Technical Appendix 5.2: Aviation Lighting Night-Time Impact Assessment

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Introduction

In the interests of aviation safety, structures of 150 m or more in height, including wind turbines, require steady red visible medium intensity aviation lighting, as set out in Civil Aviation Authority (CAA) guidance (CAA, 2016). As the Proposed Development will comprise wind turbines up to 200 m to blade tip height, there is a requirement for visible aviation lighting, which may be perceptible to receptors (people) from locations across the study area. The introduction of visible aviation lighting in rural locations, where there are fewer sources of artificial lighting and where darkness or dark skies may be an integral and valued aspect of the landscape, could lead to potentially significant landscape and visual effects at night.

This appendix is not a technical appraisal of lighting. The Applicant commissioned a specialist aviation consultant, Wind Power Aviation Consultants (WPAC), to develop an aviation lighting scheme for the Proposed Development that complies with the relevant guidance. The aviation lighting scheme was approved by the CAA on 10th February 2025. This is set out in the Wind Farm Aviation Lighting and Mitigation Technical Appendix for Appin Wind Farm, which is presented in **Volume 4**, **Technical Appendix 4.6** of the EIA Report. The assessment of the landscape and visual effects of visible aviation lighting in this appendix is therefore based on the approved lighting scheme.

This technical appendix sets out the background to the requirements for visible aviation lighting, followed by an assessment of landscape and visual effects arising for representative receptors across the study area. Receptors considered in the assessment are identified in the Landscape and Visual Impact Assessment (LVIA) contained in **Chapter 5: Landscape and Visual Amenity**. The assessment of effects of aviation lighting on residential visual amenity is considered separately in **Technical Appendix 5.3: Residential Visual Amenity Assessment**. This appendix should be read with reference to **Chapter 5: Landscape and Visual Amenity** and the accompanying visualisations (**Figures 5.14k-l**, **Figures 5.17g-h,** and **Figures 5.19g-h**) presented in **Volume 3**, along with **Technical Appendix 5.1: LVIA and Visualisation Methodology**. **Figures A5.2.1 - A5.2.3** accompany this appendix.

In August 2021, the Scottish Government established the Aviation Lighting Guidance Working Group (Scottish Government, 2021) to develop guidance to ensure that landscape and visual impacts of visible aviation lighting systems are assessed consistently. LUC contributed to the development of the guidance with direct representation on the working group. The final guidance was published collaboratively by the Scottish Government and NatureScot in November 2024 and sets out a three step process to be taken to the assessment of landscape and visual effects associated with visible aviation lighting (NatureScot, 2024). The three steps are defined as follows:

- Step 1 – Defining the lighting proposal;
- Step 2 – Understanding the baseline; and
- Step 3 – Assessing the effects.

The approach taken and scope of this assessment are considered to be consistent with the guidance.

Regulatory Background

The regulatory background to the requirements for visible aviation lighting on wind turbines is outlined in detail in Technical **Appendix 4.6** and summarised below.

Aviation Lighting Requirements

Article 222 of the Air Navigation Order 2016 sets out the statutory requirement for the lighting of 'en-route obstacles', which applies to structures of 150 m or more above ground level. The Article states: "*The person in charge of an en-route obstacle must ensure that it is fitted with medium intensity steady red lights positioned as close as possible to the top of the obstacle and at intermediate levels spaced so far as practicable equally between the top lights and ground level with an interval of not more than 52 metres*." (UK Government, 2016)

This article is incorporated into the CAA's Policy Statement on the lighting of onshore wind turbines, which states: "*The person in charge of the wind turbine generator must ensure that it is fitted with a medium intensity (2000 candela) red light positioned as close as practicable to the top of the fixed structure. A second light serving as an alternative should be provided in case of failure of the operating light*" (CAA, 2017). In practice, this means the installation of lights on the top surface of the turbine nacelle.

The CAA Policy Statement includes provision for the medium intensity 2000 candela (cd)[1] lights to be controlled by visibility sensors that may reduce the intensity of the light to not less than 10 % of the minimum peak intensity (i.e. 200 cd) in times of clear meteorological conditions, where visibility exceeds 5 km in all directions (as measured on sensors on the turbine hubs).

Additionally, the CAA requires that *"at least three (to provide 360-degree coverage) low-intensity Type B6 lights (32 candela) lights should be provided at an intermediate level of half the nacelle height."*

Lighting Specification

The International Civil Aviation Organisation (ICAO) Code – Annex 14, Table 6-3 (ICAO, 2018) sets out the specification requirements for medium-intensity obstacle lights (reproduced in Table 2 of **Technical Appendix 4.6**). These requirements vary at different vertical angles of elevation, relative to the lighting horizontal plane, which in this case will be the nacelle height of the wind turbines. The intensity of the light emitted from an aviation obstruction light is designed to vary with the observed angle. It aims to be at its brightest when observed from a similar level or just above (i.e. projecting horizontally), but less bright as the observer falls significantly below or above the light. Different manufacturers produce lights with slightly varying characteristics, though broadly similar in complying with the minimum requirements, and maximum recommendations, of these international standards.

Perception of Light

The main effect of aviation lighting comes from visibility of the aviation lights. This type of lighting will not cause sky glow, but can contrast with natural darkness, and can draw attention. In clear conditions they are generally seen as sharply defined points of red light, especially when seen against a dark sky or dark landform or where seen in landscapes with little or no existing sources of artificial light present.

The human perception of light intensity over distance follows an inverse square relationship, meaning that as the distance increases, the light must spread out over a larger surface and the surface brightness decreases. Although the actuality of the lights remains constant, the apparent light intensity (brightness) and size of a light source as perceived by people will vary dependent on distance, angle of view, and atmospheric conditions. As distances increase, the light source will appear smaller. As atmospheric conditions become less clear (a reduction in clarity with increased humidity, rain, drizzle, snow, or the presence of haze, mist, fog, or a low cloud base etc.) the brightness will appear reduced. Clarity varies at different levels within the sky, and across different places. Decline in brightness over distance is not uniform.

The brightness at which lights are perceived also depends on the background against which they are seen. They may seem brighter because of the stronger contrast when there is no moonlight for example, or when they are seen against a dark landmass rather than against a sky where there is some residual twilight. Perception of red lights by humans in periods of low light and darkness is also variable from person to person, and therefore what the eye sees in practice at night is very inconstant.

Perception of light by receptors is also subject to the type of activity being undertaken. In rural areas, many activities at night are likely to involve some form of personal light for safety, such as a headtorch, which inhibits the optical process of 'dark adaptation'. Dark adaptation is associated with chemical changes in the eye. This is a relatively slow process and can typically take up to 30 minutes of exposure to darkness for human vision to adapt. Any, even short exposure to bright light (such as street lighting within a settlement or car headlights), resets the dark adaptation process. As such, a fully dark adapted state is more likely for the generally fewer receptors who purposefully seek out dark skies and the absence of artificial lighting, for activities such as stargazing (NatureScot, 2024).

Due in part to this variability in the way that the human eye can perceive light during periods of low light and darkness, it is considered that no aviation lighting visualisation will ever be able to consistently replicate what individuals may experience in the field and should therefore only be used as a tool to aid understanding of potential effects, and not as a replacement for observations made in the field.

Potential Mitigation

A number of potential mitigation options are currently available or are being developed by the wind energy sector in collaboration with the CAA and other stakeholders. Mitigation options which may have the potential to influence the resultant landscape and visual effects which may occur from the introduction of visible aviation lighting are outlined below. Many of these mitigation measures have been available to developers for some time and have been relied upon for the assessment and determination of numerous other wind energy developments, including in relatively close proximity to sensitive locations in the UK such as nationally designated landscapes and internationally designated dark sky parks.

[1] Candela (cd) is the measurement of luminous intensity (i.e. light emitted in a particular direction by a light source) Note: a candle emits light with a luminous intensity of roughly one cd.

Reducing the Number of Lights

As an alternative to lighting all turbines, the lighting of cardinal or peripheral turbines (i.e. those located at the outer extremities of a wind farm development) is an established mitigation option for wind farms and is allowed for under the provisions of ANO Article 222 (7). In addition, the requirement for low intensity lights at mid-mast level can often be removed, with CAA agreement.

In the case of the Proposed Development, WPAC has developed a reduced lighting scheme, with four of the nine turbines lit and no low intensity lights at mid-tower level. The reduced lighting scheme was approved by the CAA on 10th February 2025 and is set out in Appendix C of **Technical Appendix 4.6** (paragraph 5).

Intensity Reduction (Automatic Dimming)

The CAA Policy Statement includes provision for the medium-intensity 2000 cd lights to be controlled by visibility sensors that may reduce the intensity of the light to not less than 10 % of the minimum peak intensity (e.g. 200 cd) in times of clear meteorological conditions (if the horizontal meteorological visibility in all directions from every wind turbine in the group is more than 5 km).

This is achieved with the installation of a sensors on wind turbines within different parts of a wind farm. These sensors measure prevailing atmospheric conditions and visibility range. Where atmospheric conditions limit visibility (based on measurements local to the site of the sensor) to distances of less than 5 km in any direction (e.g. through the presence of low cloud cover, rain, mist, haze or fog) the lights are illuminated at the necessary 2000 cd. Therefore, 2000 cd lights will normally only be seen near to their fullest intensity in closer views (i.e. somewhat less than 5 km), or perhaps due to a local patch of poor visibility (e.g. localised mist or rain) at a sensor based on the wind farm. Whilst possibly still visible in such conditions, the perceptibility of the lights is likely to be much reduced, and typically not visible at distances greater than 5 km.

This form of mitigation is permitted in the UK by the CAA through the 2017 policy statement (and does not therefore require project-specific approval from the CAA), and forms part of the Proposed Development.

Vertical Directional Intensity

Vertical directional intensity mitigation (sometimes called ‘narrow vertical beam spread’ or ‘angle intensity mitigation’) comprises the use of particular aviation lights that have greater control of the light intensity emitted at certain angles above and below the horizontal plane. It can be a very effective form of mitigation, especially in reducing potential effects for receptors located at lower elevations relative to the aviation lights but can be less effective for elevated or more distant receptors at similar vertical elevations towards which a greater luminous intensity may be emitted.

Aviation lighting is required to operate at the minimum intensities defined in ICAO, across a relatively narrow (3°) vertical beam spread, projecting horizontally from the nacelle light, between -1° to +2°, as explained in ICAO Table 6-3. Individual lights have slightly varying characteristics, though broadly similar in complying with international standards with sharply declining intensity when viewed from a lower level.

The emitted luminous intensity of a light mounted on the turbine nacelle therefore reduces at vertical angles below the horizontal plane. This results in a reduction in visible lighting at elevations of less than -1° vertical angle. That is to say, the light will appear less bright to an observer looking up at the nacelle from below, than it will to an observer at the same elevation as the nacelle. The intensity at angles below -1° may also vary dependent on the specific obstacle lighting manufacturer’s specification.

As such, this embedded mitigation within the design of the lights has the potential to substantially reduce the extent and perceived intensity of lights visible when viewed from different elevations (effectively the angle of view), when seen from either below (lower elevations) or above (higher elevations) the height of the turbine hub. A lighting intensity Zone of Theoretical Visibility (ZTV) can be helpful to illustrate the potential mitigation from an assumed aviation light, to demonstrate how light emissions may reduce relative to vertical angle from the horizontal plane, and is shown in **Figure A5.2.2** (to 45 km) and **Figure A5.2.3** (to 20 km).

There is no need to seek project-specific approval from the CAA for this form of mitigation, and it forms part of the Proposed Development.

Radar or Transponder Activated Lighting

ICAO Annex 14 also details guidance on ‘Visual Aids for Denoting Obstacles’. With specific reference to mitigation of effects on visual amenity, Note 2 outlines that “*An autonomous aircraft detection system may be installed on or near an obstacle (or group of obstacles such as wind farms), designed to operate the lighting only when the system detects an aircraft approaching the obstacle, in order to reduce light exposure to local residents*.”

A number of manufacturers have developed radar activated aviation lighting systems (aviation obstruction lighting detection system), whereby the lights would only be switched on when aircraft approach within a specified airspace zone, and this technology is currently permitted by aviation authorities in EU countries, including Germany (Federal Aviation Office) and the Netherlands (Netherlands Aerospace Centre), as well as the United States (Federal Aviation Authority).

This technology is not currently approved by the CAA and as such is not considered further as a potential mitigation option in this assessment.

Proposed Aviation Lighting Scheme and Embedded Mitigation

Due to the height of the proposed turbines (200 m to blade tip) visible aviation safety lighting is required. The proposed aviation lighting scheme which forms the basis of this assessment has been developed by WPAC and agreed with the CAA. It is described in detail in **Technical Appendix 4.6** and summarised below:

- Two medium intensity red lights on the nacelles of T1, T2, T5 and T9 (four turbines in total). The secondary light on each turbine is fitted for use in the event of failure of the primary light, and will not be lit concurrently;
- Infra-red lights (not visible to the naked eye) to Ministry of Defence specification on the nacelles of all nine turbines; and
- No intermediate level red lights (32 cd), located on turbine towers, are proposed as part of this lighting scheme.

The Applicant is committed to the implementation of intensity reduction (automatic dimming) mitigation, as described above, of the medium-intensity aviation lights to be installed on the Proposed Development. This will therefore allow for the 2000 cd lights to be dimmed to not less than 10 % of the minimum peak intensity (i.e. 200 cd) when horizontal meteorological visibility exceeds 5 km.

As set out in **Technical Appendix 4.6**, Met Office tables indicate that visibility is below 5 km for an average of 2 % of the time at Prestwick Airport. This suggests that the lights of the Proposed Development will operate (i.e. be illuminated) at 2000 cd for approximately 2 % of the time (visibility below 5 km) and operate at the equivalent of not less than 10 % of the minimum peak intensity (i.e. 200 cd) when visibility is greater than 5 km for approximately 98 % of the time. This situation is considered to represent the most reasonable maximum effect (i.e. worst case) scenario, and the predominant state in which the lights will be experienced by people across the study area.

Lights will operate between evening civil twilight (approximately 30 minutes after sunset) and morning civil twilight (approximately 30 minutes before sunrise). **Technical Appendix 4.6** notes that this will equate to approximately 11 hours per day, on average over the year, with longer durations throughout winter and shorter durations throughout summer (paragraph 18).

Lighting Specification

The Applicant is also committed to the implementation of vertical directional intensity mitigation comprising the use of aviation lights that are designed to operate close to the minimum required intensities (as discussed above). At the present time neither the proposed manufacturer or precise model and specification of aviation light to be used on the Proposed Development is known. Although the precise details of performance, and thus the mitigation delivered, will vary according to the exact manufacturer and light used, the principles as assumed in **Technical Appendix 4.6** will apply (i.e. decline in intensity with increased or decreased angle from the horizontal plane), and these are referred to in the assessment where relevant.

Technical Appendix 4.6 refers to a specific model of light that meets the ICAO requirements (the 'CEL-WT-MIC). **Table 1** below sets out the specific maximum and minimum luminous intensity values emitted at different vertical angles of elevation, as derived from the manufacturer's specification and performance statistics (CEL Aviation Lighting, 2024). Values of lights provided by other manufacturers may be different but would be comparable to comply with the ICAO requirements.

To deliver vertical directional intensity mitigation, the light uses the latest finely tuned LEDs which are designed to minimise the spillage and over-brightness, and the vertical beam spread is minimised, with the brightest beam between -1˚ and +2˚. It is important to note that aviation lights exceed the minimum requirement in the centre of the beam spread (at 0° to 1˚), as it is difficult to meet the average intensity requirement (2000 cd) across the full range of the minimum beam spread (between -1˚ and +2˚). As such, the maximum cd values between -1° and +2° listed in **Table 1** below slightly exceed 2000 cd and 200 cd respectively.

The specified aviation warning light has informed the production of the lighting intensity ZTVs (**Figure A5.2.2** and **Figure A5.2.3**, illustrating theoretical visibility over a 45 km and 20 km radius respectively). This illustrates the often much reduced luminous intensity emitted at specific vertical elevation angles, towards particular viewpoints.

Table 1 – Maximum and Minimum Luminous Intensity Relative to Viewing Angle – CEL-WT-MIC light

Vertical Angle of Lighting from Nacelle	Maximum Luminous Intensity (cd)	Minimum Luminous Intensity (cd)	Maximum Luminous Intensity at 10 % (cd)	Minimum Luminous Intensity at 10 % (cd)
Above 5°	147 cd	34 cd	15 cd	3 cd
4° to 5°	247 cd	134 cd	25 cd	13 cd
3° to 4°	481 cd	237 cd	48 cd	24 cd
2° to 3°	1160 cd	481 cd	116 cd	48 cd
1° to 2°	2119 cd	1170 cd	212 cd	117 cd

Vertical Angle of Lighting from Nacelle	Maximum Luminous Intensity (cd)	Minimum Luminous Intensity (cd)	Maximum Luminous Intensity at 10 % (cd)	Minimum Luminous Intensity at 10 % (cd)
0° to 1°	2206 cd	1968 cd	221 cd	197 cd
-1° to 0°	2036 cd	987 cd	204 cd	99 cd
-2° to -1°	996 cd	383 cd	100 cd	38 cd
-3° to -2°	394 cd	197 cd	39 cd	20 cd
-4° to -3°	199 cd	131 cd	20 cd	13 cd
-5° to -4°	131 cd	92 cd	13 cd	9 cd
Below -5°	94 cd	38 cd	9 cd	4 cd

Approach to Assessment of Lighting Effects

The assessment of effects arising from lighting follows the same approach detailed in **Technical Appendix 5.1**. It is important to note that the assessment is not a technical lighting assessment based on a quantitative measurement of light levels; it relies on professional judgement of what the naked human eye can reasonably perceive in the context of the baseline situation with regard to existing sources of artificial lighting.

The Guidelines for Landscape and Visual Impact Assessment, 3rd Edition (GLVIA3) (Landscape Institute, 2013), notes that quantitative assessments of lighting impacts will be carried out by lighting engineers (refer to **Appendix 4.6**), but that "*the visual effects assessment will also need to include qualitative assessments of the effects of the predicted light levels on night-time visibility*." (paragraph 6.12, page 103).

The assessment is based on effects arising in relation to the steady red light fixed to the top of the agreed eight turbine hubs, as illustrated in the supporting visualisations. As mentioned above, paragraph 37 of **Technical Appendix 4.6** provides some information around the reduction in apparent brightness of visible aviation lights due to adverse weather conditions such as cloud, fog etc. Technical **Appendix 4.6** states that "*When not obscured by cloud, the visibility in the area of the turbines can be expected to exceed 5 km for 98% of the time*." [Emphasis in original]. This means that the aviation lights would only be set to their maximum 2000 cd intensity 2 % of the time when visibility is limited to less than 5 km, with the reduced 200 cd intensity setting utilised for most of the time. When visibility is poor, and lights are set to the maximum emitted intensity, then the reduced visibility will limit the perceived intensity at the viewpoints. Though the maximum 2000 cd intensity values are referenced in **Table 1** and **Table 2** and **Figures A5.2.2 - A5.2.3**, in accordance with NatureScot guidance, this assessment considers the perceived effects of the aviation lights at 200 cd only, to reflect the predominant emitted intensity (NatureScot, 2024).

Reflected glow across the immediate surfaces of the turbine blades and hub may be evident under certain conditions and is represented in the visualisations. Infra-red lights are required for military and emergency service aircraft flying at night. These lights are not designed to be visible to the naked eye and are not considered further in this assessment.

When determining the magnitude of change associated with the Proposed Development, the methodology in **Technical Appendix 5.1** considers the duration of the change. For operational effects of lighting, this is deemed to be long term (but ultimately reversible). For night-time effects, the frequency of the effect should also be considered. Aviation lighting will only be apparent during hours of darkness, which changes with the seasons. In the summer months the duration of visibility of aviation lighting will reduce. It will also be activated much later at night when fewer people may be around to experience the lighting. In the winter, the converse will be the case. The period when visibility is greater than 5 km is likely to be longer in summer, due to generally better weather conditions.

Although the intensity of the emitted light remains constant (at the angle of observation), the perceived light intensity ('brightness') experienced by visual receptors (people) will also vary dependent on distance and atmospheric conditions. As distances increase, the light source will appear smaller and perceived light intensity will decrease. **Technical Appendix 4.6** provides details of the perceived light intensity at each viewpoint, and notes that as well as viewing angle being a factor, "*when considering the perception of the light from a viewpoint in general, the distance between the light and the viewpoint is likely to be the dominant factor…*" (paragraph 24).

Appendix A of **Technical Appendix 4.6** provides detailed information on the light emitted towards each viewpoint for each turbine nacelle light (in cd) as well as the perceived brightness of each nacelle light at each viewpoint in microlumens per square metre (µlx).[2] In order to place these values in context, Table 7 of **Technical Appendix 4.6** provides some examples of approximate values placed on a number of familiar comparators, including car brake lights, streetlights and objects seen in the night sky, such as the International Space Station. Where relevant, these useful comparisons are referred to in the assessment.

Baseline

Due to the reduction in perceived intensity of aviation lighting with increasing distance, significant landscape and visual effects are considered unlikely to occur beyond 20 km. As such, and in accordance with NatureScot

[2] Lux (lx) is a unit used to measure the intensity of light hitting a surface, or illuminance. Micro-lux (µlx), equals one millionth of a lux (lx) and 1 µlx is equivalent to 1 micro-lumen per square metre.

guidance (2024), the study area for the aviation lighting night-time assessment is focused within approximately 20 km of the Proposed Development.

Owing to the relatively populated nature of the 45 km study area, which includes larger population centres such as Dumfries and Ayr, artificial lighting associated with settlement and the road network is a relatively consistent feature in night-time views. The core of the study area within 20 km of the Proposed Development is generally more rural in nature due to the presence of the Carsphairn and Scaur Hills, with dark skies a feature of these uplands, though experienced by relatively few receptors (such as those wild camping). From the margins of these uplands, the experience of dark skies is subject to the influence of artificial lighting in several settlements, such as New Cumnock, Sanquhar, and Thornhill in Nithsdale; and Dalmellington, Carsphairn, and St John's Town of Dalry in the Glenkens. The transient lights of vehicles on the A76, A702, A713, and the minor road network that connect these areas are also evident in night-time views.

Within approximately 10 km of the Proposed Development, which comprises an area of rounded hill summits, coniferous forestry and upland glens, such as the Dalwhat, Shinnel, Scaur, and Afton Water valleys, settlement is limited to small villages such as Moniaive and Tynron, and scattered properties and farmsteads. As such, rural dark skies are more predominant in night-time views, with artificial lighting generally limited to lighting associated with residential properties and road users.

Cumulative Developments

While there are a number of operational wind farms located within 20 km of the Site (see **Figure 5.7c**), none have aviation lighting fitted due to their respective tip heights being below 150 m. The nearest operational wind farm to the Site with aviation lighting fitted, is Kennoxhead Wind Farm, approximately 25 km to the north (see **Figure 5.7a**).

Consented wind farms subject to aviation lighting requirements are likely to introduce visible aviation lighting into baseline night-time views within 20 km of the Site, including:

- Sanquhar II Wind Farm, approximately 1.9 km to the north-east (44 turbines at 200 m tip height);[3]
- Manquhill Wind Farm, approximately 3.4 km to the south-west (8 turbines at 200m tip height);
- Cornharrow Wind Farm, approximately 3.5 km to the south-west (7 turbines at 200 m tip height);
- Margree Wind Farm, approximately 8.8 km to the south, south-west (9 turbines at 200 m tip height);
- Divot Hill Wind Farm, approximately 9.9 km to the south, south-west (9 turbines at 200 m tip height);
- Fell Wind Farm, approximately 11.2 km to the south (9 turbines at 200 m tip height);
- Windy Standard III Wind Farm, approximately 12.0 km to the west, north-west (20 turbines at 180 m tip height);
- Lethans Wind Farm, approximately 17.2 km to the north (22 turbines at 220 m tip height); and
- Lethans Extension Wind Farm, approximately 18.4 km to the north (10 turbines at 250 m tip height).

A number of proposed wind farms, subject to aviation lighting requirements, may introduce further visible aviation lighting into baseline night-time views within 20 km of the Site, including:

- Euchanhead Wind Farm, approximately 0.5 km to the north-west (21 turbines at 230 m tip height);
- Lorg Wind Farm, approximately 1.6 km to the north-west (10 turbines at 200 m tip height);
- Cloud Hill Wind Farm, approximately 6.2 km to the north, north-east (11 turbines at 180 m tip height);
- Rowancraig Wind Farm, approximately 8.7 km to the north, north-east (6 turbines at 180 m tip height);
- Windy Standard I Repowering, approximately 8.8 km to the north, north-west (8 turbines at 200 tip height);
- Glenshimmeroch Wind Farm, approximately 10 km to the south-west (10 turbines at 200 m tip height); and
- Quantans Hill Wind Farm, approximately 10.3 km to the west, south-west (14 turbines at 200m tip height).

Due to the number of consented and proposed wind farms noted above, it is likely that night-time baseline views within 20 km of the Site will feature visible aviation lighting, prior to the introduction of the Proposed Development. In closer proximity to the Site, the consented Sanquhar II Wind Farm will introduce 19 visible aviation lights to the upland plateau that separates the Shinnel and Scaur Water valleys, while Manquhill, and Cornharrow Wind Farms will introduce visible aviation lighting to the west of the Dalwhat Water valley, within 5 km of the Site. The potential

[3] The Sanquhar II Wind Farm Revised Aviation Lighting Strategy (June 2021) comprises visible aviation lighting on 19 of the 44 turbines [Online]. Available at: https://www.energyconsents.scot/ApplicationDetails.aspx?cr=ECU00001801

effects of the Proposed Development under a Scenario 1 cumulative baseline (including operational and consented wind farms), and a Scenario 2 cumulative baseline (including operational, consented and proposed wind farms) are considered in the assessment where relevant.

Zone of Theoretical Visibility Mapping

The aviation lighting ZTV – Nacelle Lighting shown on **Figure A5.2.1** highlights the areas across the study area from which visible aviation lighting installed on the turbine hubs of T1, T2, T5 and T9 may theoretically be seen. This ZTV does not take account of potential screening provided by vegetation or buildings. To illustrate the potential variability in emitted intensity relative to vertical viewing angle, the Visible Aviation Light Intensity ZTV, shown on **Figure A5.2.2**, is coloured according to the vertical angles set out in **Table 1**. **Figure A5.2.3** shows the same information within a 20 km radius of the Proposed Development, to provide more detail. The lighting intensity ZTV does not show the reduction in perceived light intensity over distance, given it would be highly variable depending upon atmospheric conditions. As such, the lighting intensity ZTV shows a worst-case scenario of perceived lighting intensity, based on perfectly clear air conditions.

The ZTV (see **Figure A5.2.1** and **Figure A5.2.3**) indicates that theoretical visibility of the aviation lighting within 5 km of the Proposed Development is primarily focused on hill summits, including Benbrack, Castle Hill, Ox Hill, and Fingland Shoulder, as well as the elevated valley sides of the Shinnel Water and Dalwhat Water valleys. Theoretical visibility also extends along the valley floor of the Shinnel Water and more intermittently, the Dalwhat Water. Actual visibility will be reduced within 5 km of the Proposed Development, due to extensive areas of coniferous forestry, including from properties at the head of the Dalwhat Water valley.

Within 5 km to 10 km of the Proposed Development, theoretical visibility of the aviation lighting is more intermittent, and primarily limited to hill summits and elevated terrain above the Scaur Water and Water of Ken, including Cairnkinna Hill and Cloud Hill. Intervening landform obstructs theoretical visibility from the majority of lower-lying areas (including the entirety of the Scaur Water), though it extends along the Shinnel Water and Dalwhat Water to the settlements of Tynron and Moniaive respectively. Actual visibility from these settlements will be reduced due to woodland and buildings.

Between 10 km to 20 km, a similar pattern continues, with theoretical visibility of the aviation lighting intermittent and focused primarily on elevated terrain in the Lowther Hills, east of Nithsdale, and the Rhinns of Kells, west of the Glenkens. Theoretical visibility is also indicated from some lower lying settled areas, including Thornhill in Nithsdale; Wallaceton and Dunscore in the Cairn Water valley; and Corsock in the Urr Water valley. Actual visibility from these settled areas will be reduced by buildings and woodland within the valleys. To the north-west, no theoretical visibility is indicated with the exception of Hare Hill and Cairnsmore of Carsphairn, which alongside other summits within the Cairnsmore and Scaur Hills, obstruct any theoretical visibility beyond.

Analysis of Visibility

Table 8 of **Technical Appendix 4.6** provides detailed information on the emitted intensity (cd) of the brightest lit turbine nacelle light towards each LVIA viewpoint, dependent on the angle of view but excluding distance. This detailed study highlights that the maximum emitted intensity is far greater for more elevated viewpoints, than lower-lying viewpoints from the settled valleys. The following observations are made:

- For closer viewpoints within 10 km, the emitted intensity varies between a minimum of 75 cd (8 cd at 10 %) at VP3: Cairnhead Striding Arch and VP4: Shinnelhead, and a maximum of 1580 cd (154 cd at 10 %) at the summit of Colt Hill (VP1).
- For more distant viewpoints beyond 10 km, the emitted intensity directed at the viewer varies between a minimum of 342 cd (32 cd at 10 %) at VP13: A702, Shinnel Water valley, and a maximum of 2142 cd (214 cd at 10 %) at the summit of Cairnsmore of Carsphairn (VP14).

As noted above, paragraph 24 of **Technical Appendix 4.6** states that as well as viewing angle being a factor, "*when considering the perception of the light from a viewpoint in general, the distance between the light and the viewpoint is also likely to be the dominant factor*". To this end, Appendix A of **Technical Appendix 4.6** also provides calculations for perceived light intensity, as measured in microlumens per square metre (µlx). These show that despite higher values for emitted intensity due to relative viewing angle (see **Figure A5.2.3**), the more distant elevated viewpoints such as VP18: Durisdeer Rig, VP19: East Mount Lowther, and VP20: Cairn Table, will experience much lower values for perceived light intensity.[4]

The highest levels of perceived light intensity from the aviation lighting are 278.7 µlx (27 µlx at 10%) for VP1: Colt Hill, Striding Arch and 110.7 µlx (11.1 µlx at 10 %) for VP6: Benbrack, Striding Arch, owing to their proximity and similar elevation to the Proposed Development.

Perceived light intensity values are substantially lower for the more distant viewpoints, including 2.3 µlx (0.2 µlx at 10 %) for VP18: Durisdeer Rig, 4.8 µlx (0.5 µlx at 10 %) for VP19: East Mount Lowther, and 2.9 µlx (0.3 µlx at 10 %) for VP20: Cairn Table.

[4] Table 7 of **Technical Appendix 4.6** provides comparisons of approximate µlx values to examples of commonly experienced artificial lighting. The approximate illuminance of a car brake light is stated to be 100 µlx at 1 km, 25 µlx at 2 km, 4 µlx at 5 km, and 1 µlx at 10 km.

It should be noted that all the emitted (cd) and perceived (µlx) light intensity values presented in **Technical Appendix 4.6** are based on a particular model of light. They also assume perfectly clear air conditions. In reality, these values would be further reduced by atmospheric visibility.

Visualisations

To inform the assessment of aviation lighting effects, night-time photomontage visualisations accompany this report. Viewpoints were selected to illustrate views experienced by residents and road users in the Shinnel Water valley, and the settlement of Moniaive. Three viewpoints were selected and agreed with consultees as follows:

- Viewpoint 4: Shinnelhead (**Figures 5.14k-l**);
- Viewpoint 7: Shinnel Water valley near Craigencoon (**Figures 5.17g-h**); and
- Viewpoint 9: Moniaive (**Figures 5.19g-h**).

Due to the embedded design mitigation of automatic dimming, and in accordance with NatureScot guidance (2024), nacelle lights were modelled at the reduced 200 cd intensity setting, as a realistic worst case scenario. Visualisations are presented in accordance with the industry standard guidance prescribed by NatureScot, and the Landscape Institute. The methodology for the preparation of night-time photomontage visualisations is detailed within **Technical Appendix 5.1**.

Photography

NatureScot guidance for capturing night-time baseline photography states that "*It is important to capture a reasonable balance between visibility of the underlying landform and the apparent brightness of any artificial lights, as both should be visible in the image*", noting that 30 minutes after sunset (around the end of civil twilight), as an appropriate window "*when the shape of landform can still be discerned, and the night sky will still not be at its darkest, but importantly there will likely be a distinction between the sky and the land, or bodies of water*" (NatureScot, 2024).

The period of time when landform is visible along with existing light sources, and the perception of certain aspects of landscape character in fading light or darkness is possible is relatively narrow, and will vary considerably with the seasons, as well as weather and viewing conditions on any given day. The actual night-time view for most of the hours when the turbines are lit, will usually be darker, and the proposed lighting and other artificial light sources will be seen against a dark sky or dark landform. In such conditions, certain aspects of landscape character such as variations in landcover are harder to perceive. However, certain aspects of landscape character, such as the profile of an important skyline, or sense of remoteness, can be accentuated at night.

Baseline dusk photography was undertaken in accordance with NatureScot guidance for Viewpoints 4, 7, and 9. Photography was captured at dusk in clear conditions and sought to capture the presence of existing baseline sources of artificial lighting (e.g. lighting associated with settlement, street lighting, motor vehicles and other sources) present in the landscape as closely as is experienced by the human eye as feasible. Multiple ranges of photography were taken several minutes apart in increasing darkness, with the most appropriate range of baseline photography for each viewpoint selected following careful consideration.

Photomontages

The dusk photomontage visualisations provided in **Figures 5.14k-l**, **Figures 5.17g-h** and **Figures 5.19g-h** show the baseline view and aviation lighting set to 200 cd. Because of inherent limitations in representing lighting on a static photomontage, and the variable effects of atmospheric conditions, the visualisations do not seek to represent changes in emitted brightness as a result of viewing angle or perceived brightness (expressed in microlumens) as a result of distance. The dusk photomontages therefore represent a 'worst case' scenario based on emitted intensity (expressed in cd), which would be reduced in actuality due to viewing angle and viewing distance. As noted above, the maximum intensity 2000 cd setting is not represented in the visualisations or considered in the assessment due to the embedded design mitigation of automatic dimming of the aviation lights under clear conditions.

Effects on Landscape Character at Night

Many key characteristics of landscape, such as landcover, can only be fully appreciated during the day. There will be a relatively short window of time, during dawn and dusk, when landform and landcover will be visible along with existing and new light sources. As such, effects associated with visible aviation lighting are considered to be primarily visual and will be influenced by the type of activity being undertaken at night and the process of dark adaptation. However, it is acknowledged that dark skies can form a valued aspect of landscape character, which can also accentuate certain perceptual characteristics of the landscape. As NatureScot guidance notes: "*Some characteristics are weakened by darkness and are ultimately no longer present, as they are less visible, such as evidence of cultural settlement, variations in landcover and habitats, or an appreciation of key vistas. Other perceptual characteristics can however be strengthened, such as the apparent absence of development, or the profile of an important skyline… a frequently valued characteristic of many parts of the UK, and particularly Scottish countryside, is its dark skies and a general absence of visible lighting*" (NatureScot, 2024).

Theoretical visibility of the aviation lighting of the Proposed Development within 45 km is shown on **Figure A5.2.1**. Focusing on Landscape Character Types (LCT) within 10 km (see **Figure A5.2.3**), where significant effects on landscape character resulting from the aviation lighting are more likely to arise, theoretical visibility is indicated from elevated landform and summits within the host LCT 178: Southern Uplands with Forest – Dumfries and Galloway, and the contiguous LCT 177: Southern Uplands – Dumfries and Galloway, including the summits of Cloud Hill (VP8) and Cairnkinna Hill (VP11) to the north-east of the Proposed Development, and Cairnsmore of Carsphairn (VP14) to the west. A localised area of theoretical visibility is also indicated from LCT 81: Southern Uplands – Ayrshire, at the summit and Site-facing slopes of Blackcraig Hill (VP12) to the east of the Afton Water valley, and Hare Hill, beyond 10 km. However, owing to the distance of this LCT from the Proposed Development and the limited geographical extent of theoretical visibility, significant effects on landscape character are not considered likely to arise, and this LCT is not considered further.

From the host LCT 178: Southern Uplands with Forest – Dumfries and Galloway, and the contiguous LCT 177: Southern Uplands – Dumfries and Galloway, up to four aviation lights will be visible from elevated terrain and hill summits within 10 km of the Proposed Development, though actual visibility will be reduced from the former to some degree due to characteristic coniferous forestry. The emitted intensity of the nacelle lights will vary relative to viewing angle as indicated by **Figure A5.2.3**, though owing to the elevated nature of these LCTs, the viewing angle will generally be closer to the horizontal and the emitted intensity will be correspondingly higher. From more distant areas of the LCTs to the north of the Scaur Water valley (VP8: SUW near Cloud Hill, VP11: Cairnkinna Hill) and to the west of the Water of Ken (VP14: Cairnsmore of Carsphairn), the perceived intensity of the aviation lighting will be reduced due to viewing distance (see **Table 2**).

While these two LCTs do not have any recorded key characteristics which specifically relate to dark skies, where visible (and in the absence of existing sources of artificial lighting), the aviation lighting will diminish the sense of remoteness and naturalness perceived by receptors within localised areas of the LCTs. The daytime assessment from the host LCT 178: Southern Uplands with Forest – Dumfries and Galloway identified Major (significant) landscape effects within the Site, and Moderate (Significant) effects within 3 km, reducing to Minor and below (not significant) beyond. For the contiguous LCT 177: Southern Uplands – Dumfries and Galloway, Moderate (Significant) landscape effects were identified within 5 km to the north of the Site, between the Shinnel Water valley and the Southern Upland Way (SUW), reducing to Minor and below (not significant) beyond. It is likely that these effects will extend into dusk, dawn and the hours of darkness, under certain weather conditions and if key landscape characteristics can still be appreciated. The nacelle lighting itself and the reflected light falling across the blades of the proposed turbines will result in the Proposed Development still influencing landscape character and perceptual qualities such as remoteness. However, this will be very dependent on weather conditions, viewing distance and viewing angle. Under a Scenario 1 (and Scenario 2) cumulative baseline, it is predicted that effects on LCT 177: Southern Uplands – Dumfries and Galloway to the north of the Site will reduce to Minor (not significant), due to the influence of 19 lit turbines at Sanquhar II Wind Farm within the LCT, approximately 1.9 km to the north-east of the Proposed Development.

Within the lower-lying LCT 166: Upland Glens – Dumfries and Galloway, theoretical visibility of up to four nacelle lights is indicated from the Shinnel Water valley between Craigencoon and High Appin. More intermittent theoretical visibility of between one and two nacelle lights is indicated from the upper Shinnel Water valley in the vicinity of Shinnelhead, and the lower Shinnel Water valley in the vicinity of Tynron. Theoretical visibility from the Scaur Water, and the Castlefairn Water is limited to upper valley sides at the fringes of the LCT. More consistent theoretical visibility of one to two nacelle lights is indicated from the settlement of Moniaive, and extending along parts of the valley floor and the western valley sides of the Dalwhat Water. Actual visibility will be reduced to some degree due to intervening coniferous forestry and woodland within the valley, with sequential views of the aviation lighting from the minor road between Moniaive and Cairnhead likely to be intermittent. From all of the above areas of the LCT, **Figure A5.2.3** indicates that the perceived intensity of the aviation lighting will be notably reduced due to viewing angle. Due to the intermittent visibility of the aviation lighting from the LCT in the Scaur, Dalwhat and Castlefairn Water valleys, and the reduction in perceived intensity due to viewing angle, significant effects on landscape character are not considered likely to arise in these valleys.

In the Shinnel Water valley between Craigencoon and High Appin, all four of the nacelle lights will be seen in views towards the head of the valley, and the enclosing upland skyline formed by the Site and surrounding uplands, within the host LCT 178: Southern Uplands with Forest – Dumfries and Galloway, and the contiguous LCT 177: Southern Uplands – Dumfries and Galloway (see VP5: High Appin and VP7: Shinnel Water valley near Craigencoon). From the more remote head of the valley at Shinnelhead, one nacelle light will be seen extending above the dark profile of Lamgarroch (see VP4: Shinnelhead). **Figure A5.2.3** indicates that the perceived intensity of the aviation lights from the Shinnel Water valley will be notably reduced due to viewing angle. While the LCT does not have any recorded key characteristics which specifically relate to dark skies and is subject to the existing influence of artificial lighting associated with scattered properties, dark rural skies are a feature of the LCT. As such, the aviation lighting will alter the perceptual characteristics of the LCT experienced during the hours of darkness, including the sense of enclosure within the valley, and the remoteness and naturalness associated with the enclosing uplands. The daytime assessment identified Moderate (significant) landscape effects within the LCT between the north of Tynron and Appin Lodge, within approximately 8 km, reducing to Minor and below (not significant) beyond. It is likely that these effects will extend into dusk, dawn and the hours of darkness, under certain weather conditions and if key landscape characteristics can still be appreciated. The nacelle lighting itself and the reflected light falling across the blades of the proposed turbines will result in the wind farm still influencing landscape character and perceptual qualities. However, it is recognised that due to the

viewing angle, the perceived intensity of the aviation lights from the Shinnel Water valley will be notably reduced. As such this represents a very precautionary assessment.

The lower reaches of the Scaur, Shinnel, and Dalwhat Water valleys are enclosed by LCT 175: Foothills – Dumfries and Galloway. Owing to the complex landform within the LCT and higher hill summits within and surrounding the Site, relatively intermittent theoretical visibility of between one and four nacelle lights is indicated from this LCT, primarily from more elevated Site-facing slopes and hill summits, including Auchengibbert Hill, above Tynron (VP10). The daytime assessment from LCT 175: Foothills – Dumfries and Galloway identified Moderate (significant) landscape effects within 5 km (from the unit to the south of the Shinnel Water valley), reducing to Minor and below (not significant) beyond. Given the open nature of the foothills to the south-east of the Site, these effects are likely to extend into the hours of darkness (but noting that due to viewing angle, the lights will be seen at a reduced intensity as indicated by **Figure A5.2.3**).

Theoretical visibility is indicated from a small proportion of LCT 161: Pastoral Valley – Dumfries and Galloway within 10 km of the Proposed Development, and more extensively beyond 10 km to the south-east along the Cairn Water valley, including the settlements of Wallaceton and Dunscore. Due to intervening distance, and the existing influence of artificial lighting associated with properties and road users within the valley, significant effects on landscape character within the LCT are not considered likely to arise.

Effects on Designated Landscapes at Night

In terms of effects on designated landscapes and as noted previously, there will be a relatively small window of time, during dawn and dusk, when the detail of the landform is apparent along with existing and new light sources, and landscape character can still be appreciated before darkness falls. At night-time, during most of the hours when turbines will be lit, the landscape will be under darkness, with only the proposed lighting and other artificial and natural light sources being apparent. As such, the window over which effects on designated landscapes and effects on many of the associated special qualities and key attributes (which can often only be appreciated during the daytime), will be limited, though it is recognised that dark skies and the absence of artificial lighting can be a valued characteristic of a designated landscape.

Local Landscape Areas

As shown on **Figure A5.2.1** theoretical visibility of the aviation lighting is indicated from Local Landscape Areas (LLAs) within 20 km of the Proposed Development, including the Thornhill Uplands RSA, Galloway Hills RSA, Terregles Ridge RSA, and the Uplands and Moorlands LLA. Due to intervening distance and the limited theoretical visibility of aviation lighting from the majority of LLAs within 20 km of the Proposed Development, only the Thornhill Uplands RSA is considered in further detail (as per the daytime assessment).

Within the Thornhill Uplands Regional Scenic Area (RSA) (described in detail in **Table 5.15** of **Chapter 5: Landscape and Visual Amenity**), theoretical visibility of the aviation lighting is indicated from elevated terrain above the Scaur, Shinnel, Dalwhat, and Castlefairn Water valleys within 10 km of the Proposed Development, and across the Lowther Hills, east of Nithsdale, beyond 15 km. From lower-lying areas of the RSA within 10 km, theoretical visibility of the aviation lighting is most extensive in the Shinnel Water valley, between Bennan and High Appin, and more intermittently in the Dalwhat Water valley between Moniaive and Cairnhead. While dark skies are evident within the RSA owing to its rural location, there is an existing influence of artificial lighting associated with settlement (such as Thornhill, Penpont and Moniaive), scattered properties, and road users.

The night-time landscape assessment identified significant landscape effects from the following LCTs, within the western fringe of the RSA:

- LCT 166: Upland Glens – Dumfries and Galloway from the Shinnel Water valley within approximately 8 km;
- LCT 175: Foothills – Dumfries and Galloway from uplands to the east and south of the Site, within approximately 5 km; and
- LCT 177: Southern Uplands – Dumfries and Galloway from uplands to the north of the Site, within approximately 5 km.

While the introduction of aviation lighting into views from the Shinnel Water valley and enclosing uplands may impact upon the perceptual aspects of isolation and remoteness which are implicit in the RSA description, none of the key characteristics or special qualities of the RSA relate specifically to dark skies, with the majority focused on aspects of landscape composition and landcover, which will be less evident during the hours of darkness. Due to this, as well as the localised geographical extent of night-time effects in the context of the wider RSA, the aviation lighting of the Proposed Development will not result in significant effects on the RSA designation. Under a Scenario 1 cumulative baseline, Sanquhar II Wind Farm will introduce 19 lit turbines within the western fringe of the RSA, approximately 1.9 km to the north-east of the Proposed Development, while Manquhill, Cornharrow, and Divot Hill Wind Farms will introduce additional lit turbines just outside the RSA within approximately 3.5 km to 10 km to the south-west of the Proposed Development. This will increase the baseline influence of aviation lighting in night-time views from the western extent of the RSA.

Galloway Dark Sky Park

The Galloway Dark Sky Park (DSP) comprises land mostly within the Galloway Forest Park. The DSP itself is defined by a Core Zone and a Buffer Zone, with a wider Transition Zone extending approximately 15 km from the park boundary. The Dark Skies Friendly Lighting Supplementary Guidance (Dumfries and Galloway Council, 2020) provides advice on good lighting practice within the DSP to protect the quality of the dark skies within it, and across the region. The Core Zone of the DSP is located approximately 25 km to the south-west of the nearest turbine of the Proposed Development at its closest point. As illustrated by **Figure A5.2.1**, theoretical visibility of the aviation lighting from the Core Zone is very limited, restricted to the higher summits such as the Merrick, beyond 30 km from the Proposed Development. At this distance, and on occasions of clear visibility, the aviation lighting will not form a notable feature within the broad panorama of the view in which other artificial lighting is evident, and the perceived intensity of the aviation lighting will be reduced due to viewing distance. No theoretical visibility is indicated from Clatteringshaws Loch, where the Scottish Dark Sky Observatory is likely to be rebuilt (BBC, 2024). No significant effects within the Core Zone of the DSP are anticipated.

The Buffer Zone of the DSP is located approximately 14.5 km to the south-west of the nearest turbine of the Proposed Development at its closest point. It is likely that the highest sensitivity receptors visiting the DSP will be located within the Core Zone, rather than within the Buffer Zone. Theoretical visibility of the aviation lighting from within the Buffer Zone is indicated from elevated terrain west of the Glenkens, including the Rhinns of Kells and its foothills. Due to the limited number and horizontal extent of the aviation lighting seen in panoramic views, viewing distance, and the existing influence of artificial lighting in the Glenkens in views towards the Proposed Development, no significant effects within the Buffer Zone of the DSP are anticipated.

The Site is partly located within the eastern fringe of the Transition Zone, which extends approximately 15 km from the boundary of the DSP. Theoretical visibility of the aviation lighting from within the Transition Zone is indicated from summits and intermittent areas of elevated terrain between the Site and the Glenkens. While it is predicted that some significant night-time landscape and visual effects will occur locally within the eastern fringes of the Transition Zone due to introduction of the aviation lighting, no significant effects will occur within the Core Zone or Buffer Zone of the DSP.

Effects on Visual Amenity

Table 2 below details the predicted visibility of the proposed turbine lighting, as it will be seen from each LVIA viewpoint (informed by **Figures 5.11 to 5.30**). The table highlights the predicted emitted intensity of nacelle mounted aviation lighting in cd and µlx from the brightest lit visible turbine for each viewpoint informed by the values presented in Appendix A of **Technical Appendix 4.6** which take into account variability of lighting intensity based on viewing angle (cd) and viewing distance (µlx). Values are given for maximum emitted intensity of lighting and at 10% intensity, the latter of which would be more typical in clear weather conditions and provides the basis for the assessment.

The table also indicates the potential influence of coniferous forestry in further screening the theoretical visibility of turbine lighting from each viewpoint location, informed by the baseline photography and observations from fieldwork.

Table 2 - Summary of Turbine Lighting Visibility

Table Key						
Nacelle lighting potentially visible (i.e. at least one medium intensity hub light)	○	*No nacelle lighting visible*	*n/a*	*Nacelle lighting screened by forestry*	○	
Viewpoint	**Distance (km) to nearest lit turbine**	**T1**	**T2**	**T5**	**T9**	**Brightest lit visible turbine (cd and µlx) at maximum (and 10% intensity)**
VP1: Colt Hill, Striding Arch	0.5 (T1)	○	○	○	○	– T9 @ 1580 cd (158 cd) – T5 @ 278.7 µlx (27.9 µlx)
VP2: Bail Hill, Striding Arch	0.9 (T9)	○	○	○	○	– T2 @ 262 cd (26 cd) – T5 @ 42.2 µlx (4.2 µlx)
VP3: Cairnhead, Striding Arch	1.2 (T5)	n/a	n/a	n/a	○	– n/a
VP4: Shinnelhead	1.6 (T1)	○	n/a	n/a	n/a	– T1 @ 75 cd (8 cd) – T1 @ 27.9 µlx (2.8 µlx)
VP5: High Appin	2.0 (T9)	○	○	○	○	– T2 @ 108 cd (11 cd) – T9 @ 18.5 µlx (1.9 µlx)
VP6: Benbrack, Striding Arch	2.9 (T2)	○	○	○	○	– T9 @ 1451 cd (145 cd) – T5 @ 110.7 µlx (11.1 µlx)
VP7: Shinnel Water valley near Craigencoon	3.4 (T9)	○	○	○	○	– T2 @ 114 cd (11 cd) – T9 @ 6.3 µlx (0.6 µlx)
VP8: SUW near Cloud Hill	6.7 (T1)	○	○	○	○	– T9 @ 706 cd (71 cd) – T5 @ 10.7 µlx (1.1 µlx)
VP9: Moniaive	7.6 (T9)	n/a	n/a	n/a	○	– T9 @ 133 cd (13 cd) – T9 @ 2.3 µlx (0.2 µlx)
VP10: Auchengibbert Hill	8.1 (T9)	○	○	○	○	– T2, T5 @ 584 cd (58 cd) – T9 @ 6.8 µlx (0.7 µlx)
VP11: Cairnkinna Hill	8.4 (T1, T9)	○	○	○	○	– T5 @ 1697 cd (170 cd) – T9 @ 22.4 µlx (2.2 µlx)
VP12: Blackcraig Hill	9.3 (T2)	○	○	○	○	– T5 @ 2117 cd (212 cd) – T2 @ 23.1 µlx (2.3 µlx)

Table Key						
Nacelle lighting potentially visible (i.e. at least one medium intensity hub light)	○	*No nacelle lighting visible*	*n/a*	*Nacelle lighting screened by forestry*	○	
Viewpoint	**Distance (km) to nearest lit turbine**	**T1**	**T2**	**T5**	**T9**	**Brightest lit visible turbine (cd and µlx) at maximum (and 10% intensity)**
VP13: A702, Shinnel Water valley	10.9 (T9)	○	○	○	○	– T5 @ 304 cd (30 cd) – T9 @ 2.0 µlx (0.2 µlx)
VP14: Cairnsmore of Carsphairn	10.9 (T2)	○	○	○	○	– T1, T2, T9 @ 2142 cd (214 cd) – T2 @ 17.9 µlx (1.8 µlx)
VP15: Crawick Multiverse	14.5 (T1)	○	○	n/a	n/a	– T1, T2 @ 488 cd (49 cd) – T1 @ 2.2 µlx (0.2 µlx)
VP16: A713, near Stroangassel	15.0 (T5)	n/a	n/a	n/a	n/a	– n/a
VP17: A76, south of Closeburn	17.6 (T9)	○	○	○	○	– T2, T5 @ 535 cd (54 cd) – T5, T9 @ 1.4 µlx (0.1 µlx)
VP18: Durisdeer Rig	18.5 (T9)	○	○	○	○	– T5 @ 858 cd (86 cd) – T5, T9 @ 2.3 µlx (0.2 µlx)
VP19: East Mount Lowther	20 (T1)	○	○	○	○	– T5, T9 @ 1984 cd (198 cd) – T1, T9 @ 4.8 µlx (0.5 µlx)
VP20: Cairn Table	25.5 (T2)	○	○	○	○	– T5, T9 @ 1934 cd (193 cd) – T1, T2 @ 2.9 µlx (0.3 µlx)

Representative Assessment Viewpoints

Whilst the potential visibility of aviation lighting is summarised for each of the assessment viewpoints (as set out in **Table 2**), the following detailed assessment focuses on the three representative night-time viewpoints for which night-time photomontages were produced.

Table 3 - Viewpoint 4: Shinnelhead

Viewpoint 4: Shinnelhead			
Grid Reference	272894, 599213	**Figure Number**	Figure 5.14a-l
LCT	166: Upland Glens – Dumfries and Galloway	**Designated Landscape or Wild Land Area**	None
Direction of View	South-west	**Distance to Nearest Lit Turbine (km)**	1.6 (T1)
Number of Hub Lights Visible	1 (T1)	**Light Intensity: Accounting for Automatic Dimming and Vertical Directional Intensity Embedded Design Mitigation (Technical Appendix 4.6, Appendix A: Lighting Results Tables)**	T1 – 8 cd, 2.8 µlx
Location, Description of Existing View and Potential Receptors			
This viewpoint is located in the Shinnel Water valley, to the north-east of the Site. It represents views experienced by nearby residential receptors and recreational receptors using the forest track to the north of the site. The view looks south-west towards the rising valley side to the south of the Shinnel Water valley. The valley side is characterised by rough pasture and occasional trees on the lower ground, and coniferous forest on the higher ground. Outbuildings associated with the property at Shinnelhead are apparent in the foreground, to the east of view. The open minor summit of Lamgarroch, on the northern edge of the Site, contributes to the near distance horizon. The open and forested ridge of hills to the north of the Site screen direct views into the Site. At night, dark skies are experienced from this viewpoint, owing to its enclosed location at the head of the Shinnel Water valley, removed from the influence of any major population centres or other development. The only source of artificial lighting at this viewpoint is from the adjacent property at Shinnelhead, though at the time the baseline photography was taken the property was unoccupied.			
Night-Time Sensitivity			
Night-time views from this location are most likely to be experienced by residents at Shinnelhead, with recreational receptors likely to be present only occasionally during the hours of darkness. Residential receptors are considered to be of high susceptibility to changes in night-time views, though the view from the property towards the Site is filtered and screened by outbuildings and trees within the property curtilage. The viewpoint is not located within a designated or protected landscape. The value of the view is considered to be medium. **On balance, taking account of the judgements of susceptibility and value, the overall sensitivity of this viewpoint is judged to be medium-high.**			
Assessment of Visual Effects			
Figure 5.14l illustrates the view of the Proposed Development at night with the lit turbine at 200 cd intensity (representative of automatic dimming). The hub and blades of T1 will be seen, silhouetted against the sky until twilight transitions to night. The nacelle light of T1 will be visible above the dark horizon of Lamgarroch to the south-west, at a distance of approximately 1.6 km, and is likely to be seen reflecting across the turbine blades as they pass. The nacelle light will introduce artificial lighting to an otherwise dark sky, with the only other existing light source associated with the property at Shinnelhead (when occupied). The visibility and perceived intensity of lighting will vary at different times dependent on viewing conditions, whilst the duration over which the visible lighting is evident will vary seasonally, in relation to the hours of relative darkness. The aviation lighting intensity ZTV (refer to **Figure A5.2.3**) indicates that the maximum luminous intensity of light emitted due to the viewing angle from this location will be substantially reduced. The maximum cd value emitted in the direction and angle of view towards this viewpoint will be 8 cd (T1). The maximum perceived intensity of the aviation lighting at this viewpoint will be 2.8 µlx (T1), less than a car brake light at a distance of 5 km (4 µlx). The scale of change associated with the visible aviation lighting is judged to be medium. The ZTV (see **Figure A5.2.3**) indicates that theoretical visibility extends approximately 1 km to the east and west of the viewpoint along the track. Actual visibility from the track will be reduced due to enclosing coniferous forestry. The geographical extent is judged to be small, as this represents a localised view from the open upper extents of the Shinnel Water valley. **The overall magnitude of change is judged to be medium and taking account of the medium-high sensitivity will result in a Moderate (significant) visual effect.**			
Potential for Future Cumulative Effects Under Scenario 1			
Approximately three lit turbines at the consented Sanquhar II Wind Farm will be visible above the dark horizon to the north of the view, introducing aviation lighting into baseline views. Intervening vegetation will partially screen views of this scheme from this location, but more open views along the Shinnel Water valley will be available. The lit turbine of the Proposed Development is likely to read as a separate wind farm, located to the south of the Shinnel Water valley. Due to the influence of aviation lighting at Sanquhar II Wind Farm, the scale of change associated with the Proposed Development under this scenario is judged to be small. **The overall magnitude of change is judged to be low and taking account of the medium-high sensitivity will result in a Minor (not significant) visual effect**.			
Potential for Future Cumulative Effects Under Scenario 1			
Several turbines at the application stage Euchanhead Wind Farm (and to a lesser extent, Lorg Wind Farm) will be visible above the dark horizon at the head of the valley, in views to the west, and along the upper extents of the southern valley side. A number of these turbines will include nacelle lighting. In combination with Sanquhar II Wind Farm, these schemes will further increase the baseline influence of aviation lighting in baseline views. The lit turbine of the Proposed Development is			

likely to read as part of Euchanhead Wind Farm. The scale of change associated with the Proposed Development under this scenario is judged to be small.
The overall magnitude of change is judged to be low and taking account of the medium-high sensitivity will result in a Minor (not significant) visual effect.

Table 4 - Viewpoint 7: Shinnel Water Valley near Craigencoon

Viewpoint 7: Shinnel Water Valley near Craigencoon			
Grid Reference	276203, 596725	**Figure Number**	Figure 5.17a-h
LCT	166: Upland Glens – Dumfries and Galloway	**Designated Landscape or Wild Land Area**	Thornhill Uplands RSA
Direction of View	West	**Distance to Nearest Lit Turbine (km)**	3.4 (T9)
Number of Hub Lights Visible	4 (T1, T2, T5, T9)	**Light Intensity: Accounting for Automatic Dimming and Vertical Directional Intensity Embedded Design Mitigation (Technical Appendix 4.6, Appendix A: Lighting Results Tables)**	T1 – 9 cd, 0.3 µlx T2 – 11 cd, 0.3 µlx T5 – 9 cd, 0.4 µlx T9 – 8 cd, 0.6 µlx

Location, Description of Existing View and Potential Receptors

This viewpoint is located in the Shinnel Water valley. It represents more direct views experienced by road users, travelling north-west, and views experienced by nearby residential receptors dispersed along the Shinnel Water valley.
The views look up the minor road which passes through the Shinnel Water valley. The valley is characterised by pasture, dry stone walls and broadleaf woodland on the valley floor. On the higher valley sides, rough grassland and coniferous forest, in various stages of management, are more typical. There are direct views into the Site from this location. The ridge of hills which enclose the Site, to the north and south and around the head of the Shinnel Water, form the middle-distance horizon. Appin Lodge, glimpsed between areas of woodland, is visible on the hillside below the horizon to the north-west.
At night, dark skies are experienced from this viewpoint, owing to its location within the Shinnel Water valley, removed from the influence of any major population centres or other development. Artificial lighting in the vicinity of the viewpoint is limited to occasional properties in the Shinnel Water valley and the transient lights of road users.

Night-Time Sensitivity

Road users on this minor road are considered to be of medium susceptibility to changes in night-time views. Views from properties in the Shinnel Water valley will be similar (albeit typically more oblique in nature) where open views to the north-west are available.
The viewpoint is within the Thornhill Uplands RSA, indicating a higher value, though its key characteristics and special qualities are less evident at night.
On balance, taking account of the judgements of susceptibility and value, the overall sensitivity of this viewpoint is judged to be medium-high.

Assessment of Visual Effects

Figure 5.17h illustrates the view of the Proposed Development at night with the lit turbines at 200 cd intensity (representative of automatic dimming). The hub and blades of all nine turbines will be seen, silhouetted against the sky until twilight transitions to night. Lighting on the hubs of T1, T2, T5, and T9 will be visible above the dark ridgeline at the head of the Appin Burn valley, at a distance of approximately 3.4 km from the nearest lit turbine (T9). The nacelle lighting is also likely to be seen reflecting across the turbine blades as they pass. The aviation lighting will introduce artificial lighting to an otherwise dark sky, with the only other existing light sources, associated with scattered properties along the Shinnel Water valley and occasional road users.
The visibility and perceived intensity of lighting will vary at different times dependent on viewing conditions, whilst the duration over which the visible lighting is evident will vary seasonally, in relation to the hours of relative darkness.
The aviation lighting intensity ZTV (refer to Figure **A5.2.3**) indicates that the maximum luminous intensity of light emitted due to the viewing angle from this location will be substantially reduced. The maximum cd value emitted in the direction and angle of view towards this viewpoint will be 11 cd (T2). The maximum perceived intensity of the aviation lighting at this viewpoint will be 0.6 µlx (T9), less than a car brake light at a distance of 10 km (1 µlx).
The scale of change associated with the visible aviation lighting is judged to be medium. The ZTV (see **Figure A5.2.3**) indicates theoretical visibility from the Shinnel Water valley between Craigencoon and Old Auchenbrack. The geographical extent is judged to be medium, as this represents intermittent views, between breaks in tree and woodland cover, as one travels north-west up the Shinnel Water valley.
The overall magnitude of change is judged to be medium and taking account of the medium-high sensitivity will result in a Moderate (significant) visual effect.

Potential for Future Cumulative Effects Under Scenario 1

Approximately three or four lit turbines in the southern extent of the consented Sanquhar II Wind Farm will be visible just above the horizon to the north-west of the view, introducing aviation lighting into baseline views. These turbines will be partially screened from this location by roadside trees, though they will become increasingly visible to receptors further west along the valley. The lit turbines of the Proposed Development will introduce four additional aviation lights in closer proximity to the viewpoint and extend the horizontal field of view occupied by aviation lighting to the west of the view. The lit turbines will be seen in combined views with those at Sanquhar II Wind Farm, though the two schemes are likely to read as separate wind farms either side of rising landform, to the north of the Appin Burn valley. The scale of change associated with the Proposed Development under this scenario is judged to be medium.
The overall magnitude of change is judged to be medium and taking account of the medium-high sensitivity will result in a Moderate (significant) visual effect.

Potential for Future Cumulative Effects Under Scenario 1

Three additional wind turbines at the application stage Euchanhead Wind Farm, visible at the head of Appin Burn valley, in views to the north-west. These turbines are likely to introduce additional aviation lighting into baseline views, in combination with Sanquhar II Wind Farm. The lit turbines of the Proposed Development will introduce four additional aviation lights in

closer proximity to the viewpoint and extend the horizontal field of view occupied by aviation lighting to the west of the view. The scale of change associated with the Proposed Development under this scenario is judged to be medium. **The overall magnitude of change is judged to be medium and taking account of the medium-high sensitivity will result in a Moderate (significant) visual effect.**

Table 5.2.5: Viewpoint 9: Moniaive

Viewpoint 9: Moniaive			
Grid Reference	277819, 590645	**Figure Number**	Figure 5.19a-h
LCT	166: Upland Glens – Dumfries and Galloway	**Designated Landscape or Wild Land Area**	Thornhill Uplands RSA
Direction of View	North-west	**Distance to Nearest Lit Turbine (km)**	7.6 (T9)
Number of Hub Lights Visible	1 (T9)	**Light Intensity: Accounting for Automatic Dimming and Vertical Directional Intensity Embedded Design Mitigation (Technical Appendix 4.6, Appendix A: Lighting Results Tables)**	T9 – 13 cd, 0.2 µlx
Location, Description of Existing View and Potential Receptors			
This viewpoint is located on the south-western edge of the settlement of Moniaive. It represents views experienced by residents and recreational receptors, with more open views to the north-west from the settlement. Many views from within the core of the settlement will be screened by buildings. The view looks over a field of rough pasture, with houses set in woodland along the Craigdarroch Water, on the western edge of the settlement, visible in the foreground. Beyond this woodland, hills to the north of the settlement (Craigdarroch and Bardennoch Hill) rise to form the middle-distance horizon. There is a small single turbine on the hillside, in views to the south-west. At night, dark skies are experienced from this viewpoint owing to its rural location, removed from the influence of any major population centres or other development. Artificial lighting in the vicinity of the viewpoint is limited to properties at the edge of the village and the transient lights of road users.			
Night-Time Sensitivity			
Residents are considered to be of high susceptibility to changes in night-time views. The viewpoint is located in the Thornhill Uplands RSA, indicating a higher value, though its key characteristics and special qualities are less evident at night. **On balance, taking account of the judgements of susceptibility and value, the overall sensitivity of this viewpoint is judged to be high**.			
Assessment of Visual Effects			
Figure 5.19h illustrates the view of the Proposed Development at night with the lit turbines at 200 cd intensity (representative of automatic dimming). Four turbine hubs and five turbine blades will be seen, silhouetted against the sky until twilight transitions to night. Lighting on the hub of the most prominent turbine, T9, will be visible above the dark skyline of Bardennoch Hill, at a distance of approximately 7.6 km. The aviation lighting will introduce artificial lighting to a dark sky, though seen beyond artificial lighting within the village, and the lights of occasional road users. The visibility and perceived intensity of lighting will vary at different times dependent on viewing conditions, whilst the duration over which the visible lighting is evident will vary seasonally, in relation to the hours of relative darkness. The aviation lighting intensity ZTV (refer to **Figure A5.2.3**) indicates that the maximum luminous intensity of light emitted due to the viewing angle from this location will be substantially reduced. The maximum cd value emitted in the direction and angle of view towards this viewpoint will be 13 cd (T9). The maximum perceived intensity of the aviation lighting at this viewpoint will be 0.2 µlx (T9), less than a car brake light at a distance of 10 km (1 µlx). The scale of change associated with the visible aviation lighting is judged to be small. The ZTV (see **Figure A5.2.3**) indicates theoretical visibility from the majority of the settlement, though actual visibility will be limited from the core of the village due to buildings and broadleaved trees within the settlement. The geographical extent is judged to be small. **The overall magnitude of change is judged to be low and taking account of the high sensitivity will result in a Minor (not significant) visual effect.**			
Potential for Future Cumulative Effects Under Scenario 1			
No aviation lighting associated with consented wind farms will be visible from this location.			
Potential for Future Cumulative Effects Under Scenario 1			
No aviation lighting associated with proposed wind farms will be visible from this location.			

Summary of Lighting Effects

Aviation warning lights are proposed on turbines T1, T2, T5, and T9 (four turbines in total). Medium intensity 2000 cd lighting will only be activated in weather conditions where visibility is less than 5 km (estimated to be approximately 2 % of the time), with automatic dimming during clear conditions (visibility beyond 5 km in all directions from the proposed turbines) reducing the required emitted light intensity to 200 cd. As such, the reduced 200 cd setting has formed the basis of this assessment.

Landscape Effects

The daytime assessment from the host LCT 178: Southern Uplands with Forest – Dumfries and Galloway identified Major (significant) landscape effects within the Site, and Moderate (significant) effects within 3 km, reducing to Minor and below (not significant) beyond. For the contiguous LCT 177: Southern Uplands – Dumfries and Galloway, Moderate (significant) landscape effects were identified within 5 km to the north of the Site,

between the Shinnel Water valley and the SUW, reducing to Minor and below (not significant) beyond. It is likely that these effects will extend into dusk, dawn and the hours of darkness, under certain weather conditions and if key landscape characteristics can still be appreciated. The nacelle lighting itself and the reflected light falling across the blades of the proposed turbines will result in the Proposed Development still influencing landscape character and perceptual qualities such as remoteness. However, this will be very dependent on weather conditions, viewing distance and viewing angle. Under a Scenario 1 (and Scenario 2) cumulative baseline, it is predicted that effects from LCT 177: Southern Uplands – Dumfries and Galloway to the north of the Site will reduce to Minor (not significant), due to the influence of 19 lit turbines at Sanquhar II Wind Farm within the LCT, approximately 1.9 km to the north-east of the Proposed Development.

The daytime assessment from LCT: 175: Foothills – Dumfries and Galloway identified Moderate (Significant) landscape effects within 5 km (from the unit to the south of the Shinnel Water valley), reducing to Minor (not significant) beyond. Given the open nature of the foothills to the south-east of the Site, these effects are likely to extend into the hours of darkness (but noting that due to viewing angle, the lights will be seen at a reduced intensity as indicated by **Figures A5.2.2** and **A5.2.3**).

The daytime assessment from LCT 166: Upland Glens – Dumfries and Galloway identified Moderate (significant) landscape effects within the LCT between the north of Tynron and Appin Lodge, within approximately 8 km of the Proposed Development. It is likely that these effects will extend into dusk, dawn and the hours of darkness, under certain weather conditions and if key landscape characteristics can still be appreciated. The nacelle lighting itself and the reflected light falling across the blades of the proposed turbines will result in the Proposed Development still influencing landscape character and perceptual qualities.

Effects on the Thornhill Uplands RSA

While the introduction of aviation lighting into views from the Shinnel Water valley and enclosing uplands may impact upon the perceptual aspects of isolation and remoteness which are implicit in the RSA description, none of the key characteristics or special qualities of the RSA relate specifically to dark skies, with the majority focused on aspects of landscape composition and landcover, which will be less evident during the hours of darkness. Due to this, and the localised theoretical visibility of the aviation lighting in the wider context of the RSA, no significant effects on the Thornhill Uplands RSA are anticipated.

Effects on the Galloway Dark Sky Park

Very limited theoretical visibility of the aviation lighting is indicated from the Core Zone and Buffer Zone of the Galloway Dark Sky Park, at distances greater than 15 km and 25 km respectively. No significant visual effects on the Galloway Dark Sky Park are anticipated.

Visual Effects

Significant visual effects are predicted for Viewpoint 4: Shinnelhead, and Viewpoint 7: Shinnel Water valley near Craigencoon. This is due to the introduction of aviation lighting to a dark sky context, seen in relatively close proximity. Under a Scenario 1 cumulative baseline, it is predicted that these effects will reduce to not significant for Viewpoint 4: Shinnelhead, due to the influence of aviation lighting at Sanquhar II Wind Farm. No significant effects are anticipated from Viewpoint 9: Moniaive, due to the limited visibility of one lit turbine, viewing distance, and the influence of lighting within the settlement.

Outside the representative assessment viewpoints, significant visual effects are also anticipated from elevated viewpoints within approximately 8 km (where receptors are likely to be only occasionally present at night), including Viewpoint 1: Colt Hill, Striding Arch; Viewpoint 2: Bail Hill, Striding Arch; VP6: Benbrack, Striding Arch; VP8: SUW near Cloud Hill; and VP10: Auchengibbert Hill. Under a Scenario 1 (and Scenario 2) cumulative baseline, it is predicted that these effects will reduce to not significant for VP8: SUW near Cloud Hill and VP10: Auchengibbert Hill, due to the influence of 19 lit turbines at Sanquhar II Wind Farm in baseline views.

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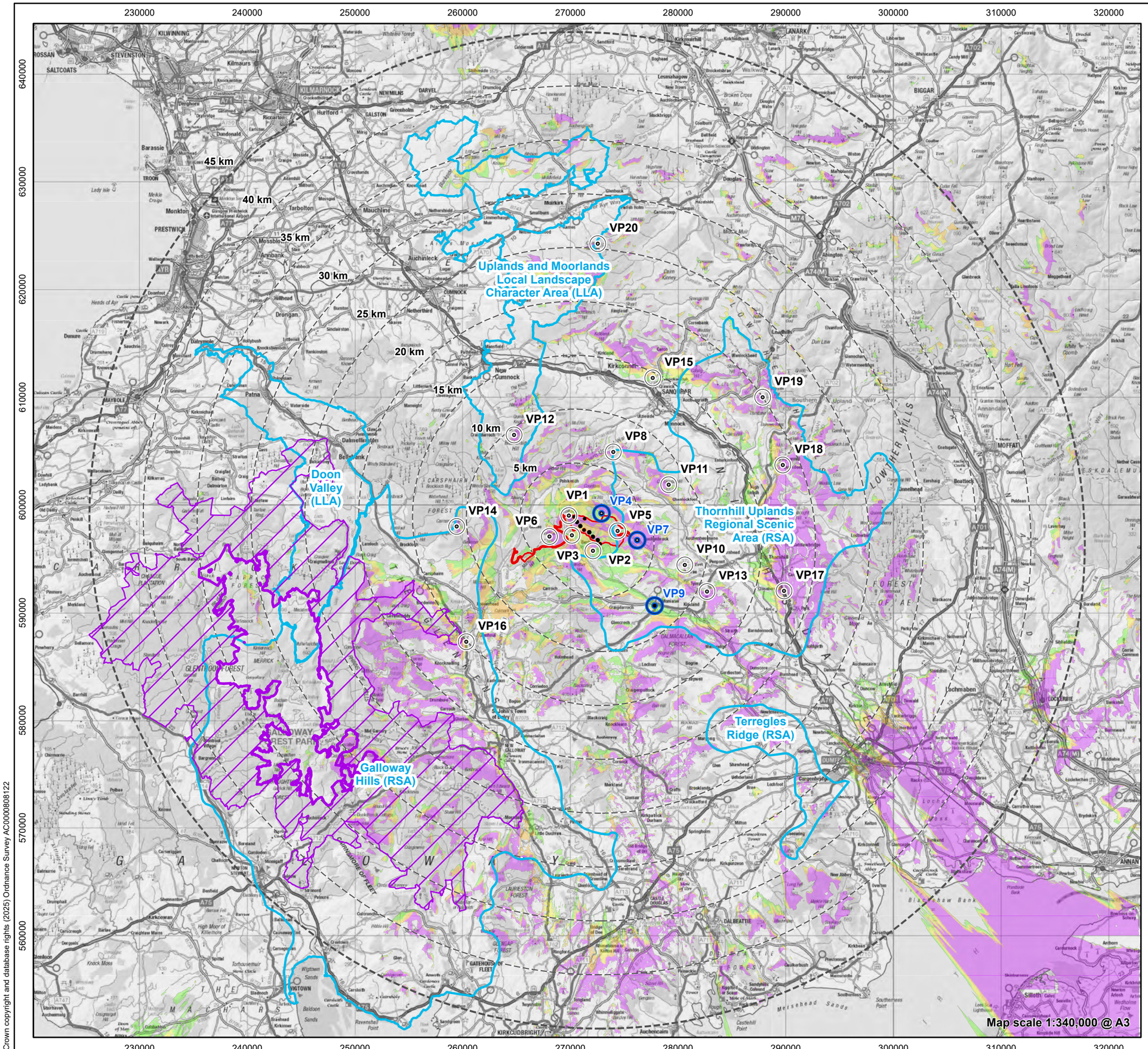


Statkraft

N

- Site Boundary
- Turbine with Nacelle Lighting
- Turbine without Nacelle Lighting
- 5 km Interval from Outermost Turbines
- 45 km LVIA Study Area
- Local Landscape Designation (LLA)* within 20 km
- Galloway Dark Skies Park Core Area
- Galloway Dark Skies Park Core Area Buffer Zone

Zone of Theoretical Visibility (Nacelle Lighting)

- 1 Nacelle Light Visible
- 2 Nacelle Lights Visible
- 3 Nacelle Lights Visible
- 4 Nacelle Lights Visible
- Viewpoint
- Nighttime Viewpoint

VP1: Colt Hill, Striding Arch
VP2: Bail Hill, Striding Arch
VP3: Cairnhead, Striding Arch
VP4: Shinnelhead
VP5: High Appin
VP6: Benbrack, Striding Arch
VP7: Shinnel Water Valley near Craigencon
VP8: SUW near Cloud Hill
VP9: Moniaive
VP10: Auchengibbert Hill
VP11: Cairnkinna Hill
VP12: Blackcraig Hill
VP13: A702, Shinnel Water Valley
VP14: Cairnsmore of Carsphairn
VP15: Crawick Multiverse
VP16: A713, near Stroangassel
VP17: A76, south of Closeburn
VP18: Durisdeer Rig
VP19: East Mount Lowther
VP20: Cairn Table

Note:
The ZTV is calculated to turbine hub height (119 m) from a viewing height of 2 m above ground level. Lit turbines will be 1,2,5, and 9. The terrain model assumes bare ground and is derived from OS Terrain 5 height data. Earth curvature and atmospheric refraction have been taken into account. The ZTV was calculated using ArcGIS Pro 3.4.0 software.

0 5 10 20 Km

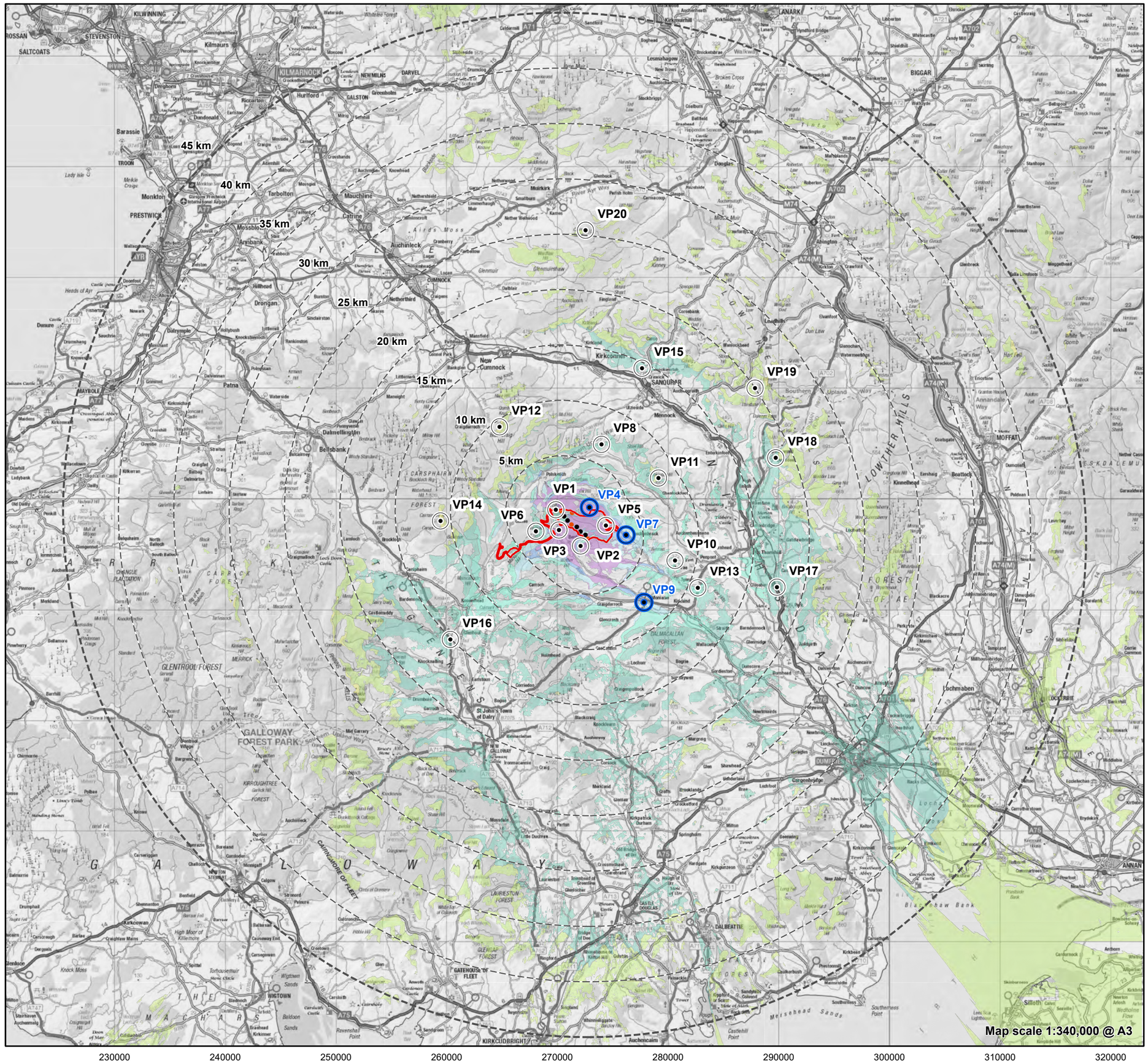
Source: LUC, Pell Frischmann, OS

Produced By: HD
Checked By: NE
Version: 00

Date: 30/04/2025
Ref: 11634_EIA_LVIA

Figure A5.2.1
Aviation Lighting Zone of Theoretical Visibility (ZTV) - Nacelle Lighting

Appin Wind Farm
EIA Report



Statkraft

N

- Site Boundary
- Turbine with Nacelle Lighting
- Turbine without Nacelle Lighting
- 5 km Interval from Outermost Turbines
- 45 km LVIA Study Area
- Viewpoint
- Nighttime Viewpoint

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VP2: Bail Hill, Striding Arch
VP3: Cairnhead, Striding Arch
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VP5: High Appin
VP6: Benbrack, Striding Arch
VP7: Shinnel Water Valley near Craigencon
VP8: SUW near Cloud Hill
VP9: Moniaive
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VP12: Blackcraig Hill
VP13: A702, Shinnel Water Valley
VP14: Cairnsmore of Carsphairn
VP15: Crawick Multiverse
VP16: A713, near Stroangassel
VP17: A76, south of Closeburn
VP18: Durisdeer Rig
VP19: East Mount Lowther
VP20: Cairn Table

Vertical Angle of Lighting from Nacelle	Maximum and Minimum Luminous Intensity (Candela/cd.)	10% of Maximum and Minimum Luminous Intensity (Candela/cd.)
Above 5°	147 to 34	15 to 3
4° to 5°	247 to 134	25 to 13
3° to 4°	481 to 237	48 to 24
2° to 3°	1160 to 481	116 to 48
1° to 2°	2119 to 1170	212 to 117
0° to 1°	2206 to 1968	221 to 197
-1° to 0°	2036 to 987	204 to 99
-2° to -1°	996 to 383	100 to 38
-3° to -2°	394 to 197	39 to 20
-4° to -3°	199 to 131	20 to 13
-5° to -4°	131 to 92	13 to 9
Below -5°	94 to 38	9 to 4

Note:
Maximum and Minimum luminous intensity based on: Contamex Europe Ltd. (CEL) - CEL-WT-MIC Medium-intensity Red 2000cd. Light - LED Aircraft Warning Light Technical Specification.
The ZTV is calculated to turbine hub height (119 m) from a viewing height of 2 m above ground level. Lit turbines will be 1,2,5, and 9. The terrain model assumes bare ground and is derived from OS Terrain 5 height data. Earth curvature and atmospheric refraction have been taken into account. The ZTV was calculated using ArcGIS Pro 3.4.0 software.

0 5 10 20 Km

Source: LUC, Pell Frischmann, OS

Produced By: HD
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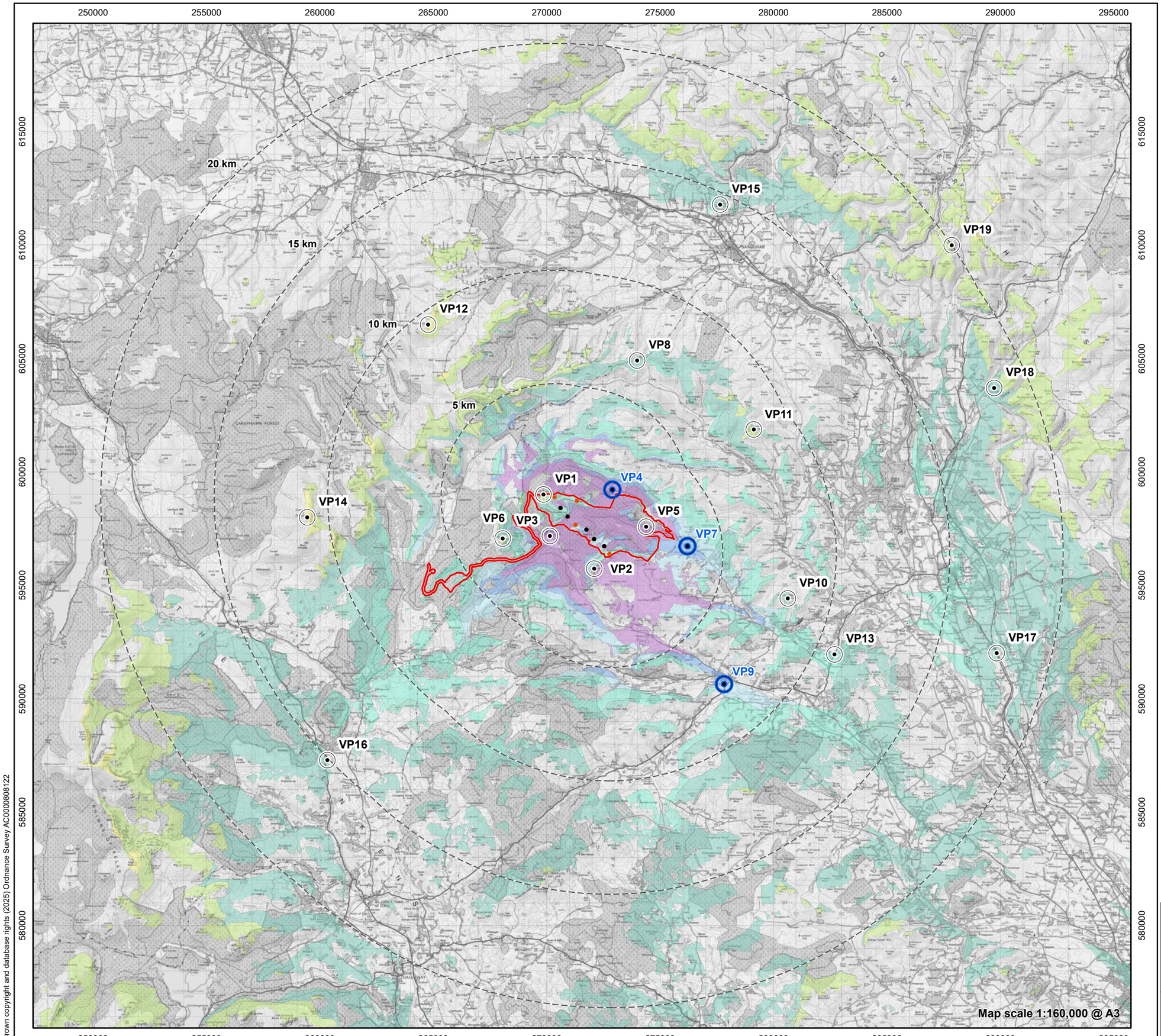
Date: 30/04/2025
Ref: 11634_EIA_LVIA

Figure A5.2.2
Visible Aviation Light Intensity Zone of Theoretical Visibility (ZTV)

Appin Wind Farm
EIA Report



Statkraft

N

- Site Boundary
- Turbine with Nacelle Lighting
- Turbine without Nacelle Lighting
- 5 km Interval from Outermost Turbines
- 45 km LVIA Study Area
- Viewpoint
- Nighttime Viewpoint

VP1: Colt Hill, Striding Arch
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VP16: A713, near Stroangassel
VP17: A76, south of Closeburn
VP18: Durisdeer Rig
VP19: East Mount Lowther

Vertical Angle of Lighting from Nacelle	Maximum and Minimum Luminous Intensity (Candela/cd.)	10% of Maximum and Minimum Luminous Intensity (Candela/cd.)
Above 5°	147 to 34	15 to 3
4° to 5°	247 to 134	25 to 13
3° to 4°	481 to 237	48 to 24
2° to 3°	1160 to 481	116 to 48
1° to 2°	2119 to 1170	212 to 117
0° to 1°	2206 to 1968	221 to 197
-1° to 0°	2036 to 987	204 to 99
-2° to -1°	996 to 383	100 to 38
-3° to -2°	394 to 197	39 to 20
-4° to -3°	199 to 131	20 to 13
-5° to -4°	131 to 92	13 to 9
Below -5°	94 to 38	9 to 4

Note:
Maximum and Minimum luminous intensity based on: Contamex Europe Ltd. (CEL) - CEL-WT-MIC Medium-intensity Red 2000cd. Light - LED Aircraft Warning Light Technical Specification.
The ZTV is calculated to turbine hub height (119 m) from a viewing height of 2 m above ground level. Lit turbines will be 1,2,5, and 9. The terrain model assumes bare ground and is derived from OS Terrain 5 height data. Earth curvature and atmospheric refraction have been taken into account. The ZTV was calculated using ArcGIS Pro 3.4.0 software.

0 5 10 Km

Source: LUC, Pell Frischmann, OS

Produced By: HD
Checked By: NE
Version: 00

Date: 08/05/2025
Ref: 11634_EIA_LVIA

Figure A5.2.3
Visible Aviation Light Intensity Zone of Theoretical Visibility (ZTV) - 20km

Appin Wind Farm EIA Report