One Earth Solar Farm

Volume 9.0: Other Post-Submission Documents [EN010159]

Supplementary Glint and Glare Assessment

October 2025

Document Reference: EN010159/APP/9.34

Revision 01

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 – Reg 5(2)(a)

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PRELIMINARY GLINT AND GLARE ASSESSMENT

One Earth Solar Farm

Our Ref: 6758

13 October 2025

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Report Details

Client: One Earth Solar Farm Ltd

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1 Executive summary

1.1.1 Eb7 have been instructed to revise the proposed embedded mitigation for One Earth Solar Farm (Proposed Development), located across the districts of West Lindsey District Council, Bassetlaw District Council and Newark and Sherwood District Council. The proposed embedded mitigation was included to avoid episodes of reflected solar glint and glare to neighbouring roads and railway lines from the proposed solar PV modules.

1.1.2 Updated study takes into account a finer level of detail of built form, vegetation and terrain derived from the project's topographical survey, as well as a larger number of analysis points along the receptors. The assessment has followed the Solar Glare Hazard methodology and Page Power glare significance criteria, commonly used for impacts on due to sunlight reflected from solar PV modules.

1.1.3 The technical assessments demonstrate that the finer level of detail derived from the project's topographical survey, and especially vegetation, buildings and terrain serve to screen the majority of glint and glare effects resulting from the Proposed Development on the road and railway network. Mitigation in the form of vegetation and temporary opaque screens will only be required for 240m along the A1133 between Hall Water Treatment Works and no. 4 Collingham Road, for 315m along the A57 between The Grove and Field House Farm, and 482m along the northern side railway line east of Far Road Bridge.

2 Legislative framework, planning policy and guidance

1.1.1 There is limited legislation, planning policies or guidance of relevance to glint and glare assessments. This assessment has been undertaken with regard to the following regulation, planning policy and guidance.

1.1 UK Regulation (EU) 139/2014

1.1.1 This regulation sets out requirements and administrative procedures related to aerodromes. The aim is to establish a consistent framework for aerodromes, ensuring safety and efficiency in aerodrome management and operation. It applies to aerodromes that meet certain traffic thresholds or are involved in commercial air transport, requiring them to obtain a certificate.

1.1.2 Chapter M on visual aids for navigation (lights), GM1 ADR-DSN.M.615 General, requires a safety assessment to identify situations where the risk of dazzling becomes unacceptable. Dazzle due to veiling luminance should not exceed 20,000 cd/m2, which could reduce the visual perception of pilots during approach and rolling, or of air traffic controllers supervising aircraft operations on, and close to the runway. Surprise (flash) effects should not be avoided on pilots at touchdown.

1.1.3 EASA Certification Specifications and Guidance Material for Aerodrome Design CS-ADR-

DSN.M.615 General 2025 has not changed in relation to glint and glare since 2014.

2.1 National planning policy

2.1.1 National Policy Statement for Renewable Energy Infrastructure (EN-3) 2024 sets out the primary policy for decisions by the Secretary of State for nationally significant renewable energy infrastructure.

2.1.2 Sections 2.10.102 to 2.10.106 set out general considerations for the assessment of impacts of glint and glare in relation to solar panels. *"Glint is defined as a momentary flash of light that may be produced as a direct reflection of the sun in the solar panel. Glare is a continuous source of excessive brightness experienced by a stationary observer located in the path of reflected sunlight from the face of the panel"*. Where receptors are likely to have potential glint and glare issues, the applicants are expected to estimate the potential impact based on the angle and duration of incidence and the intensity of the reflections. The effect of frames and supports may also be considered.

2.1.3 Sections 2.10.134 to 2.10.136 give advice on possible mitigation measures to address the impacts of glint and glare, such as anti-reflective coating with a specified angle of maximum reflection attenuation, the implementation of screening to block reflections, or adjusting the azimuth alignment or the elevation tilt angle.

2.1.4 Sections 2.10.158 and 1.10.159 state the need to consider the potential impact on receptors such as nearby homes, motorists, public rights of way, and aviation infrastructure (including aircraft departure and arrival flight paths). *"Whilst there is some evidence that glint and glare from solar farms can be experienced by pilots and air traffic controllers in certain conditions, there is no evidence that glint and glare from solar farms results in significant impairment on aircraft safety. Therefore, unless a significant impairment can be demonstrated, the Secretary of State is unlikely to give any more than limited weight to claims of aviation interference because of glint and glare from solar farms"*.

2.2 Local planning policy

2.2.1 Newark & Sherwood Local Development Framework, Draft Solar Energy, Supplementary Planning Document (July 2024, sections 6.35 to 6.38) refers to EN-3. A glint and glare assessment should identify potential receptors (including aviation) and how they could be affected, estimating the duration and intensity of the reflections. Tracking systems and other supporting structures and frames should be considered.

2.2.2 Bassetlaw Local Plan 2020-2038 Policy ST-49: Renewable Energy Generation states that glare from new solar developments should be considered.

2.3 Guidance

1.1.4 CAA (Civil Aviation Authority) interim "Guidance on Solar Photovoltaic Systems" identifies the key safety issues with regards to aviation, as solar photovoltaic (SPV) installations may cause glare, dazzle pilots, or lead them to confuse reflections with aeronautical lights. This interim guidance was published in 2010, but withdrawn in 2012. According to the guidance, it is best practice to consult with Aerodrome License Holders (ALH), the CAA, the Air Navigation Service Provider (ANSP) and/or NATS and the MoD, especially for major airports nearby, aerodromes within 5km from the proposed development or at distances that could affect the aircraft operating visual circuit. It is recommended that SPV developers include a risk assessment on planning applications. This guidance did not prescribe a formal methodology of assessment, but data on the reflectivity of solar panel material should be included for on-aerodrome SPVs.

2.3.1 CAST (Combined Aerodrome Safeguarding Team) Guidance Note GA1 'Safeguarding Guidance to General Aviation Aerodrome Managers & Operators' recommends considering glint and glare over a wide area, covering Visual Reference Points (VRPs) and other important points like the circuit. It also estates that solar reflections with potential to cause after-image ("yellow glare") are of considerable concern, especially for a pilot on approach. It recommends fixed solar panels instead of tracking systems due to the certainty over the range of times when glare is possible.

2.3.2 CAST 'Aerodrome Safeguarding Advice Note 5' (February 2024) provides high-level guidance regarding safety considerations (Air Traffic Service personnel and pilots) and study areas, but it does not prescribe a specific methodology for assessing glint and glare effects. It recommends early consultation with the aerodrome authority. A glint and glare assessment should be conducted for solar energy developments within 5 km from an aerodrome, but it could be considered out 10 km and beyond in exceptional circumstances. Safety should be considered for the Air Traffic Services (ATS) personnel at the control tower, especially within the Visual Control Room (VCR), pilots (on approach, in a visual circuit or on the ground, departing and taxiing aircraft), and Communication, Navigation, and Surveillance (CNS) equipment. Panels close to the ends of a runway should accommodate an Engine Failure After Take-off (EFATO) area, which extends 45 degrees either side from the extended runway centreline. It informs that neither UK CAA nor US FAA mandate a specific methodology for assessing glint and glare.

1.1.5 US Federal Aviation Administration (FAA) 'Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports' (2013) recommends undertaking technical assessments using the Solar Glare Hazard Analysis Tool (SGHAT), developed by Sandia National Laboratories, although alternative tools could be proposed and validated provided they use the Solar Glare Hazard Analysis Plot.

1.1.6 The 2013 FAA interim policy was superseded in 2021 by the 'Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports' (86 FR 2581). This final policy does not have the force and effect of law, but it recommends the following:

- Airports are encouraged to request an ocular analysis demonstrating no impacts to Air Traffic Control Tower (ATCT) cabs. The results are no longer required to be submitted to FAA.
- Requirements for pilots on final approach are withdrawn as glint and glare impacts from solar systems are similar to those routinely experienced from water bodies, glass-façade

buildings, parking lots, and similar features.

- The policy only applies to federally-obligated airports and solar energy systems on airport property, but installations off-airport are also encouraged to consider ocular impacts and coordinate with the local airport sponsor.
- FAA withdraws the recommended tool for ocular impact (SGHAT). FAA does not endorse a specific tool, which may not even be necessary in some cases (i.e. solar reflections are not visible from the ATCT cab).

2.3.3 Most aviation stakeholders refer to 2013 FAA interim policy as it is the only one that provides a method of assessment for glint and glare.

2.3.4 In addition to the FAA guide, this assessment has also been carried out in accordance with industry best practice and two documents published by Pager Power. Firstly, the fourth edition of the 'Solar Photovoltaic and Building Development Glint and Glare Guidance' from 2022, which includes guidance for aviation and railway operations, road users, and dwellings. Secondly, the second edition of the 'Solar Photovoltaic Glint and Glare Guidance' from October 2018, which includes methodology for the assessment of helipad operations.

2.3.5 In regard to rail, the Rail Industry Standard (RIS) RIS-0737-CCS on 'Signal Sighting Assessment Requirements' highlights that "a planned change external to the railway could affect signal sighting, for example changes that affect the built environment (for example, a new structure causing obscuration, a solar farm causing reflection)." Therefore, whilst it is clear the implementation of PVs can cause glint and glare, there is no specific guidance on how to assess this specifically towards trains.

2.3.6 The UK Highway Code states that road users should be aware of particular hazards such as glare from the Sun and should adjust their driving style appropriately. Solar PV panels reflect sunlight producing solar glare under specific conditions, which may likely pose hazard towards road users.

2.3.7 At the time of this report there was no published guidance on the effects of glint and glare on helicopters, bridleways, public rights of way (PRoW), boat users or fields with grazing animals.

3 Assessment methodology

3.1 Glint and glare definition

1.1.7 The following definitions are taken from NPS EN-3, paragraph 2.10.102:

- Glint is a momentary flash of bright light typically received by moving receptors or from moving reflectors; and
- Glare is a continuous source of bright light typically received by static receptors or from large reflective surfaces.

3.1.1 The term 'solar reflection' is used in this report to refer to both reflection types, glint and glare.

3.2 Methodology

3.2.1 The methodology for a glint and glare assessment is as follows:

- Identification of key sensitive receptors in the area surrounding the Proposed Development;
- Geometric analysis to determine if solar reflections will be visible from each receptor. Where the panels are not visible, no impact is possible upon the receptor;
- Where solar reflections are visible, a Solar Glare Hazard Analysis Tool (SGHAT) is used to estimate relevant glare metrics, including ocular hazard (using the Solar Glare Ocular Hazard Plot or SGOHP), glare frequency (both daily and annual) glare angles, direct luminance values and/or veiling luminance;
- Determination of the significance of the potential effects upon each receptor, following the specific criteria for each type of receptor with respect to published studies and guidance, and considering the calculated metrics and any relevant mitigating factors; and
- Establish whether these impacts will cause significant effects which may require additional mitigation.

3.3 Solar glare ocular hazard plot (SGOHP)

3.3.1 SGOHP is used to measure the ocular impact of any proposed solar energy system. It includes two metrics: Potential for After-image and Potential for Permanent Eye Damage. The visual impact is a function of the retinal irradiance (intensity) and the subtended angle (size) of a glare source, and it quantifies the potential to cause an after-image in the retina, which would reduce the visual performance. The ocular hazard is classified as (img. 1):

- Green glare: Low potential to cause after-image;
- Yellow glare: Potential to cause an after-image; and
- Red glare: Potential for permanent eye damage.

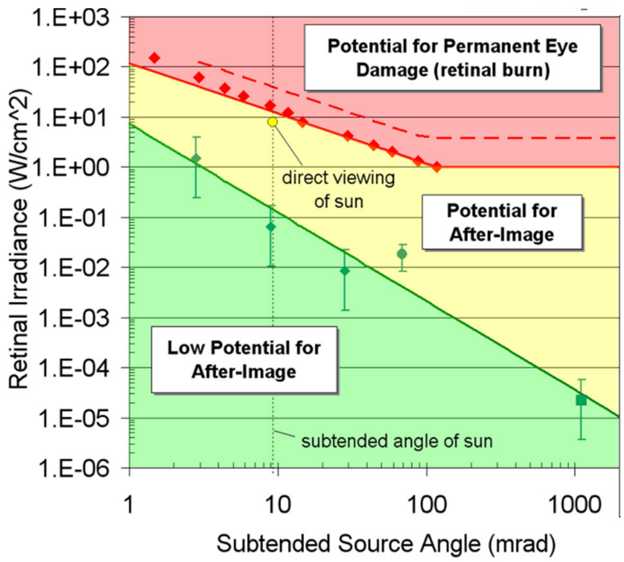


Image 1 - Retinal glare hazard ocular plot

3.3.2 SGHOP assumes that the observer is looking directly into the light source with a quick blink eye response (0.15 seconds) and the possibility to avert his gaze. In those cases, retinal burn is only possible with solar concentration systems.

1.2 Glare angle

1.2.1 The glare angle is the angle between the line of sight and a light source (i.e. a solar reflection). This is a key parameter in most disability glare metrics. Disability glare is more likely the closer the light source is to the line of sight. As a reference, reflections outside 30 degrees are considered of little relevance, reflections within 10 degrees can usually cause glare, and reflections within 2.5 degrees are very likely to cause disability glare.

1.2.2 The glare angle is considered in veiling luminance calculations. However, it is not taken into account for direct luminance or ocular hazard (SGOHP). The latter assumes that the observer is looking directly at the source of light.

3.4 Technical assumptions and limitations

3.4.1 The technical assessments have been undertaken with the following assumptions:

- The solar PV areas are assimilated to surfaces following the terrain topography at a representative height, usually the average height above ground level (AGL);
- There is no consideration for solar PV overshadowing between rows of panels, gaps between them or supporting structures, unless otherwise specified;
- Solar panels are evenly distributed across the Solar PV areas;
- Only the front part of the solar PV modules are assumed to reflect the solar rays. The rear face of the solar PV modules and other parts of the solar system (i.e. frames or supports) will have a matt finish and they will not cause solar reflections;
- Only relevant screening elements around the Site that may obstruct the Sun from view

of the solar panels are included in the model;

- Terrain elevation heights are interpolated based on Ordnance Survey (OS) Terrain 50m Digital Terrain Model (DTM) data, unless more detailed topographic data for the Site is available;
- Clear and sunny skies for the entire year, as a highly conservative worst-case scenario;
- The direct normal illuminance (DNI) and the luminous efficacy (K) of the Sun at each time step is based on the solar altitude and air mass for the Site latitude (Appendix 2);
- Fixed intensity within the cone of reflection, which is defined by the slope error of the Solar PV modules surface material;
- The combined effects of several solar PV areas are estimated cumulatively, but the effects of simultaneous solar reflections from solar PV areas with different characteristics (azimuth, tilt or reflectivity) are estimated qualitatively; and
- The calculation is undertaken at regular time steps throughout the year, typically at one minute intervals. Times are denoted in standard time with no daylight savings.

3.4.2 When permeable obstructions are considered in the calculation (i.e. deciduous trees or fences), solar rays are considered to the blocked when the cumulative permeability, after traversing several obstructions, falls below 5%.

3.4.3 The ocular hazard (SHOGP) has been calculated in this report have been undertaken using the following assumptions:

- Ocular transmission coefficient 0.5;
- Pupil diameter 0.002m; and
- Eye focal length 0.017m.

4 Evaluation criteria

4.1.1 The evaluation criteria follows 2022 Page Power guidance, which considers a combination of reflection times (frequency, instances and duration), proximity to the line of sight (glare angle) and potential ocular hazard (SGOHP). Professional experience is applied where guidance is not specific.

4.2 Impact levels for approaching aircrafts

4.2.1 The location of the solar reflection is more important than the duration of reflection on the receptors, as the receptor is fast-moving. The time of visible reflections may also be relevant in relation to operational schedules at the receptor. Solar reflections have no impact when receptors are not in use[1].

[1] FAA 2013 recommends only green glare along the final approach. FAA 2021 has no recommendation.

- Green glare or yellow glare with significant mitigation factors: Low impact;
- Yellow glare without significant mitigation: Moderate impact; and
- Red glare: High impact.

4.3 Impact levels for Air Traffic Control Towers (ATCT)

4.3.1 The ATCT is the most sensitive aviation receptor, and the FAA policy 2021 recommends avoiding ocular impacts to the ATCT cab. However, a more pragmatic approach is included in more recent guidance (Page Power 2022):

- Green glare with significant mitigation factors: Low impact;
- Green glare without significant mitigation or yellow glare: Moderate impact; and
- Red glare: High impact.

4.4 Impact levels for road receptors

4.4.1 The glare angle (between a solar reflection and the line of sight) has more of an impact on road users than the ocular hazard or the duration of glare, as the receptor is moving.

4.4.2 Impacts on local roads are always considered of low impact. Impacts on major national, national and regional roads are:

- Effective mitigation: Low impact;
- Partial mitigation: Moderate impact; and
- No mitigation:
  - Reflections not in front of view[2]: Moderate impact; and
  - Reflections in front of view: High impact.

4.5 Impact levels for railway receptors

4.5.1 Similar to roads, the glare angle is more relevant for train drivers than other metrics. Impacts on railway lines are classified as:

- Effective mitigation: Low impact;
- Partial mitigation: Moderate impact; and
- No mitigation:
  - Reflections not in front of view: Moderate impact; and
  - Reflections in front of view: High impact.

[2] The Applicant considers in front of view to be 10 degrees from the line of sight.

4.6 Impact levels for building receptors

4.6.1 For buildings, the main factor is the frequency of glare, both daily and annually, more than the ocular hazard:

- Reflections significantly screened or mitigated: Low impact;
- Reflections not screened/mitigated[3] :
  - Frequency < 90 hours/year and <60 min/day: Low impact;
  - Frequency < 90 hours/year or <60 min/day: Moderate impact; and
  - Frequency > 90 hours/year and >60 min/day: High impact.

4.7 Impact levels for other receptors

4.7.1 There is no specific guidance on glint and glare on Public Rights of Way (PRoW) or bridleways. Glare should be avoided where possible, but it is generally considered that significant effects upon pedestrians on a PRoW or riders on bridleways are not possible. The 'Advice on Solar Farms near routes used by equestrians' (The British Horse Society, 2025) states that 'any reflection is unlikely to be a direct problem to horses or equestrians because of the angles and distances involved and because the surface has a dull sheen rather than glare even on a bright day.' It also states that the BHS 'has no evidence of glint and glare from solar panels and no evidence of horses reacting to it or of it being detrimental to the health and wellbeing of horses.' The typical density of pedestrians and riders is low in a rural environment. There is little safety hazard associated with reflections towards an observer on a footpath or a bridleway, and any resultant effect is much less serious than, for example, on the road network. Furthermore, pedestrians or horses have more freedom to move beyond the solar reflection with little impact upon safety or amenity.

4.7.2 In the absence of specific glint and glare evaluation criteria for helicopters, impact levels are assimilated to those of approaching aircrafts.

4.8 Mitigating factors

4.8.1 Mitigating factors include, but are not limited to, the following:

- Solar reflections are visible in the same direction to direct sunlight. In these cases, the user is likely to be prepared and adapted for glare;
- Significant screening (i.e. trees or hedgerows, deciduous or with gaps). This increases the likelihood of reflections will be less intense and smaller;
- Times of the day/year when reflections are visible. If the reflections do not overlap with the operational times of the receptor (i.e. use of a room or rush hour on a road), there is usually no impact;

[3] 90 hours per year equate to three months (90 days) of 60 minutes per day.

- Type of road (major national, national, regional or local). The denser the traffic, the higher the risk of an accident;
- Length of the path (i.e. road/railway) affected by glare. The longer the path, the higher the risk of an accident;
- Duration of exposure. Continuous exposure may be more severe than one spread over time;
- Glare angle between the reflection and the line of sight. Glare is more intense close to the line of sight; and
- For buildings, oblique reflections impacting a window are less likely to be seen from inside.

4.9 Impact significance and mitigation

4.9.1 The significance and the need for mitigation depend on the level of impact:

- No impact: Reflection not visible. No mitigation needed;
- Low impact: Reflection visible but of limited relevance (i.e. significantly screened). No mitigation needed;
- Moderate impact: Reflection visible but not under worst-case conditions. Mitigation recommended; and
- Major impact: Reflections visible under worst-case conditions, which implies a significant impact. Mitigation and consultation required.

4.9.2 The reflective capacity of Solar PV modules, especially those designed with anti-reflective glass or produced with anti-reflective coating, have a reflective capacity equal or less hazardous than elements already in the environment such as bodies of water, glazed element in buildings (i.e. windows or curtain walls), parking lots, metal structures, wet roads or even snow on the ground. This is recognised in NPS EN-3 and FAA Policy 2021 (FAA, 2021).

4.9.3 Where there is a requirement for luminance values (i.e. certified European airports), these are evaluated against the recommended maximum levels (typically 20,000 cd/m2).

5 Proposed developments location and details

5.1 Reflector areas

5.1.1 Appendix 1 shows the proposed layouts which demonstrate the worst-case scenario for the purposes of this assessment. The blue areas denote the proposed solar PV module locations. Discreet elements (compounds, substations, BESS, and BoSS) are not included in the assessment.

5.1.2 All PV modules feature the following characteristics:

- Fixed panels (no solar tracking system);

- 15 degrees tilt (elevation) angle;
- Due South orientation (180 degrees azimuth from North); and
- Panel material: Smooth glass with Anti-reflective (AR) coating, with a slope error of 8.43 mrad. The reflectivity at different angles of incidence can be seen in image 2.

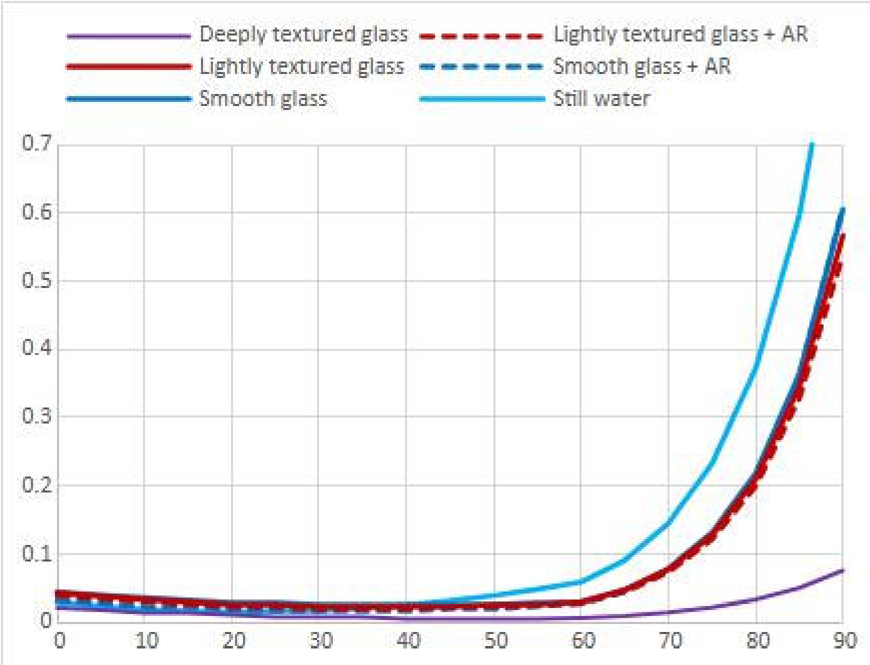


Image 2 - Reflectivity of typical solar PV module materials

5.1.3 The design includes solar PV modules at different AGL heights due to potential flooding. The PV areas have been grouped in three zones according to the heights (tbl.1). For the purpose of this report, approximately the average height has been considered for each zone.

Table 1. PV zone AGL heights

Zone	Minimum (m)	Maximum (m)	Average (m)
H1	0.7	3.5	2.1
H2	1.3	3.5	2.4
H3	1.8	3.8	2.8

5.2 Embedded mitigation

5.2.1 The proposed design includes embedded mitigation (tbl. 2 and Appendix 1) consisting of screening in the form of vegetation to provide a barrier against glare, in order to ensure potential impacts are within recommendation for receptors on the ground. Once established, these elements will have a height of 4m AGL. Vegetation may provide varying levels of cover, immediately after planting, during winter, and after maintenance (i.e. pruning). Temporary screening (4m high wooden hoarding or similar) will be implemented and removed once the vegetation achieves 4m AGL.

Table 2. Embeded mitigation (vegetation screening)

Code	Length (m)	Height (m)
SC1	240.6	4.0
SC2	315.0	4.0
SC3	482.0	4.0

6 Assessment receptors and obstructions

6.1 Study Areas

6.1.1 There is little formal guidance with regard to the maximum distance at which glint and glare should be assessed. However, based on industry best practice and past assessment experience, a study areas have been defined and used in this report (Appendix 1).

6.1.2 For ground-based receptors, including roads and railway lines, the study area comprises up to 1km from the solar PV modules. The assessment has only considered receptors within this study area and with potential view of the solar PV modules.

6.2 Road and Railway Receptors

6.2.1 The majority of roads within the 1km study area are of local importance. As any impact on local roads will be of limited low impact, these roads have not been included in the analysis. Based on the significant criteria in Solar Photovoltaic and Building Development Glint and Glare Guidance from 2022, local roads need not be included in the detailed assessment because only low impacts would be found in a worst-case scenario, which would have no significant effects. This is because traffic volumes and speeds are likely to be relatively low, resulting on low risk on local traffic.

6.2.2 Two roads of regional relevance have been included in the study (tbl. 3 and Appendix 1): A57 (Durham Road) and A1133. Both roads were split in two sections. Only the sections of the road located within 1km from the proposed solar PV modules have been considered in the analysis. Both directions of travel have been considered on these sections, with a driver eye height of 1.5m above the road.

6.2.3 There is a former railway line within the 1km study area that connected Tuxford and Lincoln. Most of this line was dismantled and it is now Skellingthorpe Walk. However, a western section of the line, up to the former High Marnham Power Station, is still used as a test track by Network Rail. This has been included in the analysis (tbl. 3 and Appendix 1). Only eastbound trains have been considered, with a driver eye height of 2.75m above the railway tracks.

Table 3. Road and railway receptors

Code	Name	Level
RD1	A113 – North section	Regional
RD2	A113 – South section	Regional
RD3	A57 (Durham road) – East section	Regional
RD4	A57 (Durham road) – West section	Regional
RW	Network Rail's High Marnham Test Track	-

6.2.4 The analysis includes a 50 degrees maximum view angle from the direction of travel for road and train drivers. Therefore, the results only show solar reflections within the field of view.

6.2.5 The analysis has been undertaken at regular intervals (50m) along the road and railway paths.

6.3 Obstruction elements

6.3.1 Elements in the landscape can act as barriers and block solar reflections from view. These include solid elements (i.e. buildings and walls) and permeable elements (i.e. vegetation and fences).

6.3.2 The present study has considered obstruction elements from a detailed topographical survey. This survey expands some 18 square km and includes the proposed solar PV areas and their immediate surrounds (Appendix 1). The survey includes information on the terrain, vegetation and buildings.

6.3.3 The surveyed terrain includes contour lines every 0.25m in height, which has been used to define the topography for the proposed solar PV areas and as an obstruction to solar reflections in the technical calculations.

6.3.4 Surveyed buildings have been included in the technical assessment where these could have a significant shielding effect on the solar reflections for particular receptors. These include barns and buildings of significant size. Houses and small elements in the landscape have generally not been considered on the analyses.

6.3.5 The surveyed vegetation includes trees and hedge, and their AGL heights (with 1m accuracy). These elements have been included and considered in the technical assessments as obstructions to solar reflections. Two characteristics have been considered: Vegetation is not completely opaque to solar rays passing through, and this permeability is higher for deciduous species in winter when trees and hedges lose their leaves.

6.3.6 As a worst-case scenario, all vegetation has been considered deciduous, and the calculation has been split in two periods: summer and winter. The length of each period has been assumed the same for all vegetation: Summer from 1st April to 30th September, and winter from 1st October to 31st March. A uniform 20% permeability has been estimated during summer and 60% during winter.

7 Technical assessments

7.1.1 Only one scenario has been considered in the technical assessment, which the worst-case for the current proposed design. The annual analysis has been split in two periods, winter and summer, each one with a different permeability for vegetation obstructions. Summer is assumed to cover from 1st April to 30th September, and winter from 1st October to 31st March. The solar positions and intensities for each period are tailored to each period.

7.1.2 The results of the technical assessments are presented in Appendix 3. The output of this analysis is limited to receptors (or part of them) receiving solar reflections within the field of view.

7.1.3 The graphs show the visible reflections throughout the year and their level of glare as perceived from the receptor. The metrics considered and displayed in Appendix 3 are the glare angle (between the line of sight and the solar reflection) and the ocular hazard (SGOHP).

7.1.4 Solar reflection maps graphs show the maximum annual glare[4] along the path each section of road or railway receiving significant solar reflections. The results are displayed separately for summer and winter months, and with and without embedded mitigation (fully grown proposed vegetation screening).

7.1.5 Annual graphs show when solar reflections are visible (days/months and times), and the highest level of glare along the entire length of the receptor analysed at each moment in time. The results are displayed with and without embedded mitigation.

7.1.6 It should be noted that the assessment assumes worst-case conditions (full sunny weather throughout the year and no cloud coverage). The risk of glare in reality will be significantly lower than predicted. For ground-based receptors (i.e. road and train drivers), solar reflexions will typically occur very close to direct sunlight from a viewer's point of view due to the timings (dawn and sunset) and the low tilt (15 degrees). This means that solar reflexions will not catch the viewer unprepared, and any potential impact will be less intense.

7.2 Results for receptor RD1

7.2.1 No visible solar reflections will be visible from the northern section of A1133.

7.3 Results for receptor RD2

7.3.1 The results show that solar reflections will only be visible from the southern section of A1133 for drivers travelling north and for a stretch of the road from Hall Water Reservoir and Treatment Works up to 200m before No.4 Collingham Road (imgs. 7 and 11). Results with and without mitigation can be seen in images 12 to 23 (Appendix 3).

[4] The maximum annual glare corresponds to the worst effect along the year. For ocular hazard (SGOHP) that is the maximum level and for glare angle it is the minimum value, as small angles occur when reflections are closer to the line of sight.

7.3.2 With no mitigation, solar reflections from the east will be visible early in the morning from mid-March to mid-September, during less than 10 min. per day (imgs. 16 and 20). Glare angles between 10 and 30 degrees can be seen mostly in summer (imgs. 12 and 13), and the ocular hazard (SGOHP) shows a stretch of yellow glare in summer (img. 18).

7.3.3 The daily frequency of glare is low, but both the glare angles and the yellow glare (SGOHP) indicate a potential for intense solar reflections that should be avoided. These solar reflections can be rated as low to moderate impact, and mitigation is recommended.

7.3.4 The analysis with mitigation includes 4m vegetation screening (SC1 in img. 4, Appendix 1) to supplement the existing low hedges (img. 7). With this screening in place, only glare angles greater than 30 degrees are visible (imgs. 13 and 14), yellow glare is reduced to a marginal section at the bend in the road (img. 21), and the number of days with glare is reduced by 70% (imgs. 17 and 23).

7.4 Results for receptor RD3

7.4.1 The results show that solar reflections will only be visible from the eastern section of A57 for drivers travelling east from 550m to 200m before Birchlands Farm (imgs. 8 and 11). Results without mitigation can be seen in images 24 to 29 (Appendix 3).

7.4.2 With no mitigation, solar reflections will be visible from the east early in the morning for a few days around the equinoxes during less than 10 min. per day (imgs. 26 and 29). Glare angles are smaller than 10 degrees, but the ocular hazard (SGOHP) shows only green glare.

7.4.3 As the daily and annual frequencies of glare are both marginal these solar reflections can be considered of low impact, which requires no mitigation.

7.5 Results for receptor RD4

7.5.1 The results show that solar reflections will only be visible from the western section of A57 for drivers travelling east from a gentle hill between Goosemoor Cottage and Wimpton House, and between Grey Oak / The Grove and Field House Farm (imgs. 9 and 11). Results without mitigation can be seen in images 30 to 41 (Appendix 3).

7.5.2 With no mitigation, solar reflections will be visible from the east early in the morning from around both equinoxes, during less than 10 min. per day (imgs. 32 and 38). Glare angles lower than 10 degrees can be seen (imgs. 30 and 31), although the ocular hazard (SGOHP) shows only green glare (imgs. 36 and 37). The annual and daily glare frequency are low. These reflections can be considered of low to moderate impact and mitigation is recommended.

7.5.3 The analysis with mitigation includes 4m vegetation screening (SC2 in img. 3, Appendix 1) to supplement the existing low hedges (img. 9). With this screening in place, most solar reflections will be eliminated (imgs. 33 and 34), with only marginal reflections visible from Goosemoor Cottage hill above The Grove to the east.

7.6 Results for receptor RW

7.6.1 The results show that solar reflections will be visible from the railway line for train drivers travelling east between Far Road and the end of the track (imgs. 10 and 11). Results with and without mitigation can be seen in images 42 to 53 (Appendix 3).

7.6.2 With no mitigation, solar reflections will be visible from the east early in the morning from mid-March to mid-September, during less than 15 min. per day (imgs. 44 and 50). Glare angles will be smaller than 10 degrees during the summer months (img. 42), and between 10 and 30 degrees in winter (img. 43). The ocular hazard (SGOHP) shows a stretch of yellow glare in summer (img. 48). This indicates moderate impacts, and mitigation is recommended.

7.6.3 The analysis with mitigation includes 4m vegetation screening alongside the railway line (SC3 in img. 3, Appendix 1). With this screening in place, yellow glare is eliminated (img. 51), and glare angles below 10 degrees are marginal (imgs. 45 and 47). This means that although it is possible that some solar reflections will be visible through the proposed vegetation screening, these will be effectively filtered to acceptable levels (green glare).

8 Conclusions

8.1.1 The technical assessments demonstrate that the finer level of detail derived from the project's topographical survey, and especially vegetation, buildings and terrain serve to screen the majority of glint and glare effects resulting from the Proposed Development on the road and railway network. Mitigation in the form of vegetation and temporary opaque screens will only be required for 240m along the A1133 between Hall Water Treatment Works and no. 4 Collingham Road, for 315m along the A57 between The Grove and Field House Farm, and 482m along the northern side railway line east of Far Road Bridge.

Appendix 1. Analysis elements

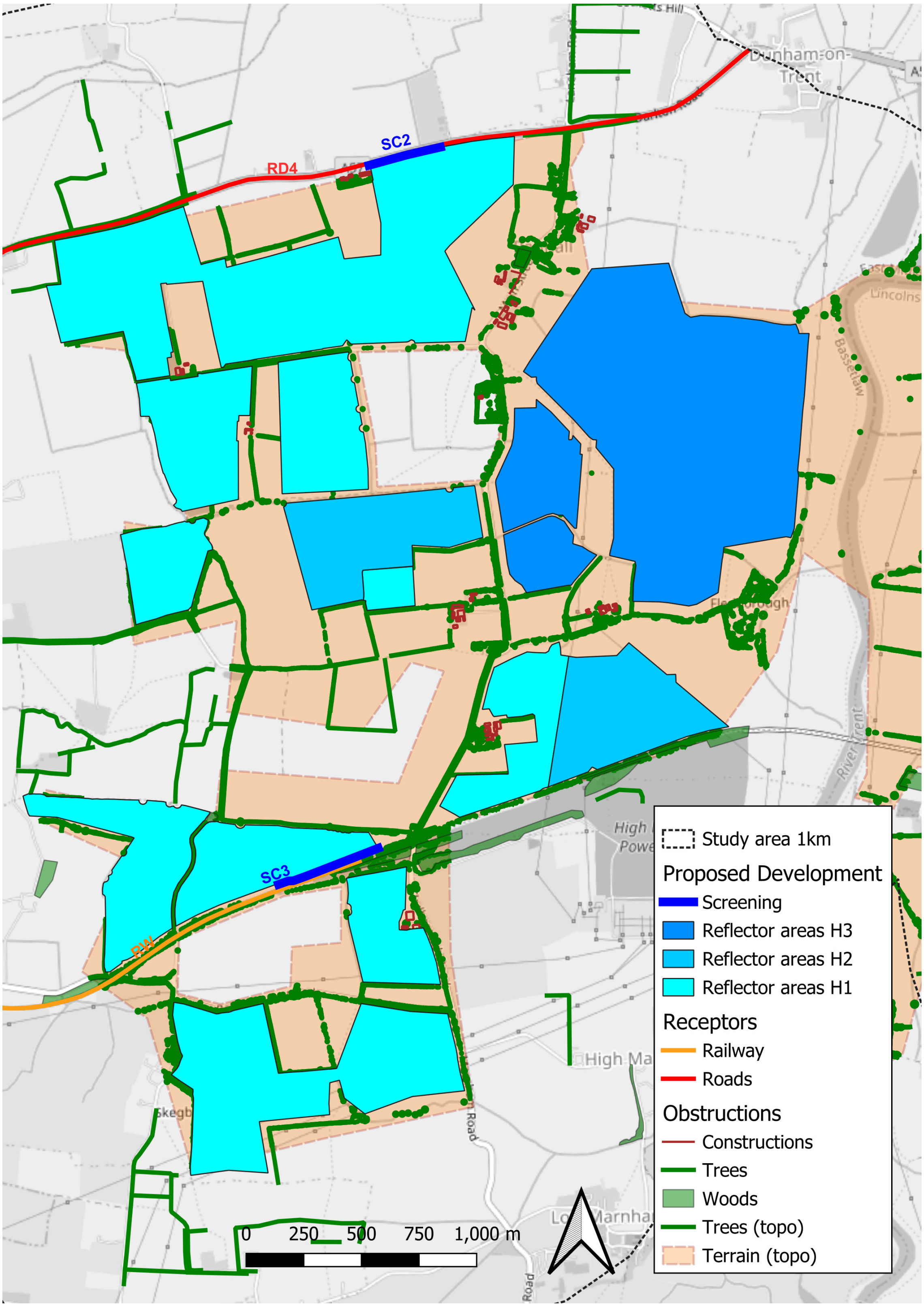


Image 3 - Analysis elements within the 1km study area (WEST section)

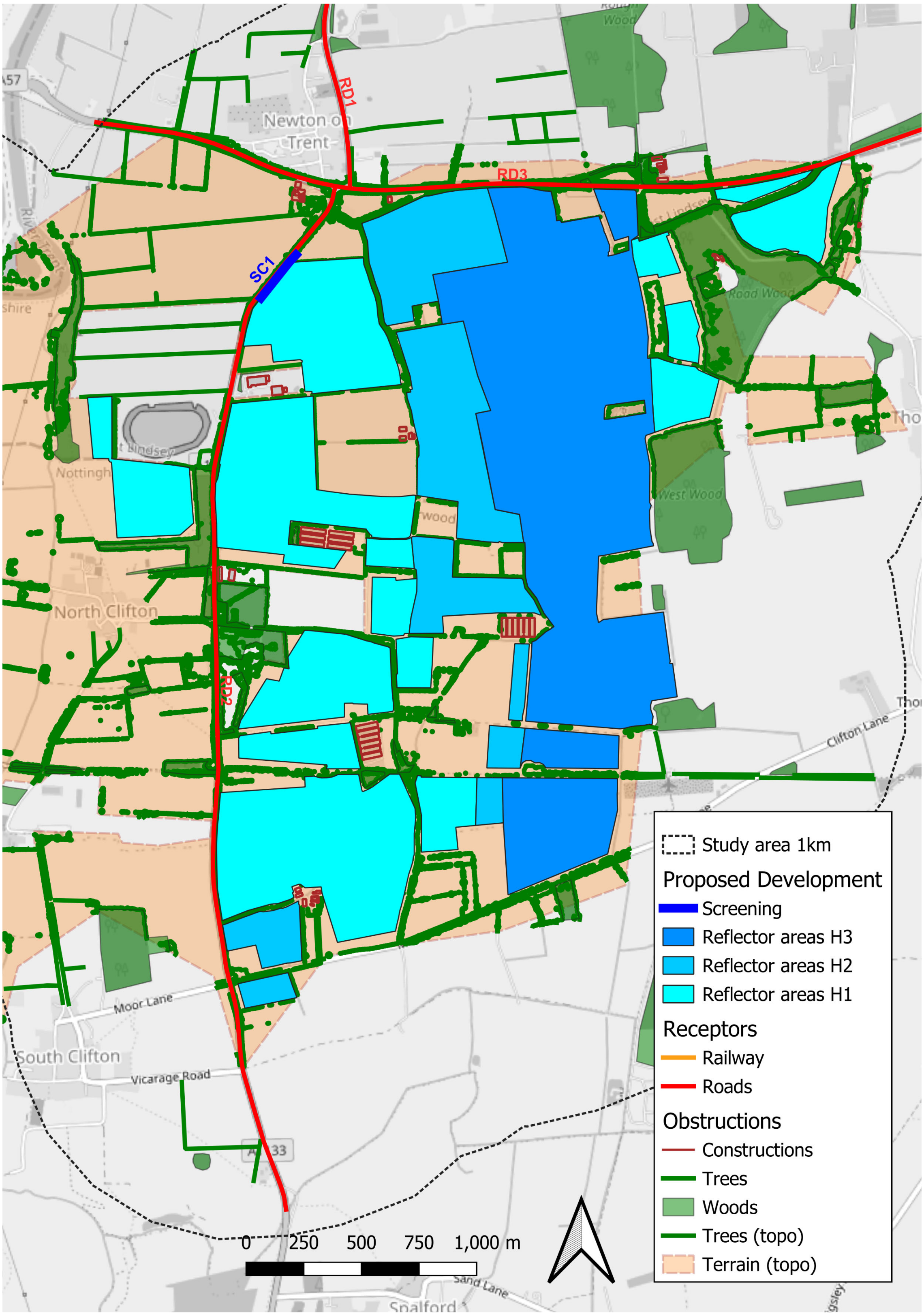


Image 4 - Analysis elements within the 1km study area (EAST section)

Appendix 2. Solar photometry

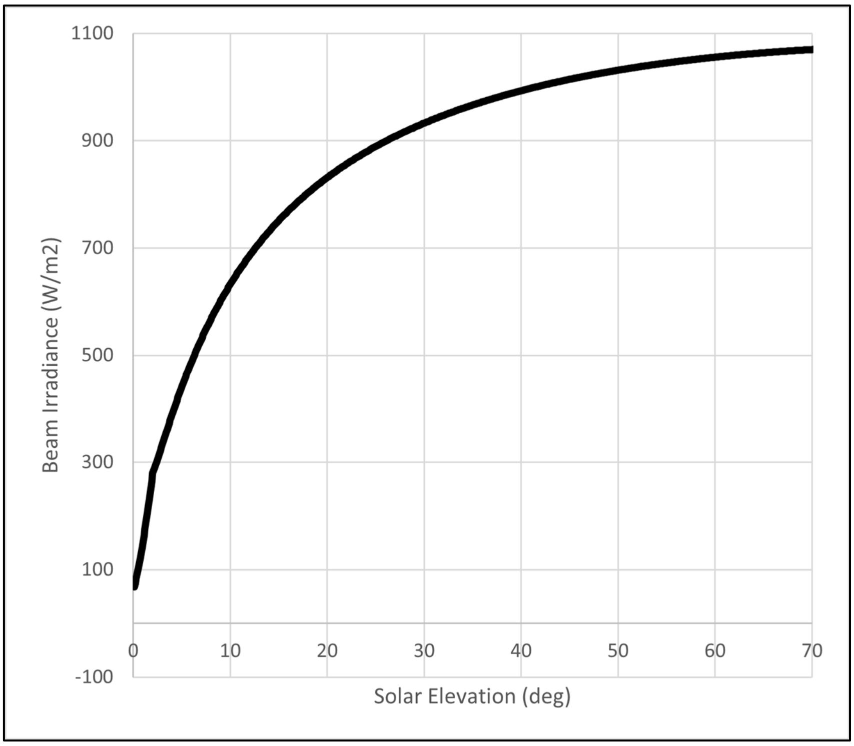


Image 5 - Solar Direct Normal Irradiance (DNI)

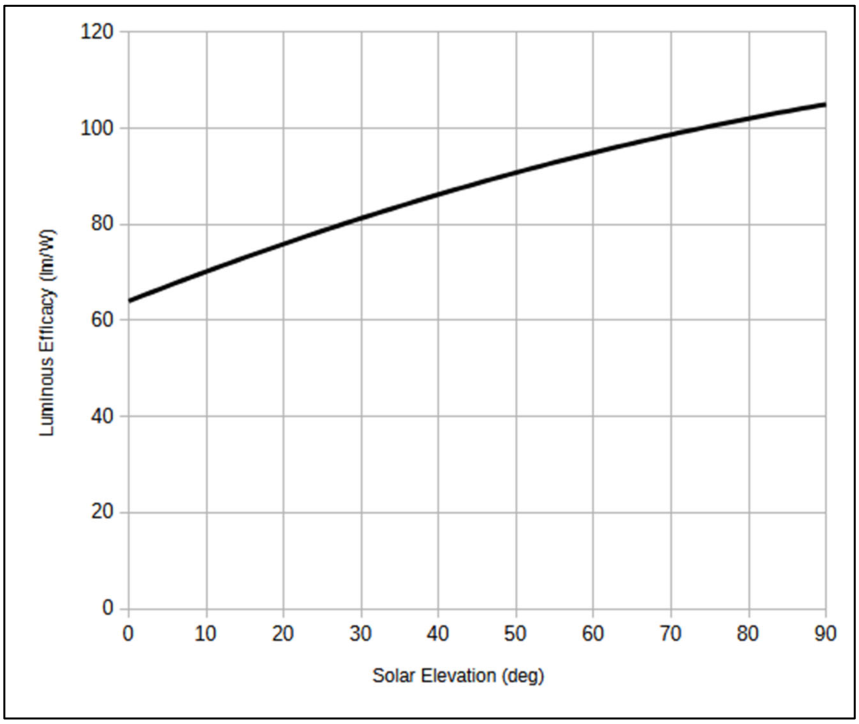


Image 6 - Sunlight luminous efficacy (K)

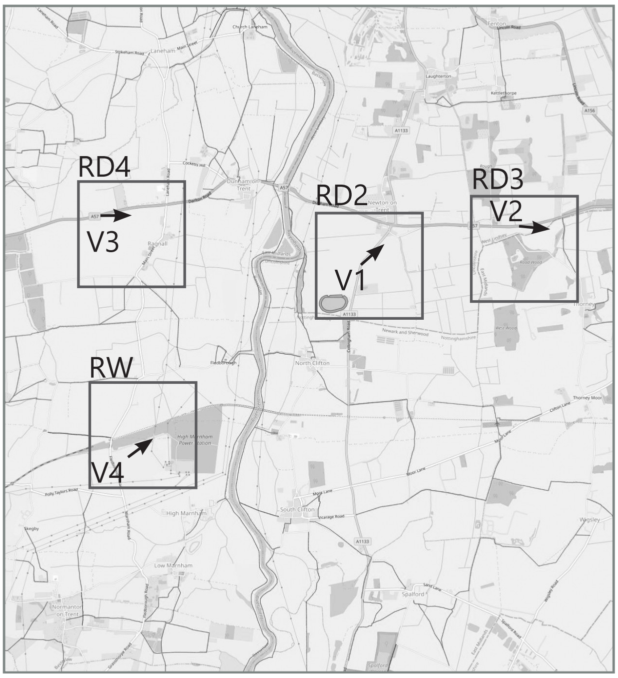
Appendix 3. Assessment results

Img. 7: View V1 - A1133 road travelling north (RD2N)

Img. 8: View V2 - A57 road travelling east (RD3E)

Img. 9: View V3 - A57 road travelling east (RD4E)

Img. 10: View V4 - Railway travelling east (RW)



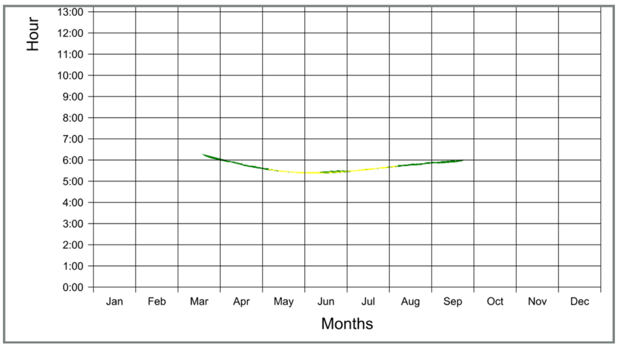
Img. 11: Location plan

Img. 12: Summer months without mitigation

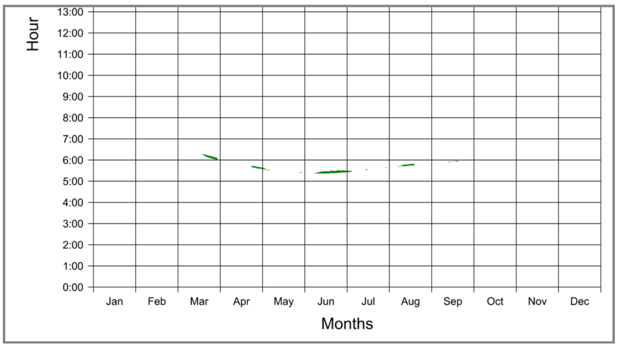
Img. 13: Summer months with mitigation

Img. 14: Winter months without mitigation

Img. 15: Winter months with mitigation

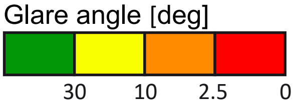


Img. 16: Annual values without mitigation



Img. 17: Annual values with mitigation

Glare angle [deg]

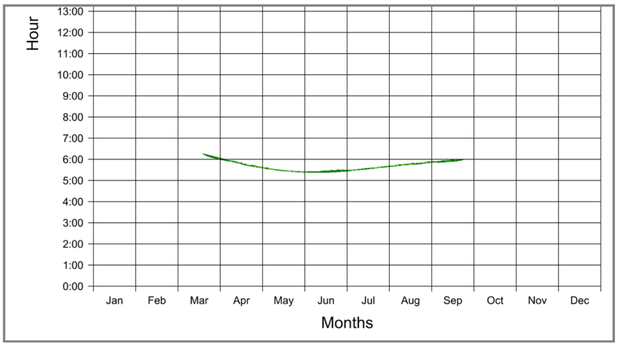


Img. 18: Summer months without mitigation

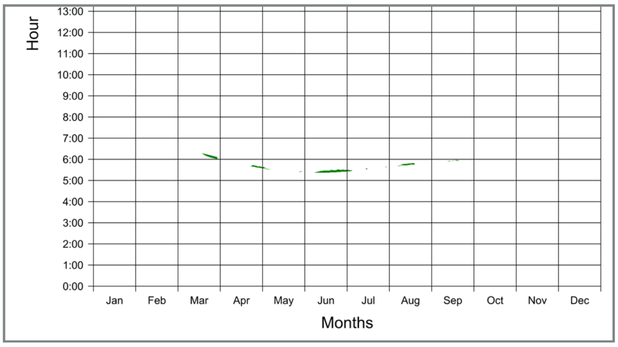
Img. 21: Summer months with mitigation

Img. 19: Winter months without mitigation

Img. 22: Winter months with mitigation



Img. 20: Annual values without mitigation



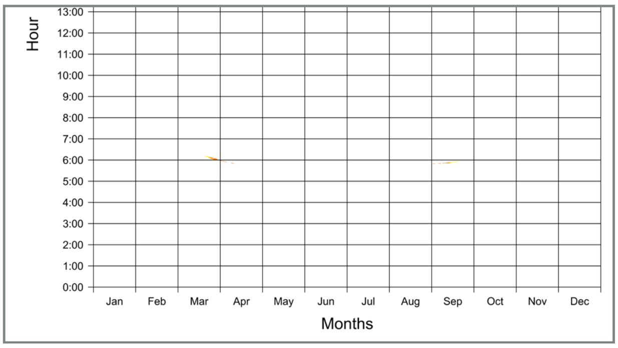
Img. 23: Annual values with mitigation

Ocular hazard

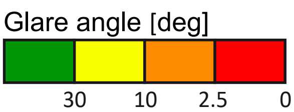
RD3 - Glare Angle

Img. 24: Summer months without mitigation

Img. 25: Winter months without mitigation

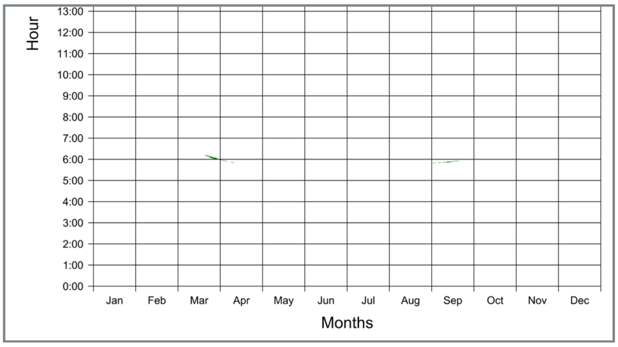


Img. 26: Annual values without mitigation



Img. 27: Summer months without mitigation

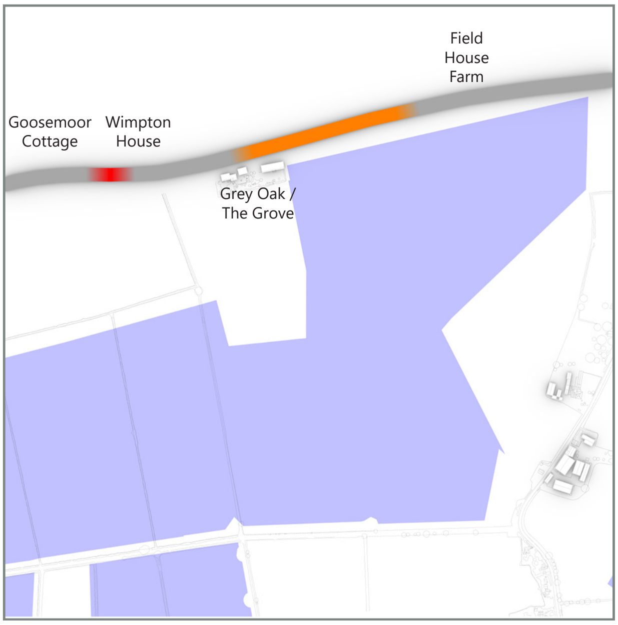
Img. 28: Winter months without mitigation



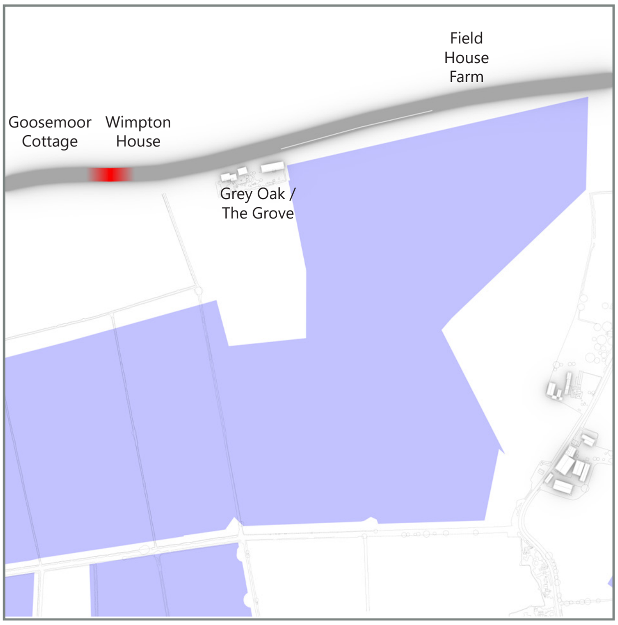
Img. 29: Annual values without mitigation

Ocular hazard

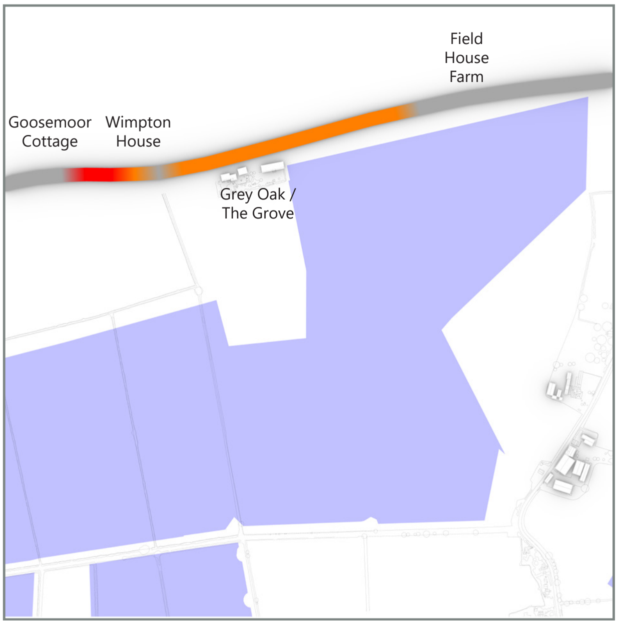
RD4 - Glare Angle



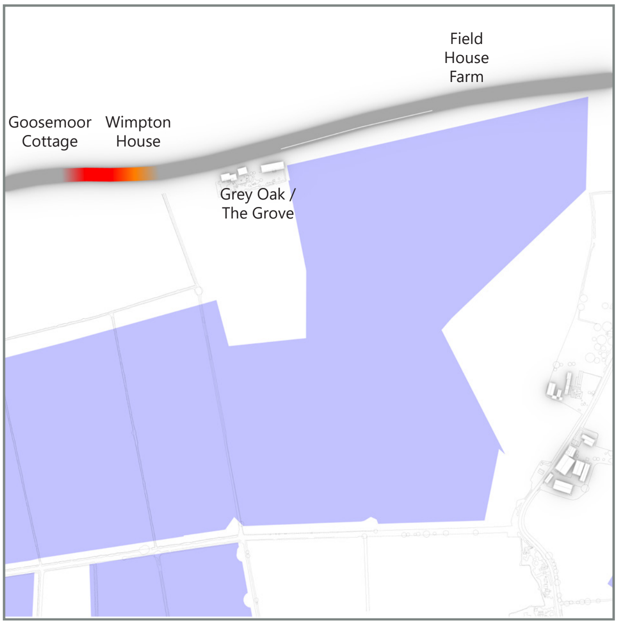
Img. 30: Summer months without mitigation



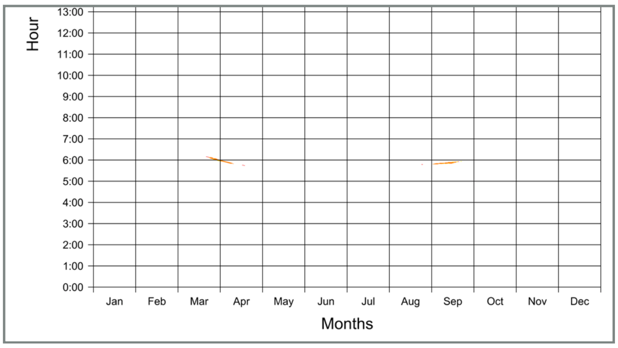
Img. 33: Summer months with mitigation



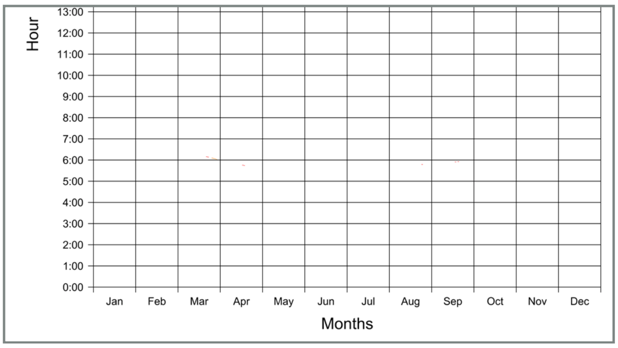
Img. 31: Winter months without mitigation



Img. 34: Winter months with mitigation



Img. 32: Annual values without mitigation

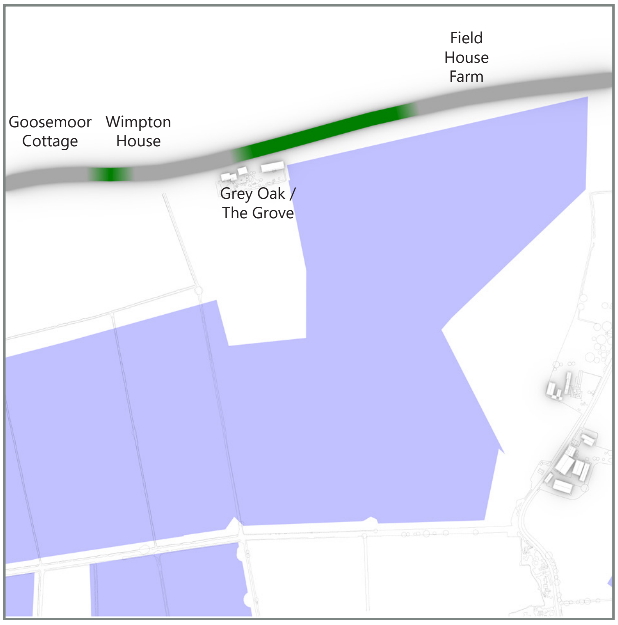


Img. 35: Annual values with mitigation

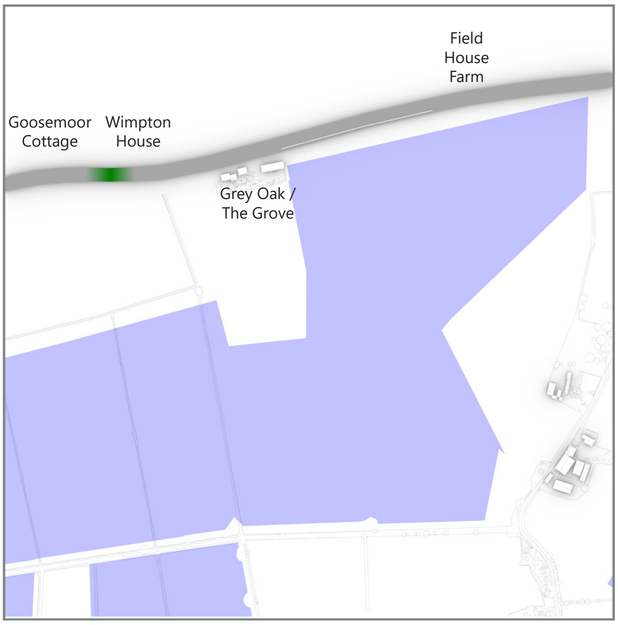
Glare angle [deg]

30 10 2.5 0

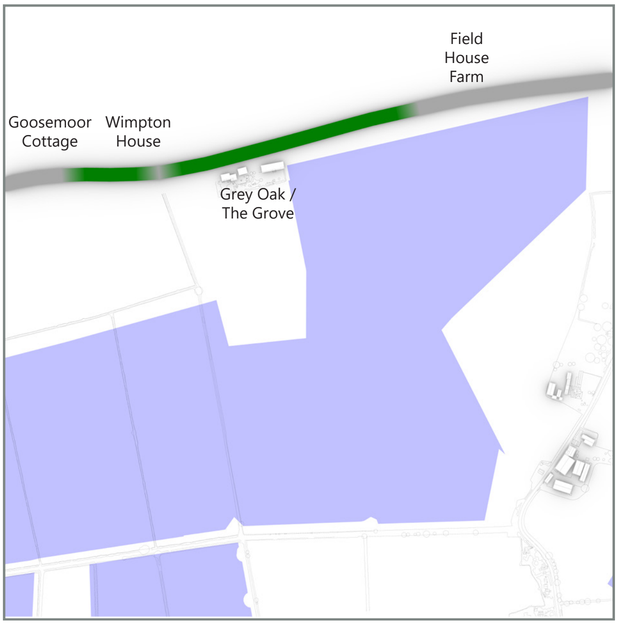
RD4 - Ocular harzard (SGOHP)



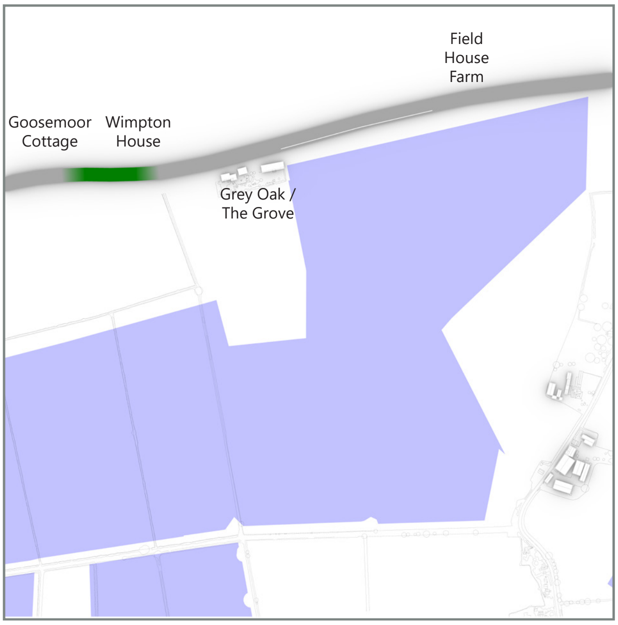
Img. 36: Summer months without mitigation



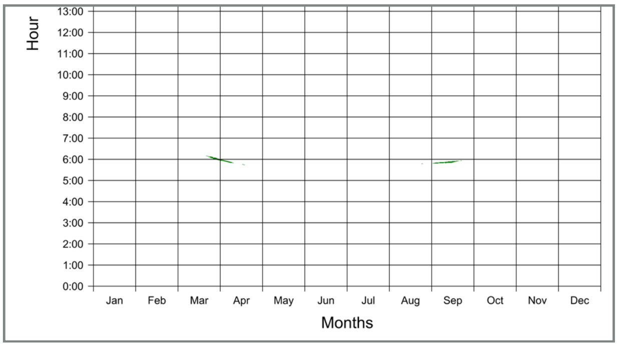
Img. 39: Summer months with mitigation



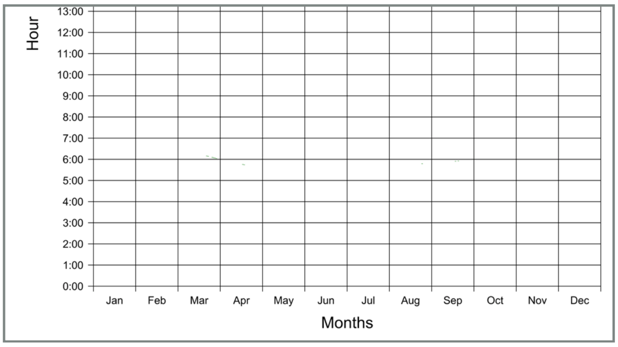
Img. 37: Winter months without mitigation



Img. 40: Winter months with mitigation



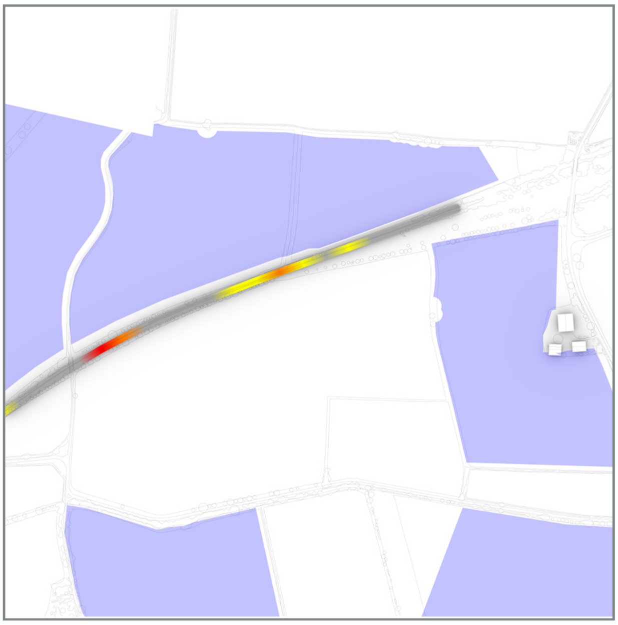
Img. 38: Annual values without mitigation



Img. 41: Annual values with mitigation

Ocular hazard

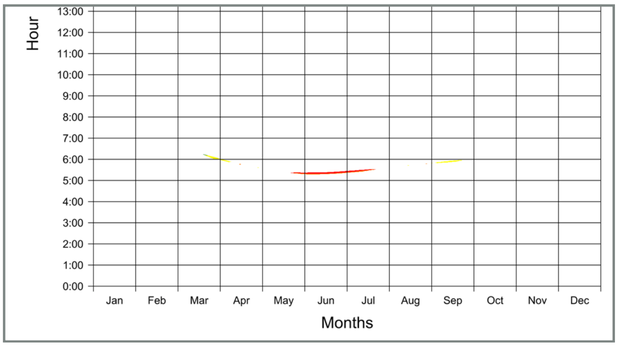
Img. 42: Summer months without mitigation



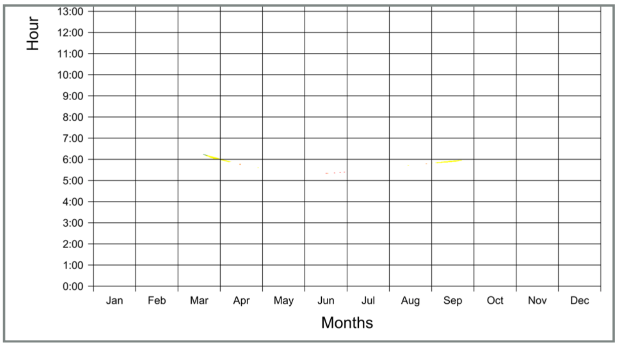
Img. 45: Summer months with mitigation

Img. 43: Winter months without mitigation

Img. 46: Winter months with mitigation

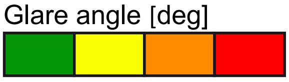


Img. 44: Annual values without mitigation



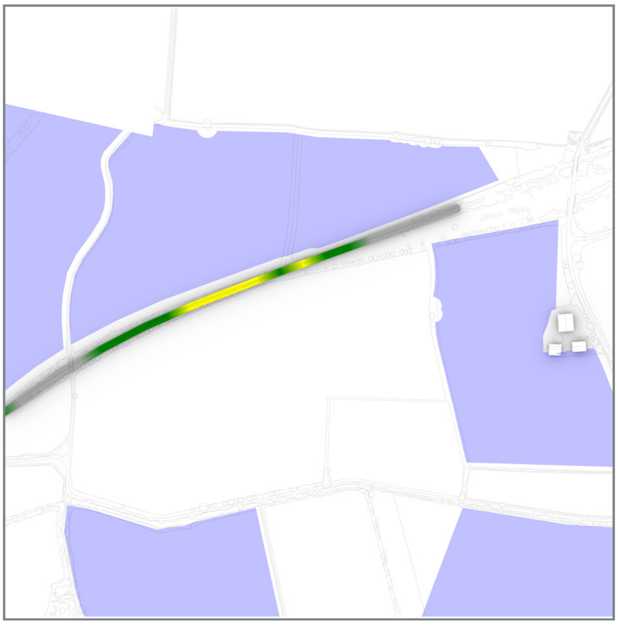
Img. 47: Annual values with mitigation

Glare angle [deg]

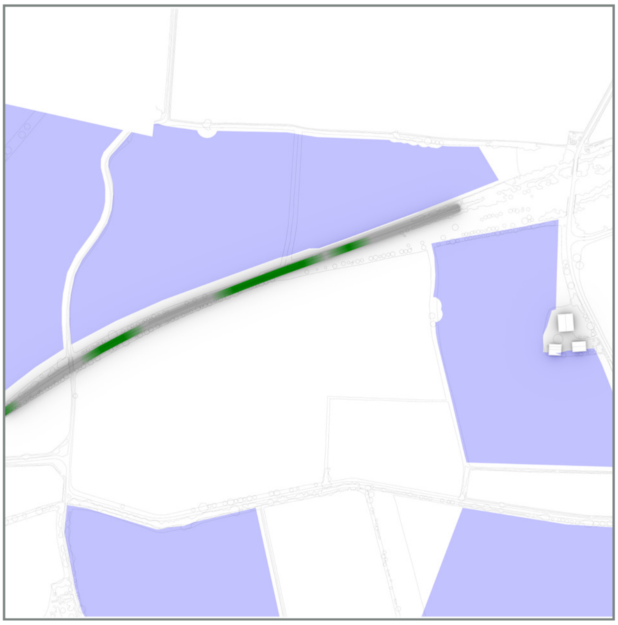


30 10 2.5 0

RW - Ocular harzard (SGOHP)



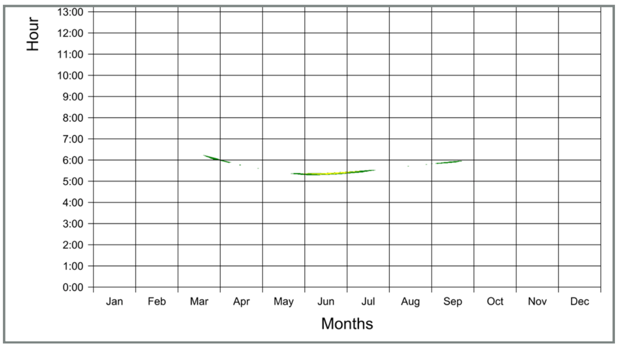
Img. 48: Summer months without mitigation



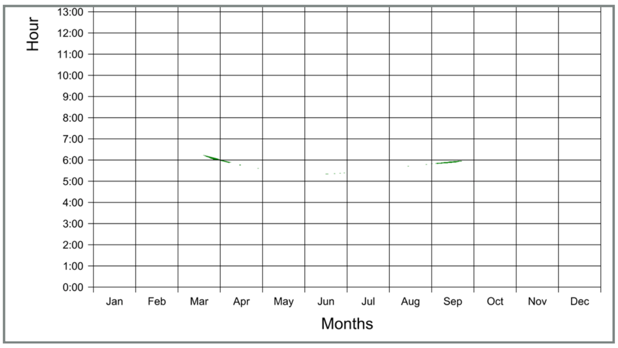
Img. 51: Summer months with mitigation

Img. 49: Winter months without mitigation

Img. 52: Winter months with mitigation



Img. 50: Annual values without mitigation



Img. 53: Annual values with mitigation

Ocular hazard

one earth
solar farm