STRENGER

Proposed Anaerobic Digestion Facility – Spring Grove Farm

Lighting Assessment

Prepared for: Acorn Bioenergy Limited

Date: May 2023

TECHNICAL CONCEPTS

ILP Environmental Zone

ILP Guidance Note 01/21: The Reduction of Obtrusive Light sets out a series of environmental zones for classifying lighting assessment study areas based on their surroundings type e.g. rural, suburban etc., and the lighting environment e.g. low district brightness, medium district brightness etc. Based on the surroundings type and lighting environment, an environmental zone can be selected, from Zone E0 to Zone E4. The obtrusive light limits associated with the relevant environmental zone(s) are then adopted for assessment purposes.

Lighting curfew

A lighting curfew is an agreed time, beyond which, a lighting installation is subject to more stringent environmental control, generally as agreed with the local planning authority (LPA). Such controls may take the form of switching the lighting installation off in its entirety, switching the lighting installation off in part, dimming the lighting installation, or the implementation of smart lighting controls. Irrespective of the adopted control measures, suitable control of obtrusive light for the pre-curfew scenario and the post-curfew scenario can generally be demonstrated by adhering to ILP Guidance Note 01/21: The Reduction of Obtrusive Light. This national guidance document defines obtrusive light level limits separately for the pre-curfew scenario and the post-curfew scenario. Lighting curfews are generally best suited to facilities where a specific activity requiring artificial lighting ceases at a specific time e.g. a floodlit sports pitch, or a supermarket. However, in many cases, particularly 24-hour operations there is no clear change in activities requiring artificial lighting. In such cases, LPAs seldom impose a lighting curfew per se. However, for the sake of robustness in assessing obtrusive light, it is usual to adopt the ILP post-curfew obtrusive light criteria beyond a certain time. Where this time is not imposed by the LPA, 23:00 hours is generally adopted.

'Light intrusion'

This occurs as a result of light spill falling on to a receptor, generally onto a residential property window (hence the term 'light intrusion') but equally could be any light-sensitive human receptor. It is assessed in terms of the amount of light falling on a surface i.e. illuminance (E) and is measured in lux. Where the receptor is a residential window, the level of illuminance is measured in the vertical plane parallel with the window, to give the vertical illuminance (E_v – lux).

'Glare' (residential context)

This is the degree of discomfort, adaptation or disability associated with a light source when viewed against a darker background. In the context of residential lighting assessment, the luminance of the background against which the intensity will be assessed is defined by means of the relevant ILP Environmental Zone. It is assessed in terms of the intensity of the light i.e. viewed light source intensity (I) and is measured in candelas (cd).

'Sky-glow'

This is the diffuse luminance of the night sky. Although there is a naturally occurring glow to the night sky, artificial lighting can potentially dominate the level of 'sky-glow'. This occurs due to direct upward lighting and reflected lighting off ground surfaces, buildings etc. reflecting off gaseous molecules in the atmosphere resulting in luminosity of the night sky. The level of 'sky-glow' will vary depending on prevailing atmospheric conditions, particularly metrological conditions i.e. cloud cover and precipitation. There are various potential means of quantifying 'sky-glow'; however, in the case of new exterior lighting installations, 'sky-glow' is addressed by means of limiting the upward light ratio (ULR) of the installation i.e. the ratio between useful light downwards and wasted light upwards towards the sky.

EXECUTIVE SUMMARY

Outline Scope

Strenger Ltd was appointed by Acorn Bioenergy Limited to undertake a lighting assessment for an exterior lighting installation associated with a proposed anaerobic digestion facility at land to the north of Spring Grove Farm, Withersfield, Haverhill CB9 7SW (hereon in, the 'Proposed Development'). The assessment is required in order to quantify the impact of artificial light associated with the Proposed Development on its surroundings. This environmental lighting assessment excludes consideration of emergency and CCTV lighting.

This report shall be read in conjunction with the following accompanying drawings produced by Strenger Ltd:

- SK-01 Residential Receptor Location Plan
- SK-02 REV_A Assessed Scheme of Lighting
- SK-03 REV_A Light Spill

Assessment

In order to assess the impacts associated with the lighting installation, the following has been undertaken:

- review of pertinent legislation, policy and guidance;
- review of the site and surrounding area using aerial photography and OS mapping;
- production of a scheme of lighting (Assessed Scheme of Lighting) suitable for environmental assessment;
- detailed 3D computational modelling of the Assessed Scheme of Lighting;
- calculation of 'light intrusion' (vertical illuminance) at residential receptors;
- calculation of 'glare' (viewed source intensity) at residential receptors;
- calculation of 'sky-glow' (upward light ratio);
- comparison of the obtrusive light levels with national guideline values;
- production of light spill contours (horizontal illuminance – lux);
- production of ray-traced lighting model imagery; and
- production of CAD drawings.

Conclusions

Based on the Assessed Scheme of Lighting, it has been demonstrated that the Proposed Development will be compliant with the residential receptor criteria as set out in the Institution of Lighting Professionals (ILP) Guidance Note 01/21: The Reduction of Obtrusive Light. Specifically, the assessed lighting associated with the Proposed Development is compliant with the obtrusive light criteria as set out for ILP Environmental Zone E2. For which, the obtrusive light criteria are as follows:

- 'Light intrusion' limit of 1 lux (E_v - vertical illuminance)
- 'Glare' limit of 98 cd (I - source intensity)
- 'Sky-glow' limit of 2.5 % (upward light ratio)

The levels of light spill to potentially light-sensitive ecological receptors are set out in Strenger drawing ref: SK-03 REV_A Light Spill.

Such as to provide an illustrative overview of the lighting model used for the assessment, ray-traced imagery of the rendered lighting model is appended to this report in Appendix A. As stated in Section 4.2, for the sake of assessing a reasonable worst-case scenario, it has been assumed that all lighting will be operating at once and the ray-traced imagery to Appendix A has therefore been produced accordingly. However, as this situation is unlikely to arise in practice, further imagery of more typical lighting scenarios is set out in Appendix B, Appendix C and Appendix D.

The following mitigation measures are integral to good lighting design, and have therefore been included in the Assessed Scheme of Lighting as a matter of course:

- the use of luminaires with zero direct contribution to upward light;
- adopting zero-degree luminaire uplift angles;
- careful aiming and positioning of luminaires;
- careful selection of luminaires;
- the use of light spill shields;
- the use of outreach brackets;
- the use of lower output luminaires bounding potentially light-sensitive ecological receptors;
- the use of optimal light distributions for their specific location and orientation;
- optimisation of mounting heights;
- the use of presence detection controls and zoned switching;
- a 365-day timer clock and photocell controls;
- using the lowest colour temperature light sources practicable (3000K generally i.e. 'warm-white', 4000K to 4300K for explosive atmosphere luminaires but only where 3000K option is not available and 4000K for luminaires selected specifically for their excellent rear light spill control where 3000K option is not available);
- the adoption of the lowest intensity LED modules practicable; and
- minimising the task illuminance level.

The following mitigation measures have been adopted in the design and planned operation of the Proposed Development:

- embedded by design, the siting of areas requiring a high level of illumination away from potentially light-sensitive ecological receptors;
- embedded by design, the erection of 2.4m to 3.0m high close-boarded timber fences as set out in Strenger drawing ref: SK-03 REV_A Light Spill; and
- by risk-assessed design & operation (by others), not lighting the site access road.

1. LEGISLATION, POLICY, GUIDANCE & STANDARDS

Legislation

Clean Neighbourhoods and Environment Act (CNEA), 2005

1.1 Light pollution was introduced within the Clean Neighbourhoods and Environment Act 2005 (CNEA 2005) as a form of statutory nuisance under the Environmental Protection Act 1990 (EPA 1990) which was amended in 2006 to include the following nuisance definition:

"(fb) artificial light emitted from premises so as to be prejudicial to health or nuisance;"

1.2 Guidance produced by the Department of Environment, Food and Rural Affairs (DEFRA), Statutory Nuisance from Insects & Artificial Light (2006) on s101 to s103 of the CNEA 2005 has also been referred to which places a duty on local authorities to ensure that their areas are checked periodically for existing and potential sources of statutory nuisances - including nuisances arising from artificial lighting. Local authorities must take reasonable steps to investigate complaints of such nuisances from artificial light. Once satisfied that a statutory nuisance exists or may occur or recur, local authorities must issue an abatement notice (in accordance with s80(2) of the EPA 1990), requiring that the nuisance cease or be abated within a set timescale.

1.3 Although light was described as having the potential to cause statutory nuisance in the CNEA 2005, no prescriptive limits or rules were set for impact assessment purposes. The criteria as set out in ILP Guidance Note 01/21: The Reduction of Obtrusive Light produced by the Institute of Lighting Professionals has therefore been referred to for the purposes of this assessment.

National Planning Policy

National Planning Policy Framework (NPPF), 2021

1.4 The National Planning Policy Framework (NPPF) states that the purpose of the planning system is to contribute to the achievement of sustainable development and constitute the Government's view on what sustainable development in England means in practice for the planning system. A principal concept contained within the NPPF is the presumption in favour of sustainable development and with regard to artificial lighting, the NPPF states:

'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 potential 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.'

International Guidance

Comission Internationale De L'Eclairage 150: Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations, 2017 (CIE-150)

1.5 The purpose of CIE-150: Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations, 2017 is to help formulate guidelines for assessing the environmental impacts of outdoor lighting and to give recommended limits for relevant lighting parameters to contain the obtrusive effects of outdoor lighting within tolerable levels. As the obtrusive effects of outdoor lighting are best controlled initially by appropriate design, the guidance given is primarily applicable to new installations; however, some advice is also provided on remedial measures which may be taken for existing installations. This Guide refers to the potentially adverse effects of outdoor lighting on both natural and man-made environments for people in most aspects of daily life, from residents, sightseers, transport users to environmentalists and astronomers.

Comission Internationale De L'Eclairage 126: Guidelines for Minimising Sky Glow, 1997 (CIE-126)

1.6 CIE-126: Guidelines for Minimising Sky Glow, 1997 gives general guidance for lighting designers and policy makers on the reduction of sky glow. The report gives recommendations about maximum permissible values for exterior lighting installations. These values are regarded as limiting values. Lighting designers should strive to meet the lowest criteria for the design. Practical implementation of the general guidance is left to national regulations.

National Guidance

Institute of Lighting Professionals (ILP) Guidance Note 01/21: The Reduction of Obtrusive Light, 2021

1.7 The ILP has proposed obtrusive lighting guidance and criteria for local authorities with a recommendation that these are incorporated at the local plan level. ILP Guidance Note 01/21 defines various forms of light pollution and describes a series of environmental zones. ILP Guidance Note 01/21 provides suitable criteria against which the effects of artificial lighting can be assessed.

Institute of Lighting Professionals (ILP) PLG 04 - Guidance on Undertaking Environmental Lighting Impact Assessments, 2013

1.8 The aim of the Guidance on Undertaking Environmental Lighting Impact Assessments (ILP PLG04:2013) is to outline good practice in lighting design and provide practical guidance on production and assessment of lighting impacts within new developments. The document was produced following the publication of the NPPF in April 2012 and the importance of lighting design being part of a planning application, this document aims to:

- provide an explanation of, and guidance on, the process for producing a lighting assessment;
- prompt the lighting designer on important aspects of specific projects which should be used to remove or minimise potential environmental problems; and
- look at the overall processes and evaluation procedures regarding lighting which are considered to be relevant.

Buglife - The Invertebrate Conservation Trust - A review of the Impact of Artificial Light on Invertebrates, 2011

1.9 A review of the Impact of Artificial Light on Invertebrates is a published literature review on how humans are changing the light environment and the impact that this has on insects and other invertebrates. It makes various recommendations and identifies several further research areas.

Institute of Lighting Professionals Guidance Note 08/18 Bats artificial lighting in the UK: Bats and the Built Environment series, 2018

1.10 This working document produced by the ILP in conjunction with the Bat Conservation Trust (BCT), is aimed at lighting professionals, lighting designers, planning officers, developers, bat workers/ecologists and anyone specifying lighting. It is intended to raise awareness of the impacts of artificial lighting on bats, and mitigation is suggested for various scenarios. However, it is not meant to replace site-specific ecological and lighting assessments.

The Royal Commission on Environmental Pollution (RCEP) – Artificial Light in the Environment, 2009

1.11 This RCEP document discusses the social benefits and drawbacks of outdoor lighting, the impacts of light pollution on organisms and ecosystems, discusses road lighting technology, and makes various concluding recommendations.

HSG38

1.12 The Health and Safety Executive published HSG38: Lighting at Work aimed at those who are responsible for health and safety at work. The guidance explains how lighting contributes to the health and safety of people at work. It deals with assessing and managing the health and safety risks attributable to lighting in the workplace, good practice and the minimum recommended illumination levels that meet health and safety requirements. As the lighting level criteria as set out in HSG38 is relatively limited in comparison to that as set out in BS EN 12464-2, no further consideration is given to HSG38 within this lighting study.

The SLL Lighting Handbook

1.13 The Society of Light and Lighting (SLL) published the SLL Lighting Handbook in addition to the SLL Code for lighting and the SLL Lighting Guides. The Handbook includes criteria from the Code and the various Lighting Guides. The Handbook includes an exterior workplace chapter, which is the most relevant to this assessment.

British & European Standards

BS EN 12464-2:2014 Light and lighting – Lighting of work places Part 2: Outdoor work places

1.14 This standard specifies requirements for lighting of tasks in most outdoor work places and their associated areas in terms of quantity and quality of illumination. In addition, recommendations are given for good lighting practice.

2. CRITERIA

2.1 In the absence of statutory guidance, ILP Guidance Note 01/21 has been used as criteria against which to assess the effects of artificial lighting associated with the Proposed Development on residential receptors; this is considered best practice.

ILP Environmental Zone Classification

2.2 The ILP has developed an Environmental Zone classification system for the categorisation of areas with regard to suitable obtrusive lighting limits. The Environmental Zone classifications are reproduced in (Table 2.1).

Table 2.1: ILP Environmental Zone Classification

Zone	Surrounding	Lighting Environment	Examples
E0	Protected	Dark (SQM 20.5+)	Astronomical Observable dark skies, UNESCO starlight reserves, IDA dark sky places
E1	Natural	Dark (SQM 20 to 20.5)	Relatively uninhabited rural areas, National Parks, Areas of Outstanding Natural Beauty, IDA buffer zones etc.
E2	Rural	Low district brightness (SQM 15 to 20)	Sparsely inhabited rural areas, village or relatively dark outer suburban locations
E3	Suburban	Medium district brightness	Well inhabited rural and urban settlements, small town centres of suburban locations
E4	Urban	High district brightness	Town/city centres with high levels of night-time activity

ILP Environmental Zone Criteria

2.3 For each Environmental Zone, obtrusive light limits for exterior lighting installations have been determined. These are summarised in (Table. 2.2 to Table 2.4) below and are intended to support decision makers in establishing whether artificial lighting is detrimental to local amenity or a potential statutory nuisance.

Table 2.2: ILP 'Light Intrusion' (vertical illuminance) Limits E_v - lux

Application Conditions	Environmental Zone				
	E0	E1	E2	E3	E4
Pre-curfew	n/a	2	5	10	25
Post-curfew	n/a	< 0.1 *	1	2	5

* *If the installation is for public (road) lighting then this may be up to 1 lux.*

Table 2.3: ILP 'Glare' (source intensity) Limits I - cd						
Application Conditions	**Luminaire group (projected area A_p in m²)**					
	0 < Ap ≤ 0.002	**0.002 < Ap ≤ 0.01**	**0.01 < Ap ≤ 0.03**	**0.03 < Ap ≤ 0.13**	**0.13 < Ap ≤ 0.50**	**Ap > 0.50**
E0 Pre-curfew E0 Post-curfew	0 0	0 0	0 0	0 0	0 0	0 0
E1 Pre-curfew E1 Post-curfew	0.29 d 0	0.63 d 0	1.3 d 0	2.5 d 0	5.1 d 0	2,500 0
E2 Pre-curfew E2 Post-curfew	0.57 d 0.29 d	1.3 d 0.63 d	2.5 d 1.3 d	5.0 d 2.5 d	10 d 5.1 d	7,500 500
E3 Pre-curfew E3 Post-curfew	0.86 d 0.29 d	1.9 d 0.63 d	3.8 d 1.3 d	7.5 d 2.5 d	15 d 5.1 d	10,000 1,000
E4 Pre-curfew E4 Post-curfew	1.4 d 0.29 d	3.1 d 0.63 d	6.3 d 1.3 d	13 d 2.5 d	26 d 5.1 d	25,000 2,500

1) d is the distance between the observer and the 'glare' source in metres

2) Upper limits for each zone shall be taken as those with column A_p > 0.5

Table 2.4: ILP 'Sky-glow' (upward light ratio) Limits ULR - %				
Environmental Zone				
E0	**E1**	**E2**	**E3**	**E4**
0	0	2.5	5	15

Determination of ILP Environmental Zone

2.4 The Proposed Development site falls within a rural area; it is considered that ILP Environmental Zone E2 would therefore be the most appropriate classification for the purposes of this assessment.

ILP Environmental Zone E2 Criteria

2.5 Based on ILP Environmental Zone E2, the obtrusive light limits for the Proposed Development are as follows:

- Pre-curfew 'light intrusion' limit of 5 lux (E_v - vertical illuminance)
- Post-curfew 'light intrusion' limit of 1 lux (E_v - vertical illuminance)
- Pre-curfew 'glare' limit # of 192 cd (I - source intensity)
- Post-curfew 'glare' limit # of 98 cd (I - source intensity)
- 'Sky-glow' limit of 2.5 % (upward light ratio)

 # 'Glare' limits calculated based on minimum 'glare' source to observer distance possible (337m) and projected area of 0 < Ap ≤ 0.002 to represent a worst-case scenario. N.B. It may be necessary to review the adopted 'glare' criteria at detailed design stage.

Adopted ILP Criteria

2.6 Such as to demonstrate that it would be possible to operate lighting during any hours of darkness (although this would only be for short periods of time and controlled via presence detection), only the post-curfew ILP criteria have been adopted for the purposes of this assessment. As such, the adopted criteria are as follows:

- 'Light intrusion' limit of 1 lux (E_v - vertical illuminance)
- 'Glare' limit of 98 cd (I - source intensity)
- 'Sky-glow' limit of 2.5 % (upward light ratio)

3. RECEPTORS

Residential

3.1 Within the context of this assessment, residential receptors are taken as those with the potential to be affected by obtrusive light associated with the Proposed Development. Key existing residential receptors which have the potential to be impacted by obtrusive light from the Proposed Development have been identified and adopted as receptor locations within this assessment. Residential receptors are positioned at local ground level +2.0 m (i.e. ground floor level windows). At such a height, the angle subtended with the light sources will be less than that if assessed at first floor level windows. The assessed receptor height therefore represents a reasonable worst-case scenario, as the level of 'glare' (viewed source intensity) will be at its maximum. The assessed residential receptors are set out in Strenger drawing ref: SK-01 Residential Receptor Location Plan. Due to significant intervening screening owing to dense woodland between the Proposed Development site and residential receptors to the south and south-east, it has not been necessary to consider such residential receptors in this assessment.

Ecological

3.2 Within the context of this assessment, ecological receptors are taken as those that have been identified as being potentially light-sensitive and having the potential to be affected by light spill associated with the Proposed Development. Key ecological receptors have been identified for the purposes of designing the Assessed Scheme of Lighting such that light spill is limited to these areas. The identified receptors are the hedgerows and treelines bounding the Proposed Development site. The levels of light spill to potentially light-sensitive ecological receptors are set out in Strenger drawing ref: SK-03 REV_A Light Spill.

4. EXTERIOR LIGHTING

Overview

4.1 Artificial lighting will be required for work during periods of reduced daylight availability and darkness, safe passage, security and health & safety requirements. The associated potential obtrusive light effects towards surrounding light-sensitive receptors would be minimised through the controlled application of lighting in accordance with current best practice. In order for the Proposed Development to operate safely, it will be necessary to illuminate the site to reasonable workplace lighting standards, balanced with obtrusive light level limits.

Assessed Scheme of Lighting

4.2 Such as to represent a reasonable worst-case scenario, for the sake of this obtrusive light assessment it has been assumed that all lighting will be operating at once. However, this situation is unlikely to arise in practice, as the lighting will be switched in zones / controlled with a presence detection system and only used as necessary when works a being undertaken within a particular zone.

4.3 An indicative outline scheme of lighting (Assessed Scheme of Lighting) has been produced for the Proposed Development. The Assessed Scheme of Lighting adopts LED luminaires; such technology offers significant energy savings and provide a high degree of optical control, thus minimising obtrusive light. With regard to this assessment, the luminaires - whilst specific, can be considered to be relatively generic; provided that sensible selection of another manufacturer's luminaires is made by a competent Lighting Engineer. The final selection of luminaires and their positioning shall be determined by the Responsible Lighting Engineer in order to meet the Proposed Development site final risk assessed lighting requirements; but bearing in mind any obtrusive lighting impact that the selection may have. The final lighting design shall cover matters such as illumination performance criteria, DSEAR requirements, CCTV lighting, emergency lighting, passive protection / electrical isolation, column protection, ingress protection, impact protection, maintenance / installation & decommissioning, underground / overhead services, additional column headloads due to increased windage from light spill shields / bracketry, building / plant mounting methods etc.

4.4 The details of the luminaires used in the Assessed Scheme of Lighting are set out in (Table 4.1) below. The Assessed Scheme of Lighting is set out in Strenger drawing ref: SK-02 REV_A Assessed Scheme of Lighting. The levels of light spill associated with the Assessed Scheme of Lighting are set out in Strenger drawing ref: SK-03 REV_A Light Spill.

Table 4.1: Assessed Scheme of Lighting Details

Reference	No. off	Manufacturer	Luminaire	Light Source	Distribution
LUM-A	9	Chalmit	Evolution X 20L	188W 3000K LED	AS
LUM-B	116	Chalmit	NexLED 801	12W 4000K LED	-
LUM-C	18	Chalmit	Protecta III LED 02L	32W 4000K LED	-
LUM-D	6	Luceco	Semita Arc	15W 3000K LED	Path
LUM-E	7	Luceco	Semita Arc	15W 3000K LED	Street
LUM-F	15	Philips	ClearFlood	830 LED 180	DX51
LUM-G	2	Philips	ClearFlood	830 LED 220	DX51
LUM-H	5	Philips	ClearFlood	830 LED 70	DX51
LUM-I	7	Trilux	Lumena Star 70	AM1R-SLR1/12000-740 4G2C ET	

Figure 4.1: Chalmit Evolution X

Figure 4.2: Chalmit NexLED

Figure 4.3: Chalmit Protecta III LED

Figure 4.4: Luceco Semita Arc

Figure 4.5: Philips ClearFlood

Figure 4.6: Trilux Lumena Star 70

5. MODELLING

5.1 Light modelling was undertaken using DIALux software, an independent lighting modelling software tool which can calculate artificial lighting scenes in exterior scenarios. The software incorporates recognised calculation methodologies and is commonly used for lighting assessment throughout Europe. An indicative scheme of lighting for the Proposed Development has been produced for the purposes of this assessment and has been inputted into the lighting model.

5.2 In order to represent a reasonable worst-case scenario for environmental assessment, the maintenance factor within the lighting model was set to 1.0, such that the scheme was assessed based on the full design lumen output, rather than the maintained minimum design lumen output.

5.3 The lighting model adopts a flat ground plane i.e. does not take account of changes in ground height. As such, the lighting model does not take into account intervening landform which would provide screening of the light sources. Furthermore, the lighting model does not take account of vegetation and off-site buildings. As such screening has not been accounted for, this can be considered to be a reasonably conservative assessment of obtrusive light.

5.4 Such as to provide an illustrative overview of the lighting model used for the assessment, ray-traced imagery of the rendered lighting model is appended to this report in Appendix A. As stated in Section 4.2, for the sake of assessing a reasonable worst-case scenario, it has been assumed that all lighting will be operating at once and the ray-traced imagery to Appendix A has therefore been produced accordingly. However, as this situation is unlikely to arise in practice, further imagery of more typical lighting scenarios is set out in Appendix B, Appendix C and Appendix D.

5.5 As stated above, the lighting model does not take into account intervening landform, vegetation and off-site buildings. Accordingly, such entities do not feature within the appended imagery.

6. MITIGATION

6.1 The following mitigation measures are integral to good lighting design, and have therefore been included in the Assessed Scheme of Lighting as a matter of course:

- the use of luminaires with zero direct contribution to upward light;
- adopting zero-degree luminaire uplift angles;
- careful aiming and positioning of luminaires;
- careful selection of luminaires;
- the use of light spill shields;
- the use of outreach brackets;
- the use of lower output luminaires bounding potentially light-sensitive ecological receptors;
- the use of optimal light distributions for their specific location and orientation;
- optimisation of mounting heights;
- the use of presence detection controls and zoned switching;
- a 365-day timer clock and photocell controls;
- using the lowest colour temperature light sources practicable (3000K generally i.e. 'warm-white', 4000K to 4300K for explosive atmosphere luminaires but only where 3000K option is not available and 4000K for luminaires selected specifically for their excellent rear light spill control where 3000K option is not available);
- the adoption of the lowest intensity LED modules practicable; and
- minimising the task illuminance level.

6.2 The following mitigation measures have been adopted in the design and planned operation of the Proposed Development:

- embedded by design, the siting of areas requiring a high level of illumination away from potentially light-sensitive ecological receptors;
- embedded by design, the erection of 2.4m to 3.0m high close-boarded timber fences as set out in Strenger drawing ref: SK-03 REV_A Light Spill; and
- by risk-assessed design & operation (by others), not lighting the site access road.

7. ASSESSMENT

'Light Intrusion' (vertical illuminance)

7.1 The levels of 'light intrusion' from the Assessed Scheme of Lighting associated with the Proposed Development have been predicted at residential receptors. The resultant levels of 'light intrusion' are set out in (Table 7.1) against the ILP post-curfew 'light intrusion' criterion of 1 lux for ILP Environmental Zone E2. Each receptor has been assigned a PASS / FAIL outcome accordingly.

Table 7.1: 'Light Intrusion' Assessment

Receptor	'Light Intrusion' Criterion - E_v (lux)	Predicted 'Light Intrusion' - E_v (lux)	Outcome
RES-01	1	0.00	**PASS**
RES-02	1	0.00	**PASS**
RES-03	1	0.00	**PASS**
RES-04	1	0.00	**PASS**
RES-05	1	0.00	**PASS**
RES-06	1	0.00	**PASS**
RES-07	1	0.00	**PASS**
RES-08	1	0.00	**PASS**
RES-09	1	0.00	**PASS**
RES-10	1	0.00	**PASS**
RES-11	1	0.00	**PASS**
RES-12	1	0.00	**PASS**
RES-13	1	0.00	**PASS**

7.2 As can be seen from (Table 7.1) above, the predicted levels of 'light intrusion' at residential receptors from the Assessed Scheme of Lighting associated with the Proposed Development are compliant with the ILP post-curfew 'light intrusion' criterion of 1 lux for ILP Environmental Zone E2.

'Glare' (viewed source intensity)

7.3 The maximum levels of 'glare' from the Assessed Scheme of Lighting associated with the Proposed Development have been predicted at residential receptors. The resultant maximum levels of 'glare' are set out in (Table 7.2) against the adopted ILP post-curfew 'glare' criterion for ILP Environmental Zone E2. Each receptor has been assigned a PASS / FAIL outcome accordingly.

Table 7.2: 'Glare' Assessment

Receptor	'Glare' Criterion - I (cd)	Predicted Maximum 'Glare' - I (cd)	Outcome
RES-01	98	15	**PASS**
RES-02	98	8	**PASS**
RES-03	98	9	**PASS**
RES-04	98	19	**PASS**
RES-05	98	16	**PASS**
RES-06	98	14	**PASS**
RES-07	98	13	**PASS**
RES-08	98	16	**PASS**
RES-09	98	12	**PASS**
RES-10	98	14	**PASS**
RES-11	98	18	**PASS**
RES-12	98	17	**PASS**
RES-13	98	17	**PASS**

7.4 As can be seen from (Table 7.2) above, the predicted maximum levels of 'glare' at residential receptors from the Assessed Scheme of Lighting associated with the Proposed Development are compliant with the adopted ILP post-curfew 'glare' criterion for ILP Environmental Zone E2.

'Sky-glow' (upward light ratio)

7.5 The level of 'sky-glow' from the Assessed Scheme of Lighting associated with the Proposed Development has been predicted. The resultant level of 'sky-glow' is set out in (Table 7.3) against the ILP 'sky-glow' criterion of 2.5 % for ILP Environmental Zone E2. Each receptor has been assigned a PASS / FAIL outcome accordingly.

Table 7.3: 'Sky-glow' Assessment

Receptor	'Sky-glow' Criterion (ULR %)	Predicted 'Sky-glow' (ULR %)	Outcome
Surrounding study area	2.5 %	0.0 %	**PASS**

7.6 As can be seen from (Table 7.3) above, the predicted level of 'sky-glow' from the Assessed Scheme of Lighting associated with the Proposed Development is compliant with the ILP 'sky-glow' criterion of 2.5 % for ILP Environmental Zone E2.

8. CONCLUSIONS

8.1 Based on the Assessed Scheme of Lighting, it has been demonstrated that the Proposed Development will be compliant with the residential receptor criteria as set out in the Institution of Lighting Professionals (ILP) Guidance Note 01/21: The Reduction of Obtrusive Light. Specifically, the assessed lighting associated with the Proposed Development is compliant with the obtrusive light criteria as set out for ILP Environmental Zone E2. For which, the obtrusive light criteria are as follows:

- 'Light intrusion' limit of 1 lux (E_v - vertical illuminance)
- 'Glare' limit of 98 cd (I - source intensity)
- 'Sky-glow' limit of 2.5 % (upward light ratio)

8.2 The levels of light spill to potentially light-sensitive ecological receptors are set out in Strenger drawing ref: SK-03 REV_A Light Spill.

8.3 Such as to provide an illustrative overview of the lighting model used for the assessment, ray-traced imagery of the rendered lighting model is appended to this report in Appendix A. As stated in Section 4.2, for the sake of assessing a reasonable worst-case scenario, it has been assumed that all lighting will be operating at once and the ray-traced imagery to Appendix A has therefore been produced accordingly. However, as this situation is unlikely to arise in practice, further imagery of more typical lighting scenarios is set out in Appendix B, Appendix C and Appendix D.

Mitigation

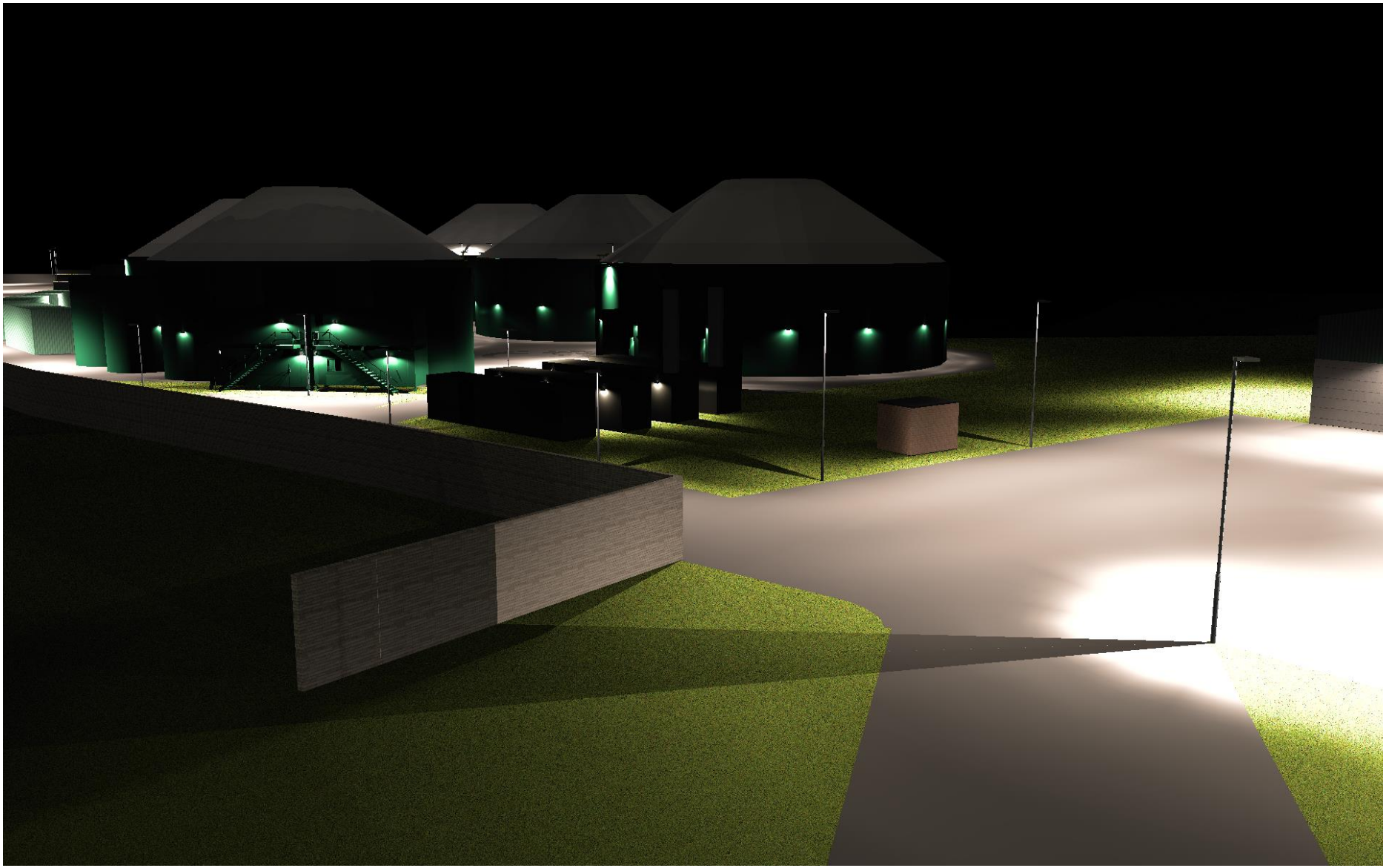
8.4 The following mitigation measures are integral to good lighting design, and have therefore been included in the Assessed Scheme of Lighting as a matter of course:

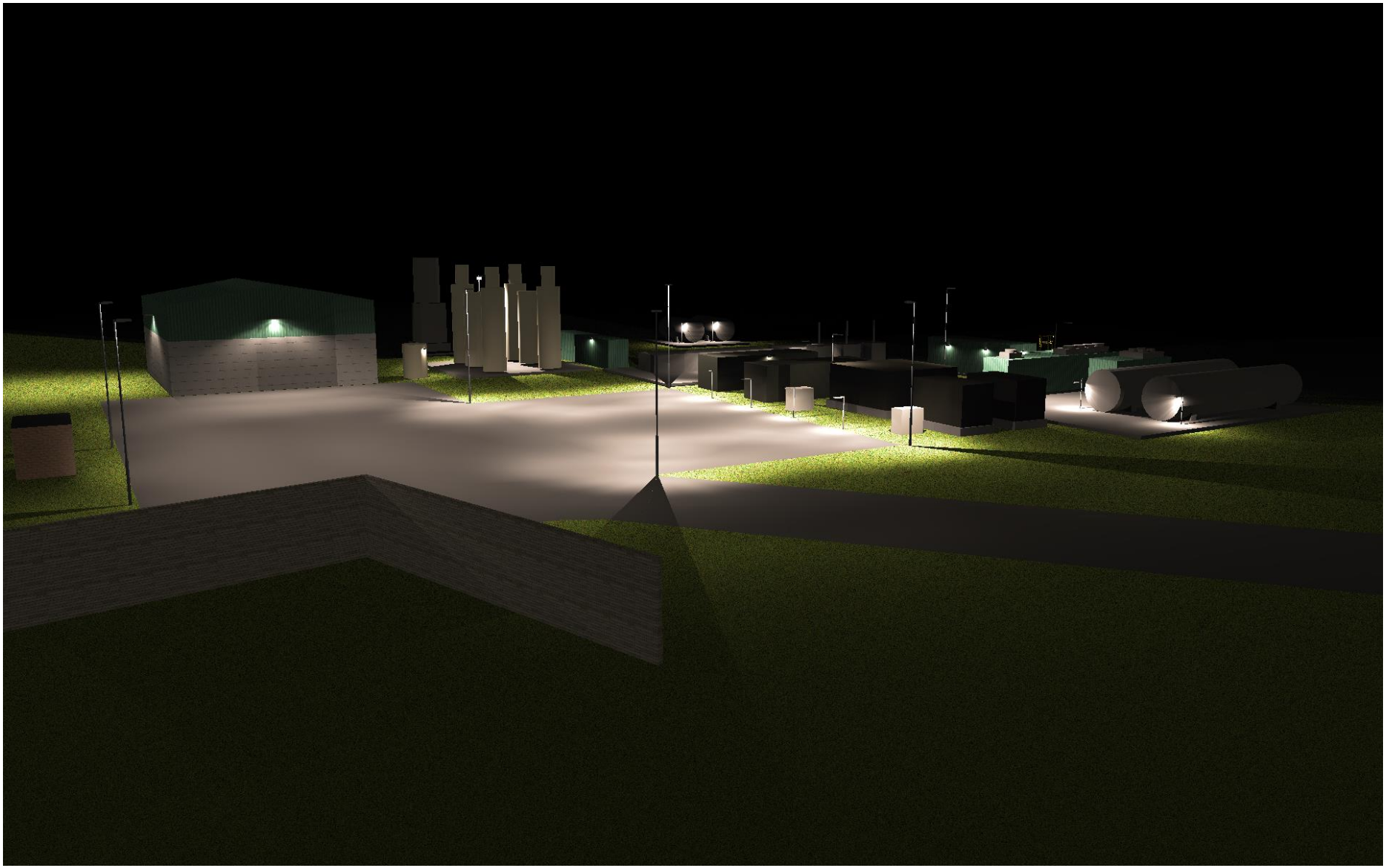
- the use of luminaires with zero direct contribution to upward light;
- adopting zero-degree luminaire uplift angles;
- careful aiming and positioning of luminaires;
- careful selection of luminaires;
- the use of light spill shields;
- the use of outreach brackets;
- the use of lower output luminaires bounding potentially light-sensitive ecological receptors;
- the use of optimal light distributions for their specific location and orientation;
- optimisation of mounting heights;
- the use of presence detection controls and zoned switching;
- a 365-day timer clock and photocell controls;
- using the lowest colour temperature light sources practicable (3000K generally i.e. 'warm-white', 4000K to 4300K for explosive atmosphere luminaires but only where 3000K option is not available and 4000K for luminaires selected specifically for their excellent rear light spill control where 3000K option is not available);
- the adoption of the lowest intensity LED modules practicable; and
- minimising the task illuminance level.

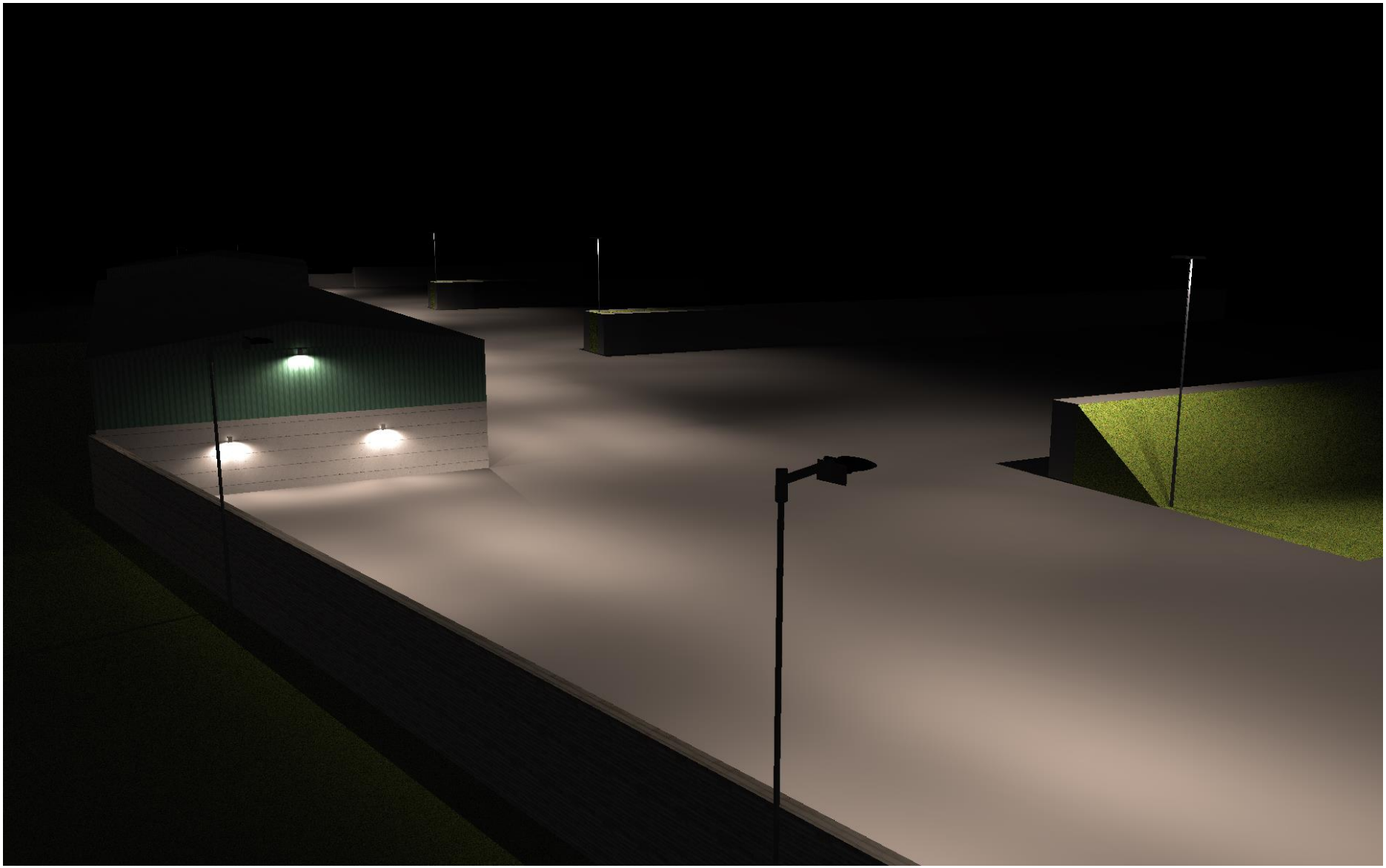
8.5 The following mitigation measures have been adopted in the design and planned operation of the Proposed Development:

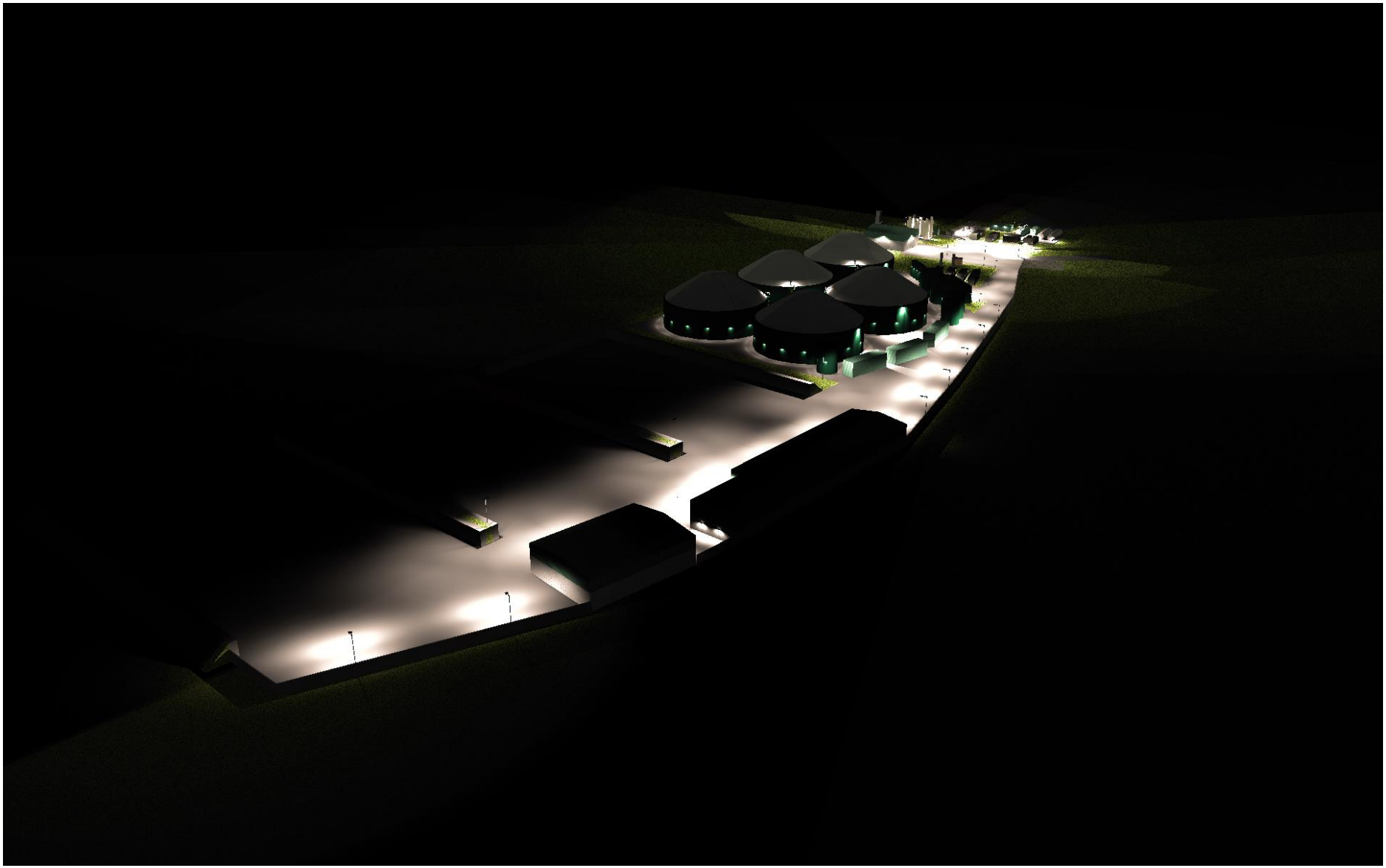
- embedded by design, the siting of areas requiring a high level of illumination away from potentially light-sensitive ecological receptors;
- embedded by design, the erection of 2.4m to 3.0m high close-boarded timber fences as set out in Strenger drawing ref: SK-03 REV_A Light Spill; and
- by risk-assessed design & operation (by others), not lighting the site access road.

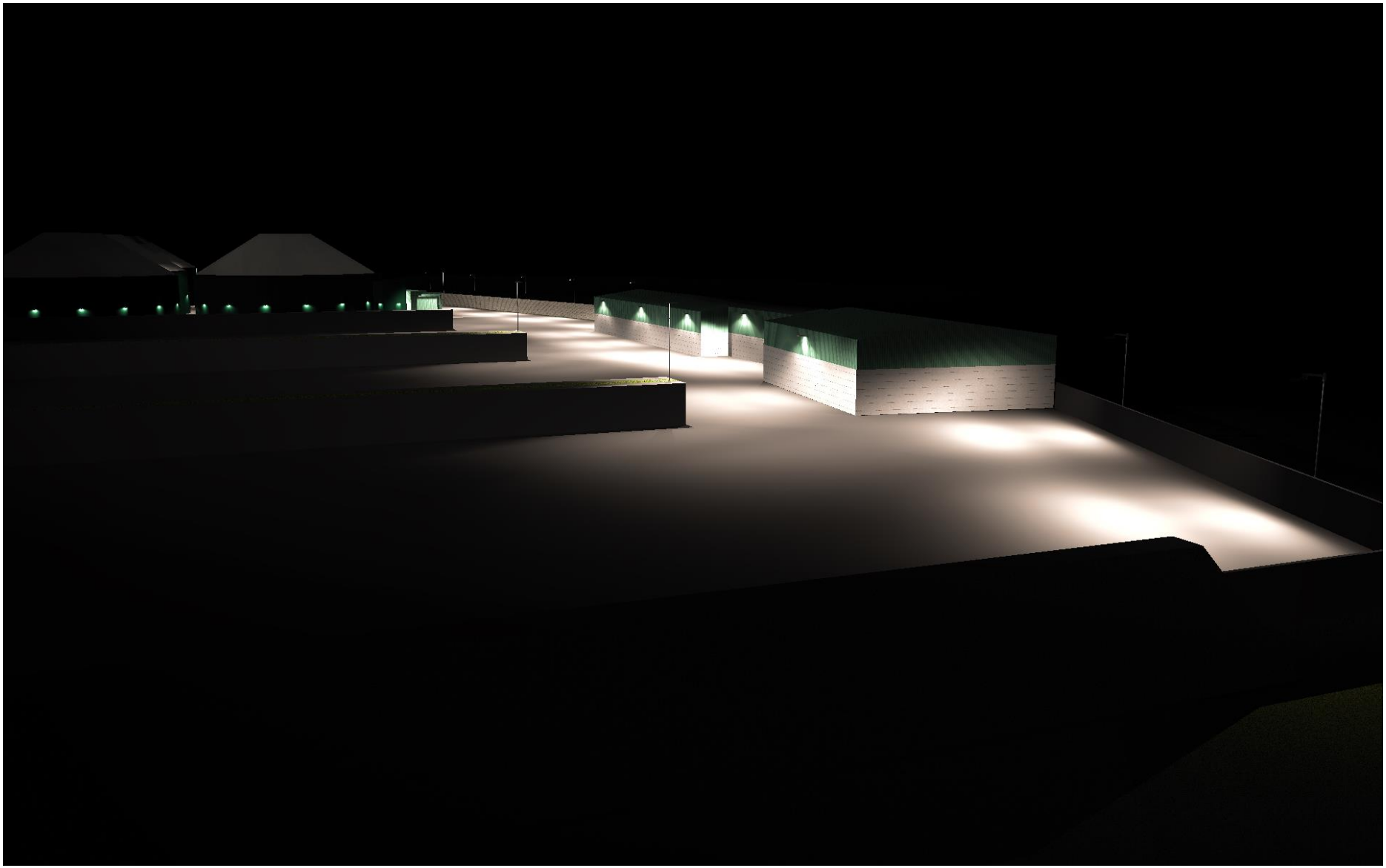
Appendix A – Lighting Model Ray-traced Imagery (all-on assessment scenario)

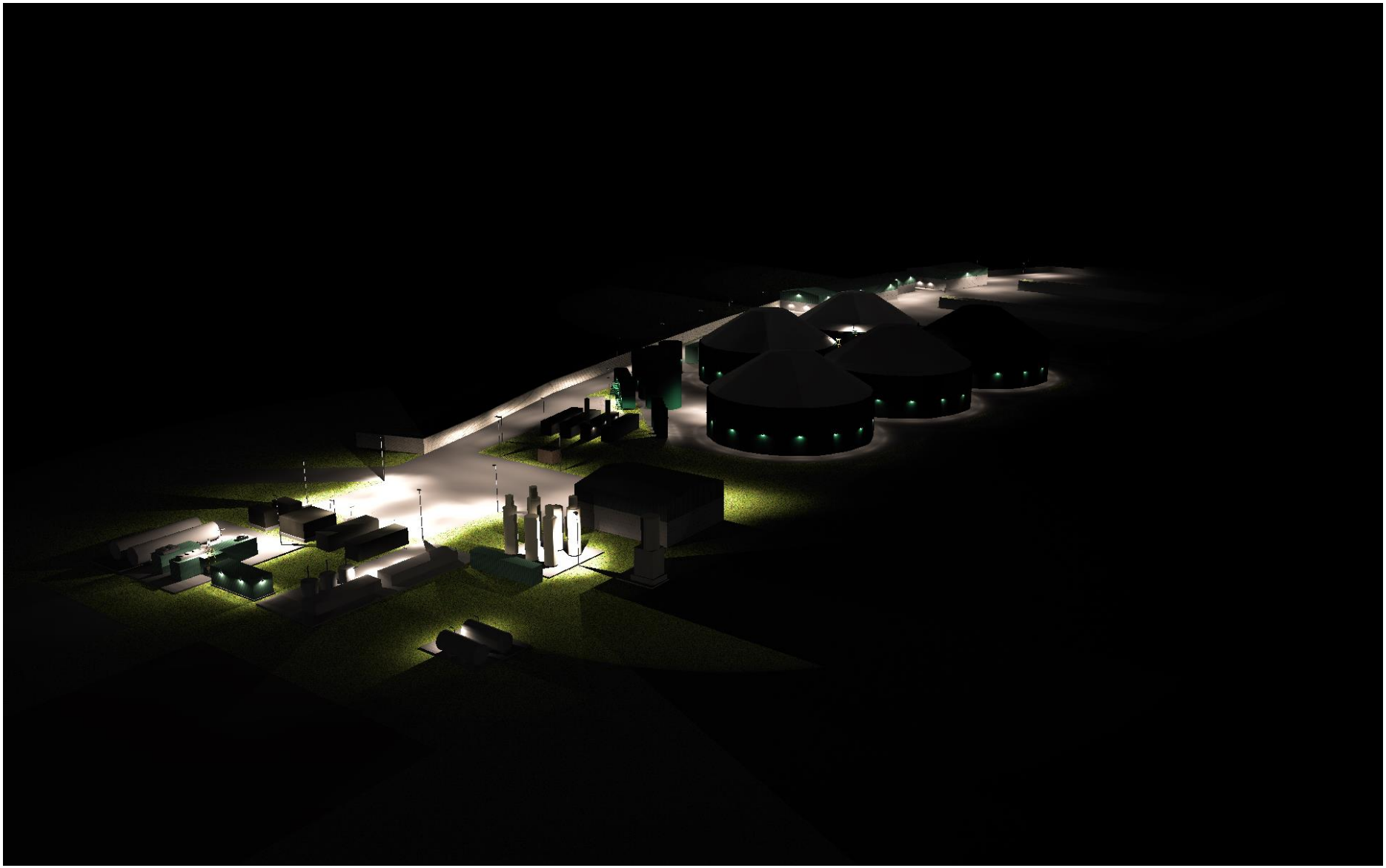




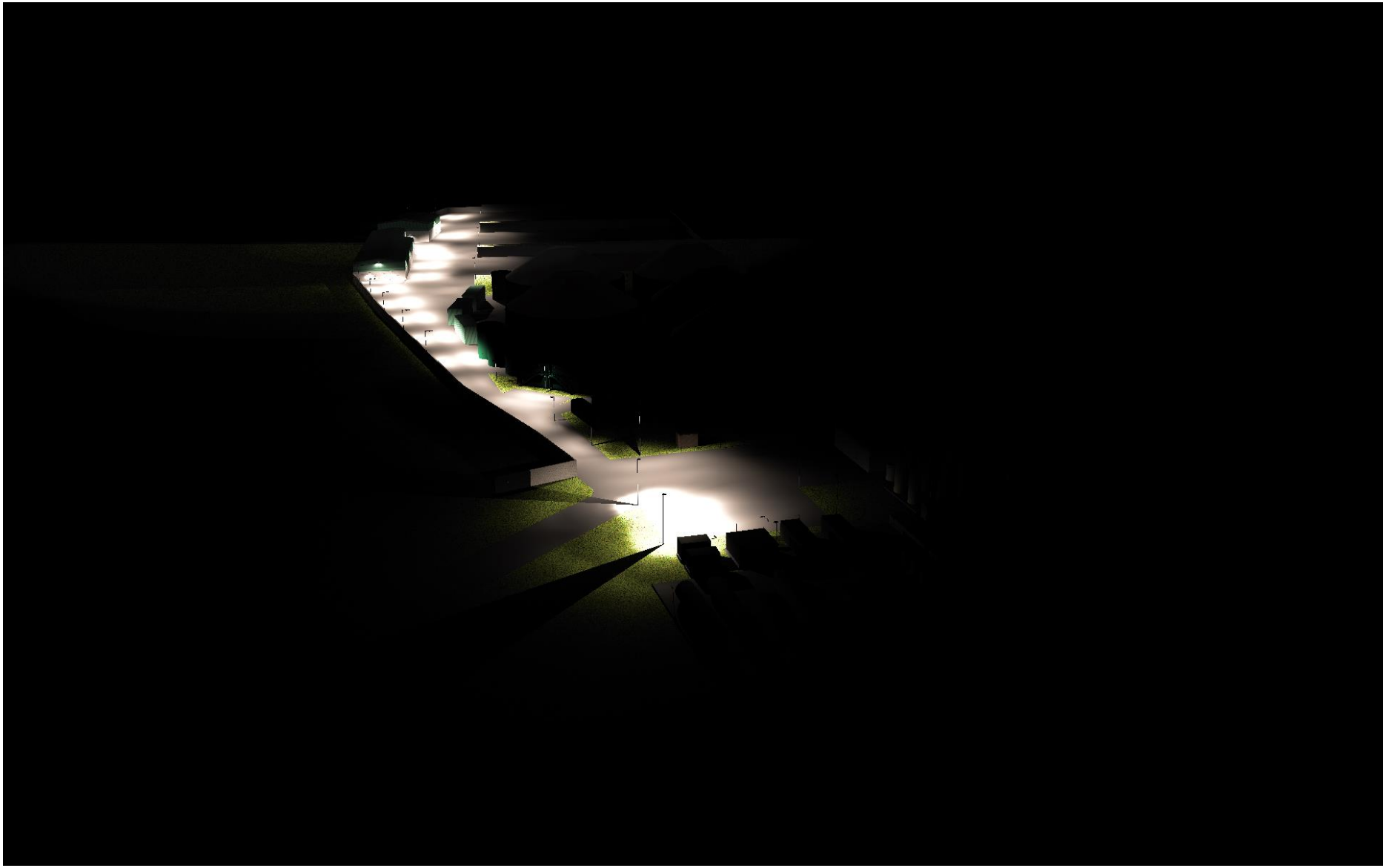




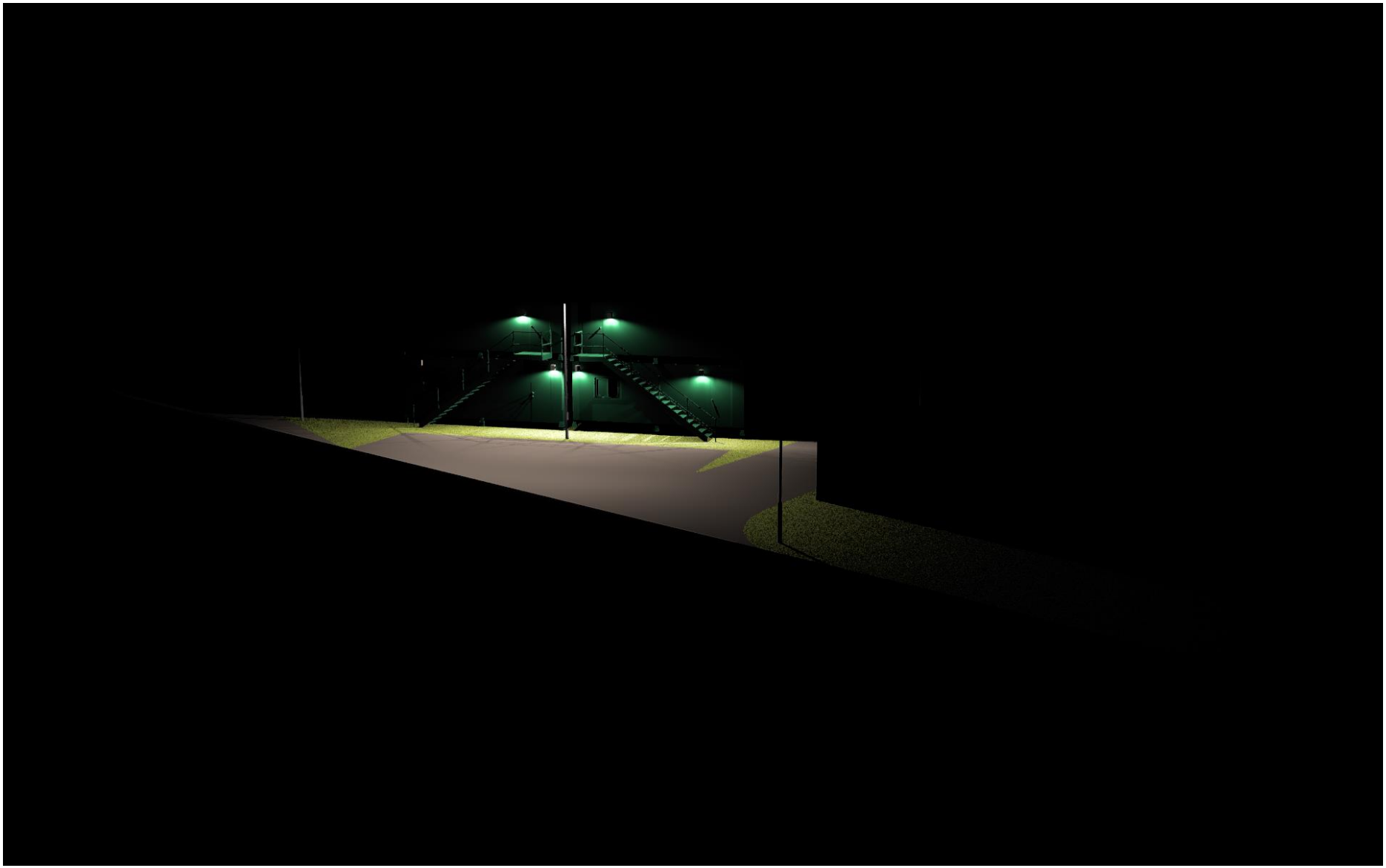




Appendix B – Lighting Model Ray-traced Imagery (delivery / collection scenario)



Appendix C – Lighting Model Ray-traced Imagery (offices scenario)



Appendix D – Lighting Model Ray-traced Imagery (tanker arrival/departure scenario)