Luton Rising
Our airport.
Our community.
Our planet.

February 2023

London Luton Airport Expansion

Planning Inspectorate Scheme Ref: TR020001

Volume 5 Environmental Statement and Related Documents

5.02 Appendix 5.2 Light Obtrusion Assessment - Part A

Application Document Ref: TR020001/APP/5.02

APFP Regulation: 5(2)(a)

The Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

London Luton Airport Expansion Development Consent Order 202x

5.02 ENVIRONMENTAL STATEMENT APPENDIX 5.2 LIGHT OBTRUSION ASSESSMENT - PART A

Regulation number:	Regulation 5(2)(a)
Planning Inspectorate Scheme Reference:	TR020001
Document Reference:	TR020001/APP/5.02
Author:	Luton Rising

Version	Date	Status of Version
Issue 01	February 2023	Application issue

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1 INTRODUCTION

1.1 Project Background

1.1.1 Luton Rising (a trading name of London Luton Airport Limited (the Applicant)) is proposing to expand London Luton Airport (the airport) by submitting an application for development consent for works that will allow the airport to grow to accommodate 32 million passengers per annum (mppa) (the Proposed Development). A current planning permission (LBC ref: 12/01400/FUL), limits passenger throughout to 18 mppa.

1.1.2 As part of the Environmental Impact Assessment, this assessment has been undertaken to assess impacts as a result of external artificial lighting for the Main Application Site, as defined in **Chapter 2** of the Environmental Statement (ES) **[TR020001/APP/5.01]**, and details any necessary light pollution mitigation measures to prevent nuisance to local communities or disruption to local sensitive wildlife.

1.1.3 This report provides a commentary on the effects of light obtrusion associated with the Proposed Development. The design of the Proposed Development has evolved to reflect the outcomes of the consultation, and the process of information gathering as the assessment progresses until submission of the application for development consent.

1.2 Light Obtrusion

1.2.1 Consequences commonly associated with light obtrusion are the loss of dark night skies and views of the stars, perception of an unsatisfactory nocturnal environment and the harming of wildlife habitats. Light obtrusion has also been shown to have detrimental effects on human health and can present serious physiological, and ecological impacts. Furthermore, light obtrusion can be a characteristic of energy waste and a contributor to climate change.

Light obtrusion characteristics

1.2.2 Light obtrusion characteristics are defined as follows and illustrated in Inset 1.1 and Inset 1.2:

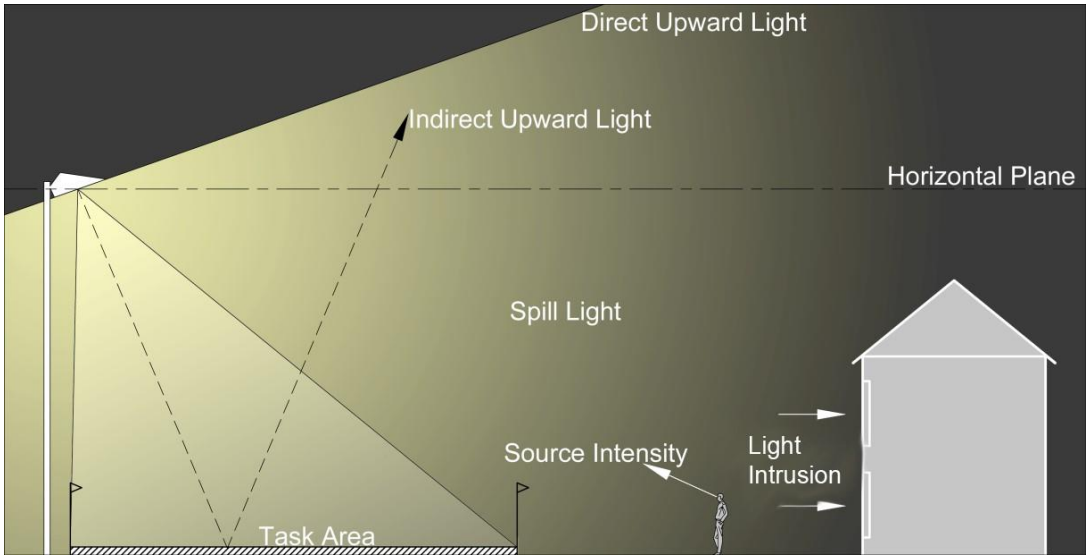
a. Light Intrusion: stray light beyond the task area onto neighbouring dwellings or sensitive receptors. Units: illuminance (E), measured in lux.

b. Source Intensity: how bright the light source appears to an observer. Units, Intensity (I), measured in candelas (cd).

c. Sky Glow: a combination of Direct Upward Light and Indirect Upward Light. This effect is often seen as a glow in the night sky (Inset 1.2) above towns and cities.

d. Façade Luminance: how bright an illuminated façade appears to the observer. Units: Luminance (L) measured in cd/m^2

Inset 1.1 Light obtrusion characteristics (extracted from ILP GN01 (Ref. 1))



Inset 1.2 Sky glow example – before intervention (Photograph by Todd Carlson (Ref. 2))

Inset 1.3 Sky glow example – after intervention (Photograph by Todd Carlson (Ref. 3))

1.2.3 Excessive sky glow is the most obvious indication of light obtrusion and obscures a clear view of the night sky. It can also adversely affect the daily patterns of human and animal behaviour.

1.2.4 In many cases, light obtrusion can be reduced without detriment to the lighting task by correctly aiming floodlights, selecting more efficient floodlight optics or simply switching off any unnecessary external lighting.

1.2.5 The existing, or baseline, lighting conditions in the Study Area, as defined in **Section 4.1.2**, have been examined as described in **Sections 5.1** and **5.2** and are reported in **Section 7**. This data has been used as a comparison with computer simulations on the proposed artificial lighting scheme to ensure that it does not adversely affect the nocturnal environment.

2 LEGISLATION, POLICY AND GUIDANCE

2.1.1 The following section identifies the legislation, planning policy and light obtrusion guidance that was used to frame this light obtrusion assessment.

2.2 Legislation

Environmental Protection Act

2.2.1 The Environmental Protection Act 1990 (Ref. 4) (Part III Statutory Nuisance and Clean Air, section 79 of Statutory nuisance and inspections therefor), gives local authorities the power to consider obtrusive artificial light as a statutory nuisance. The Environmental Protection Act states that:

> *"any artificial light emitted from premises so as to be prejudicial to health or a nuisance, constitutes "statutory nuisance" for the purpose of this Part, and it shall be the duty of every local authority to cause its area to be inspected from time to time to detect any statutory nuisances which ought to be dealt with under section 80 and, where a complaint of a statutory nuisance is made to it by a person living within its area, to take such steps as are reasonably practicable to investigate the complaint."*

Clean Neighbourhood and Environmental Act

2.2.2 The Clean Neighbourhood and Environmental Act 2005 (Ref. 5) (section 102 of the Clean Neighbourhoods and Environmental Act 2005), gives local authorities the power to consider obtrusive artificial light as a statutory nuisance. The Act makes *"exterior light emitted from premises so as to be prejudicial to health or a nuisance"* a criminal offence. The Act does not apply to artificial light emitted from an airport (section 102, subsection 4). According to the Act section 102, subsection 5 *"airport has the meaning given by section 95 of the Transport Act 2000."*

Transport Act

2.2.3 The Transport Act 2000 (Ref. 6) (section 95, sections 93 and 94: interpretations) gives the Secretary of State for Transport the authority to give directions indicating considerations to which the Civil Aviation Authority (CAA) is to have regard in deciding whether and how to exercise its function under sections 93 and 94.

2.3 Planning and Aviation Policy

Airports National Policy Statement – June 2018

2.3.1 The Airports National Policy Statement (ANPS) (Ref. 7) does not have effect in relation to an application for development consent for an airport development not comprised of an application relating to the Heathrow Northwest Runway. Nevertheless, as set out within paragraph 1.41 of the ANPS, the Secretary of State considers that the contents of the ANPS will be both important and relevant considerations in the determination of such an application, particularly where it relates to London or the south east of England. In particular, the ANPS

makes clear that, alongside the provision of a new Northwest Runway at Heathrow, the government supports other airports making best use of their existing runways as set out in Beyond the Horizon: Making best use of existing runways (MBU) (Ref. 8), which is the specific policy context for this application.

2.3.2 In addition, whilst the ANPS does not have effect in relation to the Proposed Development, it sets out a number of principles for environmental impact assessment and compliance and these will be an important and relevant consideration in the determination of the application for development consent. This assessment has followed the scope and methodologies defined through scoping, which considered the ANPS.

2.3.3 The ANPS (paragraph 5.230) states that:

> *"The construction and operation of airports infrastructure has the potential to create a range of emissions such as dust, odour, artificial light, smoke and steam. All have the potential to have a detrimental impact on amenity or cause a common law nuisance or statutory nuisance under Part III, Environmental Protection Act 1990. These may also be covered by pollution control or other environmental consenting regimes."*

2.3.4 The ANPS (paragraph 5.232) states that:

> *"For nationally significant infrastructure projects of the type covered by the Airports NPS, some impact on amenity for local communities is likely to be unavoidable. Impacts should be kept to a minimum and should be at a level that is acceptable."*

National Planning Policy Framework – July 2021

2.3.5 The National Planning Policy Framework will also be an important and relevant consideration in the determination of the Applicant's application for development consent. National Planning Practice Guidance supporting the framework encourages best practice design so as to limit the impact of light obtrusion on local amenity, intrinsically dark landscapes and nature conservation. Paragraph 185 states that:

> "*Planning policies and decisions should also ensure that new development is appropriate for its location taking into account the likely effects (including cumulative effects) of pollution on health, living conditions and the natural environment, as well as the protentional sensitivity of the site or the wider area to impacts that could arise from the development. In doing so they should: … c) limit the impact of light pollution from artificial light on local amenity, intrinsically dark landscapes and nature conservation*".

2.4 Guidance

2.4.1 This light obtrusion assessment has been undertaken in line with the following documents:

a. Institute of Lighting Professionals (ILP) Guidance Note GN01 (2021): Guidance Notes for the Reduction of Obtrusive Light (Ref. 1).
b. ILP Guidance Note GN08 (2018): Bats and artificial lighting in the UK; Bats and the Built Environment series (Ref. 9).
c. ILP Professional Lighting Guide PLG 04 (2013): Guidance on Undertaking Environmental Lighting Impact Assessments (Ref. 10).
d. Commission Internationale de L'Eclairage (CIE) 150: Guide on the limitation of the effects of light obtrusion from Outdoor Lighting Installations (2017) (Ref. 11).
e. CIE 126: Guidelines for Minimising Sky Glow (1997) (Ref. 12).
f. CIE 136: Guide to the Lighting of Urban Areas (2000) (Ref. 13).
g. Chartered Institute of Building Services Engineers (CIBSE) LG6: The Exterior Environment (2016) (Ref. 14).
h. BS EN 12464 Part 2: Outdoor Lighting (2014) (Ref. 15).
i. CIBSE Environmental Considerations for Exterior Lighting (Factfile No.7:2019) (Ref. 16).

2.4.2 These guides provide the latest design advice for the appropriate illumination of external spaces and design limits for light obtrusion effects.

2.4.3 The ILP has published a guidance note GN01 (Ref. 1) that summarises CIE 150 (Ref. 8) and offers guidance for designers to ensure their lighting schemes reduce light obtrusion. Both guides have been referred to throughout this assessment. These two documents are the most authoritative, widely recognised and adopted best practice guides for the minimisation of light obtrusion.

2.4.4 ILP GN01 (Ref. 1) proposes lighting design limits against a set of defined Environmental Zones E0 to E4. These are described in **Table 2.1**.

Table 2.1: Environmental designation

Environ. Zone	Surrounding	Lighting Environment	Examples
E0	Protected	Dark	UNESCO Starlight Reserves, IDA Dark Sky Parks
E1	Natural	Intrinsically dark	National Parks, Areas of Outstanding Natural Beauty etc
E2	Rural	Low district brightness	Village or relatively dark outer suburban locations

Environ. Zone	Surrounding	Lighting Environment	Examples
E3	**Suburban**	**Medium district brightness**	**Small town centres or suburban locations**
E4	Urban	High district brightness	Town/city centres with high levels of night- time activity

2.4.5 The Main Application Site, as defined in **Chapter 2** of the ES **[TR020001/APP/5.01]**, is within Environmental Zone E3.

2.4.6 The light obtrusion criteria defined in ILP GN01 (Ref. 1) for Zone E3 are described in **Table 2.2**. The limits for intensity of a light source from any given observer are described in terms of the intensity of the source considering visible area of the luminaire and distance to the luminaire.

2.4.7 Building Luminance obtrusive light limitation as referenced in ILP GN01 (Ref. 1), and summarised in **Table 2.2**, is applicable to buildings directly illuminated as a night-time feature as opposed to the illumination of a building caused by spill light from adjacent luminaires or luminaires fixed to the building but used to light an adjacent area. The Proposed Development is not proposed to have a night-time feature façade illumination; therefore, the Building Luminance limitation is not applicable for this assessment.

2.4.8 Light intrusion and source intensity have been assessed in this report from the viewpoints in **Table 4.1**.

Table 2.2: Guidance for limiting light obtrusion (ILP GN01 (Ref. 1))

Environmental Zones	Sky Glow ULR[1](Max %)	Sky Glow UFR[2] (ratio)	Light Intrusion Ev[3] (lux) Pre/Post-curfew	Average Building Luminance L[4] (cd/m^2) Pre-curfew
E0	0.0	n/a	0.0	0.0
E1	0.0	2.0	2.0 / 1.0	0.0
E2	2.5	5.0	5.0 / 1.0	5.0
E3	**5.0**	**8.0**	**10.0 / 2.0**	**10.0**
E4	15.0	12.0	25.0 / 5.0	15.0

Notes to table:

1. Max permitted % of luminaire flux emitted directly up into the sky. Requirement for each luminaire.

2. Max permitted % of luminaire flux emitted directly up into the sky. Requirement for scheme as a whole. The more conservative value for roads has been used.

3. Ev = Vertical illuminance (lux): measure of light reaching neighbouring facades. Requirement for each luminaire to each viewpoint.

4. L = Luminance (candelas per sq. metre): measure of how bright a surface appears Requirement for each building.

Table 2.3: Limits for light source intensity (cd) from observer positions

Zone	Curfew ?	$0<A_P \leq 0.002$	$0.002<A_P \leq 0.01$	$0.01<A_P \leq 0.03$	$0.03<A_P \leq 0.13$	$0.13<A_P<0.50$	$A_p > 0.5$
E0	Pre	0	0	0	0	0	0
	Post	0	0	0	0	0	0
E1	Pre	0.29 d	0.63 d	1.3 d	2.5 d	5.1 d	2,500
	Post	0	0	0	0	0	0
E2	Pre	0.57 d	1.3 d	2.5 d	5.0 d	10 d	7,500
	Post	0.29 d	0.63 d	1.3 d	2.5 d	5.1 d	500
E3	**Pre**	**0.86 d**	**1.9 d**	**3.8 d**	**7.5 d**	**15 d**	**10,000**
	Post	**0.29 d**	**0.63 d**	**1.3 d**	**2.5 d**	**5.1 d**	**1,000**
E4	Pre	1.4 d	3.1 d	6.3 d	13 d	26 d	25,000
	Post	0.29 d	0.63 d	1.3 d	2.5 d	5.1 d	2,500

Notes to table:

1. 'd' is the distance between the observer and the glare source in metres
2. A_p is the apparent surface of the light source seen from the observer position
3. Upper limits for each Zone shall be taken as those with column Ap>0.5

2.4.9 The curfew is defined as a time after which stricter requirements for the control of light obtrusion will apply. This may be a condition of the use of lighting applied by the local planning authority. Typically, this may be around 23:00. However, the airport operates 24 hours a day and there is no lighting curfew imposed by the local authority at this point in time.

2.4.10 Light intrusion and source intensity have been assessed in this report from the viewpoints in **Table 4.1**.

3 STAKEHOLDER ENGAGEMENT

3.1.1 The Planning Inspectorate has been engaged as part of the assessment process to obtain background data, information and records concerning light obtrusion assets relating to the Main Application Site, and to develop the assessment scope and methodology. **Table 3.1** includes relevant comments received in the Scoping Opinion which is provided as **Appendix 1.3** of the ES **[TR020001/APP/5.05]**.

Table 3.1: Scoping Opinion comments in lighting

Comment from	Date	Summary of discussion	Response
Planning Inspectorate	16 May 2019	The Inspectorate notes the intention to produce a standalone lighting assessment; however, it is not clear from the Scoping Report where the lighting assessment will be located within the Environmental Statement (ES). The lighting assessment should be clearly signposted from the relevant aspect chapters in the ES, including (but not limited to) the Biodiversity, Landscape and Visual, and Cultural Heritage aspect chapters.	The lighting assessment has been produced as a standalone report and is appended to the ES where first referenced in **Chapter 5 [TR020001/APP/5.01]** and cross referenced where appropriate.

3.1.2 Stakeholder engagement has not been undertaken specifically regarding this light obtrusion assessment, however potential impacts of light have been discussed during engagement on other relevant environmental aspects including biodiversity, and landscape and visual impacts section 4 of **Chapters 8** and **14** of the ES **[TR020001/APP/5.01]** respectively.

3.1.3 Stakeholder feedback raised the impact of light from moving cars and aircraft. These have not been included in the assessment as the dynamic lighting effects from aeroplanes or traffic cannot be meaningfully modelled or quantified due to its highly variable nature. In comparison to the effect of the sitewide lighting, headlights/aircraft lights are significantly lower powered, transient and dynamic, and therefore are not considered likely to have a significant effect.

4 ASSESSMENT METHODOLOGY

4.1 Main Application Site and Surroundings

4.1.1 The scope of the assessment is to establish the likely effects of the Proposed Development lighting installation on the surrounding area and the environment and verify that the correct illumination standards have been applied to the Main Application Site.

4.1.2 The Study Area and surroundings of the Proposed Development for this assessment is defined as the three key aspects and in various locations defined in **Figure 2.2** of the ES **[TR020001/APP/5.03]**:

a. the Main Application Site;

b. Off-site Car Parks; and

c. Highway Interventions.

4.1.3 The objectives of the proposed lighting scheme, when fully designed, shall be:

a. to limit light obtrusion and the effects of sky glow, spill light/trespass light and glare to neighbouring land and properties and strategic road network; and

b. to provide adequate lighting for access and safety requirements.

Viewpoints

4.1.4 Baseline nocturnal lighting conditions were recorded at selected viewpoints around the Main Application Site. The viewpoints selected have been informed by the Landscape and Visual Impact Assessment (LVIA) reported in **Chapter 14** of the ES **[TR020001/APP/5.01]**.

4.1.5 **Figure 14.8** shows all viewpoints of the LVIA and is provided in **Appendix C** to this assessment for reference. For the purpose of the lighting obtrusion assessment 25 viewpoints have been selected and surveyed. Selection was made based on clear viewing towards the Main Application Site, and proximity of viewpoints to receptors sensitive to light obtrusion.

4.1.6 The viewpoints visited during the survey are described in **Table 4.1**. The reference number used for the light obtrusion viewpoints follows the same reference numbers to the LVIA, for consistency of locations.

Table 4.1: List of lighting survey viewpoints and locations

VP Ref	Grid Ref (Easting, Northing, AOD)	Location Ref	Viewpoint Direction
VP02	515707.8610, 224358.9610, 149.46	Footpath near Ley Green	South west
VP05	510758.649, 218183.799, 153.70	Warren Drive, Luton Hoo Estate	North east

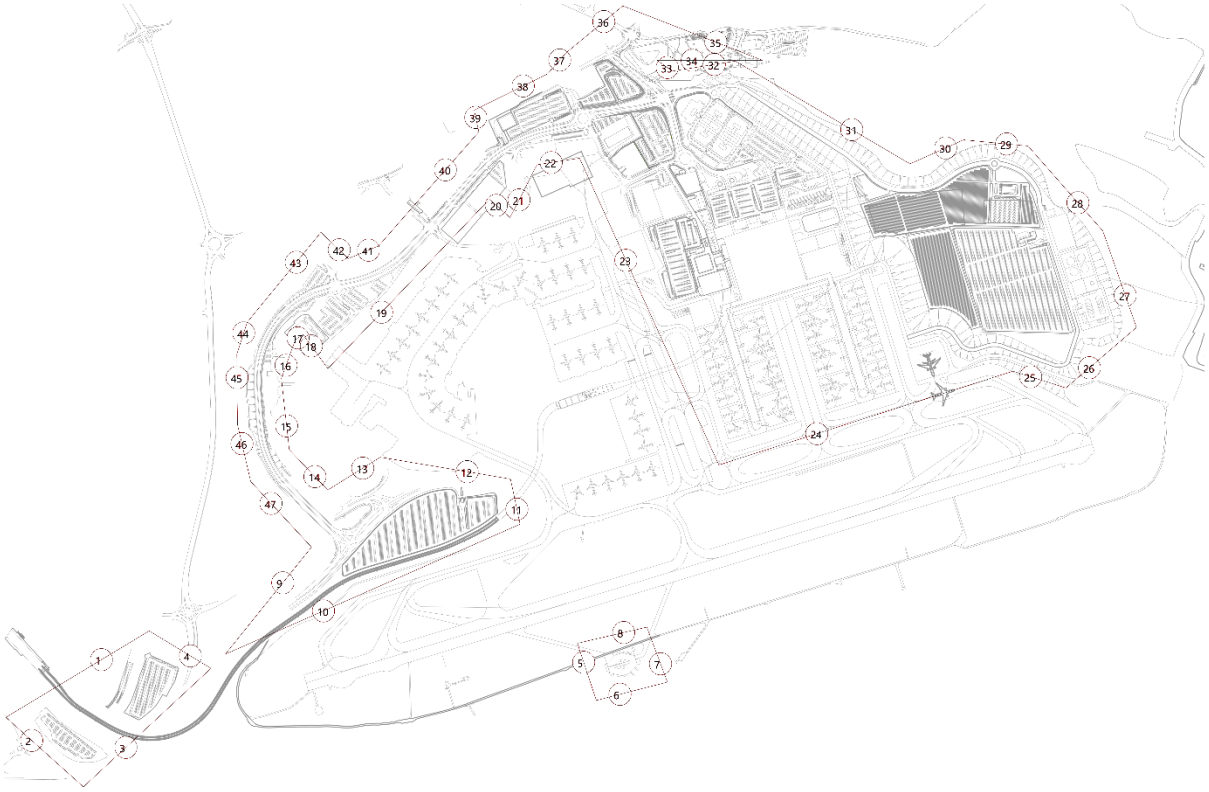
VP Ref	Grid Ref (Easting, Northing, AOD)	Location Ref	Viewpoint Direction
VP06	507450.625, 221332.483, 168.05	Dallow Downs	East
VP08	512077.530, 222678.5499, 159.20	Crawley Green Road	South
VP10a	513182.548, 222457.763, 151.10	Footpath (Offley 01)	South west
VP10b	513278.097, 222380.552, 150.94	Footpath (Offley 02)	South west
VP13	512485.557, 222150.281, 153.30	Wigmore Valley Park	South east
VP13 (continued)	512485.557, 222150.281, 153.30	Wigmore Valley Park	South west
VP14	511775.616, 222198.803, 154.23	Raynham Way	South east
VP15	511203.831, 221850.747, 145.42	Polzeath Close	South east
VP16	510663.847, 221842.382, 158.58	Powdrills Field	East
VP18	510694.662, 219683.579, 109.55	The Luton Drive	North east
VP19	510731.775, 218659.485, 140.52	Luton Hoo Parkland	North east
VP20	512336.142, 220099.179, 157.60	Footpath (Hyde 5A)	North west
VP21	511867.082, 220197.744, 158.88	Footpath (Hyde 4B)	North
VP22	511602.632, 220237.820, 155.87	Footpath (Hyde 4B)	North east
VP27	513197.655, 220494.455, 155.21	Bridleway (Hyde 3A)	North west
VP28	513714.244, 221661.595, 135.84	Footpath (Kings Walden 43)	West
VP31	514578.093, 222346.401, 150.18	Footpath (Kings Walden 09)	South west
VP32	514829.157, 222704.071, 153.71	Darley Road, near Breachwood Green	South west
VP33	514783.536, 222110.122, 150.68	Footpath (Kings Walden 07)	South west
VP34	515042.438, 221838.358, 146.76	Footpath (Kings Walden 06)	West

VP Ref	Grid Ref (Easting, Northing, AOD)	Location Ref	Viewpoint Direction
VP35	514868.018, 221287.885, 111.49	Footpath (Chiltern Way)	West
VP36	511032.734, 221677.115, 123.35	Vauxhall Way	South east
VP37	509672.893, 220184.355, 127.07	Cuttenhoe Road	North east
VP38	511298.335, 221962.522, 157.16	Mistletoe Hill	South east
VP40	511419.165, 222907.336, 158.23	Someries Hill	South east

Ecology and bats

4.1.7 Several vertical calculation planes (grids) have been used around the Main Application Site to measure illuminance levels around the perimeter of the Site resulting from the current proposed lighting design. The vertical planes extend up to 40 meters above ground level to enable a visualisation of the effects of illumination at the various heights at which different bat species fly. **Inset 4.1** (replicated in higher resolution in **Appendix E** of this report) shows all 23 of the grids used for this assessment; **Appendix E** to this report provides further details and modelling results.

Inset 4.1 Vertical Calculation Planes



4.1.8 In addition to the vertical planes described above, a horizontal calculation plane representing ground level has been used to measure illuminance across the Main Application Site.

4.2 Baseline conditions

4.2.1 Luminance measurements were recorded looking towards the Main Application Site and illumination measurements were recorded at each viewpoint in the vertical plane facing the Main Application Site at camera level and at 2 meters above ground.

4.2.2 Digital photographs were taken at each viewpoint to create a calibrated High dynamic range (HDR) image to present the luminance profile of the nocturnal scene.

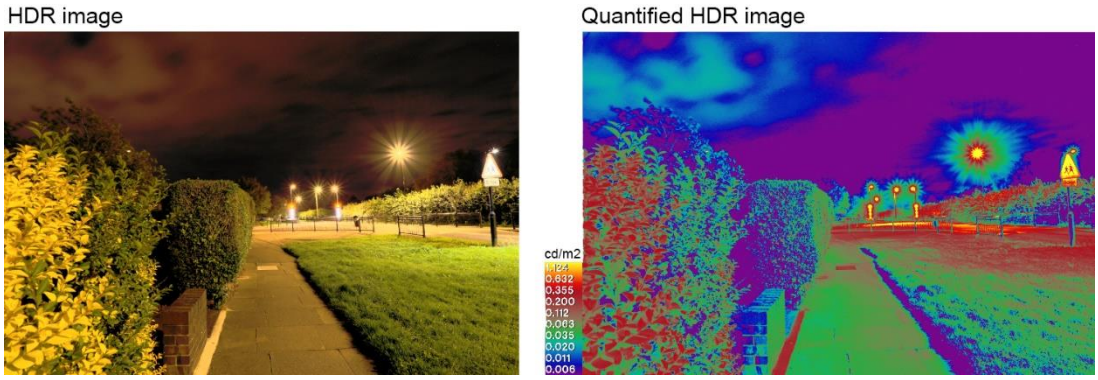
4.2.3 HDR imaging was used to reproduce a greater dynamic range of luminosity than was possible with standard digital imaging or photographic techniques. HDR images can be digitised, calibrated and interrogated for luminance information. This technique is ideal for nocturnal landscape photography, where high levels of contrast are often experienced, and for capturing the nocturnal luminance profile of the scene. Further details on this process are provided in **Appendix A** of this assessment.

4.2.4 The HDR images are created using specialist lighting software (Radiance). The objective of these luminance profile images is therefore to provide a baseline statement that can be compared against 3D simulations of the proposed lighting in the Main Application Site when viewed from those locations.

4.2.5 Examples of these HDR images can be seen in **Inset 4.2.**

4.2.6 HDR images from all viewpoints can be found in **Appendix B** of this assessment.

Inset 4.2 Example of HDR image (left) and quantified HDR image (right)



4.2.7 Photographs were taken from each viewpoint to record the extent of the existing nocturnal lighting conditions at the Main Application Site. The following methodology was used to create a HDR image, the resultant HDR image was calibrated with luminance measurements recorded at each viewpoint:

a. Camera aperture was fixed at (f-11) ISO set at 400, for low lighting conditions.
b. White balance was set to manual, no contrast adjustment, no saturation adjustment, no sharpness adjustment.
c. Photographs were taken at different exposure times; due to the dark surroundings the exposure times were 1/8s, 1/4s, 0.5s, 1s, 2s, 4s, 8s, 15s and 30s.
d. Images were processed by Radiance software to create a single image where each pixel is exposed for visibility, i.e. an HDR image.
e. Images were calibrated using the on-site luminance measurements to create a falsecolour representation of the scene.

4.3 Assessment

Lighting Design Strategy

4.3.1 The lighting design strategy assessed consists of two parts:

a. Landside lighting strategy, ‘Exterior Lighting Strategy Stage 3C Report’, **Appendix F** of this assessment which provides the lighting principles

applied to area types and remain relevant for any minor amendments to the design.

b. Apron lighting strategy, 'Proposed Flood Lighting', **Appendix G** of this assessment.

Methodology

4.3.2 This section sets out the methodology for the assessment of likely significant effects relating to light obtrusion from the Proposed Development. The light obtrusion assessment provides a prediction of the changes in lighting conditions that could arise as a result of the operation of the lighting design strategy.

4.3.3 The lighting design strategy was simulated and analysed using Radiance simulation software, to examine possible obtrusive light effects. The objective is to illustrate that light obtrusion compliance is possible or to identify where likely significant effects might occur.

4.3.4 The simulation enables the lighting design strategy to be examined in terms of the relevant guidance and provides accurate predictions, including:

a. verification that the correct illumination standards have been applied;
b. the effect of the lighting scheme on any sensitive receptors nearby;
c. the potential for light obtrusion effects and mitigation opportunities; and
d. comparison of the Proposed Development where the lighting design strategy has been implemented with the illumination measurements recorded on site (lux) to assess the impact.

4.3.5 The HDR images were captured during the baseline survey to provide a reference of the nocturnal lighting scene.

4.3.6 Light obtrusion is assessed at each viewpoint described in **Table 4.1** and shown in **Appendix C** of this assessment.

4.3.7 The simulation comprised the following steps:

a. use of 3D OS MasterMap model of the existing site and surroundings;
b. use of the Proposed Development layout;
c. use of existing viewpoints, including elevation relative to Main Application Site;
d. insert the lighting design strategy for Apron and Landside (floodlight coordinates, orientation data and photometric data) into the lighting simulation model; and
e. apply the virtual viewpoints described in **Table 4.1** to analyse the model for light obtrusion.

4.3.8 The simulation was used to examine the lighting design strategy in terms of the relevant guidance and provide accurate predictions on the following light obtrusion characteristics:

a. source intensity visible from the sensitive receptor's locations; and

b. light intrusion experienced by each sensitive receptor

Significance criteria

4.3.9 The significance of the effects is based on the magnitude of change (or impact) as result of the Proposed Development and the importance of the affected receptor/receiving environment. Magnitude/scale of change is assessed on a scale of High, Medium, Low or Very Low. Further details regarding the evaluation criteria are provided below. The importance of the affected receptor/receiving environment is assessed, in line with the PLG04 Guide to Lighting Impact Assessments (Ref. 7), on a scale of Very High, High, Medium, or Low.

Sensitivity of Receptors

4.3.10 The criteria for receptor sensitivity are described in **Table 4.2.**

Table 4.2: Sensitivity of receptor to light obtrusion

Receptor Sensitivity	Typical Example	Commentary
Very High	Protected habitats e.g. bat roosts	Receptor has negligible ability to absorb change without fundamentally altering its present character and is of very high environmental value/importance.
High	Unprotected nocturnal wildlife habitat. Heritage and listed buildings.	Receptor has low ability to absorb change without fundamentally altering its present character and is of high environmental value/importance.
Medium	Dwelling	Receptor has moderate capacity to absorb change without significantly altering its present character, has some environmental value/importance.
Low	Commercial and Industrial Premises	The receptor is tolerant/resistant to change without detriment to its character, is low environmental value/importance.

Magnitude of Effect

4.3.11 To determine the magnitude/scale of the change in lighting levels at the sensitive receptors, the following criteria have been evaluated using professional judgement:

a. type of lighting installation during construction and operation;

b. the distance between the proposed lighting installations and the sensitive receptors;
c. type of view (e.g. direct, intermittent or restricted);
d. any existing and proposed screening;
e. satisfaction of ILP GN01 (Ref. 1) guidance; and
f. likelihood of statutory nuisance.

4.3.12 The magnitude of the environmental effect is expressed in terms of deviation from the ILP GN01 (Ref. 1) recommendations (**Table 4.3**). The Main Application Site is considered to be in Zone E3 light obtrusion limits (**Table 2.1**).

Table 4.3: Determining the magnitude of an environmental impact

Impact Magnitude	Definition	Magnitude Quantified
High	Total loss or major alteration to key features of the baseline conditions which will be fundamentally changed.	All light obtrusion characteristics above Zone E4 recommended limits.
Medium	Loss or alteration to one or more key features of the baseline conditions which will be fundamentally changed.	One or more light obtrusion characteristics exceed the Zone E3 limits by more than 20%
Low	Minor shift away from baseline conditions. Changes arising from the alteration will be detectable; the underlying character of the baseline condition will be similar.	No light obtrusion characteristics exceed the Zone E3 limits by more than 20%.
Very low	Very little change from baseline conditions. Change is barely distinguishable, approximating to a “no change” situation.	Light obtrusion characteristics unchanged or below Zone E3 limits.

4.3.13 The interaction of sensitivity and magnitude are considered to determine the significance of an environmental effect on the scale described in **Table 4.4.**

Table 4.4: Determining the significance of an environmental effect

Receptor Sensitivity (Table 4.2)	Impact Magnitude (Table 4.3)			
	High	Medium	Low	Very low
Very High	Major	Moderate	Moderate	Minor
High	Major	Moderate	Minor	Negligible
Medium	Moderate	Moderate	Minor	Negligible
Low	Moderate	Minor	Minor	Negligible

4.3.14 As a general rule, major and moderate effects are considered to be significant, whilst minor and negligible effects are considered to be not significant; however, professional judgment may be applied.

5 ASSUMPTIONS AND LIMITATIONS

5.1 Site Survey

5.1.1 The atmospheric conditions may marginally affect the recorded luminance measurements made. Based on the conditions recorded during the site surveys these effects are considered immaterial.

5.2 Computation and Modelling

5.2.1 The ray-tracing software is considered to be highly accurate, however, assumptions/simplification must be incorporated into the model in terms of existing surface reflectivity factors.

5.2.2 Trees and other vegetation are excluded from this analysis (and are not required as a part of the ILP GN01 (Ref. 1) based analysis), meaning that the assessment presents the worst-case scenario. It is anticipated that obtrusive light in some situations may be mitigated by existing trees, foliage or other vegetation.

5.2.3 The lumen maintenance factor applied to the calculation is MF=1 and represents the installation performing at maximum (100%) output on day one of the installation.

5.3 Construction

5.3.1 Construction lighting would follow the requirements stated in the Code of Construction Practice (CoCP) provided as **Appendix 4.2** of the ES **[TR020001/APP/5.02]**.

5.4 Operation

5.4.1 During the operation of the Proposed Development, it has been assumed that the lighting specification in terms of column heights, light fittings and luminaire design would be selected to provide minimal light spill and glare.

5.4.2 The assessment presented in this report is based on the lighting design strategy produced for the purpose of this assessment. The lighting performance assumptions (car parks, road class, usage, illuminance levels, etc.) can be found in **Appendix F** and **Appendix G** of this assessment.

6 BASELINE CONDITIONS

6.1 Data Gathering/Survey

6.1.1 Measurements were recorded in accordance with the guidelines of ILP GN01 (Ref. 1).

6.1.2 Light measurements were taken using the following calibrated test equipment:

a. Minolta T10 illuminance meter;

b. Minolta LS110 luminance meter; and

c. Canon EOS 6D SLR digital camera.

6.2 Existing Conditions

6.2.1 A quantitative and visual survey of the existing lighting around the Main Application Site and its surroundings was undertaken on 25 and 26 February 2019 from 19:30 to 01:00. The winter was chosen to provide more hours of darkness to complete the survey within. Any minor changes or works on site undertaken since February 2019 have not materially changed the existing lighting therefore data collected remains a robust representation of the existing lighting conditions. The recorded ambient conditions were:

a. temperature from 5 to 16°C;

b. clear sky for the first night, cloud cover for the second night; and

c. slight mist, good visibility.

6.3 Survey Measurements

6.3.1 The measured values of vertical and horizontal plane illuminance and peak luminance at the selected viewpoints are provided in **Table 6.1** below.

Table 6.1: Survey measurements

VP Ref	Location	Visual Receptor	Luminance (cd/m^2)	Maximum Illuminance (lux)		
				Vertical at camera level	Vertical at 2m above ground	Horizontal at 2m above ground
VP02	Footpath near Ley Green	Residential	0.1 (skyglow)	0.0	0.0	0.0
VP05	Warren Drive, Luton Hoo Estate	Heritage	0.1 (skyglow)	0.0	0.0	0.0
VP06	Dallow Downs	Residential	0.1 (skyglow)	0.1	0.2	0.0

VP Ref	Location	Visual Receptor	Luminance (cd/m^2)	Maximum Illuminance (lux)		
				Vertical at camera level	Vertical at 2m above ground	Horizontal at 2m above ground
VP08	Crawley Green Road	Residential	0.2 (skyglow) 0.6 (road)	4.3	3.5	1.8
VP10a	Footpath (Offley 01)	Residential	0.2 (skyglow)	0.0	0.0	0.0
VP10b	Footpath (Offley 02)	Commercial	0.2 (skyglow)	0.0	0.0	0.0
VP13	Wigmore Valley Park	Commercial	0.2 (skyglow)	0.7	1.0	0.5
VP14	Raynham Way	Residential	0.3 (skyglow)	0.6	0.5	6.9
VP15	Polzeath Close	Residential	0.2 (skyglow) 0.3 (road)	1.6	1.4	1.1
VP16	Powdrills Field	Residential	0.2 (skyglow)	0.1	0.1	0.0
VP18	The Luton Drive	Heritage	0.1 (skyglow)	0.0	0.0	0.0
VP19	Luton Hoo Parkland	Heritage	0.1 (skyglow)	0.0	0.0	0.0
VP20	Footpath (Hyde 5A) Someries Castle	Residential	0.1 (skyglow)	0.1	0.2	0.0
VP21	Footpath (Hyde 4B) Someries Castle	Heritage	0.1 (skyglow)	0.1	0.1	0.0
VP22	Footpath (Hyde 4B)	Heritage	0.1 (skyglow)	0.1	0.2	0.0
VP27	Bridleway (Hyde 3A)	Residential	0.1 (skyglow)	0.0	0.0	0.0
VP28	Footpath (Kings Walden 43)	Residential	0.1 (skyglow)	0.0	0.0	0.0
VP31	Footpath (Kings Walden 09)	Residential	0.1 (skyglow)	0.0	0.0	0.0

VP Ref	Location	Visual Receptor	Luminance (cd/m^2)	Maximum Illuminance (lux)		
				Vertical at camera level	Vertical at 2m above ground	Horizontal at 2m above ground
VP32	Darley Road, near Breachwood Green	Residential	0.07 (skyglow)	0.0	0.0	0.0
VP33	Footpath (Kings Walden 07)	Residential	0.1 (skyglow)	0.1	0.1	0.1
VP34	Footpath (Kings Walden 06)	Residential	0.1 (skyglow)	0.0	0.0	0.0
VP35	Footpath (Chiltern Way)	Residential	0.1 (skyglow)	0.0	0.0	0.0
VP36	Vauxhall Way	Residential	0.3 (skyglow)	16.4	20.6	62.6
VP37	Cuttenhoe Road	Residential	0.2 (skyglow) 0.9	14.7	15.1	18.2
VP38	Mistletoe Hill	Residential	0.2 (facade)	3.1	3.1	1.3
VP40	Someries Hill	Residential	0.2 (skyglow)	0.1	0.1	0.0

6.4 General Observations

6.4.1 The nocturnal artificial lighting around and in close proximity to the Main Application Site comprises road and street lighting in context with urban and sub-urban environment, and vehicle lights along the local roads.

6.4.2 On the second night of the survey, it was also observed that there was little or no noticeable moonlight throughout the survey due to cloud cover.

6.4.3 Sky glow was observed above the local area from all viewpoints as can be seen in the viewpoint photographs. It was considered that the magnitude of sky glow observed is typical of any urban and sub-urban location in the region.

6.4.4 Observations from various viewpoints and commentary to these locations can be found in **Table 6.2**.

6.5 Viewpoint Observations

6.5.1 With reference to **Appendix B** of this assessment, **Table 6.2** below describes the observations that were made from each survey viewpoint.

Table 6.2: Survey viewpoint observations

VP Ref	Location	Observations
VP02	Footpath near Ley Green	Sky glow to the north east of the Main Application Site (from the Main Application Site and Luton town) was observed and was the main source of light obtrusion.
VP05	Warren Drive, Luton Hoo Estate	Sky glow to the south west of the Main Application Site (from the Main Application Site and Luton town) was observed and was the main source of light obtrusion. Light sources from street-lighting, car parks and apron stands lighting were visible in the nocturnal environment.
VP06	Dallow Downs	Sky glow to the west of the Main Application Site (from Luton town and the Main Application Site) was observed and was the main source of light obtrusion. Street-lighting from Luton town was visible in the nocturnal environment.
VP08	Crawley Green Road	Street lighting on Crawley Green Road was the main source of light obtrusion. Sky glow was observed to the north of the Main Application Site (from the Main Application Site and Luton town). Light sources from apron stands lighting and street-lighting were visible in the nocturnal environment.
VP10a	Footpath (Offley 01)	Sky glow to the north east of the Main Application Site (from the Main Application Site and Luton town) was observed. Light sources from street-lighting, car parks and apron stands lighting were visible in the nocturnal environment.
VP10b	Footpath (Offley 02)	As per description for VP 10a above.
VP13	Wigmore Valley Park	Sky glow to the north east of the Main Application Site (from the Main Application Site and Luton town) was observed and was the main source of

VP Ref	Location	Observations
		light obtrusion. Light sources from street-lighting, car parks and apron stands lighting were highly visible in the nocturnal environment.
VP14	Raynham Way	Sky glow to the north of the Main Application Site (from the Main Application Site and Luton town) was observed and was the main source of light obtrusion. Light sources from street-lighting car parks and apron stands lighting were visible in the nocturnal environment.
VP15	Polzeath Close	Street lighting on Polzeath Close was the main source of light obtrusion. Sky glow was observed to the north west of the Main Application Site (from the Main Application Site and Luton town). Light sources from street-lighting, car parks and apron stands lighting were visible in the nocturnal environment.
VP16	Powdrills Field	Sky glow to the north west of the Main Application Site (from the Main Application Site and Luton town) was observed and was the main source of light obtrusion. Light sources from street-lighting, car parks and apron stands lighting were visible in the nocturnal environment.
VP18	The Luton Drive	Sky glow to the south west of the Main Application Site (from the Main Application Site and Luton town) was observed and was the main source of light obtrusion. Light sources from aviation light signals were visible in the nocturnal environment.
VP19	Luton Hoo Parkland	Sky glow to the south west of the Main Application Site (from the Main Application Site and Luton town) was observed and was the main source of light obtrusion. Light sources from street-lighting, car parks and apron stands lighting were visible in the nocturnal environment.
VP20	Footpath (Hyde 5A)	Sky glow to the south/south west of the Main Application Site (from the Main Application Site and Luton town) was

VP Ref	Location	Observations
		observed and was the main source of light obtrusion. Light sources from street-lighting, car parks and apron stands lighting were visible in the nocturnal environment.
VP21	Footpath (Hyde 4B) Someries Castle	As per description above for VP20.
VP22	Footpath (Hyde 4B) Someries Castle	
VP27	Bridleway (Hyde 3A)	
VP28	Footpath (Kings Walden 43)	Sky glow to the east of the Main Application Site (from the Main Application Site and Luton town) was observed and was the main source of light obtrusion. Light sources from street-lighting, car parks and apron stands lighting were visible in the nocturnal environment.
VP31	Footpath (Kings Walden 09)	As per description above for VP28.
VP32	Darley Road, near Breachwood Green	
VP33	Footpath (Kings Walden 07)	
VP34	Footpath (Kings Walden 06)	
VP35	Footpath (Chiltern Way)	Sky glow to the east of the Main Application Site (from the Main Application Site and Luton town) was observed and was the main source of light obtrusion. Light sources from street-lighting were visible in the nocturnal environment.
VP36	Vauxhall Way	Street lighting on Vauxhall Way was the main source of light obtrusion. Sky glow was observed to the west of the Main Application Site (from the Main Application Site and Luton town). Light sources from street-lighting and car parks were visible in the nocturnal environment.
VP37	Cutenhoe Road	Street lighting on Cutenhoe Road was the main source of light obtrusion. Sky glow was observed to the west of the

VP Ref	Location	Observations
		Main Application Site (from the Main Application Site and Luton town). Light sources from street-lighting were visible in the nocturnal environment.
VP38	Mistletoe Hill	Street lighting on Mistletoe Hill was the main source of light obtrusion. Sky glow was observed to the west of the Main Application Site (from the Main Application Site and Luton town). Light sources from street-lighting were visible in the nocturnal environment.
VP40	Someries Hill	Sky glow to the north of the Main Application Site (from the Main Application Site and Luton town) was observed and was the main source of light obtrusion. Light sources from street-lighting were visible in the nocturnal environment.

6.6 Key Findings

6.6.1 The baseline survey showed that:

a. there is a significant source of light obtrusion emanating from the Main Application Site when viewed from all directions;

b. some of the roads are not illuminated;

c. very low illuminance levels (<1lux) were recorded at viewpoints located approximately 200m from the Main Application Site;

d. higher illuminance levels (>1lux) were recorded around viewpoints where street lighting was present;

e. in some instances the local topography and woodlands screens the residential receptors from Luton town and the Main Application Site;

f. the Main Application Site is relatively bright and is considered to be within Zone 3 (medium district brightness areas, small town centre or urban location); and

g. skyglow from Luton town was clearly visible from some viewpoints and is a great contributor to the surrounding environment.

Sensitive Receptors

6.6.2 The receptors surrounding the Main Application Site are identified below and include:

a. towns and districts;

b. local farms;

c. parks/woodland;
d. heritage assets;
e. commercial properties; and
f. residential properties.

7 EMBEDDED AND GOOD PRACTICE MITIGATION

7.1 Embedded Mitigation

7.1.1 The lighting design strategy includes the embedded mitigation described below:

a. apron stands masts height limited to 25 meters;
b. apron stands floodlighting upward tilt no more than 0° from horizontal;
c. a horizontal cut off and no tilt on other luminaires; and
d. shielding by structure on car parks.

7.2 Good Practice Mitigation

Construction

7.2.2 The CoCP (**Appendix 4.2** of the ES **[TR020001/APP/5.02]**) describes measures to minimise and manage light obtrusion during construction. This would be implemented by the lead contractor during the construction works to manage and mitigate adverse risks to sensitive receptors from light obtrusion risks.

7.2.3 As detailed in the CoCP, the use of temporary works lighting shall be minimised in terms of frequency and duration wherever possible. Security and task lighting shall be limited and of short duration. The following measures shall be implemented to minimise risk of adverse effects on residents and wildlife:

a. Confine lighting to the task area (using horizontal cut-off optics and zero floodlight tilt angles).
b. Orientate floodlights away from any dwellings.
c. Use lower power security lighting where possible (and ensure minimal horizontal/vertical light spill).
d. Observe a curfew when practicable (although this is not possible during 24/7 working patterns).
e. Plant lighting needs to be shielded from view by the neighbouring dwellings and sensitive habitats.
f. Use the site cabins etc, to provide shielding of the lighting from beyond construction sites.

7.2.4 Particular attention shall be paid to the likelihood of sky glow and light intrusion beyond each construction site. When the lighting is used it shall be visually checked from likely sensitive receptors (e.g. nearby residential properties) and any necessary adjustments made to ensure its visibility and intensity is reduced to a minimum.

7.2.5 The contractor shall keep a record of all lighting installed on the construction sites, which shall be available on request to show that all fixtures comply with the above conditions. Where this is not possible it shall be recorded why and what actions have been implemented to minimise effects.

8 ASSESSMENT

8.1 Construction

8.1.1 The requirements set out in the CoCP (**Appendix 4.2** of the ES **[TR020001/APP/5.02]**) would be implemented during construction, as such the lighting assessment for construction concludes that for all the viewpoints considered in this assessment, the significance of the effects is **negligible**.

8.2 Operation

8.2.1 Using the methodology provided in **Section 0**, a simulation was used to predict the performance of the lighting design strategy described in **Appendix F** and **Appendix G** of this assessment.

8.2.2 This provides accurate predictions on the following light obtrusion characteristics:

a. For each viewpoint:
   i. Source intensity visible from each viewpoint, as an omnidirectional point (candelas, cd); and
   ii. Light spill onto each viewpoint (lumens/m2, lux).
b. For each luminaire:
   i. Upward Light Ratio (ULR, %).
c. For the overall scheme:
   i. Upward Flux Ratio (UFR, ratio).
d. Ecology and bats:
   i. Illuminance onto boundaries (lux)

8.2.3 The data presented in this section considers all the lighting operating at 100% output and is a worst-case scenario.

Results - Viewpoints

8.2.4 The calculation results of light obtrusion on viewpoints are provided in **Table 8.1** below. Key points shown by the results include:

a. The brightness (source intensity) perceived by the observers from each viewpoint location is less than the respective thresholds for each luminaire for all but four viewpoints. For these four viewpoints, limits are exceeded only in the post-curfew condition:
   i. The four viewpoints (V13, V15, V16, V36) which experience limits exceeded by one luminaire are within the fire training facility, which is unlikely to be in operation post-curfew or for long periods of time.
   ii. One viewpoint (V13) also experiences limits exceeded by two road luminaires. The luminaires are of standard road lighting design. Furthermore, the sensitivity of the receptor is low (non-residential).

b. The light intrusion onto all sensitive receptors (viewpoints) is less than 10.0 lux, the maximum recommendation value for Environmental Zone E3 pre-curfew, and less than 2.0 lux, the maximum recommendation value for Environmental Zone E3 post-curfew according to ILP GN01 (Ref. 1), for all viewpoints.

Table 8.1: Obtrusive light recommendations and results output

VP Ref	Calculation Results				Notes
	Light Intrusion Ev (lux)		Number of Luminaires Exceeding Source Intensity (cd), out of 4186 luminaires		
	Pre-curfew	Post-curfew	Pre-curfew	Post-curfew	
VP02	<1.0	<1.0	0	0	-
VP05	<1.0	<1.0	0	0	-
VP06	<1.0	<1.0	0	0	-
VP08	<1.0	<1.0	0	0	-
VP10a	<1.0	<1.0	0	0	-
VP10b	<1.0	<1.0	0	0	-
VP13	1.2	1.2	0	3	One luminaire in Fire Training Ground Two on adjacent road
VP14	<1.0	<1.0	0	0	-
VP15	<1.0	<1.0	0	1	Luminaire in Fire Training Ground
VP16	<1.0	<1.0	0	1	Luminaire in Fire Training Ground
VP18	<1.0	<1.0	0	0	-
VP19	<1.0	<1.0	0	0	-
VP20	<1.0	<1.0	0	0	-
VP21	<1.0	<1.0	0	0	-
VP22	<1.0	<1.0	0	0	-
VP27	<1.0	<1.0	0	0	-
VP28	<1.0	<1.0	0	0	-
VP31	<1.0	<1.0	0	0	-
VP32	<1.0	<1.0	0	0	-
VP33	<1.0	<1.0	0	0	-
VP34	<1.0	<1.0	0	0	-
VP35	<1.0	<1.0	0	0	-

VP Ref	Calculation Results				Notes
	Light Intrusion Ev (lux)		Number of Luminaires Exceeding Source Intensity (cd), out of 4186 luminaires		
	Pre-curfew	Post-curfew	Pre-curfew	Post-curfew	
VP36	<1.0	<1.0	0	1	Luminaire in Fire Training Ground
VP37	<1.0	<1.0	0	0	-
VP38	<1.0	<1.0	0	0	-
VP40	<1.0	<1.0	0	0	-

Results – Each Luminaire

8.2.5 All luminaires have an ULR below the recommended target of 5% and therefore comply with guidance limits.

Results – Overall Scheme

8.2.6 The Proposed Development lighting design strategy has a UFR of 3.4 which is below the recommended target of 8 and therefore complies with guidance.

Results – Ecology and bats

8.2.7 The calculation results of light obtrusion on bats, as summarised in **Table 8.2** and presented on the drawings in **Appendix D** and **Appendix E**, indicate that:

a. The maximum illuminance levels on the vertical planes around apron stand, roads and surface car park locations area exceeds 10 lux on one grid (Grid No. 40) within **Table 8.2**: Vertical Illuminance on planeshowever this is where the site boundary crosses an illuminated road, hence this scenario is unavoidable. Otherwise, all values are below 4 lux.

b. The maximum illuminance levels on the vertical planes around decked car park locations (Grid Nos. 1-3) within **Table 8.2**: Vertical Illuminance on planes exceed the 10 lux threshold and the area of occurrence is from ground level up to 36 meters above ground level.

8.2.8 Refer to **Chapter 8** Biodiversity of the ES **[TR020001/APP/5.01]** where the impact of these exceedances and any mitigation measures have been considered.

Table 8.2: Vertical Illuminance on planes

Grid No.	Maximum Illuminance on the grid (lux)	Area of occurrence on the grid (From ground level up to 40m above ground level)	Main source of lighting (in close proximity to the grid)
1	14.8	From ground level up to 16m above ground	Roads, surface and decked car parks
2	13.5	From ground level up to 36m above ground	Roads, surface and decked car parks
3	14.4	From ground level up to 36m above ground	Roads, surface and decked car parks
4	0.4	From ground level up to 36m above ground	Roads and surface car parks
5	0.6	From ground level up to 16m above ground	Fire Training Ground
6	0.4	From ground level up to 16m above ground	Fire Training Ground
7	0.6	From ground level up to 32m above ground	Fire Training Ground
8	3.3	From ground level up to 24m above ground	Fire Training Ground
9	0.4	From ground level up to 28m above ground	Roads and surface car parks
10	0.3	From ground level up to 28m above ground	Roads and surface car parks
11	0.2	From ground level up to 8m above ground	Roads and surface car parks
12	0.3	From ground level up to 8m above ground	Roads and surface car parks
13	0.5	From ground level up to 4m above ground	Roads and surface car parks
14	0.5	From ground level up to 4m above ground	Roads
15	0.4	From ground level up to 4m above ground	Roads

Grid No.	Maximum Illuminance on the grid (lux)	Area of occurrence on the grid (From ground level up to 40m above ground level)	Main source of lighting (in close proximity to the grid)
16	0.6	From ground level up to 4m above ground	Roads
17	0.6	From ground level up to 4m above ground	Roads
18	0.5	From ground level up to 24m above ground	Roads and surface car parks
19	0.9	From ground level up to 8m above ground	Roads and surface car parks
20	1.9	From ground level up to 12m above ground	Roads
21	1.6	From ground level up to 12m above ground	Roads and surface car parks
22	1.6	From ground level up to 8m above ground	Roads and surface car parks
23	4.6	From ground level up to 16m above ground	Roads and surface car parks
24	3.2	From ground level up to 12m above ground	Apron stands
25	0.6	From ground level up to 12m above ground	Roads and surface car parks
26	1.3	From ground level up to 12m above ground	Road and fuel farm
27	2.1	From ground level up to 12m above ground	Road and fuel farm
28	0.9	From ground level up to 12m above ground	Road and fuel farm
29	0.6	From ground level up to 12m above ground	Roads and surface car parks
30	1.8	From ground level up to 4m above ground	Roads and surface car parks
31	3.8	From ground level up to 16m above ground	Roads

Grid No.	Maximum Illuminance on the grid (lux)	Area of occurrence on the grid (From ground level up to 40m above ground level)	Main source of lighting (in close proximity to the grid)
32	1.2	From ground level up to 12m above ground	Roads
33	1.5	From ground level up to 8m above ground	Roads
34	1.5	From ground level up to 40m above ground	Roads
35	1.4	From ground level up to 24m above ground	Roads
36	1.8	From ground level up to 12m above ground	Roads and surface car parks
37	2.7	From ground level up to 12m above ground	Roads and surface car parks
38	5.0	From ground level up to 20m above ground	Roads, decked and surface car parks
39	8.9	From ground level up to 24m above ground	Roads, decked and surface car parks
40	62.0	From ground level up to 12m above ground	Roads
41	0.6	From ground level up to 12m above ground	Roads
42	0.7	0m at ground level	Roads and surface car parks
43	0.6	From ground level up to 16m above ground	Roads and surface car parks
44	0.6	From ground level up to 12m above ground	Roads
45	0.6	From ground level up to 12m above ground	Roads
46	0.5	From ground level up to 12m above ground	Roads
47	0.5	From ground level up to 4m above ground	Roads

Results and Environmental Impact

Viewpoints

8.2.9 **Table 8.3** below presents the results of the assessment for each sensitive receptor in relation to ILP GN01 (Ref. 1) (source intensity, sky glow and light intrusion), and applies the methodology described in **Section 0** to each sensitive receptor to determine the significance of the environmental effect.

Table 8.3: Assessment results and environmental impact

VP Ref	Receptor	ILP Guidance met (Yes/No)	Magnitude	Receptor Sensitivity	Description of effect and significance
VP02	Residential	Yes	Very low	Medium	Negligible
VP05	Heritage	Yes	Very low	High	Negligible
VP06	Residential	Yes	Very low	Medium	Negligible
VP08	Residential	Yes	Very low	Medium	Negligible
VP10a	Residential	Yes	Very low	Medium	Negligible
VP10b	Commercial	Yes	Very low	Low	Negligible
VP13	Commercial	No	Very low	Low	Negligible
VP14	Residential	Yes	Very low	Medium	Negligible
VP15	Residential	No	Very low	Medium	Negligible
VP16	Residential	No	Very low	Medium	Negligible
VP18	Heritage	Yes	Very low	High	Negligible
VP19	Heritage	Yes	Very low	High	Negligible
VP20	Residential	Yes	Very low	Medium	Negligible
VP21	Heritage	Yes	Very low	High	Negligible
VP22	Heritage	Yes	Very low	High	Negligible
VP27	Residential	Yes	Very low	Medium	Negligible
VP28	Residential	Yes	Very low	Medium	Negligible
VP31	Residential	Yes	Very low	Medium	Negligible
VP32	Residential	Yes	Very low	Medium	Negligible
VP33	Residential	Yes	Very low	Medium	Negligible
VP34	Residential	Yes	Very low	Medium	Negligible
VP35	Residential	Yes	Very low	Medium	Negligible
VP36	Residential	No	Very low	Medium	Negligible
VP37	Residential	Yes	Very low	Medium	Negligible
VP38	Residential	Yes	Very low	Medium	Negligible
VP40	Residential	Yes	Very low	Medium	Negligible

8.2.10 As described in **Table 8.3** above, all of the high sensitivity receptors assessed meet ILP GN01 (Ref. 1) guidance on source intensity, sky glow and light intrusion. Four viewpoints (VP13, VP15, VP16 and VP36) do not meet ILP Guidance as described in **paragraph 8.2.4a**, but due to the very low magnitude of effect, and the medium sensitivity the predicted effects are considered negligible. Therefore, for all the viewpoints considered, the predicted effects are **negligible**, which is **not significant**.

Ecology and bats

8.2.11 The results on horizontal and vertical illuminance reported in this assessment are available to the ecologist undertaking the ecology impact assessment.

8.2.12 Any impacts in relation to bats are assessed and reported in **Chapter 8** Biodiversity of the ES **[TR020001/APP/5.01]**.

9 CUMULATIVE EFFECTS

9.1.1 A search was undertaken to identify other developments applications and allocations. Local authorities planning portals (Luton Borough Council, North Hertfordshire District Council, Central Bedfordshire Council and Dacorum Borough Council) were used to search for current planning applications. Local development plans, policies and programmes were reviewed to determine present and future potential interactions with the Proposed Development. This information was limited, but identified emerging developments that may impact the EIA.

9.1.2 **Appendix 21.1** and **21.2** of the ES **[TR020001/APP/5.01]** provide long and short lists of other developments considered in the cumulative assessment of the ES. With the following three exceptions, the other development proposals provide limited lighting information and therefore without further information and lighting studies the assessment of potential cumulative effects is not possible.

9.1.3 The exceptions include:

a. 20/01588/OUTEIA and 20/01589/OUTEIA, the sites lie 4km to the south west of the Proposed Development. Within lighting assessments at each site, the conclusions state that there is low risk of the proposed schemes exceeding the obtrusive light limitations. There is not sufficient technical information within the lighting statements to fully understand or quantify their effect or any potential cumulative effect, however due to the distance and topography of the land between these developments and it is unlikely that this development will have a significant cumulative effect.

b. 22/00990/FUL, the site lies 5.6km to the north west of the Proposed Development and is separated by Luton Town, therefore it is unlikely that this development will have a significant cumulative effect.

Construction and Operation

9.1.4 As detailed above, there is a lack of detailed information provided for the construction and operational lighting of other developments. Therefore, an assessment of cumulative effects is not possible.

9.1.5 As reported in this document, the Proposed Development is not expected to result in a significant impact on its surroundings. Given the scale and distance of other developments, and assuming they are designed and constructed in line with the recommended lighting standards as the Proposed Development, it is unlikely that the impact of Proposed Development and other developments would result in significant cumulative effects.

GLOSSARY AND ABBREVIATIONS

Term	Definition
ANPS	Airports National Policy Statement: new runway capacity and infrastructure at airports in the south-east of England
CAA	Civil Aviation Authority - an independent specialist aviation regulator.
HDR	High dynamic range image - an image with a greater range of luminosity than that which is possible with standard photographic techniques.
ULR	Upward Light Ratio - the proportion of luminaire luminous flux that is emitted above the horizontal plane, expressed as a percentage of total luminaire luminous flux.
UFR	Upward Flux Ratio - the proportion of luminaire luminous flux of the whole lighting scheme that is emitted above the horizontal plane due to direct and reflected light compared to an idealised scenario, expressed as a ratio.

Appendix A

A1 High Dynamic Range Imaging

High dynamic range (HDR) imaging is a technique used to reproduce a greater dynamic range of luminosity that is possible with standard digital imaging or photograph techniques. In simple terms, the technique produces an image where each pixel is correctly exposed and therefore it can be digitised, calibrated and interrogated for luminance information.

Inset A1.1 Photo exposure issues

A single exposure photograph cannot always correctly capture a scene. For example, in **Inset A1.1** above, parts of the first image are overexposed, while the same parts are correctly exposed in the second image.

The **Inset A1.2** below shows the equivalent HDR image, which uses multiple different exposures of the scene. It can be seen that the HDR image has the correct exposure throughout, and below is the digitised version with luminance information.

Inset A1.2 HDR example

This technique is ideal for nocturnal landscape photography, where high levels of contrast are often experienced, and for capturing the nocturnal luminance profile of the scene.

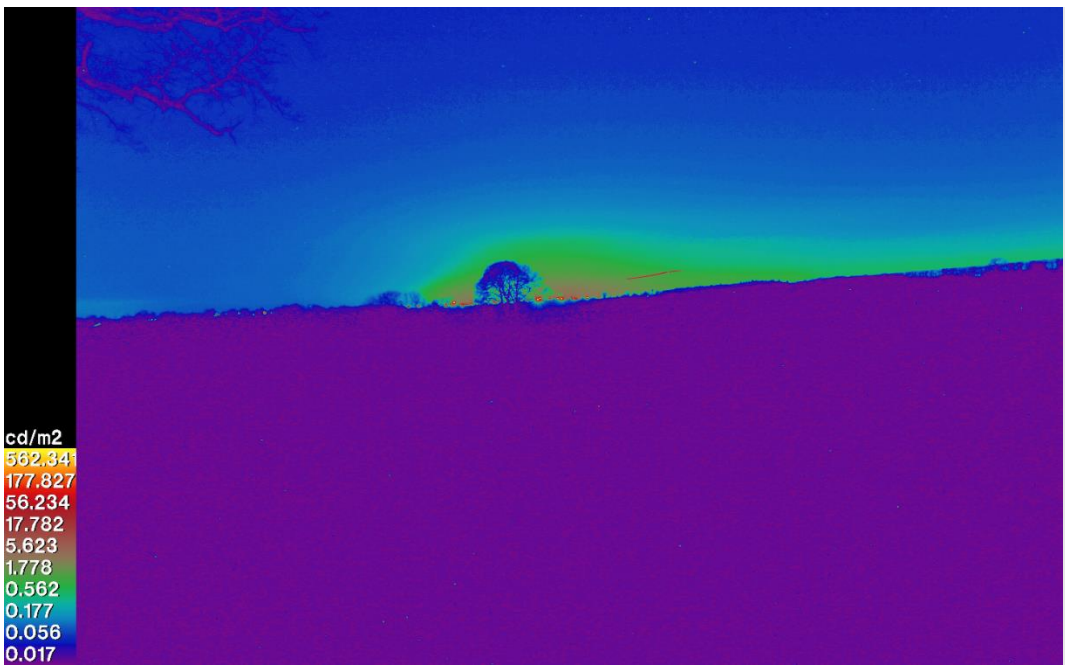
Appendix B

B1 Viewpoint HDR Images

Viewpoint 02

Inset B1.1 HDR image Viewpoint 02

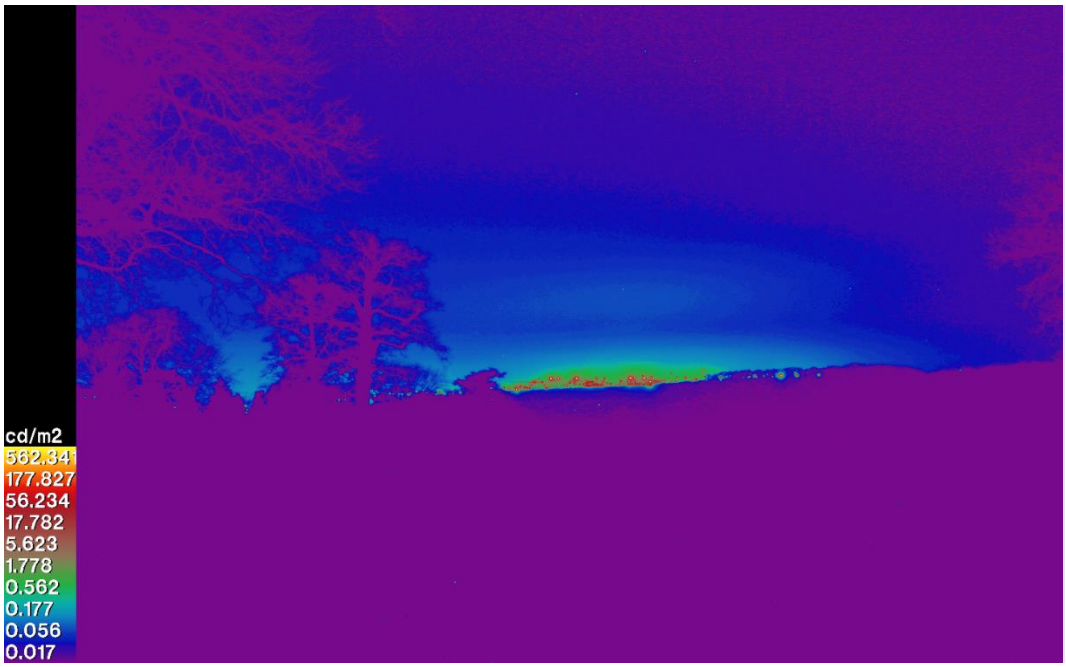
Inset B1.2 Quantitative Luminance Image Viewpoint 02



Viewpoint 05

Inset B1.3 HDR image Viewpoint 05

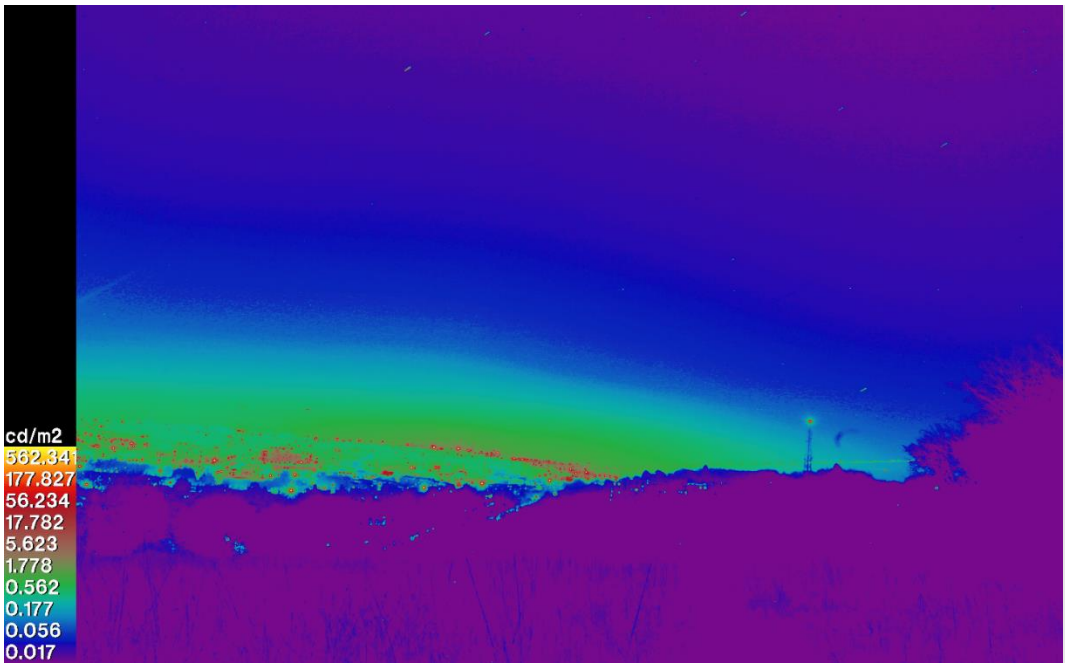
Inset B1.4 Quantitative Luminance Image Viewpoint 05



Viewpoint 06

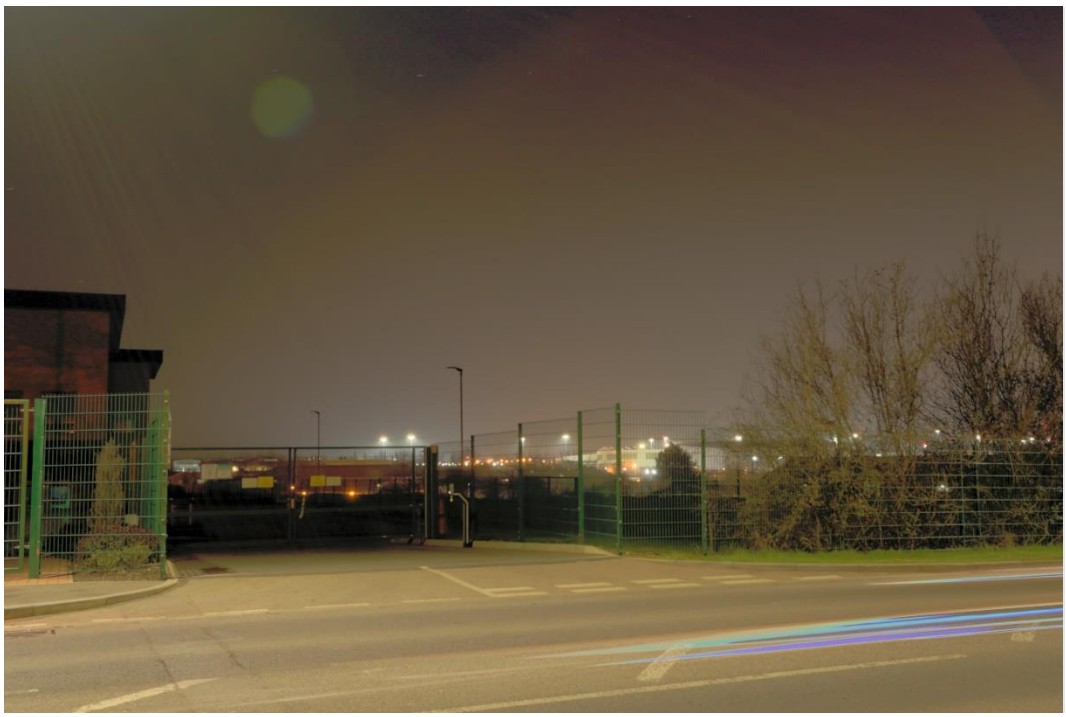
Inset B1.5 HDR image Viewpoint 06

Inset B1.6 Quantitative Luminance Image Viewpoint 06

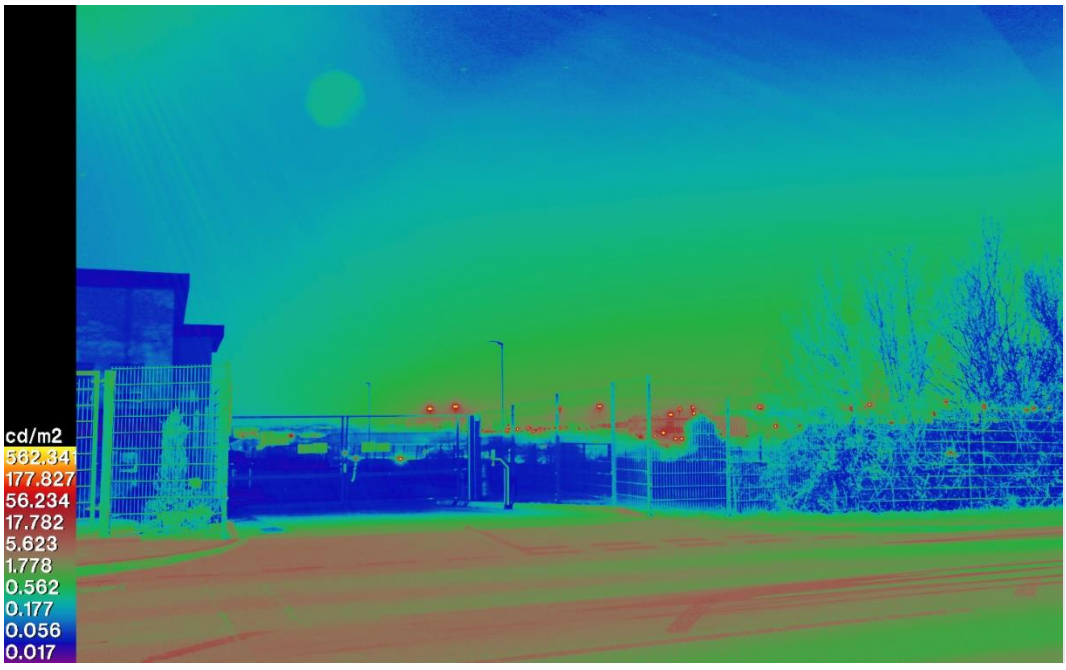


Viewpoint 08

Inset B1.7 HDR image Viewpoint 08



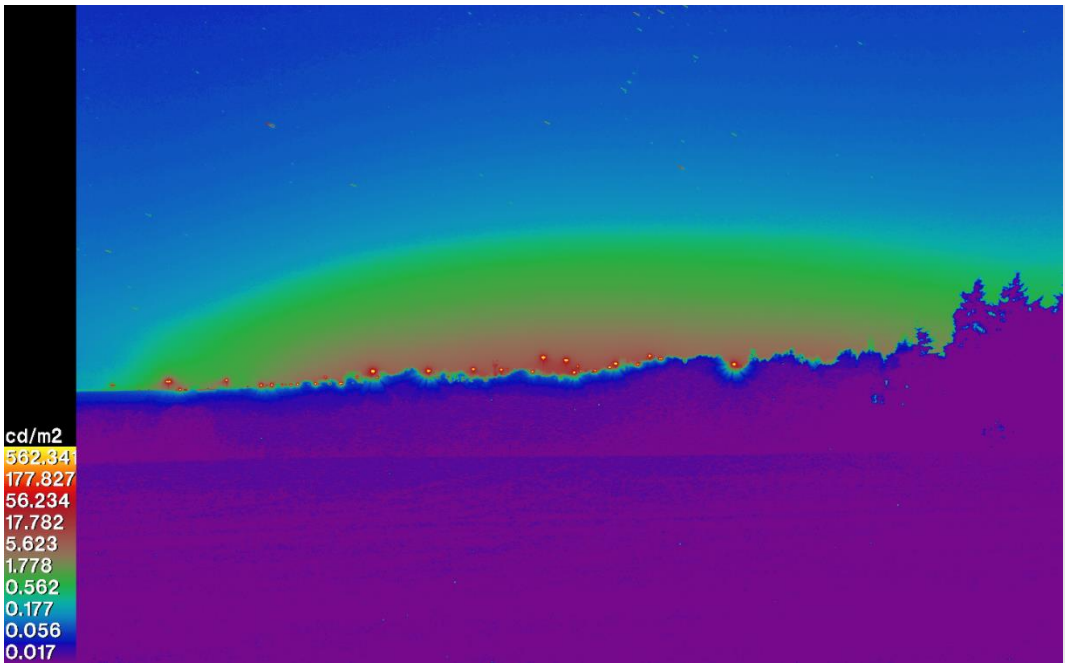
Inset B1.8 Quantitative Luminance Image Viewpoint 08



Viewpoint 10a

Inset B1.9 HDR image Viewpoint 10a

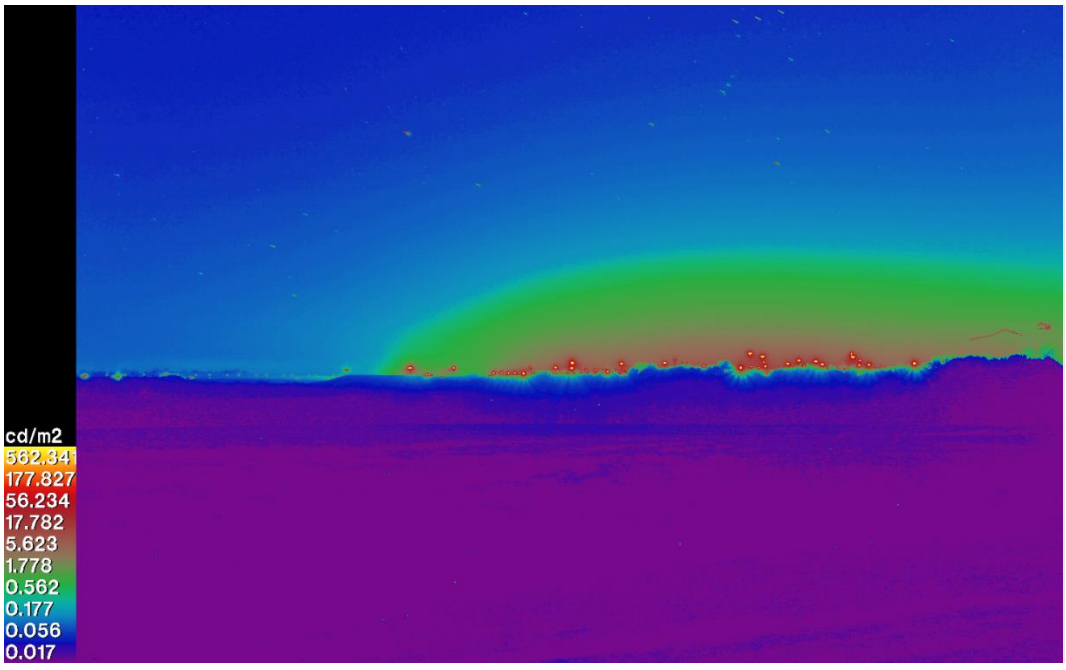
Inset B1.10 Quantitative Luminance Image Viewpoint 10a



Viewpoint 10b

Inset B1.11 HDR image Viewpoint 10b

Inset B1.12 Quantitative Luminance Image Viewpoint 10b



Viewpoint 13

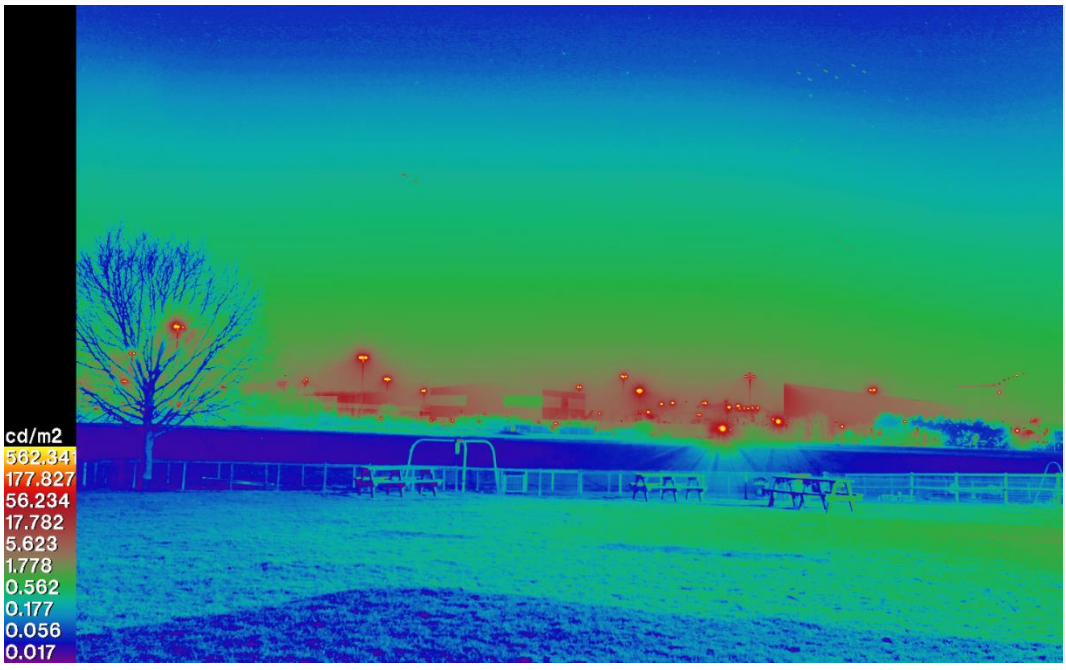
Inset B1.13 HDR image Viewpoint 13

Inset B1.14 Quantitative Luminance Image Viewpoint 13

Viewpoint 13 (continued)

Inset B1.15 HDR image Viewpoint 13 (continued)

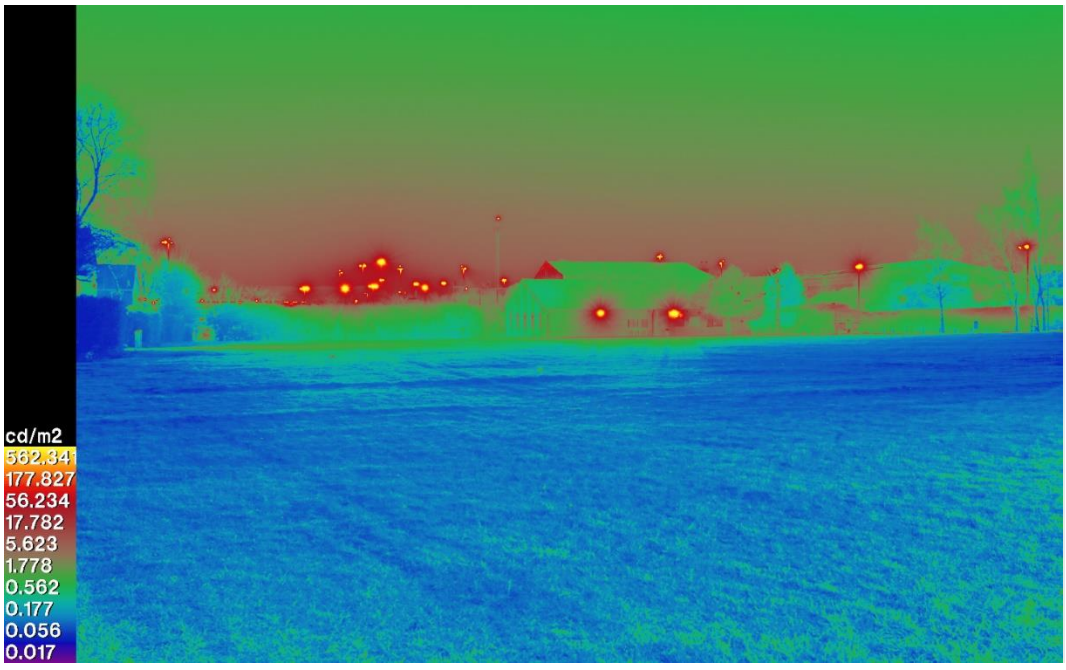
Inset B1.16 Quantitative Luminance Image Viewpoint 13 (continued)



Viewpoint 14

Inset B1.17 HDR image Viewpoint 14

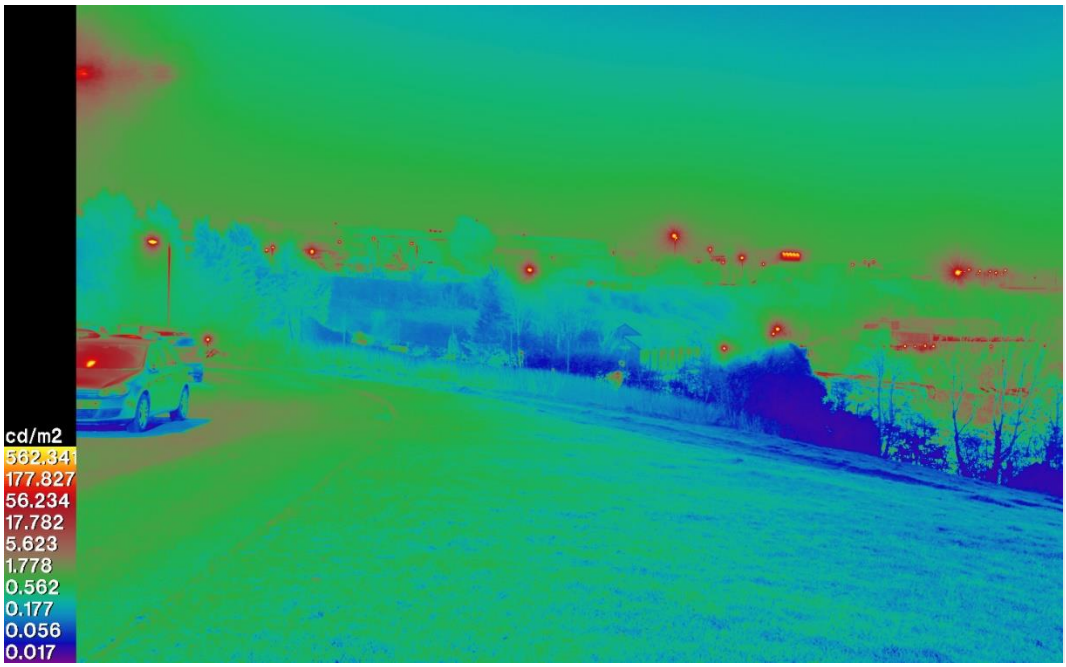
Inset B1.18 Quantitative Luminance Image Viewpoint 14



Viewpoint 15

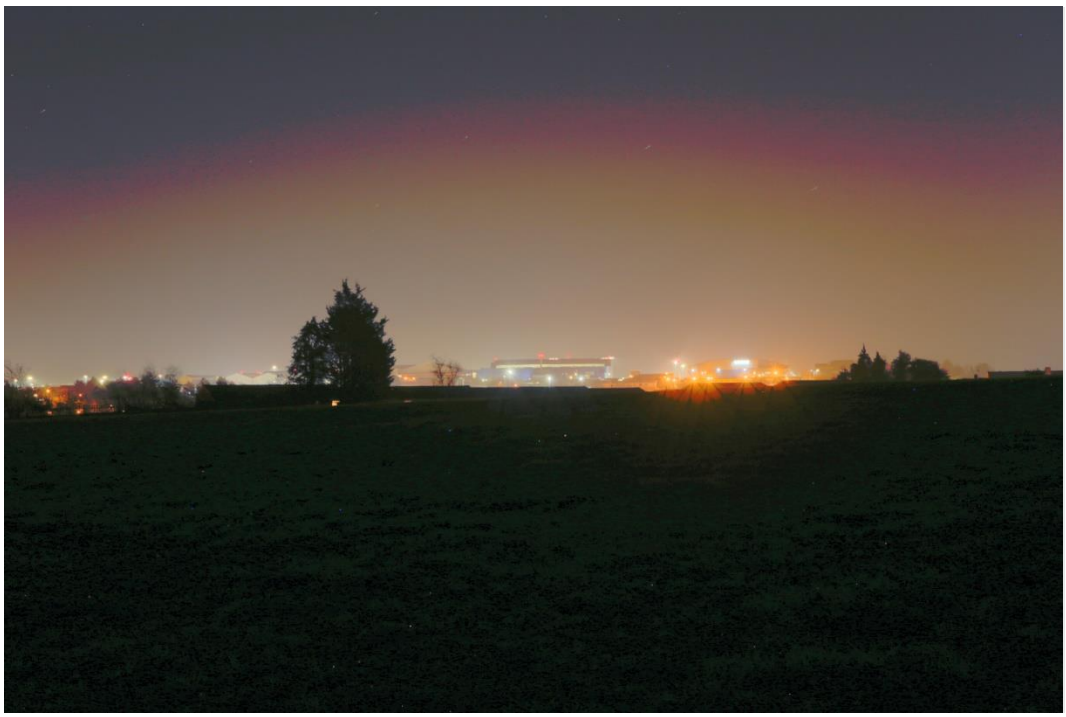
Inset B1.19 HDR image Viewpoint 15

Inset B1.20 Quantitative Luminance Image Viewpoint 15

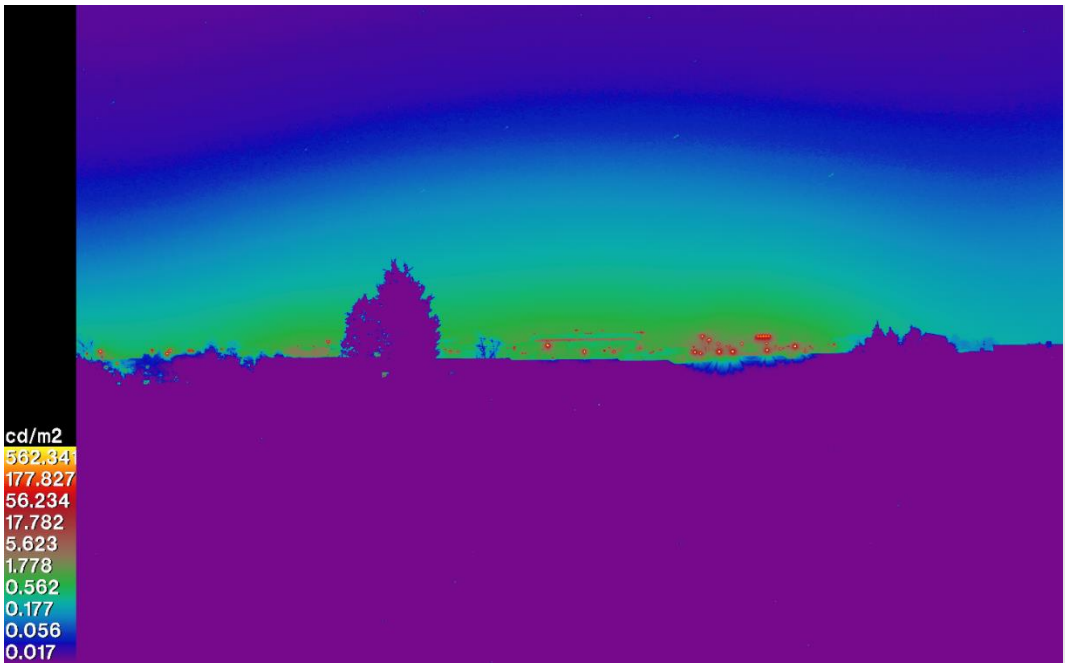


Viewpoint 16

Inset B1.21 HDR image Viewpoint 16



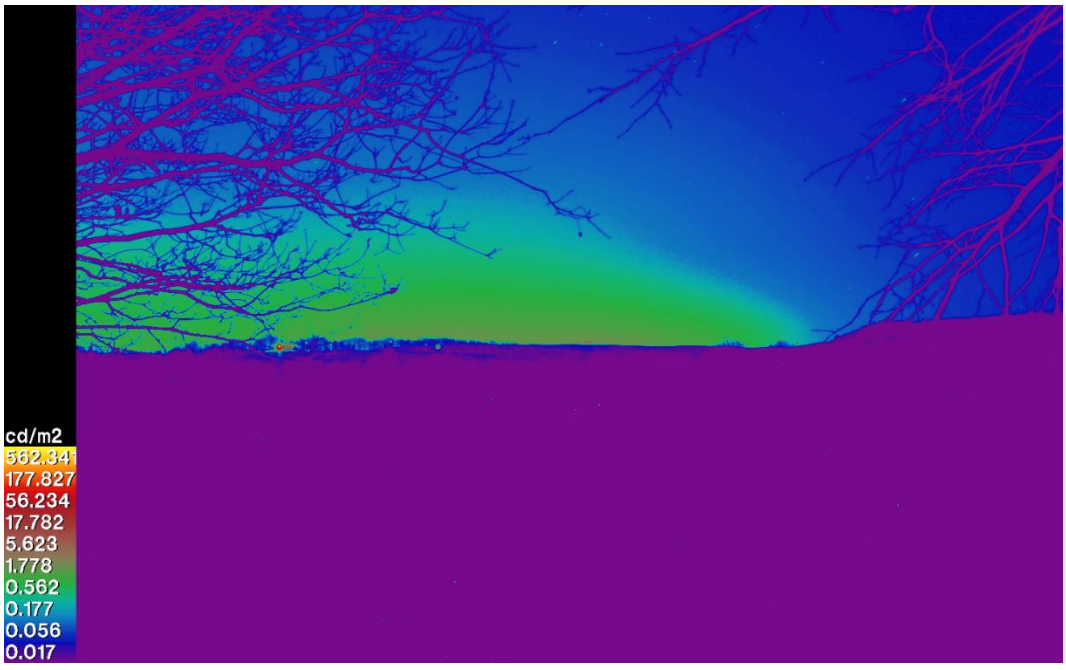
Inset B1.22 Quantitative Luminance Image Viewpoint 16



Viewpoint 18

Inset B1.23 HDR image Viewpoint 18

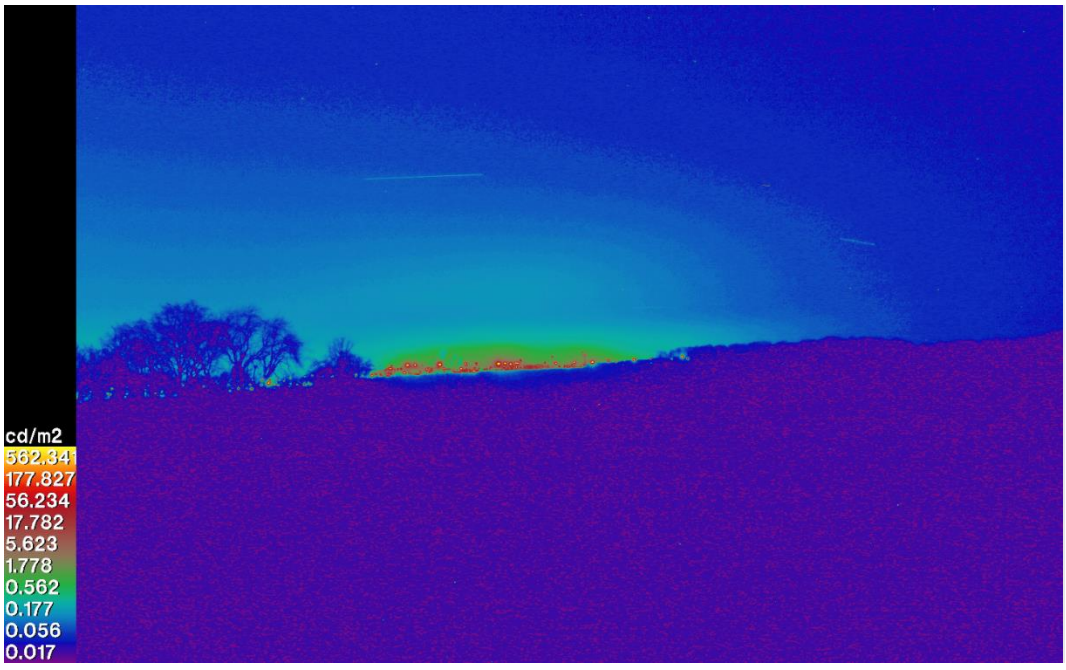
Inset B1.24 Quantitative Luminance Image Viewpoint 18



Viewpoint 19

Inset B1.25 HDR image Viewpoint 19

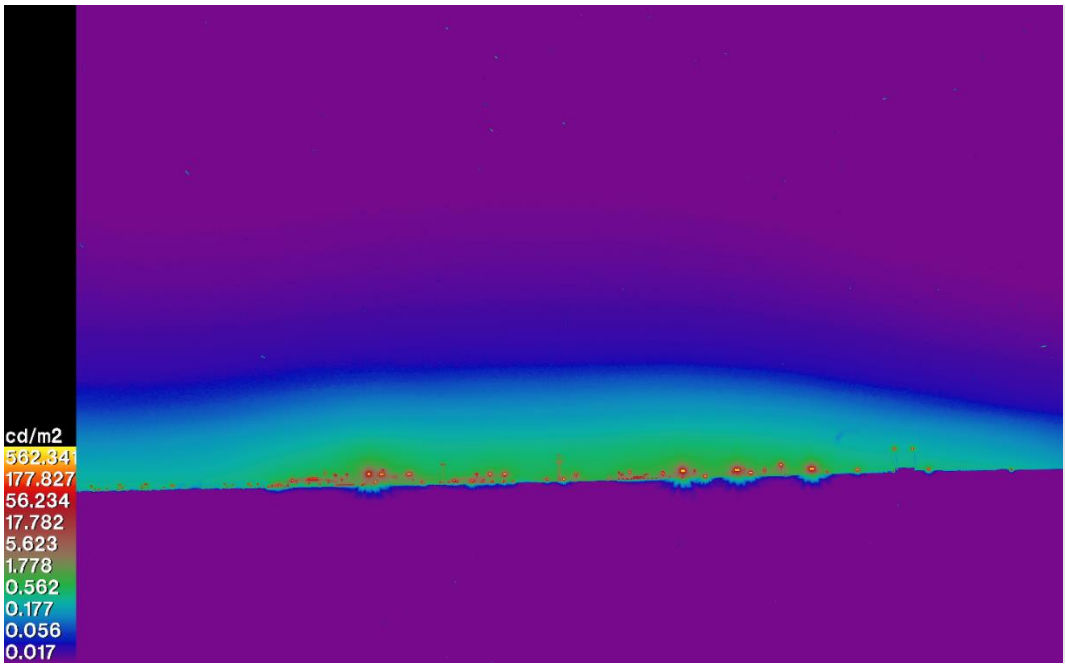
Inset B1.26 Quantitative Luminance Image Viewpoint 19



Viewpoint 20

Inset B1.27 HDR image Viewpoint 20

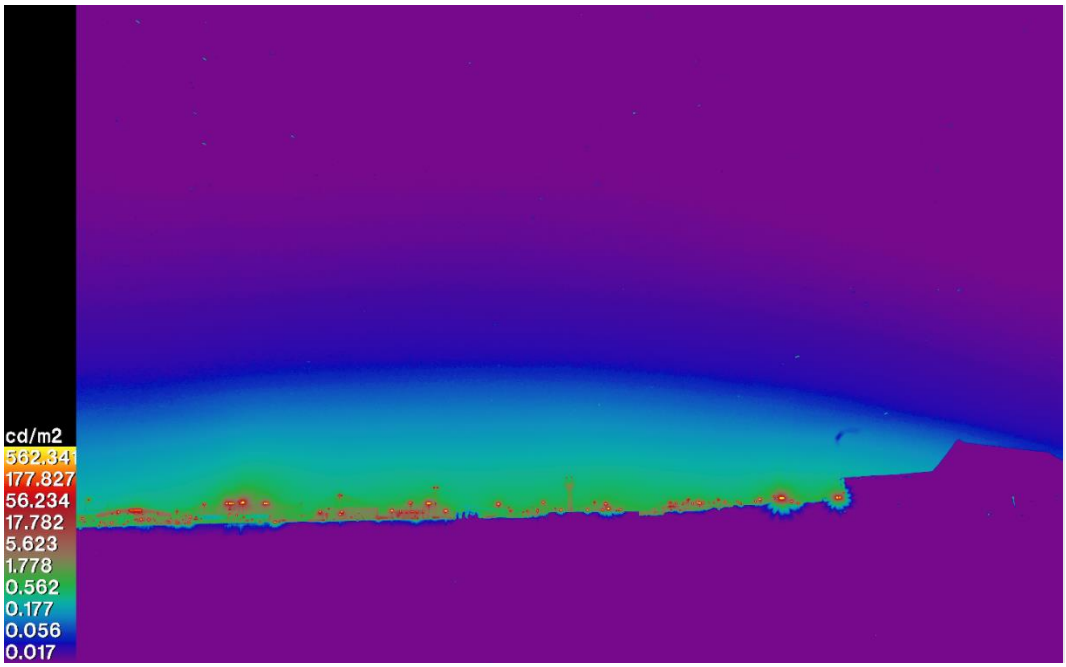
Inset B1.28 HDR image Viewpoint 20



Viewpoint 21

Inset B1.29 HDR image Viewpoint 21

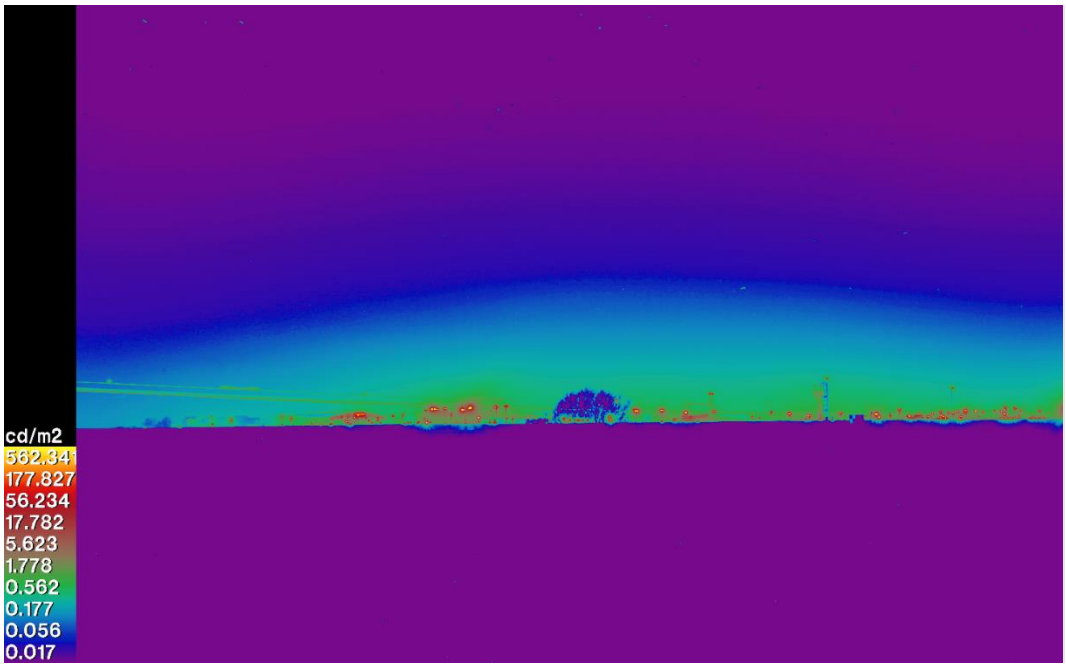
Inset B1.30 Quantitative Luminance Image Viewpoint 21



Viewpoint 22

Inset B1.31 HDR image Viewpoint 22

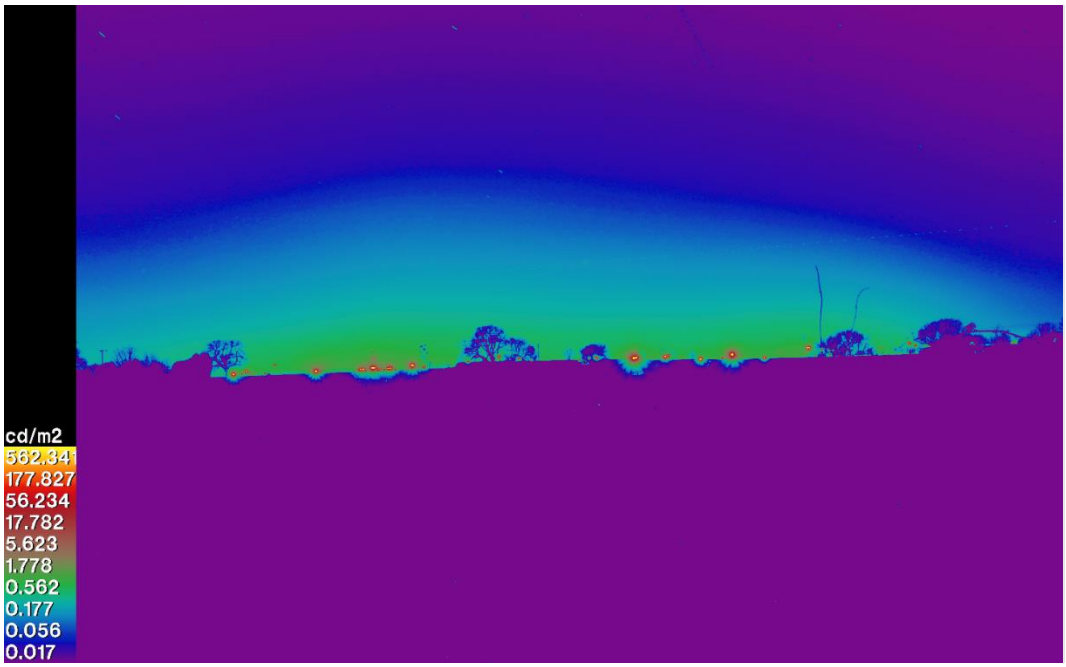
Inset B1.32 Quantitative Luminance Image Viewpoint 22



Viewpoint 27

Inset B1.33 HDR image Viewpoint 27

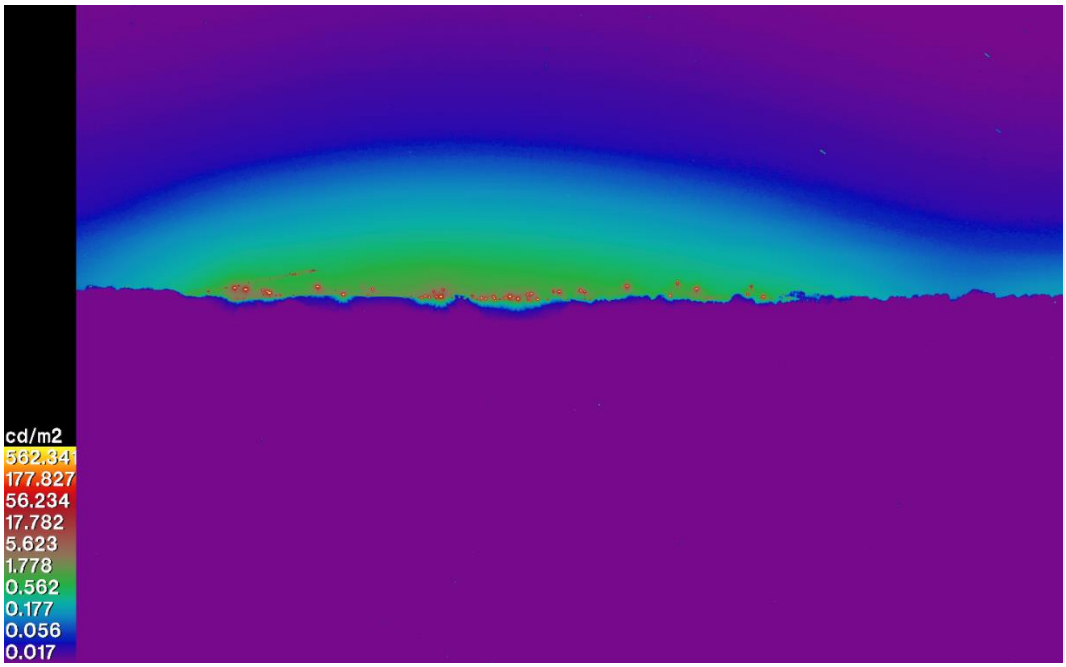
Inset B1.34 Quantitative Luminance Image Viewpoint 27



Viewpoint 28

Inset B1.35 HDR image Viewpoint 28

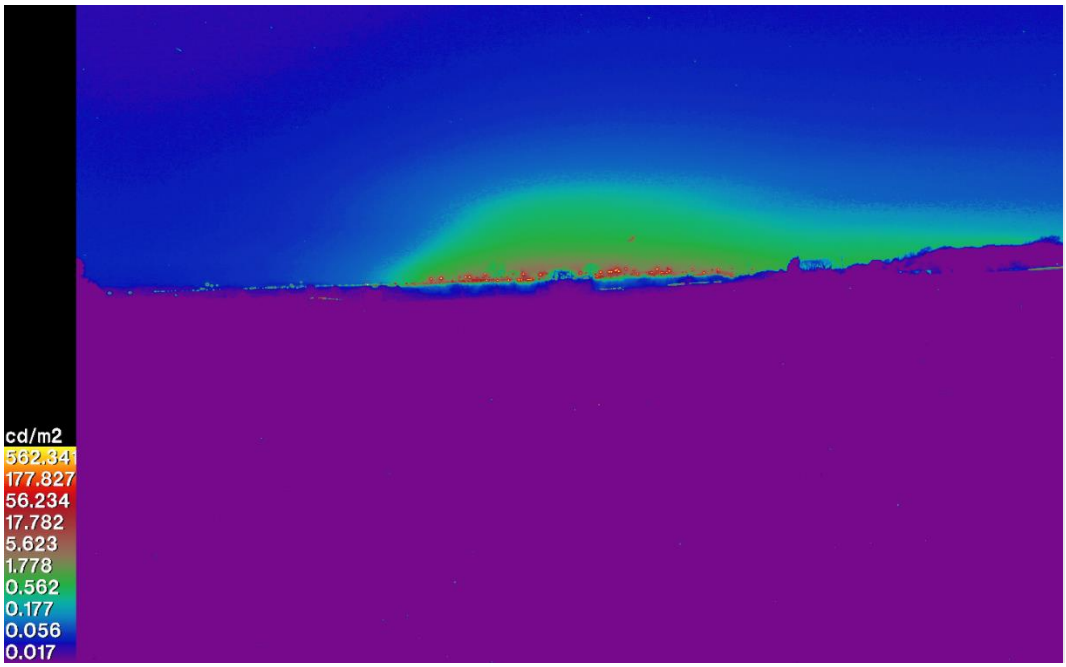
Inset B1.36 Quantitative Luminance Image Viewpoint 28



Viewpoint 31

Inset B1.37 HDR image Viewpoint 31

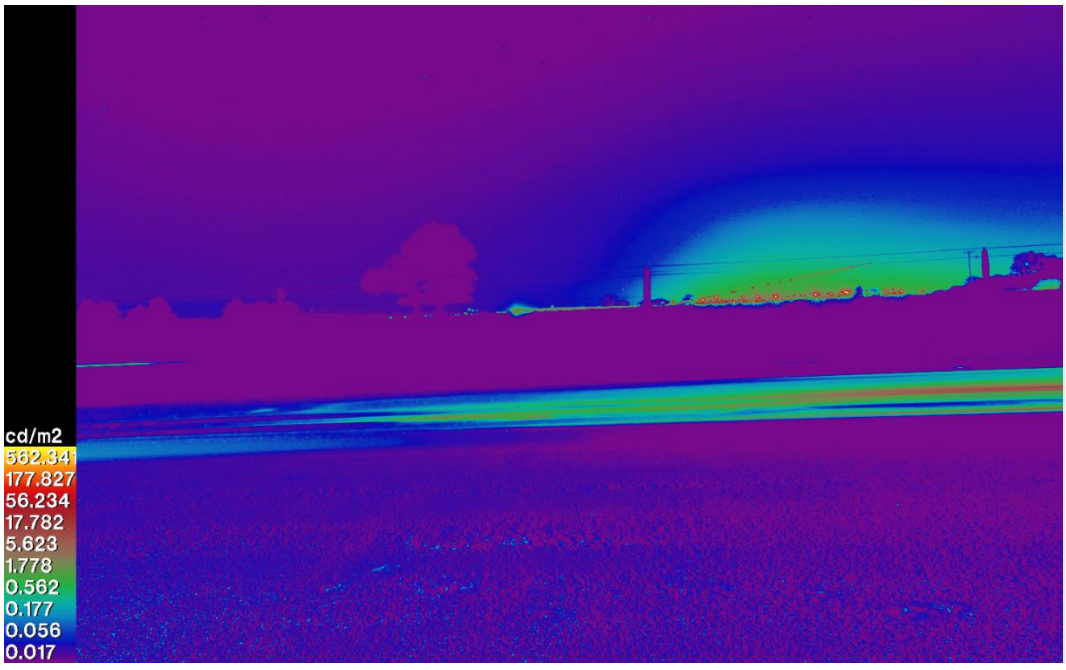
Inset B1.38 Quantitative Luminance Image Viewpoint 31



Viewpoint 32

Inset B1.39 Quantitative Luminance Image Viewpoint 32

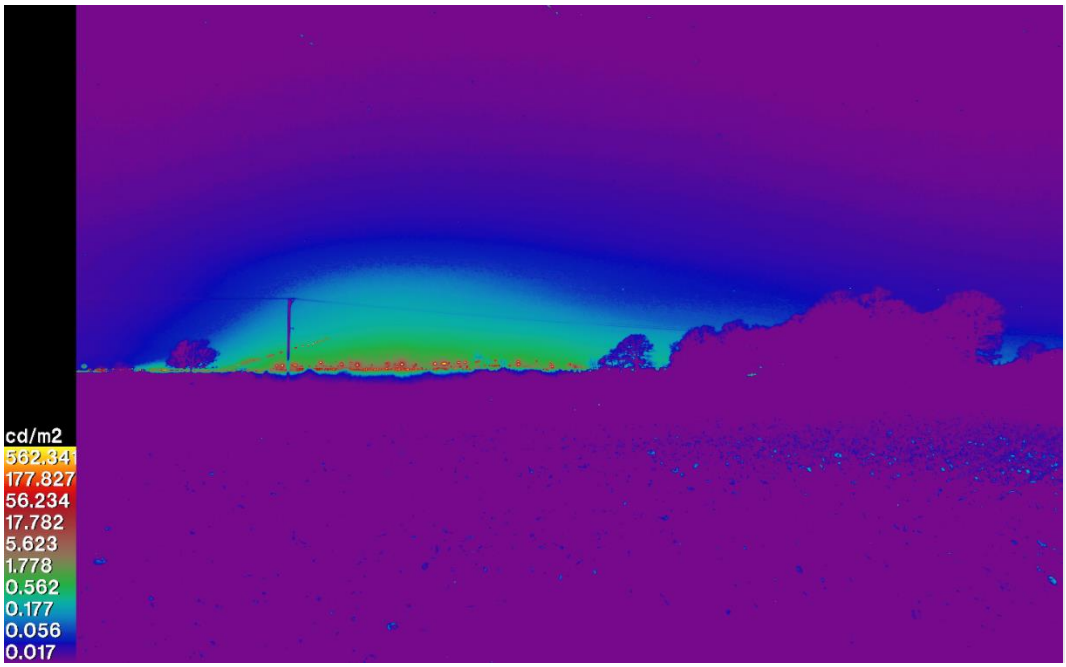
Inset B1.40 Quantitative Luminance Image Viewpoint 32



Viewpoint 33

Inset B1.41 HDR image Viewpoint 33

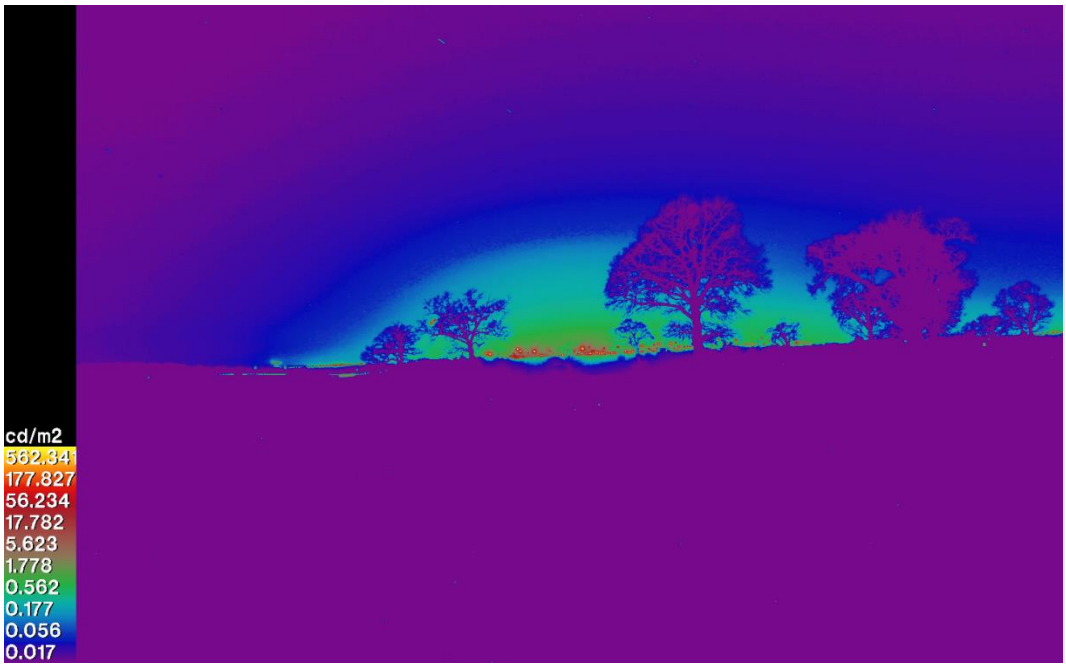
Inset B1.42 Quantitative Luminance Image Viewpoint 33



Viewpoint 34

Inset B1.43 HDR image Viewpoint 34

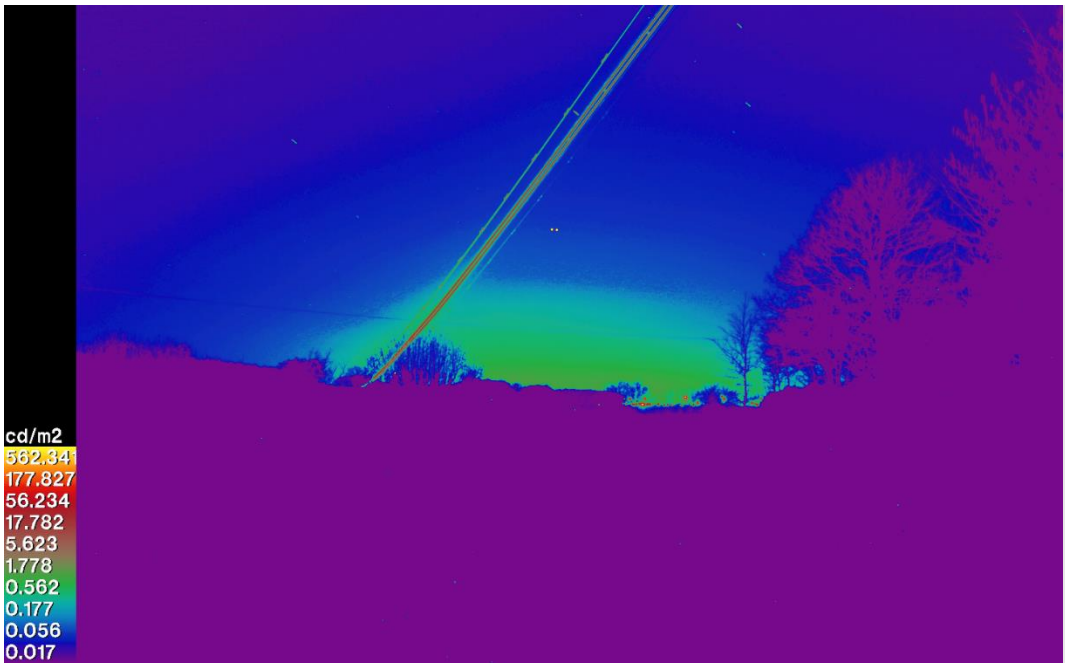
Inset B1.44 Quantitative Luminance Image Viewpoint 34



Viewpoint 35

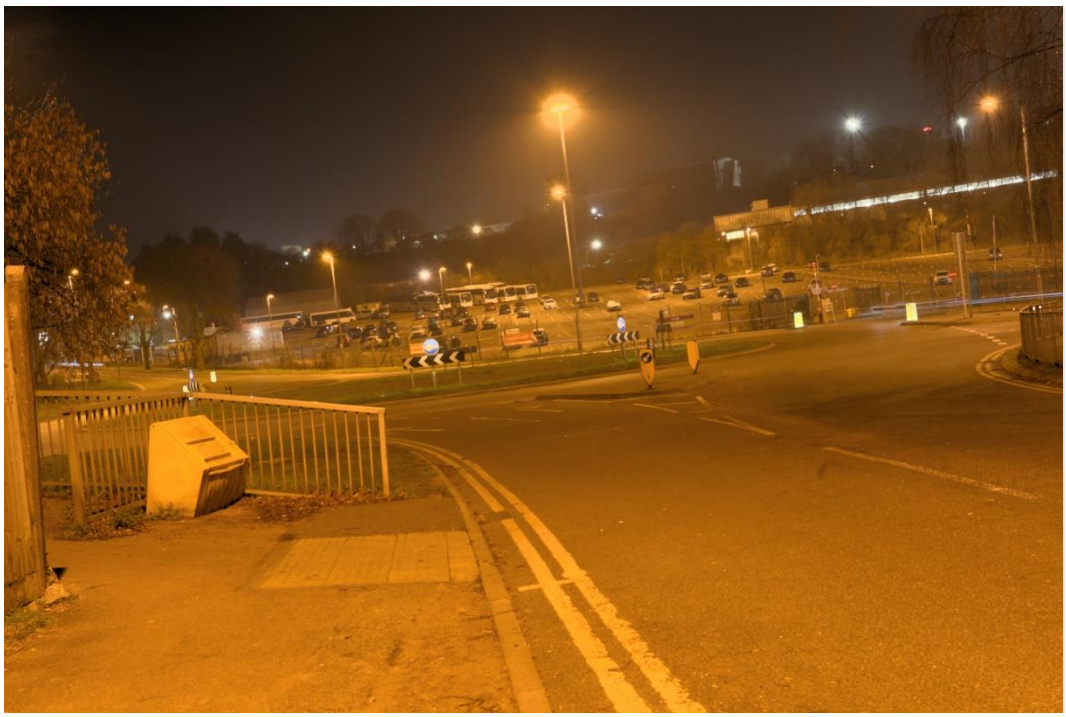
Inset B1.45 HDR image Viewpoint 35

Inset B1.46 Quantitative Luminance Image Viewpoint 35



Viewpoint 36

Inset B1.47 HDR image Viewpoint 36



Inset B1.48 Quantitative Luminance Image Viewpoint 36

Viewpoint 37

Inset B1.49 DR image Viewpoint 37

Inset B1.50 Quantitative Luminance Image Viewpoint 37

Viewpoint 38

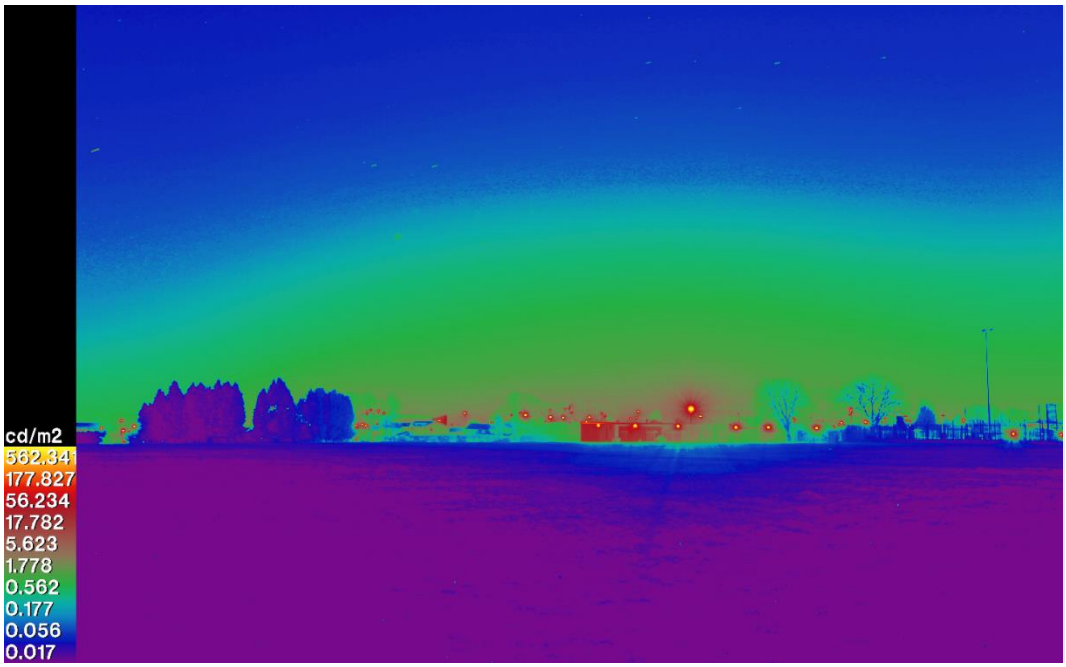
Inset B1.51 HDR image Viewpoint 38

Inset B1.52 Quantitative Luminance Image Viewpoint 38

Viewpoint 40

Inset B1.53 HDR image Viewpoint 40

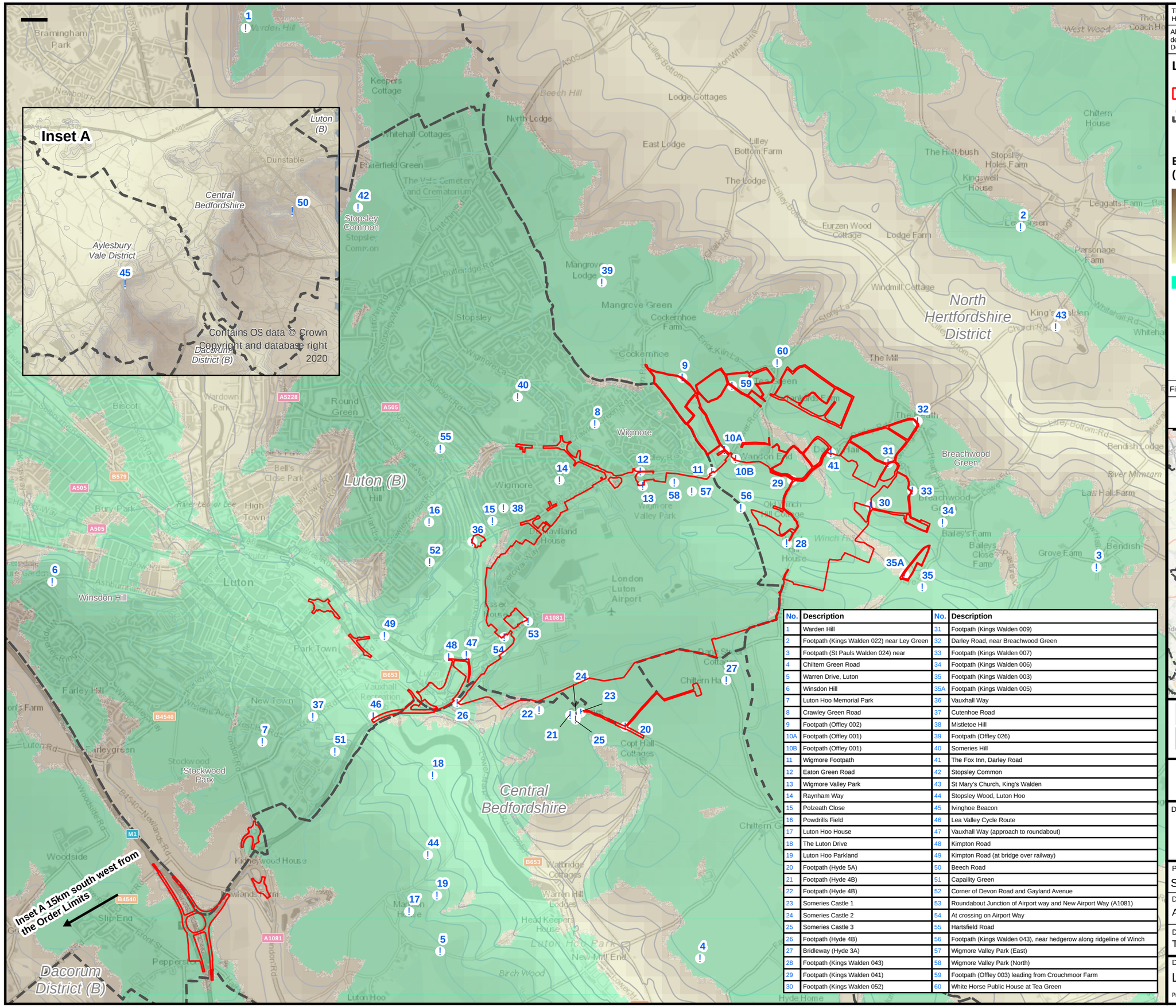
Inset B1.54 Quantitative Luminance Image Viewpoint 40



Appendix C

C1 Proposed Assessment Viewpoints

The drawing below describes the viewpoints of the lighting assessment.



No.	Description	No.	Description
1	Warden Hill	31	Footpath (Kings Walden 009)
2	Footpath (Kings Walden 022) near Ley Green	32	Darley Road, near Breachwood Green
3	Footpath (St Pauls Walden 024) near	33	Footpath (Kings Walden 007)
4	Chiltern Green Road	34	Footpath (Kings Walden 006)
5	Warren Drive, Luton	35	Footpath (Kings Walden 003)
6	Winsdon Hill	35A	Footpath (Kings Walden 005)
7	Luton Hoo Memorial Park	36	Vauxhall Way
8	Crawley Green Road	37	Cutenhoe Road
9	Footpath (Offley 002)	38	Mistletoe Hill
10A	Footpath (Offley 001)	39	Footpath (Offley 026)
10B	Footpath (Offley 001)	40	Someries Hill
11	Wigmore Footpath	41	The Fox Inn, Darley Road
12	Eaton Green Road	42	Stopsley Common
13	Wigmore Valley Park	43	St Mary's Church, King's Walden
14	Raynham Way	44	Stopsley Wood, Luton Hoo
15	Polzeath Close	45	Ivinghoe Beacon
16	Powdrills Field	46	Lea Valley Cycle Route
17	Luton Hoo House	47	Vauxhall Way (approach to roundabout)
18	The Luton Drive	48	Kimpton Road
19	Luton Hoo Parkland	49	Kimpton Road (at bridge over railway)
20	Footpath (Hyde 5A)	50	Beech Road
21	Footpath (Hyde 4B)	51	Capaility Green
22	Footpath (Hyde 4B)	52	Corner of Devon Road and Gayland Avenue
23	Someries Castle 1	53	Roundabout Junction of Airport way and New Airport Way (A1081)
24	Someries Castle 2	54	At crossing on Airport Way
25	Someries Castle 3	55	Hartsfield Road
26	Footpath (Hyde 4B)	56	Footpath (Kings Walden 043), near hedgerow along ridgeline of Winch
27	Bridleway (Hyde 3A)	57	Wigmore Valley Park (East)
28	Footpath (Kings Walden 043)	58	Wigmore Valley Park (North)
29	Footpath (Kings Walden 041)	59	Footpath (Offley 003) leading from Crouchmoor Farm
30	Footpath (Kings Walden 052)	60	White Horse Public House at Tea Green

All structure positions are indicative. The proposed works will be subject to detailed design development. The changes will be within limits of deviation specified in the Development Consent Order.

Legend

- Order Limits
- Local Authority Boundaries
- Assessment Viewpoint Locations

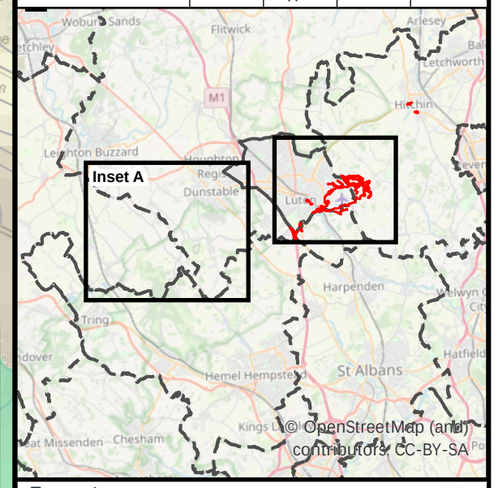
Elevation (metres above ordnance datum (AOD))

High : 260

Low : 50

Zone of Theoretical Visibility of the Proposed Development

First Issue	AB	DM CS	12/12/22	P02
Revision History	Drawn	Checked Approved	Date	Rev.



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www.lutonrising.org.uk

London Luton Airport Expansion Development Consent Order

Drawing Title

Figure 14.8 Assessment Viewpoint Locations

Purpose of issue	Suitability
SUITABLE FOR INFORMATION	S2

Drawn	Checked	Approved	Date	Scale	Size
AB	DM	CS	12/12/22	1:30,000	A3

DCO Application Ref.	APFP Regulation	DCO Document Ref.
TR020001	APFP 5(2)(a)	TR020001/APP/5.03

Drawing Number	Revision
LLADCO-3C-ARP-00-00-DR-YE-0062	P02

Project - Phase - Originator - Asset/Zone - Sub Asset - Type- Discp. - Number

Appendix D

D1 Illuminance Levels (Horizontal)

The drawing below describes the results of horizontal illuminance levels across the Main Application Site.

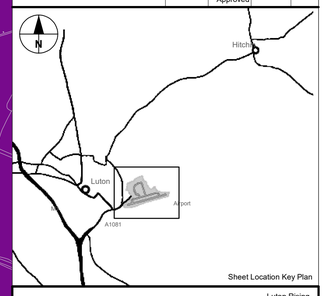
All structure positions are indicative. The proposed works will be subject to detailed design development. The changes will be within limits of deviation specified in the Development Consent Order.

Key

Illuminance (lux)

>10
9
8
7
6
5
4
3
2
1
0

Revision History	Drawn	Checked / Approved	Date	Rev.
Approve for Use	JB	EC / RM	19/08/22	P02
Approved for Use	JB	EC / RM	29/09/21	P01



Sheet Location Key Plan

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Drawing Title

Airside and Landside horizontal illuminance levels to inform LVIA and EIA

Purpose of issue	Suitability
SUITABLE FOR COORDINATION	S2

Drawn	Checked	Approved	Date	Scale	Size
J.Boyd	E. Cooper	R. Morris	19/08/2022	1:5000	A1

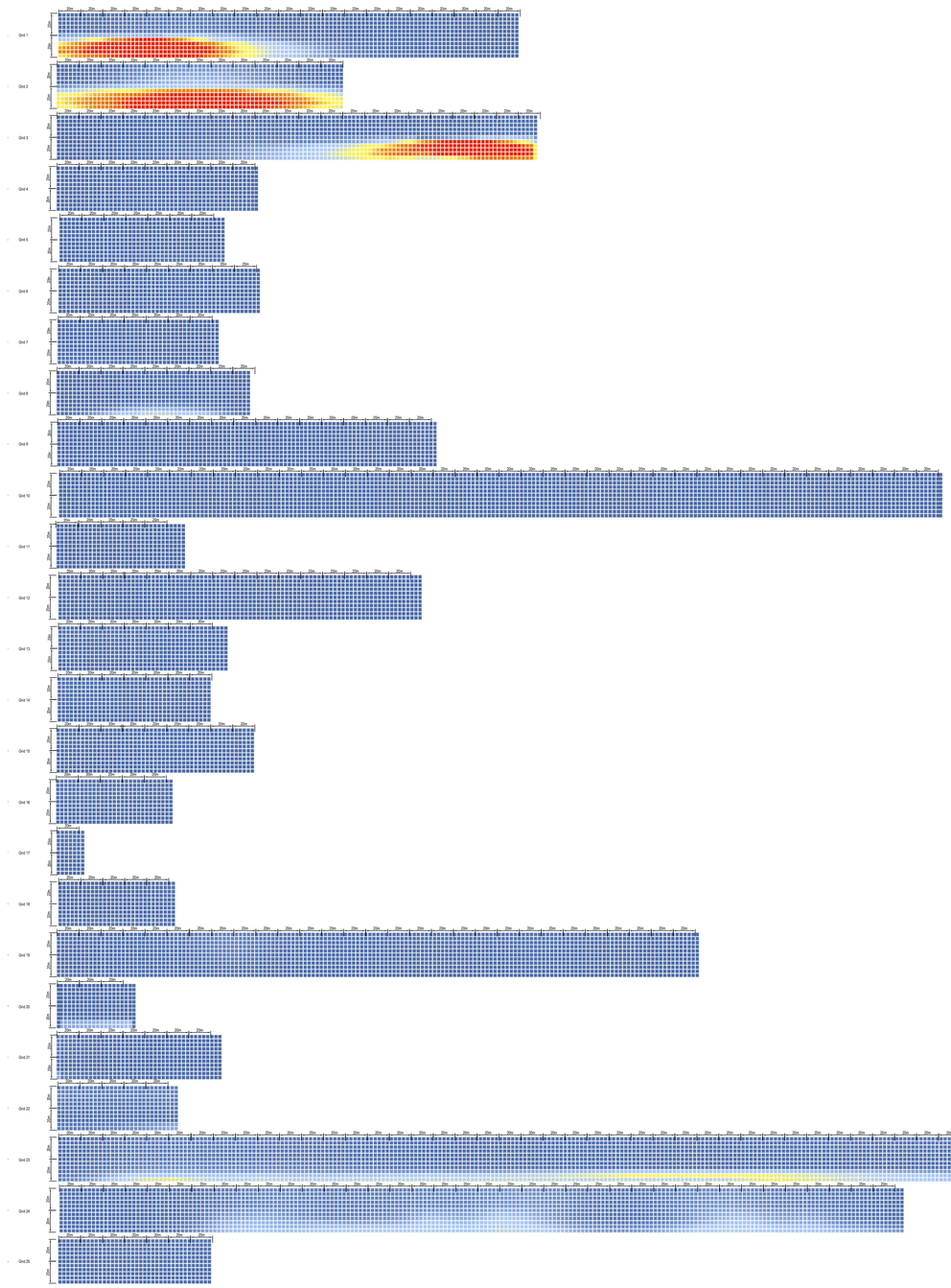
DCO Application Ref.	APFP Regulation	DCO Document Ref.
TR020001		

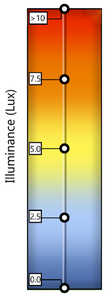
Drawing Number	Revision
LLADCO-3C-ARP-00-00-DR-YX-0001	P02

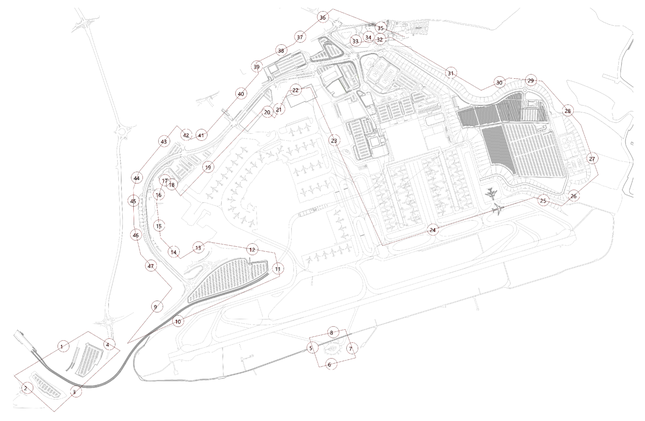
Appendix E

E1 Illuminance Levels (Vertical)

The drawing below describes the results of vertical illuminance levels at the selected grids around the perimeter of the Main Application Site.

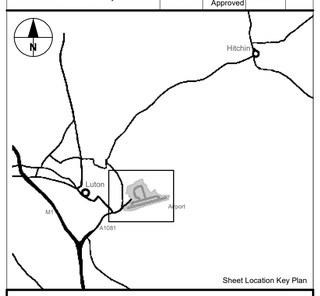






All structure positions are indicative. The proposed works will be subject to detailed design development. The changes will be within limits of deviation specified in the Development Consent Order.

Revision History	Drawn	Checked / Approved	Date	Rev.
Approved for Use	JB	EC / RM	19/08/22	P02
Approved for Use	JB	EC / RM	29/09/21	P01



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Drawing Title

Airside and Landside vertical illuminance levels to inform LVIA and EIA

Purpose of issue				Suitability	
SUITABLE FOR COORDINATION				S2	
Drawn	Checked	Approved	Date	Scale	Size
J.Boyd	E. Cooper	R. Morris	19/08/2022	1:5000	A1
DCO Application Ref.	APFP Regulation		DCO Document Ref.		
TR020001					
Drawing Number				Revision	
LLADCO-3C-ARP-00-00-DR-YX-0002				P02	