Lighting Strategy/Impact Assessment

AESC Plant 3, IAMP

Presented to: Lichfields

Issued: November 2023

Stainton Lighting Design Services Reference: SLDS-4082

Lighting and Electrical Design, quality you can see.

Report Details

Client	Lichfields
Report Title	Lighting Strategy/Impact Assessment
Site Address	AESC Plant 3, IAMP
Report No.	SLDS-4082
Stainton Lighting Design Services Contact	Elizabeth Harrison elizabeth.harrison@staintonlds.co.uk

Quality Assurance

Issue No.	Status	Issue Date	Comments	Author	Technical Review	Authorised
03	Final	13.10.2023	*For Client Comment*			
				Elizabeth Harrison Lighting Designer	Paul Brownbridge Lighting Engineer	Anthony Smith Director

About Us

Stainton Lighting Design Services Ltd. Are a UK based award-winning lighting design consultancy, established in 1996, we have a proven track record in the delivery of excellent lighting and electrical design and services.

Working predominantly in the exterior lighting market place our experienced and diverse team have delivered complex and challenging projects across the sector. Including detailed lighting and electrical design for large National Highways projects and major local authority energy projects.

We have broad experience in the delivery of architectural lighting projects from small artwork projects through major industrial structures to decorative illumination of buildings with Durham World Heritage site being one prestigious scheme.

Other associated area of expertise includes the development of Lighting Impact Assessments and other lighting reports, the design of sports, amenity, high mast and highway lighting systems along with the design specification and commissioning of architectural lighting control systems.

We can also demonstrate a proven track record, in lighting asset management with an in depth understanding of the development, management and delivery of asset management strategy as well as an experienced inhouse data collection team.

Executive Summary

Scope of Works	Lichfields working with our approved technical specialists Stainton Lighting Design Services Limited ("SLDS") were instructed through the IAMP LLP (a joint venture between Sunderland City Council and South Tyneside Council) (the 'Client') to undertake a Lighting Strategy/Impact Assessment at the AESC Plant 3, IAMP, Sunderland (the 'Site'). The assessment was completed in July 2023. The Site visit and Lighting Strategy/Impact Assessment were undertaken to inform a planning application for the Site.
Current Site Status	The Site currently comprises of existing farmers fields and an empty farm building just off International Drive, Sunderland. There are also existing HV overhead lines which previously ran through the Site extents which are now being redirected around the Site boundary.
Proposed Development	AESC Plant 3, IAMP currently comprises of existing farmers fields, accompanying dirt tracks/access and old farm building/facilities. Currently accessed from International Drive, the site is approx. 111,455m² and is planned to consist of the main Giga factory building, a pack and warehouse, office (2 storey) and various ancillary structures including a HC substation, bulk stores canopy, 3 waste collection canopies, various canopies over the yard areas, a QA lab, plant rooms, sprinkler and fire water tanks and pump house, gatehouse, and cycle shelter.
Results	With good design, implementation and management of the installation, the effect of any obtrusive light emitted by the development of AESC Plant 3, IAMP, Sunderland, either now or in the future, could be kept to an acceptable level.
Further Recommendations	It is recommended that any proposed external lighting is designed and specified in accordance with this report. Taking full advantage of the tight optical control of modern luminaries, together with careful location and orientation, the potential adverse effects associated with light trespass, glare, and sky glow, experienced by surrounding receptors will be minimised to fall in line with the limits specified in the ILP Guidance Note GN01/21. The ILP Guidance Note should be considered

	an industry-wide best-practice document with which adherence to it represents best practice for this development.
This is intended as a summary only. Further detail and limitations of the assessment is provided within the main body of the Report.	

Table of Contents

1 Introduction

AESC Plant 3, IAMP, Sunderland is an Envision AESC Gigafactory development, creating a new battery plant within the International Advanced Manufacturing Park, Sunderland (IAMP).

Stainton Lighting Design Services Ltd. were approached to assist in the Lighting Strategy/Impact Assessment for a new lighting proposal at the site.

Firstly, this report looks at the existing Site and any exterior lighting, secondly the surrounding areas and any possible viewpoint locations around the Site are considered.

Overall, this document produces a detailed description of why the Site needs to be lit and the strategical approach to how this can be achieved effectively and efficiently, whilst taking into account the safety and security of the users of the Site, road users, ecology and the Green Belt (which is located to the north and west of the Site).

2 Aim

The principle aim of this document is to cover the design options available for the proposal of new lighting, provide practical advice on mitigating any potential nuisance or spill light while offering up a compliant lighting proposal. This will form part of the main application for the AESC Plant 3, IAMP proposal, lighting application process.

As part of the application these works will consider the following:

- Lighting to the main junction to the Site, International Drive.
- Lighting to the access roads within the Site.
- Lighting related to sections of the development within the Site boundaries, for example:
  - Car parks,
  - Loading bays,
  - Walkways etc.
- Production of a detailed report using information provided by the Client and drawing on the results of a site visit conducted with Lichfields and Morgan Sindall, with some reference taken from media such as Google Earth.

The report will provide recommended mitigation actions where appropriate, as well as provide specialist advice and guidance for the implementation of any new lighting.

Additional information within the report will cover:

- Interrogation of information provided.
- Ecological and other environmental considerations.
- Comment on lighting equipment specification:
  - Light source.
  - Colour temperature.
  - Maintenance.
- Comment on switching regimes, dynamic lighting levels and curfews.
- General Mitigation.
- General Conclusion.

3 Methodology

3.1 Proposed Methodology

Within this report we have considered the main aspects of the exterior lighting to be as follows:

Firstly, any existing lighting to or near the AESC Plant 3, IAMP Site, Sunderland. The primary function here is to provide a suitable level of illumination to facilitate the access and safe use of the proposed development. The new lighting would be installed to facilitate safe manoeuvring and travel within the confines of the site, making the user aware of any nearby vehicle and/or pedestrian.

We have endeavoured to provide a lighting outline strategy which would assist in the production of a detailed lighting solution. This would take into consideration environmental and geographical conditions and fulfil the strategy's primary function of minimising the impact of the proposed lighting to the surrounding environment.

3.2 Survey Work

The survey work undertaken for the Lighting Strategy/Impact Assessment has included information provided by the Client, Site visit experience, photographs, and media such as Google Earth. The report will reference any nearby existing lighting affecting the area and provide recommended mitigation actions for any proposed lighting where appropriate.

Current lighting for the Site was as expected, with only existing lighting within the vicinity and on nearby facilities being the main approach to lighting, with some temporary lighting at the site depot while current woks to redirect the HV overhead lines are taking place. The site survey also allowed us to pick up on the extents of the scheme and get an overall feel and appreciation for the Site and its surroundings, albeit the Site location is in a popular industrial estate, the northern border to the site is in fact neighbouring a green belt. This factor was also raised as a concern at a prelim meeting before the site visit was conducted, therefore it was highlighted as a sensitive area and the decision to collect additional information at the boundary line where possible was made.

3.3 Scope of Study

The report identifies and, where possible, offers solutions to keep to a minimum any potential negative environmental effects of artificial lighting installations, which may form part of the proposals for the development.

The report also considers appropriate lighting proposals for the scheme and addresses the issues of suitable lighting levels, while minimising the likely effect, of the scheme on road users, residents, and wildlife.

The report will include mitigation methods that will help to achieve appropriate, recommended lighting levels for the Site. It will identify methods for limiting the effects of light spill or glare by recommending some limitations to any proposed lighting designs.

3.4 Surrounding Areas Considered

The Site is located within IAMP, Washington, Sunderland.

In the closer, general vicinity of the Site there are several surrounding large farmers' fields, several large warehouse facilities, and some residential properties/estates to the east and west of the Site.

Environmental Zone examples from the Institution of Lighting Professionals Guidance Notes would indicate the area to be classified as an E3 environmental zone to the southeast of the site, being classed as suburban with medium district brightness, well inhabited rural and urban settlements, small town centres of suburban locations. Teamed with an E2 environmental zone to the north/west as this is the section of the site that borders the green belt, being classed as sparsely inhabited rural settlements, small town centres of suburban locations. Considering this the overall E Zone would therefore be E2, as the worst case for 2 adjoining E zones would be classed as the one to aim for. This was also supported by 201-P01-Proposed Site Plan - Lighting Zones provided by the client.

Table 2: Environmental zones

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

3.5 Light, Ecology and Health

When selecting a light source for an outdoor application consideration should be given to the potential effects on the local ecology and general health.

Currently there are many studies being undertaken into the effects of different spectral wavelengths on the human body sleep pattern and ecology - with a lot of emphasis being placed on the amount of "Blue" light emitted by light sources.

Based on current generally accepted studies, effects on humans seem to be influenced by exposure time and proximity to the light source - and not just the level of blue light content.

The table below shows typical blue light from a variety of light sources and is taken from a publication produced by U.S. Department of Energy and is titled "Street Lighting and Blue Light - Frequently Asked Questions".

Light source	Luminous Flux (lm)	CCT (K)	% Blue*	Relative Scotopic Content	Relative Melanopic Content**
PC White LED	1000	2700	17% - 20%	1.77 - 2.20	1.90 - 2.68
PC White LED	1000	3000	18% - 25%	1.89 - 2.39	2.10 - 2.99
PC White LED	1000	3500	22% - 27%	2.04 - 2.73	2.34 - 3.57
PC White LED	1000	4000	27% - 32%	2.10 - 2.65	2.35 - 3.40
PC White LED	1000	4500	31% - 35%	2.35 - 2.85	2.75 - 3.81
PC White LED	1000	5000	34% - 39%	2.60 - 2.89	3.18 - 3.74
PC White LED	1000	5700	39% - 43%	2.77 - 3.31	3.44 - 4.52
PC White LED	1000	6500	43% - 48%	3.27 - 3.96	4.38 - 5.84
Narrowband Amber LED	1000	1606	0%	0.36	0.12
Low Pressure Sodium	1000	1718	0%	0.34	0.10
PC Amber LED	1000	1872	1%	0.70	0.42
High Pressure Sodium	1000	1959	9%	0.89	0.86
High Pressure Sodium	**1000**	**2041**	**10%**	**1.00**	**1.00**
Mercury Vapor	1000	6924	36%	2.33	2.47
Mercury Vapor	1000	3725	25%	1.82	1.95
Metal Halide	1000	3145	24%	2.16	2.56
Metal Halide	1000	4002	33%	2.53	3.16
Metal Halide	1000	4041	35%	2.84	3.75
Moonlight	1000	4681 †	29%	3.33	4.56
Incandescent	1000	2836	12%	2.23	2.73
Halogen	1000	2934	13%	2.28	2.81
F32T8/830 Fluorescent	1000	2940	20%	2.02	2.29
F32T8/835 Fluorescent	1000	3480	26%	2.37	2.87
F32T8/841 Fluorescent	1000	3969	30%	2.58	3.18

* Percent blue calculated according to LSPDD: Light Spectral Power Distribution Database, http://galileo.graphycs.cegepsherbrooke.qc.CA/app/en/home

** Melanopic content calculated according to CIE Irradiance Toolbox, http://files.cie.co.at/784_TN003_Toolbox.xls, 2015

We can see from this table the light sources with the coolest temperature generally are blue-rich, this is unavoidable. To achieve the high CRI, we need blue content as a light source with no blue content cannot render shades of blue.

For the proposed lighting we would propose a CCT no greater than 3000K (warm white) being the preferred option.

Blue-rich light sources can have an effect on certain insect species attracting them towards the light source. However, given we are promoting the use of a cut off (0% Upward Light Output Ratio ULOR) lantern this will assist with reducing the environmental impact, and should mitigate against any potential increase in insect influencing factors.

4 Planning Policy and Legislation

4.1 Legislation and Supporting Documents

A summary of the relevant and where appropriate British Standards, Institutional Guidance Notes, and other documents to which the Lighting Strategy complies are given below.

Institution of Lighting Professionals publication 'Guidance Notes for the Reduction of Obtrusive Light (GN01:2021)'

The Guidance Note reflects the changes in international guidance regarding obtrusive light as well as considering industry comment regarding the assessment and definition of obtrusive lighting.

Street Lighting and Blue Light – Frequently Asked Questions

In response to discussion of the June 2016 American Medical Association (AMA) public release, Guidance to Reduce Harm from High Intensity Street Lights, the FAQs document provides information and clarity on the above.

BS EN 12464-2:2014 Light and Lighting – Lighting of workplaces Part 2: Outdoor workplaces.

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

BS EN 13201-2:2015 Road Lighting Part 2: Performance requirements.

This part of this European Standard defines performance requirements which are specified as lighting classes for road lighting aiming at the visual needs of road users, and it considers environmental aspects of road lighting.

BS 5489-1-2020 Code of Practice for the Design of Road Lighting, Part 1: Lighting of Roads and Public Amenity Areas

This part of BS 5489 gives recommendations on the general principles of road lighting and its aesthetic and technical aspects and provides guidance on operation and maintenance. It also provides guidance on means of minimizing energy consumption and limiting the impact on the environment and adjacent property.

Institution of Lighting Professionals publication: PLG 02 – The Application of Conflict Areas on the Highway

The purpose of this document is to define a conflict area as referenced in BS5489-1:2020 Road Lighting, CIE standards and EN13201 and to provide the lighting designer with the guidance to lighting such areas and the application of the conflict areas.

Institution of Lighting Professionals publication: Guidance Note 08/18 – Bats and artificial lighting in the UK (Bats and the Built Environment series)

This document 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.

5 Outcomes

The new lighting proposal is intended to provide adequate illumination for the users of the Site, to feel safe and secure when travelling into and through the Site, as well as considering environmental and planning considerations including ecology and the Green Belt.

As part of the provision of the new lighting installations there are additional benefits that can be gained:

- Longer life luminaires.
- Better Colour rendering for facial recognition.
- Reduction of Glare through better aimed and positioned units.
- Mitigation of skyglow from existing installations.
- Prevention of light trespass.
- Less clutter through more directional luminaires.
- Substantial energy savings.
- Reduced carbon footprint.
- Adaptable installations.
- Easily maintainable.
- Variation of colour temperatures available (3000K or less preferred/recommended)
- Responsible lighting.

The new lighting installation will reduce the impact on ecology through:

- Being a more sensitive Colour Temperature
- Providing better control of the light to avoid lighting adjacent areas where lighting is not required; and
- Using cut-off lighting to avoid having any direct upward light, 0 Upward Light Output Ratio (ULOR)

6 Scope

Within the report SLDS will outline the key elements for any proposed new lighting scheme at the AESC Plant 3, IAMP site, Sunderland.

This report will:

- Outline the design ethos and explain the aesthetic aspirations of the schemes.
- Identify limitations imposed on the design methodology by the structure and surroundings, including ecology and the Green Belt.
- Provide a brief description of on-site locations.
- Provide information on key areas of activity and illumination.
- Provide site imagery indicating existing scheme.

7 Exclusions

The following items have not been included within the scope of the lighting concept report:

- Electrical power supplies.
- Planning permissions.

8 Existing Lighting and Baseline Conditions

8.1 Existing Lighting

There is some existing external/road lighting in the vicinity of the Site described as follows:

8.2 International Drive

The existing lighting at International Drive consists of 8m columns, post top mounted, warm white approx. 3000 kelvin, LED style luminaires, changing from a staggered to single sided arrangement in places.

This section of road is a single carriageway with a speed limit of 30 mph, with several junctions/turning lanes to other facilities.

Regarding the existing standard for International Drive the assumption has been made that there is a Low to Moderate Annual Daily Traffic Flow (ADT) 7000<= ADT <=40000, with National Speed Limit (NSL) of 30mph, single carriageway, the lighting class would be M4. A lighting class of M4 level requires an average illuminance level of (Lav) 0.75 Lux with a minimum overall uniformity of (Uo) 0.40 Lux.

8.3 A1290

The existing lighting at A1290 consists of 10m columns, post top mounted, warm white approx. 3000 kelvin, LED style luminaires, in a largely single sided arrangement, with smaller staggered arrangements normally near a junction.

This section of road is a single carriageway with a speed limit of 40 mph, with several junctions/turning lanes to other facilities. There are also a few signalised junctions along this section of road.

Regarding the existing standard for A1290 the assumption has been made that there is a Low to Moderate Annual Daily Traffic Flow (ADT) 7000<= ADT <=40000, with National Speed Limit (NSL) of 40mph, single carriageway, the lighting class would be M4. A lighting class of M4 level requires an average illuminance level of (Lav) 0.75 Lux with a minimum overall uniformity of (Uo) 0.40 Lux.

8.4 Temporary Site Lighting

With the works that are being carried out on the site to redirect the HV overhead lines, there has been a site base set up within the grounds of the old North Moor Farm that is to be demolished. As part of this there has been some temporary lighting put in place around the site and within the facilities to accommodate for the safe access of the site workers and staff etc.

8.5 AESC Plant 2

The lighting strategy for AESC Plant 2, which is currently under construction, is discussed in section 9.10.

8.6 General Overview

The Site is located northwest of the existing industrial units within the IAMP and the Nissan Motor Manufacturing site. Within the wider area, the Sulgrave area of Washington containing residential and industrial properties is located approximately 1km to the west, the residential area of Townend Farm is located approximately 1,500m to the east beyond the A19 and the residential area of Fellgate is located approximately 2,800m to the north.

It would be beneficial that the proposed Site follow the same rational of LED luminaires as nearby installations within the IAMP and at Nissan for consistency in the least environmentally sensitive areas where possible. The new lighting would need to be sympathetic to the location and surrounding areas that it can be viewed from.

The Site survey was carried out on the 05/07/2023 and into the early hours of the 06/07/2023 given the time of year, with the daylight survey carried out at 17:30 hours. The weather conditions at the time of the survey were dry, bright, mild with reasonable visibility, the temperature was around 12°C. The night-time survey was carried out on the same day at 23:00 hours, the weather conditions at the time of the survey were dry, clear, brisk with good visibility, the temperature was around 7°C.

Considering the time of year, the weather was mild and remained dry for the duration of the site visit. Visibility at the time of both the day and night visit was reasonable, meaning there were clear views of the Site.

It was made clear at the time of the site visit that the general topography of the surrounding area means the Site is naturally visible from several directions. In line with this there are also several visual receptors for the Site. There are tree-lined hedgerows around the general location of the Site but given the vast scale of the proposed buildings, this would only provide minimal screening.

As part of the site survey, both daytime and night-time photographs were taken to better enhance the visuals, the images taken from each viewpoint and locations for each can be seen within Appendix A of the report.

8.7 Viewpoint Locations

Please see below ariel view of the Site showing viewpoint locations used at the time of the site visit.

20. International Drive, junction to site
21. A1290 & International Drive junction
22. A1290 & Cherry Blossom Way junction
23. Dirt track off A1290
24. Follingsby Lane (bend after container sales UK)
25. Follingsby Lane (my pet stop)
26. Follingsby Lane (Hylton Grove Farm)


Amazon DNE2
24
Follingsby Ln
25
26
Downhill Ln
A1290
A19
20
IAMP- International Advanced...
21
Woofs n Scruffs - Washington
A195
A1290
Nissan Motor Manufacturing UK
22
The Fun Jungle
23
A1290
A19
Sunrise E

8.8 Readings

Please see below listed meter readings from the nighttime site visit. First table indicates meter readings from within the scheme extents, second table indicates meter readings taken at each external viewpoint location.

Within the scheme extents

Location No.	Time of Reading	Nighttime Horizontal Lux Level Reading
1	23:00	0.33 (earliest reading)
2	23:10	0.19*
3	23:13	0.22*
4	23:15	0.15*
5	23:18	0.22*
6	23:24	0.08*
7	23:27	0.08*
8	23:39	0.07*
9	23:41	0.07*
10	23:44	0.10*
11	23:50	0.09*
12	23:52	0.08*
13	23:54	0.07*
14	23:59	0.07*
15	00:01	0.09*
16	00:04	0.09*
17	00:07	0.10*
18	00:12	0.10
19	00:25	0.12
*Locations were along the site boundary with the green belt where we could physically and safely get to a suitable location to take a meter reading.		

Please note, within the scheme extents the meter readings were taken at approx. 100m apart where possible. There were sections of the site that weren't as easily accessible as others, for these locations we got as near to as possible or avoided for health and safety reasons, especially during the hours of darkness. However, not withstanding this limitation, it is considered that the number of meter readings taken are considered to provide suitable and appropriate coverage of the key locations.

As you can see the meter reading points are largely focused on the boundary line of the Site. This is considered to be a robust approach because they cover the northern and western site boundaries. These boundaries are particularly sensitive given the surrounding Green Belt and ecological habitats (particularly along the Usworth Burn which bounds the site to the north). Only a few meter readings were taken internally within the Site, given the proposed extent of the built development.

Outside the scheme extents

Location No.	Time of Reading	Nighttime Horizontal Lux Level Reading
20	00:30	10.88
21	00:35	7.7
22	00:37	14.45
23	00:42	0.12
24	00:54	0.07
25	00:58	0.05
26	01:03	0.06


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
Envision parking
International Dr
Faltec Europe
IAMP- International Advanced...
A1290
Nissan Sports & Leisure Complex
Nissan Body Shop
Proud William Gordon
Temporarily closed
SD1A
Temporarily closed

9 Lighting Strategy

9.1 Aesthetics

This section details the typical lighting levels that would be expected for the areas of the Site under consideration. The primary aim is to ensure that any proposed lighting solution can be achieved whilst ensuring best-practice and guidance environmental lighting limits can also be met.

The lighting levels proposed below have been selected from British Standard recommendations for the required activities or tasks, without significantly impacting the surrounding environment.

Any future proposals at the detailed design stage are to include a full set of calculations to provide evidence of the direct impact of any proposed lighting.

9.2 Baseline Scheme

At present and from the discussion which took place at the pre-start meeting, the expected lighting levels for AESC Plant 3, IAMP, Sunderland will be broken down for each area and detailed in the following sections.

9.3 Site Access

The Site has main access from International Drive, which is an adopted public highway, owned and operated by Sunderland City Council.

The Proposed Plan shows one main access point to the Site, linking to the main car park areas and through to the AESC Plant 3, IAMP site and Warehouse.

Conflict areas are typically junctions, intersections, roundabouts, and pedestrian crossings, where significant streams of motorized traffic intersect with each other or with other road users such as pedestrians and cyclists. At conflict areas, the visual task is generally more difficult than on straight roads, and a higher luminance or illuminance class may be selected at the conflict area.

The main purpose of lighting for a junction associated with those roads is to enable the driver adequate time and illuminance to be aware of the change in traffic, to orientate themselves and detect vehicular and other hazards. The lighting on such roads can provide some guidance for motorists but is unlikely to be sufficient for revealing objects on the road without the use of headlights.

International Drive is the main access road to the Site and is currently lit, as well as there being lighting columns situated at the junction entrance. The environmental zone would be classified as E3, with an existing speed limit of NSL 30mph, leading to the assumed lighting level being M4, resulting in the appropriate C class for the

conflict being C3 which requires an average illuminance level of (Eav) 15 Lux with a minimum overall uniformity of (Emin) 0.40 Lux.

Table A.4 below is an extract from BS5489-1:2020, A.3.2 Conflict Areas and shows the lighting class requirements to be aimed for in line with the above:

Table A.4 — *Lighting classes for conflict areas*

Traffic route lighting class	Conflict area lighting class
M1	C0
M2	C1
M3	C2
M4	C3
M5	C4
M6	C5

The Lighting Impact Assessment recommends that the design for the Site's Access Junctions should aim to achieve the lighting levels recommended within BS EN 13201-2:2015 and BS 5489-1:2020.

We would propose that for this location the design aspects follow on from the existing highway lighting along International Drive, utilising 8m columns, post top mounted with the same LED luminaires used along International Drive or relevant equivalent and stop at the back of the existing splitter island for the junction as per guidance in PLG02 The Application of the Conflict Areas on the Highway.

As previously mentioned, there is lighting to this section of International Drive, considering this and the need for a conflict area lighting class, the existing extents of the lighting would need to be assessed. This is to ensure the continuation of the lighting, for the appropriate stopping distance of the enforced speed limit. In this instance the speed limit for International Drive is 30mph leading to a 5 second rule and a distance of 67m beyond the conflict, needing to be illuminated as per the guidance in PLG02 The Application of the Conflict Areas on the Highway.

9.4 Access Road

Within the confines of the Site extents, we propose that most applicable lighting levels should be in accordance with BS EN 12464-2:2014 - Light and Lighting of Workplaces – Outdoor. For the access road through the Site, we would need to know the speed limit for vehicles using the access road. We would suggest that the speed limit is likely to be in excess of 10km/h, but less than 40km/h and therefore the aim should be to provide and achieve the appropriate lighting levels recommended for traffic areas within BS EN 12464-2:2014, Table 5.1.3, which details the applicable lighting levels required.

Table 5.1 — General requirements for areas and for cleaning at outdoor work places

Ref. no.	Type of area, task or activity	$\bar{E}_m$ lx	U_o –	R_{GL} –	R_a –	Specific requirements
5.1.1	Walkways exclusively for pedestrians	5	0,25	50	20	
5.1.2	Traffic areas for slowly moving vehicles (max. 10 km/h), e.g. bicycles, trucks and excavators	10	0,40	50	20	
5.1.3	Regular vehicle traffic (max. 40 km/h)	20	0,40	45	20	At shipyards and in docks, R_{GL} may be 50
5.1.4	Pedestrian passages, vehicle turning, loading and unloading points	50	0,40	50	20	
5.1.5	Cleaning and servicing	50	0,25	50	20	All relevant surfaces

Assuming the speed limit on the Site is greater than 10km/, but less than 40km/h, then the target lighting levels for the access road would be an average lux level (Eav) of 20 Lux and an overall uniformity minimum (Emin/Eav) of 0.40.

Given the ecological sensitive nature of this Site, we would suggest the luminaires used in the lighting design of these areas should be kept as low as possible to minimise spill light into adjacent areas. To achieve this, we would propose that the luminaire is mounted post top directly on to the column at five to six metre mounting height.

9.5 Gatehouse

As there is a variety of activity occurring at the gatehouse to the site, it would be beneficial for the area to be treat as a conflict or incorporate the same or a higher standard than that of the access road.

As the road is advised to achieve 20 lux with 40% overall uniformity, a higher level of C1 would be beneficial, resulting in 30 Lux with 40% overall uniformity. Additionally, and considering the type of vehicles that will be using the Site a mounting height of 10m columns, post top mounted would be suitable for this area.

9.6 Outdoor Car Park

For the open-air car parks within the Site, we would suggest that the aim would be to provide and achieve the appropriate lighting levels recommended for outdoor car parks.

We would class the Sites car parks as medium traffic due to the activity and usage it will be getting.

The table below is a replication of Table 5.9 from within BS EN 12464-2:2014 and shows the proposed levels to be aimed for.

Table 5.9 — Parking areas

Ref. no.	Type of area, task or activity	$\bar{E}_m$ lx	U_o –	R_{GL} –	R_a –	Specific requirements
5.9.1	Light traffic, e.g. parking areas of shops, terraced and apartment houses; cycle parks	5	0.25	55	20	
5.9.2	Medium traffic, e.g. parking areas of department stores, office buildings, plants, sports and multipurpose building complexes	10	0,25	50	20	
5.9.3	Heavy traffic, e.g. parking areas of major shopping centres, major sports and multipurpose building complexes	20	0,25	50	20	

Therefore, the target level of lighting for the car parks would be an average lux level (Eav) of 10 Lux and an overall uniformity minimum (Emin/Eav) of 0.25.

Given the ecological sensitive nature of this Site and need to reduce the impact on the Green Belt, we would suggest the luminaires used in the lighting design of these areas should be kept as low as possible to minimise spill light into adjacent areas. To achieve this, we would propose that the luminaire is mounted post top directly on to the column, at a maximum mounting height of 10m as the surrounding buildings will be at least 2 storeys in areas.

9.7 Walkways

Pedestrians and cyclists need an acceptable level of overall uniformity of illuminance to aid orientation and detection at night, as well as to provide a sense of security. The purpose of lighting on cycle tracks or footpaths is to enable users to orientate themselves, identify other users, detect potential hazards, discourage crime, and engender a feeling of safety and security. To achieve this, the design should take account of lighting on horizontal surfaces, as well as the control of glare and the colour rendering. Environmental issues should also be considered.

From the Site plan there looks to be designated walkways around the main factory building, pack and warehouse building, car park and office building within the Site boundary. There is also a footpath which runs in conjunction with the access road to the Site and gatehouse.

For the walkways within the Site the Lighting Strategy/Impact Assessment advises the design for these areas should aim to achieve the lighting levels recommended within BS EN 12464-2:2014.

Table 5.1 below is an extract from BS EN 12464-2:2014 and shows the lighting class requirements to be aimed for in the preliminary scheme options associated with industrial sites and storage areas:

Table 5.1 — General requirements for areas and for cleaning at outdoor work places

Ref. no.	Type of area, task or activity	$\overline{E}_m$ lx	U_o –	R_{GL} –	R_a –	Specific requirements
5.1.1	Walkways exclusively for pedestrians	5	0,25	50	20	
5.1.2	Traffic areas for slowly moving vehicles (max. 10 km/h), e.g. bicycles, trucks and excavators	10	0,40	50	20	
5.1.3	Regular vehicle traffic (max. 40 km/h)	20	0,40	45	20	At shipyards and in docks, R_{GL} may be 50
5.1.4	Pedestrian passages, vehicle turning, loading and unloading points	50	0,40	50	20	
5.1.5	Cleaning and servicing	50	0,25	50	20	All relevant surfaces

The target levels for the area would therefore be an average illuminance level of (Eav) 5 Lux with an overall uniformity of (Eav/Emin) 0.25 Lux. We would advise a maximum mounting height of 6 metre columns with a suitable and controlled optical distribution, 0-degree tilt with a recommended (maximum) colour temperature of 3000K. For these areas that aren't suitable for columns, wall mounted units in some locations would be appropriate.

9.8 Loading Bays

Indicated on ENV3-RPS-ZZ-XX-SK-A-000053-P06-Proposed Site Plan the warehouse unit indicates designated HGV loading and parking areas and 'Goods Yard'.

For the loading bays and areas for the Site the Lighting Strategy/Impact Assessment advises the design for these areas should aim to achieve the lighting levels recommended within BS EN 12464-2:2014.

From the Proposed Plan, we would class the loading areas as short-term handling, Table 5.7 below is an extract from BS EN 12464-2:2014 and shows the lighting class requirements to be aimed for in the preliminary scheme options associated with industrial sites and storage areas:

Table 5.7 — Industrial sites and storage areas

Ref. no.	Type of area, task or activity	$\overline{E}_m$ lx	U_o –	R_{GL} –	R_a –	Specific requirements
5.7.1	Short-term handling of large units and raw materials, loading and unloading of solid bulk goods	20	0,25	55	20	
5.7.2	Continuous handling of large units and raw materials, loading and unloading of freight, lifting and descending location for cranes, open loading platforms	50	0,40	50	20	
5.7.3	Reading of addresses, covered loading platforms, use of tools, ordinary reinforcement and casting tasks in concrete plants	100	0,50	45	20	
5.7.4	Demanding electrical, machine and piping installations, inspection	200	0,50	45	60	Use local lighting

The target levels for the area would therefore be an average illuminance level of (Eav) 20 Lux with an overall uniformity of (Eav/Emin) 0.25 Lux. We would advise a maximum mounting height of 10 metre columns with a suitable and controlled optical distribution, 0-degree tilt with a recommended (maximum) colour temperature of 3000K. For these areas that aren't suitable for columns, wall mounted units in some locations would be appropriate.

9.9 Table

Please see below summary table to show variations between the levels that would be needed throughout the Site:

Lighting Level	**Eav**	**Emin/Eav (Uniformity)**
Conflicts (C3)	15 Lux	0.40
Loading Bays	20 Lux	0.25
Access Roads	20 Lux	0.25
Walkways	5 Lux	0.25
Car Park	10 Lux	0.25

9.10 AESC Plant 2 Proposal

As part of the proposal, we have been provided with the proposed lighting design for AESC Plant 2. Using this as reference and a potential starting point for the design of AESC Plant 3, the first comment would be the proposal of 4000K. A proposal for 4000K is considered to be appropriate for AESC Plant 2 given it lies in a suburban location adjacent to the A1290, International Drive, SNOP and opposite Nissan. However, 3000K or less is considered to be more appropriate for the AESC Plant 3

along the sensitive boundary with the Green Belt. Elsewhere (particularly along the roads and pathways shared with AESC Plant 2, the lighting will be 4000K.

In addition to this the contours shown from the design do appear to be well controlled and quite tight to the extents of the site, they appear to cover 1 lux (black) to 5 lux (red), typically, for reference a full moon is approx. 0.1 lux.

The calculation summary does break down the site into specific areas of activity although, the drawing is a little difficult to cross reference the levels achieved for each area. Saying this there does appear to be good levels of overall uniformity throughout but it is hard to cross reference the averages achieved for each area.

The design also shows that there is 0% upward light out ratio (ULOR) for all fittings proposed (floodlights would depend on tilt angle of installation), bar the Helvellyn 2.0 (bollard), which states 13.3%, although the quantity is only 5 this may be beneficial to be re-assessed. This will also be assuming a 0-degree tilt for all locations; this is not stated anywhere on the design, but neither is a 5-degree tilt.

Again, from a quick overview some of the levels do appear a little high in places but there are also notes identifying ‘elevated levels due to spill light’.

10 Lighting Source Selection

The selection of LED luminaires is partly dictated by current trends within the lighting industry for using energy efficient luminaires. However, using a white light source is also important as the ability to clearly see and distinguish colours and improves the visual acuity of road users and improves users' perception of safety.

Luminaires for the area should be selected and mounted to avoid any nuisance light. Control of the light distribution of installations is necessary to limit nuisance light and sky glow.

11 Recommendations/Advice for the Detailed Lighting Design

11.1 Visual Impact on the Surrounding Area

By using highly controlled optics, and a careful selection of equipment, the impact of the lighting scheme on the environment should be minimal.

The use of LED technology provides a much wider array of optical solutions than would have been available with traditional high intensity discharge lighting. Added to this is the ability to have one 'base' luminaire to which its optical performance is altered by use of secondary 'refracting lens' technologies, and along with the ability of LED to be easily dimmed, allows the final on-site commissioning to make subtle changes to reduce environmental impact without unduly affecting the visual aesthetic.

11.2 Spill Light, Sky Glow & Light Trespass

Luminaires for the area are to be selected and installed to avoid obtrusive light. Control of the light distribution of the entire installation is necessary to limit obtrusive light and sky glow. In some cases, lighting can be intrusive at night. Consideration needs to be given to the use of shields and baffles when understanding the detailed design to assist in the alleviation of obtrusive light.

Upward light should be minimised in all installations by controlling the intensity of light from luminaires, as installed. The design, orientation and location of luminaires should be arranged to ensure that glare is minimised. In order to limit glare, an appropriate intensity class should be selected from BS EN 13201-2:2015, Table A.1. Please see below:

Table A.1 — Luminous intensity classes

Class	Maximum luminous intensity in cd / klm			Other requirements
	at 70° [a]	at 80° [a]	at 90° [a]	
G1		200	50	None
G2		150	30	None
G3		100	20	None
G4	500	100	10	Luminous intensities above 95° [a] to be zero
G5	350	100	10	Luminous intensities above 95° [a] to be zero
G6	350	100	0	Luminous intensities above 90° [a] to be zero

[a] Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.

NOTE 1 The threshold increment (*TI*) measures the veiling luminance caused by disability glare in relation to the average road surface luminance, approximately in proportion. The lamp output affects both terms equally and, therefore, the intensities in proportion to the lamp output are used in Table A.1.

NOTE 2 G.1, G.2 and G.3 correspond to "semi cut-off" and "cut-off" concepts of traditional use, with requirements, however, modified to suit the prevailing use of light sources and luminaires. G.4, G.5 and G.6 correspond to full cut-off.

All luminaires used should be good quality with optical control, flat glass, cut-off luminaires that are 'Dark Sky Association' approved, with zero light emitted at 90° and above. This will ensure that the luminaire itself produces little spill light, however correct installation and on-going maintenance is essential to ensure the overall lighting scheme installation does not produce spill light, sky glow and wasted light.

11.3 Operational Hours

The Site will be operational twenty-four hours per day, seven days per week during times of use and therefore it should be expected that the external lighting will be operational from dusk till dawn.

A dusk till dawn burning regime would equate to approximately 4,000 burning hours per annum.

11.4 Adaptive Lighting and Switching

The widening use of LED technology within the exterior lighting marketplace has created many more opportunities for adaptive lighting and switching. These can be standalone options or part of an integrated control system. Some of the options which could be applied to scheme areas are detailed below.

11.5 Simple Switching

This is simply using time clocks/photocells (daylight sensor) or typically a mix of both to switch lighting off automatically whilst it is not in use. By using this type of approach to switch different lighting circuits independently you can create simple scenes or states such as 'full' power, 'half on' or 'security level'.

We would advise that for the main areas of lighting detailed there is a simple switching control installed to restrict illumination from switch on at dusk to the intended closing hours of operation.

Pro's

- Cheap to implement and easy to maintain and will require very little technology.
- Can provide energy savings at little capital cost.

Con's

- May require additional electrical infrastructure cost to split the circuits into a sensible grouping for the required lower levels.
- The system is not easily adapted to alternative scenes in the future.

11.6 Standalone Dimming

Most modern LED luminaires will have the built-in ability for pre-programmed, or input activated, dimming profiles.

Input activated, or dynamic dimming allows the lighting to step dim, for example 100% at dusk when the lighting switches on, then 50% after a time delay period if there is no presence detection, then 25% after a further time delay period if there remains no presence detection. This could then lead to a switch off if there is no presence detection after a further time delay period. This method would adjust the lighting levels up or down depending on how busy the Site was at any particular time. This can be triggered by an input from say another standalone device such as a presence sensor, or noise sensor, or could be triggered via a switch of some kind. This input would then cause the luminaire to go into a dimmed state or return to full power from a dimmed state.

It is generally accepted that usage anywhere declines later in the evening and with less usage means that the lighting levels can also be reduced accordingly as often lighting levels are directly linked to how busy the area is. As the Site is proposed to be open 24 hours per day, then we would promote consideration is given to reducing the lighting levels to an appropriate level at an appropriate time, to suit and in accordance with the relevant shift patterns of the Site. The simplest way to achieve this would be fixed, factory pre-programmed dimming, whereby the luminaire is programmed to automatically dim each night to a certain percentage output between a certain number of hours, for example dim to 50% output between midnight and 06:00 hours. If the fixed, factory pre-programmed dimming was implemented in the proposed lighting design, then we would promote that the Lighting Designer determines a percentage value for the dim level that still achieves a lighting level in accordance with the relevant British Standard, say 1 number lighting class lower, rather than just using an arbitrary value.

Pro's

- This option is relatively cheap to incorporate and allow good uniformity, and potentially compliant levels of lighting, to be present at all times dependent on anticipated usage.
- Can provide energy savings at reasonable capital cost with very little negative effect to the visual operation of the lighting.

Con's

- Once installed it is difficult to adapt should the situation change as each individual unit would have to be reprogrammed.

11.6.1 Full Adaptive Lighting Management System

This would require the installation of a management system to control the exterior lighting elements associated with the system. Typically, it would use either wireless, mains-borne signalling, or a separate control cable network to communicate with the individual luminaires and give specific commands based on input or instruction.
This could be integrated into the building management system, if installed, so full control of the Site is capable.
This could also incorporate some of the standalone technologies to provide an intelligent system which can be both instructed to do a specific scheme, or automatically adapt to the real-world situation.

Pro's

- This type of install can provide an intelligent and adaptive lighting system maximising energy savings whilst only using the light when and where it is needed. Once the system is in place reacting to changing, or one off, situations is easy and requiring little human intervention.

Con's

- Can be expensive to install and requires training to use to its full potential.
- Often manufacturers have different protocols, and the system needs to be carefully specified and designed to ensure it will meet the Client's aspirations.

11.7 Maintenance and Energy

11.7.1 Energy Usage

The new proposed LED scheme should offer a low degree of energy consumption and maintenance.

11.7.2 Scheme Lifetime

All proposed luminaires should be a very high quality and offer a scheme with long life and high durability.
LED drivers are of all electronic construction and with the potential for long service life. Typical service life for LED drivers is 80,000 to 100,000 hours (19-24 years) with only a maximum of 10% of LED driver failures after this duration.

11.7.3 Maintenance

The scheme will require a degree of regular maintenance including aspects like luminaire cleaning, mechanical inspection of fixings, and general visual inspections. However, in line with previous comments made, we would expect the proposed lighting system should provide many years of service with little, or no, expected luminaire/control gear replacements for many years to come.

12 Publications Referred To

- BS EN 12464-1:2011 Light and lighting – Lighting of workplaces Part 1: Indoor workplaces
- BS EN 12464-2:2014 Light and Lighting – Lighting of workplaces Part 2: Outdoor workplaces
- BS EN 13201-2:2015 Road Lighting Part 2: Performance requirements.
- BS 5489-1-2020 Code of Practice for the Design of Road Lighting, Part 1: Lighting of Roads and Public Amenity Areas
- Institute of Lighting Professionals publication: Guidance Notes for the Reduction of Obtrusive Light (GN01:2020)
- Institution of Lighting Professionals publication: PLG 02 – The Application of Conflict Areas on the Highway
- Institution of Lighting Professionals publication: Guidance Note 08/18 – Bats and artificial lighting in the UK (Bats and the Built Environment series)
- Street Lighting and Blue Light – Frequently Asked Questions

13 Scheme Installation

The scheme will require new installation solutions to mount/place all the luminaires in designed and agreed locations. The new installation should cause minimal disruptions with luminaires proposed in logically designed and thought-out locations, utilising directional LED fittings.

14 Design Comments/Conclusion

The site of AESC Plant 3, IAMP, Sunderland is a large expanse of land and in turn will be a large industrial site when complete. Naturally with this there will be several different activities and tasks taking place within the Site within different areas and for different users.

This Lighting Strategy/Impact Assessment identifies the key design principles for minimising the effect of a new lighting scheme, and these should be implemented for any proposed external lighting design undertaken for AESC Plant 3, IAMP.

It is clear from the Lux readings taken at the time of the site visit that the existing area is intrinsically dark, with readings generally less than 0.4 Lux which can be considered similar to a clear night sky with a full moon. At no point around the site did the readings exceed 1.0 Lux even when the meter reading points became close to adjoining roadways. Taking this into consideration, it is without any doubt that the proposal of a new lighting installation as part of the proposed development at AESC Plant 3, IAMP will increase the lighting levels at the Site when compared to the existing baseline, nighttime readings.

The main area of concerns for the Site was the boundary along the north and west side of the proposed plot, which neighbours a green belt and ecologically sensitive areas. The readings taken along this boundary line were typically no greater than 0.10 Lux with the odd one at 0.22 and this was a location closer to the boundary with the A1290, so this may be considered contribution to this reading. It is recommended that lighting is kept to an absolute minimum in this area and any lighting that is proposed should be carefully selected and located, so as to have the minimal impact possible along this boundary with the greenbelt.

By taking full advantage of the tight optical control of modern luminaries available, in conjunction with careful consideration of the colour temperature, mounting height, location and orientation of the luminaire, as well as correctly selecting the applicable lighting levels required, the potential adverse effects associated with light trespass, glare, and sky glow, experienced by surrounding receptors will be minimised to fall in line with the limits specified in the ILP Guidance Note. The ILP Guidance Note should be considered an industry-wide best-practice document with which adherence to it represents best practice for this development.

The proposals could also be linked to an adaptive lighting system - be it simple switching or standalone dimming - this situation could be improved upon further if viable. Reducing lighting levels at times of low usage or switching off outside of the

operating hours would help towards minimising the environmental and ecological impact of any proposed lighting.

With good design and management of the lighting, the effect of the additional lighting to the environment could be kept to an acceptable level contributing very little to the existing situation in many areas.

It can be demonstrated that there will be a suitable solution for an LED lighting option for the new development. The LED solution will not only provide significantly improved benefits regarding ongoing maintenance, adaptability, and energy costs, but enables maximum mitigation of environmental and ecological impacts – particularly in relation to any adjacent areas.

15 Appendix A–Site Images

Please see below images relating to locations on site.

Location 1 from within the scheme extents towards A1290.

Location 1 from within the scheme extents towards AESC Plant 2.

Location 1 from within the scheme extents towards the site base.

Location 1 from within the scheme extents towards the green belt boundary.

Location 2 from within the scheme extents towards A1290.

Location 2 from within the scheme extents towards AESC Plant 2.

Location 2 from within the scheme extents back towards the Site base.

Location 2 back towards Location 7, along boundary

Location 5 from within the scheme extents southwest corner bordering A1290.

View from location 5, boundary line to the left of photo

View from location 5, across the Site towards the AESC Plant 2 location

View from location 5, up the west boundary edge

Location 7 from boundary line back into the Site towards A1290

Location 7 from boundary line back into the Site towards AESC Plant 2.

Additional photo location taken from the centre of the Site across towards the northwest corner

Additional photo location taken from the centre of the Site across towards the west boundary

Additional photo location taken from the centre of the Site across towards the A1290

Additional photo location taken from the centre of the Site across towards AESC Plant 2.

Location 8 along boundary towards A1290

Location 8 along boundary towards north boundary line with green belt

Location 10 along west boundary line back towards A1290

Location 10 back in towards the Site

Location 10 towards north boundary with the green belt

Location 11 along existing shrub line at boundary with the greenbelt

Location 11 along existing shrub line at boundary with the greenbelt

Location 13 along line at boundary with the greenbelt towards location 11

Location 13 across site towards AESC Plant 2 location beyond hedgerow

Location 13 towards existing boundary line to get to location 14

Location 14 along boundary towards location 17

Location 15/16 along boundary towards location 13

Location 15 across Site

Location 16 across Site towards the base building

Location 16 view back out from the Site across the greenbelt

Location 18 across Site towards west boundary

Location 19 across towards AESC Plant 2 site

Location 19 on main access road in towards Site base building

Location 20 main entrance into the site at present with security point

Existing lighting at location 20 International Drive

Location 21 junction with A1290 & International Drive

Location 21 junction with A1290/International Drive showing the AESC Plant 2 site

Location 22 A1290 junction with Cherry Blossom Way view towards proposed Giga 3 site

Location 23 dirt track towards site from the west

Location 24 Follingsby Lane (near amazon)

Location 25 Follingsby Lane (near My Pet Shop)

Location 26 Follingsby Lane (Hylton Grove Farm)

Nighttime Photos

Location 1

Location 2

Location 2 towards AESC Plant 2

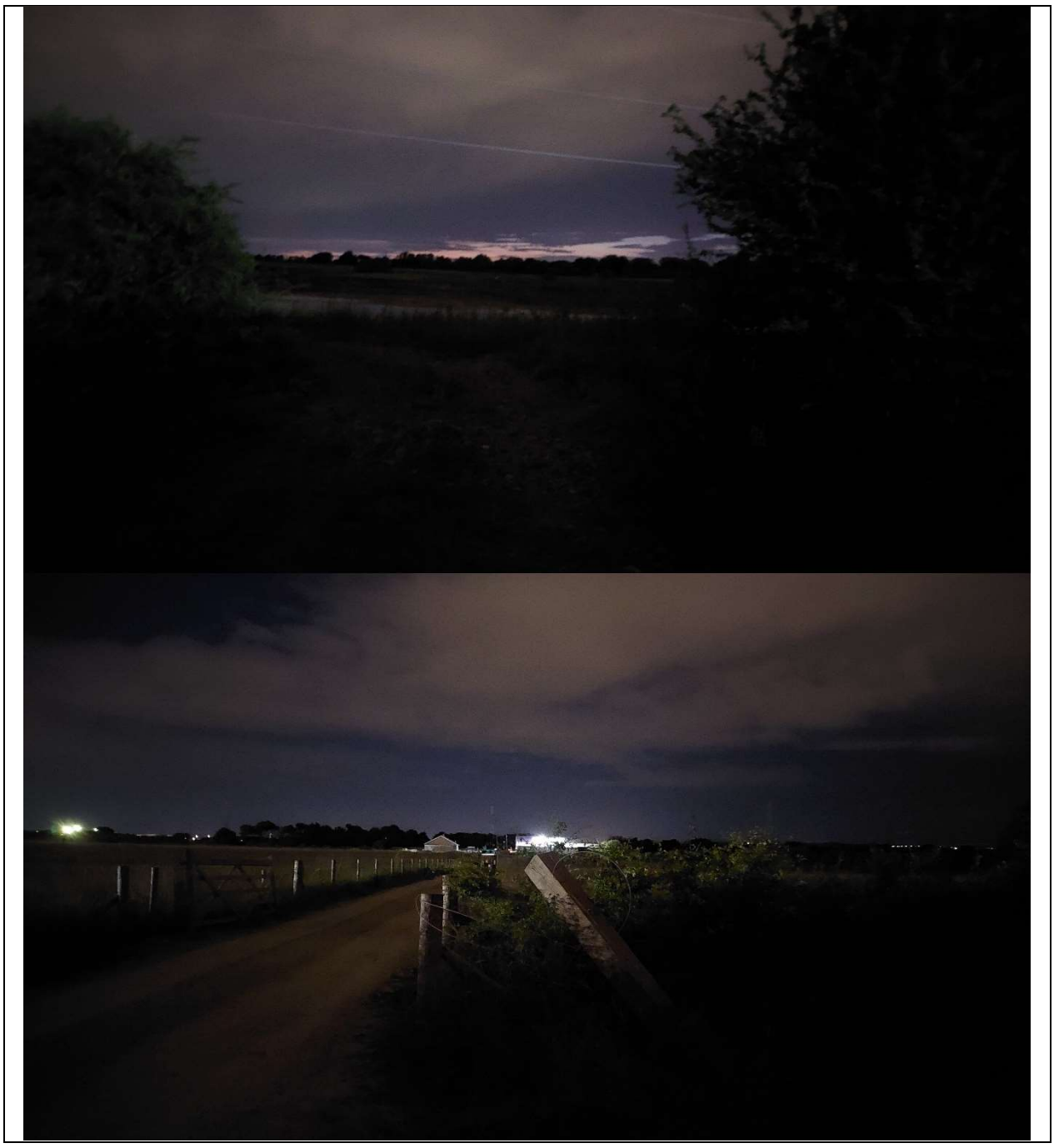
Location 3

Location 7

Location 11

Location 13

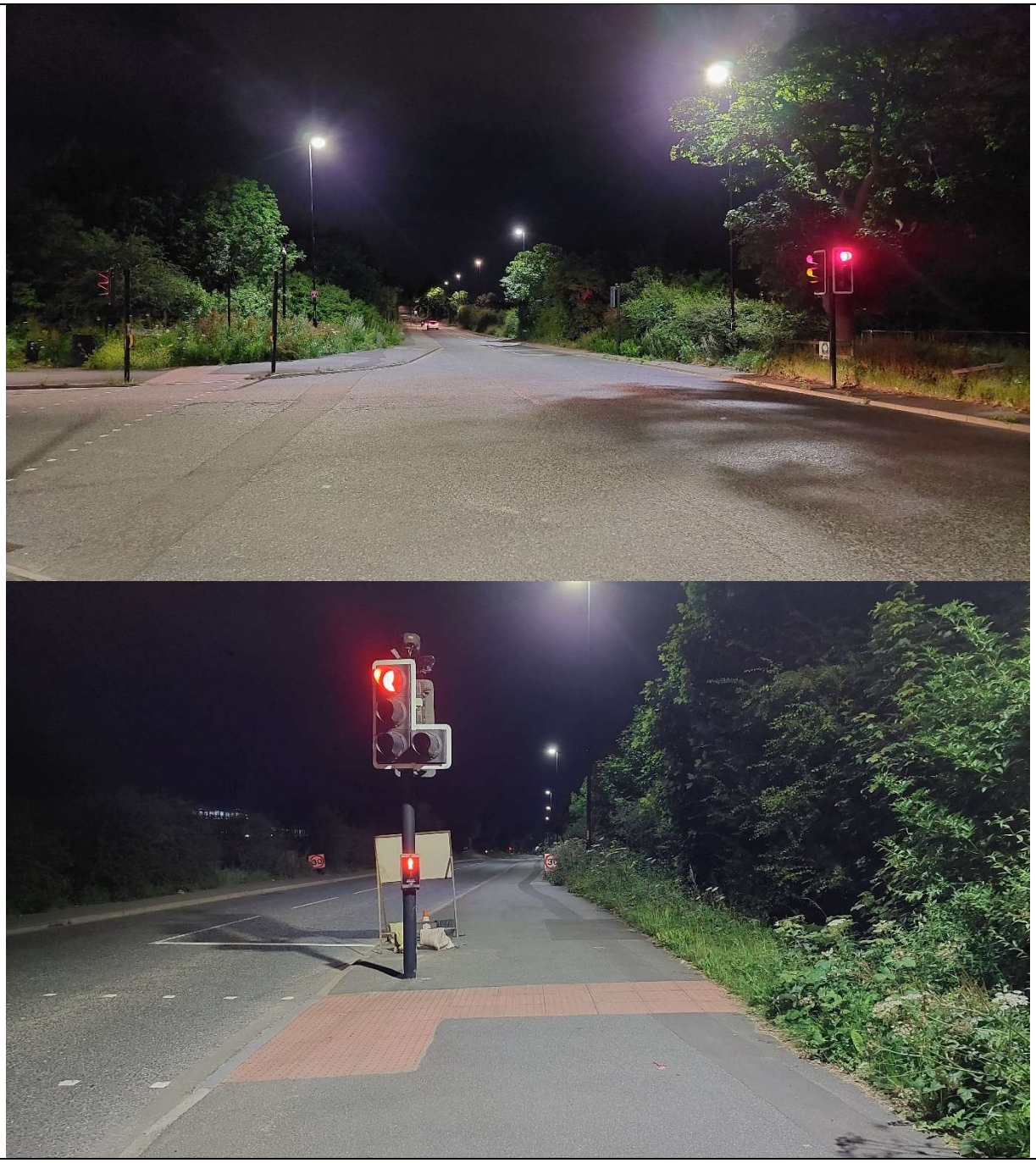
Location 16



Location 19

Location 20

Location 21



Location 22

Location 23

Location 24

Location 25

Location 26

16 Appendix B – Technical Information & Additional Considerations

This section will outline some of the technical challenges and terminology associated with lighting schemes, providing general commentary and background associated with design decisions. It will aim to provide information outlining benefits of moving to an LED light source as well as other factors and recommendations.

16.1 Technical Lighting Information

16.1.1 Types of Light Source

To ensure good colour rendering and acceptable colour appearance is provided, it is proposed to utilise luminaires with a warm white LED light source of no more than 3000 kelvin.

Additionally, people in general intuitively prefer white light to yellow light as it is much closer to natural daylight and enables us to see colours in their true shades and achieve a good level of visual acuity.

Good colour rendition and appearance are useful in car park and road environments to aid object identification, safe movement, facial recognition, and perception of safety.

In the last 5 years LEDs have become a viable light source for use in outdoor lighting applications and the technology has improved efficacy (which is measured in lumens per watt) and is a direct indicator as to how much light is emitted from the luminaire for every watt of energy it consumes.

For example, high pressure sodium (SON) is typically around 120 lumens/watts which is extremely efficient. However, the latest generations of LED chip are now in certain circumstances exceeding the 120 lumens/watt figure achieved by SON.

16.1.2 Lumen Depreciation

This is the term used for how the output of the lamp/light source deteriorates throughout its useful life.

This minimum designed level is expressed as "L" values typically L80 to as high as L95 in real terms the number following the "L" value is the percentage of light output at this point below are some examples.

A Luminaire may have the following figures

L70 @ 100,000 Hours	After 100,000 Hours of operation the LED will be 70% of its initial light output when new.
L80 @ 70,000 Hours	After 70,000 Hours of operation the LED will be 80% of its initial light output when new.

L90 @ 60,000 Hours	After 60,000 Hours of operation the LED will be 90% of its initial light output when new.
L95 @ 50,000 Hours.	After 50,000 Hours of operation the LED will be 95% of its initial light output when new.

It could be noted that a typical dawn to dusk switching regime is operational for approximately 4,000 hours.

As we always design to the level at end of life (maintained levels) once the operating life is known we can select the appropriate lumen depreciation figure.

The actual time to total failure is generally not stated but given the technology is solid state and has no working parts this is expected to be a significant length of time.

16.1.3 Lamp Colour Rendering

This refers to the light source's ability to reveal objects in their true colour as compared to a reference light source and is measured on a scale of 0 to 100 - the higher the value the better the colour rendering properties of the lamp. i.e. pure white light, natural daylight that enables colours to be seen as they would appear in daylight.

The ability of a light source to render colours of objects correctly is quantified by the CIE colour rendering group and the CIE general colour rendering index (Ra):

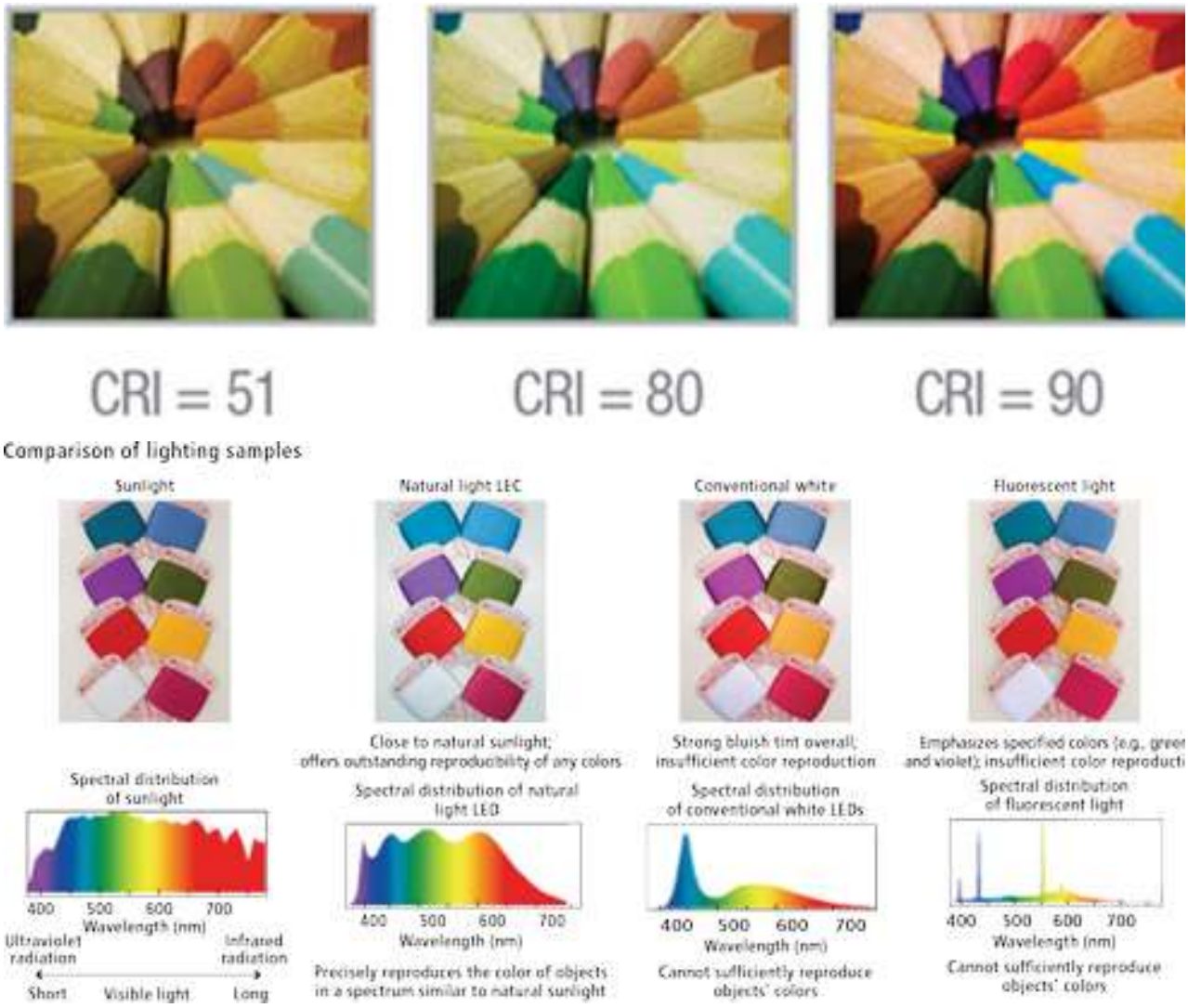
Colour rendering groups	CIE general colour rendering index	Typical Applications
1A	Ra ≥ 90	Critical colour matching
1B	90≥Ra≥80	Accurate colour judgements required for appearance
2	80≤Ra≤60	Moderate colour rendering required
3	60≤Ra≤40	True colour recognition of little significance
4	40≤Ra≤20	Not recommended for colour matching

Table - CIE colour rendering index groups

This index is based on how close a set of test colours are reproduced by the lamp under evaluation - relative to how they are reproduced by a reference light source with perfect colour rendering. Perfect matching is given a value of 100.

Below are some images which illustrate the effect of different Ra's on coloured objects.

Below are two groups of images which show the effect of Colour Rendering Index Ra on coloured surfaces.



Typical values are:

Low pressure sodium (SOX) yellow appearance	Ra = 0
High pressure sodium (SON) golden yellow appearance	Ra ≥ 25
High pressure sodium (SON-T Comfort) golden white in appearance	Ra ≥ 65
Light emitting diode (LED) used for amenity lighting neutral white appearance (4000K)	Ra ≥ 70
Light emitting diode (LED) used for amenity lighting warm white appearance (3000K)	Ra ≥ 70

The high-pressure sodium lamp has poor colour rendering for the visual task and is still a viable solution for amenity areas and access roads. However, the versatility and efficiency savings which can be achieved using LED make this the preferred solution for the majority of amenity and highway applications.

16.1.4 Colour Appearance/Colour Temperature

The colour of the light emitted by a 'near white' source is indicated by its correlated colour temperature (CCT). This is a measure of the 'warmth' or 'coolness' of the

light emitted by a source and is measured in Kelvin (K). The lower the Kelvin value, the 'warmer' the colour of the light and vice versa.

This becomes a more significant consideration when considering LED as the preferred light source as LED can be specified in a wide range of CCT derivatives - this was not typically the case for other light sources.

The main available CCT in outdoor lighting for LED's are around 5700K (cool white), 4000K (neutral white), 3000K (warm white). This figure must be considered along with CRI as these characteristics are not necessarily linked.

The table below will approximate LED characteristic to common discharge light sources to assist in understanding the difference.

The image below Illustrated the typical variation in artificial light with 1,000K very warm to the left and 10,000K very cold to the right

The 1,000K option will have poor colour rendering properties as the light has too much red content and as such will not reproduce shades of blue and green very well, alternatively the 10,000K will give a similar effect as it has too much blue content and as such will typically not show red colours very well. In exterior lighting, typically, Ra of 70 is adequate enough for the colour rendering and visual acuity required for the task.

17 Appendix C - Glossary and Terms of Reference

Beam Angle

The total angle over which the luminous intensity of a luminaire drops to 50% of the peak beam value.

Colour Rendering

The ability of a light source to render the colours of objects as similar to those under a reference light source, or an acceptable source such as daylight.

Disability Glare

Glare produced directly or by reflection that impairs the visibility of objects without necessarily causing discomfort.

Discomfort glare

Glare which causes a visual discomfort.

Glare

The discomfort or impairment of vision experienced when parts of the visual field are excessively bright in relation to the general surroundings.

Illuminance

The luminous flux density at a surface i.e. the luminous flux incident per unit area. Unit lm-m2, lux.

Luminance

The average road surface luminance (of a carriageway of a road)

Unit is candelas per square metre (cd/m2)

Lamp flux maintenance factor

The proportion of the initial luminous flux of a lamp that is produced after a set time.

Light trespass

Unwanted light from an installation falling on an area.

Light pollution

Term designating the spillage of a light into areas where it is not desired.

Louvre

A screen geometrically disposed to prevent lamps from being directly visible at a given angle.

Luminaire

Apparatus which distributes, filters, or transforms the light emitted by a lamp. It includes all the parts necessary for supporting, fixing and protecting the lamp, but not the lamp itself.

Lux

The SI unit of Illuminance equal to one lumen per square metre.

Sky glow

Localized brightening of the night sky caused by upward light interacting with particles in the air. Upward light comprises light emitted by lighting above the horizontal as well as downward light reflected upwards from illuminated surfaces. This effect is more noticeable on misty nights or when there is a low cloud base.

Spill light

Stray light from a luminaire that incidentally illuminates nearby objects or surfaces in the public environment, this can be a cause of light trespass.

Principal Area (PA)

The intended area needed to be included within the lighting design parameters, this could be anything from a roadway, footpath, car park, sports pitch/facility or conflict area.

Total Area (TA)

Generally, this comprises the principal area (PA) plus an additional safety area outside the principal area.