T02	898
H178	709318	784178	T02	876
H179	709215	784252	T02	778
H180	709312	784556	T02	954
H181	709279	784682	T02	985
H182	709116	784922	T02	1014
H183	709082	784914	T02	987
H184	709070	784913	T02	978
H185	708707	785255	T02	1122
H186	708216	784924	T02	793
H187	707874	784854	T02	894
H188	708178	784996	T02	873
H189	708305	784969	T02	817
H190	709818	785414	T02	1860
H191	709402	785500	T02	1645
H192	709405	785517	T02	1661
H193	709453	785665	T02	1809
H194	709456	785693	T02	1835
H195	705544	784509	T01	1856
H196	705680	784453	T01	1710
H197	705657	784572	T01	1765
H198	705651	784873	T01	1884
H199	706010	785393	T01	1899
H200	705999	784823	T01	1553

House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H201	708974	781721	T05	1281
H202	708947	781729	T05	1271
H203	708977	781847	T05	1186
H204	708935	781765	T05	1234
H205	708905	781831	T05	1161
H206	708838	781781	T05	1174
H207	708796	781872	T05	1074
H208	708636	781939	T05	949
H209	708397	782002	T05	836
H210	708267	782013	T05	822
H211	708078	782066	T05	804
H212	707212	781200	T05	1973
H213	707323	781217	T05	1899
H214	707484	781251	T05	1790
H215	708081	781151	T05	1700
H216	708031	781228	T05	1632
H217	707920	781237	T05	1646
H218	707831	781155	T05	1748
H219	707748	781065	T05	1858
H220	707681	781206	T05	1748
H221	707513	781338	T03	1699
H222	707561	781590	T05	1457
H223	707469	781664	T03	1445
H224	707425	781885	T05	1303
H225	707542	781969	T05	1163
H226	707609	782297	T05	890
H227	707268	782879	T03	1040
H228	706805	782611	T01	1521
H229	705896	783448	T01	1558
H230	705841	783863	T01	1508
H231	705887	784475	T01	1516
H232	706014	784437	T01	1384

House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H233	706701	784453	T01	762
H234	707338	784807	T01	771
H235	707506	784843	T01	824
H236	707514	784845	T01	828
H237	708102	782128	T05	738
H238	708956	782454	T05	741
H239	709290	782312	T05	1103
H240	709136	781735	T05	1369
H241	709182	781682	T05	1439
H242	709642	783733	T04	998
H243	709515	783040	T04	923
H244	709454	782822	T04	990
H245	709444	782792	T04	1002
H246	705567	784809	T01	1933
H247	705638	783305	T01	1850
H248	705640	784350	T01	1727
H249	705650	784374	T01	1722
H250	705583	784500	T01	1815
H251	705613	784489	T01	1784
H252	705712	784727	T01	1767
H253	705654	784815	T01	1856
H254	705800	784781	T01	1710
H255	705868	785262	T01	1914
H256	705937	785412	T01	1964
H257	705962	785280	T01	1855
H258	709053	781852	T05	1225
H259	709046	781725	T05	1326
H260	708843	782018	T05	970
H261	708760	781877	T05	1053
H262	708726	781912	T05	1008
H263	708535	781883	T05	975
H264	708421	781927	T05	913

House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H265	708252	782077	T05	759
H266	708233	782021	T05	817
H267	708187	782044	T05	800
H268	708163	782093	T05	757
H269	707974	782092	T05	819
H270	707933	782103	T05	826
H271	707283	781361	T03	1801
H272	707284	781205	T05	1930
H273	707360	781320	T05	1792
H274	707423	781321	T05	1758
H275	707786	781092	T05	1821
H276	707640	781305	T05	1673
H277	707609	781309	T05	1682
H278	707530	781439	T05	1603
H279	707518	781467	T05	1584
H280	707417	781420	T05	1677
H281	707445	781545	T05	1557
H282	707503	781557	T05	1516
H283	707479	781570	T05	1517
H284	707471	781630	T05	1472
H285	707466	781810	T05	1333
H286	707440	781835	T05	1330
H287	707401	781915	T05	1299
H288	707430	781935	T05	1264
H289	707570	781956	T05	1154
H290	707588	782057	T05	1067
H291	707733	782121	T05	923
H292	707320	782445	T05	1072
H293	706989	782647	T05	1343
H294	706850	782679	T01	1442
H295	706756	782676	T01	1480
H296	705706	783101	T01	1882

House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H297	705767	783216	T01	1772
H298	705798	783285	T01	1713
H299	705822	783531	T01	1598
H300	705842	783600	T01	1558
H301	705902	783694	T01	1476
H302	705896	783830	T04	1457
H303	705844	784342	T01	1525
H304	705959	784420	T01	1432
H305	706102	784637	T01	1375
H306	706407	784566	T01	1072
H307	706661	784461	T01	800
H308	707151	784761	T01	749
H309	707353	784818	T01	782
H310	709200	781828	T05	1337
H311	709179	781595	T05	1508
H312	709659	783758	T04	1021
H313	709633	783663	T04	971
H314	709653	783554	T04	972
H315	709531	783091	T04	917
H316	709503	783005	T04	929
H317	709478	782944	T04	938
H318	709508	782861	T04	1009
H319	709450	782849	T04	970
H320	708598	781027	T05	1829
H321	709088	781130	T05	1870
H322	709157	781278	T05	1767
H323	708833	781031	T05	1874
H324	708900	781062	T05	1865
H325	709704	783834	T04	1089
H326	709694	782393	T05	1444
H327	709723	782432	T04	1451
H328	709807	782438	T04	1508

House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H329	709837	782477	T04	1505
H330	709987	782433	T04	1649
H331	710055	782422	T04	1710
H332	710299	782705	T04	1775
H333	709157	781422	T05	1642
H334	709700	783772	T04	1064
H335	709700	783800	T04	1073
H336	709734	783831	T04	1116
H337	709777	783823	T04	1153
H338	709888	783758	T04	1241
H339	709626	782417	T05	1372
H340	709655	782420	T05	1399
H341	710093	782469	T04	1713
H342	709164	781301	T05	1751
H343	709597	781764	T05	1666
H344	709643	781469	T05	1902
H345	708679	781011	T05	1858
H346	708399	781162	T05	1674
H347	706194	782621	T01	1820
H348	707491	781202	T05	1829
H349	709000	781085	T05	1877
H350	709665	783563	T04	986
H351	708461	781151	T05	1689
H352	708290	782083	T05	751
H353	705858	782712	T01	1986
H354	706252	785486	T01	1812
H355	705733	783152	T01	1833
H356	709492	783870	T04	910
H357	710128	782412	T04	1775
H358	709404	783965	T04	884
H359	709923	781772	T05	1924
H360	709659	781632	T05	1800

House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H361	709031	781787	T05	1266
H362	707629	781952	T05	1119
H363	709130	781697	T05	1396
H364	710258	783747	T04	1600
H365	710059	782479	T04	1680
H366	707240	781420	T05	1779
H367	709301	785032	T02	1221
H368	708915	781135	T05	1800
H369	709539	783850	T04	943
H370	708323	781177	T05	1656
H371	708949	781069	T05	1874
H372	708942	781142	T05	1802
H373	708972	781153	T05	1803
H374	708783	782534	T05	552
St. Patrick's N.S	708565	781951	T03	917

17.2.5 Limitations of the Assessment

As previously stated, this calculation is based on topography alone and excludes vegetation, buildings and other man-made structures. These factors cannot be accurately predicted due to the changeable nature of these variables.

17.2.6 Assessment of Potential Effects

This assessment considers the potential shadow flicker effect of the Proposed Development on the surrounding sensitive receptors in terms of:

- Predicting and assessing the extent of shadow flicker experienced by all sensitive receptors within the shadow flicker Study Area; and
- Specifying mitigation measures, where deemed necessary.

The maximum expected daily shadow flicker for each receptor is outlined in the table below. This is the highest amount expected across the whole year on any given day. All other days will experience no more than this amount of shadow flicker, pre-mitigation.

There are no wind farms within 2km of the Wind Farm Site to be considered with the Proposed Development for cumulative effects. The IWEA Guidelines recommend that all existing and / or permitted wind farm developments within 2km of a Proposed Development should be considered in a cumulative shadow flicker assessment.

Table 17.2: Summary of Potential Shadow Flicker Listing for All Sensitive Receptors

Receptor ID	Maximum Scenario			Median Scenario			Minimum Scenario		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H1	44:04	07:11	00:34	42:15	06:53	00:32	40:34	06:36	00:31
H2	40:44	06:51	00:38	38:59	06:33	00:36	37:03	06:14	00:35
H3	26:58	05:37	00:33	24:47	05:14	00:30	24:39	05:08	00:31
H4	22:43	04:44	00:37	20:27	04:21	00:35	20:57	04:22	00:35
H5	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H6	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H7	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H8	00:00	00:00	00:00	04:49	01:09	00:17	00:00	00:00	00:00
H9	07:03	01:41	00:21	06:48	01:38	00:21	06:32	01:34	00:20
H10	14:57	03:12	00:20	14:33	03:07	00:19	14:10	03:02	00:19
H11	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H12	17:42	03:50	00:21	16:39	03:37	00:20	16:44	03:37	00:20
H13	42:23	09:12	00:42	40:15	08:45	00:40	37:28	08:09	00:39
H14	61:37	12:49	00:48	59:23	12:22	00:48	56:36	11:47	00:46
H15	65:01	13:28	00:49	62:55	13:02	00:49	60:12	12:29	00:48
H16	65:04	13:28	00:49	63:02	13:02	00:49	60:27	12:31	00:49
H17	55:18	10:47	00:39	53:20	10:23	00:38	50:46	09:53	00:36

Receptor ID	Maximum Scenario			Median Scenario			Minimum Scenario		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H18	69:16	13:12	00:42	66:28	12:40	00:40	63:04	12:01	00:39
H19	28:09	04:52	00:36	26:43	04:37	00:34	25:16	04:22	00:33
H20	30:51	05:13	00:36	29:03	04:54	00:34	27:28	04:39	00:33
H21	20:13	03:25	00:34	26:57	04:33	00:32	17:40	02:59	00:31
H22	48:50	07:35	00:39	46:32	07:14	00:37	44:00	06:50	00:35
H23	50:34	07:48	00:40	52:12	08:10	00:38	44:33	06:53	00:36
H24	12:48	02:05	00:23	12:05	01:58	00:22	11:36	01:54	00:21
H25	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H26	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H27	17:45	04:04	00:31	19:02	04:21	00:30	16:05	03:41	00:29
H28	16:38	03:48	00:31	19:03	04:19	00:30	15:02	03:26	00:28
H29	15:32	03:32	00:30	19:20	04:19	00:29	14:00	03:11	00:27
H30	14:29	03:20	00:28	15:03	03:26	00:27	13:07	03:01	00:25
H31	78:47	11:15	01:13	75:33	10:48	01:09	72:14	10:19	01:05
H32	15:16	02:20	00:27	14:27	02:13	00:26	13:50	02:07	00:25
H33	26:33	03:41	00:45	26:07	03:37	00:44	24:53	03:27	00:43
H34	00:00	00:00	00:00	12:12	02:32	00:19	00:00	00:00	00:00
H35	08:20	01:29	00:24	07:54	01:25	00:23	07:34	01:21	00:22
H36	00:00	00:00	00:00	04:31	01:05	00:17	00:00	00:00	00:00

Receptor ID	Maximum Scenario			Median Scenario			Minimum Scenario		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H37	00:00	00:00	00:00	07:06	01:05	00:21	00:00	00:00	00:00
H38	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H39	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H40	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H41	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H42	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H43	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H44	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H45	14:50	03:25	00:29	13:29	03:07	00:27	13:54	03:12	00:28
H46	24:25	05:02	00:38	21:45	04:34	00:35	22:24	04:37	00:36
H47	14:08	03:07	00:18	13:19	02:57	00:17	13:15	02:55	00:18
H48	10:58	02:28	00:17	10:16	02:20	00:16	10:16	02:19	00:17
H49	55:43	11:29	00:49	53:49	11:05	00:47	51:06	10:32	00:46
H50	66:49	09:52	00:57	64:46	09:34	00:55	62:08	09:11	00:53
H51	13:38	02:04	00:26	13:01	01:58	00:24	12:20	01:52	00:24
H52	20:54	02:53	00:26	20:20	02:48	00:25	19:44	02:43	00:24
H53	00:00	00:00	00:00	08:55	01:07	00:19	00:00	00:00	00:00
H54	10:54	01:49	00:27	10:22	01:44	00:26	09:56	01:39	00:25
H55	66:43	09:08	01:14	64:51	08:53	01:13	62:48	08:36	01:11

Receptor ID	Maximum Scenario			Median Scenario			Minimum Scenario		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H56	60:55	08:19	01:14	59:03	08:04	01:11	56:48	07:46	01:09
H57	09:59	01:48	00:26	09:26	01:42	00:24	09:00	01:37	00:24
H58	06:32	01:10	00:22	06:18	01:08	00:21	06:00	01:05	00:20
H59	00:00	00:00	00:00	04:30	00:48	00:19	00:00	00:00	00:00
H60	05:49	01:04	00:21	05:37	01:02	00:21	05:23	00:59	00:20
H61	05:08	00:59	00:20	04:57	00:57	00:20	04:48	00:55	00:19
H62	55:28	12:37	00:52	52:08	11:51	00:50	48:44	11:04	00:48
H63	09:28	02:11	00:20	09:08	02:07	00:20	08:47	02:02	00:19
H64	00:00	00:00	00:00	14:14	01:52	00:21	00:00	00:00	00:00
H65	00:00	00:00	00:00	12:48	01:39	00:21	00:00	00:00	00:00
H66	29:18	06:32	00:38	27:35	06:10	00:36	25:59	05:48	00:35
H67	00:00	00:00	00:00	04:14	00:48	00:19	00:00	00:00	00:00
H68	00:00	00:00	00:00	05:12	00:52	00:19	00:00	00:00	00:00
H69	56:12	08:08	01:00	54:07	07:49	00:58	51:32	07:26	00:55
H70	61:52	09:07	00:55	59:55	08:49	00:54	57:23	08:26	00:52
H71	104:18	16:05	01:11	100:25	15:29	01:10	96:39	14:53	01:08
H72	35:26	05:57	00:37	33:23	05:36	00:35	31:22	05:16	00:34
H73	24:11	04:03	00:35	33:16	05:31	00:33	20:54	03:30	00:32
H74	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00

Receptor ID	Maximum Scenario			Median Scenario			Minimum Scenario		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H75	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H76	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H77	13:21	02:03	00:26	12:42	01:57	00:26	12:17	01:53	00:25
H78	27:26	03:59	00:31	36:11	05:10	00:37	25:37	03:43	00:30
H79	37:38	05:24	00:42	43:36	06:17	00:40	35:08	05:02	00:39
H80	39:40	05:36	00:51	44:20	06:18	00:51	37:01	05:13	00:48
H81	48:45	08:07	00:38	46:41	07:46	00:36	44:36	07:25	00:35
H82	61:58	11:55	00:41	59:40	11:28	00:39	56:51	10:55	00:38
H83	54:28	11:01	00:39	52:15	10:34	00:37	49:50	10:05	00:36
H84	58:42	11:50	00:41	56:19	11:21	00:39	53:42	10:50	00:37
H85	63:25	12:45	00:42	61:09	12:17	00:40	57:51	11:38	00:38
H86	71:16	14:17	00:44	68:38	13:44	00:42	65:06	13:02	00:41
H87	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H88	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H89	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H90	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H91	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H92	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H93	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00

Receptor ID	Maximum Scenario			Median Scenario			Minimum Scenario		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H94	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H95	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H96	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H97	00:07	00:01	00:01	00:00	00:00	00:00	00:00	00:00	00:00
H98	00:00	00:00	00:00	17:28	03:48	00:21	00:00	00:00	00:00
H99	00:00	00:00	00:00	07:14	01:38	00:19	00:00	00:00	00:00
H100	00:00	00:00	00:00	12:24	02:35	00:19	06:16	01:13	00:14
H101	04:07	00:48	00:11	10:08	02:09	00:20	03:26	00:40	00:10
H102	10:27	02:22	00:25	10:29	02:24	00:25	09:33	02:10	00:23
H103	13:52	03:12	00:28	14:26	03:19	00:27	12:39	02:55	00:25
H104	19:27	04:28	00:31	20:42	04:44	00:30	17:36	04:03	00:29
H105	14:43	02:52	00:25	03:38	00:42	00:11	12:43	02:28	00:24
H106	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H107	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H108	50:23:	10:34	00:39	49:39	10:33	00:38	45:58	09:39	00:35
H109	45:50:	09:33	00:38	43:04	09:06	00:38	38:58	08:10	00:35
H110	71:33	14:42	00:44	68:31	14:04	00:43	63:05	12:57	00:41
H111	16:53	03:32	00:26	23:40	04:46	00:26	15:39	03:16	00:25
H112	97:21	18:40	00:50	96:31	18:37	00:48	88:35	17:00	00:46

Receptor ID	Maximum Scenario			Median Scenario			Minimum Scenario		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H113	76:15	14:51	00:46	73:24	14:17	00:44	69:36	13:33	00:42
H114	67:07	13:10	00:43	64:40	12:40	00:41	61:32	12:04	00:40
H115	124:59	23:49	00:54	123:41	23:40	00:52	113:49	21:41	00:50
H116	48:34	08:00	00:35	46:33	07:40	00:34	44:53	07:23	00:33
H117	35:19	05:57	00:38	33:15	05:37	00:36	31:40	05:21	00:35
H118	08:00	01:14	00:23	07:42	01:11	00:23	07:26	01:09	00:22
H119	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H120	10:25	02:30	00:24	10:03	02:24	00:24	09:38	02:18	00:23
H121	12:55	02:45	00:19	12:43	02:42	00:19	12:30	02:39	00:19
H122	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H123	17:03	03:42	00:21	16:15	03:32	00:19	16:22	03:33	00:20
H124	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H125	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H126	08:39	01:20	00:22	08:20	01:17	00:22	07:56	01:13	00:21
H127	77:31	14:15	00:40	74:29	13:41	00:38	70:45	13:00	00:36
H128	19:34	02:48	00:26	18:51	02:42	00:25	17:57	02:34	00:24
H129	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H130	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H131	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00

Receptor ID	Maximum Scenario			Median Scenario			Minimum Scenario		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H132	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H133	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H134	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H135	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H136	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H137	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H138	24:18	05:39	00:34	22:09	05:10	00:31	22:34	05:15	00:32
H139	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H140	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H141	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H142	00:00	00:00	00:00	01:23	00:19	00:06	00:00	00:00	00:00
H143	21:14	04:35	00:27	19:34	04:16	00:25	19:39	04:14	00:27
H144	113:50	21:06	00:50	114:08	21:11	00:47	105:59	19:32	00:45
H145	51:40	08:14	00:39	53:57	08:40	00:37	46:35	07:25	00:36
H146	61:41	09:59	00:44	63:16	10:19	00:42	54:37	08:49	00:40
H147	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H148	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H149	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H150	16:42	02:36	00:23	15:56	02:29	00:22	15:13	02:22	00:21

Receptor ID	Maximum Scenario			Median Scenario			Minimum Scenario		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H151	47:06	07:54	00:39	45:08	07:34	00:37	43:09	07:14	00:35
H152	30:51	04:39	00:30	29:18	04:26	00:28	27:49	04:12	00:27
H153	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H154	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H155	00:00	00:00	00:00	04:08	00:45	00:18	00:00	00:00	00:00
H156	17:34	02:37	00:30	26:17	03:45	00:29	16:17	02:25	00:28
H157	13:16	02:02	00:29	21:24	03:05	00:28	12:12	01:52	00:28
H158	49:51	06:51	01:06	52:48	07:20	01:03	46:44:00	06:25	01:02
H159	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H160	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H161	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H162	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H163	24:45	03:33	00:31	29:28	04:15	00:31	23:16	03:20	00:30
H164	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H165	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H166	89:48	16:35	00:43	86:13	15:53	00:41	82:02	15:07	00:39
H167	46:23	07:55	00:41	44:16	07:33	00:39	42:08	07:11	00:37
H168	23:19	03:52	00:31	33:04	05:16	00:29	20:14	03:22	00:29
H169	77:17	10:49	01:20	74:21	10:24	01:16	71:30	10:00	01:13

Receptor ID	Maximum Scenario			Median Scenario			Minimum Scenario		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H170	40:54	06:30	00:37	44:23	06:57	00:35	33:02	05:20	00:33
H171	00:00	00:00	00:00	10:10	01:24	00:20	00:00	00:00	00:00
H172	00:00	00:00	00:00	07:23	01:00	00:18	00:00	00:00	00:00
H173	00:00	00:00	00:00	05:16	00:42	00:15	00:00	00:00	00:00
H174	00:00	00:00	00:00	01:57	00:15	00:09	00:00	00:00	00:00
H175	18:19	03:41	00:27	25:45	04:59	00:26	16:49	03:23	00:25
H176	81:34:	14:47	00:41	79:09	14:18	00:38	76:19	13:46	00:37
H177	86:05	15:33	00:42	84:50	15:17	00:40	80:17	14:26	00:38
H178	87:32	15:45	00:43	85:38	15:22	00:41	81:32	14:35	00:39
H179	86:38	15:18	00:49	82:29	14:34	00:46	79:06	13:56	00:45
H180	40:22	06:56	00:40	38:31	06:36	00:38	36:24	06:14	00:37
H181	35:27	06:03	00:40	33:30	05:43	00:37	31:48	05:26	00:36
H182	51:57	08:10	00:40	54:36	08:40	00:37	46:36	07:20	00:36
H183	54:00	08:27	00:41	56:34	08:57	00:39	47:55	07:31	00:37
H184	54:47	08:33	00:41	57:01	09:00	00:39	48:26	07:35	00:37
H185	00:00	00:00	00:00	08:11	01:22	00:21	00:00	00:00	00:00
H186	59:25	08:44	00:48	56:39	08:19	00:46	53:53	07:54	00:44
H187	108:18	15:37	01:27	102:58	14:52	01:23	97:55	14:09	01:19
H188	53:05	07:47	00:51	50:52	07:27	00:49	48:09	07:03	00:47

Receptor ID	Maximum Scenario			Median Scenario			Minimum Scenario		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H189	39:11	05:48	00:36	37:45	05:35	00:35	35:44	05:17	00:34
H190	00:00	00:00	00:00	08:33	01:26	00:20	00:00	00:00	00:00
H191	17:12	02:26	00:25	16:41	02:21	00:24	16:05	02:16	00:23
H192	16:10	02:16	00:24	15:39	02:12	00:24	15:03	02:07	00:23
H193	00:00	00:00	00:00	10:07	01:23	00:20	00:00	00:00	00:00
H194	00:00	00:00	00:00	08:13	01:07	00:18	00:00	00:00	00:00
H195	00:00	00:00	00:00	04:39	00:50	00:19	00:00	00:00	00:00
H196	06:17	01:08	00:22	06:04	01:06	00:21	05:48	01:03	00:21
H197	06:00	01:04	00:21	05:43	01:01	00:20	05:31	00:59	00:20
H198	00:00	00:00	00:00	05:32	00:55	00:19	00:00	00:00	00:00
H199	00:00	00:00	00:00	12:52	01:49	00:21	00:00	00:00	00:00
H200	09:06	01:27	00:25	08:41	01:23	00:24	08:20	01:19	00:23
H201	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H202	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H203	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H204	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H205	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H206	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H207	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00

Receptor ID	Maximum Scenario			Median Scenario			Minimum Scenario		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H208	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H209	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H210	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H211	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H212	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H213	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H214	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H215	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H216	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H217	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H218	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H219	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H220	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H221	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H222	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H223	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H224	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H225	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00

Receptor ID	Maximum Scenario			Median Scenario			Minimum Scenario		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H226	29:38	06:23	00:38	21:46	04:40	00:31	27:09:00	05:50	00:36
H227	24:43	05:08	00:35	22:01	04:39	00:33	22:04	04:35	00:33
H228	14:57	03:15	00:21	14:03	03:03	00:19	14:11	03:05	00:19
H229	09:50	02:22	00:24	09:31	02:18	00:24	09:06	02:12	00:23
H230	08:13	01:52	00:24	07:55	01:48	00:23	07:36	01:44	00:23
H231	09:17	01:40	00:25	08:47	01:35	00:24	08:23	01:31	00:23
H232	11:40	02:06	00:27	11:00	01:59	00:26	10:27	01:53	00:25
H233	51:22	08:19	00:51	47:41	07:44	00:48	45:02	07:18	00:46
H234	35:19	05:06	00:39	34:24	04:58	00:37	33:00	04:45	00:37
H235	40:01	05:46	00:37	47:43	06:43	00:55	36:56	05:19	00:34
H236	40:59	05:55	00:37	47:54	06:45	00:54	37:45	05:26	00:35
H237	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H238	69:07	14:38	00:55	48:36	09:57	00:52	61:45	13:03	00:50
H239	44:51	09:37	00:37	40:15	08:26	00:35	40:53	08:46	00:34
H240	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H241	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H242	51:03	10:21	00:38	49:11	09:58	00:36	46:58	09:32	00:35
H243	77:57	16:34	00:44	75:46	16:07	00:42	72:29	15:25	00:41

Receptor ID	Maximum Scenario			Median Scenario			Minimum Scenario		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H244	30:56	06:42	00:32	29:53	06:35	00:32	27:31	05:59	00:30
H245	33:40	07:17	00:33	33:16	07:17	00:32	30:37	06:38	00:30
H246	00:00	00:00	00:00	05:03	00:50	00:19	00:00	00:00	00:00
H247	00:00	00:00	00:00	05:31	01:20	00:18	00:00	00:00	00:00
H248	05:36	01:03	00:21	05:20	01:00	00:20	05:11	00:58	00:20
H249	05:45	01:04	00:21	05:32	01:01	00:21	05:23	01:00	00:20
H250	00:00	00:00	00:00	04:59	00:54	00:19	00:00	00:00	00:00
H251	05:33	01:00	00:21	05:19	00:58	00:20	05:02	00:55	00:19
H252	06:41	01:07	00:22	06:26	01:04	00:21	06:10	01:02	00:20
H253	00:00	00:00	00:00	05:44	00:57	00:20	00:00	00:00	00:00
H254	07:09	01:11	00:22	06:48	01:08	00:21	06:38	01:06	00:21
H255	00:00	00:00	00:00	08:08	01:15	00:20	00:00	00:00	00:00
H256	00:00	00:00	00:00	09:58	01:27	00:20	00:00	00:00	00:00
H257	00:00	00:00	00:00	09:41	01:29	00:21	00:00	00:00	00:00
H258	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H259	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H260	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H261	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H262	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00

Receptor ID	Maximum Scenario			Median Scenario			Minimum Scenario		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H263	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H264	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H265	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H266	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H267	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H268	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H269	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H270	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H271	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H272	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H273	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H274	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H275	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H276	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H277	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H278	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H279	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H280	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H281	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00

Receptor ID	Maximum Scenario			Median Scenario			Minimum Scenario		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H282	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H283	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H284	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H285	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H286	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H287	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H288	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H289	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H290	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H291	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H292	30:56	07:11	00:36	28:15	06:33	00:34	29:05	06:44	00:34
H293	10:19	02:18	00:25	10:55	02:29	00:24	09:10	02:03	00:24
H294	20:14	04:22	00:22	20:42	04:31	00:21	19:24	04:11	00:22
H295	19:55	04:19	00:20	18:45	04:05	00:19	18:40	04:03	00:19
H296	00:00	00:00	00:00	05:45	01:20	00:17	00:00	00:00	00:00
H297	07:30	01:46	00:20	07:15	01:42	00:20	07:00	01:39	00:19
H298	08:01	01:54	00:21	07:40	01:49	00:20	07:24	01:46	00:20
H299	08:27	02:00	00:24	08:07	01:55	00:23	07:50	01:51	00:22
H300	08:03	01:53	00:23	07:51	01:50	00:23	07:27	01:45	00:22

Receptor ID	Maximum Scenario			Median Scenario			Minimum Scenario		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H301	09:16	02:10	00:25	09:03	02:07	00:25	08:36	02:00	00:23
H302	09:28	02:10	00:25	08:58	02:03	00:24	08:38	01:59	00:24
H303	08:29	01:35	00:25	07:59	01:29	00:24	07:43	01:26	00:23
H304	10:35	01:55	00:26	10:01	01:49	00:25	09:32	01:44	00:24
H305	12:02	02:00	00:28	11:23	01:53	00:27	10:56	01:49	00:26
H306	22:19	03:37	00:36	21:38	03:30	00:35	19:43	03:12	00:33
H307	41:46	06:42	00:48	43:03	07:02	00:46	40:38	06:38	00:44
H308	50:08	06:52	01:07	48:45	06:40	01:06	46:56	06:25	01:03
H309	33:39	04:52	00:37	32:48	04:44	00:36	31:22	04:32	00:35
H310	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H311	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H312	46:51	09:27	00:37	45:14	09:07	00:35	42:57	08:40	00:34
H313	58:13	11:53	00:45	55:58	11:26	00:44	53:07	10:51	00:42
H314	64:01	13:13	00:51	62:04	12:49	00:51	59:09	12:13	00:50
H315	76:56	16:37	00:44	74:45	16:09	00:42	71:22	15:26	00:40
H316	74:16	15:36	00:44	71:42	15:04	00:42	68:03	14:18	00:41
H317	57:56	11:57	00:40	56:13	11:39	00:39	53:01	10:55	00:39
H318	39:14	08:11	00:31	37:47	07:58	00:30	35:00	07:19	00:29
H319	33:29	07:09	00:33	32:04	06:58	00:32	28:56	06:13	00:30

Receptor ID	Maximum Scenario			Median Scenario			Minimum Scenario		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H320	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H321	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H322	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H323	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H324	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H325	39:37	07:50	00:34	38:19	07:35	00:33	36:41	07:16	00:32
H326	12:22	02:49	00:27	12:29	02:52	00:26	11:11	02:33	00:25
H327	11:26	02:35	00:27	11:33	02:38	00:26	10:31	02:23	00:24
H328	09:57	02:14	00:25	10:02	02:16	00:24	09:03	02:02	00:23
H329	09:21	02:06	00:24	09:23	02:06	00:24	08:35	01:56	00:23
H330	07:54	01:45	00:22	07:33	01:41	00:21	06:50	01:32	00:21
H331	02:36	00:30	00:08	08:56	01:56	00:21	08:07	01:46	00:19
H332	08:58	02:01	00:21	13:07	02:57	00:21	08:20	01:52	00:20
H333	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H334	41:58	08:27	00:35	40:39	08:10	00:34	38:42	07:47	00:33
H335	40:32	08:06	00:34	39:14	07:50	00:33	37:23	07:28	00:32
H336	37:43	07:28	00:33	36:20	07:12	00:32	34:38	06:52	00:31
H337	28:58	05:57	00:32	33:49	06:43	00:31	26:41	05:29	00:30
H338	20:53	04:23	00:29	28:54	05:50	00:28	19:14	04:02	00:27

Receptor ID	Maximum Scenario			Median Scenario			Minimum Scenario		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H339	13:51	03:10	00:28	17:39	03:56	00:27	12:28	02:51	00:26
H340	13:00	02:58	00:28	18:21	04:02	00:27	11:52	02:42	00:26
H341	08:51	01:43	00:17	14:43	03:03	00:20	08:07	01:34	00:16
H342	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H343	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H344	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H345	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H346	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H347	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H348	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H349	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H350	59:21	12:16	00:50	57:33	11:54	00:49	54:38	11:18	00:48
H351	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H352	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H353	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H354	00:00	00:00	00:00	06:39	00:49	00:17	00:00	00:00	00:00
H355	00:00	00:00	00:00	06:41	01:34	00:18	00:00	00:00	00:00
H356	62:08	12:10	00:42	59:52	11:43	00:40	57:03	11:11	00:39
H357	05:37	01:05	00:13	11:18	02:22	00:20	04:59	00:58	00:12

Receptor ID	Maximum Scenario			Median Scenario			Minimum Scenario		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H358	79:21	15:04	00:44	76:01	14:25	00:42	72:11	13:42	00:40
H359	00:00	00:00	00:00	12:25	02:26	00:21	00:00	00:00	00:00
H360	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H361	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H362	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H363	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H364	05:54	01:09	00:22	10:45	02:15	00:21	05:29	01:04	00:20
H365	07:50	01:31	00:16	14:02	02:56	00:21	13:07	02:44	00:19
H366	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H367	26:01	04:19	00:33	36:29	05:49	00:31	22:14	03:42	00:30
H368	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H369	55:29	10:56	00:40	53:42	10:35	00:39	51:12	10:06	00:37
H370	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H371	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H372	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H373	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
St. Patrick's N.S	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
H374	87:12:00	18:22	01:13	47:02	09:27	00:57	73:40	15:27	01:05

In the Median Scenario, it can be demonstrated from **Table 17.2**, there will be 227 receptors out of 375 that will experience some degree of shadow flicker and 148 receptors that will experience no shadow flicker. The Median Scenario impacts the most sensitive receptors and has the median overall hours of flicker per year, at 389 hours 01 minutes. H115 is expected to experience 23 hours 40 minutes of shadow flicker in a year, which is the worst affected occupied receptor. 111 sensitive receptors exceed the 2006 Guidelines of a maximum 30 minutes of shadow flicker per day, however no receptors are within 500m of any turbine. The closest receptor, H374, is within 552m of the closest turbine (T03). This has 09 hours 27 minutes of expected shadow flicker per year, and a maximum of 57 minutes of shadow flicker per day.

In the Maximum Scenario, it can be demonstrated from **Table 17.2**, there will be 191 receptors out of 375 that will experience some degree of shadow flicker and 184 receptors that will experience no shadow flicker. The Maximum Scenario and the Minimum Scenario both impact the least number of sensitive receptors. The Maximum Scenario has the highest overall hours of flicker per year, at 393 hours 17 minutes. H115 is expected to experience 23 hours 49 minutes of shadow flicker in a year, which is the worst affected occupied receptor. 115 sensitive receptors exceed the 2006 Guidelines of 30 minutes of shadow flicker per day. The closest receptor, H374, is within 552m of the closest turbine (T03). This has 18 hours 22 minutes of expected shadow flicker per year, and a maximum of 1 hour and 13 minutes of shadow flicker per day.

In the Minimum Scenario, it can be demonstrated from **Table 17.2**, there will be 191 receptors out of 375 that will experience some degree of shadow flicker and 184 receptors that will experience no shadow flicker. The Minimum Scenario has the lowest overall hours of flicker per year, at 381 hours 48 minutes. H115 is expected to experience 21 hours 41 minutes of shadow flicker in a year, which is the worst affected occupied receptor. 107 sensitive receptors exceed the 2006 Guidelines of 30 minutes of shadow flicker per day. The closest receptor, H374, is within 552m of the closest turbine (T03). This has 15 hours 27 minutes of expected shadow flicker per year, and a maximum of 1 hour and 05 minutes of shadow flicker per day.

None of the receptors are expected to experience the 2006 Guidelines recommendation of 30 hours or more of shadow flicker per year in any of the scenarios.

The calculated worst-case shadow flicker occurrences in the **Table 17.2** assumes the sun is always shining, that there is no cloud cover, the turbines are rotating and the sensitive receptor is always occupied. As previously stated, this calculation is based on topography alone and excludes vegetation, buildings and other man-made structures. As can be seen in the shadow flicker assessment attached as **Appendix 17.1** all of the proposed turbines give rise to some degree of cumulative shadow flicker, if unmitigated.

17.2.7 Assessment of Expected Shadow Flicker Impact

In order to calculate more realistic and '*real world*' occurrences of shadow flicker for the receptors that are identified as potentially vulnerable to shadow flicker (**Table 17.2**), it is necessary to identify the likely meteorological conditions which are expected to be experienced at the Wind Farm 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 Dublin Airport meteorological observatory was used as this Met Éireann observatory is the closest to the Wind Farm Site and also measures multiple environmental parameters (**Table 17.3**). This gives a good representation of data for the Proposed Development. This data was utilised to consider the probability of sunshine occurrence, and thus allow the determination of '*projected*' values for shadow flicker occurrence.

Table 17.3. Average daily sunshine hours from Dublin Airport

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.96	2.27	3.21	4.94	6.07	5.43	5.34	5.06	4.08	3.10	2.29	1.56

The worst-case predicted hours for shadow flicker are reduced by the average time the weather is cloudy annually. As discussed above, 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. This allows 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. 'Long term average sunshine hours' refers to data collected by Met Éireann.

Table 17.2 shows the potential and the expected shadow flicker values per year which are likely to be experienced by each receptor. '*Potential sunshine hours'* refers to the intervening time period between modelled sunrise and sunset. Although the projected duration of shadow flicker is reduced substantially for each sensitive receptor, they are not eliminated entirely for all of the 375 receptors within the shadow flicker Study Area of the Proposed Development. The shadow flicker results showed that for the Maximum Scenario turbine parameters, 115 receptors (30.6%) would have a maximum shadow flicker over 30 minutes per day. The Median Scenario turbine parameters, 111 receptors (29.6%) would have a maximum shadow flicker over 30 minutes per day. The Minimum Scenario turbine parameters, 107 receptors (28.5%) would have a maximum shadow flicker over 30 minutes per day. This exceeds the 2006 Wind Energy Development Guidelines of a maximum of 30 minutes of shadow flicker per day on receptors within 500m of a turbine. However, there are no receptors within 500m of any turbine.

The expected daily shadow flicker cannot be predicted as this depends on multiple variable factors such as wind direction, wind speed, cloud cover and sunshine. These factors cannot be accurately predicted to give an expected minutes of shadow flicker per day. The maximum scenario in this assessment is based on the average sunshine and average wind direction for the Wind Farm Site.

The Draft Revised Wind Energy Development Guidelines, December 2019, recommend that shadow flicker should not affect any sensitive receptor, therefore the relevant turbine (or turbines) must be shut down on a temporary basis until the potential for shadow flicker ceases. The mitigation measures to avoid exceedance of the 2019 Guideline's thresholds is outlined in **Section 17.2.9**.

17.2.8 Cumulative Effects

The IWEA Guidelines recommend that all existing and / or permitted wind farm developments within 2km of a proposed development should be considered in a cumulative shadow flicker assessment, however, the key factor to determine whether cumulative effects may occur is whether receptors are located within the Shadow Flicker Study Area of 10 times the rotor diameter for the Proposed Wind Farm.

Cumulative shadow flicker effects could arise if sensitive receptors are at risk from potential shadow flicker effects as a result of more than one wind farm. While separate wind farms are not likely to cause effects simultaneously, they could increase the cumulative total hours where a receptor is affected. In this instance, there are no proposed or operational wind farms within a 2km range of the turbines that may cause cumulative effects.

17.2.9 Mitigation Measures & Residual Effects

17.2.9.1 Likely Evolution of the Baseline

The shadow flicker effect is related to the operational phase of a wind farm. If the Proposed Development were not to proceed, the effects described in this chapter will not occur.

17.2.9.2 Construction Phase

As previously stated, the shadow flicker effect is associated with the operational phase of the wind farm and has been scoped out for the construction phase. During construction there will be no shadow flicker effect and therefore no mitigation is required.

17.2.9.3 Operational Phase

Shadow flicker control systems, consisting of light sensors and specialised software, will be installed on each of the wind turbines. The control system will calculate, in real-time:

- Whether shadow flicker has the potential to effect nearby sensitive receptors, based on pre-programmed co-ordinates for the sensitive receptors and turbines;
- Wind speed (can affect how fast the turbine will turn and how quickly the flicker will occur);
- Wind direction; and
- The intensity of the sunlight.

When the control system detects that the sunlight is strong enough to cast a shadow, and the shadow falls on a sensitive receptor or receptors, then the turbine will automatically shut down; and will restart when the potential for shadow flicker ceases at the effected receptors. Such systems are common in many wind farm developments and the technology has been well established. A case study in Scotland found that the use of turbine shut-down control modules for turbines which were causing shadow flicker at nearby offices was successful.

The proposed method of mitigation will be used to eliminate all shadow flicker effects resulting in zero shadow flicker, allowing for approximately 60 seconds for the rotor to come to a stop. This will eliminate the potential for shadow flicker to affect any of the sensitive receptors within the Study Area. This will be the case regardless of which turbine is selected within the proposed turbine range. **Appendix 17.1** contains all calculated potential shadow flicker periods for each turbine for each scenario, which covers the range of shadow flicker effects that may occur across the range of proposed turbine dimensions. The relevant data (depending on which scenario is constructed) will be input into the turbine control software. Where the final turbine specification does not match exactly with one of the three modelled scenarios an additional shadow flicker model will be run with the finalised dimensions. In the event that complaints of shadow flicker are received by the Developer / site operator or by Louth County Council, the Developer will conduct an investigation and the complaints frequency, duration and time of complaints will be considered and specialist modelling software will be used to confirm the occurrence(s). Should the complaint persist, a shadow flicker survey involving the collection of light data will also be carried out at the receptor in which the complaint was made. Further refinement of the blade shadow control system will be conducted to eliminate the shadow flicker occurrence. This could result in the shutting off turbines at specific times of day.

17.2.9.4 Decommissioning Phase

As previously stated, the shadow flicker effect is associated with the operational phase of the wind farm and has been scoped out for the Decommissioning phase. During Decommissioning there will be no shadow flicker effect and therefore no mitigation is required.

17.2.9.5 Residual Effects

The results of the shadow flicker assessment predict that Kellystown Wind Farm has the potential to result in shadow flicker at a maximum of 227 receptors surrounding the Wind Farm Site. The implementation of mitigation to cease operation of the turbines during periods of potential shadow flicker will ensure that no shadow flicker effects are experienced at any sensitive receptor within the Study Area. It is therefore considered that Kellystown Wind Farm will comply with the Draft 2019 Guidelines of no shadow flicker at neighbouring sensitive receptors within the Study Area. Following implementation of mitigation measures described in **Section 17.2.9.2**, the residual impact as a result of shadow flicker will be a **neutral, imperceptible, long-term effect**. Accordingly, it is considered that there will be no residual impact as a result of shadow flicker.

17.3 SUMMARY OF SIGNIFICANT EFFECTS

This chapter has assessed the significance of potential effects of the Proposed Development on shadow flicker.

This assessment has identified the potential for shadow flicker to affect 227 no. out of 375 no. receptors within the shadow flicker Study Area. It is proposed that a shadow control system be installed to eliminate the potential for shadow flicker from the Proposed Development. This assessment has identified that by installing a blade shadow control system on the proposed turbines, there will be no significant direct or indirect effects. Given that only effects of significant impact or greater are considered "significant" in terms of the EIA Directive the potential effects of the Proposed Development as a result of shadow flicker, when mitigated, are considered to be not significant. The Development has been assessed as having the potential to result in **neutral, imperceptible, long-term effects** overall with regards to shadow flicker. There are no predicted cumulative effects.

17.4 REFERENCES

Department of Housing, Planning and Local Government, *Draft Revised Wind Energy Development Guidelines* (2019)

Department of the Environment, Heritage and Local Government, *Wind Energy Development Guidelines* (2006)

Irish Wind Energy Association & Wind Skillnet, *Best Practice Guidelines for the Irish Wind Energy Industry* (2012)